The Practical Applicability Of Black Scholes Model And Merton's Model On Option Pricing In INDIA

Yashwin B R[1] **Chathurya[2]** **Mayank Agarwal[3]**
B.Com F&A, Department of Professional Studies, Christ University, Karnataka, India

Dr. Ravi Thangjam[4]
Department of Professional Studies, Christ University, Karnataka, India

Abstract
Titled "A Comparative study on the practical applicability of Black Scholes Model and Merton's model on option pricing in INDIA" this study aims at analysing both the model i.e. Black Scholes and Merton's model and which is more applicable in INDIA for EUROPEAN call option. This research paper tries to explore the applicability of both the models in INDIAN options market. Most of the investors are primarily concentrated with investment in the stock market and leaving the derivative market unexplored. We have taken the underlying asset as stock and only call option. This paper explains how the call option premium is calculated at the end of the maturity, by assuming time period, interest rate, discounting factor, anti-logarithm, natural logarithm etc the call option premium is calculated. Here we are taking two companies from three industries total of 6 companies to predict which model holds well in Indian call option, Using both the models we calculate call option premium and compare it with the actual call option premium the difference is calculated in percentage for both the models and compared, whichever model has lower percentage that model is more favourable in predicting the call option premium, after a few assumptions, calculations, interpretations, and the answers are favourable to Merton's model.
Key words: Call option, Black Scholes, Merton's model, Indian call option, call option premium.

I. Introduction

Options are the contracts through which the buyer gains the right from the seller, to buy the underlying asset at the strike price. On the other hand, the seller sells the right to the buyer and thus has an obligation to execute the contract. The standard lot size of stock options is 100 shares of the underlying asset, exceptions are considered during mergers, acquisitions, stock splits. The two most common option styles are –

A) American option- It's the style of option of a call or put option that gives the trader to exercise his right to exercise on or prior to its expiration date.
B) European Option: Unlike the American option, the European call or put option can only be exercised on the expiry date.

The Black Scholes model was developed by Fisher Black and Myron Scholes in the year 1973. It is one of the benchmark models in finance and is the first mathematical models which

predicts the fair pricing of options (both call and put) and the implied volatility. This model uses 5 main variables which primarily affect the price of options. These five variables are;
a) Stock Price
b) Strike Price
c) Risk free rate of interest
d) Relative Price Volatility of underlying instrument
e) Time to maturity

The Merton's model was developed by Robert C Merton in the year 1974. It is used to assess the credit risk of the financial institutions like banks and insurance companies, for their loan bond portfolio and individual holdings. this model uses six variables to calculate the option premium, these six variables are;
a) Stock Price
b) Strike Price
c) Risk free rate of interest
d) Relative Price Volatility of underlying instrument
e) Time to maturity
f) Dividend

II. Review of Literature

1. Applicability of Black Scholes Model in Indian Capital Markets

A research was conducted on the applicability of Black Scholes Merton model on the option pricing in the Indian context. For this purpose, a research was conducted by taking a sample of 10 stocks from diversified industries. The study was conducted on call options of 1-3 months. The research concluded that there was a significant difference between the pricing of options as per the Black Scholes Model and the actual market call price since the options market is inefficient and the mathematical structure of the Black Scholes model is incorrect and requires certain modifications. (Sethi, et al., 2012)

2. Effectiveness of classic versions of options Pricing models in recent waves of financial Upheavals

This research paper aims at finding the best option in the Indian market. This paper uses the a) Black Scholes Merton model b) Hull-White model and c) Hull and White (1988) Correlated Stochastic Volatility Model. For the purpose of this research, they have considered moneyness of options and the time period of options as between 1 to 3 months. The research deduced that the Hull-White stochastic model of 1988 improved the pricing error and outperforms them significantly when compared to the other models especially during the financial upheavals in the Indian economy. (Singh, et al., 2013)

3. Study of black-Scholes model and it's applications

This paper aims at discovering various formulae which can be an addition for the development of the black Scholes model. It provides for various definitions and derivations which can help the reader to understand the model better. The paper discovers derivations which helps in the development of the black Scholes formula and black Scholes partial differential equation. The paper provides a solution of the black Scholes equation and is also graphically represented. It predicts the call option values of an underlying asset by black Scholes equation which is carried out by maple software. The study provides a conclusion that the Black Scholes partial differential equation is more useful in financial engineering. (Takale, et al., 2012)

4. An Empirical Examination of the Black-Scholes Call Option Pricing Model

(Macbeth, et al., 1979) In this paper aims to observe the difference in market prices of a call option compared with the prices predicted using the Black Scholes model. this research takes into consideration the assumes of the Black Scholes model which includes, that the dividend payments are not taken into consideration, there are no taxes, no restrictions on short sales and no transaction costs involved. This paper gives an insight of testing of Black Scholes model against other option pricing models and that it does not require a constant variance rate is disclosed this paper.

III. Research Design

The research topic involves analysis of historical quantitative data. For the purpose of this research, we have referenced data from the NSE website for data pertaining to option premium for the purpose of comparing prices as per the Merton's/Black-Scholes model and the actual prices, option pricing for the options expiring on September 28, 2017, underlying stock prices from July 6, 2017 to July 12, 2017 for the purpose of calculating volatility. We have also referenced data from www.moneycontrol.com for data pertaining to dividend payments for quarter 2 of Financial year 2017-18 for the dividend data to be inputted for the Merton's model.

Hypothesis:

Since this is a research to validate and test the practical applicability and the approximation of the Black-Scholes Model to the actual option premium in comparison to the Merton's model, the hypothesis can be stated as below:

H_0: Black Scholes Model is not a closer approximation of the actual option premium relative to the Merton model

H_1: Black Scholes Model is a closer approximation of the actual option premium relative to the Merton model

The above hypothesis provides a clear emphasis on testing and validating the hypothesis that the Black Scholes model is a more accurate and consistent model compared to the Merton model option pricing model in the Indian context.

Objective of study:
In our pursuit of achieving the goal of assessing the pricing of options, we stumbled upon two models which have previously been formulated by Nobel prize winners Fisher Black, Myron Scholes and Robert C. Merton. Fisher Black and Myron Scholes formulated the Black-Scholes model and Robert Merton created a varied version called the Merton model.

The Black-Scholes model is very famous and very well-known model of option -pricing internationally. However, for the Indian context, we wanted to know which one will be the better model of option pricing and which predicts prices of options in a more effective manner. Thus, we are undergoing this research to understand the comparative applicability of both the models in the Indian context and t understand which model theoretically prices the options better.

Scope:
The study is done across 6 companies of 3 industries

1) Information Technology:
    i) Infosys
    ii) Mindtree
2) Automobile:
    i) Mahindra&Mahindra
    ii) Eicher Motors
3) Pharmaceuticals:
    i) Sun Pharma
    ii) Aurobindo

Sources of data:
The data required for the analysis is obtained from the following websites:

1. www.moneycontrol.com
2. www.nseindia.com

IV. Research Methodology

For our study, we are considering two companies each from three different industries, thus totalling an analysis of 6 companies. Since the Merton's model assumes that dividends are paid, companies which had paid dividends have been taken into consideration. The industries and the companies corresponding to each industry are:

1) Information Technology: Infosys Limited and Mindtree Limited
2) Pharmaceutical and Healthcare: Sun pharma Industries Limited and Aurobindo Pharmaceuticals Limited
3) Automobile: Mahindra and Mahindra Limited; and Eicher Motors Limited

V. Data analysis and interpretations

1) We have picked up all the available call option contracts available for the respective company's which were expiring on September 30th, 2017, ranging from June 06, 2017 to June 12, 2017. This data was collected from the NSE website.

2) Using Microsoft Excel, we then applied the Black-Scholes model to find out the theoretical call premium which needs to be paid as per the model. formula can be stated as below:

$$C = SN(d_1) - N(d_2)Ke^{-rt}$$

$$d_1 = \frac{\ln\left(S/K\right) + \left(r + s^2/2\right)t}{s \cdot \sqrt{t}}$$

$$d_2 = d_1 - s \cdot \sqrt{t}$$

C = Call premium
S = Current stock price
t = Time until option exercise
K = Option striking price
r = Risk-free interest rate
N = Cumulative standard normal distribution
e = Exponential term

s = St. Deviation
ln = Natural Log

3) We then found out the actual difference between the actual call premium and the theoretical call premium and an average of the difference was found, which formed the basis of our interpretation.

4) The next step is to find out the theoretical call premium as per the Merton's model. This was done using the following below formula:

$$C(S,t) = S\,exp(-q\tau)\Phi(d_1) - K\,exp(-r\tau)\Phi(d_2)$$

$$d_1 = \frac{ln(S/K) + (r - q + \sigma^2/2)\tau}{\sigma\sqrt{\tau}},$$

$$d_2 = d_1 - \sigma\sqrt{\tau}.$$

$C(S,t)$ = price of the European the call option,
S = current underlying asset (stock) price,

K = strike price,

$\tau = T - t$ is the current annualized time-to-expiration, where T is the expiration date,

r = the annualized risk-free interest rate,

σ = the annualized standard deviation of underlying asset price,

Φ = the cumulative distribution function for a standardized normal variable.

q= Continuous dividend yields

5) We then found out the difference between the actual call premium and the theoretical call premium as we did in the Black-Scholes model. The average difference of all the differences was found, which was uses as the basis for our interpretation.

6) In this last step, we compare the average differences as per the Black-Scholes and Merton's model and the model which provides the lesser difference is deemed to be the more accurate and consistent model.

The analysis performed is as follows:

Infosys Limited- Black-Scholes Model

Average Difference	**48.246%**

Infosys Limited - Merton

Average Difference	**48.01%**

Mindtree Limited- Black-Scholes Model

Average Difference	**3.59%**

Mindtree Limited- Merton model

Average Difference	**3.46%**

Sun pharma Pharmaceutical Industries Limited- Black-Scholes Model

Average Difference	**3.48%**

Sun pharma Pharmaceutical Industries Limited- Merton Model

Average Difference	**3.35%**

Aurobindo Pharma Limited- Black-Scholes Model

Average Difference	**-12.55%**

Aurobindo Pharma Limited- Merton Model

Average Difference	**-12.56%**

Mahindra and Mahindra Limited- Black-Scholes Model

Average Difference	**24.58%**

Mahindra and Mahindra Limited- Merton Model

Average Difference	**24.42%**

Eicher Motors Limited- Black-Scholes Model

Average Difference	**9.61%**

Eicher Motors Limited- Merton Model

Average Difference	**9.63%**

VI. Findings and Conclusion

Based on the analysis done on 6 companies of 3 different industries, we have reached to some interesting findings which can be summarized as follows:

1) Out of the analysis done for 6 companies, 4 companies favour the Merton's model as the more accurate one while the other 2 companies favour Black-Scholes model as the more accurate and consistent one.

2) The companies which favour the Merton's model are:
   a) Infosys Limited,
   b) Mindtree Limited,
   c) Sun pharma Pharmaceuticals Industries Limited and
   d) Mahindra and Mahindra Limited

   The companies which favour the Black-Scholes model are:
   a) Aurobindo Pharma Limited and
   b) Eicher Motors Limited

3) The difference between the average differences of both the Black-Scholes and Merton's model was not significant and ranged from 0.02-0.24%. As a result, there was no clear winner in terms of absolute accuracy.

4) Although the average differences between the theoretical call premium and the actual call premium was very low i.e. ranging from 3% to 12%, the individual differences of a contract on a particular date was substantial and there were many outliers present in the data set. However, averaging out those outliers, the average differences for those companies proved to be substantially lower.

5) Both the models predict a call premium which is a significant deviation from the actual call premium. Although the average of the differences of the premiums in the case of Mindtree Limited and Sun pharma Pharmaceuticals Industries Limited is only around 3 percent, for companies such as Mahindra and Mahindra Limited and Infosys Limited, the deviation is 20 plus percentage.

Both the models do not present an accurate estimation of the call premium. However, as a result of the above findings, it can be concluded that the Merton's model is a more accurate and a consistent model in predicting the call premium of stock as the underlying asset. Although the difference between the two models is not significant, Merton's model holds the upper hand.

VII. Bibliography

An Empirical Examination of the Black-Scholes Call Option Pricing Model [Article] / auth. Macbeth James D and Merville Larry j // The Journal Of Finance. - December 1979. - 5 : Vol. 34. - pp. 1173-1186.

Applicability of Black Scholes Model in Indian Capital Markets [Report] / auth. Sethi Tarun Ashok and Nilakantan N.S.. - New Delhi : Research Gate, 2012.

Effectiveness Of Classic Versions Of Options Pricing Model In Recent Waves Of Financial Upheavel [Journal] / auth. Singh Vipul Kumar and Ahmad Naseem // Asian Academy of Management Journal Of Accounting And Finance. - Nagpur : ASIAN ACADEMY of Management Journal of , 2013. - pp. 127-155.

Pricing Warrants: An Empirical Study of the Black-Scholes Model and Its Alternatives [Article] / auth. Lauterbach Beni and Schultz Paul // The Journal Of Finance. - September 1990. - 4 : Vol. 45. - pp. 1181-1209.

Study of black-scholes model and its applications [Journal] / auth. Takale K. C. and Shinde A. S. // Procedia Engineering. - [s.l.] : Procedia Engineering, 2012. - Vol. 38. - pp. 270-279.