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Economic Valuation of the Design Certificate of SMART by using Real Option `

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1. Introduction

The costs involved with nuclear power are very uncertain. This is because of a long period of construction as well as the cost uncertainties of decommission and radio active waste management. These activities are to be undertaken a long period after the end of its commercial operation.

The cost estimation involves a lot of uncertainties especially when the technologies a nuclear power adopts are not conventional but new ones that have no experiences to be applied in historical constructions like SMART.

The cost of design certificates should be included in the total cost calculation of the FOAK(First-Of-A Kind) plant of SMART. The project of the design certificate for the FOAK plant of SMART(100MWe) was launched in 2009 and planned to last for 3 years and completed in 2011 before SMART would be constructed in a domestic site in Korea. SMART has been developed as a dual product plant, one for electricity and the other for potable water. However, this study assumes SMART to be a power plant producing only electricity. It is evident that the construction of SMART would not be allowed without a design certificate. This study assumes the construction of SMART to be undertaken only when the investment is expected to generate an expected positive Net Present Value at the start of construction of the plant. In other words, the decision on the construction of the plant would be made again at the start of the construction of it. This flexibility given to the decision on the construction assumed in this study cannot be incorporated in the traditional economic evaluation method of Net Present Value(NPV), which basically assumes all the benefits and costs be expected values. If one or more of the outcomes would result in a negative NPV for the project, this is reflected in the overall NPV of the project, resulting in lowering the expected NPV of the project. There is no way in the NPV method to get rid of the negative contribution to the NPV of the project.

To reflect the flexibility given to the decision on the construction of SMART, we introduced real option method in the economic evaluation of SMART. In the process of applying real option to the economic evaluation of SMART, we can make an economic valuation of the design certificate.

2. How to apply Real Option method to the economic valuation of SMART

Options can be classified into two broad categories, financial and real, based on whether the underlying asset is a financial or real asset. Financial assets are primarily stocks and bonds that are traded in financial markets. Real assets may include real estate, project, and intellectual property, most of which are not usually traded. A real option is a right, not an obligation, to take an action on an underlying nonfinancial, real asset.

The economic valuation of an option has been developed in the financial sectors, where there are a lot of uncertainties including the behavior of prices of stocks.

A European option has a fixed maturity date, whereas an American option can be exercised anytime before the option's maturity or expiration date. Therefore, this study involves European options. A call option is a contract between parties, the buyer and the seller of this type of option. It is the option to buy shares of stock at a specified time in the future for a specified price, that is, an exercise price. Call option is traded in the financial market, and the buyer can purchase it by paying option price.

With a call option, if the underlying asset (for example, stock) value is less than the exercise price at the time of option expiration, the option is considered to be "out of the money" and, rationally speaking, will not be exercised. Thus your net payoff in this case is negative and equal to the option price. If the asset value exceeds the exercise price, the option is "in the money" and, rationally speaking, will be exercised and your gross payoff will be positive. Your net payoff, however, may be positive or negative depending on the option price.

As assumed earlier, the construction of SMART can be viewed as a two stage investment problem. The first stage involves the acquisition of design certificate. The second stage, which would only occur if the first stage is successful, involves the start of construction of SMART. Hence the focus was on the valuation of the acquisition of design certificate.

The close connection between the value of the acquisition of design certificate and a call option on a stock is as follows;

The value of underlying asset in the case of a call option is the stock price; for the construction of SMART, it is the present value of the revenue cash flow. The exercise price for the SMART is the construction cost of it. The time to expiration is the project period of the design certificate, that is, 3 years. The volatility of stock price is matched to the volatility of the present value of the revenue cash flows generated by SMART for its life time.

3. Empirical analysis

The acquisition of design a certificate can be interpreted as an option to construct SMART because SMART would not be constructed without the acquisition of a design certificate. In this respect, the economic valuation of the design certificate project can be obtained by calculating option price in a European call option. Black-Sholes model provides a closed-form solution for the equilibrium price of the European call option. Besides Black-Sholes model, there is the replicating portfolio approach in calculating option price. This study obtains the option prices by using both approaches and comparing them to confirm the calculation was carried out in the right way.

3.1 Black-Sholes model

Black-Sholes formula is as follows:

$$C_0 = S_0 N(d_1) - Xe^{-r_f T} N(d_2)$$

Where,

S_0 = The price of the underlying asset

$N(d_1)$ = The cumulative normal probability of unit normal variable d_1

$N(d_2)$ = The cumulative normal probability of unit normal variable d_2

X = The exercise price

T = The time to maturity

r_f = The risk-free rate

e = The vase of natural logarithms

$$d_1 = \frac{\ln(S/X) + r_f T}{\sigma\sqrt{T}} + \frac{1}{2}\sigma\sqrt{T}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

$\sigma =$ Volatility factor

3.2 Estimation of input variables for the application of Black-Sholes model and empirical results

The construction cost of SMART involves a great deal of uncertainties. To reflect these uncertainties, this study assumes the four different construction costs of SMART taking into consideration the discussions being made on the probable construction costs of SMART. These construction costs(billion won) are 5,000, 6,000, 6,800, and 8,000 billion won.

This study calculated an electricity selling price from SMART based on the four assumed construction costs. The selling electricity prices are to be found by securing the rate of return on the investment, which is guided and regulated by the Government. The rate of return on investment applied to Korea Hydro & Nuclear Power Co. is 2.95% at present. Electricity price is assumed to follow a lognormal distribution because there is no negative price for electricity. The standard deviation of electricity price, 14.6%, for the past period from 2001 to 2009 was used in this study. Price simulation (out of 1000) was made using Crystal Ball Excel based risk simulation software. NPV was calculated with 16.4% of a standard deviation of the rate of return based on the simulation. The standard deviation was estimated to be almost the same for all four assumed construction costs. The electricity prices were assumed to follow geometric Brownian motion with drift.

Based on the input variables described above, the empirical results obtained are shown in table 1. Table 1 includes the option values not only from Black-Sholes model but also from the replicating portfolio approach, which was not explained explicitly in this study. We found both results to be almost the same.

Table 1. Option values of SMART construction

Construction cost of SMART(billion won)		5,000	6,000	6,800	8,000
Selling electricity price (won/kWh)		91.1	105.3	116.7	133.8
Budget for the acquisition of standard design certificate of SMART(billion won)		1,700			
Option value of SMART construction (billion won)	Black-Scholes formula	2,020	2,411	2,726	3,201
	Replicating portfolio approach	2,017	2,409	2,725	3,201

4. Conclusions

The budget for the project of the design certificate of SMART was estimated to be less than the construction option values of SMART for all the range of the construction cost assumed. As a result, the budget for the project of the design certificate of SMART can be justifiable.

REFERENCES

[1] Real options, Tom Copeland, Vladimir Antikarov, 2003

[2] Project valuation using Real Options, Prasad Kodukula, PMP, Chandra Papudesu, 2006

[3] Validation and Optionality of Large Energy Industry Capital Investments, Rob Graber, Geoffrey Rothwell, Cost engineering , vol 48, No.8 August, 2006