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The Modified Black-Scholes Model via Constant Elasticity of Variance for Stock Options Valuation

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Abstract. In this paper, the classical Black-Scholes option pricing model is visited. We present a modified version of the Black-Scholes model via the application of the constant elasticity of variance model (CEVM); in this case, the volatility of the stock price is shown to be a non-constant function unlike the assumption of the classical Black-Scholes model.

INTRODUCTION

In modern finance, the importance of options in pricing theory cannot be overemphasized as they can be used for asset hedging, and to control risk. This calls for the attention of financial engineers when dealing with finance, actuarial sciences, and other related areas of applied sciences \([1-3]\). Hence, the involvement of stock options in the study of option pricing theory \([4]\). In option pricing theory, Black and Scholes assumed that the underlying stock price process, \(S_t\), follows a lognormal distribution and satisfies the stochastic differential equation (SDE) \([5]\):

\[
dS_t = S_t (\mu dt + \sigma dW_t)
\]

where \(\mu\) represents rate of return (drift coefficient), \(\sigma\) the stock price volatility rate, and \(W_t\) is a standard Brownian motion.

The question of how options based on traded stock are priced becomes possible following immediate specification of a stochastic process for the evolution of prices \([6]\). Examples of such options are European-style call or put.

According to the Black-Scholes model, the value of a European-style option on a stock at time \(t\), is \(V = V(S_t, t)\) that solves the partial differential equation (PDE):

\[
\frac{\partial V}{\partial t} + \frac{1}{2} S^2 \sigma^2 \frac{\partial^2 V}{\partial S^2} + rS \frac{\partial V}{\partial S} - rV = 0
\]

Equation (2) is the Black-Scholes model, where \(r\) is the risk-free rate, \(V \in C^{1,2}[R \times [0,T]]\), with a payoff function \(p_f(S, t)\), and expiration price, \(E\) such that:

\[
p_f(S, t) = \begin{cases} \max(S - E, 0), & \text{for European call option} \\ \max(E - S, 0), & \text{for European put option} \end{cases}
\]

where \(\max(a, b)\) implies the maximum between \(a\) and \(b\).