ESTIMATION OF OPTION VALUES IN AN EXPRESSWAY PROJECT*

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1. Introduction

According to changing in Japan government policy, reducing fund for large infrastructures are planned to implement. Japan Highway Public Corp. (JH), as a government enterprise to respond for expressway network in Japan, is also received large effect from the policy. It is estimated that investment fund for JH has been reduce from 3.46 trillion yen for next 51 years to be 1.79 trillion yen for the next 46 years (The Japan Times: July, 26 2002). This is especially a serious problem for Hokkaido prefecture, where many new expressway projects are still under decision process. As a result, the new expressway projects have to be reevaluated to ensure that the selected projects are really worth.

Traditional discount cash flow technique (DCF), e.g. standard net present value (NPV), is usually used as a standard tool to assess the feasibility of an expressway project. The conventional evaluation process gives only two possible outcomes, invest now or abandon the project. In addition, DCF seems to under estimate the project value. In contrary, management flexibility, through options, is increased when the project evaluation process uses real options approach to analyze investment under uncertainty. This eventually increases the value of the project. Therefore, this study aims to introduce real option approach, as a current state of art, in the evaluation of expressway projects. The evaluation process is demonstrated by using DOTO expressway as a pilot case study. Estimated option value, as results of the real option analysis, in the project is identified and its effects are also discussed.

2. Real Option Analysis (ROA)

The definition of real option is defined as "the right, but not obligation, to take an action (e.g. deferring, expanding, contracting, or abandoning) at a predetermined cost (called the exercise price), for a predetermined period of time (the life of the option)" (Copeland and Antikarov, 2001).

To apply ROA in planning and evaluation of expressway project, the analytical process can be summarized systematically into 4 steps (Copeland and Antikarov, 2001). First, it begins with determining the project NPV without flexibility using traditional DCF technique. Next step is modeling the uncertainty by constructing the event tree of the project. Then, options, that management can be exercised, are assigned to each node of the project event tree to become a decision tree. Finally, the option value of project can be identified by using either replicating portfolios or risk-neutral probabilities method.

3. Evaluation of DOTO Expressway Project using Real Option Analysis (ROA)

3.1 Overview of DOTO expressway project

DOTO expressway is a toll way used to connect Chitose city and Ikeda town. The project is divided into 3 sections as shown in Figure 1. Presently, DOTO expressway section A and C were already constructed, while section B is under the decision-making process.

3.2 Net Present Value of the project (Project NPV)

Estimated benefits in this study are considered mainly on user benefit, while costs are calculated from investment cost and operating and maintenance cost (O&M). Traffic volume in DOTO expressway both before and after construction of section C is estimated as shown in Table 1 and Table 2, respectively.

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*Keywords: real option, project evaluation, expressway project
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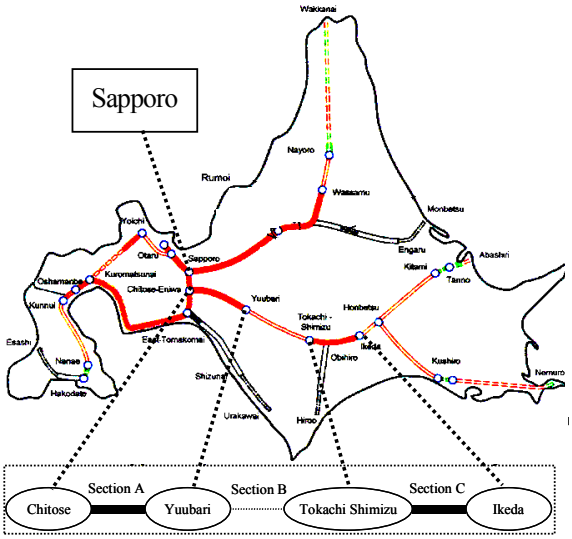
The benefit and cost from expressway section B construction is determined according to Guideline for the Evaluation of Road Investment Projects manual which can be summarized as:



Base year	: year 2001
Project life	: 40 yrs
Construction period	: 5 yrs.
Social discount rate	: 4 %
Benefit	:Reducing in travel time and vehicle operating cost
Construction cost	: 293 billion yen
O&M cost	: 430 million yen/km/yr for 81 km. =3.48 billion yen/yr

Figure 1. Overview of DOTO Expressway project

Table 1. Summary of Traffic volume in year 2001 for DOTO expressway section A and C

Origin to Destination	Chitose to Yuubari				Shimizu to Ikeda			
	Passenger car		Truck		Passenger car		Truck	
	vpd	%	vpd	%	vpd	%	vpd	%
Sapporo to Furano	34	2	2	1	0	0	0	0
Sapporo to Obihiro	1213	61	236	59	544	52	105	52
Sapporo to Kitami	42	2	8	2	33	3	6	3
Sapporo to Kuchiro	532	27	133	33	215	21	53	26
Tomakomai to Furano	6	0	2	0	0	0	0	0
Tomakomai to Obihiro	79	4	10	3	130	12	22	11
Tomakomai to Kitami	42	2	6	1	72	7	11	6
Tomakomai to Kuchiro	44	2	5	1	52	5	6	3
Summation	1991	100	402	100	1045	100	203	100
Total	2394				1249			

Table 2. Summary of Traffic volume in year 2001 for DOTO expressway if construct section B

Origin to Destination	Chitose to Yuubari				Yuubari to Shimizu				Shimizu to Ikeda			
	Passenger car		Truck		Passenger car		Truck		Passenger car		Truck	
	vpd	%	vpd	%	vpd	%	vpd	%	vpd	%	vpd	%
Sapporo to Furano	348	9	26	3	348	7	26	2	0	0	0	0
Sapporo to Obihiro	1574	39	328	38	1574	31	328	31	1574	33	328	32
Sapporo to Kitami	417	10	86	10	417	8	86	8	417	9	86	8
Sapporo to Kuchiro	920	23	296	34	920	18	296	28	920	20	296	29
Asahikawa to Obihiro	0	0	0	0	324	6	60	6	324	7	60	6
Asahikawa to Kchiro	0	0	0	0	94	2	18	2	94	2	18	2
Tomakomai to Furano	51	1	15	2	51	1	15	1	0	0	0	0
Tomakomai to Obihiro	340	8	56	6	647	13	126	12	647	14	126	12
Tomakomai to Kitami	123	3	20	2	233	5	42	4	233	5	42	4
Tomakomai to Kuchiro	285	7	40	5	498	10	75	7	498	11	75	7
Summation	4058	100	867	100	5106	100	1072	100	4707	100	1032	100
Total	4926				6179				5740			

3.3 Probability distribution of the project benefit

In benefit estimation, traffic volume is considered as the main uncertainty source. Uncertainty in traffic volume can be subdivided into two components, namely uncertainty in traffic volume in the future denoted by R_1 and uncertainty in the accuracy of traffic volume estimation for the base year denoted by R_2.

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 Wiener process, which expresses random transition along the time series as shown in [1].

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

where, Q_i is traffic volume in year i

μ is trend parameter

W_t is standard normal distribution with (0,1)

σ is volatility parameter

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

$$Q_{i+1} = Q_i(\mu + \sigma Wt + 1) = Q_i R_1 \qquad \textbf{[2]}$$

The parameter μ and σ for R_1 are estimated using 1990-1998 traffic volume data of DOUO expressway. It can be estimated that the traffic volume will increase 2 % annually since beginning of the service until year 19 of service with standard deviation of 6 %. After year 20 of service until end of project life, the traffic volume will just fluctuate with standard deviation of 6 %. While, uncertainty in R_2 is assumed that estimated traffic volume in based year may only fluctuate with standard deviation of 5 %. The parameter of R_1 and R_2 that will be used in Monte Carlo simulation can be summarized as:

R_1 : $\mu = 0.02, \sigma = 0.06$ for year 0 to year 19 and $\mu = 0.00, \sigma = 0.06$ for year 20 to year 40

R_2 : $\mu = 0.00, \sigma = 0.05$

The result from Monte Carlo simulation shows that the expected value of benefit is 387.2 billion yen with 107.3 billion yen for standard deviation (Figure 2). As the cost is estimated to be 352.5 billion yen, therefore, this project is qualified based on conventional cost-benefit analysis.

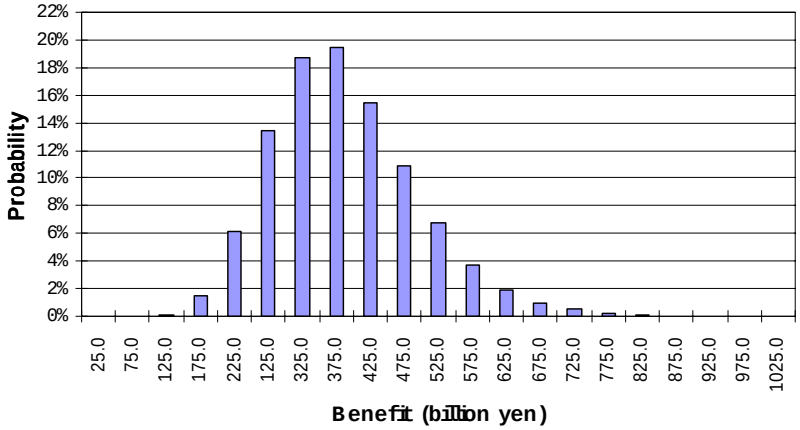


Figure 2. The benefit distribution of the project

The net present value of benefit is assumed to follow Geometric Brownian process. As a result, volatility of benefit (σ) can be determined based on the distribution of benefit [3].

$$\sigma = \frac{\text{Standard deviation}}{\text{Expected value of benefit} \times \sqrt{45}} = 4.1\% \qquad \textbf{[3]}$$

where, σ is volatility of benefit

It should be noted that uncertainty in cost and uncertainty in project life should be included as sources of uncertainty for estimation of volatility of the project NPV.

3.4 Event tree of the project

The benefit of the project is estimated to be 387.2 billion yen, while the total estimated cost of 354 billion yen is needed from the government to invest in DOTO expressway section B. By employing Discrete multiplicative binomial process to construct the event tree, the up movement (u) and down movement (d) for time period of 1 year can be estimated as $u = \exp^{(\sigma)}$ and $d = \exp^{(-\sigma)}$, where σ is the volatility of benefit. Besides, only the percentage of risk free rate (social discount rate) increases every year. As a result, the event tree of the project for 2 years can be demonstrated in Figure 3.

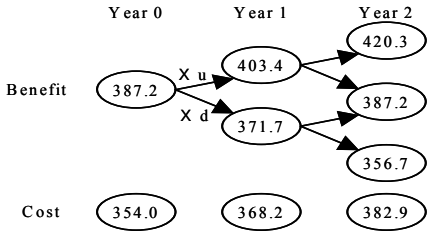


Figure 3. Event tree of the project (in billion yen)

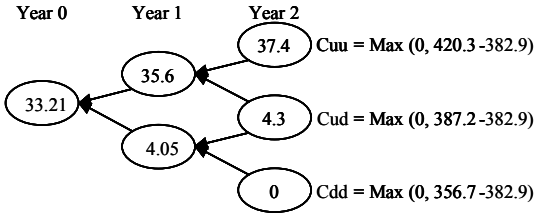


Figure 4. Project NPV by ROA (in billion yen)

3.5 Decision tree of the project

By considering that defer option is available, the management of DOTO expressway project has more flexibility. The defer option is assumed to be available for the maximum of 5 years. It is also assumed that the option can be exercised with no cost. Therefore, the defer option at each node may be exercised if the present value of the project is less than 0, otherwise we can keep the defer option alive.

3.6 Real options analysis

By using risk-neutral probability approach, real options analysis (ROA) can be performed to evaluate the project NPV, which has delay option (more flexibility). The analysis is calculated backward by starting at the end of the event tree. Then, the project NPV in based year can be obtained by using risk-neutral probability method as illustrated in Figure 4. The risk neutral probability (p) can be calculated as shown in [4].

$$p = \frac{(1+r)-d}{u-d} \qquad \textbf{[4]}$$

where, p is risk-neutral probability

r is risk free rate (social discount rate)

u is up movement

d is down movement

The option value of providing defer option at different life of the option (maximum 5 years) can be drawn in Figure 5. It can be seen that the longer the life of option is provided, the higher option value can be received. This implies that it is always better to delay the project as long as the life of defer option is offered, which seem to be an unrealistic result. Therefore, some exercise cost for defer option should exist.

Obviously, the option value that can be gained from offer defer option is relatively small (10 million yen) when compared with the value of project NPV (32.2 billion yen). Therefore, delay of DOTO expressway section B construction (defer option) is not recommended.

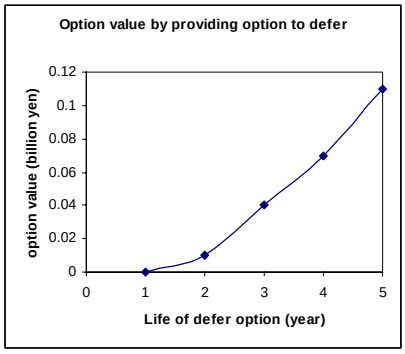


Figure 5. Option value of defer option

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