Risk Analysis of BOT Power Plant Projects

Borliang Chen [1], Guan-Yu Lin [2], Hue-Chiuen Shiong [3]

Abstract

There are difference in project financial analysis in investing BOT projects and other type of projects. While investing regular projects, the investors will adjust the project scale and chose the right timing for investment according to market conditions. But, it is unchangeable on project scale and timing for investment in BOT projects due to the contract conditions. Thus, the lack of managerial flexibility could make the BOT projects become unprofitable or even become loss in operation. In case, project agent could have the managerial flexibility in operation phase, such as project scale, product types, and product quality level, and allows the project company to adjust project according to the market conditions. Those managerial flexibilities definitely improve the profitability of projects, reduce the probability of bankruptcy, and increase the projects' value.

A project finance evaluation model is used as a base model for financial analysis of the projects. This model is for calculating profitability indices for projects' financial feasibility analysis. These indices are net present value (NPV), internal rate of return (IRR), debt service coverage ratio (DSCR), times interest earned (TIE), return on asset (ROA), return on equity (ROE), self liquidated ratio (SLR), and payback period (PB). In additions, the sensitivity analysis and Monte-Carlo simulation are performed for determining the expected value and variance of NPV. Eventually, the Black-Sholes option pricing model is used to estimate the option values of BOT projects in considering the managerial flexibility. In empirical study, a power plant project is used for demonstration of analysis.

Keyword: Black-Sholes option pricing model, managerial flexibility, profitability indices.

Introduction

The Black-Scholes Option Pricing Model has revolutionized financial engineering through the use of derivatives. A derivative is a financial instrument that derives its price from an underlying asset. An option is a derivative that affords the owner the privilege to buy or sell the underlying asset at a determined price, sometime in the future. Usually, the owner of an option pays a premium (the option price) for the right to exercise (or buy/sell the underlying asset of) that option. The Black-Scholes model finds a fair price for these options, thus allowing them to be efficiently traded.

When an investor purchases an option, the investor is said to have taken a long position in that option. These positions are important, because an investor may create a portfolio where many different positions in options and their underlying assets are held, as part of a hedge, or risk-reducing strategy. It is important to note also that the payoff from options, and derivatives in general, is a zero-sum game. When an option is exercised, a transfer of wealth occurs between the investor in the long position and the investor in the short position. Because of this, two parties must enter into the contract, covering both positions.

There are two types of options, calls and puts. A call option gives the owner the right to buy an asset for a predetermined price, at an agreed upon date. A put option gives the owner the right to sell an asset at a determined price, at an agreed upon date. The price at which the owner of an option has the right to buy or sell the underlying asset is called the strike price, or exercise price of the option, and the date at which the option may be exercised is

[1] *Associate Professor, Department of Civil and Hazard Mitigation Engineering, National United University. Miaoli, Taiwan 360*

[2] *Graduate student, Department of Civil Engineering, National United University, Miaoli, Taiwan 360.*

[3] *Instructor, Department of Civil and Hazard Mitigation Engineering, National United University.*

the maturity, or expiration date. If the option can be exercised only on the maturity date, then it is referred to as a European option, whereas if the option can be exercised anytime before the maturity date, then the option is called an American option. Trigeorgis (1996, 1993, 1991, 1987) identified seven types of real options which are shown as follows: Option to Defer, Time-to-Build Option, Option to Alter Operating Scale, Option to Abandon, Switch Option, Growth Option, and Multiple interacting Options.

Modeling

The Black-Scholes model finds a fair-market price for a European call option on a stock that does not pay dividends. It uses five parameters:

S_0 = the current stock price,

X = the strike price of the option,

r = the risk-free interest rate,

T = the time to expiration (in years),

σ^2 = the volatility of the stock.

The Black-Scholes model states that, if c is the unknown price of the call, then

$$c = S_0N(d1) - Xe^{-rT}N(d2),$$

where

$$d_1 = \frac{\ln\left(\frac{S_0}{X}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}},$$

$$d_2 = \frac{\ln\left(\frac{S_0}{X}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}.$$

Option price may be affected by the fluctuation of stock price, S, strike price, X, the time to expiration, T, the risk-free interest rate, r, and the volatility of the stock return, σ^2. Hence, the sensitivity analysis of option price is considered in this study, which is called Greek letter analysis.

(1). Δ(Delta)

Δ：sensitivity of the option price change to a small change of S

S：stock price

C：option price

$$\Delta = \frac{\Delta C}{\Delta S} \quad \text{or} \quad \delta = \frac{\partial C}{\partial S}$$

In case that, the option price is derived from the Black and Sholes model, then we could obtain the following results.

$$\delta = \frac{\partial C}{\partial S} = N(d_1)$$

(2). θ(Theta)

θ is the sensitivity of the option price change to the passage of time

$$\theta = \frac{\partial \mathrm{C}}{\partial \mathrm{t}} \quad , \quad \tau = T - t$$

$$\theta = -\frac{\sigma S \varphi(d_1)}{2\sqrt{t}} - rke^{-r\tau} N(d_2)$$ φ(x) is density function of standard normal distribution.

$$\theta = \frac{\partial f}{\partial \tau}$$

f is the derivatives value of stock price S.

(3). Γ(Gamma)

Γ is sensitivity of the delta change to a small change of S

$$\Gamma = \frac{\partial^2 C}{\partial S^2} = \frac{\partial \delta}{\partial S}$$

We can derive the following equation by Black-Scholes model.

$$\Gamma = \frac{\varphi(d_1)}{S\sigma\sqrt{t}}$$

(4). ν (Vega)

ν is the sensitivity of the option price change to a small change of σ.

$$\nu = \frac{\partial \mathrm{C}}{\partial \sigma} = \mathrm{S}\sqrt{\tau}\varphi(d_1)$$

(5). ρ(Rho)

ρ is the sensitivity of the option price change to a small change of r. r is the interest rate.

We can derive the following equation by Black-Scholes model.

$$\rho = \frac{\partial C}{\partial r} = \tau \mathrm{K} e^{-r\tau} N(d_2)$$

Empirical Study

A case of power plant project in Turkey (Bakatjan et al, 2003) is used as an empirical study of this paper to illustrate the calculation of the Black-Sholes model. The input parameters and results are shown as follow.

Input parameters

Input parameters of the power plant BOT project are shown as Table 1.

Table1. Input parameters for a power plant project

Parameters	Data
S	110 (Million US$)
K	120(Million US$)

r	0.05
T	1 year
σ	0.31
μ	0.15

Results

The analysis of real option model is shown in Table 2. Call value of the power plant project is shown in Table 3.

Table 2 Real option analysis by CRR model and BS model

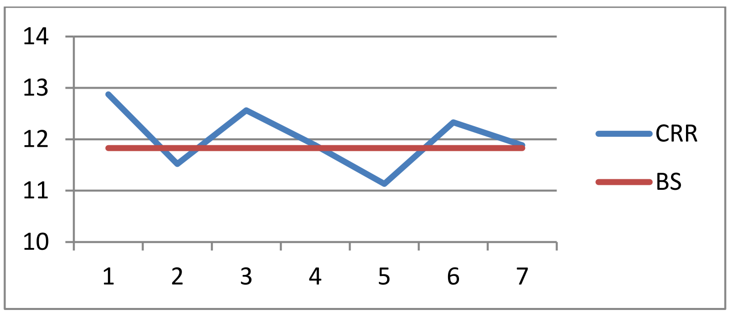
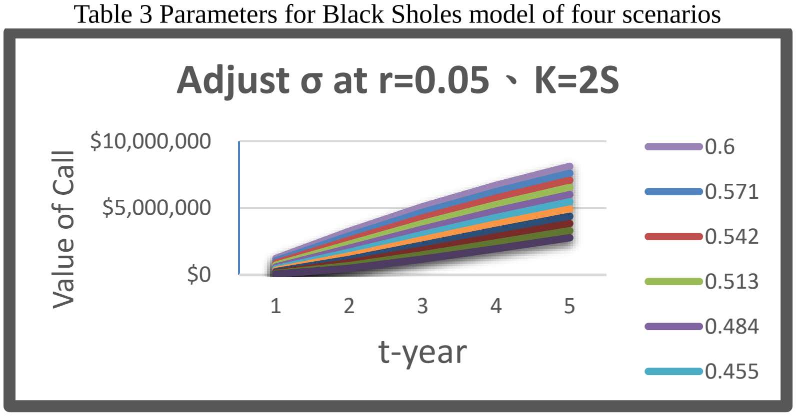
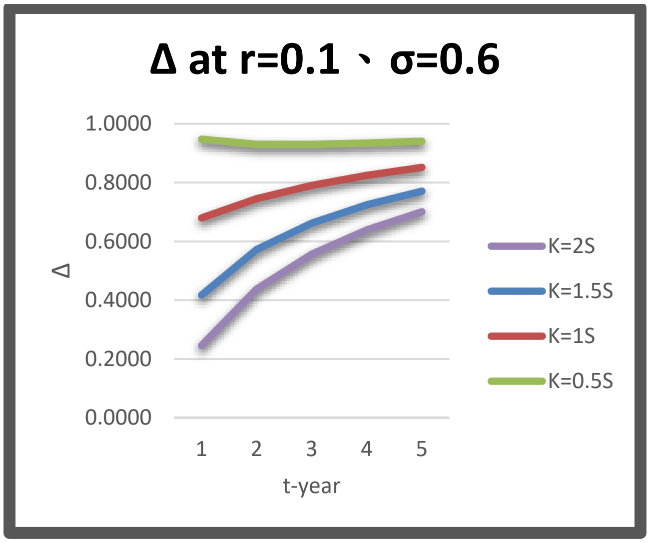


Table 3 Parameters for Black Sholes model of four scenarios



The sensitivity analysis of real option model for power plant project is shown in Table 4.

Table 4 The sensitivity analysis of Black- Sholes model for four scenarios



Conclusion

1. In this analysis, we find that there is a tendency to growth of project value in market perspective. Hence, the managerial flexibility can increase the project value.
2. In the sensitivity analysis of option price, we find that time, θ, is most critical to option price. ν, ρ, Δ, Γ are shown to have less impact on option price in sequence.

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