Role of Macroeconomic Variables in Shaping the Dynamics of Indian Stock Market Index

Abstract

This study examines how major macroeconomic factors interact with the Nifty Index over time with the help of monthly time series data from January 2013 to April to 2023. Logarithmic transformations were made to bring linearity in the time series, stationarity tests were conducted to check the applicability of models. Long-term equilibrium was established between variables Nifty Index, Crude oil prices, Foreign Exchange rates, Gold Prices Industrial production Index and call rates using a two-step cointegration procedure of Engel Granger. A vector error correction model was built to check the long term and short term dynamic relationship between the variables. The results suggested a significant short-term impact of periodic lagged values of variables Foreign exchange rates, Gold prices Industrial production index and Stock market index on the current value of stock market Index. This examination dive into the numbers and gives us a clearer picture of how different macroeconomic factors of an economy effects its financial markets.

Keywords- Cointegration, Engle-Granger procedure, Vector Error Correction Model (VECM), Foreign Exchange rates, Stock market index, Gold Prices, Industrial Production Index.

Introduction

Understandings of the interest rate, foreign exchange, oil price, inflation, and other macroeconomic variables together with the stock market indices is highly important for policymakers, investors and even researchers. As a reflection of economic activity, stock markets are subject to different oil price fluctuations, foreign exchange fluctuations, inflation rate and μ strategies. Such a study will be devoted to the Nifty Index, one of the major indices in the Indian stock market, it will be investigated concerning some variables namely crude oil price, exchange rate, consumer price index, industrial production, IPO's money supply, money market rate, gold price, etc. The central concern of this research is to investigate the long-term econometric relationships and short-run dynamics of some variables, with the help of modelling frameworks in econometrics. As economic systems are quite volatile and complex, the research advances methodologies that seek the understanding of the how and when factors. To validate the evidence collected, focus group participants were first contacted three weeks prior to the actual analysis. The post-focus group stages include data analysis, member check, and cross-analysis of regression to evaluate external validity. The use of time series regression analysis is also rigorous since it normalizes the spread of the variables.

The concept of stationarity for time series data is essential for some econometric models. As a result, the study used the Augmented Dickey-Fuller (ADF) test to test the variables for shift in means. Variables that would be classified to have non-stationarity were transformed to enable powerful modelling. The Engle-Granger two step cointegration approach was used to examine the long-term relationships and residual stationarity confirmed cointegration of variables. The study also used the Vector error correction model (VECM) which is a flexible model that captures dynamic interaction among the variables. The other critical step was optimal lag selection based on AIC criterion with SBIC as an alternative. The Ganger causality tests show the direction of relations allowing for the testing of the dependencies not just correlations. Also, Impulse Response Functions (IRFs) were used to show the effect of variations on one of the variables over the time on other variables, and the strength of these relations were also demonstrated in both time and the speed of recovery. This in-depth analysis not only points out those factors that change Nifty Index, but gives an interesting perspective on macroeconomic relations as well. This helps in investment decision, economic decision, and policy formulation. The study aims to bridge the gap between economic theory and empirical evidence, offering a framework for understanding the nexus between macroeconomic variables and financial markets.

Literature Review

Numerous studies have examined patterns regarding the influence of macroeconomic variables' dynamics on the stock market performance and how it can be beneficial for investment as well as for the formulation of economic policies. The findings from this area of research are useful in determining how inflation and interest rates, industrial production among other factors influence stock returns and this is both in theory and practice. Numerous researches have investigated such dynamics among the United States market and other developed economies. For example, Chen et al. (1986) indicated that fundamental such as those associated with industrial production and

inflation affect stock returns in the sense that dividends or earnings and discount rates are transformed in the future. Likewise, Bulmash and Trivoli (1991) studied such topics and confirmed that there are time-lagged interactions between US stock prices and a set of economic variables using an autoregressive model. The discrepancies were also recurrent in other studies like Dhakal et al. (1993) where it was confirmed that variations in the money supply do affect the level of share prices but through a chain reaction of interest rates and inflation changes. Issues of stock prices and their relationship with interest rates have also featured3. Bearing in mind that long term interest rates have been said to have adverse effects on stock returns, short term interest rates may sometimes accord superficially positive impacts indicative of a boost in profit.

Economists have revolved around the issue of the relationship between the macroeconomic indicators and the return from the stock prices under different circumstances leading some to varying conclusions. Fama (1981) and Geske and Roll (1983) pointed out that inflation had an adverse effect on stock return through its effect on real activities. In a similar way, Marshall (1992) also showed that such effects were due to real and monetary variables. In the case of emerging markets, Darat and Mukherjee (1987) pointed out the predominance of domestic factors, such as the industrial output, over foreign factors like the crude oil price and the exchange rates. On the same note, Pethe and Karnik (2000) and Bhattacharya and Mukherjee (2002) for instance claimed for India the presence of strong causal relations between the stock prices, inflation and industrial production level of the country. However, the results obtained about the intensity and the direction of causality were quite different. On the other hand, this work draws on previous studies determining the impact of seven macroeconomic factors — Index of Industrial Production, Consumer Price Index, Call Money Rate, Dollar Price, Foreign Institutional Investment, Crude Oil Prices and Gold Price — on the stock market in India through the effect on the Bombay Stock Exchange SENSEX. The period under investigation is the data from 2005 till 2012 and the method applied is regression and correlation test, as well as Granger causality test to find information about how these variables affect the Indian stock market.

In the developing markets, Rahman and Uddin (2009) and Pal and Mittal (2011) have examined the relationship between stock market and factors influencing economy in South Asia and India. It was noted that stock prices are significantly influenced by inflation, exchange rates and industrial production but though the impact and nature of these elements differed. Likewise, Sohail and Hussain (2009) reported a detrimental effect of inflation on stock prices and a few like Naik and Padhi (2012) focused on the positive influence of money supply on stock indices. This research looks at the relationship between the NSE Nifty index and six macroeconomic factors, including the exchange rate, inflation rate, industrial production index, gold price, money supply, and treasury bill yield. Monthly data was used from April 2005 to March 2014. By employing more sophisticated econometric methods including the Johansen cointegration technique, vector error correction model (VECM), impulse response function (IRF), and variance decomposition (VDC) the study seeks to establish both short- and long-term causal relationships. Findings show an inverse relationship between stock price movements and the exchange rate, inflation and industrial activities, while money supply and treasury yields have a direct relationship.

The context in hand is of Islamic finance practicing under Shariah, thus, such dynamic relationships remain largely unexplored.

Aspects like speculative investing and interest-based transactions are forbidden in Islam and so is gambling, alcohol and tobacco, and thus certain market conditions do exist. Wahyudi and Sani (2014) for example examined relations among Islamic capital markets and macroeconomic variables of Indonesia where it was shown that exchange rates and world oil price have a high influence. For example, Othman et al (2015) conducted research and found out that gross industrial production and unit price of crude oil have direct effects on Islamic equity unit trust funds in Malaysia. It can be concluded from these findings that there are fluctuations in the Islamic financial markets as a result of macroeconomic influences but in a different manner to the conventional markets.

In India, the rise of Islamic indexes like the Dow Jones Islamic Market India Total Return Index sheds new light on ethical investing in a non-Islamic nation. Dharani and Natarajan (2012) showed that Shariah-compliant stocks are viable and make up a big part of India's market value. This research expands on these findings to examine the connections between key economic factors—money supply, inflation, interest rates, and exchange rates—and the Dow Jones Islamic India index from 2006 to 2015 looking at both long-term and short-term relationships.

Johansen's cointegration tests and the vector error correction model (VECM) show a long-term balance between stock returns and macroeconomic indicators. Inflation (WPI) and money supply (M3) have a positive and important link to Islamic stock returns, while interest rates have a significant negative link.

Exchange rates, though linked, lack statistical importance. Money supply and exchange rates cause short-term effects on stock returns. Analysis of variance breakdown shows that money supply explains 16.01% of stock return changes, and exchange rates account for 21.66%. These results offer key insights into how Shariah-compliant stocks work in India highlighting how much they respond to macroeconomic factors.

On the flip side, money supply shows two different effects. It can boost economic activity and increase corporate earnings, which leads to higher stock prices. However, it can also increase inflation pressures, which raises discount rates and hurts stock returns (Mukherjee and Naka 1995; Sohail and Hussain 2009). Interest rates have an opposite relationship with stock prices. Higher rates make borrowing more expensive, which cuts into company profits and stock values (Gjerde and Saettem, 1999). Exchange rates also affect stock markets. When the local currency loses value, it can help companies that export a lot. But it can scare off foreign investors because of currency risks (Mukherjee and Naka, 1995). For countries that import a lot, a weaker currency can mean higher costs and lower profits. These different effects show how the impact of economic factors on stock markets depends on the situation. This study adds to what we already know by looking at the long-term and short-term connections between the BSE Sensex and four key economic factors: inflation (WPI), money supply (M3), interest rates (T-bill rates), and exchange rates (USD/INR).

The authors analyse monthly data from July 2001 to July 2015 using Johansen's cointegration tests and vector error correction models (VECM) to study these patterns. Their findings show a long-term balance between stock returns and these economic indicators. Inflation and money supply have a positive link, while interest rates show a strong negative connection. In the short term, the Sensex and exchange rates affect each other, while inflation and money supply boost stock prices. These results point out the growing inefficiencies in Indian capital markets, as shown by the connection between economic indicators and stock returns. This research adds to current knowledge by showing how economic basics shape stock market behaviour in a growing economy like India. It offers useful insights for policy makers, investors, and researchers.

Description of Data

The dataset for this analysis has a period of ten years starting from January 2013 to April 2024, which permits observing changes in the balance between Indian stock returns and central macroeconomics over time. The variable taken into account are Crude oil price, Exchange rate, Industrial Production Index (IPI), Consumer Price Index (CPI), Wholesale Price Index (WPI), Money supply National stock exchange (NSE) Index, Call rate and Gold price. These variables are directly relevant to the study as they capture essential administrative aspects of the Indian economy and its relationship with stock market behaviour. Crude oil price is an indicator of global oil prices and their knock-on effects on domestic oil prices and inflation. Exchange rate helps determine currency strength and international trade, which are very important for investment from outside. The industrial production index provides insight into the levels of production activity in the economy and serves as an indicator of prevailing economic conditions. The CPI and WPI stand for general inflation, which affects consumption and investment. Money Supply indicates surplus money available and its activity in the economy that determines the performance of the market. The NSE index acts as a market and stock market performance metrics, therefore its importance in measuring share earnings. Call Rates which are the interest rates charged to customers who borrow cash against their stocks, provide information regarding the short-term borrowing costs and credit policy positions. Finally, Gold Prices, which today remain one of the most reliable shields from uncertainties, allow assessing investors' attitudes to the market and their preferences for additional investment options in times of crises.

Methodology and Framework

Descriptive statistics was applied calculated for the dataset to summarize and understand its main features, including measures of central tendency and dispersion, providing an overview of the data distribution. This step provided insights into the overall data distribution and identification of potential outliers. Variables were then converted into logarithmic values in order to normalize the data distribution. To further ensure that there is not multicollinearity among the variables, a Variance Inflation Factor (VIF) test was conducted. Following, stationarity tests were conducted on the variables using the Augmented Dickey Fuller test. Next, a correlation matrix was used to examine the relationships and dependencies between the variables. Dataset was thus finalized for modelling and analysis. The below mentioned techniques were used to determine the relationship among the variables used in the study.

Cointegration

Cointegration is a statistical method used to test the long-term relationship between two or more non-

stationary time series variables particularly useful for analysing relationships over time in economic studies. To examine the long-term equilibrium relationship among the variables, the Engle-Granger two-step cointegration test was employed. First, the Augmented Dickey-Fuller (ADF) test was conducted on each variable to check for stationarity. Following this, a regression model was estimated with NSE as the dependent variable and the other variables (Crude Oil Price, Foreign Exchange rate, Industrial Production Index, CPI, Money Supply, Call rate and Gold prices) as independent variables. The residuals from this regression were then tested for stationarity using the ADF test. If the residuals were found to be stationary, it indicated the presence of cointegration.

Vector Error Correction Model

The Vector Error Correction methodology is a robust statistical approach used for modelling and understanding the long term and relationships among multiple time series variables. Vector Error correction model uses a system of equations modelled as a linear function of its own past values, the past values of all other variables and an error correction term. The incorporated error term assists in measuring the long-term equilibrium relationships making assumption that all other short-term deviations will be corrected over time. Equation (i) shows the modelling framework for Vector error correction model.

$$\Delta NSE_t = \alpha_1 \cdot \beta' Z_{t-1} + \sum \Gamma_i \Delta NSE_{t-i} + \sum \Phi_j \Delta X_{t-j} + \epsilon_t \text{ ----(i)}$$

Here, ΔNSE_t is the first difference of NSE variable (Stock Market Index), $\cdot$ Parameter $\beta' Z_{t-1}$ is the long-term cointegrating vector where Z_{t-1} is a vector of variables in the model and β' is the cointegration vector. Parameter α_1 represents the speed of adjustment from a deviation to long term equilibrium. Γ_i is the coefficient of the lagged difference of NSE and Φ_j shows the coefficient of the lagged difference of independent variables in the equation which captures the short-term dynamics of equation. ϵ_t is the error term of equation which follows a white noise process.

To check for optimum lag lengths in the VECM model the following techniques mentioned below were taken into account. The Final Prediction Error (FPE) criterion evaluates the goodness of fit of the model while penalizing complexity, balancing fit and forecast accuracy. The Akaike Information Criterion (AIC) helps select the model that best fits the data while penalizing overfitting, with a lower AIC value indicating a better model. The Hannan-Quinn Information Criterion (HQIC) also compares models like AIC but imposes a higher penalty for adding parameters, making it less prone to overfitting. Lastly, the Schwarz Bayesian Information Criterion (SBIC), also known as BIC, selects models based on their likelihood and complexity, applying a stronger penalty for adding parameters than AIC, which results in more parsimonious models. These criterions assist in determining the optimal lag length in VECM models by balancing model complexity and fit to the data. Further, to assess the stability in the model stability test was employed. It assesses that, if the VECM model is stable by ensuring its characteristic roots lie inside the unit circle. It checks that if the system's shocks cause explosive behaviour in the variables over time and if the explosive behaviour occurs does it disturbs the long-term equilibrium of the model. The Lagrange Multiplier test is used to detect autocorrelation in the residuals, indicating potential model misspecification. The null hypothesis of the test assesses the presence of serial correlation among the residuals against the alternative hypothesis of no serial correlation among residuals.

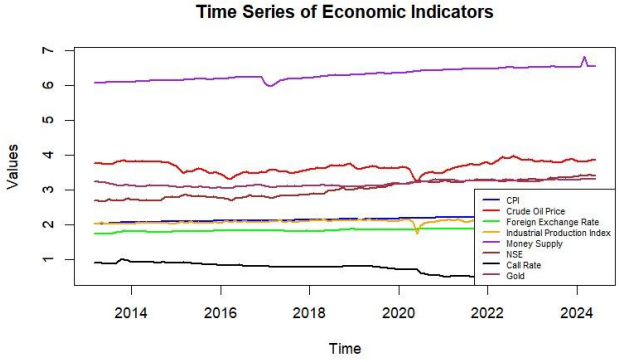

Figure 1: Log Values of Indicators at base level

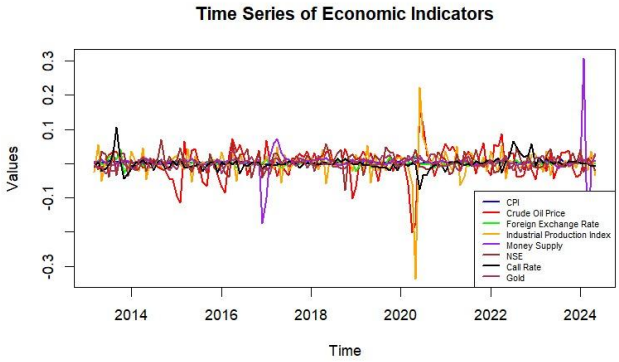

Figure 2: Log values of Indicators at first difference (stationary level)

Results

The results in Table 1 shows the descriptive statistics of dataset. Original dataset consists of 136 data pints arranged in a monthly time series order. To bring normality, linearity and stabilizing the dataset to perform a consistent analysis these values were

transformed into logarithmic form. In Table 2, the correlation matrix can be observed, a presence of high correlation among the variables can be noticed. To address the problem of multicollinearity variables *Consumer Price Index, Money Supply* were omitted for further calculations. Table 4 shows the thus obtained Variance Inflation Factors, it can be observed that all variables while taking NSE (Stock market Index NIFTY) as dependent variable has their VIF values much below the benchmark value of 5. This removes the problem of multicollinearity from further analysis.

Table 1: Descriptive statistics

Variables	Observations	Mean	Standard Deviation	Minimum	Maximum
Crude Oil Prices	136	4876.559	1649.203	1603.02	9119.55
Foreign Exchange Rate	136	69.71159	7.555434	53.3238	83.3602
Industrial Production Index	136	124.4919	14.80933	54	159.9
Consumer Price Index	136	143.5346	23.03805	104.6	186.7
Money Supply	136	2181029	870598.4	943209.1	6838414
Nifty Fifty Index	136	1198.589	651.7575	451.85	2658.03
Call Rate	136	6.040001	1.61287	3.135995	9.971509
Gold Prices	136	1497.836	293.8276	1068.25	2158.01

Table 2: Correlation Matrix

Variables	CPI	FX_Rate	IPI	CPI	M2	Nifty	Call rate	Gold
Crude Oil Prices	**1.0000**							
Foreign Exchange Rate	0.2576	**1.0000**						
Industrial Production Index	0.4066	0.6135	**1.0000**					
Consumer Price Index	0.3233	0.9616	0.6719	**1.0000**				
Money Supply	0.3312	0.9052	0.6123	0.9487	**1.0000**			
Nifty Fifty Index	0.3268	0.9191	0.5890	0.9622	0.9586	**1.0000**		
Call rates	0.0327	-0.5049	-0.3036	-0.5980	-0.6156	-0.6477	**1.0000**	
Gold Prices	0.4934	0.6944	0.4445	0.7803	0.8193	0.8371	-0.5775	**1.0000**

Table 3: Variance Inflation Factor

Variables	VIF	1/VIF
Gold Prices	3.45	0.289575
Foreign Exchange Rate	2.72	0.367402
Call rate	1.95	0.511728
Crude Oil Prices	1.93	0.517145
Industrial Price Index	1.87	0.534379
Mean VIF	2.39	

In the next step, the stationarity of variables was measured for the selection of appropriate model. Table 4 shows the results of ADF tests at first difference. The variables were found non-stationary at their base levels and stationary at their first difference. Figure 1 and Figure 2 show the graphical representation of time series plots at level and first difference. Two step Cointegration procedure of Engel-Granger was employed which showed the residuals of equation with NSE as dependent variable stationary and signifies the presence of long-term relationship among the variables. Table 5 shows stationary results for cointegrating vector of residuals

Table 4: ADF test results at first difference

Variables	Z Score	P Statistic
Foreign Exchange Rate	-9.003	0.000***
Industrial Production Index	-11.208	0.000***
NSE	-9.096	0.000***
Crude Oil Price	-8.716	0.000***
Call Rate	-8.468	0.000***
Gold Prices	-8.419	0.000***

Table 5: Stationarity results for cointegrating vector

Variable	Z Score	P Statistic
Residual	-4.60	0.0011***

The results for vector error correction model analysed from Table 6. Cointegrating term for the term equilibrium (_cel L1.) shows a negative value of -0.0419 signifying that 4.19% of the disequilibrium is corrected in each period(month) in case there is a disequilibrium in dependent variable D_NSE. This relationship is statistically significant at 95% confidence interval. Further, the short run dynamics are discussed for the variables. The lag of NSE (stock market Index) has a negative significant impact and a 1 unit of change in magnitude of lagged value of NSE reduces its current change by 0.18 units. Crude Oil Prices does not have any significant impact on current value of NSE. The lagged value of foreign exchange rates has a positive impact of 0.847 units on a 1 unit increase in NSE. Lagged value of Industrial production Index has a weak negative significant impact of 0.098 units per unit increase in current value of NSE. Further, call rates does not have any significant impact and the lagged value of Gold prices per period shows a positive impact of 0.30 units per 1 unit rise in NSE. The constant term for equation is 0.0057 which shows

the average growth in NSE in the absence of explaining factors.

Table 6: Vector Error Correction Model (LD signifies lagged difference)

Parameters	Value	Parameters	Value
AIC	-30.26048	Log Likelihood	280.452
HQIC	-29.79472	R- Square	0.2016
SBIC	-29.11432	P- Statistic	0.0003***

Variables	Coefficient	Standard error	Z-Score	P-Statistic
_cel L1.	-0.0418872	0.0179709	-2.22	0.027**
NSE.LD	-0.1786458	0.0858611	-2.08	0.037**
Crude Oil Price.LD	-0.0433773	0.0516976	-0.84	0.401
FX Rate.LD	0.8497465	0.2637986	3.22	0.001***
IIP.LD	-0.0986305	0.059283	-1.67	0.094*
Call Rate.LD	-0.0312081	0.1336544	-0.23	0.815
Gold.LD	0.3018347	0.157377	1.94	0.052*
Constant	0.0056787	0.0021329	2.68	0.009***

'*' Represents 90% confidence interval, '**' Represents 95% confidence interval and '***' Represents 99 % confidence interval

Interpreting the parameter values the relationship of this model is 99% significant. R-square of 0.2016 is low but not an highly impacting criterion for a VECM model as there are criterions such as speed of adjustment parameters, AIC, HQIC and SBIC. The negative values of AIC, HQIC and SBIC suggests a high Log-Likelihood or the goodness of fit of the model. In the above VECM model Log likelihood is relatively high suggesting that model is having a high success in capturing the dynamics of data.

Table 7: VECM Stability tests

Eigen Value	Modulus
0.5024916 + 0.09055539i	0.510586
0.5024916 - 0.09055539i	0.510586
0.2963863 + 0.1610615i	0.337321
0.2963863 - 0.1610615i	0.337321
-0.2311719 + 0.2327759i	0.328063
-0.2311719 - 0.2327759i	0.328063
-0.2810952	0.281095

Table 7: Lagrange Multiplier tests for VECM

Lag	Chi2	Df	P Statistic
1	43.4657	36	0.18330
2	38.7267	36	0.34762

Table 7, shows results of stability tests of VECM model. All modulus values are less than one suggesting that shocks within the model will dissipate over time without causing explosive behaviour and model will reach back to its long-term equilibrium. Table 8, shows the results of Lagrange Multiplier tests to check autocorrelation in residuals of the model. As, P-Statistic is relatively high the model than 0.01 we can say that no autocorrelation is present in the residuals of Lag 1 and Lag 2.

Conclusion

This study reveals the important relationship of macroeconomics variables and Indian Stock Market Index. The employment of Vector error correction model showed a positive significant impact periodic (lagged) values of gold prices and negative impact of variables industrial Production Index and Crude Oil Prices on the Stock Market Index of National Stock Exchange. This shows that investors view gold as a safe haven asset, whose price rise can suggest inflation or economics uncertainty, during investment in equities. The negative impact of lagged value of Index itself can imply that in India, developing economy with potential for growth. A period of downturn can cause another period of uprise due to investors trust and alignment of their investment strategies. A negative impact of oil prices similarly can suggest inflationary pressures and increasing production costs leading to a downfall in investor sentiment and thus, the stock market index. The positive impact of Foreign exchange rates reveal a combination of two reasons. Firstly, India being a rising economy with strong fundamental parameters and secondly, a market with open economy can lead to cheaper goods and low inflationary pressures. The reason first can be assessed as a more fundamental one.

These results can provide significant insights to the policy makers. A scope for further studies is open in the subject area as Indian Stock market can be more dynamic than anything in the world. The framework of this study can be used by researchers to conclude rhobust and significant results.

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