**1.0 Analytical formula**

The price of a put and a call can be calculated using an analytical formula with the Black-Scholes model. The value of  is the initial value of the asset price. The value of  is the strike price. The value of  is the risk-free interest rate and the value  is the volatility of the stock price. The maturity of the option in years is . The formula for the put and call respectively are given by :



and



where

,

,



and



is the expected value of the random variable .

**2.0 Stochastic simulations**

The price of a put and a call can be calculated using an analytical formula with the Black-Scholes model. The value of  is the initial value of the asset price. The value of  is the strike price. The value of  is the risk-free interest rate and the value  is the volatility of the stock price. The maturity of the option in years is . The price of a put and a call option can be approximated using stochastic simulations using the following formula



and



where  is the simulated price of the simulation  and  is the number of simulations.We can simulate the value of  using the following algorithm :

1. **Step 1 :** generate a random number from a standard normal distribution ;
2. **Step 2 :** calculate ;
3. **Step 3 :** repeat the first and second steps  times;
4. **Step 4 :** approximate the value of the put price using



or the value of the call price using

.

The values of  can be approximated using a random walk. Also, a high value of  will generate better approximations of the put and call values.

**3.0 Binomial tree**

The value of  is the initial value of the asset price. The value of  is the strike price. The value of  is the risk-free interest rate and the value  is the volatility of the stock price. The parameter  is the number of time steps of the binomial tree. The maturity of the option in years is  and the timesteps in the binomial tree is given by

.

We can approximate the price of a put or call price with the Black-Scholes model using a binomial tree. The approximated prices of the put and call are given, respectively, by



and



where

,



and

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**4.0 Reference**

Hull, J. C. (2012). Options, futures, and other derivatives. Pearson. 8th edition.