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Indian Implied Volatility Index: A Macroeconomic Study

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Abstract

The study investigates the dynamic behavior of Indian implied volatility index and its time dependent conditional correlations with selected macroeconomic variables. The volatility of macroeconomic variables is likely to put burden on inflation and also influence the economic decisions as investment vehicles. Thus, the volatility of these variables has become central issue for fund managers and investors. The study uses three macroeconomic variables, oil price, gold price and federal fund rate over the period 2nd March 2009 to 30th June 2018. The Dynamic Regime-Switching model reveals that the Indian Implied volatility index exhibits two regimes high volatility and low volatility states. There exists a high degree of synchronicity between Indian VIX and oil price movement. Oil price has significant impact on India VIX during high volatile state. The result alarms the attention of monetary policy makers. The policy of oil price deregulation has to be carefully monitored.

Keywords: implied volatility index, dynamic regime-switching model, conditional correlations, macroeconomic variables.

1. Introduction

Uncertainty in the macroeconomic environment influences the actions taken by the individuals, firms and policy makers. The macroeconomic uncertainty is resulting to low investments, savings and spending. The macroeconomic uncertainty impacts the financial markets in two ways; one way it has a direct bearing on real economy through inflation rate, output growth and price changes, on the other way, it influences the economic agent's beliefs about the future returns. A study by Dixit and Pindyck (1994) mentioned the influence of macroeconomic variables uncertainty on economic agent's investment decisions. At the macroeconomic level, investors pay attention to commodity prices changes because they are likely to put the burden on inflation and also influence the economic decisions as investment vehicles. The volatility of the commodity prices thus become the central issue for the global economy.

Oil and gold are two major commodities that invite lot of attention from risk managers, investors and academic researchers. At any given point of time, the volatility of these commodities can be driven by three important factors. These factors are (i) demand supply shock (ii) an increased sensitivity of the commodity prices to the demand supply shocks and (iii) use of commodities as the financial asset.

Other variable of interest for investors and risk managers is dollar rate. As it is a major currency reserve, change in the dollar rate influences the emerging markets and its asset price volatility. From the theoretical perspective, an increase in the federal fund rate could increase debt repayment burden on emerging markets. In addition to this country specific fundamental, it also affects capital flows and asset prices and thus investment decisions.

The relation between macroeconomic fundamentals and investor's investment decisions is intuitively appealing, given the importance of macroeconomic variables in determining the investor's investment decision on equity markets. Understanding the impact of global macroeconomic variables on investor's expectations about the future returns and its spillover effects to real economy would be worthwhile if policy makers hope to frame the policies to ensure the stable financial markets and sustainable growth.

A study by Srinivasan (2017) attempted to understand the effect of scheduled macroeconomic announcement on Indian implied volatility by using EGARCH and OLS models. The study results found that the scheduled macroeconomic announcements and information content does not have any significant impact on Indian Implied volatility

Heejoon Han, Ali M. Kutan, and Doojin Ryu (2015) examined the ability of macroeconomic and financial variables in forecasting the Korea's implied volatility index (VKOSPI) using augmented heterogenous autoregressive models (HAR) with exogenous variables. The study found that the change in Korea's macroeconomic variables has significant impact

on VKOSPI. The study concluded macroeconomic variables pay a key role in explaining the changes in VKOSPI over stock returns. Ghorbel, A., Mouna, A. B., & Boujelbene, Y. (2014) conducted a study to understand the behavioral explanation of contagion between oil price and stock market returns, the study found that there is a sharp increase in the time-varying conditional correlations between stock returns and oil prices during the oil price volatility. Imlak and Padhi (2013) examined the impact of scheduled macroeconomic announcements on the implied volatility of emerging markets. The study results found that the announcement relating to monetary policy, employment rate , the industrial output and GDP is found to be statistically significant.

An empirical study by Badshah., Frijns., & Tourani-Rad (2013) found a strong unidirectional spillover from volatility index (hereafter, VIX) to gold index and exchange rate, which shows a change in VIX leads to change in gold and exchange rate volatility. Cohen & Qadan(2010) found a unidirectional causal relation between gold price and VIX , which shows that the hike in gold price increases the market volatility during the turmoil periods. This supports the general economic principle that the investors shift from the high risky assets to low risky assets during the economic contraction periods.

Baba & Sakurai (2011) examined the role of macroeconomic variables as indicators of regime shifts in VIX index. The regime switching model found three distinct regimes in the VIX namely: low volatility period is tranquil regime, high volatility period as turmoil and extremely high volatility period crisis regime.

Baba & Sakurai (2011) found that the long term and short term government interest rates play a significant role while transmitting the index from tranquil to turmoil regime. The other category of research studies concentrated on the effect of macroeconomic announcement date on the market volatility. Füss,Mager, Wohlenberg& Zhao (2011), Vähämaa& Äijö(2011) found significant fall in the stock prices and stock index during macroeconomic announcement dates and the effect is even more during the crises period. These empirical results also suggested that the positive target rate surprise and unscheduled policy actions are causing greater volatility. Clements (2007) found that the stock market volatility increases during the Federal open market meeting dates.

The empirical studies on the relation between stock market volatility and global macroeconomic variables can be divided into two categories. The first set of studies focused on stock market volatility and commodity prices and the other category focused on US monitory policy changes and impact on emerging markets. But there is no attempt made to understand macroeconomic variables' dynamic relation with the Indian implied volatility index. Hence, this paper aims to understand the dynamic relation between macroeconomic variables with the Indian Implied volatility index regime switching behavior.

2. Data and Methodology

The chosen sample has been taken keeping in view that the growing importance of Indian economy in equity investment. After the global financial crisis and Eurozone uncertainty, global investors are looking at India as an alternative investment hub. So, the study focuses on Indian Implied volatility index and its time dependent relation with other macroeconomic variables. Macroeconomic variables selected for the study are Oil, gold and Federal interest rate.

The sample data spans from 02nd March 2009 to 30th June 2018 because Indian Implied volatility index data is available only from 2nd March 2009. This study employs low-frequency data, i.e., daily data. High-frequency data may obscure the identification of regimes information about the implied volatility index.

Markov Switching Dynamic Regression Model

Hamilton (1990) proposed Markov switching model. It is also known as regime switching model. This model involves multiple equations which characterize the time series behavior in different regimes of the selected variable. This model captures more complex dynamics of the variables by allowing them to switch between these regimes. In this model switching behavior is controlled by an unobservable state variable which follows first-order Markov chain process and it is suitable for explaining correlated data that exhibits dissimilar dynamic patterns during various time periods.

$$\text{State 1: } y_t = \mu_1 + \varepsilon_t \quad (1)$$

$$\text{State 2: } y_t = \mu_2 + \varepsilon_t \quad (2)$$

Where, μ_1, μ_2 are the intercepts of state1 and state 2 respectively and ε_t is the white noise term with variance σ^2. If the s_t is the timing of switches then the equations is expressed as follows:

$$y_t = s_t\mu_1 + (1 - s_t)\mu_2 + \varepsilon_t \quad (3)$$

Where, s_t is 1 if the process state is one other wise 2. It is difficult to infer the process state by knowing the intercept. Markov switching model allows the parameters to change the states. Markov-switching dynamic regression model with state dependent intercept is expressed as follows:

$$y_t = \mu_{st} + \varepsilon_t \quad (4)$$

If s_t =1, then $\mu_{st} = \mu_1$, if s_t =2, then $\mu_{st} = \mu_2$, where μ_{st} is an intercept parameter. In Markov switching regression the transition probabilities are of greatest interest and it can be expressed as $p_{s, s+1.}$ In two states process, P_{11} denotes the probability of remaining in state 1 in the next period, given that the state is 1 at current period. If the value is close to 1 then it is expected to stay in state 1 for a long time or process is said to be persistent.

Markov-Switching Dynamic Regression with exogenous variables is expressed as follows:

$$y_t = \mu_{st} + X_t\alpha + Z_t\beta_{st} + \varepsilon_s \quad (5)$$

Where, μ_{st} is a time dependent intercept, y_t is a dependent variable, X_t is a vector of exogenous variables with state invariant parameter α, Z_t is a vector of exogenous variable with state dependent variable β_{st}. Here X_t *and* Z_t can include lag of dependent variable y_t. The error term, ε_s is independent and identically distributed with mean zero and error variance, σ^2.

Transition probability from one state to other can be expressed in K x K matrix

$$P = \begin{bmatrix} p_{11} & \cdots & p_{1k} \\ \vdots & \ddots & \vdots \\ p_{1k} & \cdots & p_{kk} \end{bmatrix}$$

The probability of the state s_t is equal to j, where j= {1,…,k-1}, is dependent on the most recent realized value of s_{t-1} and can be express as

$\Pr(s_t = j \mid s_{t-1} = i) = p_{ij}$

P is non-negative and some of each column equal to 1.

$$p_{ij} = \frac{\exp(-q_{ij})}{1 + \exp(-q_{i1}) + \cdots + \exp(-q_{ij})}$$

$$p_{ik} = \frac{1}{1 + \exp(-q_{i1}) + \cdots + \exp(-q_{ij})}$$

Where j ϵ (1,…, k-1) and transmitted parameter q can be computed as

$$q_{ij} = -\left(\frac{p_{ij}}{p_{ik}}\right)$$

3. Empirical Results and Analysis

The empirical analysis employed three macroeconomic variables, oil, gold and federal interest rate to understand the linkage between macroeconomic variables and the Indian implied volatility index. The time series plots of these indices are presented in Figure 1. Most of these variables indicate major upheavals between January 2011 and June 2012, confirming the co-movement across the variables. The graphical representation further confirms the non-linearity with very high jumps and halts during the study period. Both these inferences confirm the application of Markov dynamic regression model on the implied volatility index and macroeconomic variables. In the application of Markov regression model, common difficulty is identifying the correct number of states. The existing literature on emerging economies and volatility studies (Baba, N., & Sakurai, Y. (2011), Di Persio, L., & Vettori, S. (2014)) support three regimes, bull, bear and recession. The estimates of Markov Dynamic Regression model with three states for Indian VIX has convergence problem. So, the study reports the existence of only two regimes under mean and variance switching model and results support Marabel Romo,J.(2001) and Chen(2009) bivariate Markov regime model. The estimates of Markov dynamic regression with two regime results are presented in Table 1 . The Markov regime switching results are estimated by using expectations-maximization algorithm. The results in Table 1 reveal the information about the regimes transition probabilities and its persistence.

The state 1 is associated with higher mean, 4.83 compared to state two, 0.413. The standard deviation of state 1 is 2.038 and that of is 0.725, which indicates that state 2 is less risky regime compared to the first state. These distinctions are crucial to understand that state 1 as highly volatile compared to state 2. The Volatility is high during stock market fall and vice versa. So, the state 1 represents a bear market situation and the state 2 is a bull market situation. The two states dynamic regression model exhibits dissimilar dynamics across unobserved regimes using state dependent variables. The estimated coefficients on lagged dependent variable in both the regimes are statistically significant and positive indicating that the today's low (high) volatility could be one of the reasons for the probability to continue the same low (high) volatile state tomorrow. The results suggest that oil is the only macroeconomic variable that affecting the Indian Implied volatility index significantly and positively during the high volatile state. The rest of the macroeconomic variables gold and federal rate do not have any impact on the Indian implied volatility index during the low volatility state, i.e the bear regime.

To summarize the results, preceding Indian implied volatility index is the only variable significantly correlated with the bull and bear market conditions. But in high volatility state, oil prices and the Indian implied volatility index are moving together. This indicates that during the market turmoil state, adding oil as asset class to the portfolio may not help in risk diversification. Turning to the regime switching probabilities, the P11 is the estimated probability that the Indian implied volatility index to stay in state 1 for the next period and the process is in state 1 in the current period. The estimated value of 0.93 indicates that state 1 is highly persistent. P21 indicates that the probability of shifting to state 1 from state 2 and the estimate is 0.03. P12 is the estimated probability that the Indian implied volatility index shift to state 2 from the current state, ie., state 1. The estimated probability value is 0.07. P22 is the estimated probability of Indian implied volatility index to continue in state 2 in the next period and the estimated value is 0.97, which infers that the state 2 is also highly persistent.

The expected average stay in each of the states also estimated. The bull or less volatile state will continue for 36 days, which is more than one month and then market shifts to bear or highly volatile state, and will continue in that state for 15 days. Both the states are highly persistent. This indicates that the emerging market investors buy and hold till they perceive that the market is going to move adverse conditions. The study results are supporting the findings of

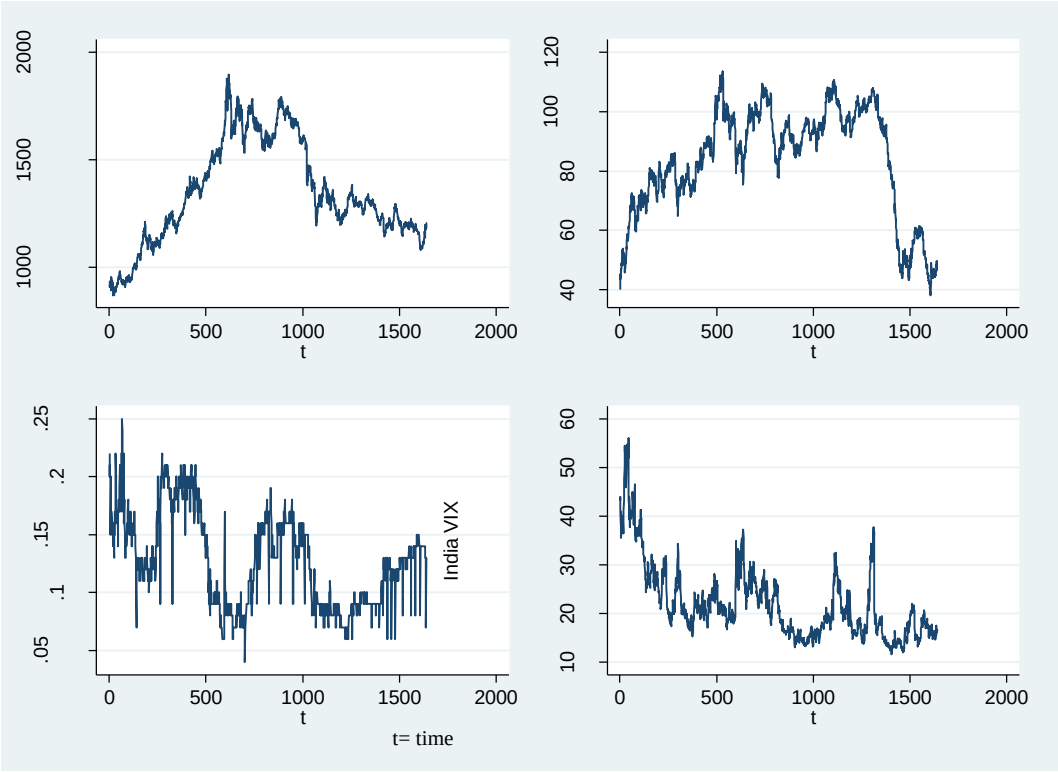

Figure 1. Time series plots for selected macroeconomic variables and Indian Implied Volatility Index.

Table 1. Markov dynamic regression estimated results using Expectation-Maximization algorithm.

	State 1			State 2		
Variable	Coefficient	Standard error	P value	Coefficient	Standard error	P value
India VIX L1	.9298181	.0178463	0.0000	. 9724104	. 0088488	0.000
Gold	-.0003247	.0004738	0.493	. 0000272	. 0001515	0.857
Oil	-.020642	.010199	0.043	. 0003394	. 001764	0.847
FedRate	-1.515553	2.89552	0.601	-.1402048	. 7185988	0.845
Mean	4.483855	1.630461	0.006	4129591	2285754	0.071
sigma1/ sigma2	2.038935	. 0939694		.7249964	.0238301	
p11	.9341868	.0222484				
P12	.0658132	.0222484				
P21	.0274903	.0080877				
P22	.9725097	.0080877				
State 1 (expected duration in days)	15.19452	5.136554				
State 2 (expected duration in days)	36.37651	10.70207				

*Shows the level of significance 5% and better.

The Figure 2 presents the predicted values of the states one and two. These predictions are one-step a head probabilities and weighted average state specific predictions.

The state 1 predicted value is slightly higher than that of state 2 predicted value, which confirms state 2 is a low volatile state.

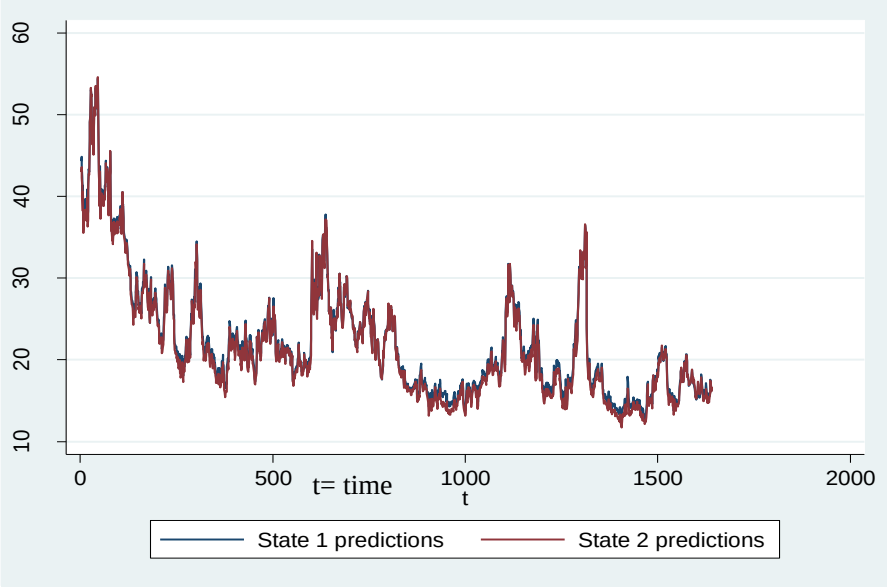

Figure 2. Comparison between the state1 and state 2 one-step ahead predicted values

Figure 3 represents the model fitness by comparing fitted values of Indian implied volatility index, residuals and actual values. Figure 4 presents the actual values of Indian VIX and its one-step ahead predicted values. Both the figures represent the good model fit.

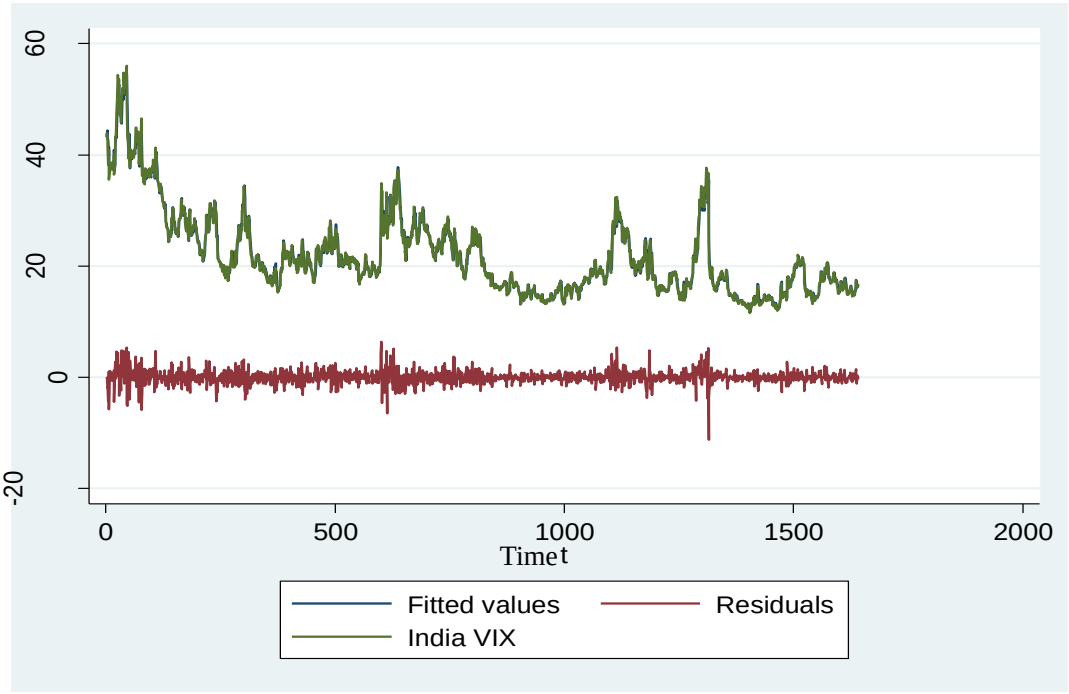

Figure 3. Model fitness by comparing fitted values of IVIX, residuals and Actual values of Indian implied volatility index.

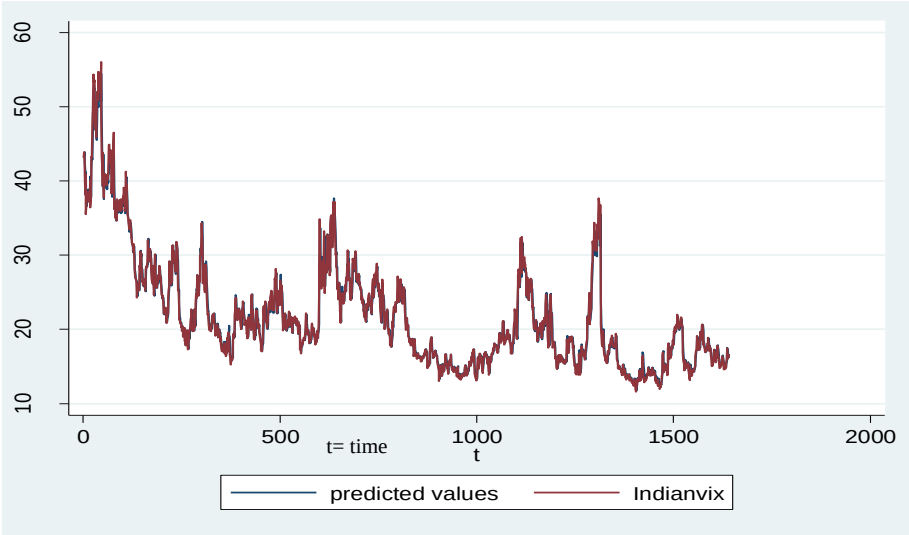

Figure 4. Indian VIX and its one-step a head predicted values.

The smoothed probabilities are estimated to understand the turning probabilities of the Indian implied volatility index, Figure 5 presented below.

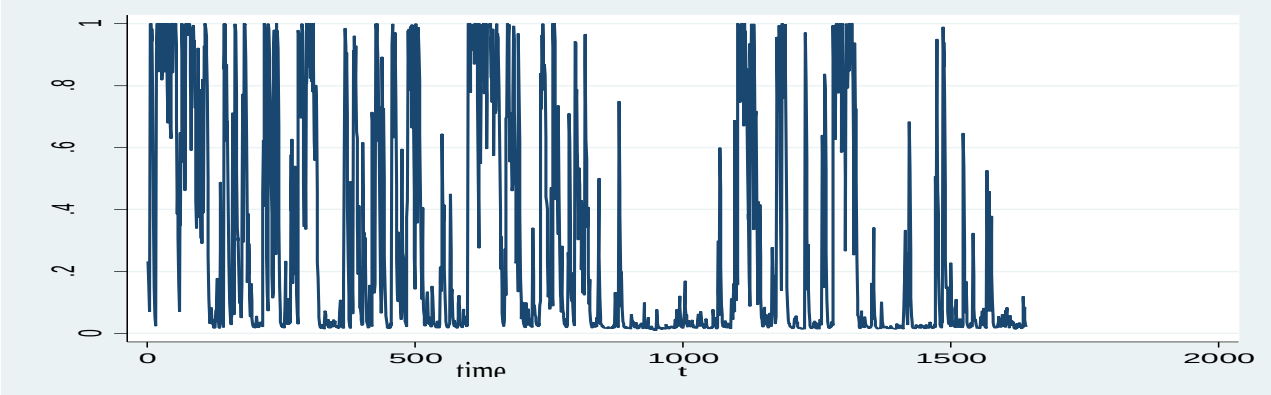

Figure 5. Predicted state turning probabilities

4. Summary and Conclusions

The study aims at modeling Indian Implied volatility index regime switching behavior and determines the state dependent time varying correlations with macroeconomic variables. The results found evidence of regime switching behavior of Indian implied volatility index and being characterized by two states during study period, i.e. 2nd March 2009 to 30th June 2018. There exists a high degree of synchronicity between Indian VIX and oil price movement. The study results show a sharp rise in the time-varying conditional correlations between the implied volatility and oil prices during the high volatility state. Which provide strong evidence of investors' herding behavior. Rapid or sharp change in the oil price can have massive effect on companies' profits and economic growth. The oil price hike can erase the government's budget, it alters geopolitical priorities and prompt whole economic reforms. These are the few reasons for the herding behavior of investors during oil price volatility.

The interaction effect between Indian VIX and oil price is less during the low volatility state. The results support that the interaction effect is less during bull market conditions with any of the selected macroeconomic variables and this state is highly persistent.

The interaction of oil price volatility with Indian stock market alarms the monetary policy attention. The policy of oil price deregulation has to be carefully monitored. The policy makers have to take corrective measures to minimize the stock market's volatility during the oil price uncertainty. The study results provide insights regarding portfolio diversification strategies across stock market volatility and macroeconomic fluctuations during high volatility regime and low volatility regime. Investors should be conscious towards the time-varying conditional correlations between implied volatility and macroeconomic variables which are key determinants for the portfolio returns.

Further research on policy intervention and international policy coordination will help the investors, risk managers and volatility traders to take make use of opportunity behind the volatility dynamics to maximize the portfolio returns.

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