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Alternative Option Pricing Models: A Review

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Abstract: A considerable progress has been made in the literature on volatility modelling and option pricing. The performance of different option pricing models is tested based on their accuracy of pricing and internal consistency of implied volatility in the presence of relevant time series data. This paper reviews alternative option pricing models categorizing them as deterministic and stochastic volatility models. The paper attempts to discuss theoretical characteristics of different option pricing models.
Keywords: Option pricing models, Implied Volatility, stochastic volatility

Introduction

The derivatives market has grown leaps and bounds in the past decade in India as well as globally. The Noble prize winning Fisher Black and Myron Scholes, 1973"Black Scholes Model " has inspired many researchers to work on alternative Option pricing models. The revolutionary and path breaking Black-Scholes model, provided major breakthrough in Option Pricing and led the world into a diverse and vast field of Financial Engineering and Option Pricing.

The significant contribution of Fischer Black, Myron Scholes, Robert Merton was recognized and were bestowed the Noble Prize in 1997 for their mathematical model in pricing Options called the "Black and Scholes Model". Prior to the existence of this model, pricing of options was done in a non-mathematical approach based on estimation and speculation that was used by traders for Option Pricing.

Rigorous efforts are being made since the four decades to root out the problem of pricing options with non-constant volatility. The suggested models can be positively categorized into deterministic volatility models and stochastic volatility models.

The assumptions of BS Model are:

a) Stock prices follow Geometric Brownian Motion
b) Return is Log normally distributed.

These assumptions have been criticized and analyzed by a host of researchers. These empirical deficiencies in the BS model have led to the pursuit of more realistic models. The existing models can be classified as Deterministic Models and Stochastic Models. The basic difference between these groups of models is volatility. Deterministic Volatility models are based on the framework that volatility can be observed in the market by measuring certain variables. Whereas, the stochastic models believe that volatility itself is not constant and cannot be observed through any variable.

The popular models from stochastic family are Heston& Nandi (2000),Heston (1993),Hull & White(1987). The models famous under Deterministic category are the CEV(Constant Elasticity of Variance) model of Cox, Foresi& Wu(2004) ,Fleming and Whaley (1998).

Even with the existence of many models, BS model is the most regularly used model. Even National Stock exchange(NSE) of India uses BS model for benchmark pricing of Nifty Index Options.

The Constant volatility and lognormal distribution of asset returns were critically challenged by many contemporary thinkers over the years, especially after the market crash of 1987(Glosten, Jagannathan, &Runkle, 1993; Derman&Kani, 1994), and in India the same was verified by Singh and Ahmad (2011).Over the years

Empirical research studies proved Constant volatility to be inconsistent with the observed market behavior. These studies have further helped to categorize volatility as Constant Volatility, Time Dependent Volatility, Local Volatility, and Stochastic Volatility. The studies have also pointed out that Stochastic Volatility captures a richer set of empirical characteristics as compared to other volatility models. Constant volatility assumes Volatility to remain constant across the time scale measured, similar to Local or Time dependent volatility. But, stochastic volatility depends empirically on the time scale measured.

Due to the Randomness of the Volatility of Asset Price, the practical applications of Stochastic Volatility models is limited. And most of the stochastic volatility models tend to be analytically less controllable. The study of Volatility and especially the stochastic volatility has become a significant study in Financial Theory.

Volatility

Volatility is the randomness of the the asset return and since it is inherent in the Asset and is not constant , hence there is no time scalethat can be associated with it.Over the years volatility has been characterized with few features based on which researchers have categorized it as

1. Historical Volatility
2. Implied Volatility
3. Forward Volatility

Historical volatility is the volatility taken from past empirical data and since it is past data it is called as Historical volatility.

Implied volatility is the calculated value from the empirical option prices existing in the market.

Forward Volatility is the volatility assumed from any forward instrument existing in the market.

Theoroticallythe volatilities are supposed to be the same ,but it does not happen in practice. Many researchers are treating actual volatility and implied volatility differently.Implied volatility in practice differs from the actual volatility.

When we plot implied volatility and empirical prices on a graph,then they normally have to move in tandem ,but instead we get a " U" shape , which is otherwise called as volatility smile. The lowest point on the curve is the point were the strike price and stock price are same(K=X) orormally called as "at the money"option.

There are many reasons for existence of Volatility smile.

The transaction costs of options are much higher than the underlying asset which is creating the volatility.Secondly,the market prices are more effected by market sentiments rather by market fundamentals.Thirdly and finally, option market and stockmarket are two different markets ,hence there will be existence of time differences.Hence the implied volatility ,calculated from empirical option prices will always differ from the actual volatility.

Due this randomness of volatility ,constant volatility models have become outdated and paved way for Stochastic volatility models.The empirical volatility has exhibited certaing characteristics as discovered by many research studies.These generalized characteristics of volatility have helped in developing stochastic volatility option pricing models.The characteristics have been observed and proved in many research studies.

Firstly, volatility tends to be closely correlated with many other economic variables, hence is effected during recession and growth periods.

Secondly, volatility is found to be clustered, that is large price changes tend to follow low price changes.

Thirdly,volatility shows dependency on the time scale that is used tomeasureit.These features have helped researchers to develop many stochastic models to price options.

Significant Stochastic Volatility Models

There are many stochastic models and only few of them are significant. The significant models are given below

1. **Scott Model** : The model developed in 1987, uses geometric approach to stock prices and Ornstein – Uhlenbek for volatility. This model has been a stable model and able to measure option prices even during economic upheavals.
2. **Johnson and Shannon**: This model developed in 1987, used a risk neutral method of calculation of option prices.

3. **Hull and White Model**: This model helps in pricing European Vanilla Options. It is a closed form of Model.
4. **Heston Model** : This model also uses Risk neutral valuation method and stands apart from other stochastic models
5. **Stein and Stein Model:** This model uses Variance and assumes that implied volatility can be negative, uses a closed form of equation and calculates using risk neutral valuation.

Conclusion

The choice of Option pricing model is based on the fact that which model among the existing models is less misspecified. The perfectly specified model is tending to be very difficult for application by practitioners. Hence the quest should be for least misspecified model. The model should also be able to give a good hedging performance. The benchmark BS model exhibits strong pricing biases , that clearly indicate errors in the stock return assumptions. Hence further research can be done to select the least misspecified model for fixing base prices of options in stock exchanges. The model should not only be simple and trustworthy, but should also have analytical traceability.

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