STOCK PRICES AND MACROECONOMIC INDICATORS: INVESTIGATING A CORRELATION IN INDIAN CONTEXT

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ABSTRACT
The objective of this paper is to find the existence of a relationship between stock market prices and the fundamental macroeconomic indicators. We build a Vector Auto Regression (VAR) model comprising of nine major macroeconomic indicators (interest rate, inflation, exchange rate, money supply, gdp, fdi, trade-gdp ratio, oil prices, gold prices) and then try to forecast them for next 5 years. Finally we calculate cross-correlation of these forecasted values with the BSE Sensex closing price for each of those years. We find very high correlation of the closing price with exchange rate and money supply of Indian economy.

Keywords BSE Sensex · Macroeconomics · VAR Model

1 Introduction
The world has witnessed a never-before-seen circumstance in the last two years: a global epidemic. The Coronavirus pandemic has had a negative impact on the entire world. As a result, it goes to reason that the global economy has been severely harmed, with protracted lockdowns and a direct impact on trade. The Indian economy hasn’t been spared either. In 2021, India’s GDP growth rate was negative for the first time in more than four decades (-8.0 percent). [1]

Despite these dire circumstances, the BSE SENSEX hit a new high of 62245.43 in October 2021. The excellent market performance contrasts sharply with real economic development, which has been hampered by most states’ localized lockdowns throughout the outbreak. As a result, the Reserve Bank of India issued a statement on May 31, 2021, warning the public that India could be experiencing a stock market bubble. A bubble is defined as a situation in which the price of a stock, financial asset, asset class, or entire sector significantly exceeds its underlying value. A stock market bubble is characterized by inflated share prices that are often far greater than a company’s basic value, which includes earnings and assets. The central bank noted in its FY21 annual report that the price surge in some companies is greater than their intrinsic value. Thus, in this paper, we will examine the daily value of the BSE SENSEX for the past ten years, as well as nine fundamental macroeconomic variables: interest rate, inflation, exchange rate, money supply, GDP, FDI, trade to GDP ratio, oil prices, and gold prices, from 1971 to 2020 [2], to determine whether India is currently in a stock market bubble.

The Real Interest Rate (percent) is a crucial macroeconomic variable since it is set by the Central Bank after thorough consideration of the country’s position and analysis of other factors such as supply and demand, inflation rate, government policies, and so on. The interest rate in 1971 was around 7.5 percent. India’s annual real interest rate was 4.38 percent in 2020. [3] The Reserve Bank of India’s Central Board of Directors makes interest rate decisions in India. The benchmark repurchase rate is the official interest rate. In 2014, the RBI’s principal monetary policy goal was price stability, with the government’s borrowing, rupee exchange rate stability, and the need to protect exports receiving less attention. The government and the central bank agreed in February 2015 to set a consumer inflation target of 4%, with a 2-percentage-point range, for the fiscal year ending in March 2017. From 2000 to 2021, India’s interest rate averaged 6.43 percent, with an all-time high of 14.50 percent in August 2000 and a record low of 4 percent in May 2020.
Inflation is described as a gradual increase in the price of products and services. Inflation is a key measure of a country’s economic health. The inflation rate is the rate at which prices, products, and services in an economy rise in general, and how this impacts the cost of living of those who live in that country. It has an impact on interest rates paid on savings and mortgages, as well as the number of state pensions and benefits received. Changes in the CPI are used to calculate India’s inflation rate. Over the previous ten years, India’s inflation rate has risen. Since 2010, however, it has been decreasing somewhat. From 2012 to 2021, India’s inflation rate averaged 5.97 percent, reaching an all-time high of 12.17 percent in November 2013 and a record low of 1.54 percent in June 2017. India’s inflation rate was 6.62 percent in 2020.

The value of a country’s currency (Indian Rupee) versus that of another country (US Dollar) or economic zone is known as the exchange rate. From 2012 to 2021, India’s inflation rate averaged 5.97 percent, reaching an all-time high of 12.17 percent in November 2013 and a record low of 1.54 percent in June 2017. Exchange rates are free-floating and fluctuate according to market supply and demand. The currency rate in 1971 was just Rs 7.52/$. The exchange rate will reach Rs 74.1/$ in 2020. The amount of cash or currency circulating in an economy is referred to as the money supply. From 1971 through 2020, the value has been steadily increasing. Since 1993, the Indian rupee (INR) has followed a market-driven exchange rate — the price is set by the demand for and supply of foreign exchange – with occasional intervention by the Reserve Bank of India. This was part of the early 1990s liberalization and deregulation initiatives. The demand for and supply of foreign exchange determine the price of the INR (forex).

In 1971, India’s GDP was at $67 billion. In the year 2020, the value was greater than $2.6 trillion. However, due to the epidemic, the country’s GDP has fallen by 8% in the last 40 years. From 2003 to 2007, India witnessed significant growth rates, averaging 9%. Due to the global financial crisis in 2008, growth slowed. India entered a phase of slower growth in 2012, with growth slowing to 5.6 percent. Other economic issues emerged, such as the Indian rupee’s deprecation, the country’s persistently high current account deficit, and weak industrial growth. India began to recover in 2013–14 when the GDP growth rate increased to 6.4 percent from 5.5 percent the previous year. With growth rates of 7.5 percent and 8.0 percent in 2014–15 and 2015–16, respectively, the acceleration persisted. However, due to the disruptive effects of the 2016 Indian banknote demonetization and the Goods and Services Tax, the growth rate slowed to 7.1 percent in 2016–17 and 6.6 percent in 2017–18, respectively. India’s GDP growth has slowed dramatically, from an all-time high of 8.3% in 2016 to barely 4.2 percent in 2019.

A foreign direct investment(FDI) is an investment in the form of controlling ownership in a business in one country by an entity based in another country. FDI net inflows (as a percentage of GDP) are currently greater than 2%. In 1971, however, it was less than 0.07 percent. The main reason for this was that, until 1991, India was essentially a closed economy. In 1991, the Narasimha Rao government, which included Finance Minister Manmohan Singh, began economic reforms. The reforms abolished the license raj, lowered tariffs and interest rates, and dissolved several state monopolies, enabling for automatic acceptance of foreign direct investment in a variety of areas. India has evolved toward a free-market economy by the turn of the century, with a significant reduction in state control of the economy and growing financial deregulation. The impact of the reforms is visible in the macroeconomic variables: FDI increased from 0.01% in 1984 to more than 0.6% in 1996.

Trade as a percentage of GDP was 36% in 2020, a little decrease from previous years, owing primarily to government policy, international relations, and, to some extent, the pandemic. However, it is still far more than it was in 1971 when it was less than 7.7% of GDP. India was largely and purposely isolated from the world markets until 1991, to defend its economy and develop self-reliance. Import tariffs, export taxes, and quantitative limits all applied to international trade. For the first 15 years after independence, India’s exports remained stagnant due to the government’s widespread disregard for trade policy. Due to the embryonic state of industrialization at the time, imports primarily comprised machinery, raw materials, and consumer products. The value of India’s international commerce has expanded dramatically since liberalization, with overall trade in commodities and services contributing 47% of GDP in 2008–10, up from 16% in 1990–91. In the merchandise trade, India accounts for 1.44 percent of exports and 2.12 percent of imports, while in the commercial services sector, India accounts for 3.34 percent of exports and 3.31 percent of imports. The European Union, China, the United States of America, and the United Arab Emirates are India’s key trading partners. Engineering items, petroleum products, chemicals and pharmaceuticals, gems and jewelry, textiles and garments, agricultural products, iron ore, and other minerals were among the top export commodities in 2006–07. Crude oil and allied items, machinery, electrical goods, gold, and silver were all major imports. The oil and gold prices are also very important macroeconomic indicators as they are very closely related to Stock prices. Oil and gold are arguably the most important commodities on the planet. Any sudden change in any of the macroeconomic variables can be analyzed using their prices.

Thus, using this set of varying and fundamental macroeconomic variables, we build a VAR model to forecast their future values. Then we use these forecasted values to find a cross-correlation with BSE Sensex Closing Price for the past 5 years and try to identify the variables which have a maximum correlation.
2 Literature Review

Sirucek, Martin (2012) [7] was one of the researchers to study the relationship between the change in money supply and the impact it created on the Dow Jones Industrial Average (DJIA) in the US markets. He had chosen this index because of the long history, stable construction and global sense. He was trying to examine if the impact of M2 and MZM (Money with zero maturity) is nearly the same or not and what role they play in the creation of a bubble. He found out that the effect of the money supply assessed through money aggregate M2 on the DJIA stock index was confirmed when imposing a delay of up to 6 months, but the effect of the MZM money aggregate on stock prices can only be proved with a delay of 6 or more months.

Richard J. Rogalski and Joseph D. Vinso (1997) [8] found out in their study that the claim made by numerous monetary portfolio theorists that information about the actual rate of expansion of the money supply is absorbed into stock returns. It also supports the idea that the stock market is efficient in terms of monetary information, as suggested by the efficient market hypothesis. Specifically, causality appears to travel from stock prices to money supply and possibly back again, rather than from money supply to stock prices. Based on their findings, they have suggested a bi-directional hypothesis of causality between money supply and stock returns. They also went further to show that there is a monetary policy implication since changes in the money supply, as a result of changes in Federal Reserve policies, will have a direct impact on common stock returns. While the stock market’s impact on monetary policy should not be used to guide policy, such influences should not be ignored due to the stock market's impact on economic activity.

Picha Vladimir (2017) [9] tried to find out the short term and long term relationship of money supply on stock market prices through portfolio balance channels as a transmission mechanism of monetary policy. The results show that with a 6 month lag, the money supply has an impact on the S&P 500 index valuation. In the long run, the impact is also discernible, as all identified asset classes can favourably influence the price of the S&P 500. The findings are then contextualised using a monetary policy framework in the latter section of the research.

Matiur Rahman (2008) [10] studied the long run and short run dynamic effects of broad money (M2) and oil price on the US Stock Market (S&P 500). The results suggest a cointegrating relationship in the above three variables. Although short-run interaction feedback links exist, the vector error-correction models do not disclose any converging long-run causal flows. The current volatility of the stock market in the United States is fueled by previous volatility. The stock market in the United States was originally depressed by negative monetary and oil shocks.

Mahfoudh Hussein Hussein Mgammal (2012) [11] had taken two hypotheses that there exists a positive relationship between the stock market price index and exchange rate in the short term and a negative relationship between the stock market price index and exchange rate in the long term. He considered two gulf countries; Kingdom Saudi Arabia (KSA) and United Arab Emirate (UAE) for this study. He found that there exists a positive relationship in the short run between exchange rate and stock market price index for UAE and a negative relationship in the long run between exchange rate and stock market price index. As far as KSA is concerned, no conclusive remarks can be made about the long term relationship between the addressed variables. Meanwhile a not so statistically significant positive short term relationship between the said variables was found out by him.

Prashanta K. Banerjee and Bishnu Kumar Adhikary (2009) [12] studied the relationship of interest rate and exchange rate with the stock market prices in Bangladesh and found that these variables have a long-run equilibrium relationship, and that a unidirectional long-term causal flow extends from changes in the interest rate and exchange rate to Bangladesh’s stock market, with no discernible interactive feedback relationships. However, due to the statistic’s low numeric value, the variables are nearly independent of one another. Investigation of the exchange rate reveals a short term net negative feedback from the exchange rate to stock market with insignificant values of contemporaneous and lagged variables.

Nozar Hashemzadeh & Philip Taylor (1998) [13] tried to examine the statistical relationship between the supply of money and stock price levels and between the level of interest rates and stock prices. Using the Granger Sims test for determining the unidirectional causality, they got inconclusive results. However in a particular instance they were able to capture the causality from interest rate to stock prices and not the other way around.

Shawkat Hammoudeha and Ramazan Sarib (2011) [14] wanted to examine the short term and long term dynamics of US Financial CDS index spreads at sector level and observe its relationship with the stock market and the short- and long-run government securities. They had deployed the Autoregressive Distributed Lag approach for achieving the said goals. In conclusion they stated that the short- and long-run results do not link changes in the bank and insurance CDS spread risks to changes in the long-run interest rates. They do not show a transmission of risk from banks or insurance firms to the long-run Treasury rate. They were also able to affirmatively say that the 2008 financial crisis has weakened the long-run equilibrium relationships among the five financial variables and strengthened the work of the common stochastic shocks.
Mohammed Omran (2003) examines the impact of real interest rates, which are a significant component of the programme, on the performance of the Egyptian stock market in terms of market activity and liquidity. The main purpose was to create a strong stock market. By applying the Engel Granger and ECM, he was able to reach to the finalised statement that there are strong long-run and short-run connections between the variables, implying that real interest rates affect stock market performance.

Trust Kganyago and Victor Gumbo (2015) examined the long run relationship between money market interest rates and stock market returns in Zimbabwe from April 2009 to December 2013. They used the OLS regression model to determine the relationship between stock market returns and interest rates. It has been empirically proved that there exists a negative relationship between them. In the short run, it was discovered that stock market returns granger causes money market returns, which can be explained by passive money caused by non functionality of the Reserve Bank of Zimbabwe.

Oliver Blanchard (1981) tried to derive a link between output, stock market and term structure of interest rates. He used the famous IS-LM Model to explain his theories. He showed that A discrete shift in the stock market results from a change in the expected sequence of profits and real interest rates as a result of a change in existing or projected policy. This, combined with the policy change, affects expenditure and output over time, supporting the initial profit and interest rate expectations. The stock market is not the "cause" of increased output, any more than the initial stock market range is the reason for increased output. They’re both the result of policy changes.

Alberto Giovannini and Philippe Jorion (1987) have tried to document the common empirical regularities in the foreign exchange market and in the US Stock market. They show that increases in interest rates are associated with increases in the volatility of returns in both the stock market and the foreign exchange market. They also proved that not taking into account the time variation of second moments may seriously affect tests of asset pricing models, and over-identify restrictions of the latent variable capital asset pricing model.

M Nezky (2013) analysed the impact of the financial crisis in the United States in 2008 on the Indonesian economy. It is examined using a Structural Vector Autoregressive (SVAR) model with five variables: the Dow Jones Industrial Average, the exchange rate, the composite stock price index (IHSG), the production index, and trade tax income. The findings suggest that the US financial crisis has an impact on the Indonesian capital market, with the Dow Jones Industrial Average playing a larger role in explaining the IHSG than the Rupiah rate, production index, or trade income tax.

Bakri Abdul Karim and M. Shabri Abd. Majid (2010) had the objective to re-examine the stock market integration and short-run dynamic interactions between the Malaysian stock market and the stock markets of its major trading partners (the USA, Japan, Singapore, China and Thailand). They used the ARDL approach and reached the following results. They stated that there exists a long-run equilibrium relationship among the stock markets. In addition, these markets are moving towards more integration, especially following the 1997 financial crisis. This might be due to a remarkable rise in the proportion of bilateral trade among the countries in the region from the pre- to post-crisis periods.

Udoka Bernard Alajekwu, Vincent N. Ezebasili and Samuel M. Nzotta (2013) investigated the effect of trade openness on the impact of stock market development on economic growth of Nigeria. According to their findings, exposure to foreign economies (trade openness) has little bearing on the growth of the Nigerian stock market in particular or the economy in general.

Chun-Da Chen, Chiao-Ming Cheng and Rza Demirer (2017) tried to capture the significance of oil and stock market momentum. They tried to scrutinize the predictive ability of oil return and volatility on stock market momentum in China, providing a fresh perspective on the oil-stock market nexus. Even after adjusting for stock market status, volatility, and important macroeconomic factors, we show that oil return volatility is a powerful predictor of industrial momentum. They conclude that market dynamics can contribute to stock market inefficiencies in such a way that these inefficiencies create significant abnormal profits for active managers.

K.P. Prabheesh, Rakesh Padhan and Bhavesh Garg (2020) tried to study the relationship between oil price returns and stock market prices during the COVID-19 era. They fitted a DCC–GARCH model which indicated a positive co-movement between the said variables. Thus, they believe that a decline in oil price returns is a bad signal for the stock market prices to also drop.

In an attempt to extract information entangled in both markets for risk prediction, the multivariate stochastic volatility structure was used by Minh Vo (2011) to model the volatility of stock and oil futures markets. The major findings of the study was firstly that stock and oil futures prices are interrelated. Their correlation is based on a time-varying dynamic mechanism that tends to strengthen as markets become more volatile. Secondly, in terms of volatility, there is inter-market dependence. Innovations in one market can have an impact on the volatility in the other. In other words,
the past volatility of the stock (oil futures) market has predictive potential over the future volatility of the oil futures (stock) market, conditioned on the persistence and historical volatility in their respective markets.

Caroline Geetha, Rosle Mohidin, Vivin Vincent Chandran and Victoria Chong (2011) [25] aimed to find a relationship between inflation and stock returns. They used the cointegration test to determine the long term relationship between the said variables. While for the short term relationship, they used Vector Error Correction Modeling (VECM). They had tested this on China, Malaysia and the US. The results of VEC show no short run relationship between the stock market, expected inflation, exchange rate, unexpected inflation, interest rate and GDP for Malaysia and the US. However, China’s VEC result show there is a short run relationship between expected inflation rates with China’s stock market.

3 Methodology

3.1 Theoretical Framework

With the advent of globalization, privatization and liberalization of global economies, the process of integration of world financial markets has accelerated. Not only price movements but various other factors and events can cause spill-over effects instantly to other markets. Hence it becomes ever more important to understand the dynamic structure by studying all the effects jointly to have a better understanding. For the same purpose, we create a vector autoregression model. [26]

The vector autoregression (VAR) model is one of the most popular, adaptable, and straightforward methods for multivariate time series analysis. It is a natural extension of the univariate autoregressive model and has proven to be particularly beneficial for forecasting and understanding the dynamic behaviour of economic and financial time series. It frequently outperforms univariate time series models and sophisticated theory-based simultaneous equations models in forecasting. Forecasts from VAR models can be generated conditional on the likely future courses of specified variables in the model, giving them a lot of flexibility.

The VAR model is often utilised for structural inference and policy analysis in addition to data description and forecasting. Certain assumptions regarding the causal structure of the data under examination are enforced in structural analysis, and the consequent causal implications of unexpected shocks or innovations to specified variables on the model variables are described. Impulse response functions and forecast error variance decompositions are commonly used to summarise these causal effects.

Let $Y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})'$ denote an $(n \times 1)$ vector of time series variables. The basic p-lag vector autoregressive (VAR(p)) model has the form

$$Y_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \ldots + \Pi_p Y_{t-p} + \varepsilon_t, \quad t = 1, \ldots, T \tag{1}$$

where $\Pi_i$ are $(n \times n)$ coefficient matrices and $\varepsilon_t$ is an $(n \times 1)$ unobservable zero mean white noise vector process (serially uncorrelated or independent) with time invariant covariance matrix $\Sigma$.

VAR models do not require as much knowledge about the forces influencing a variable. The only prior knowledge required is a list of variables hypothesized to affect each other over time.

For all the analyses, we have made use of Python. All the statistical calculations have been done using the statsmodels library, and figures have been plotted with the matplotlib library’s help.

3.2 Data

In the empirical analysis, the study uses annual time series data for a period of 50 years, i.e. 1971-2020. All data has been collected concerning India. A detailed account of all the variables considered and the source of information on the same is presented below:

The paper also includes usage of definitions and explanations from a large number of financial institutions all over the world including the World Bank, International Monetary Fund, Reserve Bank of India to name a few.

3.2.1 Methodology

The basis behind VAR is that each of the time series in the system influences each other. So, the first task was to check for the time series’s causation, i.e. whether the series could be predicted with past values of itself along with other series in the system. This was done using Granger’s Causality Test [27]. This test is easy to implement and is based upon the foundations of statistics, thus very reliable. It tests the following:
Table 1: Data and their Sources

| Indicator    | Proxy                                | Source                          |
|--------------|--------------------------------------|---------------------------------|
| 1. Interest Rate | Real interest rate (%)               | World Bank                      |
| 2. Inflation | Inflation, consumer prices (annual %) | World Bank                      |
| 3. Exchange Rate | US$ vs INR exchange rate            | World Bank                      |
| 4. Money Supply | M3 money supply                      | Reserve Bank of India           |
| 5. GDP       | GDP (current US$)                    | World Bank                      |
| 6. FDI       | FDI (inflows)                        | World Bank                      |
| 7. Trade     | Import+Export/GDP (%)                | World Bank                      |
| 8. Oil       | Crude Oil Price (current US$)        | inflationdata.com               |
| 9. Gold      | Gold Price (current US$)             | World Gold Council              |
| 10. Stock Prices | BSE SENSEX                          | BSE India                       |

**Null Hypothesis:** The past values of time series (X) do not Granger cause the other time series (Y)

**Alternate Hypothesis:** The past values of time series (X) Granger cause the other time series (Y)

Next, a co-integration test was used to establish the presence of a statistically significant connection between two or more time series. Soren Johannsen [28] devised a procedure to implement the cointegration test, making it possible to estimate all co-integrating variables even if there are more than two variables. When two or more time series are co-integrated, it means they have a long run, statistically significant relationship.

The data was then divided into two sets - train and test. Our VAR model will be fitted on train dataset and then will be used to forecast the next 4 observations. These forecasts will be compared against the actual observations present in test dataset using multiple forecast accuracy metrics.

Before beginning data analysis, stationarity checking is a requirement to ensure that the collected data doesn’t change itself when shifted in time. Granger and Newbold (1974) [29] have shown that spurious results could be obtained if the time-series data is non-stationary.

Out of many unit root tests available, the augmented Dickey-Fuller Test [30] was chosen. It tests the null hypothesis that a unit-root is present in the time series sample. In simpler terms,

**Null Hypothesis:** The data is not stationary

**Alternate Hypothesis:** The data is stationary

The ADF test helps eliminate the problem of autocorrelation by including the lagged values of the independent variable.

We then employ a model selection criterion to identify the lag length for the $VAR(p)$ model. The general approach is to fit $VAR(p)$ models with orders $p = 0, \ldots, p_{\text{max}}$ and choose the value of $p$ which minimizes some model selection criteria. Model selection criteria for $VAR(p)$ models have the form

$$IC(p) = \ln |\tilde{\Sigma}(p)| + c_T \cdot \phi(n, p)$$

where $\ln |\tilde{\Sigma}(p)| = T^{-1} \sum_{t=1}^{T} \hat{\epsilon}_t \hat{\epsilon}_t'$ is the residual covariance matrix without a degrees of freedom correction from a $VAR(p)$ model, $c_T$ is a sequence indexed by the sample size $T$, and $\phi(n, p)$ is a penalty function which penalizes large $VAR(p)$ models. [26]

Some general criteria which were available were: information criterion of Akaike [31], known as AIC; Bayesian information criterion by Akaike [32] and Schwarz [33], known as BIC; Hannan and Quinn’s HQIE [34] and Akaike’s Final Prediction Error [35] called FPE. For simplicity, we only consider AIC in our study.

$$AIC(p) = \ln |\tilde{\Sigma}(p)| + \frac{2}{T}pn^2$$

$$BIC(p) = \ln |\tilde{\Sigma}(p)| + \frac{\ln T}{T}pn^2$$

$$HQ(p) = \ln |\tilde{\Sigma}(p)| + \frac{2\ln\ln T}{T}pn^2$$

The AIC criterion asymptotically overestimates the order with positive probability, whereas the BIC and HQ criteria estimate the order consistently under fairly general conditions if the true order $p$ is less than or equal to $p_{\text{max}}$. 


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Serial correlation of errors can be assessed using the Durbin Watson’s statistic [36] after the model has been trained to ensure that it can adequately explain the variations and patterns in the time series. This statistic’s value might range between 0 and 4. There is no substantial serial association the closer it gets to the number 2. Closer to 0, there is a positive serial correlation, and the closer it is to 4 implies negative serial correlation.

In the end, we forecast the data and analyze using some metrics, namely, the MAPE, ME, MAE, MPE, RMSE and correlation.

Mean absolute percentage error,

\[ MAPE = \frac{1}{n} \sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right| \]

Mean Error,

\[ ME = \frac{1}{n} \sum_{t=1}^{n} (A_t - F_t) \]

Mean Absolute Error,

\[ MAE = \frac{1}{n} \sum_{t=1}^{n} |A_t - F_t| \]

Mean Percentage Error,

\[ MPE = \frac{100\%}{n} \sum_{t=1}^{n} |A_t - F_t| \]

Root Mean Squared Error,

\[ RMSE = \sqrt{\frac{\sum_{t=1}^{n} (A_t - F_t)^2}{n}} \]

Correlation,

\[ Corr = \frac{\sum_{t=1}^{n} (A_t - \bar{A})(F_t - \bar{F})}{\sqrt{\sum_{t=1}^{n} (A_t - \bar{A})^2 \sum_{t=1}^{n} (F_t - \bar{F})^2}} \]

where \( A_t \) represents Actual values, \( F_t \) represents Forecasted values and \( n \) represents the total number of observations.

Finally in the end, we try to find a cross-correlation between the forecasted values by our simple VAR model and the BSE Sensex Closing Price of a year to try and see which variables according to our model have highest comovement with the stock price.

When assessing information between two separate time series, cross-correlation is commonly used. The correlation coefficient of time series data might be anything between -1.0 and +1.0. The closer the cross-correlation value is to 1, the more closely the series are identical.

4 Result Analysis

4.1 Descriptive Statistics

All series have 50 data points each. The descriptive statistics are listed in Table 2.

4.2 Result Analysis

We first conducted Granger’s Causality Test, and its’ findings have been encapsulated in the table below. If a given p-value is less than the significance level (0.05), then the null hypothesis that the corresponding X series does not cause the Y (row) is rejected.

Hence, we can conclude that most of the variables (time series) in the system are interchangeably causing each other, thus ensuring that this multi-time series system can be forecasted using the VAR model.

After performing the Co-integration tests, we concluded that all variables except gold depict a long-term statistically significant connection.
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### Table 2: Descriptive Statistics

| Variable      | Statistics       |
|---------------|------------------|
| Name          | Mean  | Std Dev | Max   | Min   | 25%  | 50%  | 75%  |
| Interest Rate | 6.0397 | 2.4739  | 10.7746 | -1.9838 | 4.8688 | 6.6276 | 7.5463 |
| Inflation     | 7.7698 | 4.9397  | 28.5987 | -7.6339 | 4.72910 | 7.1193 | 10.01453 |
| Exchange Rate | 32.73  | 21.2548 | 74.0996 | 7.5244  | 10.445  | 33.9263 | 46.6497 |
| Money Supply  | 52.2   | 19.2366 | 88.8760 | 22.83545 | 36.7160 | 45.4524 | 73.6782 |
| GDP           | 7.9 × 10^{11} | 8.4 × 10^{11} | 28.7 × 10^{11} | 0.67 × 10^{11} | 2.1 × 10^{11} | 3.8 × 10^{11} | 12.1 × 10^{11} |
| FDI           | 0.7834 | 0.8918  | 3.6205  | -0.0296 | 0.0446  | 0.5338  | 1.5140 |
| Trade         | 26.6923 | 15.0506 | 55.7937 | 7.6696  | 13.7703 | 22.27443 | 40.5775 |
| Oil           | 33.5058 | 24.2194 | 91.48   | 3.6     | 16.6075 | 26.0100 | 43.4400 |
| Gold          | 597.1235 | 466.8005 | 1773.73 | 43.455  | 298.423 | 399.634 | 815.8595 |

### Table 3: Granger Causality Test Results

| Variable | intr_x | infl_x | exrate_x | msupply_x | gdpx | fdi_x | trade_x | oil_x | gold_x |
|----------|--------|--------|----------|-----------|------|-------|---------|-------|--------|
| intr_y  | 1.0000 | 0.0004 | 0.0525   | 0.0081    | 0.0026 | 0.0014 | 0.0126  | 0.0393 | 0.0003 |
| infl_y  | 0.0012 | 0.9999 | 0.0097   | 0.0854    | 0.0166 | 0.2291 | 0.1873  | 0.2832 | 0.0453 |
| exrate_y| 0.0183 | 0.0721 | 1.0000   | 0.0022    | 0.00002 | 0.0152 | 0.0788  | 0.0007 | 0.0026 |
| msupply_y| 0.00129 | 0.0114 | 0.0000033 | 1.00000   | 0.0030 | 0.4678 | 0.0078  | 0.00013 | 0.0200 |
| gdpx    | 0.2565 | 0.8064 | 0.00026  | 0.00074   | 0.9999 | 0.0000 | 0.0000  | 0.00082 | 0.0394 |
| fdi_y   | 0.4965 | 0.3113 | 0.0000   | 0.0025    | 0.0000 | 1.0000 | 0.0000  | 0.0084 | 0.3326 |
| trade_y | 0.0027 | 0.5176 | 0.0000   | 0.0004    | 0.0000 | 1.0000 | 0.0000  | 0.0000 | 0.0000 |
| oil_y   | 0.0017 | 0.3954 | 0.0001   | 0.0016    | 0.0000 | 0.0000 | 1.0000  | 0.0000 | 0.0000 |
| gold_y  | 0.0745 | 0.02561 | 0.0034  | 0.00099  | 0.0000 | 0.0000 | 0.0007  | 0.0000 | 1.0000 |

After dividing the data into train and test, stationarity checking of variables was done for the train dataset before any modelling. The results of the Augmented Dickey – Fuller Test (ADF) have been presented in the Table 5. The test revealed that all the original time series were non-stationary. So the series was differenced and tested repeatedly until stationary.

Then, we then try to find the optimal lag order for our VAR model. To do this, we iteratively fit the VAR model’s orders and pick the order that gives a model with the least AIC.

As we can see in Table 6, the AIC drops to lowest at lag 6. Finally, we fit the model with lag order 6, and summary of Regression Results is available in the Appendix.

If there is any correlation left in the residuals, then there is some pattern in the time series that is still left to be explained by the model. So, checking for serial correlation ensures that the model is sufficiently able to explain the variances and patterns in the time series. So we check for serial correlation of errors, using Durbin Watson’s Statistic.

As we can see in Table 7, the value of the statistic for all variables is reasonably close to 2 thus implying there is no significant serial correlation.

Finally, we forecast the values, but the forecasts are generated on the scale of the model’s training data. So, we bring it back up to its original scale by de-differencing twice.

Finally we evaluate our predicted values by using some metrics.

As we can see, the lowest Mean Absolute Percentage Error is for the variable GDP.

Finally we calculate the cross correlation of each of the variables with the BSE Sensex Index. Cross correlation is basically a way to measure the degree of similarity between a time series and a lagged version of another time series.

As seen in Table 9, we can see very high correlation of closing price of BSE Sensex with our forecasted Exchange rate and also a very high negative correlation with the money supply in the economy.
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Figure 1: Correlation Matrix of Residuals

Figure 2: Forecast v/s Actual Values
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Table 4: Co-integration tests

| Variable     | Test Stat | C(95%)     | Signif |
|--------------|-----------|------------|--------|
| interest_rate| 2314.45   | 179.5199   | True   |
| inflation    | 1699.95   | 143.6691   | True   |
| exchange_rate| 1252.52   | 111.7797   | True   |
| money_supply | 878.0     | 83.9383    | True   |
| gdp          | 524.72    | 60.0627    | True   |
| fdi          | 327.18    | 40.1749    | True   |
| trade_gdp    | 136.65    | 24.2761    | True   |
| oil          | 13.29     | 12.3212    | True   |
| gold         | 2.96      | 4.1296     | False  |

Table 5: Augmented Dickey-Fuller Test Results

| intrate   | infl  | exchrate | msupply | gdp     | fdi    | trade  | oil    | gold    |
|-----------|-------|----------|---------|---------|--------|--------|--------|---------|
| Original  | Stat. | Stat.    | Non-Stat.| Non-Stat.| Non-Stat.| Non-Stat.| Non-Stat.| Non-Stat.|
| 1 Diff.   | Stat. | Stat.    | Stat.   | Stat.   | Stat.   | Stat.   | Stat.   | Stat.   |
| 2 Diff.   | Stat. | Stat.    | Stat.   | Stat.   | Stat.   | Stat.   | Stat.   | Stat.   |

Table 6: Finding optimal order of VAR Model

| Lag | AIC  | BIC  | FPE  | HQIC |
|-----|------|------|------|------|
| 1   | 71.6636 | 75.3872 | 1.44e+31 | 73.0284 |
| 2   | 70.2192 | 77.3661 | 0.62e+31 | 72.8217 |
| 3   | 61.8216 | 72.4616 | 1.43e+28 | 65.6687 |
| 4   | -83.7014 | -69.4971 | 2.82e-30 | -78.605 |
| 5   | -135.839 | -117.998 | -5.41e-60 | -129.49 |
| 6   | -138.587 | -117.035 | -3.70e-66 | -130.98 |
| 7   | -128.346 | -103.01 | -2.17e-65 | -119.503 |
| 8   | -129.305 | -100.11 | -4.18e-69 | -119.226 |

Table 7: Durbin-Watson’s Statistic

| intrate | infl  | exchrate | msupply | gdp    | fdi    | trade  | oil    | gold    |
|---------|-------|----------|---------|--------|--------|--------|--------|---------|
| DW-Statistic | 2.29 | 1.54 | 2.04 | 1.88 | 2.37 | 2.26 | 1.87 | 1.89  | 2.29 |

Table 8: Forecast Accuracy

| Variable     | MAPE  | ME    | MAE   | MPE   | RMSE  | Corr   |
|--------------|-------|-------|-------|-------|-------|--------|
| Interest     | 4.9088| -26.489| 26.489| -4.9088| 27.406| -0.1613|
| Inflation    | 4.7579| 11.9666| 22.3888| 2.0928| 25.9987| 0.7175|
| Exchange Rate| 0.541 | 38.0589| 38.0589| 0.541 | 43.6972| 0.885 |
| Money supply | 0.5724| -45.5798| 45.5798| -0.5724| 53.0154| -0.6675|
| GDP          | 0.2295| -4.5e11| 5.9e11| -0.1764| 6.4e11| 0.6008|
| FDI          | 2.1177| -1.5415| 3.4943| -1.0873| 3.9586| 0.7758|
| Trade        | 0.3922| 15.8482| 15.8482| 0.3922| 21.3357| 0.3672|
| Oil Price    | 2.0576| -81.6239| 81.6239| -2.0576| 97.2881| 0.5737|
| Gold         | 0.3511| -143.9981| 538.1676| -0.035| 799.0659| -0.8961|

5 Conclusion

Thus we can conclude that exchange rate and money supply in the economy has the highest correlation with the stock price according to our macroeconomic VAR model of Indian Economy for the period 2016-2020.
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Table 9: Cross correlation Analysis

| Variable       | Lag 0    | Lag 1    | Lag 2    | Lag 3    | Lag 4    |
|----------------|----------|----------|----------|----------|----------|
| Interest Rate  | -0.3004222 | -0.42945014 | 0.29787696 | 0.36007481 | -0.00163329 |
| Inflation      | 0.27767763 | 0.2200911 | 0.44715304 | 0.07745795 | -0.43940031 |
| Exchange Rate  | 0.84163439 | 0.44541292 | 0.17535062 | -0.1844046 | -0.56882276 |
| Money supply   | -0.95955797 | -0.22346008 | 0.19206048 | 0.23868043 | -0.56882276 |
| GDP            | -0.01482224 | -0.33866955 | -0.472503 | 0.00854506 | 0.30269995 |
| FDI            | 0.59155563 | 0.58269897 | 0.0791308 | -0.42699511 | -0.30877878 |
| Trade          | 0.08044143 | 0.06655474 | -0.32441759 | -0.38734856 | 0.28026067 |
| Oil Price      | -0.13386997 | 0.12290279 | -0.23555443 | -0.35581185 | 0.32172806 |
| Gold           | -0.68531379 | -0.52501217 | -0.19410922 | 0.09670092 | 0.57442169 |

These results give us insights into the importance of spot exchange rate and money supply in influencing stock prices in India. Thus an investor should keep a close eye on these indicators as well, while making financial decisions.

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6 Appendix
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Figure 3: Trends
### Results for equation interest_rate

|            | coefficient | std. error | t-stat | prob |
|------------|-------------|------------|--------|------|
| const      | -0.23319    | NAN        | NAN    | NAN  |
| L1.interest_rate | -0.284635   | NAN        | NAN    | NAN  |
| L1.inflation  | 0.226275    | 8.457636   | 0.027  | 0.979|
| L1.exchange_rate | 0.562518    | NAN        | NAN    | NAN  |
| L1.money_supply | 0.308042    | 20.641894  | 0.015  | 0.988|
| L1.gdp       | 0.000000    | NAN        | NAN    | NAN  |
| L1.fdi       | -0.021129   | NAN        | NAN    | NAN  |
| L1.trade_gdp | -0.537611   | NAN        | NAN    | NAN  |
| L1.oil       | 0.359864    | 4.006895   | 0.090  | 0.928|
| L1.gold      | 0.000834    | NAN        | NAN    | NAN  |
| L2.interest_rate | -0.702900   | NAN        | NAN    | NAN  |
| L2.inflation | -0.241780   | NAN        | NAN    | NAN  |
| L2.exchange_rate | -0.194578   | NAN        | NAN    | NAN  |
| L2.money_supply | -0.525270   | NAN        | NAN    | NAN  |
| L2.gdp       | 0.000000    | 0.000000   | 0.003  | 0.998|
| L2.fdi       | -0.430571   | NAN        | NAN    | NAN  |
| L2.trade_gdp | -0.072731   | NAN        | NAN    | NAN  |
| L2.oil       | 0.056889    | NAN        | NAN    | NAN  |
| L2.gold      | -0.019298   | 0.672091   | -0.029 | 0.977|
| L3.interest_rate | -0.063917   | NAN        | NAN    | NAN  |
| L3.inflation | 0.401605    | NAN        | NAN    | NAN  |
| L3.exchange_rate | 0.080207    | NAN        | NAN    | NAN  |
| L3.money_supply | 0.490812    | NAN        | NAN    | NAN  |
| L3.gdp       | 0.000000    | NAN        | NAN    | NAN  |
| L3.fdi       | -0.463571   | 140.939997 | -0.003 | 0.997|
| L3.trade_gdp | -0.216786   | 29.823469  | -0.007 | 0.994|
| L3.oil       | 0.328096    | 2.284541   | 0.144  | 0.886|
| L3.gold      | 0.032701    | NAN        | NAN    | NAN  |
| L4.interest_rate | 0.595324    | NAN        | NAN    | NAN  |
| L4.inflation | 0.446932    | NAN        | NAN    | NAN  |
| L4.exchange_rate | 0.951425    | NAN        | NAN    | NAN  |
| L4.money_supply | -0.303263   | NAN        | NAN    | NAN  |
| L4.gdp       | 0.000000    | 0.000000   | 0.038  | 0.970|
| L4.fdi       | -0.160988   | 75.955216  | -0.002 | 0.998|
| L4.trade_gdp | -1.087531   | NAN        | NAN    | NAN  |
| L4.oil       | 0.421400    | 4.009961   | 0.105  | 0.916|
| L4.gold      | -0.040524   | 0.428476   | -0.095 | 0.925|
| L5.interest_rate | -0.304453   | 13.106586  | -0.023 | 0.981|
| L5.inflation | 0.233324    | NAN        | NAN    | NAN  |
| L5.exchange_rate | -0.640186   | NAN        | NAN    | NAN  |
| L5.money_supply | -0.047940   | NAN        | NAN    | NAN  |
| L5.gdp       | 0.000000    | NAN        | NAN    | NAN  |
| L5.fdi       | 0.381768    | NAN        | NAN    | NAN  |
| L5.trade_gdp | -0.173662   | 12.692847  | -0.014 | 0.989|
| L5.oil       | -0.105078   | NAN        | NAN    | NAN  |
| L5.gold      | 0.084945    | NAN        | NAN    | NAN  |
| L6.interest_rate | 0.424178    | NAN        | NAN    | NAN  |
| L6.inflation | 0.325731    | 4.742912   | 0.069  | 0.945|
| L6.exchange_rate | 1.129787    | 18.575799  | 0.061  | 0.952|
| L6.money_supply | -0.490681   | NAN        | NAN    | NAN  |
| L6.gdp       | 0.000000    | NAN        | NAN    | NAN  |
| L6.fdi       | 0.469469    | 145.055940 | 0.003  | 0.997|
| L6.trade_gdp | -0.306968   | NAN        | NAN    | NAN  |
| L6.oil       | -0.075969   | NAN        | NAN    | NAN  |
| L6.gold      | 0.000472    | 0.571871   | 0.001  | 0.999|

Figure 4: Equation for Interest Rate
### Results for equation inflation

| coefficient | std. error | t-stat | prob |
|-------------|------------|--------|------|
| 0.133588    | NAN        | NAN    | NAN  |
| -0.439772   | NAN        | NAN    | NAN  |
| -0.616923   | 27.577661  | -0.022 | 0.982|
| -0.995454   | NAN        | NAN    | NAN  |
| -0.413137   | 67.550713  | -0.006 | 0.995|
| -0.000000   | NAN        | NAN    | NAN  |
| 0.083348    | NAN        | NAN    | NAN  |
| -0.144485   | NAN        | NAN    | NAN  |
| -0.269640   | 13.112588  | -0.021 | 0.984|
| 0.016861    | NAN        | NAN    | NAN  |
| 0.188887    | NAN        | NAN    | NAN  |
| -0.010861   | NAN        | NAN    | NAN  |
| 0.533112    | NAN        | NAN    | NAN  |
| 0.348507    | NAN        | NAN    | NAN  |
| 0.000900    | 0.000000   | 0.004  | 0.997|
| 0.461912    | NAN        | NAN    | NAN  |
| 0.012176    | NAN        | NAN    | NAN  |
| 0.204419    | NAN        | NAN    | NAN  |
| 0.009596    | 2.199423   | 0.004  | 0.997|
| 0.391851    | NAN        | NAN    | NAN  |
| -0.188892   | NAN        | NAN    | NAN  |
| 0.307192    | NAN        | NAN    | NAN  |
| -0.131089   | NAN        | NAN    | NAN  |
| 0.000000    | NAN        | NAN    | NAN  |
| 0.532194    | 401.226925 | 0.001  | 0.999|
| 0.712093    | 97.597467  | 0.007  | 0.994|
| -0.185561   | 7.476500   | -0.002 | 0.980|
| 0.016044    | NAN        | NAN    | NAN  |
| -0.110123   | NAN        | NAN    | NAN  |
| 0.217596    | NAN        | NAN    | NAN  |
| -0.638656   | NAN        | NAN    | NAN  |
| 0.218955    | NAN        | NAN    | NAN  |
| -0.000000   | 0.000000   | -0.014 | 0.989|
| 0.083453    | 248.563866 | 0.000  | 1.000|
| 0.688965    | NAN        | NAN    | NAN  |
| -0.316143   | 13.122619  | -0.024 | 0.981|
| 0.040737    | 1.402190   | 0.029  | 0.977|
| 0.554682    | 42.891377  | 0.013  | 0.996|
| -0.224800   | NAN        | NAN    | NAN  |
| 0.535410    | NAN        | NAN    | NAN  |
| -0.623429   | NAN        | NAN    | NAN  |
| 0.000000    | NAN        | NAN    | NAN  |
| 0.488563    | NAN        | NAN    | NAN  |
| 0.119043    | 41.537414  | 0.003  | 0.998|
| 0.179726    | NAN        | NAN    | NAN  |
| 0.005476    | NAN        | NAN    | NAN  |
| 0.134257    | NAN        | NAN    | NAN  |
| -0.294400   | 15.521260  | -0.019 | 0.985|
| -1.179485   | 60.789484  | -0.019 | 0.985|
| 0.577883    | NAN        | NAN    | NAN  |
| -0.000000   | NAN        | NAN    | NAN  |
| -0.972456   | 474.689324 | -0.001 | 0.999|
| 0.330286    | NAN        | NAN    | NAN  |
| -0.093445   | NAN        | NAN    | NAN  |
| 0.021645    | 1.871450   | 0.012  | 0.991|

Figure 5: Equation for Inflation
### Results for equation exchange_rate

|          | coefficient | std. error | t-stat | prob |
|----------|-------------|------------|--------|------|
| const    | 0.085972    | NAN        | NAN    | NAN  |
| L1.interest_rate | 0.152416    | NAN        | NAN    | NAN  |
| L1.inflation  | 0.307779    | 10.815983  | 0.028  | 0.977|
| L1.exchange_rate | 0.192318    | NAN        | NAN    | NAN  |
| L1.money_supply | 0.026057    | 26.397749  | 0.001  | 0.999|
| L1.gdp  | 0.000000    | NAN        | NAN    | NAN  |
| L1.fdi  | -0.119312   | NAN        | NAN    | NAN  |
| L1.trade_gdp | 0.075081    | NAN        | NAN    | NAN  |
| L1.oil  | -0.000225   | 5.124199   | -0.000 | 1.000|
| L1.gold | -0.012054   | NAN        | NAN    | NAN  |
| L2.interest_rate | 0.285717    | NAN        | NAN    | NAN  |
| L2.inflation  | 0.345353    | NAN        | NAN    | NAN  |
| L2.exchange_rate | 0.029588    | NAN        | NAN    | NAN  |
| L2.money_supply | 0.154733    | NAN        | NAN    | NAN  |
| L2.gdp  | 0.000000    | 0.000000   | 0.007  | 0.994|
| L2.fdi  | 0.146425    | NAN        | NAN    | NAN  |
| L2.trade_gdp | -0.438077   | NAN        | NAN    | NAN  |
| L2.oil  | 0.029932    | NAN        | NAN    | NAN  |
| L2.gold | 0.004257    | 0.859499   | 0.005  | 0.996|
| L3.interest_rate | -0.164516   | NAN        | NAN    | NAN  |
| L3.inflation  | 0.086697    | NAN        | NAN    | NAN  |
| L3.exchange_rate | -0.150667   | NAN        | NAN    | NAN  |
| L3.money_supply | -0.184039   | NAN        | NAN    | NAN  |
| L3.gdp  | -0.000000   | NAN        | NAN    | NAN  |
| L3.fdi  | 0.109269    | 100.240113 | 0.001  | 0.999|
| L3.trade_gdp | -0.258110   | 38.139532  | -0.007 | 0.995|
| L3.oil  | -0.155808   | 2.921697   | -0.053 | 0.957|
| L3.gold | -0.018088   | NAN        | NAN    | NAN  |
| L4.interest_rate | -0.370784   | NAN        | NAN    | NAN  |
| L4.inflation  | 0.132488    | NAN        | NAN    | NAN  |
| L4.exchange_rate | -0.056836   | NAN        | NAN    | NAN  |
| L4.money_supply | 0.122289    | NAN        | NAN    | NAN  |
| L4.gdp  | -0.000000   | 0.000000   | -0.040 | 0.968|
| L4.fdi  | 0.232875    | 97.134791  | 0.002  | 0.998|
| L4.trade_gdp | 0.643561    | NAN        | NAN    | NAN  |
| L4.oil  | -0.272105   | 5.128110   | -0.053 | 0.958|
| L4.gold | 0.007580    | 0.547954   | 0.014  | 0.989|
| L5.interest_rate | -0.167501   | 16.761265  | -0.010 | 0.992|
| L5.inflation  | -0.111723   | NAN        | NAN    | NAN  |
| L5.exchange_rate | -0.121416   | NAN        | NAN    | NAN  |
| L5.money_supply | -0.261186   | NAN        | NAN    | NAN  |
| L5.gdp  | -0.000000   | NAN        | NAN    | NAN  |
| L5.fdi  | 0.640649    | NAN        | NAN    | NAN  |
| L5.trade_gdp | 0.270724    | 16.232158  | 0.017  | 0.987|
| L5.oil  | -0.306634   | NAN        | NAN    | NAN  |
| L5.gold | 0.007900    | NAN        | NAN    | NAN  |
| L6.interest_rate | -0.167561   | NAN        | NAN    | NAN  |
| L6.inflation  | -0.035440   | 6.865439   | -0.006 | 0.995|
| L6.exchange_rate | -0.256064   | 23.755529  | -0.011 | 0.991|
| L6.money_supply | -0.212558   | NAN        | NAN    | NAN  |
| L6.gdp  | 0.000000    | NAN        | NAN    | NAN  |
| L6.fdi  | -0.125070   | 185.502612 | -0.001 | 0.999|
| L6.trade_gdp | 0.508614    | NAN        | NAN    | NAN  |
| L6.oil  | -0.071415   | NAN        | NAN    | NAN  |
| L6.gold | 0.012656    | 0.731333   | 0.017  | 0.986|

Figure 6: Equation for Exchange Rate
Results for equation money_supply

|         | coefficient | std. error | t-stat | prob  |
|---------|-------------|------------|--------|-------|
| const   | -0.085424   | NAN        | NAN    | NAN   |
| L1.interest_rate | 0.144962   | NAN        | NAN    | NAN   |
| L1.inflation    | -0.058515  | 9.844696   | -0.006 | 0.995 |
| L1.exchange_rate | 0.472058   | NAN        | NAN    | NAN   |
| L1.money_supply | 0.472649   | 24.027184  | 0.020  | 0.984 |
| L1.gdp          | 0.060800   | NAN        | NAN    | NAN   |
| L1.fdi          | -0.077548  | NAN        | NAN    | NAN   |
| L1.trade_gdp    | -0.262966  | NAN        | NAN    | NAN   |
| L1.oil          | 0.241790   | 4.664030   | 0.052  | 0.959 |
| L1.gold         | -0.062721  | NAN        | NAN    | NAN   |
| L2.interest_rate | 0.067385   | NAN        | NAN    | NAN   |
| L2.inflation    | 0.013765   | NAN        | NAN    | NAN   |
| L2.exchange_rate | -0.238750  | NAN        | NAN    | NAN   |
| L2.money_supply | -0.061335  | NAN        | NAN    | NAN   |
| L2.gdp          | -0.060000  | 0.000000   | -0.062 | 0.998 |
| L2.fdi          | -0.109097  | NAN        | NAN    | NAN   |
| L2.trade_gdp    | -0.160399  | NAN        | NAN    | NAN   |
| L2.oil          | 0.147677   | NAN        | NAN    | NAN   |
| L2.gold         | -0.065318  | 0.782315   | -0.087 | 0.995 |
| L3.interest_rate | -0.165713  | NAN        | NAN    | NAN   |
| L3.inflation    | 0.040508   | NAN        | NAN    | NAN   |
| L3.exchange_rate | -0.194678  | NAN        | NAN    | NAN   |
| L3.money_supply | 0.208376   | NAN        | NAN    | NAN   |
| L3.gdp          | 0.060000   | NAN        | NAN    | NAN   |
| L3.fdi          | -0.241064  | 164.054200 | -0.001 | 0.999 |
| L3.trade_gdp    | -0.466394  | 34.714545  | -0.014 | 0.989 |
| L3.oil          | 0.118849   | 2.659324   | 0.045  | 0.964 |
| L3.gold         | -0.064364  | NAN        | NAN    | NAN   |
| L4.interest_rate | 0.041753   | NAN        | NAN    | NAN   |
| L4.inflation    | 0.226924   | NAN        | NAN    | NAN   |
| L4.exchange_rate | 0.376096   | NAN        | NAN    | NAN   |
| L4.money_supply | -0.079170  | NAN        | NAN    | NAN   |
| L4.gdp          | 0.060000   | 0.000000   | 0.040  | 0.968 |
| L4.fdi          | 0.061757   | 88.411942  | 0.000  | 1.000 |
| L4.trade_gdp    | -0.348112  | NAN        | NAN    | NAN   |
| L4.oil          | 0.065036   | 4.667598   | 0.017  | 0.986 |
| L4.gold         | -0.016465  | 0.498747   | -0.033 | 0.974 |
| L5.interest_rate | -0.214700  | 15.256079  | -0.014 | 0.989 |
| L5.inflation    | 0.155150   | NAN        | NAN    | NAN   |
| L5.exchange_rate | -0.455397  | NAN        | NAN    | NAN   |
| L5.money_supply | 0.122893   | NAN        | NAN    | NAN   |
| L5.gdp          | -0.060000  | NAN        | NAN    | NAN   |
| L5.fdi          | 0.275608   | NAN        | NAN    | NAN   |
| L5.trade_gdp    | -0.059468  | 14.774466  | -0.004 | 0.997 |
| L5.oil          | -0.072446  | NAN        | NAN    | NAN   |
| L5.gold         | 0.000003   | NAN        | NAN    | NAN   |
| L6.interest_rate | 0.076967   | NAN        | NAN    | NAN   |
| L6.inflation    | 0.197836   | 5.520754   | 0.036  | 0.971 |
| L6.exchange_rate | 0.766220   | 21.622927  | 0.033  | 0.974 |
| L6.money_supply | -0.282569  | NAN        | NAN    | NAN   |
| L6.gdp          | 0.060000   | NAN        | NAN    | NAN   |
| L6.fdi          | 0.249688   | 168.844201 | 0.001  | 0.999 |
| L6.trade_gdp    | 0.030144   | NAN        | NAN    | NAN   |
| L6.oil          | -0.021314  | NAN        | NAN    | NAN   |
| L6.gold         | -0.062398  | 0.665658   | -0.004 | 0.997 |

Figure 7: Equation for Money Supply
Results for equation gdp

| coefficient | std. error | t-stat | prob |
|-------------|------------|--------|------|
| const       | 118583492.99, 110308 | NAN     | NAN  | NAN  |
| L1.interest_rate | -708695180.494527 | NAN   | NAN   | NAN   |
| L1.inflation | -416718517.229955 | 17527989402.936615 | -0.002 | 0.998 |
| L1.exchange_rate | -6276927561.162581 | NAN   | NAN   | NAN   |
| L1.money_supply | -10508276494.284945 | 427791997030.464966 | -0.025 | 0.980 |
| L1.gdp     | -0.825997 | NAN | NAN | NAN |
| L1.fdi     | 5866098950.755015 | NAN | NAN | NAN |
| L1.trade_gdp | 5059523121.626891 | NAN | NAN | NAN |
| L1.oil     | -92295550.563979 | 8340722988.329269 | -0.011 | 0.991 |
| L1.gold    | 277379041.679279 | NAN | NAN | NAN |
| L2.interest_rate | -3669331157.852364 | NAN | NAN | NAN |
| L2.inflation | 556704260.098745 | NAN | NAN | NAN |
| L2.exchange_rate | 346087446.046876 | NAN | NAN | NAN |
| L2.money_supply | -6201226628.572609 | NAN | NAN | NAN |
| L2.gdp     | -0.550328 | 24.381438 | -0.023 | 0.982 |
| L2.fdi     | -4178513376.591919 | NAN | NAN | NAN |
| L2.trade_gdp | 10446815260.778844 | NAN | NAN | NAN |
| L2.oil     | 7765242232.323683 | NAN | NAN | NAN |
| L2.gold    | -164060510.241228 | 13928726243.558262 | -0.012 | 0.991 |
| L3.interest_rate | 1095722845.826894 | NAN | NAN | NAN |
| L3.inflation | 1767088681.815888 | NAN | NAN | NAN |
| L3.exchange_rate | -985499717.110599 | NAN | NAN | NAN |
| L3.money_supply | -5396719884.736495 | NAN | NAN | NAN |
| L3.gdp     | 0.958658 | NAN | NAN | NAN |
| L3.fdi     | -1587013434.385668 | 2929904607886.257812 | -0.001 | 1.000 |
| L3.trade_gdp | 12897728160.63431 | 61897512897.450806 | 0.021 | 0.983 |
| L3.oil     | 1501816879.961464 | 47347934860.728470 | 0.032 | 0.975 |
| L3.gold    | 16301453.535722 | NAN | NAN | NAN |
| L4.interest_rate | 4705512095.301861 | NAN | NAN | NAN |
| L4.inflation | -551876125.790607 | NAN | NAN | NAN |
| L4.exchange_rate | -5807264184.776396 | NAN | NAN | NAN |
| L4.money_supply | 6804122964.365443 | NAN | NAN | NAN |
| L4.gdp     | 0.441102 | 10.364104 | 0.001 | 0.935 |
| L4.fdi     | -4398440557.995688 | 1574130437142.816650 | -0.003 | 0.998 |
| L4.trade_gdp | -11687115777.810457 | NAN | NAN | NAN |
| L4.oil     | 7117840252.346230 | 83104248768.337448 | 0.086 | 0.932 |
| L4.gold    | -324626218.448193 | 8879932163.608112 | -0.037 | 0.971 |
| L5.interest_rate | 1037338360.845517 | 271626857612.484114 | 0.004 | 0.997 |
| L5.inflation | 3612769519.683293 | NAN | NAN | NAN |
| L5.exchange_rate | 13296098918.876871 | NAN | NAN | NAN |
| L5.money_supply | 12315851165.670496 | NAN | NAN | NAN |
| L5.gdp     | 1.373623 | NAN | NAN | NAN |
| L5.fdi     | -88756240.375844 | NAN | NAN | NAN |
| L5.trade_gdp | 5605122608.390803 | 263052342516.097107 | 0.002 | 0.998 |
| L5.oil     | 8764132626.437925 | NAN | NAN | NAN |
| L5.gold    | -416404908.184592 | NAN | NAN | NAN |
| L6.interest_rate | 463683463.995586 | NAN | NAN | NAN |
| L6.inflation | 1492207889.101734 | 98294264283.012436 | 0.015 | 0.988 |
| L6.exchange_rate | 994775889.224476 | 384973298169.810486 | 0.003 | 0.998 |
| L6.money_supply | -351261529.106602 | NAN | NAN | NAN |
| L6.gdp     | 1.275879 | NAN | NAN | NAN |
| L6.fdi     | 1042141517.835778 | 3006186613999.894531 | 0.000 | 1.000 |
| L6.trade_gdp | -16972312362.702223 | NAN | NAN | NAN |
| L6.oil     | 4402213569.071266 | NAN | NAN | NAN |
| L6.gold    | 424028427.647013 | 11851706974.312450 | -0.036 | 0.971 |

Figure 8: Equation for GDP
Stock prices and Macroeconomic indicators: Investigating a correlation in Indian context

| Equation for FDI | Coefficient | Std. Error | t-Stat | Prob |
|------------------|-------------|------------|--------|------|
| const            | -0.058882   | NAN        | NAN    | NAN  |
| L1.interest_rate | 0.018833    | NAN        | NAN    | NAN  |
| L1.inflation     | 0.014166    | 1.206491   | 0.012  | 0.991|
| L1.exchange_rate | 0.079964    | NAN        | NAN    | NAN  |
| L1.money_supply  | -0.029428   | 2.929945   | -0.007 | 0.994|
| L1.gdp           | 0.006000    | NAN        | NAN    | NAN  |
| L1.fdi           | -0.013352   | NAN        | NAN    | NAN  |
| L1.trade_gdp     | -0.044275   | NAN        | NAN    | NAN  |
| L1.oil           | 0.051922    | 0.568745   | 0.091  | 0.927|
| L1.gold          | 0.002784    | NAN        | NAN    | NAN  |
| L2.interest_rate | -0.053619   | NAN        | NAN    | NAN  |
| L2.inflation     | -0.028054   | NAN        | NAN    | NAN  |
| L2.exchange_rate | -0.013202   | NAN        | NAN    | NAN  |
| L2.money_supply  | -0.044996   | NAN        | NAN    | NAN  |
| L2.gdp           | 0.096000    | 0.006000   | 0.010  | 0.992|
| L2.fdi           | 0.077437    | NAN        | NAN    | NAN  |
| L2.trade_gdp     | 0.157937    | NAN        | NAN    | NAN  |
| L2.oil           | -0.009476   | NAN        | NAN    | NAN  |
| L2.gold          | -0.002949   | 0.095398   | -0.031 | 0.975|
| L3.interest_rate | 0.017879    | NAN        | NAN    | NAN  |
| L3.inflation     | 0.029497    | NAN        | NAN    | NAN  |
| L3.exchange_rate | -0.023549   | NAN        | NAN    | NAN  |
| L3.money_supply  | 0.021803    | NAN        | NAN    | NAN  |
| L3.gdp           | 0.000000    | NAN        | NAN    | NAN  |
| L3.fdi           | 0.072013    | 20.005269  | -0.064 | 0.997|
| L3.trade_gdp     | -0.101556   | 4.233193   | -0.024 | 0.981|
| L3.oil           | 0.047991    | 0.324286   | 0.148  | 0.882|
| L3.gold          | 0.000503    | NAN        | NAN    | NAN  |
| L4.interest_rate | -0.024500   | NAN        | NAN    | NAN  |
| L4.inflation     | -0.013708   | NAN        | NAN    | NAN  |
| L4.exchange_rate | 0.095011    | NAN        | NAN    | NAN  |
| L4.money_supply  | -0.017239   | NAN        | NAN    | NAN  |
| L4.gdp           | 0.060000    | 0.006000   | 0.090  | 0.929|
| L4.fdi           | -0.031793   | 10.761211  | -0.003 | 0.998|
| L4.trade_gdp     | -0.026510   | NAN        | NAN    | NAN  |
| L4.oil           | 0.020390    | 0.569181   | 0.036  | 0.971|
| L4.gold          | -0.062811   | 0.066819   | -0.103 | 0.918|
| L5.interest_rate | -0.044363   | 1.868371   | -0.024 | 0.981|
| L5.inflation     | 0.067792    | NAN        | NAN    | NAN  |
| L5.exchange_rate | -0.044155   | NAN        | NAN    | NAN  |
| L5.money_supply  | -0.026321   | NAN        | NAN    | NAN  |
| L5.gdp           | 0.000800    | NAN        | NAN    | NAN  |
| L5.fdi           | 0.030591    | NAN        | NAN    | NAN  |
| L5.trade_gdp     | -0.102164   | 1.801644   | -0.557 | 0.955|
| L5.oil           | 0.031352    | NAN        | NAN    | NAN  |
| L5.gold          | -0.00144    | NAN        | NAN    | NAN  |
| L6.interest_rate | 0.027682    | NAN        | NAN    | NAN  |
| L6.inflation     | 0.019999    | 0.673217   | 0.030  | 0.976|
| L6.exchange_rate | 0.081635    | 2.636680   | 0.031  | 0.975|
| L6.money_supply  | 0.028604    | NAN        | NAN    | NAN  |
| L6.gdp           | 0.000000    | NAN        | NAN    | NAN  |
| L6.fdi           | 0.036315    | 20.589356  | 0.002  | 0.999|
| L6.trade_gdp     | -0.017292   | NAN        | NAN    | NAN  |
| L6.oil           | 0.060739    | NAN        | NAN    | NAN  |
| L6.gold          | -0.004382   | 0.081172   | -0.054 | 0.957|

Figure 9: Equation for FDI
Stock prices and Macroeconomic indicators: Investigating a correlation in Indian context

![Results for equation trade_gdp](image)

Figure 10: Equation for Trade/GDP Ratio
### Results for equation oil

| coefficient | std. error | t-stat | prob |
|-------------|------------|--------|-------|
| const       | 0.159591   | NAN    | NAN   |
| L1.interest_rate | -0.303649 | NAN    | NAN   |
| L1.inflation      | -0.130351 | 32.276845 | -0.004 | 6.997 |
| L1.exchange_rate  | 1.986143  | NAN    | NAN   |
| L1.money_supply   | 1.967132  | 78.775585 | 0.025  | 6.980 |
| L1.gdp           | 0.000000  | NAN    | NAN   |
| L1.fdi           | -0.766985 | NAN    | NAN   |
| L1.trade_gdp     | 0.673172  | NAN    | NAN   |
| L1.oil           | 0.436490  | 15.291500 | 0.029  | 6.977 |
| L2.gold          | 0.012962  | NAN    | NAN   |
| L2.interest_rate | -0.097633 | NAN    | NAN   |
| L2.inflation     | -0.065681 | NAN    | NAN   |
| L2.exchange_rate | -0.012349 | NAN    | NAN   |
| L2.money_supply  | 0.414852  | NAN    | NAN   |
| L2.gdp           | -0.000000 | 0.000000 | -0.026 | 6.979 |
| L2.fdi           | -0.566746 | NAN    | NAN   |
| L2.trade_gdp     | -0.293817 | NAN    | NAN   |
| L2.oil           | 0.028412  | NAN    | NAN   |
| L2.gold          | 0.000013  | 2.569400 | 0.000  | 1.000 |
| L3.interest_rate | -0.920523 | NAN    | NAN   |
| L3.inflation     | 0.127986  | NAN    | NAN   |
| L3.exchange_rate | -0.009179 | NAN    | NAN   |
| L3.money_supply  | 1.783360  | NAN    | NAN   |
| L3.gdp           | 0.000000  | NAN    | NAN   |
| L3.fdi           | -0.664371 | 537.868891 | -0.001 | 6.999 |
| L3.trade_gdp     | -1.595758 | 113.815195 | -0.014 | 6.989 |
| L3.oil           | 0.093924  | 8.718866  | 0.011  | 6.991 |
| L3.gold          | 0.066449  | NAN    | NAN   |
| L4.interest_rate | 0.495353 | NAN    | NAN   |
| L4.inflation     | 0.270247  | NAN    | NAN   |
| L4.exchange_rate | 0.149982 | NAN    | NAN   |
| L4.money_supply  | -1.841740 | NAN    | NAN   |
| L4.gdp           | -0.000000 | 0.000000 | -0.036 | 0.971 |
| L4.fdi           | 0.186876  | 289.867614 | 0.001  | 6.999 |
| L4.trade_gdp     | -1.205935 | NAN    | NAN   |
| L4.oil           | 0.160261  | 15.303198 | 0.010  | 6.992 |
| L4.gold          | -0.018356 | 1.635192  | -0.011 | 6.991 |
| L5.interest_rate | -0.443897 | 90.018618  | -0.009 | 6.993 |
| L5.inflation     | 0.642534  | NAN    | NAN   |
| L5.exchange_rate | -3.457421 | NAN    | NAN   |
| L5.money_supply  | -0.743220 | NAN    | NAN   |
| L5.gdp           | 0.000000  | NAN    | NAN   |
| L5.fdi           | 0.795202  | NAN    | NAN   |
| L5.trade_gdp     | -0.726985 | 48.439667 | -0.015 | 6.988 |
| L5.oil           | -0.311576 | NAN    | NAN   |
| L5.gold          | 0.091387  | NAN    | NAN   |
| L6.interest_rate | 0.753844  | NAN    | NAN   |
| L6.inflation     | 0.934076  | 18.106358 | 0.052  | 6.959 |
| L6.exchange_rate | 2.362557  | 70.890753 | 0.033  | 6.973 |
| L6.money_supply  | 0.159123  | NAN    | NAN   |
| L6.gdp           | 0.000000  | NAN    | NAN   |
| L6.fdi           | 0.840651  | 553.573021 | 0.002  | 6.999 |
| L6.trade_gdp     | 1.541680  | NAN    | NAN   |
| L6.oil           | -0.013034 | NAN    | NAN   |
| L6.gold          | -0.030858 | 2.182428 | -0.014 | 6.989 |

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Figure 11: Equation for Crude Oil Prices
### Results for equation gold

| Parameter               | Coefficient | Std. Error | t-stat | Prob  |
|-------------------------|-------------|------------|--------|-------|
| const                   | 3.157898    | NaN        | NaN    | NaN   |
| L1.interest_rate       | -12.68172   | NaN        | NaN    | NaN   |
| L1.inflation           | 7.158862    | 269.390832 | 0.027  | 0.979 |
| L1.exchange_rate       | -8.027117   | NaN        | NaN    | NaN   |
| L1.money_supply        | -6.886191   | 657.479287 | -0.010 | 0.992 |
| L1.gdp                 | -6.000000   | NaN        | NaN    | NaN   |
| L1.fdi                 | 3.961574    | NaN        | NaN    | NaN   |
| L1.trade_gdp           | 17.595521   | NaN        | NaN    | NaN   |
| L1.oil                 | -4.512351   | 127.626407 | -0.035 | 0.972 |
| L1.gold                | -4.072823   | NaN        | NaN    | NaN   |
| L2.interest_rate       | 9.710609    | NaN        | NaN    | NaN   |
| L2.inflation           | 14.432982   | NaN        | NaN    | NaN   |
| L2.exchange_rate       | 2.699224    | NaN        | NaN    | NaN   |
| L2.money_supply        | 6.195685    | NaN        | NaN    | NaN   |
| L2.gdp                 | -6.000000   | 0.000000   | -0.010 | 0.992 |
| L2.fdi                 | 1.014437    | NaN        | NaN    | NaN   |
| L2.trade_gdp           | -7.698629   | NaN        | NaN    | NaN   |
| L2.oil                 | 5.778311    | NaN        | NaN    | NaN   |
| L2.gold                | 0.879055    | 21.407247  | 0.004  | 0.997 |
| L3.interest_rate       | -4.220243   | NaN        | NaN    | NaN   |
| L3.inflation           | -3.406817   | NaN        | NaN    | NaN   |
| L3.exchange_rate       | -11.664318  | NaN        | NaN    | NaN   |
| L3.money_supply        | -9.060694   | NaN        | NaN    | NaN   |
| L3.gdp                 | -0.000000   | NaN        | NaN    | NaN   |
| L3.fdi                 | 9.241320    | 4489.1776  | 0.002  | 0.998 |
| L3.trade_gdp           | 13.853092   | 949.927998 | 0.015  | 0.988 |
| L3.oil                 | -1.817363   | 72.769679  | -0.025 | 0.980 |
| L3.gold                | -0.819558   | NaN        | NaN    | NaN   |
| L4.interest_rate       | -3.792883   | NaN        | NaN    | NaN   |
| L4.inflation           | -6.558392   | NaN        | NaN    | NaN   |
| L4.exchange_rate       | -24.358961  | NaN        | NaN    | NaN   |
| L4.money_supply        | 15.623148   | NaN        | NaN    | NaN   |
| L4.gdp                 | -0.000000   | 0.000000   | -0.031 | 0.975 |
| L4.fdi                 | 4.272921    | 2419.382290 | 0.002  | 0.999 |
| L4.trade_gdp           | 6.835022    | NaN        | NaN    | NaN   |
| L4.oil                 | -1.421828   | 127.724040 | -0.011 | 0.991 |
| L4.gold                | 0.066031    | 13.647687  | 0.004  | 0.996 |
| L5.interest_rate       | 3.028091    | 417.466979 | -0.007 | 0.994 |
| L5.inflation           | 2.348386    | NaN        | NaN    | NaN   |
| L5.exchange_rate       | 9.826497    | NaN        | NaN    | NaN   |
| L5.money_supply        | 8.837885    | NaN        | NaN    | NaN   |
| L5.gdp                 | 0.000000    | NaN        | NaN    | NaN   |
| L5.fdi                 | 1.158491    | NaN        | NaN    | NaN   |
| L5.trade_gdp           | 15.670654   | 464.288692 | 0.039  | 0.969 |
| L5.oil                 | 2.613895    | NaN        | NaN    | NaN   |
| L5.gold                | -0.630155   | NaN        | NaN    | NaN   |
| L6.interest_rate       | -9.436771   | NaN        | NaN    | NaN   |
| L6.inflation           | 5.414153    | 151.069780 | 0.036  | 0.971 |
| L6.exchange_rate       | -12.826781  | 591.670652 | -0.022 | 0.983 |
| L6.money_supply        | -16.122420  | NaN        | NaN    | NaN   |
| L6.gdp                 | -0.000000   | NaN        | NaN    | NaN   |
| L6.fdi                 | -4.986392   | 4620.248735 | -0.001 | 0.999 |
| L6.trade_gdp           | -1.051623   | NaN        | NaN    | NaN   |
| L6.oil                 | 9.354370    | NaN        | NaN    | NaN   |
| L6.gold                | -0.517907   | 18.215048  | -0.028 | 0.977 |

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Figure 12: Equation for Gold Prices