EVALUATION OF DOTO EXPRESSWAY PROJECT CONSIDERING EXTENSION OPTION USING REAL OPTION ANALYSIS*

by Preda PICHAYAPAN**, Kunihiro KISHI**
and Keiichi SATOH**

1. Introduction

As budget for expressway projects in Japan is continuously decreasing, planning for a new project has to be planned economically. By observing from existing unprofitable projects, it can be found that lower traffic volume or higher maintenance cost than forecasting values are normally the reasons. Therefore, uncertainty in forecasting traffic volume and estimated maintenance cost should be included in the evaluation process. The problems are especially a serious for Hokkaido prefecture, where many expressway projects are still in implementing process. Thus, this study examines the effects of implementing processes for DOTO expressway project by considering uncertainty in traffic volume estimation and also operating and maintenance cost (O&M cost). The presently progress is evaluated and compared to the progress that has extension option to extend the project later in the future using Real Option Approach (ROA) applying Monte Carlo Discount Cash Flow technique (Monte Carlo DCF).

2. DOTO Expressway Project

2.1 Overview of DOTO Expressway Project

DOTO expressway is a toll road using to connect cities in eastern part of Hokkaido. The sections from Chitose to Yubari (42.1 km.) and Tokachi-shimizu to Ikeda (50.3 km.) are already in constructed since 1999 and 1995 respectively. However, the expressway connecting Yubari and Tokachi-shimizu (Section A) and the extension section from Ikeda to Kushiro (Section B) is currently constructing as shown in Figure 1. The presently the implementing progress of DOTO expressway projects can also be summarized in Table 1.

Figure 1. Overview of DOTO Expressway project

2.2 Proposed Implementing Process

From presently progress, it can be seen that section B is constructed faster than section A. This is a doubt among planners that the current progress is really good strategy. It is considered to be more efficiently to connect the existing expressways together (Yubari to Shimizu) before extent it (Ikeda to Kushiro). Thus, extension option is set up in this study as to continue implement section B after section A is already constructed. Then the proposed process, which has extension option, is evaluated and compared with currently progress (Without option) as shown in Figure 2.

Table 1. Progress of DOTO expressway project

	Distance (km.)	Date of Approval	% Completion in 2002
Section A	81	Dec 1998	9 %
Section B	84	Nov 1993	16 %

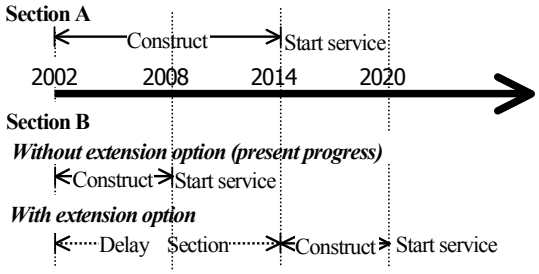

Figure 2. The implementing process with and without extension option

*Keywords: Real Option Analysis, Monte Carlo DCF, Extension option
** Div. of Urban Environmental Eng., Graduate School of Eng., Hokkaido Univ.,
(North 13, West 8, Kita-ku, Sapporo, Hokkaido, Japan, TEL011-706-6822, FAX 011-726-6216)

3. Discount Cash Flow (DCF) and Real Option Analysis (ROA)

In normal practice, it is usually acceptable to use discount cash flow (DCF) technique to evaluate transportation project due to its simplicity. Unfortunately, uncertainties in forecasting variables are not taking into account in DCF process. Real Option Analysis (ROA), a currently state of art, provides capability to incorporate uncertainty in the evaluation process. ROA measures investment opportunities in real assets considering uncertainties in forecasting variables.

To introduce ROA in evaluation of transportation project, Monte Carlo discount cash flow method (Monte Carlo DCF) is applied. Monte Carlo DCF has same basic assumptions as DCF technique while using simulation to incorporate uncertainty in the evaluation process. By modeling uncertainty in future traffic volume and also operating and maintenance cost to follow a stochastic process, simulation can be done by repeating same procedure of DCF for a set of generated data. Thus, Monte Carlo DCF is considered to be the building block of DCF technique.

4. Modeling Uncertainty in Benefit and Cost

As estimated benefits and costs in the expressway project have to be forecasted from the whole project life, thus, benefits and costs are subjected to uncertainty. Forecasted traffic volume, both in national highway and expressway, and predicted operating and maintenance cost (O&M) is considered to be the major source of uncertainty for benefit and cost estimation respectively. To account uncertainty in the analysis, forecasting variables are assumed to follow a stochastic process. This is done by modeling the traffic volume and O&M cost using Geometric Brownian Motion (GBM) as shown in **(1)**. As the forecasting variables have only positive value, thus, it is more realistic to model natural logarithm of the variables to follow GBM.

$$\frac{\Delta X}{X} = \mu \Delta t + \sigma \varepsilon_t \sqrt{\Delta t} \qquad \textbf{(1)}$$

where, X : variables X (traffic volume or O&M cost)

μ : drift parameter

σ : variance parameter

ε_t : normal distributed random variable with a mean of 0 and a standard deviation of 1, N(0,1)

4.1 Traffic Volume Estimation

From historical traffic volume data, it can be seen that there is fluctuation in traffic volume due to its uncertainty. Thus, this study assumes that there would be uncertainties in traffic volume in both national highway and expressway. The natural logarithm of traffic volumes is assumed to follow GBM. Then, drift parameter is estimated from traffic volume in OD 1999 and forecasting traffic volume in OD 2020. The variance of the process is calculated from historical data of traffic volume. Thus, future traffic volume can be generated as shown in Figure 3.

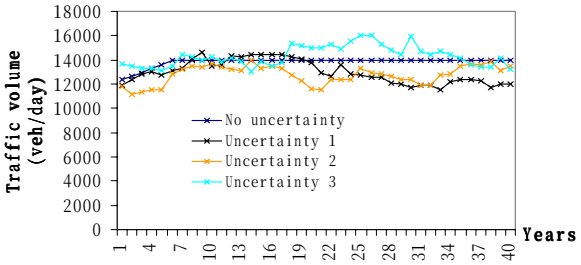

Figure 3. Example of generated traffic volume

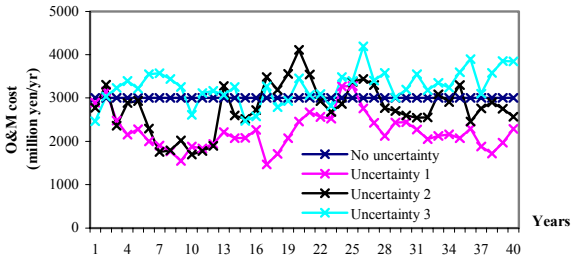

Figure 4. Example of generated O&M cost

4.2 Operating and Maintenance Cost (O&M cost) Estimation

Operating cost of the project is accrued from labor cost in toll collection while road surface maintenance, snow removal and safety cost are calculated for maintenance cost. The O&M cost is approximately 3000 million yen per year for section A project and 3250 million yen per year for section B project.

As O&M cost is the estimated cost in future, thus, the cost is model with stochastic process (GBM). O&M cost is predicted to be spent equally for whole service life, therefore, the drift parameter is 0. For the variance parameter, historical data of O&M cost in Hokkaido is used. The forecasted O&M cost can be generated as shown in Figure 4.

5. Social Loss when Deferring Projects

An expressway is a kind of infrastructure project, the government usually concerns more about the benefit that project can give to whole society than its profit. Like other infrastructure projects, its service usually does not just stop at their estimated life of the project (30-40 years). Instead, the service should continue to serve society even when the project has already ended. The structure of the expressway may be deteriorated, however, new projects are expected to replace the old one. Therefore, the expressway project can be considered as a continuous project rather than a stand-alone project.

By treating expressway project as a continuous project, the benefit from the project should be generated continuously since the service has been started. Then, if the decision makers delay the investment decision of the expressway project, the expressway is also postponed. In the defer year, net user benefit, which is expected to be occurred when expressway is constructed, disappeared. This forces some road users, who have willingness to use expressway, to travel with longer travel time as well as higher cost (higher vehicle operating cost, VOC). Moreover, traffic safety benefit (resulted from saving in traffic accident when user can use expressway) is not gained. As a result, the losses, which are occurred to the social as a whole, should be considered in ROA process when the project has to be deferred as:

$$SL_i = \Sigma UB_i - \Sigma UC_i \quad \textbf{(2)}$$

where, SL_i : Social Loss due to delay investment decision in year i (yen/year)
UB_i : Users Benefit in year i (yen/year)
UC_i : Users Cost in year i (yen/year)
i : year that the project have been deferred

6. Monte Carlo Discount Cash Flow (Monte Carlo DCF)

6.1 Basic Assumptions

The basic assumptions for the benefit and cost estimation are summarized as shown in Table 2.

Table 2. Basic assumptions using in evaluation process

	Section A	Section B
Construction period	12 years	6 years
Construction cost	283.5 billion yen	252 billion yen
Maintenance cost	3000 million yen per year	3250 million yen per year
Based year	Year 2002	
Project life	40 years	
Social discount rate	4 %	

6.2 Benefits and Costs Estimation

In reality, various kinds of benefits such as driving comfort, effects on regional economic development, etc. should be included in the benefit estimation. However, those benefits are hard to estimate in monetary term and accuracy is questionable. Therefore, this study considers only the benefit that could be estimated in monetary term which practitioners usually account for.

The investment cost for expressway project can be roughly categorized into 2 types, construction cost and operating & maintenance cost (O&M cost). The construction cost is estimated to be spent equally 12 years for section A and 6 years for section B. Operating cost of the project is accrued from labor cost in toll collection while road surface maintenance, snow removal and safety cost are calculated as maintenance cost. The O&M cost is approximately 3000 million yen per year for section A project and 3250 million yen per year for section B project.

6.3 Results of Monte Carlo DCF

Monte Carlo simulation is employed to combine uncertainty in both traffic volume and O&M cost. The simulation used generated traffic volume and O&M cost, which follow stochastic process, to calculate benefit and cost for 5000 sets of data. The distribution of net benefit (NPV) in case of with and without extension option can be shown in Figure 5 while expected values of benefit and cost are summarized in Table 3.

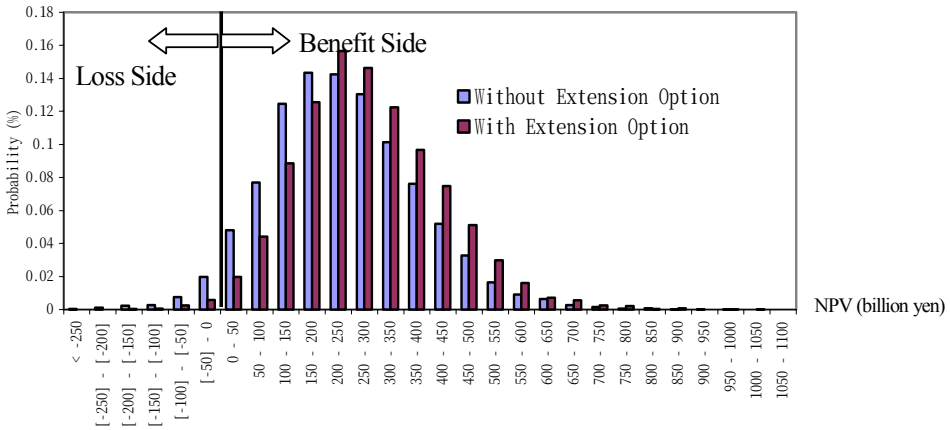

Figure 5. Distribution of NPV of the project with and without extension option

From Figure 5., it can be seen that not only the expected net benefit from project with extension option is higher than the one from without extension project but also the percentage that the project may get loss is also reduced. The possibility that the project will get loss for without extension option is 3.4 %, while the possibility is reduced to be about 1 % for the project that have extension option.

Table 3. Summary of Simulation results

	Without extension option (Present progress)	With extension option
Total Benefit (B)	675.2	654.3
Total Cost (C)	436.5	373.7
Net Benefit (B-C)	238.7	280.6
Value of extension option	41.9	

Note : value in billion yen

From the results of simulation, the benefit in case with extension option is less than the benefit in case without extension due to the effect of social loss. However, the net benefit in case with extension option is higher compare with the one in case without extension option. As value of extension option is defined in (3) as the different in net benefit of the project between have and do not have extension option, thus, the project gets extra benefit of 41.9 billion yen if project selects extension option.

Value of extension option = Net benefit with extension option – Net benefit without extension option (present progress) **(3)**

7. Conclusions and Recommendations

This study examines the currently progress of DOTO expressway project compare with the progress that have option to extend the project later in the future considering uncertainties in the evaluation process. This is done by applying Monte Carlo discount cash flow method (Monte Carlo DCF) as alternative technique in Real Option Approach (ROA). The results show that the value of the project in case the progress has the extend option is greater than presently progress. The possibility that the project will get loss is also reduced. Moreover, uncertainty in the extension project is considered to be reduced by observing from the finish project. Therefore, it is recommended that DOTO expressway section A from Yubari to Tokachi-shimizu should be implemented without delay. Then, the expressway section B from Ikeda to Kushiro should be deferred and constructed after section A is already constructed.

8. References

1. Dixit, A. K. and Pindyck, R. S., *Investment under Uncertainty*. Princeton University Press, Princeton, New Jersey, 1994
2. Study Group on Road Investment Evaluation, *Guidelines for the Evaluation of Road Investment Projects*. Japan Research Institute, Tokyo, 2000
3. Trigeorgis, L., *Real Options*. The MIT Press, 2002