Do Indian stock prices respond to domestic macroeconomic variables?

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Abstract

The volatility in the Indian stock markets in the last couple of decades has raised a pertinent question - are these meaningful institutions that are linked to the overall macroeconomic health of the country or are they mere casinos where people make and lose millions? Keeping in mind this question, the present study investigated the effect of a subset of macroeconomic variables on the Indian stock market. The study uses monthly time series data covering the period from April 2005 to December 2019 and employs the ADF unit root test, Johansen co-integration test, VECM, and Granger causality for data analysis. Variance decomposition analysis has also been performed to determine the significance of each variable in generating fluctuations in other variables. The results show that the macroeconomic variables are co-integrated with the stock prices suggesting the presence of a long-run relationship. The pairwise Granger causality test indicates that the exchange rate, money supply, and short-term interest rate granger cause stock prices. The VDC analysis indicates that stock prices in India are relatively exogenous in relation to other macroeconomic variables. The study concludes that volatility in stock prices in the future to a certain extent can be forecasted by the information provided by the selected macroeconomic fundamentals.

Keywords: *Macroeconomic variables, stock market, unit root test, Granger causality test, Variance decomposition analysis, VECM*

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Introduction

Following globalisation and liberalisation of the Indian economy, the Indian stock market has undergone a series of essential changes which resulted in its improvement (Mishra, 2018). However, unlike mature stock markets of developed nations, the Indian stock market is likely to be more sensitive to various factors.

Studies carried out to identify the factors that affect stock prices agree that the intrinsic value of a stock depends on multiple factors. The risk exposure of the company, earnings of the company, and the growth rate have a direct bearing on the stock prices of a company. These factors, in turn, rely on different factors like the macroeconomic environment in which they operate, the industry they belong to and the performance of the company. However, the impact of macroeconomic fundamentals on stock market returns has gained much traction from economists, financial analysts, investors and policy makers due to the fact that the stock market is an integral part of the economy (Pandian, 2013).

The researchers focussed on a number of macroeconomic factors including exchange rate, country's real activity, money supply, interest rate, inflation and prices of precious metals. Exchange rate can be linked to stock prices through flow oriented model and portfolio balance model. In the case of flow oriented model, weakening of the domestic currency in relation to foreign currency negatively affects the firm's future cash flows by negatively affecting the firm's competiveness in the international market. This implies that exchange rate granger cause stock prices (Dornbusch and Fischer, 1980). On the other hand, portfolio balance model argues that increase in stock prices attracts foreign capital which increases the demand for domestic currency. This implies that stock prices granger cause exchange rate (Branson *et al.,* 1977). In addition, in an export-dominant economy, stock prices react negatively to exchange rate appreciation while in an import-dominant country, stock prices react positively to exchange rate appreciation.

The linkage between interest rate and stock prices can be explained by its impact on the firm's future profitability either by raising the borrowing cost or by causing recession in the economy (Ratanapakorn and Sharma, 2007). Another plausible explanation can be from the asset portfolio allocation perspective (Abdullah and Hayworth, 1993; Ratanapakorn and Sharma, 2007). Both the arguments suggest that a negative relationship exists between interest rate and stock prices.

The theoretical framework postulates a positive relationship between industrial production and stock prices. The positive relationship can be explained by the impact of industrial production on firms' expected future cash flows. As the production capacity of an economy rises during economic expansion, the ability of the firm to generate cash flows is also positively affected. Thus, increase in industrial production is favourable to firms' expected future cash flows, which in turn, make the firms' stock prices more attractive to investors (Patel, 2012; Ratanapakorn and Sharma, 2007). However, in reality, the relationship between the two variables has been much more difficult to establish.

Homa and Jaffee (1971) explained the relationship between money supply and stock prices. According to them, a decrease in money supply will raise the interest rate and reduce capital investments. Reduction in capital investments will decrease the firm's sales and causes the firm's earnings to fall. The fall in earnings will result in low dividends and hence, the stock prices will fall. On the other hand, an increase in the money supply will reduce the interest rate and increase the interest-sensitive expenditure. The increase in interest-sensitive expenditure will raise the firm's earnings. Thus, when supply of money increases, the dividend expectations of investors increases and as a result, stock price increases. The positive linkage between stock prices and supply of money was observed by Mukherjee and Naka (1995), Al-Sharkas (2004) and Ray (2012).

The impact of inflation on stock prices has been studied extensively. One theory asserts that inflation positively influences stock prices because investment in equity is a hedge against inflation (Fisher, 1930). The positive relationship between the two variables was observed by Abdullah and Hayworth (1993), Ratanapakorn and Sharma (2007) and Ogunmuyiwa and Okuneya (2014). The negative relationship between inflation and real activity via quantity theory of money can explain the adverse impact of inflation on stock prices. The negative relationship between the two variables was observed by Fama (1981), Pal and Mittal (2011) and Naik and Padhi (2012).

For gold prices, theoretically, an inverse relationship exists between gold prices and stock market indices (Tursoy and Faisal, 2018). The reason for the inverse relationship may lay in the perception of the investor. Investors who foresee a bearish market usually invest in the commodity market (Patel, 2012). However, in India, the equity culture is not as developed as in other developed nations, and investing in gold is deeply ingrained in the Indian social psyche (Mishra *et al*., 2010).

Thus, the above discussion gives rise to the following research questions:

RQ1. Whether Indian macroeconomic variables significantly influence Indian stock prices in the long run.

RQ2. To what extent do the shocks in macroeconomic variables explain fluctuations in stock prices?

In the present study, the researcher attempts to find answers to the above research questions and show the combined impact of macroeconomic variables on Indian stock prices. The findings of the study can be applied and generalised to various transitioning and emerging economies. The key findings of the present study will be helpful to policymakers, regulators, private equity investors and mutual fund managers.

Prior Research

There is a plethora of studies that have examined the impact of various macroeconomic variables on stock prices for India and various industrialised and emerging economies. Aggarwal (1981) studied the dynamic relationship between exchange rate and stock prices under floating exchange rate regime and found that exchange rate is positively related to US stock prices. Chen *et al.* (1986) observed that changes in anticipated inflation, unexpected inflation, industrial production, changes in risk premium and term structure were significant factors affecting the stock returns in New York Stock Exchange (NYSE). Dhakal *et al.* (1993) applied Vector Autoregression (VAR) to study the relationship between money supply and stock prices, and concluded that money supply has a direct causal impact on stock prices. Soenen and Johnson (2001) showed that stock prices are positively affected by real output whereas inflation does not significantly affect stock prices. Tsoukalas (2003) applied Granger Causality test to study the causal relationship between macroeconomic variables and stock prices in the Cypriot equity market. The study found that inflation, industrial production, money supply and exchange rate have the ability to predict stock prices in the Cypriot equity market. Maghayereh (2003) observed that inflation and interest rate have a negative impact on stock prices while foreign reserves, industrial production and domestic exports positively affect stock prices in Jordan. Meike (2006) studied the effect of macroeconomic variables on stock prices in emerging Sri Lankan stock market and found that stock prices react negatively to changes in inflation rate, interest rate and exchange rate while changes in money supply affect stock prices positively. Ratanapakorn and Sharma (2007) investigated the dynamic relationship between stock returns in US and macroeconomic variables. The findings of the study showed that US stock returns are positively linked with industrial production, exchange rate, inflation, money supply and short-term interest rate while a negative linkage was observed between long-term interest rate and stock prices. Humpe and Macmillan (2009) investigated the impact of macroeconomic variables and stock prices from US and Japanese prespectives, and concluded that US stock prices react positively to changes in industrial production and are negatively related to inflation and long-term interest rate. On the other hand, Japanese stock prices are positively related to industrial production and are adversely affected by changes in money supply. Pal and Mittal (2011) studied the impact of interest rate, gross domestic savings, inflation and exchange rate on Indian stock market returns and observed that inflation has a negative impact on stock prices on both National Stock Exchange and Bombay Stock Exchange. Applying Granger Causality test, Shiva and Seth (2015) investigated the dynamic relationship between gold prices, exchange rate and stock prices on the Indian stock market, and found evidence of unidirectional causality between gold prices and stock market performance. Joshipura and Peswani (2018) studied the stocks listed on National Stock Exchange and concluded that investing in a portfolio of high-risk growth stocks is a bad investing strategy in the Indian stock market.

Mahmood *et al.* (2015), Najaf *et al.* (2015) and Saleem and Alifah (2017) provided empirical evidence from Pakistan on the impact of macroeconomic variables on stock prices. Mahmood *et al.* (2015), Najaf *et al.* (2015) found that stock prices in Pakistan react negatively to inflation. The findings of Najaf *et al.* (2015) further concluded that foreign domestic investment positively affects Karachi Stock Exchange (KSE 100). Saleem and Alifah (2017) showed that interest rate granger causes stock prices in Pakistan. Evidence from Turkey is provided by Tursoy and Faisal (2018) who concluded that in the long run as well as in the short run, gold prices have a negative impact on stock returns in Turkey. Ning *et al.* (2018) used error correction model and Granger Causality test to study the relationship between the selected macroeconomic variables and stock prices in China. They concluded that in mainland China, exchange rate and money supply play an important role while in Hong Kong, exchange rate is the driving force.

Mukherjee and Naka (1995), Kwon and Shin (1999), Brahmasrene (2007), Mishra *et al.* (2010), Pal and Mittal (2011), Giri and Joshi (2017) and Ning *et al.* (2018) applied Johansen co-integration test and found that the macroeconomic variables and stock prices are linked in the long run, while Bhattacharya and Mukherjee (2003) did not find such relationship between macroeconomic variables and stock prices in India.

The results of literature suggest that the impact of macroeconomic variables on stock prices is not completely established in the economic theory and hence, provide us with the opportunity to add to the existing knowledge. To add to the originality and value to the existing literature, the present paper studies the impact of a unique combination of six macroeconomic variables, namely, INR/USD exchange rate, broad money supply, short-term interest rate, inflation, gold prices and index of industrial production on Indian stock prices. Further, the paper will incorporate variance decomposition analysis to have a better understanding of the relationship between the variables.

The remaining paper is organised as follows: Section 3 discusses the data and methodology; Section 4 discusses the long and short-term relationships and Section 5 contains the concluding remarks.

Data and Methodology

Data and its Sources

The objective of the study is to examine, establish and determine the impact of exchange rate, money supply, interest rate, inflation, gold prices and industrial production on Indian stock prices. To fulfil the objective, the study used monthly observations from 2005:4 to 2019:12 (Year: Month). The time period that the study selected is arbitrary. The monthly data for the stock prices has been taken from NSE website. The data for exchange rate, money supply, interest rate, inflation and industrial production have been obtained from RBI website. The gold prices data have been procured from the World Gold Council.

To reflect the impact of money market, short-term interest rate and money supply are used. The weighted average call money rate is used as the proxy for short-term interest rate while M3 represents the money supply. The goods market is represented by industrial production and inflation. The wholesale price index is used as the proxy for inflation and the index of industrial production represents the industrial production in India. The impact of the price of precious metals will be reflected by gold prices expressed in $ per Troy Ounce. International exchange rate and stock prices reflect the securities market expressed by INR/USD exchange rate and Nifty 50 respectively.

Table 1 Operational Definition

Variables	Proxy	Symbol used	Expected Relation
Indian Stock Prices	Nifty 50	NIFTY	---
Exchange Rate	INR/USD Exchange Rate	EXR	-ve
Money Supply	M3	MS	+ve
Short-term Interest Rate	Weighted Average Call Money Rate	INT	-ve
Inflation	WPI (Base Year= 2004-05)	INF	+ve
Gold Prices	$ per Troy Ounce	GP	-ve
Industrial Production	Index of Industrial Production (Base Year= 2004-05)	IIP	+ve

Source: Authors' research

The expected signs are based on the findings and existing economic theories.

The study proposes the following model:

$$NIFTY = f\,(EXR, MS, INT, INF, GP, IIP) \quad (1)$$

Where, *NIFTY* indicates Indian stock prices, *EXR* is exchange rate, *MS* represents money supply, *INT* is interest rate, *INF* is inflation rate, *GP* indicates gold prices and *IIP* represents industrial production.

Research Methodology

All the variables have been transformed into natural logarithms and graphically analysed with the help of line charts. Augmented Dickey Fuller (ADF) test has been used to determine the order of integration. For the purpose of establishing long-term relationship, Johansen Co-integration analysis is employed. The Johansen Co-integration analysis produces trace statistics and maximum Eigenvalue statistics. These two statistics are used to determine the number of co-integrating vectors. In a situation where the result produced by λ_{trace} test and the λ_{max} test are conflicting, the study can progress based on the result of λ_{trace} test. Further, Vector Error Correction Model has been applied followed by Granger Causality test and variance decomposition.

Unit Root Test

A unit root test examines whether a time series variable is stationary or non-stationary by using an autoregressive model. The presence of a unit root in the data is checked by employing the Augmented Dickey-Fuller (ADF) test and it tests the null hypothesis that the autoregressive model has a unit root. The more negative the ADF test statistic, the stronger the chances of rejection of the null hypothesis. Although there are many available tests for verifying the presence of a unit root, we used this test because of its popularity and wide application in the previous studies [Maghayereh, 2003; Ratanapakorn and Sharma, 2007 and Shiva and Seth 2015].

ADF test involves the estimation of the following equation:

$$\Delta Y_t = \alpha + \pi t + \delta Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-1} + \varepsilon_t \quad (2)$$

Where Y_t is a Random walk with an intercept and time trend.

Johansen Co-integration analysis and VECM

After establishing the time series properties of the variables, Johansen Co-integration test will be employed to test for the presence of long-run relationship among the variables in Model 1. Li *et al.* (2020) explained that when two data sets are co-integrated, it actually means that the two variables cannot wander off in opposite directions for a very long period of time and will come back to a mean distance. The short-run disequilibrium that will arise can be explained by the error correction term (ECM). λ_{trace} (Lamda Trace) and λ_{max} (Lamda Max) statistics will test the number of co-integrating vectors in the system.

The λ_{trace} and λ_{max} statistics can be computed by the following equations:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{K} In(1-\lambda_i) \quad (3)$$

$$\lambda_{max}(r, r+1) = -T\ In(1-\lambda_i) \quad (4)$$

If there exists long-run relationship between the studied variables, a causal relationship between the variables can be determined by estimating Vector Error Correction Model (VECM).

$$DLnNIFTY_t = \mu_1 + \gamma_1 Z_{t-1} + \sum_{i=1}^{p} \theta_{1i} DLnNIFTY_{t-1} + \sum_{i=1}^{p} \delta_{1i} DLnEXR_{t-1} + \sum_{i=1}^{p} \tau_{1i} DLnMS_{t-1} + \sum_{i=1}^{p} \rho_{1i} DLnINT_{t-1} + \sum_{i=1}^{p} \omega_{1i}\ DLnINF_{t-1} + \sum_{i=1}^{p} \xi_{1i}\ DLnGP_{t-1} + \sum_{i=1}^{p} \eta_{1i}\ DLnIIP_{t-1} + \varepsilon_t \quad (5)$$

Where, μ is the constant term, Z_{t-1} is the error correction term, p is the lag length, $\gamma, \theta, \delta, \tau, \rho, \omega, \xi$ and η are the parameters to be estimated and ε_t is the error term.

Granger Causality Test

Granger Causality analysis is a statistical hypothesis test for determining whether one time series data is useful in predicting another. In Granger (1969) approach, X is a cause of Y, if X helps to increase the accuracy of the prediction of Y with respect to a prediction considering simply past values of Y. The test exhibits two types of output, namely, unidirectional relationship and bidirectional relationship.

To test the Granger Causality, the following equations are used:

$$(Y)_t = \alpha + \sum_{i=1}^{m} \beta_i (Y)_{t-i} + \sum_{j=1}^{n} \tau_j (X)_{t-j} + \varepsilon_t \quad (6)$$

$$(X)_t = \omega_0 + \sum_{i=1}^{m} \gamma_i (Y)_{t-i} + \sum_{j=1}^{n} \theta_j (X)_{t-j} + \varepsilon_t \quad (7)$$

Estimation Results

To test the long-run relationship between the variables, it is required to determine the order of integration of each series. However, before applying the unit root test, a graphical presentation of the data is the first step in the analysis of time series variables. The line graphs in Figure 1 show that the selected variables may contain unit root since their respective means and variances are not constant and require further investigation by employing unit root test.

The present study applied Augmented Dickey Fuller test to determine the order of integration of the variables and the results are summarised in Table 2. The calculations are made in Schwarz Information Criteria (SIC) with the maximum lag length of 13 lags. From Table 2, it is clear that the null hypothesis, time series has a unit root, could not be rejected for all the variables. All variables become stationary after taking their first order difference.

Figure 1: Line charts of Variables (at Level)

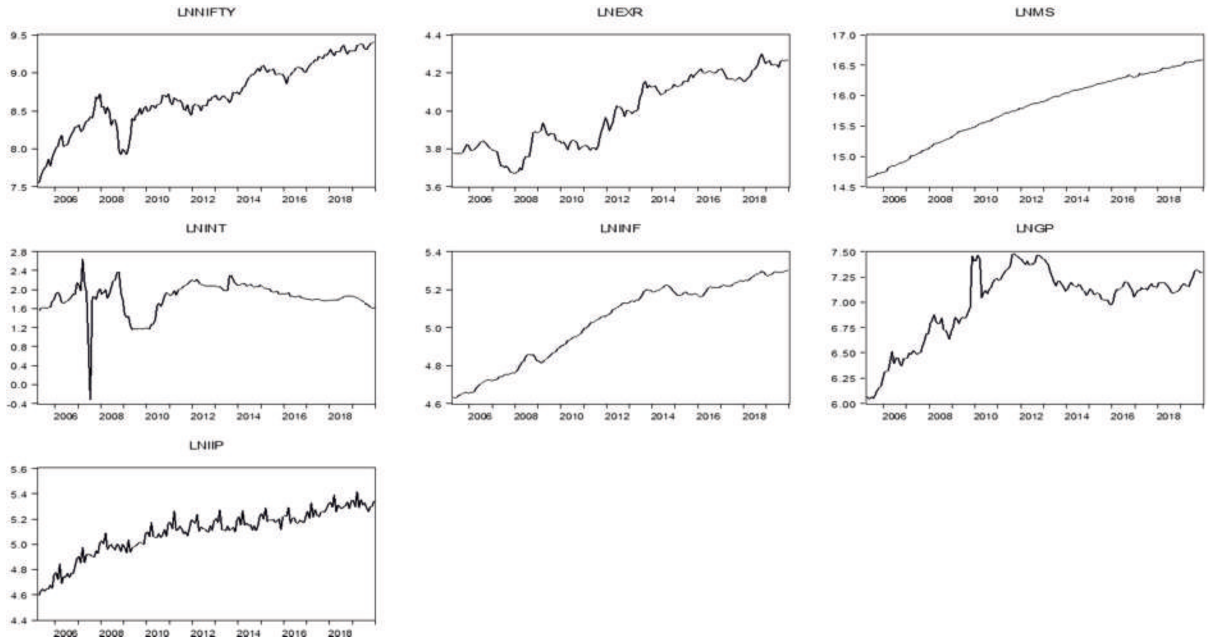

Table 2 Augmented Dickey Fuller Test Results

Variables	On levels	On first difference
LnNIFTY	-3.750	-12.686***
LnEXR	-2.785	-9.596*
LnMS	-2.044	-3.333***
LnINT	-0.388	-9.946*
LnINF	-1.203	-8.229*
LnGP	-2.180	-12.702*
LnIIP	-3.424	-3.304***

Source: Authors' computation

Notes: The optimal lag length for the ADF regression is selected based on Schwarz information criterion.

, and *** Denote significance at the 1 %, 5 % and 10 % levels, respectively.*

Table 3 VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	896.562	NA	6.32e-14	-10.527	-10.397	-10.474
1	2434.700	2930.653	1.40e-21	-28.150	-27.113*	-27.729
2	2521.434	158.070	9.01e-22*	-28.596*	-26.652	-27.807*
3	2561.972	70.522	1.00e-21	-28.496	-25.644	-27.339
4	2610.947	81.141	1.02e-21	-28.496	-24.736	-26.970
5	2659.565	76.521	1.04e-21	-28.491	-23.824	-26.597
6	2703.460	65.452	1.15e-21	-28.431	-22.856	-26.169
7	2758.354	77.306*	1.12e-21	-28.501	-22.019	-25.870

Source: Authors' computation

**Indicates lag order selected by each criterion*

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Table 3 VAR Lag Order Selection Criteria

Panel A: Trace hypothesized no. of CE(S)				
	Eigenvalue	**Trace statistic**	**5% Critical value**	***p-value***
None	0.314	211.212*	125.615	0.000
At most 1	0.250	145.567*	95.753	0.000
At most 2	0.190	95.507*	69.818	0.000
At most 3	0.128	58.834*	47.856	0.003
At most 4	0.100	34.869*	29.797	0.012
At most 5	0.058	16.448*	15.494	0.035
At most 6	0.033	5.999*	3.841	0.014
Panel B: Maximum Eigenvalue hypothesized no. of CE(S)				
	Eigenvalue	**Trace statistic**	**5% Critical value**	***p-value***
None	0.314	65.644*	46.231	0.000
At most 1	0.250	50.060*	40.077	0.002
At most 2	0.190	36.673*	33.876	0.022
At most 3	0.128	23.965*	27.584	0.135
At most 4	0.100	18.421	21.131	0.114
At most 5	0.058	10.448	14.264	0.184
At most 6	0.033	5.999*	3.841	0.014

Source: Authors' computation

Notes: Sample: 2005M08 2019M12.

Trend assumption: Linear deterministic trend. Series: LnSP, LnEXR, LnMS, LnINT, LnINF, LnGP and LnIIP. Lags interval (in first differences): 1 to 2

**Denotes coefficient significance at the 5% level.*

Table 5 Normalised Co-integrating Coefficients

LnSP	LnEXR	LnMS	LnINT	LnINF	LnGP	LnIIP	C
1.000	6.478*	-2.043	2.327*	-15.159*	1.568*	11.916*	-2.044
	(2.152)	(2.057)	(0.418)	(3.952)	(0.616)	(3.044)	
	[3.009]	[-0.993]	[5.560]	[-3.835]	[2.545]	[3.914]	

Source: Authors' computation

Notes: SEs are in ( ) while t-values are in [ ].

**Denotes significance at the 5% level.*

Table 6 VECM result with SEs and t-values

Error Correction:	D[LnNIFTY]	D[LnEXR]	D[LnMS]	D[LnINT]	D[LnINF]	D[LnGP]	D[LnIIP]
CointEq1	**-0.0236***	-0.0007	0.0045*	-0.0902*	0.0012	-0.0068	0.0022
	(0.007)	(0.001)	(0.001)	(0.024)	(0.000)	(0.007)	(0.004)
	[-3.373]	[-0.357]	[3.949]	[-3.687]	[1.858]	[-0.955]	[0.474]
D[LnNIFTY(-1)]	-0.1130		0.0123	-0.1883	0.0125	-0.1200	0.0807
	(0.088)	(0.024)	(0.014)	(0.308)	(0.008)	(0.090)	(0.059)
	[-1.278]	[-2.587]	[0.849]	[-0.609]	[1.517]	[-1.331]	[1.346]
D[LnEXR(-1)]	-0.7811*	0.2440*	0.0171	-0.5558	0.0563	-0.6196	0.4402
	(0.31401)	(0.088)	(0.051)	(1.097)	(0.029)	(0.320)	(0.213)
	[-2.48749]	[2.765]	[0.330]	[-0.506]	[1.918]	[-1.935]	[2.066]
D[LnMS(-1)]	0.7337	0.1115	-0.0351	1.6687	0.0711	0.0692	-1.0638*
	(0.479)	(0.134)	(0.078)	(1.674)	(0.044)	(0.488)	(0.325)
	[1.53071]	[0.827]	[-0.445]	[0.996]	[1.586]	[0.141]	[-3.271]
D[LnINT(-1)]	0.0663*	-0.0074	-0.0039	-0.0451	-0.0008	0.0240	-0.0064
	(0.02315)	(0.006)	(0.003)	(0.080)	(0.002)	(0.023)	(0.015)
	[2.86728]	[-1.148]	[-1.026]	[-0.558]	[-0.386]	[1.017]	[-0.408]
D[LnINF(-1)]	-0.0665	-0.1395	-0.3121*	2.9380	0.5007*	-0.1300	-2.9432*
	(0.832)	(0.233)	(0.137)	(2.907)	(0.077)	(0.848)	(0.564)
	[-0.079]	[-0.596]	[-2.277]	[1.010]	[6.433]	[-0.153]	[-5.214]
D[LnGP(-1)]	0.1307	-0.0399	0.0029	0.3458	-0.0009	0.0459	0.1326*
	(0.077)	(0.021)	(0.012)	(0.271)	(0.007)	(0.079)	(0.052)
	[1.680]	[-1.826]	[0.231]	[1.272]	[-0.129]	[0.579]	[2.513]
D[LnIIP(-1)]	0.1322	-0.0727	-0.0556*	0.6028	0.0169	0.0740	-0.7351*
	(0.136)	(0.038)	(0.022)	(0.476)	(0.012)	(0.138)	(0.092)
	[0.970]	[-1.898]	[-2.479]	[1.266]	[1.333]	[0.532]	[-7.952]
C	0.0007	0.0014	0.0130*	-0.0626	0.0004	0.0104	0.0214*
	(0.009)	(0.002)	(0.001)	(0.033)	(0.000)	(0.009)	(0.006)
	[0.080]	[0.534]	[8.168]	[-1.850]	[0.477]	[1.059]	[3.268]

Source: Authors' computation

Notes: SEs are in ( ) while t-values are in [ ].

**Denotes significance at the 5% level.*

The long-run relationship between the variables is investigated by employing Johansen Co-integration test. However, before applying the Johansen Co-integration test, appropriate lag length is required to be selected. There are various methods for the selection of appropriate lag length; the present study used Akaike information criterion to select the lag length and the details are summarised in Table 3. We have selected two lags as suggested by Akaike information criterion and Hannan-Quinn information criterion. The Johansen Co-integration test uses λ_{trace} and λ_{max} statistics to test for the number of co-integrating vectors. The summary of the results for both the test statistics is presented in Table 4. The λ_{trace} test statistics identified seven co-integrating vectors, while λ_{max} test statistics identified three co-integrating vectors. Thus, the presence of co-integrating vectors indicates the existence of long-run equilibrium relationship between the macroeconomic variables and stock prices.

We normalised one co-integrating vector on stock prices (see Table 5) and found a significant negative relationship with exchange rate. The negative relationship between exchange rate and stock prices were reported by Najef *et al.* (2015) and Meike (2016). On the contrary, Mukherjee and Naka (1995) and Sohail and Hussain (2009) found a positive linkage between exchange rate and stock prices. However, it is important to note that a firm's stock price response towards the movements in exchange rate depends on the nature of the firm. The relationship between gold prices and stock prices in India is found to be negative, which indicates that investors who foresee a bearish market, take a position in gold futures to safeguard their investments. The negative relationship between gold prices and stock prices has been supported by the findings of Ray (2012).

Surprisingly, the present study found a significant negative relationship between the index of industrial production and stock prices in India. This result is inconsistent with the findings of Mukherjee and Naka (1995), Soenen and Johnson (2001), Humpe and Macmillan (2009) and Hussainey and Ngoc (2009), who found a positive relationship indicating that growth in industrial production increases the earnings of the firms which, in turn, increases the present value of the firm and thereby increases the stock price. The positive relationship between inflation and stock prices suggests that investment in equity is perceived as a hedge against inflation. The positive relationship between inflation and stock prices is supported by the findings of Al-Shami and Ibrahim (2013), Ogunmuyiwa and Okuneya (2014), Shrestha and Subedi (2014) and Zare (2017), but inconsistent with the findings of Pal and Mittal (2011). The interest rate has a negative effect on stock prices in India in the long run. The negative relationship between the variables is due to the fact that as the interest rate increases, the cost of borrowing funds from banks also increases, thus, limiting the amount of funds borrowed. Limited borrowing will eventually lead to less business spending, which will slow the growth of a company. This sequence of events may result in reduced earnings for firms, which adversely affects stock prices. The study also found that money supply (although positive) is not significantly related to stock prices. Figure 2 shows the long-run relationship between the Indian stock prices and selected macroeconomic variables. The figure indicates that the relationship fluctuates and is highly volatile.

The error correction term tells us the speed at which our model returns to equilibrium. The error correction coefficient should be negative indicating that our model returns to equilibrium after an exogenous shock. From Table 6, it can be seen that the sign of the error correction coefficient in determination of LnNIFTY is negative (-0.0236) and the t-value (-3.373) is statistically significant at the 5% level. The size of the coefficient of the error correction term in the present study signifies that 2.36% of the disequilibrium in the long-run relationship is corrected every month as the stock market index settles back into its equilibrium. Analysing the output of VECM summarised in Table 6, it can be concluded that volatility in INR/USD exchange rate and changes in short-term interest rate affect the Indian stock prices in the short-run.

Figure 2 Long-run relationship between the Indian stock prices and selected macroeconomic variables

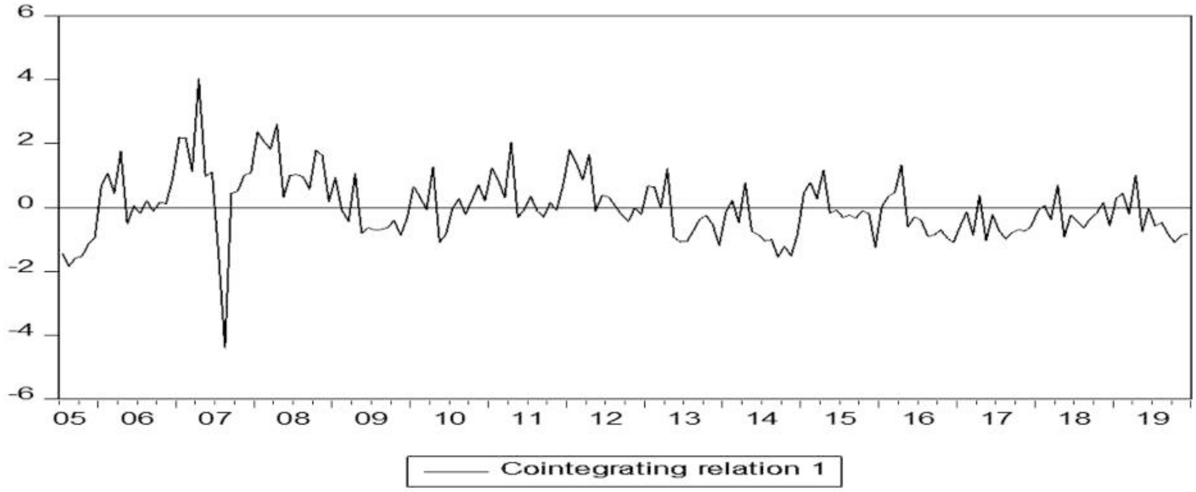

Table 7 Results of Pairwise Granger Causality Test-2 Lags (Log Differenced Series)

Null Hypothesis:	Obs	F-Statistic	Prob.	Decision
DEXR does not Granger Cause DSP	175	8.51979	0.0003	Reject*
DSP does not Granger Cause DEXR	175	4.58735	0.0115	Reject**
DMS does not Granger Cause DSP	175	3.18670	0.0438	Reject**
DSP does not Granger Cause DMS	175	0.13939	0.8700	Accept
DINT does not Granger Cause DSP	175	2.78658	0.0644	Reject***
DSP does not Granger Cause DINT	175	0.72302	0.4868	Accept
DINF does not Granger Cause DSP	175	1.54413	0.2165	Accept
DSP does not Granger Cause DINF	175	0.95168	0.3881	Accept
DGP does not Granger Cause DSP	175	0.94461	0.3909	Accept
DSP does not Granger Cause DGP	175	0.52811	0.5907	Accept
DIIP does not Granger Cause DSP	175	0.49529	0.6103	Accept
DSP does not Granger Cause DIIP	175	6.25205	0.0024	Reject*

Source: Authors' computation

*Note: * denotes significance at 1% level, ** denotes significance at 5% level and *** denotes significance at 10% level*

Pairwise Granger Causality test is employed to investigate the short-run causal relationship between the selected variables. The results of the pairwise Granger Causality test are presented in Table 7. From the table, it can be observed that bidirectional causality exists between INR/USD exchange rate and stock prices in India. A unidirectional causality is seen between money supply and stock prices; the causality flows from money supply to stock prices. The results also show evidence of a unidirectional causality between short-term interest rate and stock prices, and the causality flows from interest rate to stock prices. Further, stock prices granger causes industrial production. From the causality analysis, it can be concluded that INR/USD exchange rate, money supply and short-term interest rate are helpful in forecasting stock prices in India. Inflation and gold price do not show the ability of forecasting the stock prices.

Table 8 Variance decomposition

VDC of	Months	DSP	DEXR	DMS	DINT	DINF	DGP	DIIP
DSP	1	100.00	0.00	0.00	0.00	0.00	0.00	0.00
	6	94.05	0.91	1.08	2.02	0.42	1.09	0.40
	12	94.79	0.63	1.13	1.75	0.33	1.05	0.29
	24	95.31	0.42	1.15	1.61	0.28	1.03	0.17
DEXR	1	17.43	82.56	0.00	0.00	0.00	0.00	0.00
	6	19.05	76.89	0.25	1.70	0.21	1.27	0.59
	12	18.11	78.04	0.18	1.60	0.22	1.18	0.63
	24	17.47	78.76	0.15	1.57	0.21	1.15	0.65
DMS	1	0.68	2.67	96.63	0.00	0.00	0.00	0.00
	6	7.37	3.86	67.29	0.27	2.19	1.55	17.43
	12	10.21	4.27	57.81	0.28	2.28	1.19	23.93
	24	13.08	4.75	48.54	0.29	2.41	0.85	30.05
DINT	1	0.63	1.77	0.00	97.58	0.00	0.00	0.00
	6	1.09	3.08	0.61	93.65	0.08	0.41	1.05
	12	1.03	3.39	0.71	93.44	0.06	0.26	1.07
	24	0.97	3.59	0.78	93.43	0.04	0.14	1.01
DINF	1	1.17	5.35	0.07	0.01	93.37	0.00	0.00
	6	1.40	8.22	0.89	0.33	87.96	0.26	0.89
	12	1.48	8.30	0.59	0.22	88.69	0.16	0.52
	24	1.53	8.47	0.40	0.16	89.04	0.09	0.29
DGP	1	0.19	0.06	0.34	0.00	1.32	98.06	0.00
	6	1.88	2.27	5.95	0.17	0.77	87.87	1.06

Source: Authors' computation

Variance decomposition (VDC) is important as it helps to determine the significance of each variable in generating fluctuations in other variables. The results of VDC are summarised in Table 8. The findings indicate that stock prices in India are relatively exogenous in relation to other macroeconomic variables since 95.31% of its variance is explained by its own shock even after a period of 24 months. Among the selected macroeconomic variables, short-term interest rate presents the highest participation in the stock market shocks, and in the 24th month, it can explain 1.61% of the variances in stock prices.

The VDC of exchange rate reveals that after 24 months, 78.76% of the variance is explained by its own shock. Further, stock prices can explain 17.47% of the variances in INR/USD exchange rate. The VDC of money supply indicates that in the 1st month, 96.63% of its own variance is explained by its own shock. However, the shock of money supply to shock on money supply fades away overtime. After 24 months, more than 50% of its own shock is explained by innovation in other macroeconomic variables. A similar observation is made in case of IIP. The VDC of IIP revealed that IIP accounts for 91.93% of its own shocks in the 1st month and the shock of IIP to shock on IIP slowly fades over time. In the 6th, 12th and 24th month, stock prices explain greater percentage of variability in IIP as compared to other macroeconomic variables. The results of VDC further suggested that short-term interest rate, inflation and gold prices are also more exogenous.

Concluding Remarks

The present paper examines the long-run relationship between Indian stock market and selected macroeconomic variables (INR/USD exchange rate, money supply, short-term interest rate, inflation, gold price and industrial production). The multivariate Johansen Co-integration test identified seven co-integrating vectors suggesting that a long-run equilibrium relationship exists between Indian stock market and macroeconomic variables. Further, in the long-run, Indian stock market negatively reacts to exchange rate, gold price, index of industrial production and interest rate while money supply (although insignificant) and inflation are positively related to Indian stock market movements. In the study, it was established that in the short-run, INR/USD exchange rate and short-term interest rate influence the stock prices in India.

The output of the pairwise Granger Causality test indicated that exchange rate has a feedback relationship with the Indian stock market. Further, the results also suggest that money supply and interest rate granger cause stock prices. In other words, INR/USD exchange rate, money supply and short-term interest rate are helpful in predicting the Indian stock market movements.

There exists evidence from the variance decomposition that the macroeconomic variables and interest rate can explain only 1.61% of the variance in stock prices after 24 months, and the findings suggested that the Indian stock prices are exogenous. However, the presence of co-integration (as suggested by Johansen Co-integration test) and the causality indicates that the Indian stock market does not seem to be efficient. As such, volatility in the stock prices in future can be forecasted by the information provided by the selected macroeconomic fundamentals.

The study has two limitations, *First*, the present study does not have a long time period. Technically, co-integrating analysis requires at least 30 years of data. Second, the present study did not consider long-term interest rate. Therefore, researchers can extend the study by considering a longer time frame and also include other macroeconomic variables in their future endeavours.

Applicability and Generalizability

The findings of the study can be applied and generalised to various transitioning and emerging economies. Private equity investors and mutual fund managers can take appropriate decisions regarding their investments. The key findings of the present study will also be helpful to policymakers and regulators.

The long-run relationship between the exchange rate and Indian stock prices is found to be negative, which implies that the government should take proper measures to strengthen the Indian currency in order to ensure the performance of the Indian stock market. The negative relationship between gold prices and Indian stock prices implies that when the stock market sees a bearish trend, investors invest in gold in order to safeguard their investments. The sign of the long-run co-integrating coefficient of interest rate is negative, which suggests that interest rate affects the borrowing capacity of firms and the central bank of India can use the interest rate as an effective monetary instrument.

Data Source

Data relating to Indian stock prices is obtained from the official website of National Stock Exchange while data for exchange rate, money supply, short-term interest rate, inflation and index of industrial production are sourced from the website of Reserve Bank of India. The monthly observations of gold prices are collected from the website of World Gold Council.

Declaration of Conflict of Interest

The authors declare no potential conflict of interest with respect to the research, authorship, and publication of this article.

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