ECONOMIC EVALUATION OF A RENEWAL PROJECT OF THE CONSTRUCTION CIVIL AFFAIRS ADMINISTRATIVE SERVICE SYSTEM IN KOREA USING REAL OPTIONS

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Abstract
This study evaluated the economic value of a renewal project of the Construction Civil Affairs Administrative Service System for Online processing of construction related permissions and licensing in Korea using real options. In this study, the volatility was calculated using the probability distribution of the change in the benefit from the renewal. The change in the economic value was verified through the flexibility of the decision-making such as of the options to defer, contract and expand, to eliminate the future uncertainty. We concluded that a renewal project has economic value even though the passive NPV had a negative(-) value because of the sum of the existing passive NPV and the option premium for the future's uncertainties associated with flexibilities.

Key words: *real options, information system renewal, construction permission and licensing system in Korea*

1. INTRODUCTION

In Korea, the informatization level of the construction industry had been significantly lower than those of other industries until the mid-1990s. To improve the efficiency of construction projects through informatization, the Ministry of Land, Infrastructure, and Transport (MOLIT) of Korea introduced the continuous acquisition & life cycle support (CALS) to public construction projects in the late 1990s. CALS is the informatization strategy that was devised by the U.S. Department of Defense to implement electronic government. The construction CALS in Korea has been defined as the informatization system for orderers and relevant construction companies to exchange and share the production information of all processes of construction projects such as the planning, design, construction, and maintenance processes. For the construction CALS project, the Korea Institute of Civil Engineering and Building Technology established and is operating five systems: the road and river construction project management system, the road facilities maintenance system, the land compensation system, the construction civil affairs administrative service system, and the construction CALS portal system. Of the aforementioned systems, the construction civil affairs administrative service system (CCAASS) was developed in 2003 and has been operated since.

The system has long been developed and linked to relevant external systems. Accordingly, it has become inconvenient to use and less efficient, and its users' requests for system renewal have become significant. However, the system renewal requires redevelopment investments. An economic efficiency analysis is required to determine if an investment should be made for the system renewal. The economic efficiency of the information system is generally analyzed with the passive Net Present Value (NPV) model based on the discounted cash flow. The passive NPV model does not consider the future environment change. If a model actively responds to the external environment change, the originally assessed economic value may change. However, the passive NPV model does not consider the value that can be obtained from the decision-making flexibility due to the future uncertainty.

To address such limitation of the passive NPV model, the real option can be used as a value assessment model.

In this study, the real option was used to assess the economic value of renewal project for the CCAASS. To assess the intrinsic value of the project, five variables were used: the underlying asset value, strike price, volatility, risk free rate, and option expiration date. Of these variables, the volatility is determined from the probability distribution of the change in the benefit during the assessment period. The volatility influences the assessment of the intrinsic value of the project.

In this study, the number of civil petitions that will be registered in the CCAASS from 2014 to 2019 and the cost of filing the petitions shouldered by the civil petitioners (excluding the obligatory costs, e.g., the road occupancy cost and the fee) were used as the proxy variables of volatility. To minimize the volatility distortion, the Monte Carlo simulation process was introduced. Through such simulation, the volatility value was determined.

The civil petition filing cost was calculated by adding the time spent for the direct visit to the licensing institution to the time duration of the system input work for filing the civil petition through the CCAASS. The time a civil petitioner took to file a civil petition was monetized, and the difference of such value before the renewal from that after the renewal was assumed to be the benefit. Because the renewal cost was intensively paid in the redevelopment period and the redevelopment period was short (one year), the intrinsic value of the project was assessed according to the flexibility of the decision-making such as the options to defer, contract and expand. Finally, the limitation of the use of the real option for the renewal value assessment was described and an alternative plan for it was proposed.

2. NECESSITY OF THE CONSTRUCTION CIVIL AFFAIRS ADMINISTRATIVE SERVICE SYSTEM RENEWAL

2.1 INTRODUCTION OF THE CONSTRUCTION CIVIL AFFAIRS ADMINISTRATIVE SERVICE SYSTEM

In the CCAASS that electronically processes all work procedures, a civil petitioner can file a construction-related civil petition through the Internet, and the licensing institution can handle, complete, and perform the follow-up management of the civil petition filed via the Internet or in writing. This system has functions that electronically process 47 kinds of construction related permitting and licensing tasks, including the road occupancy permission, which is managed by MOLIT. As shown in Figure 1, this system is divided into two sub-systems: the system for civil petitioners to file civil petitions via the Internet, and the system for the licensing institution to electronically handle the filed civil petitions. The CCAASS was developed in 2003 and has been operated since, and is linked to 11 relevant external systems to electronically handle permission and licensing. Civil petitioners, 25 licensing institutions under MOLIT and Ministry of Security and Public Administration, and 17 local governments are using this system.

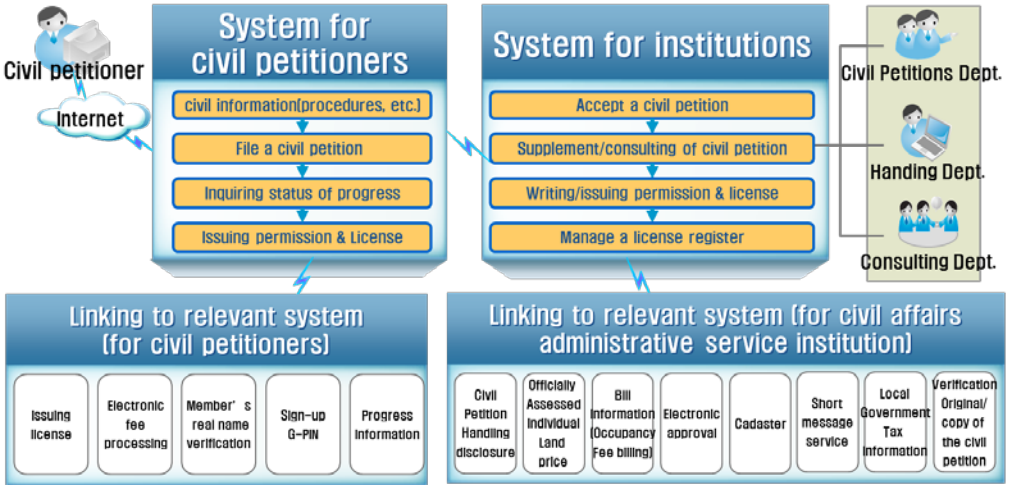

Figure 1. Structure of the Construction Civil Affairs Administrative Service System

2.2 NECESSITY OF RENEWING THE CONSTRUCTION CIVIL AFFAIRS ADMINISTRATIVE SERVICE SYSTEM

The CCAASS was developed more than 10 years ago. Since then, its licensing procedure has often been changed according to the revisions of permission and licensing-related laws and business processes. In addition, the system has been improved or supplemented in fragments to reflect user requests as soon as possible. It has also been linked to relevant external systems to ensure fast permission and licensing. Accordingly, the system functions became complicated and the system's performance was degraded. Requests for system renewal are increasing because civil petitioners and the persons in charge of licensing institutions want to simplify the permission and licensing procedure and provide user-oriented service. To meet such demands, the number of steps for filing a civil petition had to be reduced from four steps (civil petition selection, civil petitioner data entry, filling in the form, and document attachment) to two steps (civil petition selection and filling in the form). Next, a user-friendly service was needed, e.g., the rearrangement of the favorite menus and functions of civil petitioners and persons-in-charge. Finally, new functions had to be developed for user convenience, such as the *preliminary review application* function that shows whether the licensing is possible before the civil petitioner formally files a civil petition.

3. CONCEPT OF THE REAL OPTIONS AND REVIEW OF PRECEDING STUDIES

3.1 CONCEPT OF THE REAL OPTIONS

The real options assess the intrinsic option value of a real asset based on the pricing theory for the financial options. The buyer of the real options pays the price for the right to buy or sell the underlying asset, and owns the right. On the contrary, the seller of the real options receives the agreed amount from the buyer and has the responsibility to follow the right exercised by the buyer. The real options refer to the sum of the intrinsic option premium in the project and the passive NPV based on the discounted cash flow, as shown in Equation (1) (Trigeorgis et al., 2004; and Marha et al., 1999).

$$Expansive\ NPV = Passive\ NPV + Option\ Premium \quad (1)$$

Diverse real option types, such as deferring, expanding/contracting, abandoning, staging, growing, and compounding, can be used according to the characteristics of the project until the uncertain situation is settled (Mun, 2002; and Trigeorgis et al., 2004). The Black-Scholes model and the binomial option model are representatively used to assess the intrinsic value of the project using the real options. The Black-Scholes model is based on the European options, with which the option right can be exercised only upon the expiration of the option. The binomial option model is based on the American options, with which the option right can be exercised even before the expiration of the option (Jeong et al., 2010). These models calculate the intrinsic option value of the project using the underlying asset value, strike price, volatility of the underlying asset value, risk free rate, and option expiration date, as shown in Table 1.

Table 1. Variables comparison between the financing options and the real options

Variable	Financial Options	Real Options
S	Stock price	Value of the underlying asset
X	Strike price	Exercise price
T	Time to expiration	Time to expiration
σ	Volatility of stock price	Volatility of the underlying asset
ϒ	Risk free rate	Risk free rate

The binomial option model uses such variables to calculate the intrinsic value of the project through the following equations. First, the binomial option model discretely calculates the rise hedge probability and the fall hedge probability according to the rise and fall rates for the specific period, as shown in Equation (2).

$$u = \exp(\sigma), \quad d = \exp(-\sigma) = \frac{1}{u}, \quad p = \frac{(1+r_f)-d}{u-d}, \quad q = 1 - p \tag{2}$$

Where, r_f is the risk free rate, σ is the volatility of the underlying asset value, u is the rise rate, d is the fall rate, p is the rise hedge probability, and q is the fall hedge probability

Using the rise and fall probabilities in Equation (2), the expected option value at a specific point is calculated (Copeland et al., 2003).

$$C = \frac{(pC(u) + qC(d))}{1 + r_f} \tag{3}$$

Where, $C(u)$ and $C(d)$ mean the expected value of the call option when the underlying asset value rises or falls at a specific point, and C is the expected call option value for the single period.

Finally, using a process called recursive backward induction in Equation (4), the pointer t = 0 becomes the option value.

$$\begin{aligned} If\ t = T-1, \quad C(u) &= Max\{[\frac{pC(u)+qC(d)}{1+r_f}], \ S(u)-X\}, \\ C(d) &= Max\{[\frac{pC(u)+qC(d)}{1+r_f}], \ S(d)-X\} \end{aligned} \tag{4}$$

3.2 REVIEW OF PRECEDING STUDIES AND DIFFERENCE WITH THIS STUDY

Black and Scholes (1973) devised a financial option as a method of assessing the value of the financial asset. Myers (1977) suggested the real option theory by applying the financial option theory to the evaluation of the real asset to overcome the limitation of the passive NPV. Thereafter, many scholars proposed real option models that can be applied to diverse industries, such as finance, R&D, resource development, SOC/real estate investment, and information technology. For example, Trigeorgis and Lenos (1996) reported that the timing, expanding, and contracting options are suitable for cases wherein the investment timing and amount must be adjusted according to the change in the external environment after an investment in an R&D-concentrated industry. Longstaff and Schwartz (2001) assessed the option value by applying the Monte Carlo simulation to determine the volatility of the underlying asset value. Thus, diverse real option models were presented according to the investment project type, including the option to defer, timing option, option to abandon, option to expand/contract, growth option, time to build option, option to switch, and multiple options. The preceding studies on the information system development can be summarized as follows. Panayi and Trigeorgis (1998) analyzed the value of the information technology infrastructure establishment and the expansion of the bank computer network using the concept of the growth option. Taudes (1998) developed the growth option model for software development, which was applied to the introduction of EDI system. Tiwana et al. (2006) assessed the value of the incremental expansion model in software development. Giachetti (2012) assessed the value of the flexible decision-making according to the uncertainty using the investment timing deferment option model and Monte Carlo simulation. Einwegerer (2008) suggested a real option model for the integration of relevant systems. In Korea, Kim (2001) analyzed the economic value of the EDI system based on its quantitative and qualitative effects and costs. Park (2005) assessed the option value by changing the opportunity cost of an IT investment project according to the lapse of time. Choi et al. (2003) presented a real option assessment model and application method for large-scale investment projects such as info-communications.

Thus, many studies have been performed on value assessment using the real options as the investment scale increased in the IT technology and information system sectors since the early 2000s. However, it seems that there has been no study yet on the assessment of the option value of the information system renewal using the real options.

This study differs from preceding studies as follows. In this study, the value of the time that a civil petitioner must spend was monetized using the number of civil petitions by year and the value of the civil petitioners' time, and the difference between the value before and after the renewal was assumed to be the benefit. Next, the benefit from the renewal refers to the value of the underlying asset. The volatility of the underlying asset that influenced the option value was calculated with the probability distribution of the change in the benefit after the renewal. Monte Carlo simulation was performed to determine the objective volatility. Finally, in the case wherein the redevelopment cost investment was concentrated in a short time and the volatility was relatively low, the intrinsic value of the project was empirically analyzed according to the option types.

4. EMPIRICAL ANALYSIS

4.1 BASIC DATA

Since the start of the operation of the CCAASS in 2004, the persons in charge of permission and licensing have been registering the civil petitions of civil petitioners that are filed through the Internet or through direct visits to the licensing institutions. Table 2 (a) and (b) show the number of civil petitions by year after 2004. Labor costs arise when civil petitioners visit the licensing institutions or fill in the civil petition information and documents in the CCAASS. The labor cost can be calculated as a time value, similar to an hourly wage. The wage per hour can be estimated based on the data published by the Ministry of Labor and the Bank of Korea, which include the wage statistics by business, the average wage, and the working hours. In this study, civil petitioners' average wage per hour was determined to be 7.01 dollars. Then it was estimated that a civil petitioner needs three hours to visit a licensing institution and file a civil petition. It was assumed that an average of one hour is spent for the civil petitioner to fill in the civil petition information in the CCAASS after he/she prepared the documents and went through the four steps. The civil petitioner may use any of various means of transportation to visit the licensing institution. In this case, the civil petitioner must pay the additional cost. However, the transportation expense was not considered in this study because there was no historic data on it based on the means of transportation. In addition, the persons in charge of licensing can benefit from the renewal. However, because the civil petitions filed in writing were registered to the system even before the renewal, the time value of the persons in charge of licensing was not considered in the estimation of the benefit from the renewal. Table 2 (c) and (d) show the estimated costs that civil petitioners paid according to the number of civil petitions by year, the civil petitioner's wage per hour, and the time spent for filing the civil petitions.

Table 2. Number of civil petitions and paid cost by year (Unit: $)

Item / Year	(a) No. of applications by visit	(b) No. of applications via the Internet	(c) Paid cost of the visiting application	(d) Paid cost of Internet application	(e) Sum of paid costs
2004	10,678	3	224,604	21	224,625
2005	10,713	85	225,340	596	225,936
2006	10,207	310	214,697	2,174	216,870
2007	10,388	333	218,504	2,335	220,839
2008	11,571	1,774	243,388	12,438	255,826

2009	11,710	2,821	246,311	19,779	266,091
2010	8,747	3,450	183,987	24,189	208,176
2011	9,212	4,041	193,768	28,333	222,101
2012	9,374	3,311	197,175	23,215	220,390
2013	10,119	2,703	212,846	18,952	231,798

4.2 CALCULATION OF THE RENEWAL BENEFITS AND THE REDEVELOPMENT COST

To assess the economic value of the renewal, the redevelopment cost of the renewal (including the maintenance cost during the period to be assessed) and the benefit from the renewal were used. The obligatory costs for civil petitioners, such as road occupancy costs and fees, were excluded from the benefit estimation process. One-year system redevelopment and five-year system maintenance were assumed. Accordingly, six years were set as the length of the period to be assessed, and the benefit from the renewal during the period was used as the value of the underlying asset. The redevelopment cost and the maintenance cost were used as the strike prices. To estimate the benefit, the number of applications from 2015 to 2019 was first estimated, as shown in Table 3, considering that the yearly rate of increase in the number of applications from 2004 to 2013 was 2.6%. The unit price that was applied to Table 2 (c) and (d) was substituted in Table 3 (a) to calculate the required cost before the renewal. Table 3 (b) was obtained as the required cost before the renewal. Next, to calculate the required cost after the renewal, it was assumed that the ratio of Internet application would increase from 18% to 35%. In addition, it was assumed that the renewal would reduce the number of civil petition information entry steps from four steps to two steps, and shorten the entry time to 20 minutes. Under such assumptions, the required cost was calculated as shown in Table 3 (c). The benefit from the renewal was estimated using the difference between the required cost before the renewal and that after the renewal, as shown in Table 3 (d).

The investment cost arises from the system redevelopment and maintenance during the period to be assessed. In this study, the system renewal cost was estimated as shown in Table 3 (e), considering the system redevelopment and maintenance calculation criteria and the redevelopment scale in the *Software Project Price Calculation Guide (2013)* published by the Korea Software Industry Association. The redevelopment cost was calculated as 15% of the total development cost. The system maintenance cost was calculated as 2% of the sum of the total development cost and the renewal cost. To convert the maintenance cost to its present value, the average 10-year government bonds rate of return Korea of 5.15% as of 2006 was applied as the risk free rate.

Table 3. Estimated benefit from the system renewal (Unit: $)

Item / Year	(a) No. of applications	(b) Paid cost before renewal	(c) Paid cost after renewal	(d) Benefit of renewal	(e) Investment in renewal
2014	13,155	242,895	187,935	54,960	205,857
2015	13,497	249,210	192,821	56,389	31,565
2016	13,848	255,689	197,834	57,855	33,190
2017	14,208	262,337	202,978	59,359	34,900
2018	14,578	269,158	208,256	60,903	36,697
2019	14,957	276,156	213,670	62,486	38,587
Total	84,244	1,555,446	1,203,494	351,952	380,796

Using the benefit and renewal cost, the passive NPV was calculated as -28,844 dollars. In view of the discounted cash flow, this value was less than zero, and implied no economic value.

4.3 CALCULATION OF THE VOLATILITY OF THE UNDERLYING ASSET

The volatility is an important variable for the assessment of the economic value using the real options. To calculate the volatility, Crystal Ball, a risk analysis software, was used for the Monte Carlo simulation. The yearly probability distribution of the change in the cost paid by civil petitioners was used as the input for the Monte Carlo simulation. Then the difference between the costs before and after the renewal was used as the output.

One thousand random numbers were generated for each year as the condition for the Monte Carlo simulation. The reliability was determined within the range of ±95%, and the lognormal distribution was used for the distribution model. The lognormal distribution has a value greater than zero, and is generally used to calculate the probability distribution of consecutive data such as stock prices. Using the Monte Carlo simulation, the volatility of the underlying asset was calculated as 3.29%. This value of the volatility is relatively lower than the other study results.

4.4 ASSESSMENT OF THE VALUE OF THE RENEWAL PROJECT USING THE REAL OPTIONS

With the variables in Table 4, the intrinsic value of CCAASS renewal project was calculated.

Table 4. Variables for the analysis model

Variables	Description	Value
S	Value of the underlying asset(benefit of the renewal project)	351,952$
X	Exercise price for redevelopment and maintenance	380,796$
T	Length of the period to be assessed	6 year
σ	Volatility of the underlying asset	3.29%
ϒ	Risk free rate	5.15%

The decision-making for the renewal project can be changed even before the expiration of the option to settle the uncertainty in the future. Therefore, the binomial option model was used to assess the intrinsic value of the project. Because the renewal period was short and the cost was intensively invested in the redevelopment, the intrinsic value of the project was assessed according to the flexibility of the decision-making such as the options to defer, contract and expand.

4.4.1 Value assessment according to the deferment of the renewal project

The option to defer can be used to determine whether the renewal project must be deferred or started as planned. The option to defer has the form of the American call option. From the calculations of the binomial option model using Equations (2) to (4), the expansive NPV was 0 dollar. By substituting the expansive NPV value into Equation (1), the option premium was obtained as 28,844 dollars. The option to defer increased the underlying asset value by 8.2% compared with that of the passive NPV. The expansive NPV was 0 dollar because the volatility was low. Had the volatility been 6.4%, the expansive NPV would have been 725 dollars or more.

4.4.2 Value assessment according to the contraction of the renewal project

It was assumed that the renewal investment cost decreased by 40% due to the lack of funds, and that the number of civil petitions via the Internet decreased by 30%. In this case, the option to contract could be exercised. The option to contract has the form of the American put option. Under such assumption, from the calculations of the binomial option model using Equations (2) to (4), the expansive NPV was found to have been 114,172 dollars. By substituting the expansive NPV value into Equation (1), an option premium of 143,016 dollars was obtained. The option to contract increased the underlying asset value by 40.6% compared with that of the passive NPV.

4.4.3 Value assessment according to the expansion of the renewal project

It was assumed that the renewal investment increased by 30% according to the users' requests, and that the number of civil petitions via the Internet increased by 40%. In this case, the option to expand could be exercised. The option to expand has the form of the American call option. Under such assumption, from the calculations of the binomial option model, the expansive NPV was found to have been 95,412 dollars. By substituting the expansive NPV value into Equation (1), an option premium of 124,256 dollars was obtained. The option to expand increased the underlying asset value by 35.3% compared with that of the passive NPV.

5. CONCLUSION

Since the CCAASS was developed in 2003, it has become complex and difficult to use because the permission and licensing functions have often been changed and the system has been linked to relevant external systems. Accordingly, there has been growing user demand to address such problem. To meet such needs, investments in the system renewal are required. The economic efficiency of the information system establishment is generally analyzed using the passive NPV based on the discounted cash flow. However, the discounted cash flow does not consider the future changes in the situation, and assesses the economic value only with the benefit and cost. To overcome the limitation of the discounted cash flow, the real options can be used. In this study, the volatility was calculated using the probability distribution of the change in the benefit from the renewal. The change in the economic value was verified through the flexibility of the decision-making such as of the options to defer, contract and expand, to eliminate the future uncertainty. This study is meaningful in that it used the real option for the information system renewal for the first time. The intrinsic value of the project was assessed in a case wherein the strike price was intensively exercised in a short time and the volatility was relatively low. In addition, the economic value of the system renewal project was higher when the real option was used rather than the passive NPV.

There are a few constraints in the assessment of the intrinsic value of the system renewal project. First, when the volatility is calculated, not only the civil petitioner's benefit but also the reduction of the labor cost of the persons in charge of licensing and the benefit from the streamlined business flow from the application of the civil petition to the follow-up management must be considered. Additional studies are required on the future uncertainty of the variables for benefit calculation and the complicated correlation with the strategic decision-making factors. Finally, studies are needed on the value assessment study model for the case wherein the system is renewed over a long time or relevant systems are integrated.

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