Analyzing Dependence of Key Macroeconomic Variables on BSE Using Regression

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ABSTRACT
This paper aims to analyze the dependence of key macroeconomic variables on Bombay Stock Exchange (BSE) Sensex using regression modelling technique in RStudio. Monthly data points spanning a period from 2012 to 2019 has been used for the empirical investigation. The results of the model indicate that long-term interest rate (LTINT), consumer price index (CPI), and Morgan Stanley Capital International (MSCI) are found to be significant while index of industrial production (IIP) and foreign exchange (FX) are insignificant. Also, the value or r-square indicates that 93% of the variation in the dependent variable is explained by the selected independent variables. Also, the dataset was checked for normality and linearity using appropriate graphs. The results of this paper will be of immense use for the investors in predicting the stock price movement.

KEYWORDS
Foreign Exchange, Macroeconomic Variables, Regression, RStudio, Sensex

1. INTRODUCTION
Stock market refers to the collection of markets and exchanges where regular buying, selling and issuance of shares on publicly-held companies take place. These trades take place through institutionalized formal exchanges and over-the-counter marketplaces that are often guided by a set of rules and regulations. There can be multiple stock exchanges operating in a country which allow transactions in stock and other securities such as debentures, bonds, commodities and futures. The leading stock exchanges in India include National Stock Exchange (NSE) and Bombay Stock Exchange (BSE), along with several other stock exchanges forms the Indian Stock Market. Bombay Stock Exchange (BSE) is one of the oldest stock exchanges in India and it was established in 1875. BSE has a market capitalization of more than 2,18,730 billion as on May 2021. Unlike NSE, BSE has its flagship index Sensitivity Index (Sensex) which includes top 30 companies. Sensex is often regarded as the barometer of the Indian stock market. A Stock exchange plays an important role in the world economy by serving as an anchor of the modern economic system. Stock exchanges help the companies to raise the funds that can be channelized for the purpose of expansion and growth. Stock exchanges also allow the people to make investments in order to earn higher profits.

Investments in stocks have always been a lucrative proposition for the investors. This proposition has motivated the scholars and academicians around the world to do research on what factors are
more likely to impact the stock market. Thus, it becomes imperative to study the cause and effect relationship between these variables and stock market so as to enhance the predictive ability of models for predicting stock prices.

From the past few decades, there has been a paradigm shift in investment in capital market from developed economies like US to emerging markets such as India in search of higher returns. For instance, Srivastava (2010) studied the relationship between macroeconomic factors such as inflation, interest rate and industrial production on Indian Stock Market. Megaravalli and Sampagnaro (2018) examined the relationship between stock markets of India, China and Japan and macroeconomic factors like foreign exchange and inflation.

In this paper, we examine the impact of macroeconomic variables such as inflation, foreign exchange rate (INR/USD), industrial production, interest rate, and Morgan Stanley capital international world index on BSE Sensex by taking monthly data points from 2012 to 2019 using regression model in R-studio and develop a regression equation for forecasting.

This paper is split into seven sections. Section one represents the introduction that gives a brief overview of the Indian stock market. Section two illustrates the literature review of relevant studies. Section three represents the objectives of the study while section four illustrates the research methodology adopted to achieve the objectives of this study. Section five shows the empirical findings of regression model using R. Section six discusses about the managerial implications of the study. Section seven gives the conclusion of the study.

2. LITERATURE REVIEW

This study carries out a comprehensive literature review on both developed and emerging economies. While most of the research work has been done to analyze the impact of different variables on stock indices, macroeconomic variables have emerged as potentially significant indicators to explain the movements in stock indices. Therefore, we have identified 5 factors (macroeconomic variables) viz. Foreign Exchange (FX), Index of Industrial Production (IIP), inflation, Long Term Interest Rate (LTINT), Morgan Stanley Capital International (MSCI) world index as the most common factors to work upon.

Kwon and Shin (1999) concluded that macroeconomic variables such as the production index, exchange rate, trade balance and money supply are co-integrated with the stock prices and also claim that the stock price indices are not the leading indicators for economic variables. The authors employed econometric tools such to examine the relationship between the macroeconomic variables and stock market. Later, Nasseh and Strauss (2000) revealed that Industrial Production, Business survey of manufacturing orders, short and long run interest rates, short run production, foreign stock prices are significantly related to the stock price of all six European nations. Also, Phylaktis and Ravazzolo (2005) revealed that there is significant relationship between the stocks and foreign exchange markets. Furthermore, the authors reveal financial crisis had temporary impact on these markets. Few years later, Adam and Tweneboah in the year 2008 concluded that macroeconomic variables such as treasury bill rate, consumer price index, and foreign direct investments impact the stock price in the long run and inflation and exchange rates matter in the short run only. Later, Adjasi (2009) analyzed the impact of macroeconomic variables on stock price volatility in Ghana and concluded that high volatility of cocoa prices has a significant impact on stock prices. On the contrary, high volatility in gold prices, oil prices and money supply have a negative impact on the stock prices as it reduces the stock price volatility. Humpe and Macmillan (2009) examined the impact of macroeconomic variables on United States (US) and Japan stock markets and the results indicate that United States (US) stock prices are positively influenced by industrial production but factors like inflation and long-term interest rate had a negative impact. Also, the stock prices of Japan are positively influenced by industrial production but negatively impacted by money supply. The authors also say the results are contradictory due to the slump in the Japanese economy during the 1990s and consequent liquidity trap thereafter.
Rjoub et al. (2009) analyzed the impact of Arbitrage Pricing Theory (APT) on Istanbul stock exchange and the findings reveal that there is significant relationship between the macroeconomic variables chosen for study and Istanbul stock exchange. One year later, Srivastava (2010) concluded that three out of five variables namely industrial production, wholesale price index and interest rate are relatively more significant that can impact the Indian stock market in long run. On the contrary, the other two variables namely MSCI world index and foreign exchange rate are found to be less significant implying stock prices in India depends majorly on domestic macroeconomic variables. Further, Paramati and Rakesh in the year 2011 revealed that there is bidirectional relationship between industrial production and stock indices (NSE and BSE). On the contrary, GDP has no relation with BSE but has a unidirectional relation with NSE. In the same year, Pal and Mittal (2011) revealed that variables such as inflation had a significant impact on both indices chosen for study. On the other hand, interest rate had a positive relation with S&P CNX Nifty only and foreign exchange rate only impacts the BSE Sensex. Also, gross domestic savings had no impact on both the indices.

Khan and Zaman (2012) investigated the relationship between macroeconomic variables and stock market and the results revealed that Gross Domestic Product (GDP) and exchange rate have positive impact while consumer price index has a negative impact and rest other variables were found to be insignificant. Further, Shahbaz et al. (2013) indicate that foreign direct investment, domestic savings, income and inflation significantly affect the development of stock market in Pakistan. Furthermore, Lai et al. (2013) concluded that foreign exchange markets have greater influence on stock markets than domestic macroeconomic variables. Two years later, Barakat et al. (2015) indicate there is a causal relationship between macroeconomic variables and stock markets of Egypt and Tunisia except for CPI which is found to be insignificant in case of Tunisia.

Li et al. (2015) revealed that the researchers have used same type of econometric measurements and the authors recommend to reading these types of papers to have a better understanding of concepts and tools. Mensi et al. (2016) examined the impact of country risk ratings and macroeconomic factors on stock markets of Gulf Cooperation council countries and the results indicate that Financial Risk rating had a positive and significant impact on the GCC countries stock markets. Also, macroeconomic variables such as MSCI global market index and oil price contributed in the performance of stock markets whereas no significant contribution was found with respect to gold price, US treasury bill rate and bong rate. Mohammed and Rumman (2018) concluded that interest rate has negative relation with both indices while Gas price and money supply have positive impact on QE1. Also, Oil has positive and producer price has negative relation with RII. One year later, Pal and Garg said that macroeconomic variables chosen for study do impact stock market development.

Parab & Reddy (2019) examined the relationship between macroeconomic variables and Indian stock market using Bai-Perron approach. The findings of the study indicate a significant impact of select macroeconomic indicators on the stock market across the structural breaks. Chang et al. (2019) investigated the impact of macroeconomic variables on stock market in the short and long run both using ARDL approach. The empirical findings reveal that the trade balance, exchange rate and interest rate had a negative impact on the stock prices of Pakistan in the long run. Whereas, During the post crisis period, consumer price index positively affects the Pakistan’s stock market in the long run. Later, Asravor & Fonu (2020) analyzed the relationship between the macroeconomic variables and the Ghana stock exchange using the ARDL cointegration approach. The findings of the study revealed that significant cointegration exists between chosen macroeconomic indicators and the stock market. However, money supply, inflation, and human capital had a negative impact whereas foreign direct investment and interest rate had a positive impact. Kalam (2020) analyzed the impact of macroeconomic factors on the stock market of Malaysia using multiple regression and ARDL approach. The empirical findings of the study reveal that there exists significant relationship between the select variables in both long and short run. Also, the authors suggest the policy makers to keep interest rates low to improve the economic performance of the country. In the same year Chan et al. (2020) investigated the relationship between macroeconomic indicators and stock market using
QARDL and ARDL models. The findings of the study reveal that industrial production index, trade balance and foreign direct investment had a significant impact on the stock market across the crisis periods. Furthermore, results of QARDL approach reveal that impact of exchange rate, interest rate and consumer price index on the stock market vary across bearish, bullish and normal states in the short run. Later, Sahoo et al. (2020) examined the relationship between macroeconomic variables and stock markets of India and the USA. The findings of the study reveal that inflation and interest rate have no impact on the BSE while GDP and GDP per capita had a significant impact on the Sensex. On the contrary, none of the variables were found to be significant in case of DOW Jones.

Elangkumaran & Navratnaseel (2021) investigated the relationship between Colombo Stock Exchange (CSE) and the macroeconomic variables using a multiple regression model. The findings of the study report that Gross Domestic Product (GDP) and Exchange Rate (ER) had a significant positive correlation with the stock market. On the contrary, Interest Rate (IR) had a negative correlation with the Sri Lankan stock market. Later, Syed (2021) examined the symmetric and asymmetric relationship between macroeconomic factors and the Indian stock market using ARDL and NARDL approach across the Global Financial Crisis (GFC). The findings of the study reveal that macroeconomic variables have a symmetric relationship in the long run whereas asymmetric relationship is observed in the short run. However, during the crisis period the relationship turns asymmetric in the long run too. Using the same methodology later, Pole & Cavusoglu (2021) investigated the cointegration between macroeconomic factors and Nigerian Stock Exchange (NSE). The authors report that money supply and aggregate industrial production had positive and significant relationship with the stock market. On the other hand, foreign exchange and inflation had a negative impact on the Nigerian stock market. In the end, the authors conclude that macroeconomic variables have impact on the stock market in the long and short run both.

Neifar et al. (2021) examined the cointegration and causality relationship between macroeconomic factors and United Kingdom (UK) using Johansen cointegration and Granger causality techniques. The empirical results of the study reveal that no cointegration and causality relationship from macroeconomic factors to stock market exist. However, one way causality was observed from exchange rate to stock market. Also, the results of VAR non causality/Block exogeneity Wald test reveal that unidirectional causality from Inflation and Exchange rate to stock market. On the contrary, using the same methodology Dempere (2019) revealed that the long run cointegration exist between select macroeconomic factors and the stock exchanges of United Arab Emirates (UAE). Also, bidirectional causality exists between Emirati stock exchanges and money supply whereas significant unidirectional causality running from stock exchanges to oil prices. Bhuiyan & Chowdhury (2021) analyzed the impact of macroeconomic factors on the different sectors of US and Canada. The empirical results reveal that there is strong and long run relationship between the select variables of US whereas no significant variables were observed in case of Canada. However, US money supply and interest rates can explain the movement in the Canadian stock market.

3. OBJECTIVES OF THE STUDY

Based on the literature review we observe that majority of the studies have analyzed the impact of macroeconomic variables on Indian stock market and none of the studies have developed a forecasting equation based on these variables. Therefore, this study aims to analyze the impact and develop a regression equation for forecasting. Following objectives have been formulated for this study:

1. To investigate the relationship between key macroeconomic variables and BSE Sensex.
2. To develop a regression equation based on these variables for forecasting.
4. RESEARCH METHODOLOGY

The research is descriptive in nature as secondary data has been collected from various sources. Monthly Data spanning a period of last ten years starting from 2010 to 2019 comprising of 90 data points has been considered for this study. Data on Sensex will be obtained from BSE official website; inflation and exchange rate will be obtained from global rates dot com and investing dot com and data on Nifty has been obtained from NSE official website. Index of industrial production and long-term interest rate have been obtained from Organization for Economic Co-operation and Development (OECD). Data on the Morgan Stanley Capital International (MSCI) world index has been obtained from Yahoo finance.

Multiple Regression

Multiple Regression is the procedure for quantifying the relationship of dependent variable with two or more independent variables. Decision on the number of independent variables should be included in the analysis is based on the importance of their contribution and meaningfulness. Moreover, multiple regression is widely used technique for examining the relationship between the Independent variables and the dependent variables. In the literature many studies have used this technique for investigating this relationship such as Kalam (2020); Elangkumaran & Navratnaseel (2021), etc. Methods have been generated for the best selection of independent variables. The independent variables are called explanatory variables because of their use in explaining the variation in the dependent variables. They are also referred as predictor variables because of their use in predicting the dependent variable. As is the case in simple linear regression, in multiple regression one interprets its utility for estimation or prediction of dependent variable for given values of other variables. This multiple regression is called prediction equation, which helps in assessing the relative importance of variables related to dependent variable.

Before one makes use of a Multiple Regression Equation (MRE), it is desirable to determine first whether it is, in fact worth using. In this regard coefficient of multiple determinations ($R^2$) is utilized together with the assessment of its significance and the significance of standardized partial regression coefficients. Adjusted $R^2$ value is necessary in order to make the coefficient comparable. Adjusted $R^2$ value is derived through taking care of the sample size variation between groups, variation in degree of freedom between models compared or variation in the number of variables included in the MRE.

The general regression equation is given below in equation (1)

$$ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n + e_i $$  \hspace{1cm} (1)

Where $Y$ is the dependent variable and $\beta_0$ is the beta constant. $\beta_1, \ldots, \beta_n$ are the beta coefficients whereas $X_1, \ldots, X_n$ are the explanatory variables. $e_i$ is the error term or the unexplained variables.

5. REGRESSION MODELING USING R

As the relationship amongst the variables is established in the text. The mathematical relationship amongst the variables is studied through linear regression. The impact of IIP, LTINT, CPI, FX, and MSCI is studied over Bombay stock exchange. The linear multiple regression modeling is used in two stages. The conditions of linearity and normality of the model is checked through residual and quantile plots (Figure -1 and 2). In stage one the multiple-regression is studied and non-significant predictor variables are removed. In stage two the step-wise regression studied in order to identify the successive impact of predictors on dependent variable. ‘R-Studio’ is used for mentioned data analysis.
Figure 1 and 2 shows the results of linearity and normality of the dataset. Figure 2 reveals that the dataset is more or less normally distributed while Figure 1 reveals that the non-linearity of the data set as it is evident from the literature that the stock market time series data is of non linear nature.

The results of stage 1 multiple regressions are given in table -01.
Residual standard error: 1871 on 84 degrees of freedom. Multiple R-squared: 0.9231, Adjusted R-squared: 0.9185, F-statistic: 201.6 on 5 and 84 DF, p-value: < 2.2e-16.

It could be observed from the table that the regression model under study is significant. Further, three independent variables i.e., LTINT, CPI and MSCI are playing a significant role in the model. The coefficient of determination clearly indicated that around 93% variation in the dependent variable is caused by all of these independent variables together (not necessarily equally distributed). This shows a high impact of independent variables on dependent variables. The modified regression model after removing the non-significant variable can be given by;

Residual standard error: 1875 on 86 degrees of freedom. Multiple R-squared: 0.9209, Adjusted R-squared: 0.9182, F-statistic: 333.9 on 3 and 86 DF, p-value: < 2.2e-16

Once again, a significant regression model can be observed. The p-value lies far below level of significance and the F-statistics is also above the F-critical. The coefficient of determination depicts that nearly 93% variation in the predicted variables is caused by three predictors of the model which is marginally low in comparison to five predicting variables in table above.

The two regression equations (2) and (3) can be given by;

\[
BSE = 7825.742 + 51.038 \times IIP + 1005.191 \times LTINT - 691.186 \times CPI + 44.190 \times FX + 86.569 \times MSCI \ldots (2)
\]

\[
BSE = 16034.070 + 1047.256 \times LTINT - 784.014 \times CPI + 96.020 \times MSCI \ldots (3)
\]

In stage 2 the forward step-wise regression is used starting with intercept alone and then progressing with independent variables one by one. The Akaike information criterion (AIC) is used

| Table 1. Regression model 1 |
|----------------------------|
| **Coefficients** | **Estimate** | **Std. Error** | **t-value** | **Pr (>|t|)** |
| Intercept          | 7825.742    | 6357.415       | 1.231       | 0.2218       |
| IIP                | 51.038      | 41.457         | 1.231       | 0.2217       |
| LINdTINT           | 1005.191    | 423.345        | 2.374       | 0.0199*      |
| CPI                | -691.186    | 107.591        | -6.424      | 7.59e-09***  |
| FX                 | 44.190      | 71.734         | 0.616       | 0.5395       |
| MSCI               | 86.569      | 7.371          | 11.756      | < 2e-16      |

Significance codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

| Table 2. Modified regression (I.V. = CPI, LTINT, MSCI; D.V. = BSE) |
|---------------------------|
| **Coefficients** | **Estimate** | **Std. Error** | **t-value** | **Pr (>|t|)** |
| Intercept              | 16034.070    | 3234.222       | 4.958       | 3.55e-06***   |
| LTINT                  | 1047.256     | 422.180        | 2.481       | 0.0151*       |
| CPI                    | -784.014     | 87.176         | -8.993      | 5.07e-14***   |
| MSCI                   | 96.020       | 4.097          | 23.437      | <2e-16***     |

Significance codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1871 on 84 degrees of freedom. Multiple R-squared: 0.9231, Adjusted R-squared: 0.9185, F-statistic: 201.6 on 5 and 84 DF, p-value: < 2.2e-16.

Once again, a significant regression model can be observed. The p-value lies far below level of significance and the F-statistics is also above the F-critical. The coefficient of determination depicts that nearly 93% variation in the predicted variables is caused by three predictors of the model which is marginally low in comparison to five predicting variables in table above.

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\]

\[
BSE = 16034.070 + 1047.256 \times LTINT - 784.014 \times CPI + 96.020 \times MSCI \ldots (3)
\]
as an estimator, the variable that reduced the AIC value of the model on inclusion are considered successively. This shows that including the particular independent variable causes a less loss of information in the model. That makes the regression model as a better predicting tool.

The step-wise model analysis started with considering the dependent variables and intercept as an independent variable. The intercept itself shows a significant impact on the dependent variable with p-value falling far below the level of significance. The AIC value of 1582.8 drops to 1418.17 on inclusion of first independent variable MSCI. At this step inclusion of MSCI causes a highest drop of 164 points and hence included, further inclusion of CPI drops the AIC value to 4.24 points and a marginal correction in AIC value is further caused by IIP in next step, while FX causes an increment in AIC value on inclusion and hence dropped from the model.

The model using step-wise regression is more refined as it included four variables out of five independent variables in the model with moderations made using AIC score. This shows that these four variables have the highest information coverage of the model. The regression model thus obtained is given by;

\[
BSE = 9794.727 + 56.706 \times IIP + 1029.365 \times LTINT - 716.531 \times CPI + 88.480 \times MSCI \quad (4)
\]

Table 3. Modifies regression (I.V. = CPI, LTINT, MSCI; D.V. = BSE)

| Coefficients | Estimate | Std. Error | t-value | Pr (>|t|) |
|--------------|----------|------------|---------|----------|
| Intercept    | 9794.727 | 5475.391   | 1.789   | 0.0772   |
| IIP          | 56.706   | 40.275     | 1.408   | 0.01628  |
| LTINT        | 1029.365 | 419.981    | 2.451   | 0.0163*  |
| CPI          | -716.531 | 99.050     | -7.234  | 1.92e-10*** |
| MSCI         | 88.480   | 6.729      | 13.150  | <2e-16*** |

Significance codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1. Residual standard error: 1864 on 85 degrees of freedom, Multiple R-squared: 0.9227, Adjusted R-squared: 0.9191, F-statistic: 253.8 on 4 and 85 DF, p-value: < 2.2e-16.

It can be observed that the model under study is significant and explains nearly 93% variation in the dependent variable. The equation of the model is given by;

\[
BSE = 9794.727 + 56.706 \times IIP + 1029.365 \times LTINT - 716.531 \times CPI + 88.480 \times MSCI \quad (4)
\]
SENSITIVITY ANALYSIS OF THE MODEL CAN BE OBSERVED FROM FIGURE - 3

Figure 3 shows that LTINT shows the sharpest increasing impact on Bombay stock exchange while keeping all other factors constant. While MSCI shows the sharpest decline in Bombay stock exchange, if other independent variables stand still and do not contribute to the model.

6. MANAGERIAL IMPLICATIONS

This study has implications for all kinds of investors such as High networth Investors (HNIs), Foreign Institutional Investors (FIIs), Domestic Institutional Investors (DIIs), retail investors, etc. The investors can consider the movement of macroeconomic variables to predict the movement of stock market more precisely. Therefore, chances of earning more profit and loosing less money. Moreover, the findings of this study have implications for the policy makers in designing the optimal policies for the economic growth.

7. CONCLUSION

This study has made an effort to investigate and examine the relationship of key macroeconomic variables namely IIP, MSCI, CPI, LTINT and FX on BSE Sensex using regression modelling technique on R-studio and also, to develop a regression equation for forecasting. The results of the model indicate that LTINT, CPI and MSCI are significant while IIP and FX are insignificant. Also, the value of r-square indicates that 93 percent of the variation in the dependent variable is explained by these independent variables. Furthermore, forward step-wise regression has been employed to refine the regression equation. The results of forward step-wise regression indicates that four out of five variables play a significant role in the modelling process that is only FX has been dropped during the model building process as it causes the increase in AIC score. Also, Residual plot and Q-Q plot have been used for determining the linearity and normality of the data respectively. The graphs show the data is normally distributed but at the same time have a non-linear characteristic. Sensitivity analysis was also performed and the results indicate LTINT causes a sharpest increase in Bombay stock exchange while MSCI causes a sharpest decline in Bombay stock exchange. The present has further scope for more comprehensive results. The present study can be extended over a longer period of time and more variables such as crude oil prices, money supply can be added to examine its impact on Indian stock market and a more precise and accurate regression equation can be developed for forecasting.

CONFLICT OF INTEREST

The authors of this publication declare there is no conflict of interest.

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