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Review Article

Preidictive Power of Implied Volatility

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Abstract

Volatility prediction has been one of the most crucial topics in the hallways of financial markets. It is of vital significance in the areas of risk management, asset pricing and financial decision making process for several stakeholders. Many volatility models prevail for predicting future volatility but one of the most intriguing methods is the implied volatility which is mainly a market-centered volatility forecast. Present study is an attempt to know the suppositions of various researchers transversely assets and markets that have tested the predictive abilities of the implied volatility in order to understand its supremacy as compared to the other models.

Keywords: Volatility, implied volatility, asset pricing, moneyness, call options, put options, measurement errors, historical volatility.

INTRODUCTION

Volatility prediction has been one of the most investigated and critical issue confronted by various researchers and practitioners in financial market corridors. To deal with the issue, researchers have introduced countless number of models in the past, based on various assumptions and market setups. These models aid various stakeholders to predict the future volatility of an asset with various degrees of preciseness. A new way of predicting volatility was later on introduced where, given a model, the volatility can be impliedly calculated from the price of an asset observed in a real market. This volatility is called implied volatility. In other words, implied volatility is professed as a market's expectation of future volatility, and is thus a market-centered volatility forecast. Various studies have tested the predictive ability of implied volatility across markets for several assets. These tests have been performed more in markets of developed countries as compared to the developing countries. The present study is an attempt to analyze and review these studies in order to know the predictive ability of the implied volatility.

Implied volatility

Implied volatility is a market-built forecast. It is generally derived through price of an option contract. To know the implied volatility from an option contract, one needs to use an option pricing model (like Black and Scholes model which was the first model introduced to calculate an option's value through a simple equation). Option pricing models use information about certain variables, out of which one being volatility of the underlying asset, in order to provide the theoretical value of the option contract. If now the price of an option contract is observed from the real market, then the volatility can be known iteratively through the model. This volatility is known as implied volatility which is implied in the option contract price publicized in the market. One can take the Black and Scholes option pricing model or any other acceptable option pricing model to extract the implied volatility from the given parameters. Given an observed European call option price C_o for a contract with strike price K and expiration date T, the implied volatility σ_{iv} is defined as the volatility input to the, say, Black and Scholes (BS) formula such that

$$C_{BS}(t, S; K, T; \sigma_{iv}) = C_o$$

Where, C_{BS} is the fair value of the option calculated from the BS model. The option implied volatility is often interpreted as a market's expectation of volatility over the option's maturity, i.e. the period from t to T. Suppose that the true (unconditional) volatility is σ over a period T. If BS model is correct, then

$$C_{BS}(t, S; K, T; \sigma_{iv}) = C_{BS}(t, S; K, T; \sigma)$$

For all strike prices. That is the graph of $\sigma_{iv}(K)$ against K for fixed t,S,T and r, observed from option prices mirrored in the market should be a straight horizontal line. But, it is well known that the Black and Scholes σ_{iv} differ across strikes. And variation across strike prices has been indicative of a shape like a smile (instead of a horizontal line) when one plots the BS implied volatility σ_{iv} against strike price K.

OBJECTIVES OF THE STUDY

The main objective of the present paper is to review the findings of various researchers in respect of implied volatility measurements for various products in the stock market across nations. This analysis is done to address the following aims:

1. To review literature on predictive power of implied volatility as compared to other volatility models.
2. To review literature on the shape of the implied volatility when plotted against strike prices.
3. To review the existing literature on implied volatility calculations and weighing schemes.

REVIEW OF LITERATURE

1) Articles on weighing schemes and calculation of implied volatilities:

If the assumptions underlying any option pricing model, were completely obligatory and the option markets were absolutely efficient, then on any particular date all options on a specific stock would be priced to give the same daily standard deviation. But in realism this is not frequently the case even in a market which is highly efficient. This is because some options are more dependent upon a precise measurement of the standard deviation than others. For example, for ITM options with little time to maturity, an exact measurement of the standard deviation hardly matters. However, for other types of options it may be very essential. Since synchronous option prices of different strike prices and maturity yield different standard deviations, multifarious schemeshave been proposed for amassing the information from different options into a single volatility assessment. Mostly weighing schemes dispense equal weights to in- and out-of-the-money options, and maximum give heavier weights to near-the-money options. Few exceptions are there like the Chiras and Manaster (1978), where attention on percentage pricing errors result in the heaviest weight dropping on the deepest out-of-the money call and put options. Given time-varying volatility, it is desirable to construct maturity-specific implicit volatilities from all options having common maturity. Various studies, nonetheless, pool through maturities.

So as per the BS model's money ness-and-maturity related biases, researchers have tried to discover techniques to "live with a smile". One tactic suggested by Bakshi Cao and Chen (1997) is using "implied - volatility matrix". For example the option to be evaluated is ITM and has three months to expiration, one can use as input to the BS formula the volatility implied by three months calls of similar money ness. Each time one can estimate via any one of the six alternate collections of call options traded on a given day included in the matrix: ST calls, MT calls, LT calls, OTM calls, ATM calls and ITM calls. These maturity-based or money ness-based parameter estimates are then applied to price or hedge options in the corresponding maturity or money ness category. Some studies are presented in more details in the following paragraphs.

Latane and Rendleman (1976) initially suggested the estimation of standard deviation of the stock rate of return by the implied standard deviation (ISD) on the assumption that investors behave as if they price options according to BS model. Their data set consisted of weekly closing option and stock prices of twenty four companies whose options traded on Chicago Board of Options Exchange for 38 weeks beginning October5, 1973 and ending June28, 1974. They calculated the ISD's for all options written on a particular stock and used the weighted average of the ISD's (WISD) as estimators of return variability. The form of weighting system used by them was:

$$\text{WISD} = \left[\sum_{j=1}^{N} ISD_{ijt}^{\;2} d_{ijt}^{\;2}\right]^{0.5} \left[\sum_{j=1}^{N} d_{ijt}\right]^{-1} \qquad \text{--------------- [1]}$$

Where

$WISD_{it}$= weighted average implied standard deviation for company i in period t, i=1 to 24, t =1 to 39.

ISDijt= implied standard deviation for option j of company i in period t

N = the number of options analyzed for company i and is always greater than or equal to 2.

d_{ijt}= partial derivative of the price of option j of company i in period t with respect to it's ISD using the Black and Scholes model.

The weekly hedge returns were calculated separately for over and undervalued options for various criteria for option selection and hedge- ratio determination. The criteria used were individual option's ISD, the underlying stock's WISD, and the ex-post time series standard deviation. The strategy, based upon the historical series of rates of return, was considered to be a naïve strategy against which the returns generated from the use of the WISD could be compared. Under the assumption that the WISD is the proper measure of the standard deviation, Latane and Rendleman expected absolute higher return for strategies employing WISD. They find all the portfolios employing WISDs to produce significant (at 5 percent level of significance) mean excess returns, which are also consistently higher than those using the ex-post deviations. They concluded WISDs based upon the Black and Scholes model to be useful not only in determining proper hedged positions, but also in identifying relatively over and undervalued options. Latane and Rendleman (1976), suggested that the best predictive performance could be obtained by using the information available in all option contracts.

Schmalense and Trippi (1978) assumed the validity of the Black and Scholes model and imputed the standard deviation from weekly observations of closing prices over the period April 1974 to May 1975 for six widely traded stocks and their options. They tested the Black and Scholes model by using the implied volatility values to find model prices and then comparing these model prices with the actual market prices. Their main objective was to find out the determinants of the changes in the implied standard deviation values over time. As compared to Latane and Rendleman(1976), they used a arithmetic average of implied standard deviations, based on closing prices, as an estimator of the standard deviation and checked the behaviour of the changes in the averages overtime. They find the changes in volatility to contain nonwhite –noise elements, which would indicate market inefficiency, given the volatility of the BS model. But, because actual volatilities change overtime, as do the average implied standard deviations, the BS model may be inappropriate.

Chiras and Manaster (1978) derived their results using the more general Merton model which adjusts the BS model for a specific dividend policy where dividends are assumed to be paid continuously such that the yield is constant. They used this general Merton model to derive the implied standard deviations by adopting a different scheme from Latane and Rendleman (1976) and Schmalensee and Trippi (1978). They thought that the price elasticity of options with respect to their implied standard deviations must be considered to have a rational measure of returns. They calculated the weighted implied standard deviations as:

$$WISD = \frac{\sum_{j=1}^{N} ISD_j \frac{\partial w_j}{\partial v_j}\frac{v_j}{w_j}}{\sum_{j=1}^{N} \frac{\partial w_j}{\partial v_j}\frac{v_j}{w_j}} \qquad \text{....................[2]}$$

Where

N = the number of option on an asset for a given date

WISD = the weighted implied standard deviation on an asset for a given date

ISD_j = the implied standard deviation of option j for an asset

$\frac{\partial w_j}{\partial v_j}\frac{v_j}{w_j}$ = the price elasticity of j option as regards its implied standard deviation (v).

They verified the hypothesis that the implied standard deviations are improved predictors of standard deviations of future stock returns than those acquired from historic stock returns and found the results to be in favour of the hypothesis. They also tested the efficiency of the CBOE (Chicago Board of Options Exchange) by developing a trading strategy using the WISDs. All option positions are maintained over one month. During 22 holding periods from June 1973 to April 1975, 118 positions were formed and 93 of them were found to show paper profits which averaged out to be \$9.96 per position per month.

Chiras and Manaster assert that the results of their study specify market inefficiencies. Though, they acknowledged that the observed differences between ISDj could be described by usage of non-simultaneous data, ex-post nature of their tests and elimination of transaction costs from the data.

Macbeth and Merville (1979) scrutinized closing prices of options on 6 underlying securities. Their approach to testing BS model's validity is based on direct comparison of model prices to actual prices. According to this approach, they estimated the implied standard deviation by substituting the observed market prices into BS equation and numerically solving it for its only unobservable quantity, the variance. The average implied standard deviations for at-the-money options (assuming that at-the- money options are efficiently priced) are placed in the model to generate the expected option prices. Then the model prices are compared to the actual realized option prices. The test is intended to show whether model prices are unbiased estimates of actual prices or whether there are consistent deviations that can be exploited for better prediction or for making above- normal profits. For a sample of daily closing prices for six stocks from 31 December, 1975 to 31 December 1976, they observe this statistics to be an increasing function to the extent to which the option is in-or out-of-the-money. The results of Macbeth and Merville (1979) were unerringly opposite to those stated by Black and Scholes.

In common option pricing models, a closed form solution does not exist to implied volatility and various authors have developed several approaches to provide this closed form solution. Chambers and Nawalkha (2001), investigated the various approaches to provide a closed form solution for calculating volatility from the common option pricing models. Particularly, they examined the Chance's model, Corrado and Miller's model and Bharadia, Christofides and Salkin's model for approximating implied volatility from an option pricing model. In addition to this, they developed a simplified extension of Chance's model that has greater accuracy than previous models. For all the closed form solutions the underlying model for options is the Black and Scholes option pricing model. They majorly used data from the Chance's study and after applying all the models, calculated the estimation error defined as the difference between the true volatility and the model's estimate of volatility. Amongst all the solutions the authors claimed their extension of the Chance's model to be the best approximation for the volatility from an option pricing model.

Ewing in 2010 probed the relative precision of 6 procedures for approximating the Black and Scholes implied volatility established by Curtis and Carriker, Corrado and Miller, Brenner and Subrahmanyam, Chargoy-Corona and Ibarra-Valdez, Bharadia et al., and Li. Each of these procedures were tested and scrutinized for accuracy using NTM options over two data sets, corn and live cattle, spanning contract years 1989 to 2008 and 1986 to 2008 respectively. He used near-the-money data as majority of traded options were concentrated on at-or near-the-money options and several of the approximations were developed for at-the-money options in previous literature. For testing the accuracy of various methods, Ewing analysed the mean errors, the mean percent errors and other moments of the error distributions such as variance and skewness. Furthermore, measures of goodness of fit, dogged through an adjusted R^2, and accuracy over observed fluctuations in market variables, such as moneyness, time to maturity and interest rates, were also evaluated. The benchmark implied volatility was taken to be the BS implied volatility which was calculated using an iterative process in SAS which considered each of the implied volatility values until the difference between the prophesied call and the actual call price was less than 0.001.

With each of the methods analyzed, there were clear and robust results which demonstrated that the Corrado and Miller model most accurately approximated the implied volatilities, followed by Bharadia(1996) and Li (2005) methods.

2) Articles on at-the-money (ATM) implied volatilities

Beckers in 1981 studied the predictive ability of implied volatilities, considering the issue of optimal weighing schemes of standard deviations when there are several options on the same stock. A weighing scheme that concentrated mainly on the ISD for at-the-money options was applied. Specifically, on any single observation day the following loss function was minimised:

$$f(\mathrm{ISD}) = \sum_{i=1}^{I} w_i (C_i - BS_i(\mathrm{ISD}))^2 / \sum_{i=1}^{I} w_i, \qquad \text{....................[3]}$$

Where
C_i = market price of option i,
BS_i = Black and Scholes option price as a function of the ISD,
I = total number of options on an asset with the same maturity,

w_i = weight for the ith option $= \frac{\delta BS_i(\mathrm{ISD})}{\delta \mathrm{ISD}}$ (i.e., the first derivative of the Black and Scholes option formula w.r.t. the standard deviation).

After providing the evidence, the author concluded that most of the relevant information got reflected in the price of ATM options. The reason for the same was suggested to be the fact that the other options are generally not as sensitive to an exact specification of the underlying variance. Moreover, the author suggested the reason that the BS model does not hold exactly for in-the-money or out-of-the-money options might have influenced the results.

Day and Lewis in 1992, associated the implied volatilities extracted from options on the underlying S&P 100 index to GARCH and EGARCH models. The authors majorly relied on the suggested results from previous studies that the implied volatility from ATMs yields an unbiased estimate of the average variance over the life of the option. They highlighted that the above result followed from the reflection that the BS model is approximately linear in average volatility. They further suggest that the specification error in the estimates of IVs can be minimized by focusing on ATM options.

Harvey and Whaley (1991) used S&P 100 index call and put transactions data on CBOE from 1August 1988 to 31 July, 1989. They applied an American-style option pricing model (the binomial model) to calculate a time series of implied volatilities. The authors analyzed the effect of valuation simplifications on the time series properties of implied market volatility. They used the ATM options to estimate implied volatility on the ground that they are the most sensitive to changes in the volatility rate. They measured vega of a European option which is given as,

$$\frac{\partial v}{\partial \sigma} = Sn(d_1)\sqrt{T}, \qquad \text{.............................[4]}$$

Where, $d_1 = \frac{\ln\left(\frac{S}{X}\right)+(r+0.5\sigma^2)T}{\sigma\sqrt{T}}$

And S is the index level, X is the exercise price, r is the interest rate, σ is the volatility rate, T is the time to expiration. The authors claimed that since S and $\sqrt{T}$ are positive, if the probability value from the normal distribution is maximized, then the derivative is maximized. For the standard normal distribution this take place with the value of zero. Using ATM option ensures that S/X is close to one and ln (S/X) is close to zero.

Jorion in 1995, compared the implied volatilities with the moving average model and a GARCH (1,1) model for the three currencies, namely the German deutsche mark (DM), the Japanese yen (JY) and the Swiss franc (SF). The author analyzes the informational content as well as the predictive power of volatility implied in option prices. Informational content is measured through the ability of the explanatory variable to forecast 1-day volatility. Predictive power is tested through concentrating on the volatility over the remaining life of the option contract. Jorion relied on the results shown by Beckers (1981) about using only ATM options, instead of using various other weighting schemes, and therefore considered only ATM calls and puts in his paper.

Macbeth and Merville (1979) examined daily closing prices of options on six underlying securities and compared BS model's validity through directly comparing model prices to actual prices. They estimated the implied volatility by substituting the observed market prices into BS equation and numerically solving it for knowing the variance. The average implied standard deviations for at-the-money options (assuming that at-the- money options are efficiently priced) are used in the BS model to know the expected option prices. Then the model prices are compared to the actual realized option prices.

3) Articles comparing Implied volatilities with other time series models

Bluhm and Yu (2001) analyzed DAX index at the Frankfurt stock exchange from January 1988 to June 1999 by comparing the implied volatility forecast with historical mean model, EWMA model, four ARCH-type models and a stochastic volatility model. The evaluation criteria used were MSPE, bounded violations, and the LINEX loss function. In addition to this, a trading strategy was also applied to know the predictive power of various models. The authors resolved that the ranking of any model was sensitive to the error measurements and the forecast horizons. The authors found it difficult to state which method was the clear winner. However, they concluded that when option pricing is the primary interest, the SV model and IV should be used. Moreover, the trading strategy suggested that the time series models were no better than the implied volatility in predicting volatility.

Canina and Figleswki (1993) used the binomial model to capture the implied volatilities from closing prices of OEX from March 1983 to March 1987 to forecast subsequent realized volatilities. The authors don't agree with following the weighted scheme suggested by Latane and Rendleman to calculate the implied volatilities. In order to avoid the application of any weighing scheme they sub-divide the sample into groups according to maturity and intrinsic value (that is the difference between market price and strike price). The authors then run the regression test for rationality of the implied volatility forecast. If the forecast is the true expected value of the conditional volatility, regressing realized volatility on their expectation should produce regression estimates of 0 and 1 for alpha and beta respectively. Deviations from this value would indicate bias and inefficiency in the forecast. The authors concluded that neither implied volatility nor realized volatility pass in the rationality test. Rather the authors found it to be reasonably perfect to combine both implied and realized volatilities to forecast future volatility.

Chiras and Manaster derived their results using the more general Merton model to derive the implied standard deviations by adopting a different scheme from Latane and Rendleman (1976) and Schmalensee and Trippi (1978). They calculated the weighted implied standard deviations as mentioned earlier. They tested the hypothesis that the implied volatilities are superior predictors of standard deviations of future stock returns than those obtained from historic stock returns. The results indicated that the null hypothesis can be accepted. They also tested the efficiency of the CBOE (Chicago Board of Options Exchange) by developing a trading strategy using the WISDs.

Christensen, and Prabhala (1998) compared the implied volatility of the S&P 100 index option with that of the realized volatility by taking the monthly data from November 1983 to May 1995. They used only at-the-money options in their study. They found the predictive power of implied volatility to be better than the realized volatility. They took the reason for the same as the usage of longer time series and non-overlapping data.

Day and Lewis in 1992, compared the implied volatilities from closing prices of call options on the S&P 100 index to GARCH and EGARCH models from 1983 to 1989. The implied volatility was added to GARCH and EGARCH models as an exogenous variable. The within-sample incremental information content of implied volatilities was then analyzed using a likelihood ratio test of many nested models. The out-of-sample predictive content of these models was also scrutinized. This was achieved by regressing expost volatility on the IVs and the forecasts from GARCH and EGARCH models. The out-of-sample comparisons designated that weekly volatility is difficult to predict. The results accepted the hypothesis that implied volatility and the GARCH and EGARCH forecasts are unbiased, though they were unable to conclude about the relative information content of GARCH forecasts and implied volatilities.

Dunis and Chen in 2005 compared 16 models including a historical volatility model, implied volatility model, the Riskmetrics model, GARCH(p,q) model, AR(p) based models, SV model, neural network model and combination models. Each time series model was complemented by a "mixed" version counterpart by integrating the implied volatility data. The data was taken from 1998 to 2003 for two foreign exchange rates: EUR/USD and USD/JPY and benchmarked against the two naive models i.e, the random walk model and the Riskmetrics. In addition to using the traditional forecasting accuracy measures, the risk management efficiency under the VAR framework and trading performance with a volatility filter strategy were also applied. No single volatility model could be declared as an overall winner in terms of all the three performance criteria. Though "mixed" models incorporating market data for currency volatility, NNR models and model combination performed better many of the times. Mixed models incorporating implied volatility seemed to be good performers in terms of forecasting accuracy, risk management and trading. Hence, the authors rejected the null hypothesis that implied volatility does not add value in cultivating forecasting accuracy and risk management.

Jorion in 1995, compared the implied volatilities with the moving average model and a GARCH (1,1) model for the three currencies: the German deutsche mark (DM), the Japanese yen (JY) and the Swiss franc (SF). The author analyzes the informational content as well as the predictive power of volatility implied in option prices by considering only ATM calls and puts. Informational content is measured through the ability of the explanatory variable to forecast 1-day volatility. Predictive power is tested through concentrating on the volatility over the remaining life of the option contract. The out-of-sample outcomes specified that the IVs are better than MA and GARCH in predicting future volatility in the foreign exchange market. The result was in sharp contrast to those of Canina and Figlewski (1993), who reported IVs to be enhanced performers than the time series models in the US stock market. The obvious explanation for the contrast being reserved as the reason that S&P 100 index option IDSs were measured with extensive errors because of stale prices and due to the difficulty of arbitraging between the option and the underlying stock market.

Latane and Rendleman (1976) used a data set consisting of weekly closing option and stock prices of twenty four companies. These options were traded on Chicago Board of Options Exchange for 38 weeks from October5, 1973 to June28, 1974. They calculated the IVs for all options written on a particular stock and used the weighted average of the IVs as estimators of return variability. Options were divided into over and undervalued options and then the weekly hedge returns were calculated for both separately for various criteria for option selection and hedge- ratio determination. They find all the portfolios employing weighted IVs to produce significant mean excess returns, which were also consistently higher than those using the ex-post deviations. They concluded WISDs based upon the Black and Scholes model to be useful not only in determining proper hedged positions, but also in identifying relatively over and undervalued options.

Padhi and Shaikh (2014) study the call and put options as predictors of future realized return volatility by taking the data from one-month ATM CNX Nifty index options from June 4, 2001 to May 31, 2011. The authors minimize the measurement errors by taking an average of call and put option implied volatilities. The study concludes that the average implied volatility incorporates the information about the future realized return volatility, and suggests the investors to use implied volatility as the predictor of future realized return volatility for risk management purposes.

CONCLUSION

The present study concentrates on reviewing the literature on various aspects of implied volatility. Since its introduction, authors have tried to test various assets across markets in order to predict the implied volatility of these assets. Earlier studies concentrated on coming up with weighing schemes in order to deal with the problem of different volatilities indicated by different categories of options. Later studies concluded that ATMs or NTMs reflect all the information content of option prices and yield unbiased estimate of volatility. They also started reporting results according to moneyness and maturity categories of options. Comparing implied volatility forecast with the other volatility models was also targeted by many studies. The empirical evidence on testing the predictive power of implied volatility is mixed. For example Latane and Rendleman (1976), Chiras and Manaster (1978), and Beckers (1981) found evidence favorable: the weighted implied standard deviation explains more of the crosssectional variation in the future standard deviations of individual security returns as compared to historical volatilities. Day and Lewis (1992) found that the IVs from S&P100 index options contain incremental information to the GARCH models. Canina and Figlewski (1993) found evidence against: i.e. the IVs from S&P100 index options have little predictive power for subsequently realised volatility than simple historical volatilities. Jorion (1995) found that the implied volatility is a high quality estimator in terms of exante forecasting power. There was no clear cut conclusion from these studies as some concluded that implied volatility is no better than historical models while others concluded the opposite. Some studies also preferred to combine information content of implied volatility into the historical conditional volatility models and proved it to be a better option for predicting future volatility and pricing options contracts.

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