Value of extension option in DOTO expressway project considering uncertainty in traffic demand

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1. Introduction

As budget for expressway projects in Japan is continuously decreasing, planning for a new project has to be planned economically. The problems are especially a serious for Hokkaido prefecture, where many expressway projects are still required to complete the network. Thus, this study examines the effects of implementing processes for DOTO expressway project. Uncertainty in forecasting traffic demand is modeled and used in the evaluation process. The approved plan is evaluated and compared with 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.

2. 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 Tokachishimizu 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.
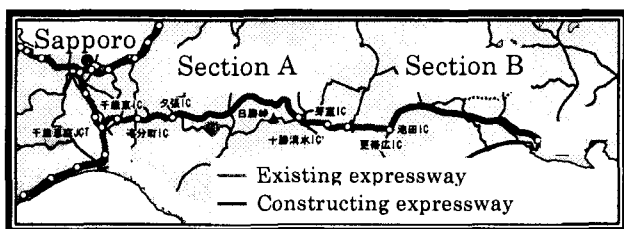

Figure 1. Location of DOTO expressway project

3. Real Option Analysis

In 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, then, can measures investment opportunities 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 demand, 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.

To apply ROA in DOTO expressway project, extension option is adopted. It can be seen from approved progress that section B is constructed faster than section A. This is a doubt among planners that the current progress is really a good strategy. This is because it is considered to be more efficiently to connect the existing expressways together (Yubari to Tokachishimizu) 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 as shown in Figure 2. Then, the value of extension option can be estimated as a difference between net benefit from the project when have and do not have extension option as expressed in eq. (1).

$$VO = NB_w - NB_{wo} \qquad (1)$$

where, VO : Value of extension option

NB_w : Net benefit from project with extension option

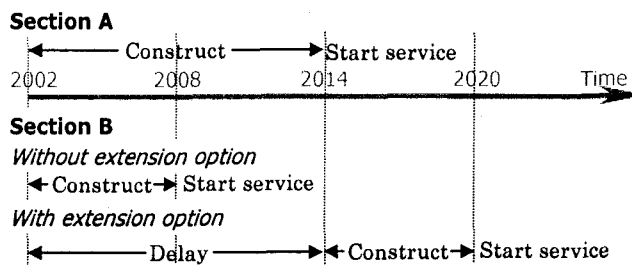NB_{wo} : Net benefit from project without extension option

Figure 2. Implementing process with and without extension option

4. Traffic demand estimation

Traffic demand for each section is determined using Origin-Destination (OD) table in year 1999 and 2020. Total traffic demands in 1999 are estimated to be 8531 vpd and 6586 vpd for Yubari-Tokachishimizu and Ikeda-Kushiro section respectively. For year 2020, expected traffic demand for Yubari-Tokachishimizu is 14128 vpd and 9772 vpd will use road section Ikeda-Kushiro. Estimated traffic demand for road section Yubari – Tokachishimizu is shown in Table 1.

Table 1. Predicted traffic demand in 1999 and 2020

	Kushiro	Obihiro	Kitami	Abashiri	Nemuro
Sapporo	1112 (3023)	1834 (4465)	622 (1879)	539 (577)	66 (432)
Hakodate	278 (121)	172 (64)	1 (22)	1 (23)	0 (46)
Otaru	289 (160)	204 (205)	176 (103)	3 (56)	6 (64)
Muroran	178 (151)	68 (170)	1 (42)	1 (21)	4 (34)
Yubari	0 (9)	0 (27)	0 (3)	0 (0)	0 (5)
Tomakomai	128 (518)	264 (788)	158 (154)	156 (69)	0 (113)
Chitoze	106 (44)	206 (143)	66 (29)	66 (8)	5 (1)
Noboribetsu	65 (21)	51 (19)	0 (8)	0 (1)	10 (0)
Eniwa	10 (29)	98 (37)	54 (9)	5 (7)	112 (1)
Date	9 (7)	2 (11)	0 (2)	0 (0)	209 (1)
Kitahiroshima	48 (23)	272 (42)	58 (16)	101 (2)	0 (1)
Ishikari	3 (41)	175 (63)	93 (23)	0 (4)	0 (6)
Not Hokkaido	143 (109)	191 (40)	81 (27)	14 (3)	17 (6)
Total	8531 (14128)				

All values are in vehicle per day (vpd)

Values in ( ) are in year 2020

5. Uncertainty in traffic demand

Traffic demand is known as a main factor that has great effects in evaluation of expressway project. The uncertainty is modeled by assuming that the future traffic demands follow normal distribution. The predicted demand, resulting transportation models, is considered to be mean value, while values for standard deviation are vary from 0 – 20 %. Figure 3. show the paths of future traffic demand for Yubari-Tokachishimizu section with standard deviation 20 %.
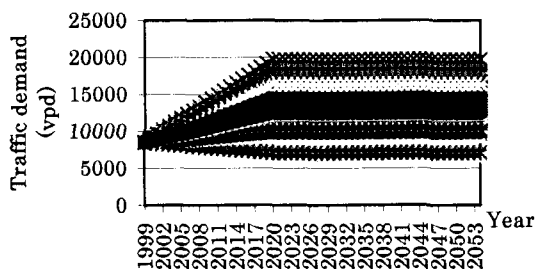

Figure 3. Uncertainty in traffic demand

6. Results

The basic assumptions using in the evaluation process can be summarized in Table 2.

Table 2. Basic assumptions for evaluation process

	Section A	Section B
Distance	81 km.	84 km.
Construction time	12 years	6 years
Construction cost	283.5	252
Maintenance cost	3	3.25
Based year	Year 2002	
Project life	40	
Social discount rate	4 %	

All cost are in billion yen

The generated future traffic demands are used as an input for Monte Carlo DCF. 5000 simulations are done and the results can be shown in Figure 4.
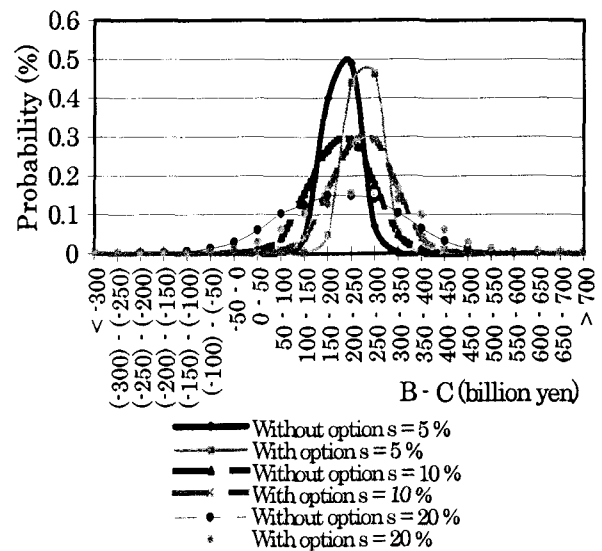

Figure 4. Probability distribution of Net benefit of projects

From the distribution, the value of extension option is calculated and estimated to be 46.2 billion yen for all cases. From Figure 4., it also can be noticed that the net benefit of the project start to have negative value since sigma greater than 10 %.

7. Conclusions and Recommendations

This study examines the approved progress of DOTO expressway project and compares with the progress that have extension option considering uncertainties in traffic demand. 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. 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.