Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 22, 2009

Evaluation of an Investment Opportunity from the Perspective of Reliability Enhancement

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1. Introduction

We study the evaluation methodology to reflect investment risks invoked by uncertainties using the real option approach, that is, how to evaluate the investment opportunity with the consideration of reliability enhancement. We try to suggest potential investment opportunities from the perspective of the traditional Discount Cash Flow, *DCF*, methodology and the real option approach, and eventually compare results between them to demonstrate the aptitude of Real Option Approach, *ROA*, for a power sector investment (Dixit and Pindyck 1994).

In the traditional discount cash flow contexts, a wide range of uncertainties and flexibilities inherent in the electricity industry influence as the negative factors which would finally damage a future project value, while the real options approach can deal with those uncertainties in a different fashion by providing flexibilities when a prospective investment goes under consideration.

2. Methods and Results

In a bid to demonstrate the clear cut merit of the real option approach, we approach the method to show the comparative advantage between the DCF and the real option approach.

$$\Omega = \max[V_{DCF}, V_{ROA,} 0] \qquad [1]$$

2.1 DCF Model

It is known that a representative method of DCF approaches is the Net Present Value, *NPV*, to determine whether or not invest under the condition in which the difference between revenue and investment cost is larger than zero. This approach assumes that all uncertainty is reflected in the risk premium associated with the cost of capital. Gomez (2004) used the concept of the capital recovery factor, CRF, to reflect the risk premium for NPV calculation of a new nuclear power plant in consideration with its life expectancy.

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1} \qquad [2]$$

where, *i* is interest rates which is the nominal cost and *n* is the number of life expectancy in years.

Revenues from this new investment can be calculated;

$$R = [P \times CF - \underline{C}] \times MWYEAR \qquad [3]$$

where, *R* is net revenue per year in millions of dollars, MWYEAR is the quantity of megawatt-hours, MWh, produced per year, *P* is the electricity price in \$/MWh, and AVC is the average variable or production cost in \$/MWh. $\underline{C}$ is average variable cost at full capacity divided by the maximum MWh generated.

$$NPV = {}^{R}/_{\delta} - IC \qquad [4]$$

Where, δ is the appropriate discount rate, IC is investment costs. In this case, the tax issues are ignored for the sake of simplicity.

2.2 Real Option Model

We apply the concept of trigger value to determine value of real option, that is, *the boundary value at which an investor is indifferent either investing or waiting for better information* (Rothwell 2006). His model is oriented to use for the competitive electricity industry, while we, on top of the model itself, revise his model to apply into the vertical integrated system, Korean electricity industry.

The reason using the real option is that it provides more flexible approach when facing an investment project with uncertainties upfront. According to Dixt (1994), he defines the value of [Ω] of postponing the investment is according to a regime as such,

$$\Omega = \begin{bmatrix} B \cdot R^{\gamma} & if\ R \le R^{*} \\ \frac{R}{\delta} - I & if\ R \ge R^{*} \end{bmatrix} \qquad [5]$$

where, B is a parameter characterizing the investor's indifference between investing and waiting.

Since one of the model's assumption states that the revenue of a commodity follows Geometric Brownian motion while its price has the feature of Mean Reversion, the solution can be derived by the Ito lemma as follows,

$$\begin{bmatrix} dR = \mu R dt + \sigma R dz \\ \frac{1}{2}\sigma^2 R^2 + \Omega''(R) + \mu R \Omega'(R) - \delta\Omega(R) = 0 \end{bmatrix} \qquad [6]$$

Where, $\mu$is a drift rate and z demonstrates random Brownian motion or winner process.

Assuming an investor is indifferent to investing or waiting, *B=1*, and the positive value of waiting is equal to

$$\Omega = B \cdot R^{\gamma} \qquad [7]$$

and then substituting equation [7] into the second equation [6] ,

$$\frac{1}{2}\sigma^2\gamma(\gamma-1)+\mu\gamma-\delta=0 \quad [8]$$

We consider an electricity industry which is totally regulated by the government in which the plant's future revenues shows zero growth rate and γ can follow only positive values, the value of γ can be found as,

$$\gamma=\frac{1}{2}+\frac{1}{2}\sqrt{1+\frac{8\delta}{\sigma^2}} \quad [9]$$

The initial investment cost can be found by taking derivatives with respect to R of the equation [5],

$$R^*=\frac{\gamma}{(\gamma-1)}\delta\cdot IC \quad [10]$$

Finally, by incorporating the plant size, W, and the investment trigger value IC^*, the construction trigger value K^* is ,

$$K^*=\left(\frac{\gamma-1}{\delta\cdot\gamma\cdot}\right)\frac{R^*}{\mathrm{W}}\times 8.766 \quad [11]$$

where, 8.766 is the average number of hours in a year divided by 1,000, the number of kilowatts in a megawatt. δ is discount factor and γ is a parameter to be determined.

The equation [11] demonstrates the boundary value where investment would be undertaken now if the actual construction cost ($/kW) are less than the trigger value K^*.

2.3 Empirical Evaluation

2.3.1 Data

For our analysis, we refer the data of the report, *Development of Strategy for NPP Export (2007)* which studied on how to encourage the Korean NPP export under the upcoming second nuclear renaissance and then revise to take into account of cost of reliability increase for new NPP. We assume a new NPP needs as much as 10% of total construction cost to make allowance for safety issues. Here the total costs considering reliability costs are in the parenthesis.

Table I: Comparison of NPPs Economics

	OPR1000 (953MWe×2)	APR1400 (1,341MWe×2)
Total Capital cost *(Million USD)*	3,329 (3,660)	4,046 (4,450)
Unit Capital cost *(USD/KWe)*	1,747 (1,922)	1,508 (1,659)
O&M cost *(USD/MWh)*	46.7	41.7

Source: Development of Strategy for NPP Export (2007)

2.3.2 Comparison of Trigger Values

With a real cost of capital of 10% considering the capital intensiveness and the long term project periods, as long as 10 years including a project planning stage, the capital recovery factor, δ, is 0.102259 over a 40 year life span.

In case of NPV evaluation with the assumption that electricity price is $40/MWh, *CF* is 90%, the minimum average cost $20/MWh. The trigger value under NPV evaluation is K^*_{NPV} = *(40 - 20)*0.9*8.766/0.102259 = $1543/KW* which is the result that demonstrates an investor should not invest in any plant technology illustrated in Table I. Since the investment capital cost of both technologies are greater than the trigger value calculated.

Using the equation [11], we can calculate the trigger value with the real option approach. For the purpose of considering the regulated scheme, we assume the annual variance, σ^2 of percentage changes in net revenues is 4.2%, γ with the equation [9] is 2.763. Accordingly, the trigger value K^*_{ROA} = $984.56/KW.

3. Conclusions

The power sector investment necessitates careful considerations about numerous variables in association with its capital intensiveness and long term period, most of which are, although, uncertain and hard to predict. It is the real option approach that can reflect those variables which play an important role in a new power plant investment. As shown the result suggested by the empirical evaluation above, a potential investor won't invest until the investment trigger value reaches $1543/KW under the NPV while he could try to invest as soon as the investment trigger value hits $984.56/KW.

The insight in this case is that a potential investor would loss an opportunity to construct a nuclear power plant if he only relies on NPV approach but he is able to take advantage of investment opportunities with an evaluation result using real option approach.

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