Evaluation of DOTO Expressway using Real Option Approach

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1. Introduction

Nowadays, standard discounted cash flow (DCF), such as Net Present Value (NPV), is very popular model for project evaluation. However, the DCF model is found to lack in flexibility, contingency and volatility when compare with real option approach. Therefore, this study wants to apply real option approach to evaluate infrastructure project (DOTO expressway as a case study).

2. Real Option Approach

Option in finance means rights to purchase (call option) or sell (put option) assets with fixed price in the future or until expiration date. Real option approach, therefore, is an approach to option on real assets as shown in Table 1.

Table 1.Comparison of financial asset and real option

Financial asset (Option)	Investment in real asset (Real Option)	Investment in Infrastructure (Real Option)
Stock price	NPV of profit	NPV of benefit
Exercise price	Project cost	Project cost
Life of option	Investment can postpone	Investment can postpone
Risk free rate	Risk free rate	Social discount rate
Variance of profit rate	Risk of project profit	Risk of social benefit

In conventional NPV (Net Present Value) method, the results of the process usually provide only two choices, launch the project right now or quit the project forever. However, many options, such as postpone, abandon, expand, or reduce scale of the project, are available in real option approach as illustrate in [1].

Enlarge NVP = Conventional NVP + Option value **[1]**

In real option approach, Binomial model is currently the most widely used, for example Black Scholes (B.S) model. The binomial model describes option value movement over time, where the asset value can move to one of two possible options with associated probabilities. The range of potential outcomes is called cone of uncertainty as shown in Figure 1.

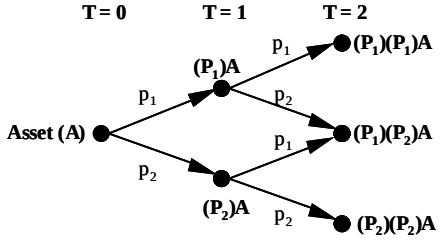

Figure 1. The Binomial Model (Credit Suisse First Boston Corporation, 1999)

3. Overview of DOTO Expressway Project

DOTO expressway is a toll way using to connect Chitose prefecture and Ikeda prefecture. The project is divided into 3 sections as shown in Figure 2.

Presently, DOTO expressway section A and C were already constructed, while section B is freezing project due to bad economic situation.

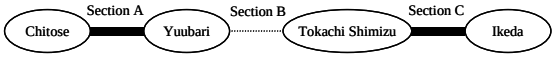

Figure 2. Overview of DOTO Expressway project

4. Benefit and Cost Estimation

Benefits in this study are considered mainly on user benefit while costs are calculated from investment cost and operating and maintenance cost (O&M). The benefit and cost from expressway section B construction is determined according to Guideline for the Evaluation of Road Investment Projects manual as shown in Table 2.

Table 2. Summary of benefits and costs in the project

Base year : year 2001	**Project life** : 40 yrs.
Construction period : 5 yrs.	**Social discount rate** : 4 %
Benefit : Reducing in travel time and travel cost	
Construction cost : 293 billion yen	
O&M cost : 430 million yen/km/yr x81 km =3.48 billion yen/yr	

In benefit estimation, traffic volume is a main parameter that has uncertainty. Two risk factors in traffic volume estimation process, namely R_1 and R_2, are used to identify the benefit uncertainty. R_1 is represented fluctuation in annual growth factor for future traffic volume estimation, while R_2 is the different between the estimated and the real traffic volume in based year.

To understand the effect of R_1 to the fluctuation in traffic volume, traffic volume fluctuation rate $\Delta Q/Q$ is assumed to follow the winner process, which express random transition along the time series as shown in [2].

$$\frac{\Delta Q}{Q} = \frac{Q_{i+1} - Q_i}{Q_i} = \mu\ \Delta t + \sigma\sqrt{\Delta t} Wt \qquad \textbf{[2]}$$

where, Q_i is traffic volume in year i

μ is trend parameter

σ is volatility parameter

W_t is standard normal distribution with (0,1)

When $\Delta t=1$, the [2] can be written as [3].

$$Q_{i+1} = Q_i(\mu + \sigma\ Wt + 1) = Q_i R_1 \qquad \textbf{[3]}$$

The parameter μ and σ are estimated using 1990-1998 traffic volume data of DOUO expressway. By considering uncertainty in both benefit and cost estimation, 3 risk cases are set up to evaluate the project (Table 3).

Table 3. Details of the risk cases

Parameter	Risk case 1	Risk case 2	Risk case 3
R1	0 to 19th μ = 0.02 σ = 0.06 20th to 40th μ = 0.00 σ = 0.06	μ = 0.00 σ = 0.06	μ = 0.00 σ = 0.06
R2	Mean = 0 Std. deviation =0.05	Mean = 0 Std. deviation =0.05	Mean = 0 Std. deviation =0.05
Total cost (billion yen)	352.5	352.5	Vary

5. Risk Analysis

Risk case 1 and 2 are set up to have uncertainty only in benefit estimation, while risk case 3 vary for both benefit and cost estimation. For uncertainty in benefit estimation, volatility in traffic volume estimation (σ) in all risk cases is set up to be 6 %. However, 2 % traffic growth rate (μ) is assumed only in risk case 1 (from opening the project until year 19 of the project life).

(1) Risk Case 1

The result shows that the expected value of benefit is 387.2 billion yen with 107.3 billion yen for standard deviation (Figure 3). As the cost is estimated to be 352.5 billion yen, therefore this project is qualified based on conventional cost-benefit analysis.

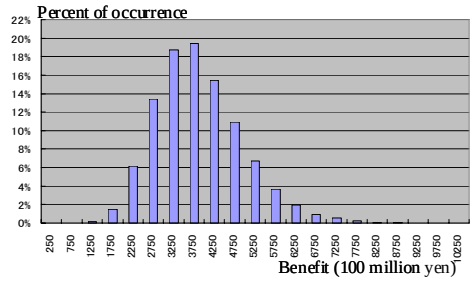

Figure 3. The distribution of benefit in risk case 1

(2) Risk Case 2

Expected value of the benefit is 288.2 billion yen while standard deviation is 79.5 billion yen. As a result, the project is considered to be terminated (benefit < cost).

(3) Risk Case 3

From Table 4., the project will be feasible if the construction cost and O&M cost can be reduced more than 20% and 9.6%, respectively.

Table 4. Variation in Investment cost and O&M cost (in billion yen)

Construction cost		O&M cost		Total cost
No change	293	No change	59.5	352.5
Reduce 20 %	23.4	No change	59.5	293.9
Reduce 20 %	23.4	Reduce 5 %	56.5	290.9
Reduce 20 %	23.4	Reduce 9.6 %	53.8	288.2
Reduce 20 %	23.4	Reduce 10 %	53.5	287.9
Reduce 20 %	23.4	Reduce 15 %	50.6	285.0

6. Calculation of Option Value

(1) Benefit Estimation Process

The process in which benefit arises is formulated to calculate option value. The net present value of benefit is assumed to follow geometry Brown motion [4]. The benefit is calculated by Monte Carlo DCF method. σ is determined using standard deviation of benefit distribution and benefit computation period (45 years) with 1 year as a base unit [5].

$$\frac{dPBn(t)}{PBn(t)} = \mu dt + \sigma W(t) \quad \textbf{[4]}$$

$$\sigma = \frac{\text{Standard deviation}}{\text{Expected value of benefit x } \sqrt{45}} = 4.1\% \quad \textbf{[5]}$$

where, μ is trend parameter (social discount rate)
W(t) is standard normal distribution with (0,1)
σ is volatility parameter

With uncertainty of benefit, the value of option (delay option) when postpone the project for 2 years is identified from the risk-neutral probability approach.

(2) Evaluation of Risk Case 1

Basic asset (current value of benefit) is 387.2 billion yen, while the total investment of 354 billion yen is need from government to construct expressway section B. By assuming that Basic asset (benefit) follows the geometric Brown movement, rising proportion (u) and reduce proportion (d) after 1 year are u= $\exp^{(\sigma)}$ and d= $\exp^{(-\sigma)}$. Besides, only percentage of risk free rate (social discount rate) increases every year.

Adjustment NVP can require pay off (benefit that will be gained when make use of option) after calculate from last 2 years as shown in Figure 4.

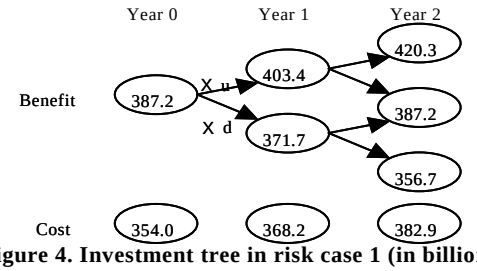

Figure 4. Investment tree in risk case 1 (in billion yen)

Considering based year, the NPV of total net benefit is 33.2 billion yen (387.2 －354.0). While the value of delay option (33.7 billion yen) is calculated using risk-neutral probability approach (Figure 5). Therefore, the value of option (delay investment for 2 years) is 0.6 billion yen. As the option value is very small compare to total NPV of net benefit when we do not consider option, it can be said that there is not worth to postpone the project.

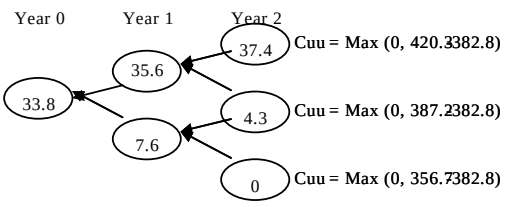

Figure 5. NPV of option value (in billion yen)