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Empirical Testing of the Information Efficiency of Implied Volatility in Indian Options Market

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Abstract

Price discovery is the basic function of derivatives. For an efficient discovery of price, future realized volatility must have the capacity of being determined through implied volatility. The study examines the forecast quality of the implied volatility in determining the realized future volatility. The study focuses on the one month call options based on CNX Nifty for the time period June 2001 to December 2014. The results indicate that the implied volatility overestimates the future volatility and the degree of biasness increases with increase in time to expiry, whereas the directional efficiency of implied volatility is correctly specified.

Keywords: Implied Volatility, Future realized volatility, Information efficiency, Options, Black Scholes

JEL Classification: G13, G14, G17

Paper Classification: Research Paper

Introduction

Discovery of price is the fundamental function of derivatives market and the volatility of prices is often traded upon in the options market. In case the option markets are efficient then the volatility contained in the option price is an efficient estimate of future realized volatility. An option's implied volatility is considered as a good proxy for future volatility of the underlying asset and is presumed that implied volatility should be an efficient predictor of future volatility because it contains the information what is either publicly available or contained in the historical data (Lau & Morales, 2003). Latane and Rendleman (1976) were the first to examine that call option implied volatility predicts future volatility better than predictors based on historical data in case of stock options. It is generally assumed that the market makes use of all the available information in order to create the expectations about the future volatility and hence the implied volatility reveals the market's true volatility estimate (Christensen & Hansen, 2002). This sets forwards the ground for testing the relationship between implied volatility, historical volatility and future realized volatility. It in turn helps in estimating the efficiency of options market.

Review of Literature

Latane and Rendleman (1976) studied options for 24 companies traded on CBOE over a period of October 1973 to June 1974. They established four measures to describe the standard deviation of underlying stock returns. They derived different implied standard deviations by employing Black Scholes Model for each stock. They concluded that weighted average standard deviation performs better than historical volatility in estimating future volatility of underlying stock returns. Chiras and Manaster (1978) analyzed CBOE data to make a comparison between weighted implied volatility and historical volatility of the underlying asset. They found that the implied volatility had better performance in making a forecast of the volatility of the stock price during the life of option. They also attempted to find out the possibility of earning excess returns by buying options with low implied volatilities and selling options with high implied volatilities. This strategy allowed the investor to book a profit of 10% per month. Their study has provided support to the Black Scholes model. Beckers (1981) investigated the predictive ability of implied volatility. He considered closing price data of CBOE stock options over April 75 to July 77. He considered dividend and the significance of weights in interpretation of volatilities. Beckers concluded that implied volatility had more power in predicting cross sectional stock volatility in comparison to historical volatility. He also found that implied volatility a biased and informationally inefficient estimator for volatility forecasting in comparison to historical volatility. Gemmill (1986) examined the implied volatility from equity options, and reported that in the money and at the money options got accurate estimates for implied volatility measures. He further stated the implied volatility was not capable to efficiently forecast future volatility. Day and Lewis (1992) focused on call options drawn on S&P 100 index for 319 weeks over the time span from November 1983 to December 1989, to study time series behavior of implied volatility. They compared implied volatility with the weekly volatility estimates from the GARCH and the Exponential GARCH models, and concluded that implied volatility was informative and unbiased predictor of future index return volatility. They also concluded incremental information content was not captured by implied volatility. Thus, implied volatility was not an informationally efficient forecast of future volatility. Canina and Figlewski (1993) analyzed the information content of implied volatility by focusing on the closing prices of S&P 100 index call options. They performed a regression of realized volatility over the remaining life of the option on the corresponding implied volatility. They found that implied volatilities from options across different maturities and moneyness have 'no statistically significant correlation with realized volatility at all' and appear to be even worse than the 60 day historical volatility to forecast future S&P 100 index volatility.

Clewlow and Xu (1993) examined the dynamic properties of underlying asset, its realized volatility and volatilities implied from option prices traded on Chicago Mercantile Standard & Poor 500 Index futures for the time period of 1985 to 1992. They found that estimators of historical volatility which utilize the full range of daily price information were significantly more efficient. They also showed that the implied volatilities exhibit substantial skews in addition to the smiles. Lamoureux and Lastrapes (1993) investigated implied volatility under the framework of Hull and Whites (1987) stochastic volatility option pricing model. They studied at the money CBOE call options on 10 non dividend paying stocks for the period April 82 to March 84 and compared the one day and option life time volatility forecasts with those from GARCH and Historical volatility estimates. They concluded that Implied Volatility was biased but informative, and that historical volatility contributed additional information in forecasting future stock return volatility. Jorion (1995) examined foreign currency future options on Chicago Mercantile Exchange. He used daily closing prices of options on the Deutsche Mark futures, the Japanese Yen futures and the Swiss franc futures over the time period of January 1985 to February 1992. He found that implied volatility was close to an unbiased forecast of the volatility over the next day, but was a more biased forecast of the volatility over the remaining life of the option. He also provided simulations for small sample biases usually ignored in regressions of predictive ability and showed that measurement errors can substantially distort inferences. Christensen and Prabhala (1998) examined the ability of implied volatility to forecast future realized volatility and the remaining fruitful life of option. They took daily closing prices of at the money S&P 100 index call options over a period of139 months from November 1983 to May 1995. They proposed an adhoc sampling procedure to construct non-overlapping volatility series, which they believed would yield more reliable and consistent regression results than overlapping time series data. They concluded that the implied volatility subsumes all the information in the option market to forecast future volatility whereas historical volatility did not contribute incremental information beyond that already existed in implied volatility.

Fleming (1998) examined the performance of implied volatility as forecast of future stock price volatility using daily transaction data on S&P 100 Index options over October 1985 to April 1992, excluding October 1987 stock market crash period. He used implied volatility estimated from the modified binomial model of Fleming and Whaley (1994). He employed the Generalised Moments Method to solve the problem of serial correlation for evaluating the unbiasedness and efficiency of implied volatility of S&P 100 Index. He found that the implied volatility was a biased but substantially informative forecast of future index volatility, and also that implied volatility was informational efficient relative to other estimates of volatility such as 28-day historical volatility and GARCH forecast. Gwilym and Buckle (1999) concluded that the historical volatility estimators had greater forecast accuracy than implied volatility for the UK markets and implied volatility contained more information than historical information. Teoman (2002) tried to examine the implied volatility of index options of NASDAQ and S&P 100 index from January 1996 to November 2001 with returns on the index. He tried to analyze the change of implied volatility around three major events i.e. Asian currency crisis, Russian crisis, World trade centre and tried to find out whether Implied volatility of NASDAQ index option and that of S&P 100 index option changed at distinct rates over the period of analysis. He found the implied volatility was a good predictor of actual volatility. Annualized monthly implied volatility was significantly higher than the actual volatility for both index options in line with empirical observations. Corrado and Miller (2005) examined the forecast quality of CBOE Implied volatility indices based on S&P 100 and Nasdaq 100 stock indices for the time period from 1988 to 2002. They found that the forecast quality of CBOE implied volatility for S&P 100 improved during period 1995 to 2002.

Lau and Morales (2003) analyzed the information efficiency of the OTC currency options on the Czech koruna and the Polish zloty for the time period from January 1999 to December 2000. They argued that the Czech and Polish markets were more efficient than mature markets because of higher relative participation of informed dedicated investors which offset the effects of relative illiquidity and higher transaction costs in these markets. They also found that the implied volatility anticipated the direction of volatility correctly but had a bias of over predicting it. Shu and Zhang (2003) studied the relationship between implied and realized volatility using S&P 500 index option prices over the period, January 1995 and December 1999. They also tested the stability of this relationship by considering different measurement errors. They found that implied volatility outperformed historical volatility and even subsumed the information contained in historical volatility. They also showed that the option market processed information efficiently. Figlewski (2004) discussed the issue of forecasting volatility using historical data and forecasting long term volatility with ARCH family models. He found that Historical volatility provided more accurate forecasts as compared to conditional volatility. He also suggested that the persistence in the volatility smile indicates that the model used for estimation of implied volatility is not the model which market is employing for pricing the options. He concluded that the implied volatility did not pass the test of forecast rationality test. Kim, Park and Hyun (2007) derived the explicit formula for a European option as Merton's (1973) by assuming that the excess return of an underlying asset followed a lognormal process. They claimed that the implied volatility by adhoc Black Scholes formula used by practitioners did not mean the future volatility of the returns of an underlying asset, but that of excess returns. They validated the claim by applying regression among the implied volatility, realized volatility, and the historical volatility of returns and excess returns, using SPX and OMX index options. They confirmed that implied volatility was a good predictor for future volatility.

Srivastava, Yadav and Jain (2006) studied different estimators of historical volatility and conditional volatility for assessment of forecast ability of implied volatility. They used sample of 44 shares over a period of January 1995 to June 2005. They found extreme value estimators could not capture the volatility in appropriate manner except for Parkinson's estimate that has exhibited some merit while forecasting volatility for short term. Yang (2006) concentrated on the investigation of implied volatility in the Australian Index Option Market. He examined the relation between implied volatility and historically realized volatility by using S&P / ASX 200 (XJO) index options over a five year period from April 2001 to March 2006. He, after accounting for errors in variable problem (arising because of infrequent trades, low volumes and long maturity cycle) , found that both call and put options implied volatilities were nearly unbiased and superior to historical volatility in forecasting future realized volatility. Kumar (2008) investigated the Indian market for the information efficiency of the implied volatility and concluded the results in favour of implied volatility as an estimator of future realized volatility. Bakanova (2010) analyzed the information content of implied volatility in the crude oil market by considering the daily time series of light, sweet crude oil futures and options traded on the NYMEX for the period from November 1986 to December 2006. He employed instrumental variable approach and found that implied volatility did predict future realized volatility and historical volatility did not add any additional information beyond that of implied volatility. Ionesco (2011) analyzed the predictive power of implied volatility, simple historical volatility and exponential historical volatility. He used monthly observations of S&P 500, FTSE 100, and DAX equity and option markets for the time period of 2004 to 2010. He indicated that implied volatility was an informationally efficient and unbiased estimator of one month advance future volatility. An option derives its value from an underlying asset. On the contrary, the payoff of the option was not a linear function of the underlying asset price. Thus, the option price could not be assumed to be a linear function of the underlying asset. Shaikh and Padhi (2013) analyzed the options for causal relationship between ex-ante and ex-post in Indian scenario. They found that ex-ante volatility contained all the market related information which can be utilized to forecast future ex-post volatility.

Research Gap and Purpose of the study

The information efficiency of implied volatility has been explored less in Indian context. As far as Indian context is concerned the informational efficiency of the implied volatility in containing information about the future realized volatility has hardly been explored for continuous cross-sectional data for long term. Whereas, the cross sectional data has been appreciated in developed markets (Latane & Rendleman, 1976; Chiras & Manaster, 1978).

The purpose of this study is to estimate whether implied volatility is a significant, unbiased and sufficient variable for forecasting future volatility. Along with the testing of informational efficiency of implied volatility, the efficiency of the options market will also get tested.

Research Methodology

Data

The present study focuses on the daily closing prices of options traded on Nifty index. Options on Nifty index are the most widely traded options of the National Stock Exchange. These options are European in nature, so there is no problem of early exercise. The sample were considered one month options (Christensen & Prabhala, 1998) expiring on the last Thursday of the month for the time frame from June 2001 to December 2014. On each trading day, the closing value of option on each strike price has been considered. The time to maturity was calculated in terms of number of calendar days available for expiry.

Method of Sample selection

The sampling design for the selection of data points to be included in the final sample involves the filtration of complete data through following steps:

Step 1. The call options considered for the study are collected on the working day immediately following the expiry date of the previous month's options. These call options approximately have one month (i.e. four to five weeks) time to expiration. This step gives us non-overlapping data points with maximum time to expiry of one month.

Step 2. Out of selected data points of options in step 1, those which satisfy the boundary condition i.e. $c>((Fe^{(-r\tau)})-X$ has been selected.

Step 3. Call Options must have some trade volume. So the observations which had less than 50 contracts being traded on that day have been dropped. Also, observations which have the settlement price equating to zero have also been rejected out of the sample because such value would not allow the optimal solution to occur in estimation of Black Scholes Implied Volatility

Step 4. The call options for which the optimal solution for Black Scholes Implied Volatility could not be converged through Newton Raphson method have also been dropped.

Step 5. The call options which are finally considered for the analysis are further divided into different sub samples for the analysis purpose. The data screening statistics for the Nifty options are given in Table 1

Table 1: Data Screening Statistics for the Nifty Options

Total Call Contract Observations	46314
Criteria	
Observations not satisfying Boundary Conditions	3816
Observations with less than 50 Contracts being Traded	10840
Observations with very low Settlement Price(i.e. less than Rs.1.00)	5080
Observations for which No Convergence is achieved for BSIV	2076
Observations Rejected for synchronisation of Nifty Futures Time Series with Nifty Call Options Time Series	106
Rejected Data	21918
Rejected Data (in %)	47.32
Remaining Data Points considered for Analysis	24396
Sampled Data (in %)	52.68

Step 6. Finally, options considered for further analysis have been divided into subsamples on the following basis:

Criteria 1. Moneyness Boundaries. The options, based on the boundaries of moneyness i.e. $\eta = S_t / X_t$ where St is the index level and Xt is the exercise price of the option, are categorized into following categories

DOTM: Deep-Out-of-The-Money Options: If η ε (0,0.85),

OTM: Out-of-The-Money Options : If η ε (0.85 ,0.95),

ATM: At-The-Money Options: If η ε (0.95 ,1.05),

ITM: In-The-Money Options: If η ε (1.05,1.15),

DITM: Deep In The Money Options: If η ε (1.15,∞)

Criteria 2. Time To Expiry Limits. The options are categorised on the basis of Time to Expiry as follows:

VS: Very short: less than 5 days to Expiry, S: Short: 5-10 days to Expiry, M: Medium: 10-20 days to Expiry, L: Long: more than 20 days to Expiry.

Formation of Subsamples: For the purpose of creating subsamples, the complete sample has been adjusted on the dimensions of moneyness and time to expiry and the study gets the subsamples as shown below in Table 2.

Table 2: Subsamples created on the dimensions of moneyness and time to expiry

	DOTM	OTM	ATM	ITM	DITM	Total
Very Short	5	108	1137	308	209	1767
Short	86	652	2789	759	241	4527
Medium	341	2025	5657	1851	415	10289
Long	382	1943	3478	1461	549	7813
Total	814	4728	13061	4379	1414	24396

Thus, following the above sampling procedure, the study has 20 buckets of call options varying on the frames of time to expiry and moneyness. In the further study, the sub samples would be termed as shown in Table 3.

Table 3: Abbreviations for the subsamples

	DITM	**ITM**	**ATM**	**OTM**	**DOTM**
Very Short	VSDITM	VSITM	VSATM	VSOTM	VSDOTM
Short	SDITM	SITM	SATM	SOTM	SDOTM
Medium	MDITM	MITM	MATM	MOTM	MDOTM
Long	LDITM	LITM	LATM	LOTM	LDOTM

Theoretical Background of the study

Implied volatility, σ_{IV} for a call option is calculated by back solving the Black Scholes Call Option Pricing equation.

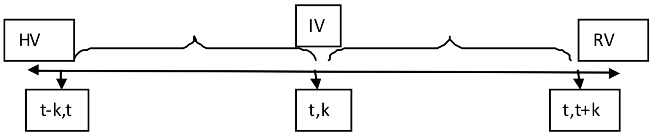
Realised volatility, σ_{RV}, is the expost realized volatility of the underlying asset over the period t to t+k , σ_{IV} is the implied volatility at time t, which is measured as

$$\sigma_{RV} \equiv RV_{t,t+k} \approx \frac{1}{k} \sum_{t=i}^{k-1} r_{t+i}^2$$

Historical Volatilty, σ_{HV}, is the historical volatility of the underlying asset over the preceding period t-k to t; which is measured as

$$\sigma_{HV} \equiv HV_{t-k,t} \approx \frac{1}{k}\sum_{t=i}^{k-1} r_{t-i}^2$$

The time period i.e. 'k' been kept equal to the rolling window of 30 days from the time-point 't' in order to match with the one month call options.



According to Figlewski (2004), σ_{IV}=E_{mkt} [σ]=E[σ | Φ_{mkt}] and {S_{t-1},S_{t-2},………………}⊆Φ_{public}⊆Φ_{mkt}. In other words, the information contained in the implied volatility is reflection of the expected market volatility. The expected market volatility equates itself to the information available to the public, market and the information contained in the stock prices over a period of time.

$\therefore \sigma_{RV}=\sigma_{IV}+\varepsilon$

$E[\varepsilon]=0; E[\sigma_{IV},\varepsilon]=0$

Where , σ_{RV}, σ_{IV} are realized volatility and implied volatility respectively.

Hypotheses

Considering the above discussion, the study would evaluate the following null hypothesis, as suggested by Kumar (2008) and Canina and Figlewski (1993):

H1: *Implied volatility provides useful information on future realized volatility (informativeness property of Implied volatility).*

$\sigma_{RV}= \alpha_1+ \beta_1 \sigma_{IV}+\varepsilon_1$ ……………………………………………(1)

H2: *Implied volatility contains information beyond that contained by historical volatility (informational efficiency).*

$\sigma_{RV}= \alpha_2+ \beta_2 \sigma_{HV}+ \varepsilon_2$……………………………………………(2)

H3: *Implied volatility is an unbiased estimator of future volatility (unbiasedness property).*

$\sigma_{RV}= \alpha_3+ \beta_3 \sigma_{IV} + \lambda_3 \sigma_{HV}+\varepsilon_3$…………………………………(3)

For testing these hypotheses, the heteroskedasticity corrected feasible weighted least squares has been carried out to estimate the coefficients of equations 1, 2 and 3. In case of heteroskedastic models, information content of observations vary with the level of variance as the observations that have high variance do not have as much information about the location of regression line in comparison to the observations with the lower levels of variance. In such cases the linear ordinary least squares is not an efficient way of estimating regression line. Thus the concept of Feasible Weighted Least Squares (FWLS) is being adopted. The basic idea of feasible weighted least squares is to reweigh the data in such a way so that all the observations contain the same level of information about the location of the regression line. In this case, the observations are said to be homoskedastic and the estimates of regression coefficients are said to be efficient and reliable. So observations that have more noise are given small weights and those containing more information are given higher weights. The procedure involves the OLS estimates of the mode of interest followed by an auxiliary regression to generate an estimate of the error variance, and then finally weighted least squares using as weight the reciprocal of the estimated variance.

In order to find out the correct estimation of the regression results restrictions on coefficients are being imposed, and then the F-statistic has been calculated for the restriction sets described below:

Restriction set 1. If implied volatility contains information in forecasting the future volatility then β_1 must be significantly different from zero (i.e.β_1=0 for equation 1),

Restriction set 2. If historical volatility can explain future realized volatility then β_2 must be significantly different from zero (i.e. β_2=0 for equation 2) , and

Restriction set 3. If implied volatility can forecast the future volatility accurately and contains all the information of historical volatility then the joint hypothesis $\alpha_3=0,\beta_3=1,\lambda_3=0$ must be tested for equation 3.

Empirical Results and Discussion

The results of the hypothesis 1 (based on equation 1) are shown in Table 4. It can be seen that the results for the heteroskedasticity corrected least squares are found to be satisfactory in case of samples having long term of maturity. Also it can be noticed that the value of Adjusted R^2 is satisfactory in case of DOTM options across all horizons of maturity.

Table 4: Results of the Regression Analysis for the equation 1

	Coefficient	S.E.	t-statistic	p-value	Adj. R2	F-statistic	p-value
VSDOTM							
α_1	0.055818	0.100424	0.5558	0.6171	0.8135	18.453	0.0232
β_1	0.427751	0.099575	4.296	0.0232			
VSOTM							
α_1	0.269296	0.025884	10.4	6.85E-18	0.11725	15.2121	0.0001
β_1	0.175649	0.045035	3.9	0.0002			
VSATM							
α_1	0.158097	0.007529	21	8.89E-83	0.082061	100.946	8.49E-23
β_1	0.30479	0.030336	10.05	8.49E-23			
VSITM							
α_1	0.203871	0.00828	24.62	1.45E-74	0.0895	198.164	4.79E-35
β_1	0.068644	0.004876	14.08	4.80E-35			
VSDITM							
α_1	0.21648	0.014668	14.76	5.10E-34	0.0028	0.57388	0.4495
β_1	0.00747	0.009861	0.7576	0.4496			
SDOTM							
α_1	0.283105	0.028167	10.05	4.59E-16	0.501104	86.3763	1.52E-14
β_1	0.251681	0.02708	9.294	1.52E-14			
SOTM							
α_1	0.067362	0.012862	5.237	2.21E-07	0.26964	240.603	2.22E-46

(Continued)

β_1	0.586267	0.037796	15.51	2.22E-46			
SATM							
α_1	0.081909	0.004681	17.5	4.65E-65	0.16122	527.272	7.45E-107
β_1	0.543302	0.023661	22.96	7.45E-107			
SITM							
α_1	0.228497	0.005745	39.77	4.06E-187	0.0869	72.7232	8.15E-17
β_1	–0.0538212	0.006311	–8.528	8.15E-17			
SDITM							
α_1	0.216271	0.015406	14.04	4.74E-33	0.011	3.6925	0.05584
β_1	0.030378	0.015809	1.922	0.0558			
MDOTM							
α_1	–0.0160391	0.022027	–0.7282	0.467	0.5514	419.031	3.36E-61
β_1	0.846337	0.041345	20.47	3.36E-61			
MOTM							
α_1	0.011761	0.005471	2.15	0.0317	0.41512	1437.59	4.02E-238
β_1	0.808142	0.021314	37.92	4.02E-238			
MATM							
α_1	0.088967	0.00304	29.27	2.41E-175	0.17052	1154.48	2.77E-230
β_1	0.497031	0.014628	33.98	2.78E-230			
MITM							
α_1	0.074182	0.005798	12.79	5.80E-36	0.2274	543.004	1.85E-105
β_1	0.491611	0.021097	23.3	1.85E-105			
MDITM							
α_1	0.226124	0.011918	18.97	3.82E-58	0.0237	11.048	0.000967
β_1	0.058656	0.017647	3.324	0.001			
LDOTM							
α_1	0.0261899	0.029758	âˆ’0.8801	0.3794	0.3509	207.013	8.95E-38
β_1	1.05855	0.073572	14.39	8.95E-38			
LOTM							
α_1	0.001744	0.004436	0.3931	0.6943	0.5256	2152.95	0
β_1	0.995852	0.021462	46.4	0			
LATM							
α_1	0.045009	0.003095	14.54	1.47E-46	0.4309	2633.7	0
β_1	0.769322	0.014991	51.32	0			
LITM							
α_1	0.049743	0.004957	10.04	5.78E-23	0.39395	950.026	4.43E-161
β_1	0.615923	0.019983	30.82	4.43E-161			
LDITM							
α_1	0.0725	0.01378	5.261	2.06E-07	0.2187	154.415	2.01E-27
β_1	0.433418	0.034879	12.43	2.11E-31			

The Adjusted R^2 value signals that implied volatility explains approximately 50% of the future volatility. The F-statistic is given for the regression with the restriction that coefficient β(1)is equal to zero. In order to conclude upon the issue of informativeness property of implied volatility, the coefficient must be significantly different from zero. Looking at the values of F-statistic and p-value, it can be observed that the restriction is being rejected for all cases except for VSDITM and SDITM. So, the results give indication that the implied volatility provides information for future volatility especially in case of DOTM options and the options with long term to expiry (i.e. more than 20 days to expiry in case of monthly options).

The results shown in Table 5 are the outcome for the Hypothesis 2 (Equation 2), which aims to test the informational efficiency of the implied volatility. Informational efficiency of the Implied volatility is an indication of efficient and mature options market. It is clearly indicated that the results are not as positive as compared to those obtained in Hypothesis 1. However, the results are considerable in positive sense only in case of DITM options and options with long term to expiry. Also, options with VSATM sample also perform somewhat satisfactorily. The F-statistic results for the regression with the restriction that β_2 is equal to zero. In order to indicate that the implied volatility has more explanatory power than the historical volatility in forecasting future volatility, the restriction must be accepted. The restriction has got rejected in all the samples except in case of VSOTM but on the flip side the value of Adjusted R^2 is too low to consider this single case. Thus, it can be said that Indian option market needs to get mature.

The results in the Table 6 are for the Hypothesis 3. The results try to indicate whether the implied volatility is an unbiased estimator of future volatility in comparison to the historical volatility. The regression results confirm the results of hypothesis 1 which indicated that Implied volatility contain information for future volatility. It can be observed that regression is satisfactory in case of DOTM, OTM options and options with long term to maturity. The restrictions set on the regression, $\beta_1=0, \beta_2=1$ and $\lambda=0$ should be accepted in order to prove the IV is the unbiased estimation of future volatility. As it is quite evident in table 6 the restriction has been rejected in case of all the samples, which indicates the implied volatility is not an unbiased estimator of the future volatility.

Table 5: Results of the Regression Analysis for the equation 2

	Coefficient	S.E.	t-statistic	p-value	Adj. R2	F-statistic	p-value
VSDOTM							
α_2	0.575912	0.012876	44.73	2.46E-05	0.9768	169.673	0.000977
β_2	0.607557	0.046642	13.03	0.001			
VSOTM							
α_2	0.397037	0.045619	8.703	4.59E-14	0.0093	0.9962	0.320481
β_2	0.120877	0.121101	0.9981	0.3205			
VSATM							
α_2	0.129356	0.003851	33.59	1.58E-171	0.30985	502.952	2.90E-92
β_2	0.355213	0.015839	22.43	2.90E-92			
VSITM							
α_2	0.14712	0.012986	11.33	4.43E-25	0.0895	31.1848	5.18E-08
β_2	0.376519	0.067424	5.584	5.18E-08			
VSDITM							

(Continued)

α_2	0.095242	0.015051	6.328	1.55E-09	0.20268	53.1129	6.77E-12
β_2	0.538366	0.073872	7.288	6.78E-12			
SDOTM							
α_2	0.687832	0.06433	10.69	2.42E-17	0.1079	11.2815	0.00117
β_2	0.672195	0.20013	3.359	0.0012			
SOTM							
α_2	0.166402	0.011016	15.11	2.17E-44	0.15142	116.814	3.79E-25
β_2	0.425771	0.039394	10.81	3.79E-25			
SATM							
α_2	0.132406	0.004051	32.69	3.77E-198	0.0884	267.985	1.55E-57
β_2	0.355933	0.021743	16.37	1.55E-57			
SITM							
α_2	0.163181	0.007266	22.46	6.99E-86	0.0592	48.444	7.41E-12
β_2	0.262025	0.037646	6.96	7.41E-12			
SDITM							
α_2	0.095087	0.013775	6.903	4.56E-11	0.2783	93.55	6.89E-19
β_2	0.602929	0.062334	9.673	6.89E-19			
MDOTM							
α_2	0.541256	0.027207	19.89	6.71E-59	0.037	14.1792	0.000195
β_2	−0.256901	0.068224	−3.766	0.0002			
MOTM							
α_2	0.140625	0.004359	32.26	1.32E-184	0.20162	512.155	2.88E-101
β_2	0.414297	0.018307	22.63	2.88E-101			
MATM							
α_2	0.126543	0.002884	43.88	0	0.11252	712.448	7.22E-148
β_2	0.411253	0.015408	26.69	7.22E-148			
MITM							
α_2	0.155046	0.004628	33.5	1.57E-192	0.08385	169.515	7.22E-148
β_2	0.309245	0.023752	13.02	3.91E-37			
MDITM							
α_2	0.100438	0.010087	9.957	4.53E-21	0.309943	186.501	2.75E-35
β_2	0.650682	0.047646	13.66	2.75E-35			
LDOTM							
α_2	0.34935	0.026298	13.28	2.41E-33	0.01989	8.7349	0.003316
β_2	0.214343	0.072524	2.955	0.0033			
LOTM							
α_2	0.103787	0.004644	22.35	1.22E-98	0.245778	633.839	2.87E-121
β_2	0.594891	0.023629	25.18	2.87E-121			
LATM							
α_2	0.128206	0.002941	43.6	0	0.1827	778.511	9.03E-155

(Continued)

β_2	0.412623	0.014788	27.9	9.03E-155			
LITM							
α_2	0.125874	0.003835	32.82	2.03E-177	0.2137	397.928	1.76E+78
β_2	0.394171	0.01976	19.95	1.76E-78			
LDITM							
α_2	0.09573	0.006634	14.43	3.09E-40	0.32	258.969	5.48E-48
β_2	0.573473	0.035636	16.09	5.48E-48			

The results are similar to those found by Canina and Figlewski (1993), Day and Lewis (1992), Lamoureux and Lastrapes (1993) and are opposite to what is found out by Jorion (1995); and Christensen and Prabhala (1998).

Table 6: Results of the Regression Analysis for the equation 3

	Coefficient	S.E.	t-statistic	p-value	Adj. R2	F-statistic	p-value
VSDOTM							
α_3	0.430498	0.017426	24.7	0.0016	0.99986	307678	3.25E-06
β_3	0.128039	0.015336	8.349	0.014			
λ_3	0.476763	0.013783	34.59	0.0008			
VSOTM							
α_3	0.363105	0.042259	8.592	8.64E-14	0.04975	299.97	2.47E-57
β_3	0.093981	0.041169	2.283	0.0245			
λ_3	0.152039	0.097984	1.552	0.1238			
VSATM							
α_3	1.00035	0.001284	779	0	0.11872	67634	0
β_3	0.018913	0.001552	12.18	3.54E-32			
λ_3	0.010722	0.005487	1.954	0.0509			
VSITM							
α_3	0.131363	0.010308	12.74	4.11E-30	0.607089	52440.3	0
β_3	0.042527	0.007597	5.598	4.84E-08			
λ_3	0.343876	0.060735	5.662	3.46E-08			
VSDITM							
α_3	0.105081	0.016186	6.492	6.37E-10	0.2157	32485.6	6.48E-272
β_3	–0.00985231	0.005628	–1.751	0.0815			
λ_3	0.55871	0.073384	7.613	9.88E-13			
SDOTM							
α_3	0.413977	0.068993	6	4.96E-08	0.57609	986.558	8.83E-65
β_3	0.226697	0.022961	9.873	1.18E-15			
λ_3	0.352944	0.192295	1.835	0.07			
SOTM							
α_3	0.008986	0.011101	0.8095	0.4185	0.40802	243.529	9.85E-106
β_3	0.511351	0.03431	14.9	2.11E-43			

(Continued)

λ_3	0.2995	0.03083	9.715	6.46E-21			
SATM							
α_3	0.066232	0.004752	13.94	1.06E-42	0.180146	289.993	1.90E-163
β_3	0.387348	0.021724	17.83	2.31E-67			
λ_3	0.230885	0.021266	10.86	6.47E-27			
SITM							
α_3	0.143272	0.008161	17.56	4.50E-58	0.261741	32816.7	0
β_3	0.052134	0.005264	9.904	8.10E-22			
λ_3	0.426789	0.034295	12.44	1.86E-32			
SDITM							
α_3	0.102734	0.0156	6.586	2.87E-10	0.281252	8299.63	1.84E-240
β_3	0.012007	0.011206	1.071	0.285			
λ_3	0.619946	0.063686	9.734	4.58E-19			
MDOTM							
α_3	0.06094	0.022872	2.664	0.0081	0.621253	149.876	9.02E-62
β_3	0.878501	0.037184	23.63	1.48E-73			
λ_3	0.026124	0.025812	1.012	0.3122			
MOTM							
α_3	0.016366	0.00484	3.382	0.0007	0.444157	359.838	3.09E-187
β_3	0.628239	0.021745	28.89	6.07E-154			
λ_3	0.164127	0.01742	9.422	1.17E-20			
MATM							
α_3	0.075875	0.0031	24.48	8.16E-126	0.193244	581.256	0
β_3	0.406561	0.015756	25.8	7.72E-139			
λ_3	0.154729	0.013934	11.1	2.34E-28			
MITM							
α_3	0.069326	0.005676	12.21	4.83E-33	0.2362	690.948	9.65E-301
β_3	0.410031	0.022425	18.28	9.38E-69			
λ_3	0.116622	0.02072	5.629	2.10E-08			
MDITM							
α_3	0.104684	0.011233	9.319	7.25E-19	0.286841	4388.07	0
β_3	0.005374	0.012928	0.4157	0.6779			
λ_3	0.610631	0.048055	12.71	1.97E-31			
LDOTM							
α_3	0.051731	0.027136	1.906	0.0574	0.416	3.74304	0.01129
β_3	1.09462	0.070071	15.62	8.06E-43			
λ_3	0.015049	0.048371	0.3111	0.7559			
LOTM							
α_3	0.003774	0.004283	0.8813	0.3783	0.52545	14.366	2.94E-99
β_3	0.862876	0.025281	34.13	2.19E-200			

(Continued)

λ_3	0.116634	0.019073	6.115	1.16E-09			
LATM							
α_3	0.040766	0.002651	15.38	1.08E-51	0.502961	199.042	3.99E-119
β_3	0.645025	0.014851	43.43	0			
λ_3	0.123438	0.011502	10.73	1.86E-26			
LITM							
α_3	0.042591	0.003992	10.67	1.22E-25	0.5256	576.571	4.95E-247
β_3	0.491676	0.018415	26.7	3.43E-128			
λ_3	0.170667	0.016565	10.3	4.46E-24			
LDITM							
α_3	0.056601	0.009811	5.769	1.33E-08	0.3421	1650.97	2.55E-273
β_3	0.125559	0.023695	5.299	1.69E-07			
λ_3	0.521535	0.037045	14.08	1.26E-38			

Observing the magnitude of coefficients, it is found that the implied volatility overestimates the future volatility and the extent of biasedness increases with the increase in time to expiry. Thus, it can be said that the implied volatility has the power to anticipate the direction of future volatility correctly but with a bias of over predicting it. The overestimation results are also found by Gwilym and Buckle (1999). It is also observed that in some cases the Adjusted R^2 was considerable but the restrictions were not confirming it, which indicated the overestimation of volatility by the implied volatility. The results can be supported with the argument of Figlewski (2004) that implied volatility may not pass the rationality test tested through restrictions even though it may contain significant information about future volatility is a signal that in case of implied markets are not efficient.

Conclusion

The results have indicated that the implied volatility provides information for the future volatility. It has also been found that Indian options market needs to improve upon in case of informational efficiency of implied volatility i.e. the ability of implied volatility to discover the future volatility is not better than that of the historical volatility. Moving along with the lines of efficiency it has been found that implied volatility overestimates the future volatility and the degree of biasness increases with increase in time to expiry. So the directional efficiency of implied volatility is correctly specified but with over-prediction in magnitude of future volatility.

It was observed that implied volatility in Indian context could be better employed to assess the direction of future volatility but in case of magnitude estimation of future volatility, implied volatility did an overestimation and had a biased estimation. It was also found implied volatility did not have as explanatory power as compared to historical volatility which indicated that Indian options market still needed to mature in order to capture all the information content in implied volatility so as to enhance the efficiency in price discovery of underlying assets through derivatives.

Limitations of the Study and Scope for Future Research

One main limitation of the study is that it has focused on the implied volatility obtained from index call options. Index is further based on stocks, so the results may vary in case of individual stocks. The study has assumed the impact of holidays on the stock exchange as constant. Further research can be carried out by considering different stocks and by employing conditional volatility measures for calculating the future volatility.

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