Value of Defer Option in Otaru-Yoichi Expressway Project

Hokkaido University　○ Graduate Student　Pichayapan Preda
Hokkaido University　Research Associate　Kunihiro Kishi
Kitami Institute of Technology　Associate Professor　Takahashi Kiyoshi
Hokkaido University　Professor　Keiichi Satoh

1. Background

With the current policy of the Japanese government that aims to reduce budget for large infrastructure, it is urgent to acknowledge the agendas for new expressway projects in Hokkaido. Evaluation of new projects by using traditional discount cash flow technique (DCF), as a standard tool, is found to be under evaluated value of the project. Therefore, this study aims to adopt real option analysis (ROA), as a current state of art, to assess Otaru-Yoichi expressway project. By providing the right to defer, the value of the project considering uncertainty can be explored.

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). Real Option is considered as a kind of decision analysis process that concentrates on real assets. It enables the project to benefit from the upside potential of an opportunity while controlling the downside risk. Therefore, the value of an option is simply the different in Net Present Value (NPV) between the result gathered from traditional discount cash flow technique (DCF) and the output from Real option analysis as shown in [1].

Value of option = Conventional NPV – NPV from ROA　　[1]

In real option approach, it is usually required the complex mathematic such as partial differential equation or dynamic programming which makes it difficult to apply in real world situations. By introducing Binomial model as an approximation method to apply real option analysis, it is found that the model is simple to use practically.

3. Overview of Otaru-Yoichi Expressway Project

Presently, Otaru city and Yoichi town is connected by National highway route 5 with total length of 26.8 km. The highway is a 2 lanes road (7.0 meters width). Average Annual Daily Traffic (AADT) of the highway in 1999 is 16,796 vehicles per day.

The Otaru-Yoichi expressway project is a toll way, which runs parallel with National highway route 5 with 24 km. in length. The project is designed to be temporary 2 lanes divided expressway, which can be expanded to be 4 lanes divided expressway in the future. The location of the project can be shown in Fig. 1.

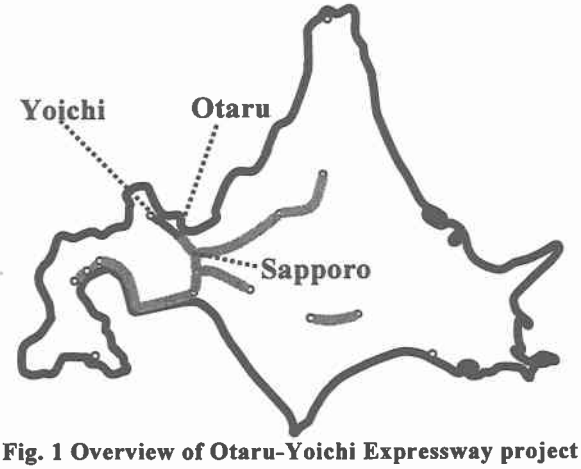

Fig. 1 Overview of Otaru-Yoichi Expressway project

4. Benefits and Costs Estimation

To estimate benefits accrued from building an expressway project, traffic volumes in both national highway route 5 and expressway, in cases with and without expressway, have to be predicted. The traffic volume for highway in the future is gradually increasing, due to normal growth, from currently until year 2020. After year 2020, the traffic volume is considered to be only fluctuated but not increased. The growth rate for traffic volume in National highway route 5 is calculated by using data from Origin-Destination table (OD table) in year 1999 and 2020. For traffic volume in the expressway, diversion factor (JH model) is used to predict percentage of users who will divert from using the National highway to expressway.

Benefits from construction of the expressway project are considered to emerge from reducing in traffic accidents, saving in travel time and travel cost. Construction cost together with operating and maintenance cost (O&M) are set up to be the cost of the project. The results of benefit and cost estimation are summarized in Table 1.

Table 1. Summary of benefits and costs of the project

Base year	Year 2002
Social discount rate	4 %
Project life	40 years
Construction period	5 years
Present Value of Construction cost	111.1 billion yen
Present Value of O&M cost	84.6 billion yen
Present Value of Benefits	212.2 billion yen
Net Present Value of Project (NPV)	16.5 billion yen
Benefit-Cost ratio (B/C)	1.08

5. Uncertainty in the expressway project

To consider the uncertainty in the expressway project, this study considers only the uncertainty in benefit estimation. As traffic volume in the future plays a major role in benefit estimation of the expressway project, therefore it is selected to be the source of uncertainty of the project. The future traffic volume, then, is assumed to follow Geometric Brownian Motion (GBM), which is a kind of Markov process, as shown in [2].

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

where, Q_i is traffic volume in year i

μ is growth factor

σ is volatility factor

W_t is standard normal distribution with (0,1)

With GBM, the traffic volume in the future is depended on the traffic volume in the previous year. In addition, the process also includes the uncertainty in the last term, which also distributes as the standard normal distribution with mean 0 and standard deviation 1.

By providing uncertainty to traffic volume in the future, benefits of the project are also subjected to uncertainty. Monte Carlo simulation is used to determine the uncertainty by random numbers, that distributes as the standard normal distribution, and repeating the rate of return calculation for 5,000 times. The random number is generated by excel worksheet function and then perform chi square test to check its distribution. Then, the random numbers are used to generate a future traffic volume, which lastly provides the rate of returns of the project. As a result, standard deviation of rate of return of the project can be determined, which will be in ROA.

6. Value of Defer Option

Considering that the expressway can be deferred as an option in ROA, the value of defer option can be identified. The value of option is depended on how long the project can be deferred. By varying the maximum year to defer the project, the value of defer option can be determined using ROA as shown in Fig. 2

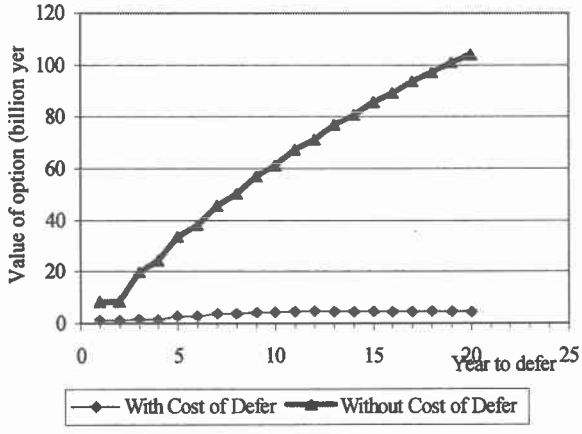

Fig. 2 Value of defer option (with and without cost of defer)

From Fig. 2, it is obvious that the longer the maximum year to defer is provided, the higher the value of defer option is gathered. The result implied that it is always a good strategy to defer the expressway project infinitely, which is unrealistic.

To overcome the problem, cost of defer is introduced as a cost when the project has to be deferred. The cost of defer is defined as the lost in net social benefits in the year that the project has to be deferred. The lost in net social benefit is calculated from the net benefit that people can receive if the project is implemented. Therefore, the cost of defer is the difference between total user benefits and toll fee paid by users as shown in [3]. As a result, the value of defer option when taking exercise cost into account can be calculated by using ROA, which can be shown in Fig. 2.

$$CD_i = \sum_N B_i - \sum_M C_i \qquad [3]$$

where, CD_i is Cost of Defer in year i

B_i is Users Benefit in year i

C_i is Users Cost in year i

N is Number of components in Users Benefit

M is Number of components in Users Cost

The result of the analysis shows that the value of defer option when considered cost of defer increases continuously and stays constant since year 16. Therefore, deferring the project for more than 16 years will not give any additional value to the project.

7. Conclusion

This study applies real option analysis to explore timing of Otaru-Yoichi expressway project. The project is subjected to have uncertainty in future traffic volume on both National highway route 5 and the expressway. Then, the effect of this uncertainty on the benefit of the project is determined by running Monte Carlo simulation. Value of defer option (with and without cost of defer) when varying year to be deferred can be explored. As a result, the project reaches maximum value (providing defer option) if the decision to invest can be made within 16 years.

8. References

1) Copeland, T., and Antikarov, V., *Real Options : A Practitioner's Guide*. TEXERE LLC, NY, 2001

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3) Trigeorgis, L., *Real Options*. The MIT Press, 2002

4) Savvides, S.C., Risk Analysis in Investment Appraisal. *Project Appraisal*, Volume 9, Number 1, pp. 3-18, 1994