A Real Option Approach to Valuating Infrastructure Investments

By

Hyuk Lee

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Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
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Committee in charge

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Abstract

A correct methodology for valuing an infrastructure investment is essential to both of two parties, government and private concessionaires, in order to allocate the project risks reasonably and fairly and makes the project successful. Real Option Analysis (ROA) can be a good approach for appropriately valuing an infrastructure investment because it can capture the "uncertainties of the project and flexible managerial strategies" (Dixit, and Pindiyck, 1994) during the investment horizon by using option pricing model.

This study investigated the value of project using DCF method and ROA approach, the cause of the gap, and project value from ROA approach when adding government guarantees such as MRG and the option to abandon. Additionally, this paper identified how the project value from ROA approach would change when variable assumptions were adjusted. In conclusion, what these results can suggest to the policy makers was covered.

Keyword: Infrastructure Investment, Social Overhead Capital, Real Option, Valuation, Financial Modeling, Public Private Partnership.

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Ⅰ. Introduction

Infrastructures refer to basic facilities which do not directly used for production activities, but is essential to country-wide sustainable development, such as roads, railways, schools, sewage systems, communications, and power supplies which do not used in production activities directly but is essential to country-wide sustainable development (Collins, 2009). Button (1998) discussed the importance of public capital on the role of endogenous growth processes in an urban economy. On the other hand, Aschauer (1989) argued that there was a significant linkage between productivity growth of a country and infrastructure provision and provided arguments about the role of public policy in stimulating regional development.

Traditionally, the government was in charge of expanding and operating infrastructure facilities such as roads, railways, schools and sewage systems. Although the demand for new and improved infrastructure facilities continues to increase as economies grow, it is difficult to accommodate this demand due to government budget constraints (PIMAC[1], 2009). In other words, governments face an ever-increasing need to find sufficient financing to develop and maintain infrastructure required to support growing populations and are challenged by the demands of increasing urbanization, the rehabilitation requirements of aging infrastructure, the need to expand networks to new populations, and the goal of reaching previously unserved or underserved areas (ADB, 2009)

Today, capital and technological/managerial know-how from the private sector is being utilized in infrastructure projects (Qin, Pu, and Hu, 2009). Infrastructure investments are arrangements where the private sector constructs and operates infrastructure facilities in order to help provide and deliver public services and gain a profit during the operating period (PIMAC, 2009).

By introducing capital and technology from the private sector, it is possible to supply the necessary infrastructure to the public in a timely manner (PIMAC, 2009). Brandao and Saravia (2008) argued that the participation of private capital in public infrastructure investment projects has been sought by many governments who perceive it as a way to overcome budgetary constraints and foster economic growth. Moreover, infrastructure investment help provide better, more efficient public services by taking advantage of the private sector’s know-how and creativity. Irwin (2003) suggested five government goals of in infrastructure investment: (a) internalizing externality in infrastructure markets, (b) overcoming failures in markets for financing infrastructure, (c) mitigating political and

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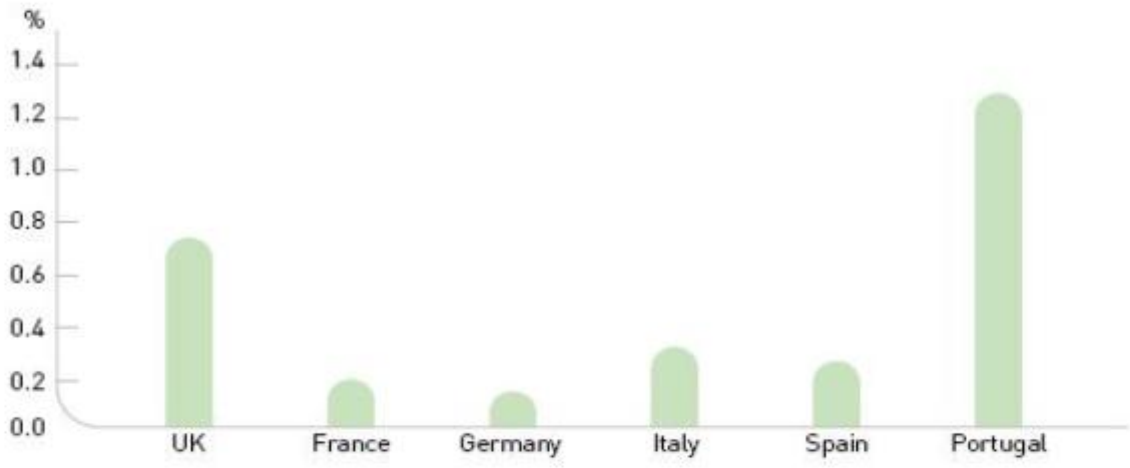
[1] PIMAC (Public-private-partnership Investment Management Center), established in 2005 as a is a government agency that supports the government in developing policies and plans on Public-Private Partnership (PPP) and in implementing PPP projects. PIMAC conducts Value for Money tests and lends assistance in the designation of concessionaire. This is done through support in formulating requests for proposal, evaluation of project proposal, and negotiation with potential concessionaire. PIMAC is also in charge of capacity building of public officials and provides support for foreign investors through investment consultation (PIMAC, homepage).

regulatory risks, (d) circumventing political constraints on prices or profits, and (e) redistributing resources to the poor via infrastructure.

Throughout infrastructure investments, the government and the private sector cooperate on an ongoing basis to provide public services related to infrastructure facilities (PIMAC, 2009). In particular, the government plans and evaluates projects, approves detailed implementation plans of the project company, and supports the implementation of the projects, and the private sector designs, builds, finances and operates the facilities.

According to PriceWaterhouseCoopers (2009), infrastructure investments are actively pursued and developed in various sectors around the world. Europe, Japan, Australia and many other countries around the world today seek private investment in expanding infrastructure. The scope of infrastructure investment projects is now worldwide, extending the reach from existing transportation facilities to social infrastructure facilities, such as schools and hospitals (World Bank, 2009).

<Figure 1> Average 2000-2005 PPP Activity in Major EU Countries as a Percentage of Mean GDP



(Source: PriceWaterhouseCoopers, 2009)

However, infrastructure investments are exposed to various risks such as credit risk, revenue risk, cost overrun risk during a long period of time, almost more than 20 years (Kreydieh, 1996). These risks can discourage private sector from invest on infrastructure actively. Accordingly, the government provides several incentives in order to alleviate project risk that concessionaire should bear such as Minimum Revenue Guarantee and option to abandon (Huang and Chou, 2006).

One of the famous government incentives is Minimum Revenue Guarantee (MRG). It means that "the government is obliged to cover the shortfalls between a pre-specified level of MRG and operating revenues realized by concessionaire" (Huang and Chou, 2005). The government also gives the concessionaire the option to abandon. If the project revenue turns out to be fairly below the original estimation, the concessionaire can exercise a put option: requiring government to buy out this project at a "predetermined price" (Mcdonald and Siegel). The presence of MRG and the option to abandon will increase the concessionaire's flexibility and investment decisions and thus increase the project value. (Yang and Dai, 2006)

Meanwhile, a correct methodology for valuing the project is essential to both of two parties, government and private concessionaires, in order to negotiate the agreements and allocate the project risks reasonably and fairly. And Discounted Cash Flow (DCF) method is one of the common tools used among various project participants in infrastructure investments in Korea. However, DCF method fails to accurately calculate additional values such as MRG and the option to abandon because DCF method assumes that future cash flow is static and all of uncertainties and risk reflected in the discount rate (Kim, 2008). Real Option Analysis, ROA, on the other hand, can be an alternative to overcome these problems because it can take into account uncertainties of the project and flexible managerial strategies during the investment horizon by using option pricing model (Kim, 2008).

The purpose of this study is to propose an appropriate valuation model for infrastructure investment by applying existing model proposed by Cox et al. (1979) and Hull (2006). To put it concretely, this paper investigate the value of project using DCF method and ROA approach, the cause of the gap, and project value from ROA approach when adding government guarantees such as MRG and the option to abandon. Additionally, this paper identified how the project value from ROA approach would change when variable assumptions were adjusted. In conclusion, what these results can suggest to the policy makers will be covered.

Ⅱ. Theoretical Background

As a tool for valuing an infrastructure investment, this study first applied the discounted cash flow method, and the real option approach derived from binomial option pricing model implemented to compare project values between each of approach.

2.1. Discounted Cash Flow (DCF)

One of the maxims in finance is that "the money received in different time periods is of different value (Gremmenos and Xilas, 2004)." The DCF analysis is designed to take into account the time value of money and calculate a net present value (Kim, 2008. p.4).

Net present value refers to the difference between the present value of the future cash flows from an investment and the amount of investment. Present value of the expected cash flows is computed by discounting them at the required rate of return (BKM, 2001). In other words, The NPV of an investment is the sum of all net cash flows discounted using a single discount rate, usually the cost of capital to the investors (Kim, 2008). DCF is used to determine the cumulative benefit of future net cash flows in current terms and if the result is positive, the investment is acceptable and vice versa (BKM, 2001).

2.2 Binomial Option Pricing Model

Embedded options can exist in some projects or financial instruments that affect both their values and their risk–return characteristics, and this paper used binomial option pricing model for data analysis. Binomial option pricing model, first developed by Cox, Ross and Rubinstein in 1979, is simpler to be derived than the Black-Scholes Model. According to Hull, the basic assumption of this model is that the price of the underlying asset can either increase or decrease from the current level (S_0) at Su (u>1) or Sd (u<1).

As the figure below shows, f_u is the payoff from the option when S_0 moves up; f_d is the payoff from the option when S_0 moves down. The situation can be illustrated as below when we extend the time period to multi-step (Cox, Ross, and Rubinstein, 1979). If there is only one time period, for the convenience of calculation, the call option price on the expiration data can be as follows (Hull, 2006).

f_u= Max (S_u-X , 0), when the asset price goes up
f_d= Max(S_d-X , 0), when the asset price goes down

The portfolio value should be equal in both cases, because we have already supposed that there is no arbitrage opportunity (Cox, Ross, and Rubinstein, 1979).

$$\Delta S_u - F_u = \Delta S_d - F_d$$

Where: Δ is the number of the underlying asset to make the portfolio riskiness (Hull, 2006).

$$\Delta = \frac{S_u - S_d}{f_u - f_d}$$

If there is no arbitrage opportunity, as mentioned before, the present value of the portfolio should be discounted by r, the risk-free rate (Cox, Ross, and Rubinstein, 1979).

$$\Delta S - f = (\Delta S_u - f_u)e^{-rT}$$
$$f = \Delta S(1 - ue^{-rT}) + f_u$$

In conclusion, all the equations can be simplified to

$$f = e^{-rT}[pf_u + (1-p)f_d]$$

This is the calculation procedure for the binomial option pricing during one time period. As for the multi-time period, most principles are almost the same except for the 'starting point (Hull, 2006)'.

Cox et al. (1979) emphasized that binomial option pricing gave rise to a simple and efficient numerical procedure for valuing options for which premature exercise may be optimal.

2.3 Real Option Approach

An option is defined as the right, without an associated symmetric obligation, to buy or sell a specified asset (Trigeorgis, 1996, p69). When the underlining asset is a financial asset, for example the option is a financial option (Dai, 2007). In 1977, Myers extended underling assets to non-financial assets and proposed the term real option.

According to Borison (2005), a real option refers to the application of option pricing theory to value investments in non-financial or real assets where much of the value is attributable to flexibility and learning over time and it is a right, not an obligation, to take an action at a predetermined cost for a pre determined period of time (Dixit, and Pindiyck, 1994). Real option approach (ROA), first developed by Myers, has been academically investigated as an alternative to the DCF method since 1977.

ROA borrows its basic concept from financial options as deducible from its terminology (Copeland, and Antikarov, 2003). Thus, the value of real options are also function of the value of the underlying risk asset (S), the exercise price (X), the time to expiration (T), the volatility of the underlying risky asset(σ), the risk free asset (R_f), and so on (Kim, 2008).

<Table 1> Comparison between real options and financial options

Real Options	Parameter	Financial Options
Expected NPV of Cash flow	S	Value of underlying asset
Investment Cost	X	Exercise Price
Time to Maturity	T	Time to Maturity
Uncertainty about the NPV	σ	Standard Deviation of the Underlying asset
Risk-free Rate	R_f	Risk-free Rate
Other cost of opportunities	D	Dividend

(Source: Copeland, and Antikarov, 2003)

The value calculated by ROA is related to the uncertainty of a project. Contrary to DCF analysis, which depreciate the value of the investment as much as volatility increase, ROA tries to find a value the managerial flexibility, i.e. embedded option, in the project (Kim, 2008).

<Table 2> Types of Real Options

Terminology	Right Type	Option Type
Deferral Option	right to delay the start of a project	American Call
Option to Abandon	right to abandon a project	American Put
Option to Abandon	right to sell a fraction of project	American Put
Option to Expand	right to scale up a project	American Call
Switching Option	right to switch between two projects	Combination of American call and Put

(Source: Copeland, and Antikarov, 2003)

In addition, other compound options such as options to options, rainbow options on investment with multiple source of uncertainty are applied in finance sectors (Kim, 2008).

Ⅲ. Literature Review

3.1 Studies on Concepts and applications of ROA Approach

Academic studies on real option had been continuously carried out since 1980s. Hayers and Garvin (1982) pointed out that the DCF valuation neglected the value of strategic flexibility and proposed the need of new method. Myers (1984) asserted 4 major limits of the DCF failed to link "Today's investment" to "Tomorrow’s opportunities" and compared the ROA to "Bridging the gap between financial theory and corporate strategy and developed the term real options to describe the connection between strategy and financing and was first to link future investment options and call options. Harrison and Perdue (2006) pointed out that financial projections such as DCF approach were often made on the assumption of "all else being equal." They emphasized the significance of marketing activities that could determine the value of a particular project under consideration but was seldom directly recognized in finance (Harrison and Perdue, 2006). They also examined the significance of marketing in evaluating the investment potential of a project (Harrison and Perdue, 2006).

Some researchers introduced the concept of ROA approach embedded options in project that can influence the projects' feasibility. Mcdonald and Siegel (1986) presented the model to evaluate the option to wait, that is, defer. Trigeorgis and Mason (1987) demonstrated the merits of applying the decision tree analysis, one of real option pricing models, to real investments. Myers and Majd (1990) developed the model for assessing abandonment value using option pricing theory. Dixit and Pindyck (1994) demonstrated the need to apply financial option pricing model to investment valuations. Coperland and Atrikaerov (2001) insisted that binomial option pricing models more apt for corporate finance practices than the Black- Sholes Model.

Others applied the real options methodology in various different domains such as mining (Slade, 2001), intangible assets (Bouteiller, 2002), research and development (Dai, 2007), technology assessment (Shishko ana Ebbeler, 2004), manufacturing (Bengtsson, 2001), corporate real estate (Ashuri and Baabak, 2010).

<Table 3> **Summary of studies related to and real option**

Year	Author	Title	Major Issue of studies
1. limits of DCF Approach			
1982	Hayersand Garvin	Managing as if tomorrow mattered	This paper points out limitations of DCF method in various aspects.
1984	Myers	Finance theory and financial strategy	This paper covers issues on the relationship between finance and theory and finance strategy, pointing out limitations of DCF method.
2006	Harrison and Perdue	Where Does Marketing Fit into the Capital Budgeting Equations	This paper emphasizes significance of marketing approach in evaluating the investment potential of a project pointing out limitations of DCF.
2. Introduction of Embedded options in projects			
1986	Mcdonald and Siegel	Waiting to Invest	This paper studies the optimal timing of investment in an irreversible project where the benefits from the project and the investment cost follow continuous-time stochastic processes.
1987	Trigeorgis and Mason	Valuing Managerial Flexibility	This book deals with project appraisals under uncertainty with the valuation of managerial operating flexibility and strategy by applying the decision tree analysis.
1990	Myers and Majd	Abandonment Value and Project Life	This paper presents a general procedure for the abandonment value of capital investment project by analyzing an option to abandon a project for its salvage value using option pricing theory.
1994	Dixit and Pindyck	Investment under Uncertainty	This book develops the theories of investment behavior for industry dynamics and for government policy concerning investment and applied them to a wide variety of business problems.
2001	Coperland and Atrikaerov	valuation: measuring and managing the value of companies copland	This book provides valuation frameworks used in practitioners' work, with detailed case studies involved in developing and using valuations. It also covers financial option pricing techniques to the valuation of investment decisions, real options.

2000	Slade	Valuing Managerial Flexibility: An Application of Real-Option Theory to Mining Investments	This paper presents the real-option model and the econometric estimates of the transition equations to value a mining project using historic data on spot prices.
2002	Bouteiller	The Evaluation of Intangibles: Advocating for an Option Based Approach	This paper provides a picture of the methods and measures applied to the evaluation of Intangibles using real option theory.
2007	Dai	A Real Options Approach, Pricing a Pharmaceutical R&D project	This paper implements the Least Squares Monte Carlo Approach to value a pharmaceutical R&D project.
2004	Shishko and Ebbeler	A Real-Options Approach for NASA Strategic Technology Selection	This paper examines the use of real options valuation in the context of prioritizing advanced technologies for NASA funding and offers a set of computational procedures that quantifies the option value of each technology.
2001	Bengtsson	Flexibility and real options	This paper considers manufacturing flexibility and real options from an industrial engineering/production management perspective.
2010	Ashuri and Baabak	Valuation OF Flexible Leases for Corporate Tenantes Facing Uncertainty in Their Required Workspaces	This paper develops a real option approach for valuing flexible leases with expansion, contraction, and cancelation options from the corporate tenant perspective.

3.2 Studies on ROA Approach for Valuing Infrastructure Investment

In the fields of infrastructure, researchers introduced ROA for the alternative of NPV approach for valuing infrastructure investments using binomial model or Black-Scholes model. Rose (1998) examined and evaluated two options for a toll road, the "concession period" option and the deferral of the concession fee and acknowledged that the options can help in the proper estimation of the value of project. Ho and Liu (2002) developed a real option pricing model taking into account the uncertainties concerning the project net cash flow and the construction cost. They concluded that their model constitutes a basis for PPP project financial evaluation (Ho and Liu, 2002). Ford (2002) used a binomial option pricing model to represent alterations in design an infrastructure investment and concluded that the option can enhance managerial flexibility. Vandoros and Pantouvakis (2007) compared between real options and the NPV method by the use of a hypothetical project and examined how the real options analysis could improve the financial evaluation of an infrastructure project.

Among issues about valuing infrastructure projects, there have been researches specialized in studying the values of government guarantees because government guarantees, regard as options in a financial point of view, were one of the unique characteristics of infrastructure investment different from other investments. Santi (2003) applied real options approach to proposed method for design and formulation of government supports. Hang and Chou (2005) conducted the valuation of MRG (Minimum Revenue Guarantee) and the option to abandon. They found that both of the values counteracted each other: when the option MRG value increased, the option value of abandon decreased and vice versa (Hang and Chou, 2005). Takashima, Yagi, and Takamori (2009) studied the interaction between a private firm and a government when they time an investment decision while in a public-private partnership using a real options framework and consider the degree of sharing in the cost of the investment and the risk in the operation of the project. They concluded that the guarantee of the government is large and the cost sharing rate for the private firm is low, then the private firm-maximizing policy exercises the investment option earlier than the project value-maximizing policy (Takashima, Yagi, and Takamori, 2009). Brandao and Saraiva (2008) studied a real option model for a minimum traffic guarantee (MTG) in a toll road that links the Brazilian Midwest to the Amazon River. They concluded that the use of public private partnerships (PPP) with guarantees and caps on total government outlays can be modeled effectively using option pricing methods and can be a solution to attract private investment to high risk public infrastructure projects (Brandao and Saraiva ,2008).

Some researches are specialized in advanced quantitative methods for applying real options such as Monte Carlo Simulation and fuzzy model. Yang and Dai (2006) applied real option approach to concession decisions; the option to adjust concession price, the option to develop surrounding land, the option to expand project capacity. They used algorithm based on the Monte Carlo simulation to find optimal solutions. Cheah and Liu (2006) suggested that the value of options embedded in projects should be properly accounted for so as to strike a better balance between risk and benefit and studied ROA approach using Monte Carlo simulation for valuing the case of the Malaysia-Singapore Second Crossing. They concluded that ROA could be a promising tool for valuing various options (Cheah and Liu, 2006). Qin, Pu, and Hu (2008) established the fuzzy real option financial evaluation model of the BOT infrastructure project. They concluded that the uncertain factors increased the option value of the project and the value of this increment contributed to investor to re-evaluate the project value of the BOT infrastructure from the option angle.

<Table 4> Summary of studies related to real option and infrastructure investment

Year	Author	Title	Major Issue of studies
1. Introduction of real option methodologies for valuing infrastructure investments			
1998	Rose	Evaluation of two options: concession period option deferral concession fee option	This paper examined and evaluated two options for a toll road, the concession period option and the deferral of the concession fee.
2002	Ho and Liu	Development of an option pricing model, incorporated two variables: project net cash flow and construction cost	This paper pointed out that the option model provides an adequate framework for the PPP financial evaluation
2002	Ford	Evaluation of a binomial option pricing model to design flexibility	This paper concluded that Real options can boost the project flexibility
2007	Vandoros and Pantouvakis	Using Real Options in Evaluating PPP	This paper compared between real options and the NPV method by the use of a hypothetical project
2. Valuing Government Guarantees in Infrastructure Investment			
2003	Santi	Government Supports as Real Options in BOT Highways Projects	This paper measures the value of government supports in highway BOT project mitigating financial-related risk in the projects based on Real Options theory.
2005	Hang and Chou	Valuation of the minimum revenue guarantee and the option to abandon in BOT infrastructure	This paper uses the real option approach to value the minimum revenue guarantee and the option to abandon that government provide private sector with in BOT infrastructure projects and explore the

		projects	interaction between the two options.
2008	Brandao and Saraiva	The option value of government guarantees in infrastructure projects	This paper studies a real option model for a minimum traffic guarantee (MTG) in a toll road at Brazil.
2009	Takashima, Yagi, and Takamori	Government guarantees and risk sharing in public-private partnerships	This paper studies the interaction between a private firm and a government when they time an investment decision while in a public private partnership using a real options framework
3. Valuing Government Guarantees in Infrastructure Investment using Monte Carlo Simulation			
2006	Yang and Dai	Concession Decision Model of BOT Projects Based on a Real Options Approach	This paper studies a real option valuation approach to capture flexibility values in BOT projects, and shows a numerical example based on the Monte Carlo simulation to find optimal solutions.
2006	Cheah and Liu	Valuing Government Support in Infrastructure Projects as Real Options Using Monte Carlo Simulation	This paper studied ROA approach using Monte Carlo simulation for valuing the case of the Malaysia Singapore Second Crossing.
2008	Qin, Pu, and Hu	Investment Decisions in the BOT Transport Infrastructure Applying Fuzzy Real Option	This paper adopts a fuzzy real option model to value a BOT Transport infrastructure investment that can be divided into more than one step to invest.

Ⅳ. Hypothesis Development and Methodology

4.1 Valuation Issue of Infrastructure Investment

The critical success factor for an infrastructure investment is the efficient and effective allocation of project risks and returns among the government and the concessionaire (Ashuri, Kashani, and Lu, 2010). Some risks such as construction or regulatory risk are clearly controllable; however, some risks such as the revenue risk cannot be controlled by any of parties (Takashima, Yagi, and Takamori, 2009). The project revenue risk is the risk the revenue generated from the project may be lower than the projections used in the financial valuation of the project, and it generally occurs when the actual volume falls below the estimation (Ashuri, Kashani, and Lu, 2010). Such shortfalls may negatively affect concessionaire's rate of return on investment and ability to meet its financial obligations (Hang and Chou, 2005). Kreydieh (1996) found that the main problems that faced the Eurotunnel project were the result of an unsatisfactory risk allocation and sharing through his case study.

How can we allocate project risk equitably and effectively (Ashuri, Kashani, and Lu, 2010)? Risk management and allocation should be followed by risk measurement. Considering that a risk is defined as the unexpected variability of asset prices, a correct methodology for valuing a project is essential for an 'equitable and effective sharing of the risks' that would be agreeable to both of the government and the concessionaires (Qin, Pu, and Hu, 2009).

Traditionally, Discounted Cash Flow (DCF) method and specifically the deterministic Net Present Value (NPV) analysis have been used to evaluate infrastructure projects (Ashuri, Kashani, and Lu, 2010). However, these conventional methods are inadequate to properly evaluate infrastructure projects since they do not explicitly capture and treat uncertainty about demand, which is the most important sources of uncertainty during the operation phase of projects (Ashuri, Kashani, and Lu, 2010).

Moreover, the uncertainty about the future concessionaire's revenue of infrastructure projects impacts the concessionaire return on investment (Ashuri, Kashani, and Lu, 2010). There is no systematic approach in the conventional DCF analysis to describe how the discount rate should be adjusted to reflect the risk of project revenue, and the choice of exogenous discount rate is absolutely critical in the proper evaluation of infrastructure projects since the project NPV from DCF method is very sensitive to changes in the value of discount rate. Additionally, the DCF approach is unable to determine the correct market value of the government support options properly (Ashuri, Kashani, and Lu, 2010).

The limitations of the DCF approach can be alleviated by using a real options analysis (ROA) that provides an integrated framework to evaluate investment opportunities under dynamic market uncertainty (Dixit and Pindyck, 1994). Real option refers to the opportunity to choose a course of action that an investor has when investing in something such as a business project (www.qfinance.com, 2011). In valuing infrastructure investment, real option analysis can capture the flexibilities of managerial strategy, option values that management can exercise if the project cash flow is below than the estimation, such as MRG and the option to abandon.

In Korea, NPV derived from DCF approach are the most common tools for evaluating infrastructure investment during entire project life cycle among public sectors and concessionaires. Especially, PIMAC and other government agencies in charge of evaluating proposals for infrastructure investment are using DCF method for value for money (VFM) test. VFM test refers to the comparison between the value of private finance initiative and that of government-funded projects. According to Infrastructure investment s act in Korea, infrastructure projects cannot be undertaken when better value for money was not created compared to the conventional procurement except for certain special cases. And 'guideline for value for money test' (PIMAC, 2010), suggests DCF method as a tool for VFM tests. However, considering the drawbacks of DCF method as mentioned above, more researches on real option analysis for valuing infrastructure investment are required in Korea.

4.2 Hypotheses Development

This paper develops real option valuation models in a case and compared them with that of DCF method. Additionally, several hypotheses related to the ROA approach for infrastructure investment will be tested in this paper.

Scenarios for hypotheses are as follows.

<Table 5> Descriptions of scenarios

Scenario	Methodology	Description
D[2]-0	DCF	A project NPV from DCF method
R[3]-1	ROA	A project NPV with minimum revenue guarantee (70% of estimations)
R-1.5	ROA	A project NPV with increased minimum revenue guarantee (90% of estimations)
R-2	ROA	A project NPV with European option to abandon (80% of salvage value)

[2] D stands for discounted cash flow method

[3] R stands for real option approach

R-2.5	ROA	A project NPV with increased European option to abandon (90% of salvage value)
R-3	ROA	A project NPV with American option to abandon (80% of salvage value)
R-3.5	ROA	A project NPV with increased American option to abandon (90% of salvage value)
R'[4]-1	ROA	A project NPV with minimum revenue guarantee (70% of estimations) and more uncertainty in project revenue
R'-2	ROA	A project NPV with European option to abandon (80% of salvage value) and more uncertainty in project revenue
R'-3	ROA	A project NPV with American option to abandon (80% of salvage value) and more uncertainty in project revenue
R-1∩ 2	ROA	A project NPV with minimum revenue guarantee (70% of estimations) and European option to abandon (80% of salvage value)
R-1∩ 3	ROA	A project NPV with minimum revenue guarantee (70% of estimations) and American option to abandon (80% of salvage value)

If Government provides guarantees in order to alleviate the project risks, this project becomes safer and favorable in the viewpoint of concessionaire. Concretely, if the government provides MRG, the concessionaire can request government to cover the gap between MRG threshold and the real revenue as a subsidiary. Therefore, the concessionaire can expect project cash inflow would be at least the same as MRG threshold even in the worst case. On the other hand, if the government provides an option to abandon, the concessionaire can sell this project to government as a pre-determined price, exercise price of the put option. The concessionaire will liquidate this project when the exercise price is greater than the present value of cash flow in case concessionaire hold this project. Therefore, embedded options in the project will enhance the project value.

Particularly, the concessionaire can have European option to abandon, the option to liquidate only at certain point or American option to abandon, the option to liquidate during a certain period. Because the concessionaire can have more managerial flexibility and strategy in case of American option, project value with American option will be greater than that of

[4] In R', more uncertain cases, the up-move and down-move factors are ±50% rather than ±30%

European option.

<Table 6> Descriptions of hypotheses 1

Hypothesis 1-1 : Project NPV from ROA approach will be greater than that of DCF method if there is MRG in the contract: D-0 < R-1.

Hypothesis 1-2 : Project NPV from ROA approach will be greater than that of DCF method if there is American option to abandon in the contract: D-0 < R-2.

Hypothesis 1-3 : Project NPV with European option to abandon will be greater than that of American option to abandon: R-2 < R-3.

The government can extend its coverage of guarantee by raising MRG threshold or coverage ratio of the option to abandon. It means that the project is protected by stronger guarantees and it makes the project more attractive to private sectors. As a result, the project values will be greater than previous cases.

<Table 7> Descriptions of hypotheses 2

Hypothesis 2-1 : If the MRG threshold rise up, project NPV will be increased: R-1 < R-1.5.

Hypothesis 2-2 : If the coverage for salvage value expands further in case of European option to abandon, project NPV will be increased: R-2 < R-2.5

Hypothesis 2-3 : If the coverage for salvage value expands further in case of American option to abandon, project NPV will be increased: R-3 < R-3.5

Meanwhile, the volatility, a measure of how much the underlying moves (Irwin, 2003), can have an influence on project value from ROA approach. A higher volatility of an underlying asset leads to higher value of financial option in financial option theory. This is because extremely good outcomes can improve the option payoff without limit, but extremely poor outcomes cannot worsen the payoff below zero (Irwin, 2003). This asymmetry means that volatility in the underlying asset price increases the expected payoff to the option, thereby enhancing its value (BKM, 2001).

The same principle will also be applied in real option cases. If government guarantees exist, values of more uncertain projects will be greater than those of less uncertain projects because the guarantees will 'prove their real worth' for a riskier project.

<Table 8> Descriptions of hypotheses 3

Hypothesis 3-1 : If the revenue becomes more volatile (R'), project NPV with MRG will be increased in case of MRG: R-1 < R'-1.

Hypothesis 3-2 : If the revenue becomes more volatile (R'), project NPV from ROA approach will be increased in case of European option to abandon: R-2 < R'-2.

Hypothesis 3-3 : If the revenue becomes more volatile (R'), project NPV from ROA approach will be increased in case of American option to abandon: R-3 < R'-3.

Lastly, Combined guarantees mean that more embedded options exist in the project. Therefore, project values of combined guarantees will be greater than those of single guarantee.

<Table 9> Descriptions of hypotheses 4

Hypothesis 4-1 : If government guarantees are combined, MRG and European option to abandon, the project NPV will be greater than that of single guarantee: R-1 or R-2 < R-1∩2.

Hypothesis 4-2 : If government guarantees are combined, MRG and American option to abandon, the project NPV will be greater than that of single guarantee: R-1 or R-3 < R-1∩3.

Ⅴ. Data Analysis

5.1 Methodology

To test hypotheses, an illustrative example on a port investment is presented. At first, DCF method is applied and then ROA approach is also applied with the same raw data used in DCF. Project values by ROA approach will be re-calculated with some adjustment in variables such as type of guarantee, coverage of guarantee, and period of uncertainty.

This paper uses the binomial option pricing model to evaluate the real option. In terms of embedded options, MRG is regarded as a put option in each period, and the option to abandon is also regarded as a put option at certain time, European put, or in each period, American put. Even though call options government can exercise in certain situation exist in the real contract, this paper does not consider this aspect for the efficient analysis.

5.2 Project Overview

AA Port was one of the national priority projects designed to meet future demand driven by Korean position as a regional shipping and logistics hub. The bustling Busan port in South Korea was one of the top Far East ports in terms of volume, and industry groups in Korea were intent on redeveloping the port as a centerpiece of the country's future economic development in the face of stiffening global competition, particularly from China (PFI, 2008).

The port expansion plan calls for the construction of 30 new shipping berths between 2005 and 2011, to be located in a new port 25km away from the current location. The current port would be redeveloped into a multi-purpose facility housing a logistics and commerce centre, exhibition and cultural centre, leisure park, and international passenger terminal, with development to take place over a 10-year period until 2015 (PFI, 2008). Upon completion, it will be a container terminal, handling maximum capacity of 2.7 million twenty foot Equivalent Units (TEUs) per year (MKIF, 2008).

AA Port was a build, transfer, operate, BTO, project under South Korea's Private Participation in Infrastructure, PPI, Act. Upon completion, it would consist of four 50,000 ton berths of container terminals covering more than 1,400m with a maximum annual capacity of 2.7m TEU. The site was on the north side of Gadukdo in Busan City, on the southeast coast of the Korean peninsula. The existing port in Busan was the sixth largest port in the world with a handling capacity expected to exceed 13m TEUs in 2007 (PFI, 2008).

AA Container Terminal, the SPV for the project, has a 29-year and three-month concession from Ministry of Land, Transport and Maritime Affairs to develop, operate and maintain the second and third phase developments at the AA Port (PFI, 2008). BB Infrastructure Fund would take a major equity stake in AA Port Container Terminal, making it the operator's shareholder (AA Port financial model, 2008).

<Table 10> Overview of AA Port

Title	Description
Government authority	Ministry of Land, Transport and Maritime Affairs
Concession term	29 years and 3 months from the start of the operation
Concession term commencement	Under construction, Operation commencement expected in 2012
Site area	840,000m^2
Berthing facilities	Four 50,000 ton berths
Capacity	Estimated maximum handling capacity 2.7 million TEUs per year

(Source: AA Port financial model)

<Table 11> General Terms and Conditions

Title	Description
Interest Payment to the Shareholders for Shareholders Loan:	Not paying or making any Interest of Shareholders` Loan to any Shareholder except; (a) the periodic Debt Service Coverage Ratio(DSCR) is no less than 1.0 and the cumulative DSCR is no less than 1.2 ; (b) the amount standing to the credit of each Debt Service Reserve Account is no less than the Debt Service Reserve Requirement; (c) the amount standing to the credit of the Operating Reserve Account is no less than the Operating Reserve Requirement; and (d) No Default has occurred and is continuing or would occur as a result of such Payment.
Distribution to Shareholders:	Not paying or making any Distribution to any Shareholder except ; (a) the periodic DSCR is no less than 1.1 and the cumulative DSCR is no less than 1.5 ; (b) the amount standing to the credit of each Debt Service Reserve Account is no less than the Debt Service Reserve Requirement ; (c) the amount standing to the credit of the Operating Reserve Account is no less than the Operating Reserve Requirement; (d) no Default has occurred and is continuing or would occur as a result of such Distribution; and (e) the first Repayment Date under the Facility Agreement has occurred.

Debt Service Reserve Requirement	On the Operating Start Date, the Debt Service Reserve Account shall be initially funded in an amount equal to the Debt Service Reserve Requirement Amount from the Senior Loan Facilities. Thereafter, the Debt Service Reserve Account shall be funded up to the Debt Service Reserve Retirement Amount on each Repayment Date. In this paragraph "Debt Service Reserve Requirement Amount" means the aggregation of i) the scheduled Senior Loan Facilities and Term Loan Facilities principal amount due and payable in nine (9) months and ii) the interest amount of the Senior Loan Facility The Debt Service Reserve Requirement shall be released on the first date on which all of the following conditions have been fulfilled; (a) the periodic Debt Service Cover Ratio for each of the two most recent years is at lease 1.60; (b) no Event of Default has occurred and is continuing; and (c) 50% of principal of the Senior Loan Facilities and Term Loan Facilities has repaid.
Operating Reserve Requirement:	On the Operating Start Date, the Operating Reserve Account shall be initially funded in an amount equal to the Operating Reserve Requirement Amount from the Senior Loan Facilities. Thereafter, the Operating Reserve Account shall be funded up to the Operating Reserve Retirement Amount on each Repayment Date. In this paragraph "Operating Reserve Requirement Amount" means the aggregation of i) the staff costs scheduled due and payable in three (3) months and ii) the general expenses and maintenance costs due and payable in three (3) months. The Operating Reserve Requirement shall be released on the first date on which all of the following conditions have been fulfilled; (a) the periodic Debt Service Cover Ratio for each of the two most recent years is at lease 1.30; and (b) no Event of Default has occurred and is continuing

(Source: AA Port financial model)

5.3 DCF Approach to Investment Valuation

In order to assess the net present value of the project via DCF approach, cash flow analysis should be done first. Cash flows of the investment are composed of cash inflows and cash outflows. In this investment, cash inflows are port cargo revenue. Cash outflows are investment costs, operating costs, taxes, and other sales and purchase cost. There are also interest cost and payback of the principal in this project. However, in order to simplify this analysis, it is assumed that there is no debt financing, it means the total investment is only funded through equity.

5.3.1 Cash inflows

Forecasting Sales is probably the most important step in building up a financial model and valuing the project. If the sales are forecasted wrongly then all other estimates will be wrong as well, as sales is the key driver of the project.

In the base case, long-term annual traffics are assumed to converge to 1,600,000 TEU per annum. The sensitivity analysis of traffic forecasting is as follows.

<Table 12> Forecasted annual traffic

Year	2011	2012	2013	2014	2015	2016	...	2040
Traffic 120%	960	1,152	1,344	1,536	1,728	1,920	...	1,920
Traffic 110%	880	1,056	1,232	1,408	1,584	1,760	...	1,760
Traffic 100%	800	960	1,120	1,280	1,440	1,600	...	1,600
Traffic 90%	720	864	1,008	1,152	1,296	1,440	...	1,440
Traffic 80%	640	768	896	1,024	1,152	1,280	...	1,280

(Source: AA Port financial model)

Port due per TEU is KRW 51,000 as of the end of 2005, and would be adjusted every year in return to the escalation of Consumer Price Index (CPI).

5.3.2 Cash outflows

Cash outflows in the project consist of investment costs for construction and operating costs, and investment costs are composed of survey, design, construction, compensation, and others. Total investment costs for construction are KRW 685,850 in millions.

<Table 13> Project construction costs

Description	Project cost	Total Investment cost
Survey	145	157
Design	7,352	7,952
Construction	379,000	444,814
Compensation	-	-
Incidental	13,761	15,856
Equipment	105,078	128,865
Taxes	-	-

Reserve for Operation	5,476	6,595
Total project cost	510,812	604,239
Price fluctuation Reserve	93,426	-
Construction interest	81,611	81,611
Total Investment Cost	685,850	685,850

(Source: AA Port financial model)

Operating costs are the recurring expenses which are related to the operation of the project such as labor costs, general expenses, and maintenance, replacement (equipment and port facilities). And, operating costs fall into two broad categories; variable costs and fixed costs.

In this case, approximately 20% of total operating costs are variable costs and 80% are fixed costs. In order to simplify the case, variable costs are assumed to inversely proportional to revenues. Total operating cost for 30 years are KRW 2,963,704 in millions.

5.3.3 Weighted average cost of capital (WACC)

A project's capital structure analysis should be done first in order to calculate WACC of the project. In this case, I assumed that the total investment is only funded through equity, therefore, WACC is equal to the cost of equity. WACC of this project calculated through CAPM approach is 13.53%

<Table 14> Key factors for calculating WACC

Title	Output	Description
R_f	4.56%	3yr - Government bond (Mar. 2006 ~ Mar. 2011)
$E(R_m)$	12.05%	Annualized rate of return of KOSPI200 (Mar. 2006 ~ Mar. 2011)
Market risk premium	7.49%	$E(R_m) - R_f$
β	1.20	Average beta of ship building & logistics industry (from Fn Guide)
$E(R_i)$	13.53%	$R_f + [E(R_m) - R_f] * \beta$

5.3.4 NPV of the project

After cash flows and WACC is determined, the Net Present Value can be calculated. The present value calculation is performed by multiplying the discount factor and the cash flows for each year in the projection period. The NPV of this project is KRW -252,335 in millions.

<Table 15> NPV of the project from DCF method

Title	Total	2007	2008	2009	2010	2011	2012	2013	…
Total Investment cost	-685,850	-13,658	-195,520	-118,045	-158,938	-199,689	0	0	…
Revenue	5,041,188	0	0	0	0	0	48,321	60,305	…
Operating cost	-2,963,704	0	0	0	0	0	-38,473	-42,703	…
Operating profit	2,077,483	0	0	0	0	0	9,848	17,601	…
Net operating CF	1,391,634	-13,658	-195,520	-118,045	-158,938	-199,689	9,848	17,601	…
PV of net operating CF	-252,335	-12,031	-151,695	-80,671	-95,673	-105,878	4,599	7,241	…

The DCF incorporates numerous assumptions, each of which can have a sizeable impact on valuation. As a result, the DCF output should be viewed in terms of a valuation range based on a series of key input assumptions, rather than as a single value (Rosenbaum, 2008). The exercise of deriving a valuation range by varying key inputs is called sensitivity analysis. Key valuation drivers such as WACC, and revenue forecasting sensitized inputs in a DCF. The project NPV from DCF method is determined between KRW -417,324 and KRW 528,031 in millions as we adjust two variables: revenue forecast and WACC.

<Table 16> Sensitivity analysis

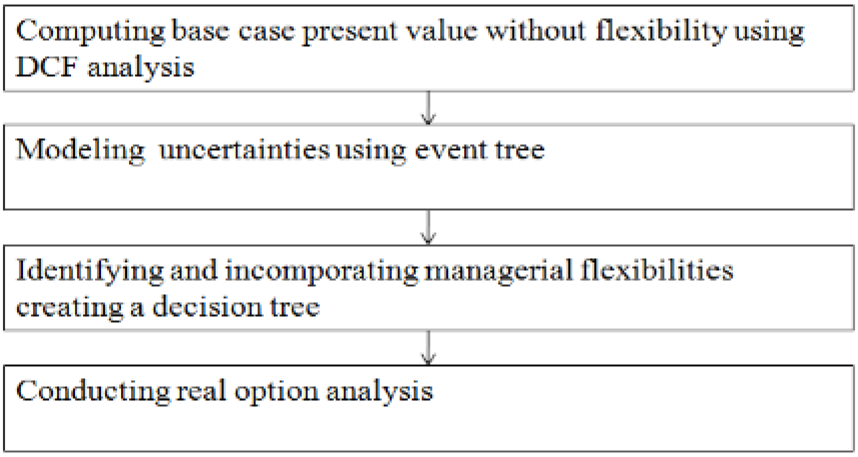
		Weighted Average Cost of Capital						
		7.00%	9.00%	11.00%	13.53%	14.00%	16.00%	18.00%
revenue forecast	120%	206,898	25,281	-89,045	-174,878	-185,891	-220,695	-241,149
	110%	99,854	-50,927	-144,734	-213,607	-222,227	-248,734	-263,171
	100%	-7,190	-127,134	-200,423	-252,335	-258,564	-276,774	-285,193
	90%	-114,234	-203,342	-256,112	-291,064	-294,900	-304,813	-307,215
	80%	-221,278	-279,549	-311,801	-329,792	-331,236	-332,852	-329,237
	70%	-328,322	-355,756	-367,490	-368,520	-367,572	-360,892	-351,259

5.4 Real Option Approach to Investment Valuation

5.4.1 Procedure for valuing real options

Copeland and Antikarov (2003) suggested four-step process for real option valuations. ① The first step is to calculating project NPV using traditional DCF method that have no value of uncertainty. ② The second step is to structuring an event tree for building up the value of uncertainties. This tree visually and systemically shows the uncertainty that drives the volatility of an underlying asset during the project life (Kim, 2008). ③ The third step is to turn the event tree into decision tree into a decision tree by reflecting management decision into each of the node. ④ The last step is to conduct a real option analysis and value the total project values. This result is combined values of the NPV without flexibility and payoff the real option in the project (Copeland and Antikarov, 2003). This study also applied this four-step process for valuing an infrastructure investment.

<Figure 2> Four-step process of valuing real options



(Source: Copeland and Antikarov, 2003)

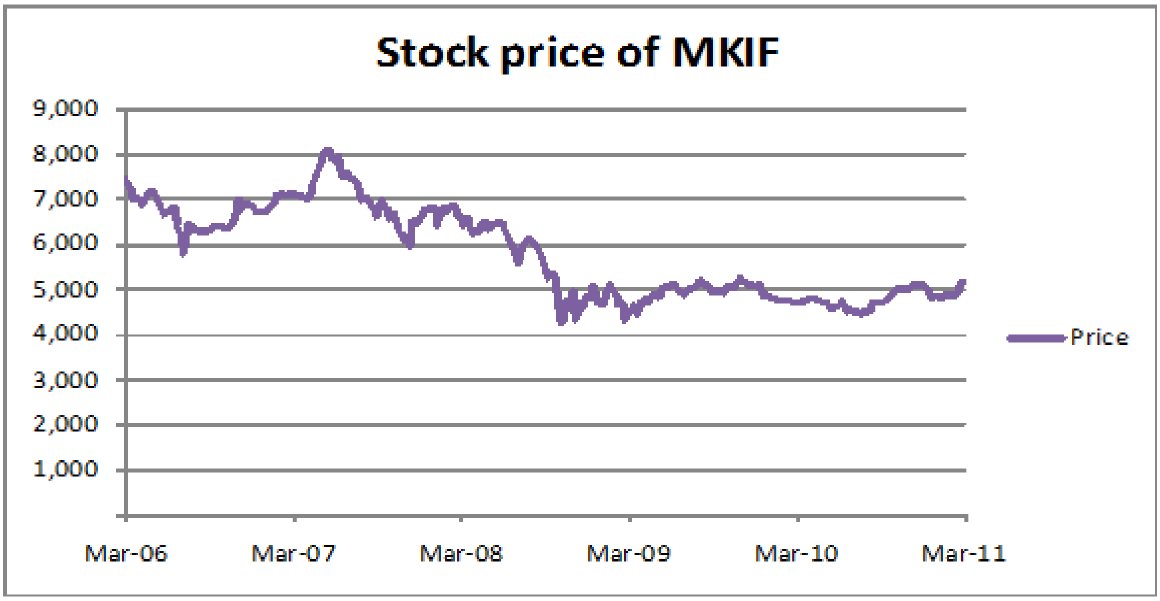
5.4.2 Key variables

Previous studies by Hull (2006) and Irvin (2003) suggested various variables such as fair value of underlying asset, investment cost, uncertainties, and time to maturity for valuing a real option. This paper, however, focused on one key variable, volatility of the project, to structure an event tree assuming other variables the same as those of DCF.

To be concrete, all the project uncertainties are assumed to be reflected in volatility of revenues, and it is defined as upward and downward movement of the project. The up-move and down-move factors are ±30%, annualized standard deviation of stock price of Macquarie Infrastructure Investment Fund, MKIF[5], between March 2006 and March 2011 which is the only listed company specialized in infrastructure investments, such as Incheon Grand Bridge and Seoul Subway line 9, in Korean stock market as of March 2011.

[5] MKIF is managed by Macquarie Shinhan Infrastructure Asset Management Co., Ltd., and a joint venture between the Macquarie Group and Shinhan Financial Group. MKIF was established in December 2002 and listed in Korean stock market in March 2006 (MKIF Homepage). MKIF has been known as one of the major investor in Korean infrastructure facilities since early 2000.

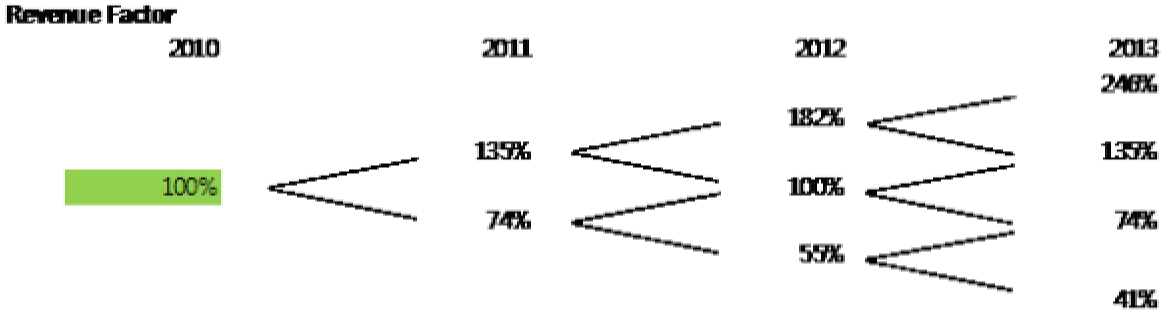
<Figure 3> Stock price of MKIF, Mar 2006 ~ Mar 2011



5.4.3 Modeling the uncertainty using event tree

This study assumed that uncertainties only exist for the first three years after the completion of construction, 2011 to 2013. After 2013, the project would converge to stability for the rest of operating period. And, this paper applied binomial option pricing model during multi-period for valuing projects.

<Figure 4> Binomial tree of revenue factors



5.4.4 Incorporating government guarantees as options

This paper assumed two of government guarantees: MRG and the option to abandon. And, these guarantees exist during the period of uncertainty, 2011 to 2013.

5.4.4.1 Minimum revenue guarantee

If MRG threshold is 80% of revenue estimates, and the real revenue accounts for 70% of revenue estimates, the government should cover the gap, 10% (=80%-70%). Therefore the concessionaire can expect at least 80% of revenue estimates even in the worst outcome. An illustrative decision tree with MRG is as follows.

<Figure 5> Decision tree with minimum revenue guarantee

5.4.4.2 The option to abandon

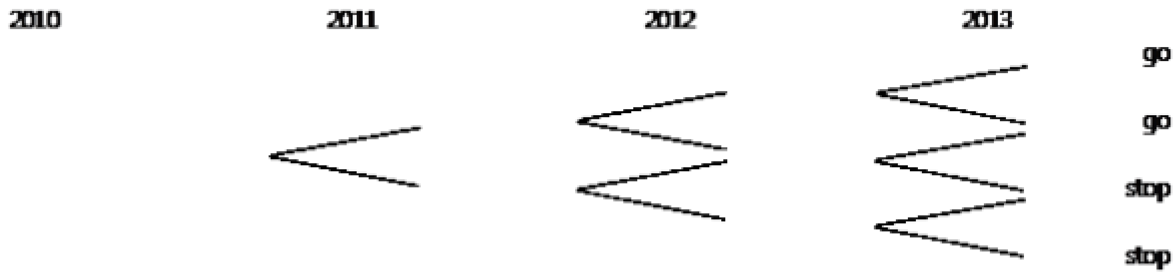
An option to abandon a concessionaire can exercise means that government should buyout a project at a pre-determined price in case the value exceeds going concern value and the concessionaire wants to sell out this project. If coverage ratio of abandonment is 80%, the exercise price is 80% of residual value. The residual value in each period is already contained in the business contract and financial model. Meanwhile, this paper did not assume any transaction cost such as taxes and due diligence fees.

<Table 17> Exercise price for the option to abandon

Year	2011	2012	2013
Pre-determined residual value	1,104,367	1,136,319	1,160,432
Coverage ratio	80%	80%	80%
Exercise price	828,275	852,239	870,324

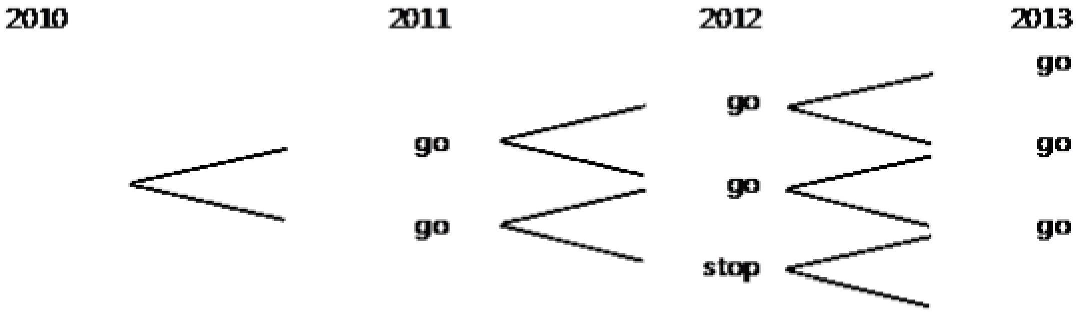
If the concessionaire has a European option to abandon, a decision tree with the option is as follows.

<Figure 6> Decision tree with European option to abandon



If the concessionaire has an American option to abandon, a decision tree with the option is as follows.

<Figure 7> Decision tree with American option to abandon



5.4.5 Conducting a real option analysis

Meanwhile, p, risk neutral probability, can be calculated as follows.

$$p = \frac{1 + r_f - d}{u - d} = \frac{1 + 4.56\% - (1 - 21.4\%)}{(1 + 21.4\%) - (1 - 21.4\%)} = 0.61$$

$$(1 - p) = (1 - 0.61) = 0.39$$

Using this decision tree and p, we can obtain project NPVs from ROA approach in various cases. Detailed procedures and the outcomes in all the cases are described in the following chapter.

5.5 Result of Data Analysis

Project NPVs for in each case are as follows. Outcomes of ROA approach, all of whom are beyond project NPV by DCF, are between 387,368 and 559,550.

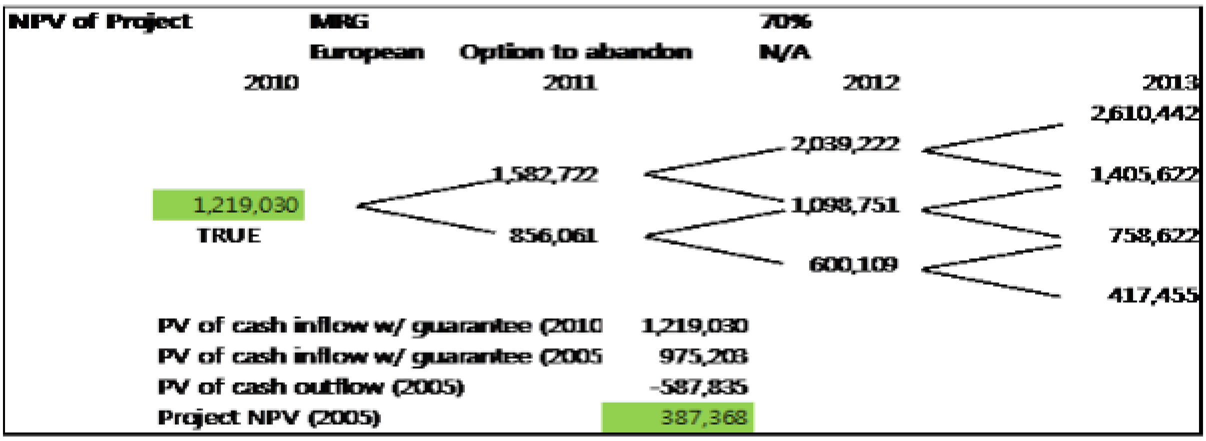
<Table 18> Project NPVs of each scenario

Scenario	Methodology	Project NPV
D-0	DCF	-252,335
R-1	ROA	387,368
R-1.5	ROA	390,044
R-2	ROA	455,328
R-2.5	ROA	486,733
R-3	ROA	456,332

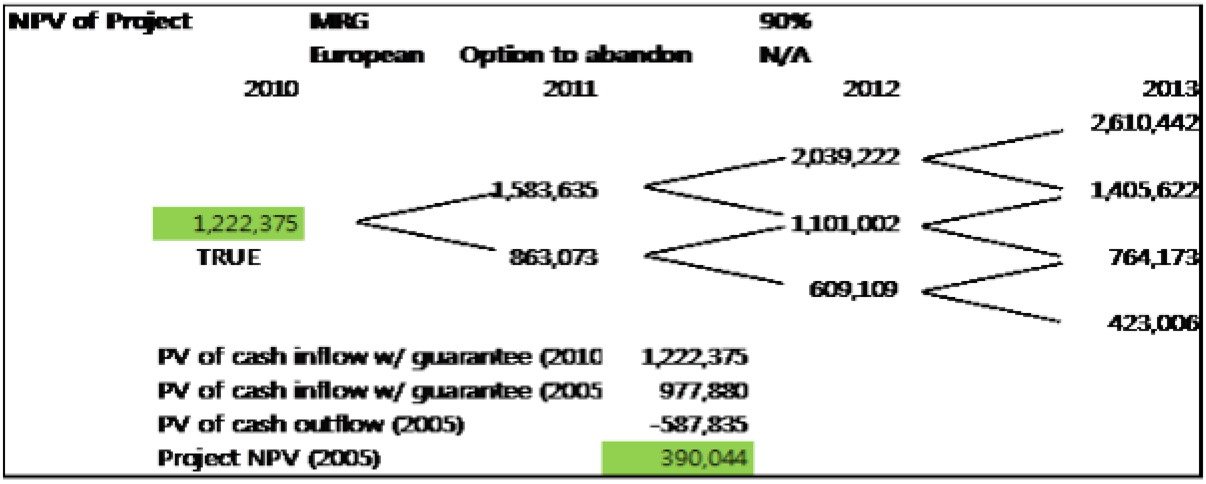
R-3.5	ROA	488,086
R'-1	ROA	391,123
R'-2	ROA	553,976
R'-3	ROA	563,126
R-1∩ 2	ROA	559,149
R-1∩ 3	ROA	559,550

Decision trees in each case are as follows.

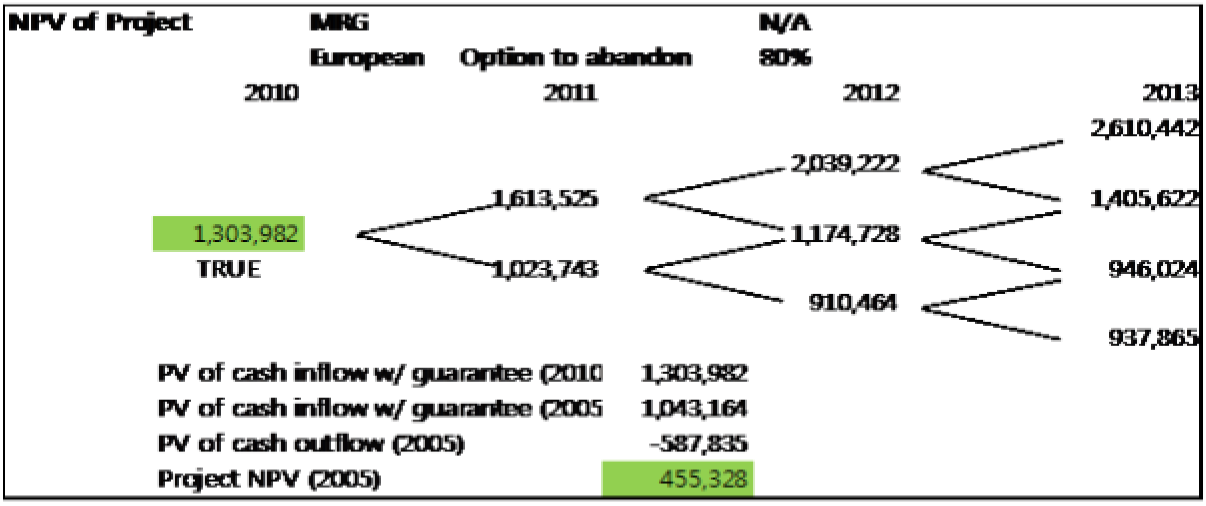
<Figure 8> Project NPV in R-1 scenario



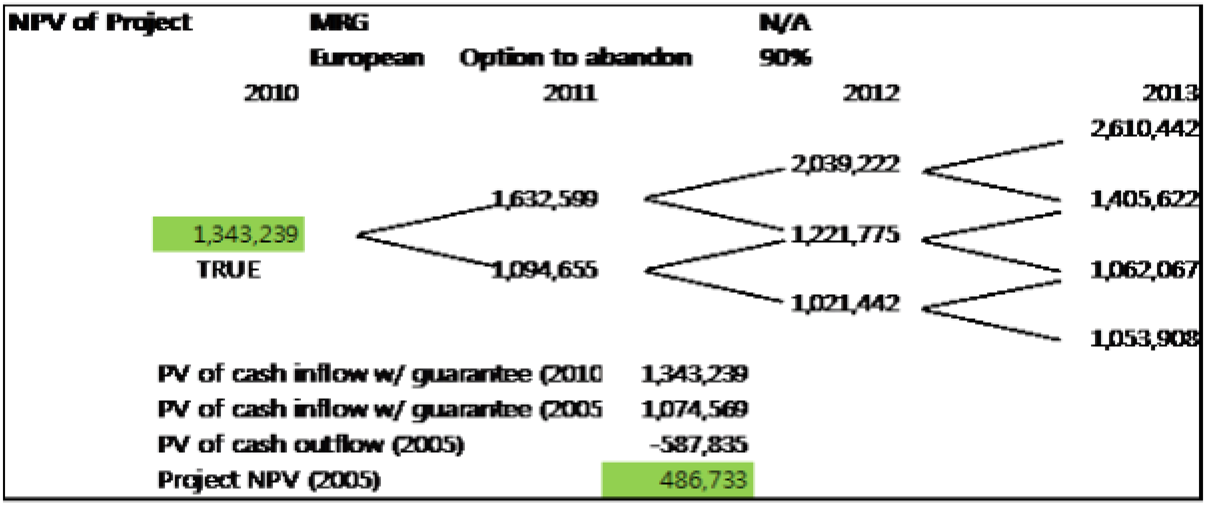
<Figure 9> Project NPV in R-1.5 scenario



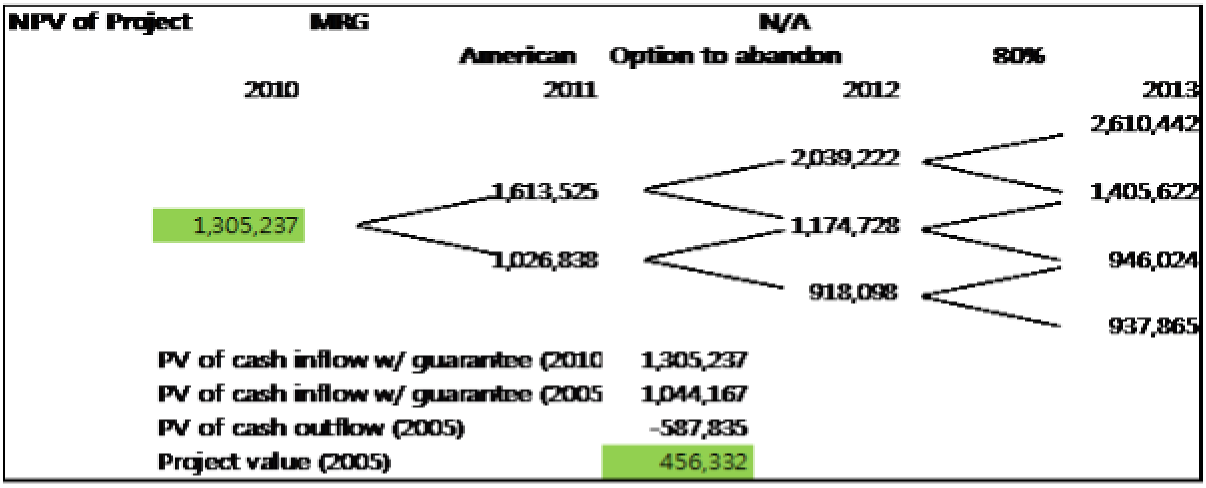
<Figure 10> Project NPV in R-2 scenario



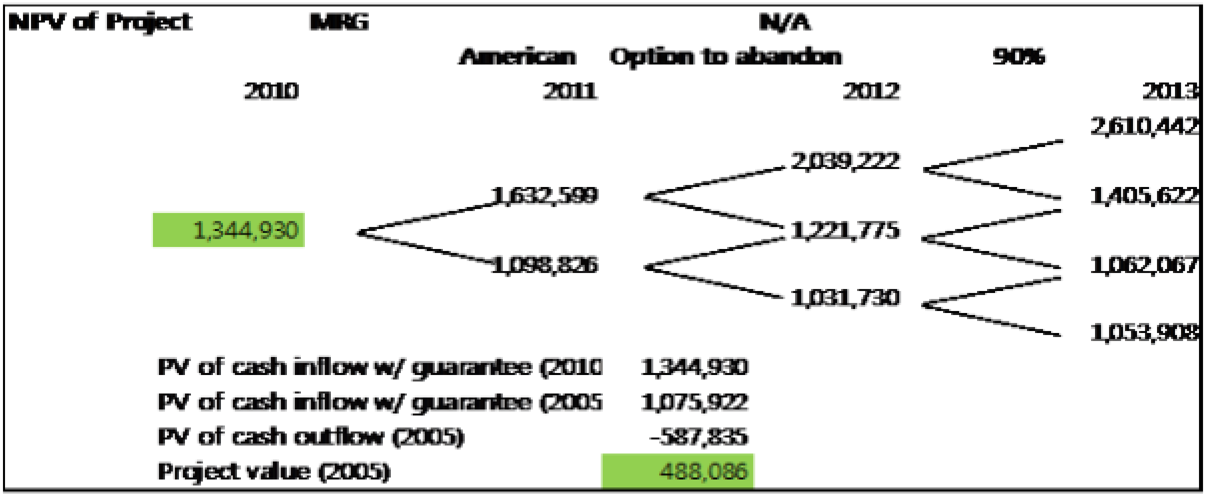
<Figure 11> Project NPV in R-2.5 scenario



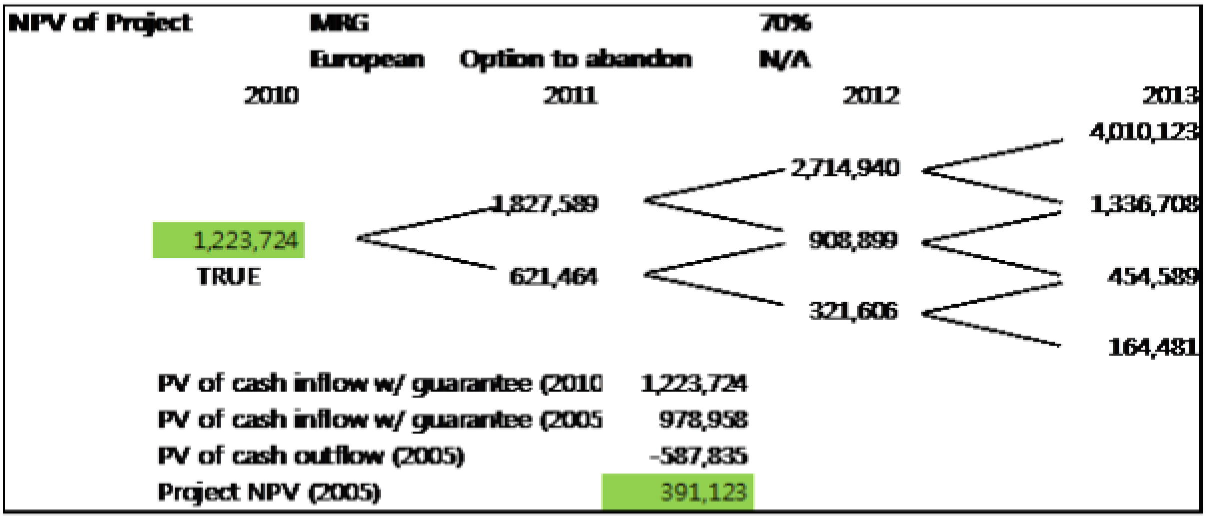
<Figure 12> Project NPV in R-3 scenario



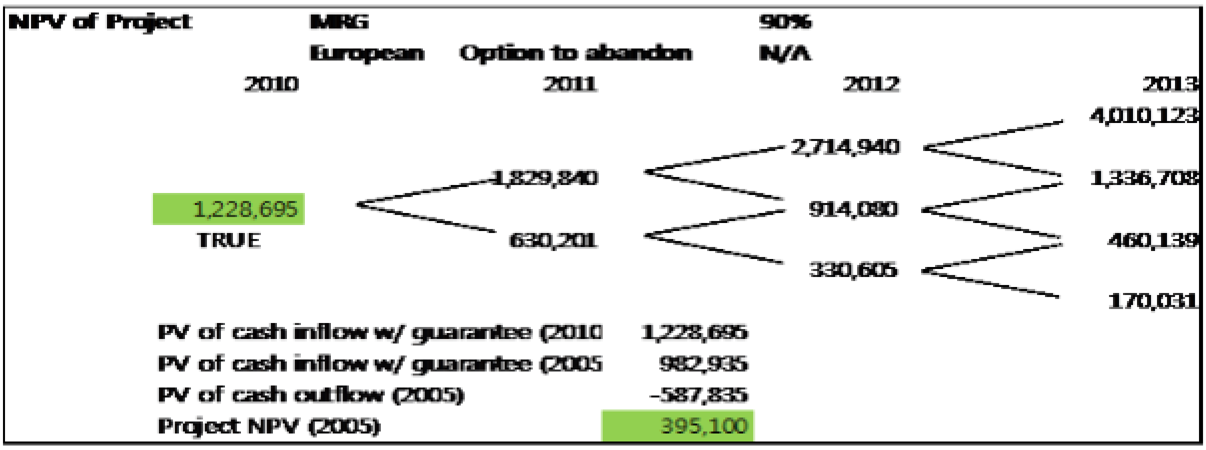
<Figure 13> Project NPV in R-3.5 scenario



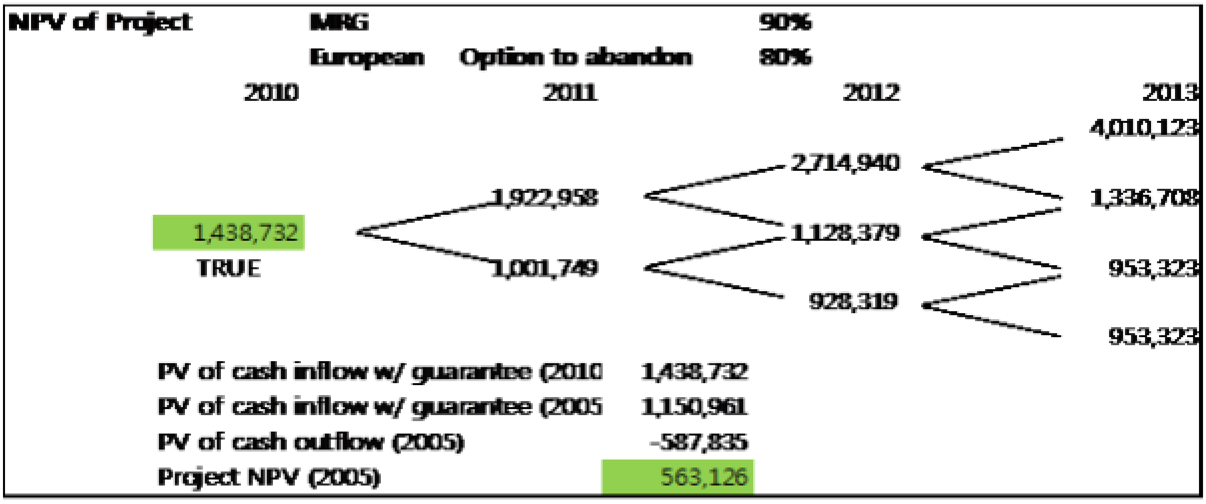
<Figure 14> Project NPV in R'-1 scenario



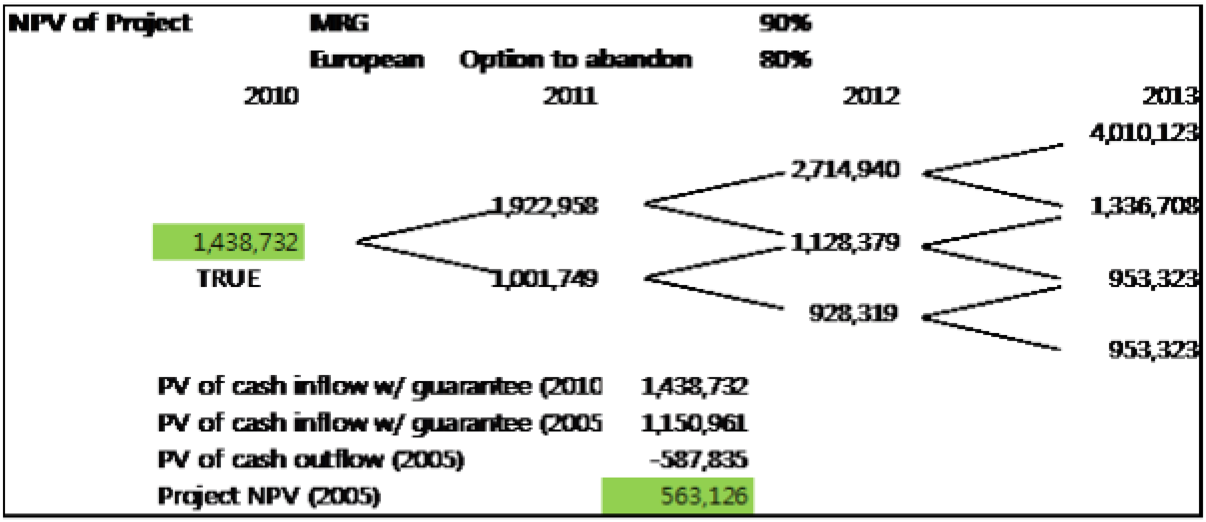
<Figure 15> Project NPV in R'-2 scenario



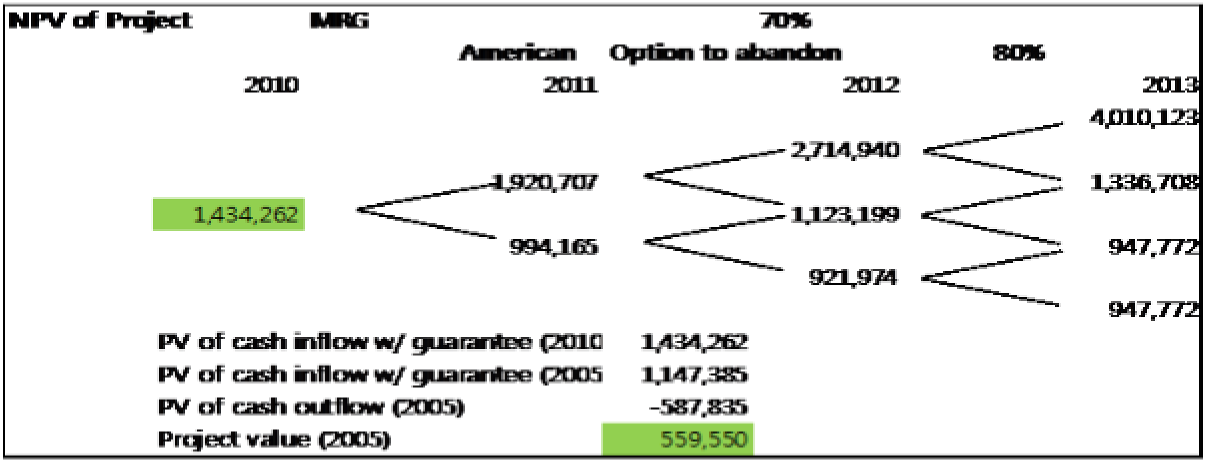
<Figure 16> Project NPV in R'-3 scenario



<Figure 17> Project NPV in R-1∩2 scenario



<Figure 18> Project NPV in R-1∩3 scenario



We can test previous hypotheses through these outcomes and the results of the tests are as follows.

Project NPV in R-1, KRW 387,368 Mil. , is greater than that of D-0, KRW -252,335 Mil. → H 1-1 is accepted.

Project NPV in R-2, KRW 455,328 Mil. , is greater than that of D-0, KRW -252,335 Mil. → H 1-2 is accepted.

Project NPV in R-3, KRW 456,332 Mil. , is greater than that of R-2, KRW 455,328 Mil. → H 1-3 is accepted.

Project NPV in R-1.5, KRW 390,044 Mil. , is greater than that of R-1, KRW 387,368 Mil. → H 2-1 is accepted.

Project NPV in R-2.5, KRW 486,733 Mil. , is greater than that of R-2, KRW 455,328 Mil. → H 2-2 is accepted.

Project NPV in R-3.5, KRW 488,086 Mil. , is greater than that of R-3, KRW 456,332 Mil. → H 2-3 is accepted.

Project NPV in R'-1, KRW 391,123 Mil. , is greater than that of R-1, KRW 387,368 Mil. → H 3-1 is accepted.

Project NPV in R'-2, KRW 553,976 Mil. , is greater than that of R-2, KRW 455,328 Mil. → H 3-2 is accepted.

Project NPV in R'-3, KRW 563,126 Mil. , is greater than that of R-3, KRW 456,332 Mil. → H 3-3 is accepted.

Project NPV in R-1∩ 2, KRW 559,149 Mil. , is greater than that of R-1, KRW 387,368 Mil. and R-2, KRW 455,328 Mil. → H 4-1 is accepted.

Project NPV in R-1∩ 3, KRW 559,550 Mil. , is greater than that of R-1, KRW 387,368 Mil. and R-3, KRW 456,332 Mil. → H 4-2 is accepted.

Ⅵ. Conclusion

6.1 Summary and Implications of Study

This study proposed an alternative viewpoint to DCF method for valuing infrastructure investments. Contrary to DCF method, ROA approach not only captures uncertain business environments and opportunities in the investment, but also mathematically calculates the value of managerial strategies (Button, 1998) that cannot be reflected enough through DCF analysis, in spite of the support of the sensitivity analysis, the scenario model, and other complementary analysis.

This study measured the project value by DCF method and ROA approach and compared project values when considering government guarantees such as MRG and the option to abandon in various cases. In conclusion, the result of this study indicated:

(1) If the government provides guarantees, a project becomes safer and favorable to concessionaires and that leads to the enhancement of the project value because the concessionaire can have more managerial flexibility and strategy due to embedded options in the project.

(2) If the government extends its coverage of guarantee by raising MRG threshold or coverage ratio of the option to abandon, the project is protected by stronger guarantees and more attractive to private sectors, therefore, the values appreciate.

(3) The volatility can have an influence on project value from ROA approach. A higher volatility of an underlying asset leads to higher value of financial option in financial option theory, and the same principle is applied in the cases of this study. If government guarantees exist, values of more uncertain projects is greater than those of less uncertain projects

(4) Combined guarantees mean that more embedded options exist in the project. Therefore, project values of combined guarantees are greater than those of single guarantee.

6.2 Policy Implications

In Korea, government authorities such as Ministry of Strategy and Finance and Ministry of Land, Transport and Maritime Affairs are using DCF approach as a common tool for testing the feasibilities of infrastructure investments and making contracts with private sectors. However, when policy makers failed to forecast future cash flows such as toll revenue, this might lead to tremendous financial burden on the government and criticism from citizens. For example, some SOC facilities such as Seoul Outer Highway and Womyeon-san Tunnel owned by private companies were protected by Minimum Guarantee Revenue. Since the real cash flows of these facilities were substantially below the forecasting levels, government has covered the loss for the past several years. These risks cannot be considered in DCF analysis appropriately and when the future cash flow is unsuccessfully forecasted, the feasibility of the project is seriously distorted.

Real Option Approach can alleviate these problems because it can capture the uncertainties and flexibilities of projects quantitatively. For instance, cash flows of transport projects such as road, railroad and port are generally riskier than those of environment projects such as sewage systems. It means MRG or the option to abandon for transport projects are more valuable to private sectors than those of environment projects. Therefore, policy makers can differentiate the guarantee level according to the project types.

6.3 Recommendation for Future Studies

This study suggests ROA approach as an alternative valuation method for infrastructure investments, showing that ROA can capture the values of managerial flexibilities and strategies due to embedded options that the government provides to the concessionaires.

Despite these findings, there remain some limitations to this study. Firstly, even though ROA can capture managerial flexibilities, it is still based on the concept of net present value. It is still not easy to properly estimate future cash flow of infrastructure investment. And the project value of ROA approach will be inadequate if the future cash flow such as revenue and operating expense is inappropriately projected. Secondly, it is very difficult to determine project volatility in infrastructure investment. Contrary to financial investment such as stock and bond, we cannot easily obtain proper data about infrastructure investment. All infrastructure investments have intrinsic volatilities in their cash flows and many of them would be hardly correlated with each other. For instance, the volatility of toll revenue of highway in Seoul seems to have almost nothing to do with that of Busan. Even in this study, we assumed that the project volatility is equal to that of historical stock price of MKIF, because we cannot obtain the intrinsic volatility of future revenue of this project. For further studies, many of subjects about these limitations and solutions will be investigated

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