An Analysis Of Variations Of Implied Volatilities Of A Selected Sample Of Indian Call Options

Dr. DEBASIS BAGCHI*

Abstract

In India trading in derivatives is recently introduced. Market Regulators find volatility in Indian market is much higher than in developed market. The higher volatility induces investors to buy Call options since they are willing to pay higher premium. This paper seeks to understand what are the causes of volatility. We, therefore, examine the implied volatility (calculated using Black-Scholes model) of Call options of a sample of largest traded option stocks in India. We use volume of options traded, strike price, option premium and stock price in various combinations as variables in our analysis. Our investigation yields mixed results. In certain cases, the mean volatility of in-the-money call options is higher than that of, out-of-the-money call options while in other cases opposite results are observed. The regression analysis finds that the volume of traded option has a significant negative relationship on the implied volatility. The ratio of strike price plus premium to stock price is also found to be negatively related to implied volatility. We also find positive relationship of these two variables on implied volatility in some cases. The results are similar to the findings of Rubenstein. The reasons for the contradictory results are not clear but may perhaps be due to fluidity of general political and economic condition prevailing in India during the period under study. This may have led to asymmetric behaviour on the part of the investors. We, however, find premium-volume differential of the call options is positively related to the volatility of all the sample stocks.

Key words : Implied Volatility, Trading Volume, Strike Price, Call Options Premium, Black-Scholes Model.

JEL Classification code : G13, G14.

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* BENGAL ENGINEERING COLLEGE DEEMED UNIVERSITY
HOWRAH – 711103, INDIA
E-mail : dbagchi2000@yahoo.co.in

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Introduction

The derivative trading is recently introduced in Indian capital market. The procedural and regulatory norms for the market are being evolved. In the recent past, the regulatory authority in India set up a research group for the purpose of advising the authority on derivative trading. The group, called JRV group, observed that volatility in Indian market is quite high as compared to developed markets and also that volatilities are not constant but vary over time. The group also suggested a margin fixation methodology and an initial methodology for volatility estimate via an exponential moving average method. In a nascent market, which is in a developing stage, the sources of high volatility are not precisely known, perhaps because of interplay of several economic variables on the stock price.

Several research studies found option trading improved the efficiency of the underlying assets market. Studies also found that the derivative market is primarily dependant on cash (equity) market and options played a positive role in making an incomplete market a complete one. Empirical studies investigating effects on options trading on stock price behaviour reported various characteristics. Easley et.al (1998) found that stock price and option trading volumes are complementary and different volumes of options trading by the informed traders gave rise to favourable and adverse reactions on the price of the underlying stock. It is of importance, therefore, to understand behaviour of volatility related to underlying assets prices.

The volatility can be calculated on the basis of historical prices and also on the basis of volatility implied by an option traded in the market. Although results are inconclusive, general consensus seems to favour the notion that implied volatility is a better measure for option pricing than pricing based on historical volatility. The reasons for variations of implied volatilities are still not clear. However, it is reasonable to believe that option trading volume, strike price, option premium and stock prices play some roles in the variations of the implied volatilities of the stock. This study, therefore, focuses on the cross-sectional impact of option trading volume; strike price and premium of the options on the volatility of the underlying stock prices. The rest of the paper is organized in the following way. In section-II, we present survey of existing research studies, while in section III, methodology, data and the model used in the study are explained. In section-IV, the experimental results are documented and discussed. The section-V, concludes the study.

Literature Survey

There is a large volume of research studies in the area of volatility of stock prices. Chiras and Manester (1978) using Chicago Board Options Exchange data found implied volatility as a better forecast measure than the historical volatility, during the lifetime of the options. Klomsky (1978) reported differential variations of stock prices during the period between in and after expiration week of the options. Danthine (1978) reported reduced volatility due to existence of future markets. Ross (1989) found evidences that increase of volatility of asset prices are linked to increased flow of information. Manster and Rendleman (1982) reported strong positive linkage between option market and stock market and argued that option prices reflect additional information vis-à-vis stock prices. MacBeth and Merville (1979) examined different call options of the same stock and compared their implied volatilities. They found high implied volatility for in-the-money options and low volatility for out-of-the-money options. Rubenstein (1989) following Macbeth and Merville documented mixed results. The total period of study is divided into two equal time period and the two sub-periods give opposite results relating to volatility.

The results of the study on the impact of listing options in the exchange are reported by various researches. Wayes and Tennenbrum (1979) found option listing catalyzed and increased the volume of underlying assets trading. Kumar et.al (1975) documented increase of trading volumes of underlying stock after introduction of stock options trading. Several other researches, e.g., McCann and Weble (1994), Bollen (1998) reported inconsistencies in the direction of volatility effect over time. Skinner (1989) reported that introduction of options helped in stabilizing the trading of the underlying stock. .Detemple and Jorin (1990) investigated reverse impact of option trading, i.e. impact on volatility following delisting of options and found among other things, reverse of listing effect on the stock price and stock volatility. Cao (1999) on the other hand reported that introduction of derivatives reduces price volatility and he argued that this is due to availability of more information. It seems that the fundamental assessment of volatility effect is still remained incomplete and inconclusive.

Methodology

As may be observed from the earlier studies that sources of volatility measures are unknown due to presence of some unidentifiable economic variables. However variation of volatility may be the cause of factors, like, trading volume, strike prices, option premium etc. The answer may be partially found in Black-Scholes model, but investigation in that direction may not lead to logical conclusion. Since, our effort is to explain whether volatility could be explained cross-sectionally by the known market information, we seek to develop a model via multiple regression analysis. The basic model is as follows:

$$Y_{ti} = \alpha_{ti} + \beta_{1ti} X_{1ti} + \beta_{2ti} X_{2ti} + \beta_{3ti} X_{3ti} + \varepsilon_I \qquad (1)$$

Subject to,

$E(\varepsilon_i) = 0$,

$V(\varepsilon_i) = \sigma^2$ for all i

ε_i and ε_j are independent for all $i \neq j$

ε_i and X_j are independent for all i and j

ε_i are normally distributed for all i

There are no linear dependencies in the explanatory variables,

and where :

Y_{ti} = Implied volatility of option i at time t

α_i = intercept

X_{1ti} = Natural logarithm of the traded Call option volume (in INR thousand) of the option *i* at a given strike price at time *t*

X_{2ti} = Strike price of Call option *i* at time *t* plus premium of the same strike price option *i to* Stock price of *i* at the time *t*

X_{3ti} = Natural logarithm of premium of Call option *i* at time *t* at a given strike price to trading volume (in INR thousands) of the same traded option at time *t*.

β_{1ti}, β_{2ti} and β_{3ti} are regression coefficients and ε_I is the error term.

Independent variables :

There are three independent variables in the equation (1). The logarithm of the traded volume is likely to reveal how far volume of option trade affects the volatility of a stock. A positive coefficient would mean higher trading volume leading to higher volatility, while a negative coefficient would mean higher volume leading to lower volatility.

The second variable, i.e. ratio of strike price and premium of the option to stock price is a proxy measure to assess the behaviour of risk of the stock at a given time. It shows variation of option cost (strike price + premium) with respect to stock price.

The third variable, i.e. option premium to volume of option is a measure that shows whether changes in premium relative to changes in volume of traded option affect the volatility. A positive co-efficient will mean that investors are not indifferent to premium-volume differential and price volatility of the stock is also induced by this variable.

The implied volatility is calculated using Black-Scholes model on the basis of various strike prices of the individual options with respect to a given expiration day of the option. We consider only the Call options volatility because Indian market is characterized by high volatility, which makes Call options attractive and investors are expected to pay higher premium on Call options that have greater volatility.

Data

We select three largest traded Call options stocks, viz. Reliance Industries, State Bank of India and TISCO. The data on options are collected for four consecutive trading days, i.e. 5^{th} to 8^{th} April, 2004 and also on 27^{th} April, 2004, which is the option expiration day. The data include strike price, volume of trade in thousand of Indian rupees, closing Call option premium and opening and closing stock price. The data are collected from National Stock Exchange website and from the newspapers. The Black-Scholes model is used, since it is easy to use and implied volatility calculated from stochastic models are found to yield results that are very similar to Black-Scholes.

Discussion of Results

In table-1, the descriptive statistics of the implied volatility of the total sample and the individual companies for different Call options in respect of in-the-money Calls and out-of-the-money Calls are shown. It is observed that in respect of State Bank of India, the out-of-the-money Call options have slightly higher volatility (mean 30.20%) and in-the-money Call options have lower volatility (mean 27.47%). These findings support MacBeth and Marville results. However, for other companies, namely, Reliance and TISCO, the implied volatility is higher for the in-the-money Call options with mean 74.84% and 72.47% respectively, while for out-of-the-money Call options, the respective means are found to be lower at 47.22% and 56.44%. The mixed results point to the fact that the characteristic biases of the variables that affect volatility in Indian market are not clearly understood.

In table-II, correlation coefficients of the regression variables are shown. We observe correlation coefficients are statistically significant for different measure for each individual company. For instance, the correlation coefficient between the ratio of strike price plus premium to stock price (SM) and logarithm of premium to volume (LPV) is significant for Reliance Industries, while for State Bank of India correlation between logarithm of volume traded (LV) and LPV is significant. Similarly for TISCO, the significance is observed for correlation coefficient between volatility and SM. It seems, therefore, volatility is affected by the market parameters, in a different manner for different companies. It is, therefore, difficult to extract exact natures of biases that affects variations of volatility in Indian market. However, results are consistent with the earlier research findings.

Multivariate Analysis :

The table-III shows the results of regression analysis. The explanatory power of the regression model is low. In respect of Reliance Industries the R^2 is highest being 54%. (Adjusted R^2 is 49.8%) , while for State Bank of India the R^2 is found to be lowest being 24.8% (Adjusted R^2 is 11.6%). The F-statistic for all the companies and for the whole sample are significant while D-W statistic are modest. Analysis reveals that the log of volume (LV) as well as ratio of strike price and premium to stock price (SM) are good explanatory variables for estimating volatility. Regression coefficients of both the variables are negative and statistically significant. However, as may be observed, that for State Bank of India, the coefficients are positive and statistically insignificant. It is , therefore, imperative to draw inference at this stage that investors view higher volatility in case of Reliance Industries and TISCO as an indicator of lower cut-off between total cost of option and future stock prices that leads to higher volume of trade, while for State Bank of India, the investors estimate that higher volatility would lead to just the opposite process. In fact, in-the-money call options are found to have higher implied volatilities in the two former cases while same (in-the-money) Call options are found to have lower implied volatilities for the latter company, i.e. State Bank of India. The reverse assessment of the investors may be due to the underlying political and economic conditions prevailing in India during the period under study. India was undergoing election and macroeconomic policies of the Indian government were in a volatile state. In such a fluid situation, investors, as a result behaved, on the basis of two extremities of positive expectations and negative expectations leading to what has been observed in the analysis.

The logarithm of option to traded volume of the said call option has positive relationship on the volatility in all cases, signifying thereby that investors view premium-volume differentials as an important indicator for predicting volatility. It also shows that lower premium does not induce an investor to buy the Call. The decisive aspect is the trade-off between strike price and stock price. The adjusted R^2 s for all the models are found to be low. It appears therefore that model could explain relatively low percentage of variations in the volatility of stock prices.

Conclusion :

The implied volatility of stocks in Indian market is reported to be high. The high volatility would induce the investors to pay high premiums on options and accordingly Call options would be attractive for buying. We investigate implied volatility behaviour of Call options of three most traded Call options stocks in the Indian market. We find mixed results. The mean volatility in-the-money Call options is higher and out-of-the-money Call options is lower for two stocks, while it is reverse for the reminder stock. The correlation coefficients amongst the various variables show that volatility is affected in a different manner for different companies. The regression analysis shows that the trading volume of options has a significant negative impact on the implied volatility. In addition . strike price and premium with stock price parity has a negative relationship with the implied volatility, although relationship is not statistically significant. The above relationships are observed for two stocks, while, it is found to be just the opposite for the third stock, i..e. the State Bank of India. The reason for such behaviour may perhaps be due to the underlying political and economic conditions prevailing in India, during the period under study. In a fluid economic situation, investors behave in extremities of uncertainties, leading to the observed phenomenon. On the other hand Call options premium-volume differentials have positive influence on the implied volatility in all cases, implying that lower premium does not, but the trade-off between strike price and stock price, induce an investor to buy the Call.

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Table-1

Descriptive Statistics Of Implied Volatility

The implied volatility of the stock prices in percentage is calculated through the application of Black-Scholes model on per annum basis from volatility per trading day using the formula :

$$\text{Volatility per annum} = \text{volatility per trading day} \times \sqrt{\text{number of trading days per annum (243 days)}}.$$

Total Sample :

	Minimum (%)	Maximum (%)	Mean (%)	Standard Deviation (%)
In-the-money-call Option	6.90	126.55	60.61	33.90
Out-of-the-money call Option	16.25	78.60	48.17	13.58

Individual Company Wise Data :

COMPANY		Minimum (%)	Maximum (%)	Mean (%)	Standard Deviation (%)
Reliance Industries	In-the-money-call Option	10.00	126.55	74.84	43.36
	Out-of-the-money call Option	26.36	63.90	47.22	10.52
State Bank of India	In-the-money-call Option	6.90	52.85	27.41	13.06
	Out-of-the-money call Option	16.25	38.45	30.20	6.52
The Iron & Steel Co. Ltd.	In-the-money-call Option	43.57	111.50	72.47	24.01
	Out-of-the-money call Option	39.95	78.60	56.94	10.05

Table-II

Descriptive Statistics Of Implied Volatility

The implied volatility of the stock prices is calculated through the application of Black-Scholes model. The LV, i.e. of option trading volume, is expressed as the log value of the quantum in thousands of Indian rupees. The SM is calculated as the strike price of a call option plus premium of the same call option on a particular date divided by the mean price of the stock taken as the arithmetic average of the opening and closing prices on that particular date. LPV is the logarithmic value of the premium amount of a call option on a particular date divided by its trading volume in thousand of Indian rupees on that particular date. There are 452 observations.

Correlation Co-efficient:

Reliance Industries

	Volatility	LV	SM	LPV
Volatility	1	-.197	-.493	.318
LV		1	-.464	.253
SM			1	-.329 *
LPV				1

* Correlation significant at 1% level

State Bank of India

	Volatility	LV	SM	LPV
Volatility	1	-.318	.382	.399
LV		1	-.214	-.707 *
SM			1	.066
LPV				1

* Correlation significant at 1% level

TISCO

	Volatility	LV	SM	LPV
Volatility	1	-.197	.479 *	.208
LV		1	-.087	-.485*
SM			1	.008
LPV				1

* Correlation significant at 1% level

Whole sample

	Volatility	LV	SM	LPV
Volatility	1	-.139	-.451 *	.172
LV		1	-.280 *	-.345 *
SM			1	-.055
LPV				1

* Correlation significant at 1% level

Table –III

Heteroskedasticity Consistent Ordinary Least Squares (OLS) Estimates Of Volatility As A Function Of Market Parameters.

The implied volatility of the stock prices is calculated through the application of Black-Scholes model. The LV, i.e. of option trading volume, is expressed as the log value of the quantum in thousands of Indian rupees. The SM is calculated as the strike price of a call option plus premium of the same call option on a particular date divided by the mean price of the stock taken as the arithmetic average of the opening and closing prices on that particular date. LPV is the logarithm value of the premium amount of a call option on a particular date divided by its trading volume in thousand of Indian rupees on that particular date. t-values are given in the parentheses.

	Reliance Industries	**State Bank of India**	**TISCO**	**Whole Sample**
Intercept	418.327 (6.152)*	-33.808 (-.697)	260.969 (5.092)*	315.965 (7.628)*
LV	-8.488 (-4.431)*	0.282 (.173)	-1.780 (-1.198)	-3.932 (-3.500)*
SM	-315.049 (-5.106)*	58.222 (1.365)	-182.068 (-3.776)*	-234.577 (-6.383)*
LPV	2.460 (1.511)	1.918 (1.303)	1.089 (.835)	0.630 (.564)
R^2 Adjusted R^2 D-W Statistics	0.540 0.498 0.860	0.248 0.116 0.749	0.299 0.248 0.690	0.299 0.275 0.475
F-statistic	12.913	1.871	5.838	13.871

* Statically significant at one percent level.