# VOLATILITY INFORMED TRADING IN THE OPTIONS MARKET: EVIDENCE FROM INDIA

**Rajesh PATHAK**

*Department of Finance and Accounting, IBS-Hyderabad, IFHE, Dontanpally, RR District,*
*Telangana 501203, India*
*E-mail: rpathak@ibsindia.org*

**Abstract.** The purpose of this paper is to investigate the trading activity in options market based on information about expected future volatility in spot market. We employ Common Implied Volatility as a measure of expected volatility and options volume and changes in Open Interests as measures of options trading activity. We first test for simultaneous information flow in the two markets using multiple regression technique. Next, we test for information based or hedge based use of options using Trivariate Vector-auto Regression framework. We further consider the classes of options moneyness and the market trends in our analysis to examine if the trader's preference of options changes with change in description of options intrinsic value and market environment. We use daily closing data of S&P CNX Nifty Index options traded on National Stock Exchange, India. We, for the most part, find negative and significant relationship in contemporaneous regression suggesting active trading by arbitrageurs. A feedback relationship is observed in vector auto regression analysis suggesting that options are traded in India for both information based trading and hedging purposes. We also observe the relationship to be varying when market trends and classes of options moneyness are considered. This indicates that traders are not indifferent in their choice of trading venue when market conditions and factors change. The results of this study are helpful for traders in managing the risk and return of their portfolio based on volatility forecast. This study is distinctive as it examines the scarcely researched area of volatility informed trading in an emerging market set up.

**Keywords:** options, volatility, informed trading, moneyness, volume, open-interest, hedging, arbitrage.

**JEL Classification:** G1.

## Introduction

While financial theory has well emphasized the role of derivatives in trading a gamut of risks in financial markets (such as equity risk, exchange rate risk, interest rate risk, and credit risk), their role as a vehicle to trade on information has emerged as an additional economic function in empirical financial research. Market microstructure theory suggests that, price movements are largely caused by the arrival of new information and their incorporation into market prices through trading. A sizeable literature[1] have

documented the use of derivatives on directional information and their role in predicting future price movements but, the corresponding issue of trading of derivatives based on non-directional information, like information about future volatility, remains to be examined in literature in detail. Since volatility forecast is central in finance due to its use in pricing of derivatives as well as for financial activities like portfolio selection and asset management, a study on volatility informed trading of derivatives becomes essential.

The theory of options pricing is unclear about the exact nature of volume-volatility relationship (Sarwar 2005). Black (1975) argues that informed traders may be attracted towards options due to the economic benefits like lower transaction cost and higher leverage associated with trading

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[1] (Bhattacharya 1987; Stephen and Whaley 1990; Chan *et al.* 1993; Easley *et al.* 1998; Chan *et al.* 2002; Chakravarty *et al.* 2004; Chen *et al.* 2005; Chang *et al.* 2010; Pan and Poteshman 2006)

options. As a result, the option trades may be informative about future price volatility due to the fact that pricing options requires volatility as an input parameter. Conversely, researchers also argue the hedge related use of options arising due to asset's price volatility, which may cause option trading to follow the price volatility. This study examines the relationship between implied volatility and the trading activity of options to understand the kind of use options have in the Indian market and thus contributes to the literature on the price discovery function of derivatives.

Options are securities with non-linear payoff structure. As a result, a volatility informed trader can only bet on his information in options market (unlike a trader with directional information who, besides options, can also trade stocks or futures). Lack of empirical proof of this fact stimulates us to conduct this study. Moreover, as the focus of microstructure literature has been on intraday pattern rather than inter-day dynamics, studies using publically available data with daily frequency are very sparse. Besides, a large number of small traders who are unable to incur the cost to access private information trade mostly on freely available information. Thus, a study investigating the volatility related information contained in options trading using publically available daily data is imperative. It would benefit the traders at large in maximizing their payoffs. The data of S&P CNX Nifty index options traded on National Stock Exchange (NSE), India is employed for this study. This study, to the best of our knowledge, is the first to address the issue of volatility informed trading of options in Indian market.

Our study period i.e. January 2004 – December 2011, is considerably longer period compared to that of the existing studies and includes years of up, down, and recovery trends in the market. Derivatives are popular instrument to trade on negative news due to short selling restrictions in spot market. Moreover, options in different moneyness categories offer different leverage and liquidity and they also have different future volatility estimates (Shaikh, Padhi 2014). These factors may have implications for participants in the market as it can significantly affect their payoffs. Thus, we consider market trends and option's moneyness classes in our analysis to uncover a particular trend or moneyness class (if any) which is preferred by informed traders or hedgers.

The next section presents a brief literature review. Section 3 highlights the objective of the study and section 4 discusses, in detail, the data and methodology used for this study. Section 5 presents the empirical results of the study and section 6 concludes it.

## 1. Literature review

Latane and Rendleman (1975) are the first to examine the information content of implied volatility about option prices. As the sensitivity of option contracts across series of options vary, they employ weighted implied standard deviation (WISD) as a measure of market forecast of return variability (computed by weighting the implied volatility of series of options on a given day by sensitivity of option price to implied volatility). They use options data of 24 companies listed on Chicago Board of Options Exchange (CBOE) and address three main objectives in the study. First, they study the usefulness of WISD in identifying over or under priced options and thereby reducing risk in hedge positions. Secondly they examine relationship between WISD and ex-post volatility and further they test the stability of the cross sectional average of WISD. They report the following results. The portfolio based on WISD price projections produces significant abnormal returns, which confirms the usefulness of WISD in determining proper hedge positions and identifying over and under priced options. They report significant correlation between WISD and ex-post volatility, which proves WISD as a better estimate of future volatility. Regarding the stability of cross sectional average of WISD they report strong tendency of volatility to move together with time.

Chiras and Manaster (1978) compare the predictability of historical volatility and weighted implied volatility for future stock returns variance. They report that options implied volatility is a better predictor of realized stock returns volatility. Beckers (1981) studies the predictive accuracy of implied standard deviation (ISD) for future price variability and finds that option implicit standard deviation is an efficient measure of future price variability. However, Canina and Figlewski (1993) study the S&P 100 Index options for the period March 15, 1983 to March 28, 1987 and document that implied volatility (IV) computed using Black-Scholes options pricing formula is inefficient, biased and inferior estimate of market's future volatility forecast, when compared to historical volatility.

Chen, Cuny and Haugen (1995) study the relationship between stock volatility, *basis* [2] and open interests in futures market using S&P 500 Index. They base their study on the intuition that when volatility increases in the market, investors prefer to entice more people in the market for risk sharing. Those investors reduce their risk exposure not only by selling their stock upholding alone but also by selling related futures contract. Such activity may result in decreasing basis and increasing open interest due to enhanced participation into the market. They find that increase in expected volatility results in decrease in basis and increase in open interest.

Kyriacou and Sarno (1999) have examined the dynamic relationship between derivatives trading and volatility of the underlying asset using daily data of FTSE 100 Index, its futures and options. The trading activity is measured by daily futures and options volume standardized by open interest

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[2]   They define *basis* as the difference between the market futures price and fair futures price where fair futures price is cash price index grossed up by risk free rate and adjusted for expected dividends.

whereas cash index volatility is estimated alternatively by adjusted daily price changes, daily price changes, squared return and GARCH(1,1). They follow Koch (1993) and use simultaneous equation model to examine the relationship as opposed to vector-auto regression, which does not allow for simultaneity and possibly can cause misspecification problems. They report that expected future volatility, futures volume and options volume are determined in a system of equations that allows for both simultaneity and feedback.

Mayhew and Stivers (2003) study the information content of implied volatility about firm level volatility using options on 50 most highly traded stocks listed on CBOE during 1988–1995. They report that for most actively traded options the implied volatility subsumes almost all information about firm level volatility. However, results of this study are biased towards actively traded stocks and cannot be generalized. Sarwar (2005) studies the relationship between expected future volatility of S&P 500 Index and aggregate options volume. He conducts the study separately for call and put options and for moneyness classes. He, for the most part, reports strong feedback relationship between the options volume and expected future volatility, however results for at-the-money (ATM) and out-of-the money (OTM) options are found to be more pronounced.

Ni, Pan and Poteshman (2008) study whether options volume is informative about future volatility of the underlying assets. Motivated by the unique characteristics of options market that it suits to volatility informed investors well, they conduct this study employing unique dataset of stock options trade provided by CBOE over the period of 1990 to 2001. They argue that if the option volume is informative about future stock volatility then non market maker net demand for volatility should be positively related with future stock volatility. They compute the non market maker demand for volatility by aggregate sum of net options volume (both call and put) weighted by options *vega*[3] across strike prices. They test the relationship using multiple regression framework where realized volatility (RV) is regressed against non market maker demand for volatility along with a set of control variables (lags of RV, lags of implied volatility, dummy for earning announcement date, stock volume and options volume). They report significant positive relationship between options non market maker demand for volatility and subsequent realized volatility. They further argue that some options market trades represent bets both on volatility and direction (for example, a naked call buyer benefits both from increasing stock price and increase in volatility) whereas other trades like *straddles*[4] are primarily bets only on volatility. If the predictability reported earlier

is due to informed volatility trading then the straddle type of trades should have stronger predictability. They conduct tests for the above argument by extracting the total options demand for straddle trade from total non market makers demand for options and find that demand, which is due to straddle trade, are strong predictor of volatility compared to demand that were not straddle trade.

Based on the literature review, we make the following observations. First, Implied volatility from options market is an efficient measure of expected price volatility and second, that linkage of option trading activity and expected volatility of underlying asset is not examined in detail. We examine the same issue using implied volatility as a measure of expected price volatility whereas daily number of contracts traded and changes in open interest measure trading activity in options market.

## 2. Objectives

The objectives of the study are as follows:
- To examine the dynamic relationship between options aggregate trading activity and expected future price volatility of the underlying asset.
- To examine if the classes of options moneyness and the market trends affect the direction and the strength of such relationship.

## 3. Data and methodology

We use options summary transaction data of S&P CNX Nifty index provided by NSE, India. The summary transaction data includes expiry date of the contracts, series of available exercise prices, type of options (Call/Put), daily Open, High, Low, Close and Settlement prices of Nifty index options, number of contracts traded, daily trading value (Rs. in Lakh), daily open-interests (OI) and daily changes in OI. We collect data for the period January 01, 2004 to December 31, 2011. We follow Sarwar (2005) and exclude the options with trading volume of less than 3 contracts and the expiry day transaction data. The Nifty index options are European during the period of study. We observe that other than long term index options (3 quarterly and 8 half yearly contracts), which trade rarely, NSE has three month trading cycles and accordingly three contracts namely near month, next month and far month contracts are available for trade at any point in time. We find that near month contracts are the most traded options and the volume starts shifting to next month contracts around the expiry week of the near month contract.

For this study, we consider all the options where number of contracts traded exceeds 3 irrespective of their maturities. On a given day, trading activity is measured alternatively by aggregating the number of contracts traded (hereafter referred as volume) and the changes in open interests (COI)

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[3] *Vega* shows the sensitivity of options prices to changes in the volatility of the underlying assets. Vega is most sensitive for at-the-money options.

[4] *Straddle* is an option trading strategy where a trader buys a call and sells a put with same strike price and maturity.

across strike prices and maturities. We compute common implied volatility (CIV) as a measure of expected future volatility by averaging the Black-Scholes implied volatility computed for series of options on a day weighted by the sensitivity of option price to implied volatility or options *vega*. We compute the common implied volatility and measures of trading activity i.e. volume and COI for call and put options separately.

To identify the market cycles we plot daily closing values of S&P CNX Nifty index against period of study. Based on the graph (Fig. 1) we segregate it into three periods namely *Uptrend* (January 01, 2004 to January 20, 2008), *Downtrend* (January 21, 2008 to May 17, 2009) and *Recovery* phase (May 18, 2009 to December, 2011). The break dates are selected after close observation of the index value and returns during the period of study. Our examination indicates that on average market went up during 2004–2007. The plot of index values shows that market started moving down around January, 2008. A significant fall was witnessed around third week of January, 2008 (January 15, 2008: 2 per cent down, January 18: 3 per cent down) and on January 21, 2008 the benchmark index fell by massive 8.7 per cent and this momentum continued further too. This 8.7 per cent fall was among the 10 biggest falls of the stock market thus far and one possible reason for this fall may be the proposal of Securities and Exchange Board of India's (SEBI) to tighten the rules for purchase of shares and bonds in Indian companies through the participatory note (PN) route. Nonetheless, it is interesting to note that in a way Indian market sensed the downturn months before Lehman brothers announcement of bankruptcy i.e. on September 15, 2008, which subsequently affected markets worldwide and led to severe economic crisis.

Similarly, the index value plot also shows that the benchmark Nifty50 index started recovering around mid of March, 2009 (for example 13th March: 3.8 per cent up, 23rd March, 4.7 per cent up and this continued). However, glancing deeper, we find that on May 18, 2009 the market went up by more than 16 per cent (hitting the third circuit level for index i.e. 10 per cent, 12 per cent and then 15 per cent) and then this trend continued. One of the reasons of

this biggest surge was the election results announced on May 16, 2009 (Saturday) that pronounced a clear verdict on the government and that meant much awaited stability in a country where we had many promising reforms blocked by warring government allies. These events made us to identify January 21, 2008 and May 18, 2009 as brake dates for new trends in the market. It is noteworthy that in both Uptrend and Recovery, the market moves upward but they are different phenomena. During Uptrend, the market touches new highs for the very first time whereas, during Recovery the upward movement gradually restores the earlier highs. We also classify options in moneyness categories namely in-the-money (ITM), at-the-money (ATM) and out-of-the-money (OTM) contracts following Chen *et al.* (2005) and Chan *et al.* (2009).

ITM/OTM call options are options with strike price ranging from 80/105 to 95/120 percent of index value in spot market and corresponding put options are options with strike price ranging from 105/80 to 120/95 percent of index value in spot market. Both ATM call and put options are options with strike prices ranging between 95 to 105 percent of the underlying index value i.e. S&P CNX Nifty Index. We consider a call option deep-in-the-money (DITM) if strike prices are less than 80 per cent and deep-out-of-the-money (DOTM) if strike prices are greater than 120 per cent, and vice-versa for a put option. However, due to very thin trading (less than 1 percent) in DITM and DOTM options, they are not considered for any further analysis in this study.

We use Granger causality testing approach to investigate the relationship between future price volatility and options market trading activity by estimating Tri-variate Vector-auto Regression (TVAR) model where endogenous variables are common implied volatility, aggregate volume and aggregate changes in open interests. Vector-auto Regression model omits the contemporaneous interaction between variables however; it is possible that these variables are concurrently determined. To test this possibility we run following multiple regression (Eq. (1)) to examine the contemporaneous relationship between the expected future volatility and measures of trading activities.
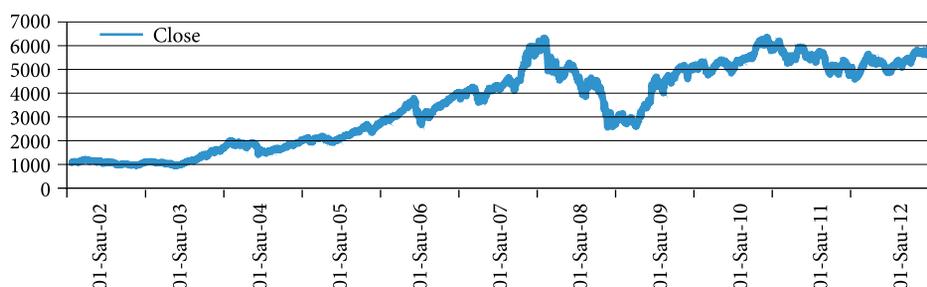


Fig. 1. Daily close value of S&P CNX Nifty 50 index

Regression Model:

$$h_t = \beta_{01} + \beta_{11} Vol_t + \beta_{12} D_u Vol_t + \beta_{13} D_d Vol_t +$$
$$\beta_{21} COI_t + \beta_{22} D_u COI_t + \beta_{23} D_d COI_t + \varepsilon_t. \quad (1)^5$$

Here $h_t$ is CIV on day $t$, $Vol_t$ is aggregate options volume and $COI_t$ is aggregate changes in open interests on day $t$. $D_u$ and $D_d$ are dummies for Uptrend and Downtrend market phases. $D_u$ takes the value 1 during Uptrend period and 0 otherwise whereas $D_d$ takes the value 1 during Downtrend period and 0 otherwise. The Recovery Period is considered to be the reference category here. Interaction terms are included due to objective of examining any significant change in relationship between volatility, volume and *COI* with change in market trends.

Following TVAR model is used to examine the causality where $h_t$ is common implied volatility (*CIV*), $V_{t-i}$ are lags of aggregate daily options volume, $O_{t-i}$ are lags of aggregate changes in daily open interest (COI) and $l$ is the number of lags in the regression. Before running the TVAR the prerequisite of variables being stationary is verified.

$$h_t = A + \sum_{i=1}^{l} \alpha_{1i} V_{t-i} + \sum_{i=1}^{l} \beta_{1i} O_{t-i} + \sum_{i=1}^{l} \gamma_{1i} h_{t-i} + \varepsilon_t;$$

$$V_t = B + \sum_{i=1}^{l} \alpha_{2i} V_{t-i} + \sum_{i=1}^{l} \beta_{2i} O_{t-i} + \sum_{i=1}^{l} \gamma_{2i} h_{t-i} + \mu_t;$$

$$O_t = C + \sum_{i=1}^{l} \alpha_{3i} V_{t-i} + \sum_{i=1}^{l} \beta_{3i} O_{t-i} + \sum_{i=1}^{l} \gamma_{3i} h_{t-i} + \pi_t. \quad (2)$$

We expect $\alpha_{1i}$ and $\beta_{1i}$ coefficients to be significant for options market to be informative about future volatility whereas significant $\gamma_{2i}$ and $\gamma_{3i}$ coefficients would mean the expected future volatility determining the trading of options, meaning the use of options for hedging purposes. Here, lag lengths $l$ in each case is determined using Akaike Information criterion (AIC).

Further, it is known that different options provide varying degree of leverage and liquidity and the preference of options may also change with change in market environment. Considering these issues, we examine the possible change in relationship due to different market trends (Up, Down and Recovery) and due to change in options moneyness (ITM, ATM and OTM) by repeating the TVAR analysis using system of Equations (2) for different market trends and classes of options moneyness after due classification of the dataset.

## 4. Empirical results

Table 1 presents the summary statistics and the statistics of stationarity and normality test on the key variables of call and put options data across series of options aggregated for

Table 1. Summary statistics of S&P CNX Nifty index options (Aggregate)

| Estimates | Call options | | | Put Options | | |
|---|---|---|---|---|---|---|
| | Common_impvol | Total_vol. (in Lakh.) | Total_COI (in lakh.) | Common_impvol | Total_vol. (in Lakh.) | Total_COI (in lakh.) |
| Mean | 0.237 | 4.621 | 10.898 | 0.008 | 4.686 | 12.257 |
| Median (p50) | 0.219 | 1.234 | 5.585 | 0.006 | 1.334 | 6.955 |
| S.D | 0.088 | 6.188 | 25.514 | 0.009 | 6.191 | 18.530 |
| Max | 1.377 | 38.387 | 747.508 | 0.266 | 36.090 | 216.741 |
| Min | 0.058 | 0.012 | −64.657 | 0.000 | 0.007 | −88.734 |
| Std. Error (mean) | 0.002 | 0.141 | 0.582 | 0.000 | 0.141 | 0.423 |
| Skewness | 2.286 | 1.744 | 14.582 | 13.057 | 1.647 | 2.278 |
| Kurtosis | 19.327 | 6.015 | 380.644 | 333.293 | 5.492 | 16.919 |
| ADF Test stats. | −16.39 | −7.43 | −30.2 | −27.67 | −6.19 | −24.56 |

*Note:* Table 1 presents the summary statistics of important variables from the study for call and put options separately. Common_impvol represent estimated common implied volatility measured Vega weighted average of implied volatility of options. Total_vol. (in Lakh.) shows the turnover whereas Total_COI represent the total changes on open interest. We report first four moments namely mean, standard deviation (S.D), Skewness and Kurtosis along with positional average median (the 50th percentile or p50). The highest and lowest observation value and the statistics for stationarity test (ADF test) are also reported. The negative value (in italics) of Total_COI (in lakh) variable indicates negative changes in open interest meaning excess of closure of outstanding positions compared to new positions. The number of observations is 1922 in all cases for both call and put options.

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[5] We drop intercept dummy terms of Uptrend and Downtrend from Equation (1) due to them having a Variance Inflation factor (VIF) exceeding 5 when included in the regression equation. However, we test if common implied volatility (CIV) are different during the sub-periods defined as Uptrend, Downtrend and Recovery period by running a separate dummy variable regression model with intercept and find the CIV to be significantly different across trends at less than 1% level of significance.

Table 2. Contemporaneous regression results

| Category | Total Volume | Total COI | Up Total Vol | Down Total Vol | Up COI | Down COI | Cons. | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| **Call Options** | −0.0013*** (−3.92) | −4.7E-05 (−0.35) | 0.0092*** (5.38) | 0.0213*** (17.59) | −0.0001 (−0.68) | 0.0003 (1.12) | 0.2263*** (97.40) | 0.2243 |
| **Put Options** | −0.0004*** (−11.78) | −3.0E-05** (−2.67) | 0.0034*** (8.86) | −0.0003** (−2.25) | 0.0003*** (10.51) | 3.1E-05 (1.18) | 0.0083*** (33.53) | 0.3544 |

*Note:* **, *** represent the significance of coefficients at 5% and 1% levels. Table 2 shows the contemporaneous regression results for call and put options where estimated coefficients of explanatory variables i.e. total volume, total COI and their interaction with up and down dummies, are reported along with their t-statistics in parenthesis. $R^2$ of the regressions are shown in the last column and the number of observations in each of the regressions is 1922.

the period of study. For call options, the proxy of expected future volatility measured by common implied volatility (common_impvol) has an average of 23.71% with a standard deviation of 8.8% however the maximum and the minimum values indicate that the expected daily volatility is not stable. Unlike call options, the mean common implied volatility for put options is found to be low i.e. 0.8% with a low standard deviation of 0.9%. The maximum and minimum volatility also suggest that expected volatility of put options is relatively stable. The reported skewness and kurtosis values suggest that sample data do not come from normally distributed population[6].

We also conduct the unit root test to examine the stationarity of all the three variables i.e. Common_implvol, Total_vol. and Total COI, as a prerequisite for further use of these variables in time series regressions. We conduct Augmented Dickey-Fuller Test (ADF test) for this purpose and the hypothesis that the series is non-stationary is rejected at 1% level of significance (critical Z test value equals to −3.43) for all three variables and for both call and put options. We alternatively conduct Phillips-Perron unit root test and find similar test statistics as reported for ADF test.

Table 2 reports the contemporaneous regression results for both call and put options. We find that the total volume, for both call and put options, is having significant negative effect on daily-implied volatility during recovery period. This implies that an increase in options trading reduces the expected future volatility of Nifty spot index during recovery period and is consistent with Sarwar (2005). The COI is also found to be negatively affecting the implied volatility during recovery period. However, we find COI is not significant in the case of call options. These results suggest that in general arbitragers and other market players operate actively in Nifty index options market due to which significant portion of volatility related information is impounded in the two markets simultaneously.

The volume and COI are also interacted with Uptrend and Downtrend dummies to test if the relationship is consistent across market trends. The coefficients of total volume for call options during both Uptrend and Downtrend periods turn out to be positive and significant. This implies that the effects of volume during Up and Down periods significantly differ from the Recovery period. The overall impact of call options volume during Up ($\beta_{11} + \beta_{12}$) and Down periods ($\beta_{11} + \beta_{13}$) turns out to be positive meaning an increase in call options trading increases the expected value of spot market future volatility. COI for call options is not having significant impact on volatility and this remains consistent across trends.

The impact of volume in the case of put options is also found to be significantly different from recovery period however, the overall impact is positive during Uptrend and negative during Downtrend. COI of put options is found to be having negative impact on volatility during recovery period and is significantly different only from that of Up period. Moreover, the overall impact during Up period is still negative though, the magnitude changes from 0.004% to 0.001%. Results of COI for both call and put options imply that a positive change in the open interest indicates a fall in expected future volatility. Overall, the options trading activity and volatility are found to be instantaneously related. However, the magnitude of adjustment to information differs across market trends. Our regression equation (1) explains a significant proportion of total variance in expected future volatility (22.4% and 35.4% for call and put options respectively) and the VIFs of the variables in the regressions remain below 2 indicating no multi-collinearity among independent variables.

Table 3 presents the result of TVAR that test for direction of information flow between spot and options markets. We report the sign and significance of the parameters estimated through equation (2)[7]. We observe a significant

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[6] The Shapiro-Wilk test is also conducted to test the null hypotheses that the sample data comes from normally distributed population. The *W* statistics is found to be lower however, the p-values for every variable are found to be significant which rejects the null hypothesis of normality.

[7] Coefficient estimates of the same are available on request.

impact of own lag/s in all three regressions for both call and put options except for call options volume (Total_vol) during Down period. It suggests that the own lag/s of the variables is/are prominent predictor/s.

We find from put options results, that the total volume is significantly affecting the implied volatility till two lags during Aggregate and Up periods but with alternate signs. This implies that volatility initially falls with a rise in options volume but then rises on the subsequent day, which is consistent with under-reaction hypotheses in literature. We find that during the Down period, the volume is not having significant effect on volatility however, during recovery period the second lag of volume is found significant. The consistent alternate sign of coefficients strongly supports the under-reaction hypothesis where volatility first undershoots and then subsequently adjusts upward. The significant lagged put options volume supports the volatility information related trading of Nifty Index put options.

The impact coefficient of total COI on implied volatility for put options is having alternate sign but only second lag is positive and significant during Aggregate and Up periods.

During Downtrend, the impact of COI is positive for both lags but only first lag affects significantly. No significant relationship between COI and volatility is observed during Recovery period. We observe that COI affects volatility on $(t + 2)$ day during aggregate and up periods where $t$ is the transaction day. The consistent results during aggregate and up periods are possibly due to total period of study largely overlapping with up period. During down period COI affects volatility till next day only. We observe that volatility related information from COI is transmitted faster during Downtrend compared to that of Uptrend.

The impact of put options implied volatility on both total volume and COI from Table 3 suggests the following: During aggregate period the first two lags of implied volatility have significant impact on volume with alternate signs showing under-reaction. However, during up period, though the sign of coefficients remain consistent, only second lag is found affecting positively and significantly. During Down and Recovery periods the sign of the lag coefficients remain positive but insignificant. The implied volatility is affecting the COI significantly till two lags during Recovery period

Table 3. Results of TVAR for aggregate period and sub-periods (Up, Down and Recovery)

| Dependent Variable | Lag Variable | All | | | Up | | | Down | | | Rec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lag1 | Lag2 | Lag3 | Lag1 | Lag2 | Lag3 | Lag1 | Lag2 | Lag3 | Lag1 | Lag2 |
| **Put Options** | | | | | | | | | | | | |
| **Imp_Vol** | Imp_Vol | +*** | +*** | NA | +*** | +*** | NA | +*** | +*** | NA | +*** | +*** |
| | Total_Vol | –** | +** | NA | –*** | +*** | NA | – | + | NA | – | +** |
| | COI | – | +** | NA | – | +** | NA | +** | + | NA | + | – |
| **Total_Vol** | Imp_Vol | –** | +** | NA | – | +** | NA | + | + | NA | +* | + |
| | Total_Vol | +*** | +*** | NA | +*** | +*** | NA | +*** | +* | NA | +*** | +*** |
| | COI | + | +*** | NA | – | – | NA | + | + | NA | – | + |
| **COI** | Imp_Vol | + | +** | NA | + | + | NA | + | – | NA | +*** | –** |
| | Total_Vol | –*** | +*** | NA | –* | +*** | NA | + | + | NA | –* | +*** |
| | COI | +*** | +*** | NA | +*** | + | NA | +*** | – | NA | +*** | +** |
| **Call Options** | | | | | | | | | | | | |
| **Imp_Vol** | Imp_Vol | +*** | +*** | + | +*** | +** | +** | +** | +*** | – | +*** | –** |
| | Total_Vol | +* | – | + | +* | – | + | +* | – | + | – | + |
| | COI | +* | + | – | +** | + | + | + | – | – | + | – |
| **Total_Vol** | Imp_Vol | + | – | + | + | + | – | –* | + | +* | +* | – |
| | Total_Vol | +*** | + | +*** | + | +* | + | + | + | + | +*** | +*** |
| | COI | + | + | +* | +*** | – | – | + | + | + | – | + |
| **COI** | Imp_Vol | – | +* | + | –** | – | +** | –** | +*** | – | + | + |
| | Total_Vol | – | + | + | – | – | +*** | –* | + | – | – | +*** |
| | COI | +*** | + | –** | +*** | + | –*** | +*** | + | – | +*** | + |

*Note:* *** is $p < .01$, ** is $p < .05$ and * is $p < .10$. In Table 3, all represents regression estimated based on aggregate data for entire period of study. Up, Down and Rec. indicate regression estimates during Uptrend, Downtrend and Recovery period as indentified in the study. Imp_vol indicates daily common implied volatility (CIV), Total_vol indicates total number of contracts traded daily across series of options. COI represents daily aggregate changes in open interests across series of options. N.A stands for not available meaning the lag length criteria not suggesting inclusion of the particular lag in the regression.

and the alternate signs of coefficients indicate that with rise in volatility the COI increases first but, on subsequent day it falls indicating an overreaction effect. No significant impact of volatility is found on COI during Up and Down periods however, the aggregate impact is found to be positive for both lags, significant only for lag 2.

The results of Call options in Table 3 indicate that impact of total volume on volatility is not significant at 5% level across periods of study. The signs of lag coefficients are alternate consistently. Unlike volume, the COI is having positive and significant effect during up period. This suggests that the volatility informed traders do not primarily use call options to trade on their information. Call options implied volatility is not affecting volume too across periods of study however, it affects COI significantly during down period till three lags which, indicates hedge related use of call options during downtrend. The first lag of volatility is also negative and significant during up period. Volume and COI are found predicting each other significantly in many instances, as expected, due to both being measures of options market trading activities. Nevertheless, these results are not highlighted as this study addresses different issue.

The results of TVAR for different classes of options moneyness are reported in Table 4. We find that the total volume for put options has positive and significant impact on implied volatility for OTM and ITM options with the lag of one day. COI does not have significant effect on volatility. Implied volatility also has significant impact either on volume or on COI across moneyness classes.

Results for Call options show that an increase in options volume results in rise of expected volatility the next day but is significant only for OTM options enforcing volatility information based trading of Nifty call OTM options. The implied volatility is also affecting the total volume till two lags with alternate signs but only for OTM options. This indicates the overreaction in trading OTM call options on the expectation of increase in future volatility and points the hedging role of OTM call options. COI for call options is not found affecting volatility across moneyness classes however; volatility is found affecting the COI significantly for ATM options. The results for call options indicate the feedback relationship between the two markets for OTM options making them preferred instruments for both informed traders and hedgers.

## Conclusions

The study investigates the dynamic relationship between future volatility of S&P CNX Nifty Index and trading activity of Nifty options. Two alternative measures of trading

Table 4. TVAR results for different classes of options moneyness

| Category | Dependent Variable | Lag Variable | ATM | | OTM | | ITM | |
|---|---|---|---|---|---|---|---|---|
| | | | Lag1 | Lag2 | Lag1 | Lag2 | Lag1 | Lag2 |
| **Put Options** | Imp_Vol | Imp_Vol | +*** | +*** | +*** | +*** | +*** | +*** |
| | | Total_Vol | + | – | – | +*** | – | +*** |
| | | COI | +* | – | + | –* | + | + |
| | Total_Vol | Imp_Vol | + | – | + | + | – | + |
| | | Total_Vol | +*** | +*** | +*** | +*** | +*** | + |
| | | COI | + | +*** | +*** | – | +** | – |
| | COI | Imp_Vol | +* | – | + | + | – | + |
| | | Total_Vol | – | +*** | –*** | +*** | –*** | –*** |
| | | COI | +*** | +*** | +*** | +*** | +*** | –*** |
| **Call Options** | Imp_Vol | Imp_Vol | +*** | +*** | +*** | +*** | +*** | +*** |
| | | Total_Vol | + | + | +** | – | + | + |
| | | COI | – | + | + | + | – | + |
| | Total_Vol | Imp_Vol | + | + | +** | –** | + | + |
| | | Total_Vol | +*** | +*** | +*** | +*** | +*** | +*** |
| | | COI | –*** | + | +** | –** | +*** | + |
| | COI | Imp_Vol | –* | +*** | +* | – | + | + |
| | | Total_Vol | + | +*** | –*** | +** | –*** | + |
| | | COI | + | +* | +*** | + | +* | +** |

*Note:* *** is $p < .01$, ** is $p < .05$ and * is $p < .10$: Here Options moneyness categories ATM, OTM and ITM are At-the-Money, Out-of-the-Money and In-the-Money options. Imp_vol indicates daily common implied volatility (CIV), Total_vol indicates total number of contracts traded daily across series of options. COI represents daily aggregate changes in open interests across series of options. Lag lengths are determined based on AIC criterion.

activity i.e. trading volume measured by aggregate number of contracts traded and changes in open interest, are considered in the study. We examine both contemporaneous and lead lag relationship between expected volatility and options trading activity and also analyse the relationship separately for different market trends and options moneyness for both call and put options.

The contemporaneous regression results show that options volume is significantly related with future volatility and it is consistent across market trends for both call and put options. The positive relationship between volume and volatility can be attributed to shift of liquidity from the spot market to the options that result into increase in the options volume and the spot market volatility. Moreover, our results are also consistent with the theoretical relationship of volatility with options prices.

We also find that COI is related with volatility only in the case of put options but turns out insignificant during Downtrend. Moreover, when data post January, 2011 (relatively smaller downtrend) is dropped from analysis, COI is found to be significantly affecting volatility only during Up period. This suggests COI as a contemporaneous predictor only in good times. The lead lag relationship based on TVAR model suggests the predictability of options trading activities for future volatility indicting volatility informed trading in options. However, feedback relationship is also observed in few cases suggesting both information and hedge based use of Nifty options. When options are classified based on moneyness, we find OTM call options are the most prominent contracts preferred by both informed traders and hedgers. The sign and significance of the coefficients vary with varying market trends and options moneyness suggesting that trader's preference changes with changing market environment.

Based on our empirical analysis the main findings can be highlighted as follows:

– The options in India have both the information based and the hedging based uses which is consistent with the leverage (information based trading) and the liquidity (hedge related trading) hypotheses.
– OTM options contracts are the most preferred options class for trading by both informed traders and hedgers in Indian market.

Although this study considers two important factors, i.e. options moneyness classes and market trends to examine the dynamic relationship between the spot and the options markets yet, other factors such as options liquidity, time to maturity can be considered to extend the study further. As this study uses index options data, the results are more appropriate for trading based on market wide information. A study on component stocks using stock options contracts may help to know the venue of informed trading in terms of idiosyncratic information about firms.

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**Rajesh PATHAK**, Dr., is an assistant professor at IBS-Hyderabad (Icfai Foundation of Higher Education) in department of Accounting and Finance. His research interests include equity derivatives and its roles, price discovery and corporate finance. He teaches undergraduate, graduate, and executive courses in finance and allied areas such as accounting for managers, management accounting, financial risk management, security analysis and portfolio management, financial management, strategic financial management etc.