CHAPTER 2

REVIEW OF LITERATURE ON IMPLIED VOLATILITY AND OPTION STRATEGIES.
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This chapter is discussed under the following headings:

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2.1 Volatility:

Volatility essentially refers to uncertainty arising out of price changes of shares. Volatility is one the inputs in a theoretical option pricing model which cannot be directly observed. But many option strategies require an accurate prediction of volatility. Therefore, an option trader needs some method of determining whether his/her expectations about Volatility are actually realized in market price.

2.1.1 Future volatility:

Future volatility is that which every trader wants to know, the volatility that best describe the future distribution of price of an underling contract. When future values can be accurately predicted then future volatility can be calculated and used in the theoretical pricing model to arrive at an accurate theoretical value but the uncertainly factor proves impractical to use future volatility.

2.1.2 Historical volatility:

Though future is unpredictable with certainty, one can make a wise guess about the future volatility from the historical data. The latter will serve as an attracting point to make an estimate of future volatility. Additional information will further help in arriving at a more
realistic figure for volatility. The two important parameters to be considered for calculation of historical volatility are historical period over which the volatility is to be calculated and the time interval between successive price changes. The longer the historical period the better the volatility characteristics for a contract a trader may have to examine a whole variety of historical time periods.

2.1.3. Implied Volatility:

In a theoretical option pricing model, the parameter values from historical data are substituted to arrive at a price. But this is not the most common way of computing the option price because it is difficult to measure the volatility of the underlying asset. Historical volatility may not be an accurate estimate and it changes over time. A direct measurement of volatility is, therefore, difficult in practice. Nevertheless, the option prices are quoted in the market. This implies that even if we do not know the volatility, the market knows it. For instance, consider the Black-Scholes formula the factors are interest rate, the price of the underlying asset, exercise price, time to expiry and the volatility of the rice of the underlying. Except volatility all the other parameters can be easily measured and are either quoted constantly or specified in the contract itself. Consider a call option since a call option price increase with volatility there is a direct
relationship between the two. One can take the option price quoted in the market and working backwards deduces the market’s opinion about the volatility of the option over the remaining life of the option. This is called implied volatility arrived from the quoted price of option is called the implied volatility.

The calculation of implied volatility is not direct and it should be arrived by trial and error. On an initial assumption of a particular value of volatility, the option price is calculated using Black-Scholes formula. If the calculated price is the same as the quoted price, then assumed volatility is the implied volatility; if not, the same procedure is repeated with another volatility data until we arrive at a value for which the calculated price equals the quoted price. One unusual feature of implied volatility is that it does not appear to be constant across exercise prices. That is, if the value of the underlying asset, the interest rate and the time to expiry are fixed the prices of options across exercise prices should reflect a uniform value for the volatility. But in practice, this is not the case, even puts and calls give slightly different implied volatilities. The following figure shows the implied volatility as a function of exercise price. It can be observed how the volatility of the options deeply in-the-
money is greater than for that at-the-money. This is called volatility smile or skew.

\[ \begin{align*}
\text{Figure 2.1. Smile Effect} \\
\sigma & \quad \text{Implied Volatility} \\
S & \quad \text{Strike Price}
\end{align*} \]

In practice, volatility is neither constant nor predictable for time scales of more than a few months; this limits the validity of any model that assumes the contrary. This problem may overcome by pricing options with implied volatility. Thus, one trading strategy is to calculate implied volatilities of all options on the same expiry date and then buy one with the lowest volatility and sell one with the highest volatilities with the belief that prices move in such a way that implied volatilities become more or less comparable and the trader makes a profit on his/her portfolio.
2.2 Causes of Volatility:

There are two main reasons for volatility on a stock price in the market:

i. Trading of the stock in the stock markets which implies that volatility will be more when the markets are operational as compared to the time when markets are closed.

ii. Information obtained by the investors about the expected future performance of the company or the stock, which affects the stock prices.

While these are two different assumptions about the reasons for volatility, various studies conducted on the subject implied that the volatility was mainly as a result of trading rather than information about future expected returns.

2.3 Factors influencing the option prices:

The value of an option depends on six factors:

(a) The spot price or current price of the underlying stock.

(b) The exercise price or strike price of the underlying asset.

(c) The time to maturity or time to expiration.

(d) Volatility of the underlying asset or volatility in the price of underlying asset.
(e) The risk free rate of interest.

(f) Dividends expected during the life of the option, in case of dividend paying stocks.

2.4 Review of literature:

The review of literature on implied volatility and option strategies reveals the following:

Anuradha Guru, (2009)\textsuperscript{5} presented the historical perspective in which derivatives have developed in India and present certain issues which have been widely debated in the context of these markets in India, while also presenting the international context of the debates. On their journey of innovation, derivatives have not been free from controversies. They have often been held to be too complex to comprehend. The leverage that these products provide to investors raises concern. Recently, the present global financial crisis is being attributed to the housing mortgages being repackaged and sold as collateralized debt obligations and other exotic derivative products to financial institutions, pension funds and individuals. Policy markers around the world are now having a relook as the problems being posed by derivatives viz. lack of homogeneous rules and accounting standards; the excessive freedom allowed to market players to innovate and the lack of complete statistics for exchange-
traded and OTC transactions. Leaders are talking about the need for more transparency and accountability in the functioning of derivative markets.

**Bennell and Suteliffe, (2003)** The most often challenged assumption is the normality of stock returns ignoring heteroscedasticity. As it was difficult to obtain a closed form of parametric solution, several nonparametric approaches were also tried, among which Artificial Neural Network (ANN) based models have emerged as a promising alternative.

**Black and Scholes (1973)** the valuation of options has generated tremendous interest among academics and investors alike, and a number of valuation models have been developed. The most popular model to date is the Black-Scholes which is based on the assumption that stocks continuously compounded rate of return follows a normal distribution. The model however, exhibits systematic biases from observed option prices. This model compared the theoretical value of option price (calculated from their Black and Scholes model) with the actual market prices and observed that “the model tends to overestimate the value of an option on a high variance security, market traders tend to underestimate the value, and similarly while the model tends to underestimate the value of an option on a low
variance security, market traders tend to overestimate the value”. The measure of stock return variance used in their study was the sample variance of historic stock returns. However they said that the divergences between the theoretical and actual prices were not substantial enough to be counted for economic importance as the transaction cost of trading in options lessened the potential profit.

Ghanathe Ramesh at al. (2013)\(^8\) observed that Derivative market (Future and Option) has increased drastically from 2001 to 2013 around 300 times and can further increase in future. This change affected by some factors like government policies budgets, bullion market, inflation, political condition. This study focuses much on the progress of derivative market in India which attracts the attention of scholars, research firms, and university, corporate to conduct more research in the relevant area to add to the literature.

Gupta Sheetal (2014)\(^9\) This study highlighted S&P CNX NIFTY call and put options for analysis for the sample period starting from January 1, 2003 through December 24, 2008. The objectives of study were to check whether implied volatility is a better predictor of volatility of future stock returns than historical volatility or not, to check whether there exists any correlation between historical volatility and implied volatility, to examine whether Black and Scholes model is
misspecified or not by investigating the existence of volatility smile in case of S&P CNX Nifty options traded at NSE and to examine the predictive accuracy of the Black-Scholes model in pricing the Nifty index option contracts. The result of this study showed that implied volatility is more efficient predictor of option prices than historical volatility and there is a significant and positive correlation between historical volatility and implied volatility in case of the near month call and put option contracts. The implied volatility graphs for different samples depict the shape of a ‘Smile’ which indicates that out-of-the-money options and in-the-money options are having high volatility values while near-the-money options are having low volatility values, The BS model provides pricing errors but pricing errors are less in the case of near-the-money call options, errors slowly increase as moneyness increases.

He attributed this to an increasing fear of another market crash like that in 1987, noted that, consistent with this hypothesis, low strike price option are priced higher (i.e., with higher implied volatilities) than are other options. The market prices these options as though there is bigger chance of large drop in the stock price than would be suggested by the Black-Scholes assumptions.
Isaac J. Faber and Kelsey Eargle. (2014) focused whether a superior forecast for security volatility can be derived by finding a balance between historical data, implied volatility and an empirical implied distribution. Data are evaluated from option contracts and historical prices sampled on the first trading day of every month over a five year period from 2007 to 2012. These data are analyzed to determine the value of a weighted combination of the three sources of information and to uncover if this approach provides a forecast with a higher correlation to realized volatility. A linear optimization solution is formulated to determine the best possible composite volatility forecast. The results of the test show that there is statistically significant evidence in which the composite volatility forecast is preferred at a 95% confidence level over individual forecasts. With a better predictor for security volatility, this optimization process could be applied to the creation of portfolios that better meet investor risk preference.

Jayapalan .C (2013) provided a simple option pricing model to traders and other market participants in the market, to enable them to quote the optimum price through market prices of the underlying stock with market Index, Nifty. The simplicity and ease of the proposed model may appeal to the traders, operators and other
market participants. Option prices produced by the proposed model are close to the actual price for varied range of strike prices. The Model works perfectly to call in-the-money, at-the-money, and near out-of-money.

Kawee Numpacharoen and Nattachai Numpacharoen (2013)\textsuperscript{12} purposed their research to derive a new algorithm for obtaining a realistic implied correlation matrix. One contemporary method has limited scope from its simplified assumption of equi-correlation matrix. However, the result of this limitation is not realistic and cannot be applied to most applications. Another existing method may produce the realistic correlation matrix that is not positive-semi define. To handle this problem, expand the existing algorithm to obtain the realistic implied correlation matrix by using the relationship between two implied volatility of the portfolio of the underlying. Once the realistic and valid implied correlation matrix is obtained, one can use this information in various applications such as portfolio optimization; stress testing, option pricing, dispersion trading, and so forth.

Kedarnath Mukjerjee and Mishra .R.K, (2004)\textsuperscript{13} The empirical findings of research confirms that the open interest based predictors are significant in predicting the spot price index in underlying cash
market in both the periods i.e., just after the initiation of the index option in the market and in the later sub period. But, as far as the volume based predictors are considered, it shows some changing evidence. Though insignificant just after the initiation, the volume based predictors have shown significant explanatory power in the later sub period.

**Macbeth and Merville (1979)**\(^{14}\) find that the B-S model under prices in the money options and overprices out of the money options. They also found that the volatility of the underlying stock decreases as the stock price rises.

**Madhu Sudan Kumar at el, (2013)**\(^{15}\) have used different simple methods to calculate the expected return and to interpret the annualized volatility. They have seen from the results that the same set of data gives variations in expected returns and affects the volatility. Their analysis shows that approximate value of option prices derived by different methods are very closed to the data of option price mentioned in Derivatives option trading at NSE.

**Mark Rubinstein (1994)**\(^{16}\) has pointed out that the performance of the Black-Scholes model has determined in recent years in the sense that options on the same stock with the same strike price that should
have the implied volatility actually exhibit progressively different implied volatilities.

**Mitra S. K. Dr. (2012)** He observed that stock index futures sometimes suffer from ‘a negative cost-of-carry’ bias, as future prices of stock index frequently trade less than their theoretical value that include carrying costs. Since commencement of Nifty future trading in India, Nifty future always traded below the theoretical prices. This distortion of future prices also spills over to option pricing and increase difference between actual price of Nifty options and the prices calculated using the famous Black-Scholes formula. Fisher Black tried to address the negative cost of carry effect by using forward prices in the option pricing model instead of spot prices. Black’s model is found useful for valuing options on physical commodities where discounted value of future price was found to be a better substitute of spot prices as an input to value options. In this study the theoretical prices of Nifty options using both Black Formula and Black-Scholes Formula were compared with actual prices in the market. It was observed that for valuing Nifty Options, Black Formula had given better result compared to Black-Scholes.

**Nejat Seyhun and Xuewu Wang (2012)** tested the prediction of standard option pricing models that there is no relation between past
stock returns and stock option prices. Using the individual stock options data, they showed that puts are significantly overvalued relative to calls after large stock price increases and calls are significantly overvalued relative to puts after large stock price decreases. This is exactly opposite to what they had observed in index options. They argued that it was the autocorrelation structure of the individual stock returns that drives this valuation effect, which has been shown to be both economically and statistically significant. Overall, their results suggest that past stock returns exert an important influence on individual stock option prices.

Peeyush Bangur and Dr. Sandeep Malu, (2014)\textsuperscript{19} investigated the relationship between daily returns open interest and trading volume for Nifty, an Index of National Stock Exchange of India. Findings of the study reveal that GARCH model is an appropriate model to forecast the volatility. The study finds that the persistency of volatility is very high and very less than unity, implying that current information can be used to predict future volatility. When open interest and trading volume is included in the analysis, the study reveals that the persistency of the volatility is present. The decomposition of volume into expected and unexpected component indicated component of volume significantly changes in volatility.
Puja Padhi (2011)\textsuperscript{20} examines the implied volatility linkages among the Asian, American and European stock markets. For this purpose, the study makes use of implied volatilities calculated from the market prices of stock index options from India (IVIX), Japan (VXJ), Hong Kong (VHSI), South Korea (VKSOPI), the US (VIX) and Germany (VDAX). The results of the study suggest that the US implied volatility index has substantial impact over the variations of other international implied volatility indices, thus raising the possibility of it constituting a usable risk factor for investors trading internationally; another issue here relates to abrupt changes in the VIX giving rise to potentially destabilizing contagion over volatility internationally. The implications of their results for India specifically at the market’s current state of financial development are, at first glance, comforting, since none of the examined volatility indices bears a notable impact over their Indian equivalent, a fact perhaps indicative of the market’s lag in terms of integration with the global financial system. However, their study suggest that integration expands with time.

Rekha Kala A.M. Dr. and Dr. Shyam Lal Dev Pandey, (2012)\textsuperscript{21} conducted study to analyze the feasibility of Black-Scholes-Merton differential equation model for stock option pricing in Indian stock exchanges. The result of the study can be used to predict the
suitability of using Black-Scholes-Merton differential equation model for stock option pricing in Indian stock exchanges. The result of the analysis found that Black-Scholes-Merton model is more useful in call option pricing than the put option pricing and also impact of timing is more relevant for the put option pricing than for call option pricing.

Robert E. Whaley (1982)\(^{22}\) examined the performance of the Black-Scholes formula relative to that of more complicated option formulas that allow for early exercise. His findings indicate that formulas allowing for the possibility of early exercise do better at pricing than the Black-Scholes formula. The Black-Scholes formula seems to perform worst for options on the stock with high dividend paying payouts. The true American call option formula, on the other hand, seems to fare equally well in prediction of option prices on stocks with high or low dividend payouts.

Sandeep Srivastava (2013)\(^{23}\) examines the role of certain non-price variable, open interest and trading volume, from the stock option market in determining the price of underlining shares in cash market. In order to examine the significance of these variables, he used the call and put option open interest and volume based predictors as given by Bhuyan and Yan (2002). The results show that these predictors have significant explanatory power with open interest.
being more significant compared to trading volume. The study provides deterministic parameters that can be used by the uninformed investors to predict the price of underlying shares using stock options market data and fortunate the profitable trading strategies based on it. Finally he provides support to the view that presence of option market improves the price discovery in underlying asset market.

**Sophie Xiaoyan Ni, Jun Pan, and Allem M. Poteshman, (2005)**

They presented that investors can trade on positive and negative information about firms in either the stock or the option market, and a well-developed literature examines the use of options to make directional trades. They also presented two additional results which each provide further confirmation for the proposition that the investors bring volatility information to the option market. First, non-market maker net volatility demand constructed from transactions which open new option positions is a stronger predictor of the future volatility of underlying stocks then net volatility demand constructed from transactions which close existing option positions. Second, the impact on option prices from each unit of net non-market maker volatility demand significantly increases as informational asymmetry intensifies in the days leading up to earnings announcements dates.
**Subrata Kumar Mitra (2006)** He opined that Black-Scholes (B-S) formula, a well-known model for pricing derivative securities, exhibits certain systematic biases from observed option prices in the market. In the study conducted by Subrata Kumar Mitra, an attempt was made to reduce the biases and improve the accuracy of option price estimation using Artificial Neural Networks (ANN). It is based on all Nifty call option prices quoted on National Stock Exchange for the period May 28, 2004 to June 30, 2005. It was found that the error between the quoted option prices and estimated option prices using the Black-Scholes formula reduces to a large extent, when the original formula is modified using an Artificial Neural Network model. The usefulness of ANN is also validated with out-of-sample data.

**Suman, (2011)** According to Suman in the absence of the empirical evidence, it would be difficult to know the behavior of the stock market volatility. While empirical tests of return-volatility behavior are plentiful for developed stock markets, the focus on developing and emerging stock markets has only begun in recent years the interest in these emerging markets has arisen from the increased globalization and integration of the world economy in general and that of financial markets in particular. The globalization and integration of these markets has created enormous opportunities
for domestic and international investors to diversify their portfolios across the globe. As a result, rigorous empirical studies examining the efficiency and other characteristics of these markets would be of great benefit to investors and policy makers at home and abroad. In this study an effort has been made to reevaluate the results of previous studies concerning the topic stock market volatility in developing countries so that a realistic conclusion can be drawn.

**Poon, Ser-Huang, and Clive W.J. Granger. (2003)** Financial market volatility is an important input for investment, option pricing, and financial market regulation. The emphasis of this review article is on forecasting instead of modeling; it compares the volatility forecasting findings in 93 papers published and written in the last two decades. Provided in this paper as well are volatility definitions, insights into problematic issues of forecast evaluation, data frequency, extreme values and the measurement of "actual" volatility. They compare volatility forecasting performance of two main approaches; historical volatility models and volatility implied from options. Forecasting results are compared across different asset classes and geographical regions.
2.5 Summary of the reviews:

2.5.1 Reviews on Black-Scholes Model

Dr. Rekha Kala A.M. and Dr. Shyam Lal Dev Pandey, (2012)\textsuperscript{28} conducted a study to analyze the feasibility of Black-Scholes-Merton differential equation model for stock option pricing in Indian stock exchanges. The result of the analysis found that Black-Scholes-Merton model is more useful in call option pricing than the put option pricing and also impact of timing is more relevant for the put option pricing than for call option pricing. Jayapalan.C (2013)\textsuperscript{29} provided a simple option pricing model to traders and other market participants in the market, to enable them to quote the optimum price through market prices of the underlying stock with market Index. The simplicity and ease of the proposed model may appeal to the traders, operators and other market participants. The outcome of the research is that the Black-Scholes Option pricing model is very simple and easy to use for option pricing. Mark Rubinstein (1994)\textsuperscript{30} has pointed out that the performance of the Black-Scholes model has determined in recent years that options on the same stock with the same strike price that should have the implied volatility actually exhibit progressively different implied volatilities. He attributed this to an increasing fear of another market crash like that in 1987, noted that, consistent with
this hypothesis, low strike price option are priced higher (i.e., with higher implied volatilities) than are other options. The market prices these options as though there is a bigger chance of a large drop in the stock price than would be suggested by the Black-Scholes assumptions. According to the study pricing decision can be taken by using implied volatility. Robert E. Whaley (1982) examined the performance of the Black-Scholes formula relative to that of more complicated option formulas that allow for early exercise. His findings indicate that formulas allowing for the possibility of early exercise do better at pricing than the Black-Scholes formula. The Black-Scholes formula seems to perform worst for options on the stock with high dividend paying payouts. The true American call option formula, on the other hand, seems to fare equally well in prediction of option prices on stocks with high or low dividend payouts. According to him Black and Scholes model does not perform well when the dividend pay-out ration of the company is very high.

**2.5.2 Reviews on volatility and implied volatility:**
Isaac J. Faber and Kelsey Eargle (2014) focused on superior forecast for security volatility can be derived by finding a balance between historical data, implied volatility and an empirical implied distribution. Kawee Numpacharoen and Nattachai Numpacharoen (2013) purposed their research to derive a new algorithm for obtaining a
realistic implied correlation matrix. One contemporary method has limited scope from its simplified assumption of equi-correlation matrix. However, the result of this limitation is not realistic and cannot be applied to most applications. Another existing method may produce a realistic correlation matrix that is not positive-semi define. To handle this problem, they expanded the existing algorithm to obtain the realistic implied correlation matrix by using the relationship between two implied volatilities of the portfolio of the underlying assets. According to them realistic and valid implied correlation matrix provides information in various applications such as portfolio optimization; stress testing, option pricing, dispersion trading, and so forth. Puja Padhi (2011)\textsuperscript{34} examines the implied volatility linkages among the Asian, American and European stock markets. For this purpose, the study makes use of implied volatilities calculated from the market prices of stock index options from India (IVIX), Japan (VXJ), Hong Kong (VHSI), South Korea (VKSOPI), the US (VIX) and Germany (VDAX). The results of the study suggest that the US implied volatility index has substantial impact over the variations of other international implied volatility indices, thus raising the possibility of it constituting a usable risk factor for investors trading internationally; another issue here relates to abrupt changes in the VIX giving rise to potentially destabilizing contagion over volatility
internationally. The implications of their results for India specifically at the market’s current state of financial development are, at first glance, comforting, since none of the examined volatility indices bears a notable impact over their Indian equivalent, a fact perhaps indicative of the market’s lag in terms of integration with the global financial system. Madhu Sudan Kumar at el, (2013)\textsuperscript{35} has used different simple methods to calculate the expected return and to interpret the annualized volatility. They have seen from the results that the same set of data gives variations in expected returns and affects the volatility. Their analysis shows that approximate values of option prices derived by different methods are very close to the data of option price mentioned in Derivatives option trading at NSE.

On review of the literature, it is found that there are different models for measurement of volatility and determination of option prices but very less of research is available on selection of option strategies by using volatility based models; therefore, the present study focus on implied volatility by using Fischer Black and Myron Scholes model developed in the year 1973 for call option\textsuperscript{36}. The present study adds to the literature as how the traders and investors can enter into option contract by using volatility based strategies to maximize net option pay-offs.