The Application of Managerial Flexibility on Financial Feasibility of University Dormitory Projects

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Abstract

There is a major difference in investing BOT projects and other projects. While investing regular projects, the investors could adjust the project scale according to market conditions. But, it is unchangeable on project scale in BOT projects due to the conditions of contracts. Thus, the lack of managerial flexibility could make the BOT projects become unprofitable or even get loss. In case, project agent could relief 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. This will definitely improve the profitability of projects, reduce the probability of bankruptcy, and increase the projects' value.

A project finance evaluation model (PFEM) is used as a base model for financial analysis of the projects. This model is used to calculate 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 model is used to estimate the option values of BOT projects in considering the managerial flexibility. A dormitory project in National United University is adopted in empirical study.

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 the maturity, or expiration date. If the option can be

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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

$$c = S_0N(d1) - Xe^{-r}TN(d2),$$

where

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

and

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

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

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

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

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

$$\theta = -\frac{\sigma S \varphi(d_1)}{2\sqrt{t}} - rke^{-r\tau} N(d_2)$$ 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、Kappa、Omega)

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

$$\nu = \frac{\partial f}{\partial \sigma}$$

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

(5). ρ(Rho)

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

$$\rho = \frac{\partial f}{\partial r}$$

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

The case of university dormitory of National United University (NUU) at Taiwan is to illustrate the PDMM as an empirical study of this paper. It is a BOT project of dormitory in National United University. The input parameters and results are shown as follow.

Input parameters

Input parameters of the National United University dormitory BOT project are shown as Table 1. These parameters are useful only when loan relationship exist between the concessionaire and the debt holders.

Table1. NUU input parameters

Item	Variable	Value	Remarks

Revenue in operation period	$E[X]$	31,906,005	Expected revenue in first period
Standard deviation of revenue	σ_X	3,190,601	10% of expected revenue in first period
Covariance	ρ_{X,R_m}	0.7	Covariance of revenue and market return
Market risk	σ_m	0.25	
Risk-free interest rate	r_f	2.44%	
Fixed bankruptcy cost	b_f	9,571,801	30% of expected revenue in first period
Coefficient of variable bankruptcy cost	b_v	0.15	

Results

Table 2 Four scenarios for case study

	Case 1	Case 2	Case 3	Case 4	Unit
Total bed numbers	710	1420	2130	2840	bed
Total construction cost	205,689,625	408,844,293	611,998,960	815,153,627	NT$
Average construction cost	86,816	86,281	86,103	86,014	NT$/Ping
NPV	1,687,097	20,101,236	38,515,374	56,929,512	NT$
IRR	9.16%	9.99%	10.27%	10.42%	
Pay back year	38	31	29	29	year

Table 3 Parameters for Black Sholes model of four scenarios

	d_1	d_2	$N(d_1)$	$N(d_2)$	C
Case1-710	0.871	-0.856	0.808	0.196	1,042,618
Case2-1420	0.874	0.801	0.809	0.789	2,476,639
Case3-2130	0.169	-0.054	0.567	0.478	3,959,003
Case4-2840	0.165	-0.038	0.565	0.485	5,384,882

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

		Δ	θ	Γ	ν	ρ
Case1-710	Call	0.977	-197,185	0.0000000081	91,724	14,318
	Put	-0.023	423,190	0.0000000081	91,724	-587,988
Case2-1420	Call	0.837	-6,214,439	0.0000000734	4,949,733	5,044,753
	Put	-0.163	1,105,070	0.0000000734	4,949,733	-1,320,038
Case3-2130	Call	0.624	-9,726,444	0.0000000191	14,618,621	5,790,061
	Put	-0.376	4,436,320	0.0000000191	14,618,621	-7,960,196
Case4 - 2840	Call	0.617	-14,129,039	0.0000000144	21,728,893	8,800,597
	Put	-0.383	6,804,920	0.0000000144	21,728,893	-11,523,635

Conclusion

1. In analysis of the base case, we find that u=1.332. It implies that there is a tendency to growth in market perspective.
2. The option price for the Case1 with 710 beds is NT$ 1,609,478. For case 2 with 1420 beds, the option price is NT$ 3,112,422. For case 3 with 2130 beds, the option price is NT$8,289,660. For case 4 with 2840 beds, the option price increase to NT$11,199,085.
3. 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.

References

1. A. Dias, Jr., and P. G. Ioannou, (1996), " Company and Project Evaluation Model for Private Promoted Infrastructure Projects", Journal of Construction Engineering and Management, ASCE, 122(1), pp. 71-82.
2. Black, F. and Scholes, M. (1973)," The Pricing of Options and Corporate Liabilities", Journal of Political Economy, 81(3), 637-659.
3. Duffie, D. and Pan, J. (1997), "An Overview of Value at Risk," The Journal of Derivatives, pp.7-49.
4. Trigeorgis, L. and S. P. Mason, (1987), "Valuing Managerial Flexibility," Midland Corporate Finance Journal, 5(1), 14-21.
5. Trigeorgis, L., (1991), "A Log-Transformed Binomial Numerical Analysis Method for Valuing Complex Multi-Option Investments," Journal of Financial and Quantitative Analysis, 26(3), 309-326.
6. Trigeorgis, L., (1993), "The nature of option interactions and the valuation of investments with multiple real options," Journal of Financial and Quantitative analysis, 28(1), 1-22.
7. Trigeorgis, L., (1996), Real Option Managerial Flexibility and Strategy in Resource Allocation, MIT Press, Cambridge Massachusetts.
8. Winston, W. L. (2001), "Financial Models Using Simulation and Optimization II – Investment Valuation, Options Pricing, Real Options & Product Princing Models", Publised by Palisade Corporation, Newfield, NY.
9. Ye, Sudong and Tiong, Robert L. K. (2000), "NPV-at-risk method in infrastructure project investment evaluation", Journal of Construction Engineering and Management, Vol. 126, No. 3, pp 227-233.
10. Trigeorgis, L. and S. P. Mason, (1987), "Valuing Managerial Flexibility," Midland Corporate Finance Journal, 5(1), 14-21.
11. Trigeorgis, L., (1996), Real Option Managerial Flexibility and Strategy in Resource Allocation, MIT Press, Cambridge Massachusetts.