Master of Science in Engineering

Real Option based Economic Feasibility Model for Housing Remodeling Projects

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Abstract

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After the global financial crisis, domestic construction industry has gone through a rapid recession. This resulted in gradual market shift towards architectural remodeling. Architectural remodeling not only improves residential environment but it has many advantages such as increase of each unit's exclusive area, free space within the horizontal or extension of an annex building, and increase number of household through splitting the household of bigger pyeong, etc. However, in case of the Korean market for apartment remodeling, due to various regulations and problem with business promotion procedures, majority of business is slow despite the figure that remodeling volume is not that small. Also, feasibility study which decides to push ahead public house remodeling business will have a flaw using net present value's law; it

has a flaw of not considering properties of each phase of remodeling business and future's uncertainty. Hence, this research will improve the problem of traditional value assessment method of net present value's law. It will also consider one of the real options such as binomial model in order to supplement NPV which is used in current feasibility study. This research was based on real successful cases of public house remodeling and it was possible for feasibility study which was more realistic and valid. This research provided foundation for development of Korean public house remodeling market. There is high anticipation of increasing the validity by improving the problems of current feasibility study and economic efficiency assessment.

Keywords: Remodeling, Real Option Model, Economic Analysis, Apartment Housing, Urban Regeneration

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Table of Contents

List of Tables

List of Figures

Chapter 1. Introduction

1.1 Research Background and Objective

As the global housing market has been stagnating after the 2008 global financial crisis, construction companies have been steadily increasing their interest in the apartment housing remodeling market. Along with rising interests, numerous related agents began to participate in remodeling projects which have a lot of advantages such as improving residential environment, expanding area of exclusive use space per households, and increasing number of households due to horizontal or annex extension. However, regulations and problems that occur during the procedures are deterring most of remodeling projects from being pushed forward. Also, an investment assessment standard or a project feasibility reviewing method for union members and investors are yet to be devised. In that sense, despite the attention from agents within remodeling markets, there is almost no project that has been successful(Kim, 2002).Therefore, a need for project feasibility assessment method considering issues that could rise when the project is pushed forward by revising the already existing method is increasing.

The methodology currently used in domestic market to analyze feasibility and value of a project is Discounted Cash Flow method. However, DCF method assumes that initial situation to decide the investment is constantly valid as it evaluates the value of project by determining future cash flow in present(Ahn,

2012). Moreover, DCF method cannot precisely assess value of a project that has a long project term and a high possibility of change in a project form such as remodeling and real estate development project (Kim, 2009).As domestic apartment housing remodeling projects are also applying DCF method to analyze project value and are affected by regulations, policies, and uncertainties from external factors, there are far less completion cases than operating cases. A method to complement DCF method which creates many problems in remodeling project feasibility review, is an application of Real Option.

Real Option Theory complements DCF method that determines future cash flow in present and considers various uncertainties that could emerge in the middle of project with flexibility. With these merits, Real Option is used mostly in companies as a tool to evaluate investment value on a strategically important juncture.

The study applies Binomial Trees among the techniques of Real Option to assess apartment housing remodeling project feasibility. Through this method, Deferral Option and Abandonment Option Value are calculated on the basis of Deferral and Abandonment cases that occur most frequently when promoting the remodeling project. Based on the process, the study will suggest a value assessment method that is more feasible than the existing one by considering option values that can arise at the reviewing phase of apartment housing remodeling project.

1.2 Research Scope and Methodology

The study is based on actual cases that went successful and was conducted for apartment housing remodeling project feasibility review in domestic market through the procedures and methods listed below. The range of study is confined to large repair of apartment complexes. (The process of the overall research methodology is exhibited in Figure 1-1)

(1) Study a project feasibility reviewing method that is used in the early stages of remodeling project through arrangement and analysis of existing references related to domestic apartment housing remodeling project feasibility.

(2) Study the application method of Real Option within the concept of Real Option and remodeling project feasibility review by going through related references.

(3) Calculate option value through Deferral Option and Abandonment Option that can be applied to remodeling project.

(4) Confirm the fitness of suggested models by verifying the models that improved existing project feasibility review based on collected data from successful cases of domestic apartment housing remodeling.

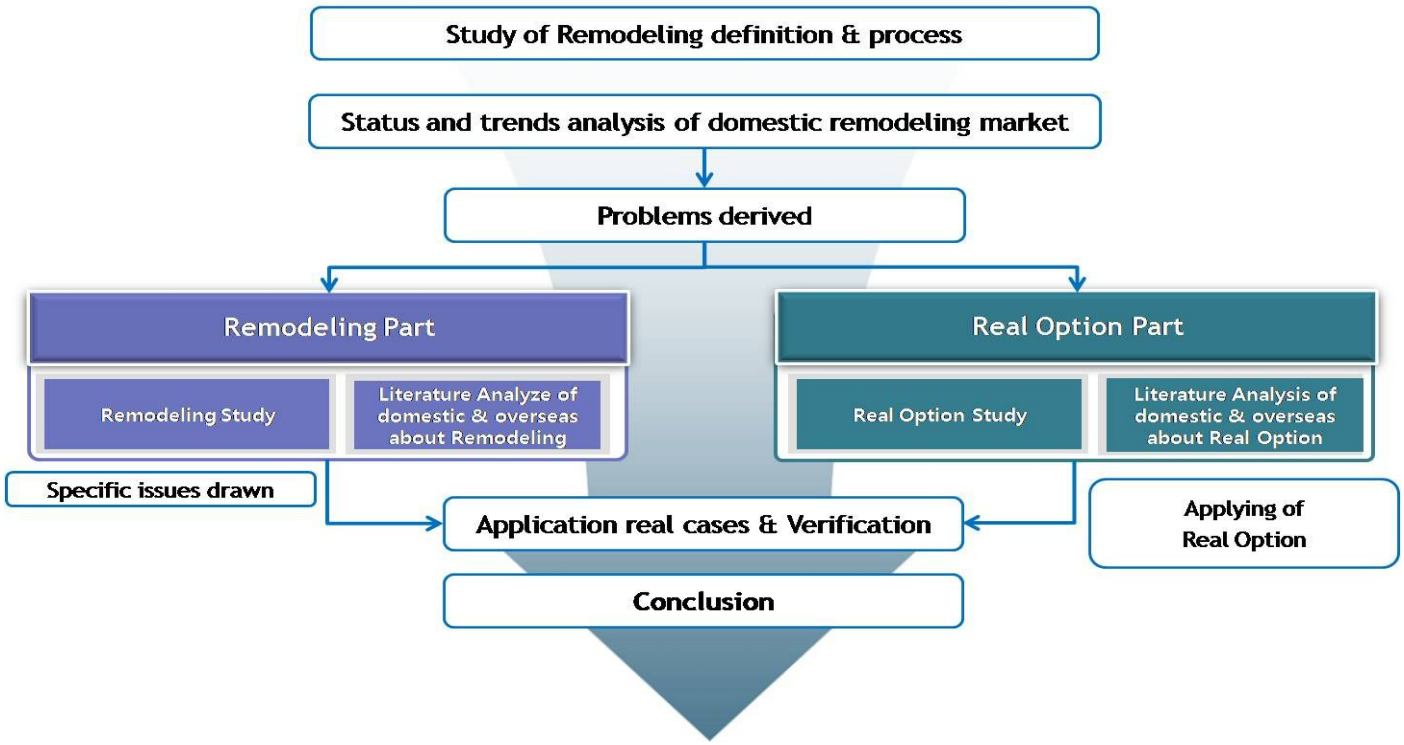

Figure 1-1 Research Process

Chapter 2. Preliminary Study on Apartment Housing Remodeling

This chapter discusses the previous researched about Apartment Housing Remodeling. First of this chapter, Definition and Concept of Remodeling. At the second chapter, Find out about Current Situation and Problems of Domestic Apartment Housing Remodeling. Last, Analyze the Research Trends and Limits of Remodeling Project Feasibility.

2.1 Definition and Concept of Remodeling

The definition of remodeling differs among countries and researchers. There has been no exact definition and setting-up the scale for remodeling. However, the definition is getting more concrete as the Building Construction Law is revised. The concept of remodeling "which is defined according to domestic and international references, it means a renovation of building and it generally refers to recovering and improving the function of aged buildings."(Cho, 2004). In addition, according to the Housing Act, the term is defined as "remodeling refers to an act of having a major repair to restrain deterioration of building or improve its function." On the building Codes, it reads "remodeling is an act of having a major repair or extending part of buildings to restrain deterioration or to improve its function." In sum, the

terms related to renovation of buildings, such as remodeling, renovation, and reform, lacks refinement of concepts and integration of meanings. The terms in domestic law such as extension, reconstruction, relocation, major repair, and alteration of the purpose of use, falls on the same group.

2.2 Current Situation and Problems of Domestic Apartment Housing Remodeling

According to a 2007 report 'Comparative Analysis between Reconstructing and Remodeling Feasibility' published by Korea Planners Association, the number of aged apartments older than 20 years is estimated to be roughly 1.4 million. Most of these apartments are high-rise buildings over 15 stories. Therefore, it is less likely to have feasibility through increased floor area ratio which is mostly applied to low-rise reconstructed apartments. Moreover, as apartments that have been built after 1992 have 40 years of construction limit after being built, the only alternative to improve the building would be a remodeling. However, in the time of real estate market hitting low due to excessive supply of housing, remodeling projects are making slow progresses because of regulations and uncertainties.

According to the 'Statistics of Buildings in late 2010' issued by Ministry of Land, Transport and Maritime Affairs, buildings aged more than 20 years are approximately 3.87 million which makes 58% of the entire buildings in late 2010. The number of buildings aged between 10 and 20 years is 1.6 million and the figure for buildings aged less than 10 years is 1.2 million, which makes 24% and 18% respectively. The number of buildings aged over 15 years that can be remodeled is 4.65 million which takes 69.7% of the total. The number of total buildings in Korea is approximately 6.67 million and its gross area is 3,263,000,000 square meters. Residential buildings take 67.2% with 4.49 million and within 67.2%, the ratio of apartment housing is roughly

51.57% According to the statistics from the private sector(Real Estate Serve : http://www.serve.co.kr), 38.5% of apartments in metropolitan area including Seoul, Gyeong-gi, and Incheon are the buildings that are subject to remodeling. Also, 47% of apartments in Busan, Ulsan, and South Gyeong-sang area exceeded acceptable standards. Although there is a number of the supply of apartments subjected to remodeling, the actual number of domestic cases that had completed major repair remodeling of apartment complex is three. The situation is due to the phased characteristic of remodeling projects that contains lots of problems as listed on Table 2-1

Table 2-1 Problems in Apartment Housing Remodeling Project

Classification	Problem
Law	• Vertical extension prohibited • General sales prohibited(Allowed within 10% of the number of households)
Price	• Rise of deductible • Restriction of mortgage loan(LTV, DTI) • Burden of taxation on union due to houses that exert selling claim • Burden of lending rate on union members • Excessive cost for structure repair and strengthening • Difficult to assure the increasing effects of asset value
Society	• Desire to increase asset through remodeling • Inadequate awareness of advantages that remodeling brings
Structure	• Restricted area due to existing structure • Difficulty of construction for box frame apartments • Difficulty of constructing underground parking lots • Difficulty of applying an earthquake-resistant design
Etc	• Older generations appeals needlessness of remodeling • Lack of systemized remodeling process manual

2.3 Trends and Limits of Remodeling Project Feasibility

As stated on table 2-2, the ratio of buildings older than 15 years is increasing among the domestic aged buildings and life expectancies of the buildings are nearing their limits. Thus, more residents are moving into newly built apartments and the number of apartment complexes that are being reconstructed and remodeled is steadily rising.

Table 2-2 Present Condition of Domestic Aged Buildings by Regional Groups (Ministry of Land, Transport and Maritime Affairs, Statistics for Buildings in late 2010)

Classification	Total Number of Buildings	Constructed Buildings Older than 15 Years	Ratio (%)
Seoul	656,931	520,897	79%
Busan	384,263	323,183	84%
Daegu	252,832	195,127	77%
Incheon	211,494	148,410	70%
Gwangju	138,220	104,320	75%
Daejeon	129,955	95,517	74%
Ulsan	126,268	79,383	63%
Gyeonggi	1,012,975	550,709	54%
Gangwon	366,761	248,189	68%
Chungbuk	348,788	241,111	69%
Chungnam	498,011	330,985	66%
Jeonbuk	409,254	276,680	68%
Jeonnam	593,863	442,898	75%
Gyeongbuk	740,652	524,365	71%
Gyeongnam	660,422	468,982	71%
Jeju	145,829	100,227	69%

However, as mentioned in paragraph 2.2, even though the number of partment complexes that need remodeling or those already being remodeled is increasing, it is nearly impossible to find cases of successful move in after the remodeling is done. The reason for this situation mainly lies on the problems of cost indicated on Table 2-1. In other words, construction companies will participate in projects if profits are expected, and remodeling union members want to take as less responsibility as possible. Because of the discord, most of the projects are being delayed. Therefore, the necessity of appropriate studies for analyzing project and economic feasibilities has become evident. Advanced research related to those are making progresses as in table 2-3.

Table 2-3 Preliminary Research Related to Remodeling Feasibility

Author(Year)	Content	Limitation
Kim et al. (2001)	An Economic Evaluation Method for Remodeling Project - Focusing on the Rental apartment -	Valuated by valuation method
Kim (2002)	Remodeling project feasibility assessment	Considers general buildings rather than concentrating on apartment housings
Kang et al. (2005)	Evaluation Method for value Analysis in the Remodeling of Apartment Building	Not considers economic feasibility review
Kwon et al. (2006)	Constitution of Work Process for the Remodeling Construction Project in Planning Phase	Cultivates project conducting process, including project feasibility
An et al. (2004)	A Study on Developing Profit Model for Remodeling of Apartment Houses	Analyzes profit model through LCC & NPV
Kim et al. (2010)	A Study on the Economic Profitability of Hospital Building Remodeling	Confined to hospital buildings, lacks credibility
Shin et al. (2003)	A Study on the Feasibility of the Apartment Remodeling in the provinces - Focusing on S Apartment in Daejeon City -	Feasibility analysis mainly on construction cost
Yoo et al. (2006)	A Study on the Building of Remodeling Evaluation Model	Feasibility analysis by applying Hedonic Mode
Kim et al. (2002)	Economic Assessment Through Case Study of Remodeling	Economic feasibility analysis on flat with shops
Choi (2006)	A Study on Economical Efficiency Analysis of Apartment Remodeling	Feasibility analysis through NPV

Real Estate Price Calculation Method and Economic Feasibility Analysis Method are normally used for remodeling project feasibility analysis. Sales Comparison Approach is commonly used for Real Estate Price Calculation Method and Net Present Value method is commonly used for Economic Feasibility Analysis (Kim, 2002). However, projects with distinctive phased characteristic such as apartment housing remodeling projects have uncertainties and risks on each phase on Figure 2-1. Therefore, complemented project feasibility evaluation model that considers the uncertainties is needed.

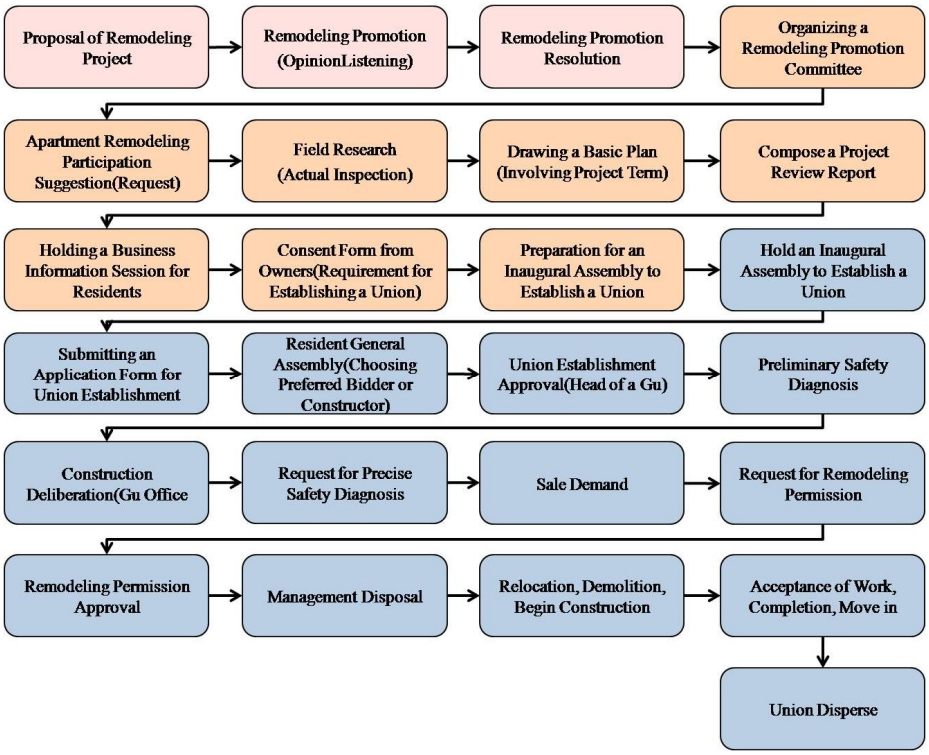

Figure 2-1 Project Conduction Stages of Apartment Housing Remodeling

2.4 Summary

In this chapter, definition and concept of remodeling is described and remodeling status and problems of domestic public housing was examined. Based on this, feasibility of domestic remodeling research trend and limitations were derived. First, remodeling concept was defined using literature related to domestic remodeling, housing law, construction law, etc. Considering current domestic regulations, the following terminology can be ruled to include in the concept of remodeling: extension, reconstruction, rebuilding, relocation, major repair, and alternation of the purpose of use, etc. Then, after considering remodeling status of domestic public housing and problems, despite the fact that there are many buildings that needs remodeling, it is analyzed that the successful case are rare; the reason is shown on table 2-1. Based on this, after analyzing research trend in feasibility of remodeling and limitations, despite the fact that remodeling business has clear staged business characteristics, it was found that the existing uncertainties or risks that exists in each stage is not properly considered during feasibility review. Thus, there is a need of remodeling feasibility assessment model that consider these uncertainties or risks that exists in each business stage.

Chapter 3. Theoretical Study

On this chapter, the concept and categories of Real Option are defined before the Real Option is being applied to remodeling project feasibility review. Moreover, examples from domestic construction industry that have been studied through Real Option Method are analyzed for the research.

3.1 Overview and Categories of Real Option

The most widely used model for a company valuation and an investment project assessment is Discount Cash Flow Model. The model is criticized for its inappropriateness to assess investment projects with uncertain future cash flow. That is, DCF model not only disregards the flexibility of investment decision making that occurs during the projects but has a problem of calculating the value by simply discounting the future cash flow(Park, 2009). Real Option Theory was devised to complement the weakness of DCF method. As Real Option Theory can assess the project value by considering numerous variables and uncertainties that may occur throughout the investment project, it is earning its reputation as a more flexible project value assessment tool than the existing DCF method.

“Real Option Theory was originally suggested by Myers(1977) and it is based on the concept of financial option”(Park, 2009). Real Option Theory is an expanded concept that integrates Real Option of financial engineering with tangible property or valuation of projects. It is commonly used when an investor makes a decision by involving the value of option. Until now in project valuation method, things that are already invested cannot be restored and decisions were made in the present by determining things that could happen in the future. However, Real Option Theory can fully consider many variables and uncertainties that could arise along the process of projects and that could help to decide intentions of investment more flexibly. However, the flow of each period in Real Option is monthly or yearly-based so that it can be calculated, whereas in financial option, it is mathematically the infinitesimal time unit. Because of the time interval in financial options is so short that it cannot be judged, it is more likely to make errors if this mathematical model is applied to Real Option. Also, financial option extracts option value through replicating portfolio of underlying asset under the no-arbitrage condition. However, there is a limit in estimating variability of underlying asset, as Real Option has no underlying asset that can be replicated.

Valuation methods by Real Option are mainly Black-Scholes Model, Binominal Option Pricing Model, and Monte Carlo Simulation (Park BJ, 2009).

Black-Scholes Model is an option theory presented by Fischer Black, Myron Scholes, and Robert Merton published in a journal of Chicago University in 1973. This model consists of variability which shows uncertainty, period of time to expiration date, exercise price, present price, and risk free rate. Option theory was drawn from these five data.

Binominal Option Pricing Model is a tree model developed by Cox, Ross, and Rubinstein in 1979. The price of option is independent from the probability of stock price movement, and the model the basic assumption of the model is that it follows binominal distribution when the stock price either rises or falls. In the asymptotic case this binomial model converses to the Black-Sholes model.

Generally, Real option contracts are as follows in Table 3-1. When investors or decision makers make a decision, they can expand, contract, defer, and abandon the investment on the project depending on the situation (Copeland and Antikarov, 2001; Park , 2009).

Table 3-1 Types of Real Option (Trigeogis, 2004)

Type	Meaning	Applicable Industries
Deferral Option	An option that can lease or purchase valuable land and resources and can also defer an investment till a favorable time emerges	Natural resources extraction, Real estate development, Agricultural industry
Phased Option	An option that can abandon the project halfway if new information is disadvantageous to the project. Each phase is regarded as an option for value of the next phase and it can be valuated by complex option	R&D clustered industry Medicine development Large-scale energy production facilities
Operation Scale Alteration Option	An option that can expand production scale or accelerate resource use. Reversely, operation scale can be reduced if market conditions are disadvantageous than expected	Natural resources industry, Fashion and clothing, Consumer goods, Industrial real estate
Abandoning Option	An option that if market conditions are severely depressed, management can permanently abandon current operation and secure sales value of assets other than capital goods in secondhand market	Airport, Railways Launching new items in markets with uncertain financial service
Replacement Option	An option that can alter production combination of facilities according to supply and demand	Alters a product, Alters an input
Growth Option	An option that initial investment is necessary or is connected to project chains that initial investments are mutually affiliated. It offers future growth opportunity	High technology, R&D, Strategic take over, Multinational operation
Multiple Interaction Option	An option that a value of option can alter if option exists complexly than when option exists independently	Actual projects related to all of industries

3.2 Preliminary Research of Real Option

Real Option Theory has been restrictedly applied to domestic construction related fields as stated on Table 3-2, and there are not many case studies related to Real Options.

Table 3-2 Preliminary Research of Real Option

Author(Year)	Content	Applicating Field
Hwang et al. (2007)	Economic feasibility of Real Option and port development	Civil engineering
Kim et al. (2008)	Real estate development value assessment through Real Option Model	Real estate
Jung et al. (2008)	Feasibility assessment on private investment project through Real Option	Architecture Civil engineering
Kim et al. (2009)	Development of a support model for overseas construction market entrance decision making through Real Option and scenario analysis	Architecture Civil engineering
Park et al. (2010)	Study on valuation and investment juncture of real estate development project through Binominal Option	Real estate
Kim et al. (2011)	Effects of housing price variability on option value and redevelopment point	Real estate
Moon et al. (2011)	Study on valuation of reconstruction project through Real Option	Architecture

Hwang et al. (2007) assessed economic validity of port investment to conduct research on preliminary validity of South Incheon Port International Passenger Terminal Bank Protection Project by comparing when DCF valuation method is applied and contract option is applied. Kim et al.(2008) chose Black-Scholes Model and Binominal Option Pricing Model among various assessment techniques to apply to actual real estate trading cases. From that, they calculated the value Expand Option and Deferral Option. Jung et al. (2008) showed the variation in validity of investment by calculating its value through considering excess earning distribution ratio and minimum revenue guarantee ratio in economic feasibility assessment of private investment projects. Kim et al.(2009) assessed market entrance item via calculating NPV, contracting options, and deferring options to conduct financial valuation of overseas construction market entrance by companies. Park et al.(2010) analyzed Business profitability with NPV to valuate project value assessment for office development. Also, by applying Binominal Model to calculate Deferral Options, the profitability of the project that reflects strategic value for active response is suggested. Kim et al.(2011) verified the effect of house price variability on the juncture of real estate redevelopment, under the idea that variability of selling house price immensely affects project feasibility. Moon et al.(2011) proved that the item that considers strategic flexibility has higher profitability than the existing one whose profitability determinded based on DCF method and calculated a U.S.-style phased complex(abandoning) option value.

3.3 Summary

In this chapter, the summary and category of the real option is examined and an advanced research was conducted. Theory of real option can be seen as the expansion of the financial engineering theory and real asset or the project's appraised value where the decision making of the investor includes the value in the judgment. Models frequently used in real option theory are Black-Scholes Model, Binominal Option Pricing Model, Monte Carlo Simulation Model and so forth. The main concept of the real option theory is that through the model, investor or even the decision makers are able to judge whether to expand, contract, delay, and forfeit the investments in the business. There have not been much advanced research cases for real option in the construction sector. Only in the domestic civil engineering and real-estate sector have been cases where the real option had been applied; however, it had not been used frequently when assessing the business value but rather exist as a theory.

Chapter 4. Remodeling Feasibility By Using Binominal Model

In this chapter, among the real option methods referred above, Binominal Lattice Model is applied to apartment housing remodeling feasibility review. For this, basic Binominal Lattice Model is deducted to calculate option value by defining input variables and option parameter used in Binominal Lattice Model.

4.1 Feasibility By Using Binominal Model

Because remodeling project shows distinctive phased characteristics as in Figure 1-1, feasibility reviews considering uncertainties that could occur in each phase are needed. To minimize the risk, option is considered as a hedging measure in Real Option. Thus, the expanded idea of NPV should be calculated by adding the existing NPV to the calculated value of an option. The project valuation can be defined as following:

$$\text{Dynamic NPV} = \text{Static NPV} + \text{Option Premium} \quad (1)$$

Dynamic NPV adds option premium value to NPV that made a static prediction of the future cash flow. This leads to the minimization of the risk

when valuating as it considers the environmental change of in and out and to the flexibility of investment decision making. In the study, binominal option is used among the real option method as mentioned in paragraph 1.1 to calculate the value of Option Premium which is one of two consisting factors of Dynamic NPV.

4.2 Feasibility Assessment Model of Using a Binomial Model

Binominal Model assumes that the price of underlying asset has only two probabilities as figure 2-1: Rising or falling for a certain period of time. P is a risk-neutral probability of the price of underlying asset rising, 1-P is a probability of falling. If the price moves from S to Su, it indicates a rise, and if it moves from S to Sd, it displays a drop.

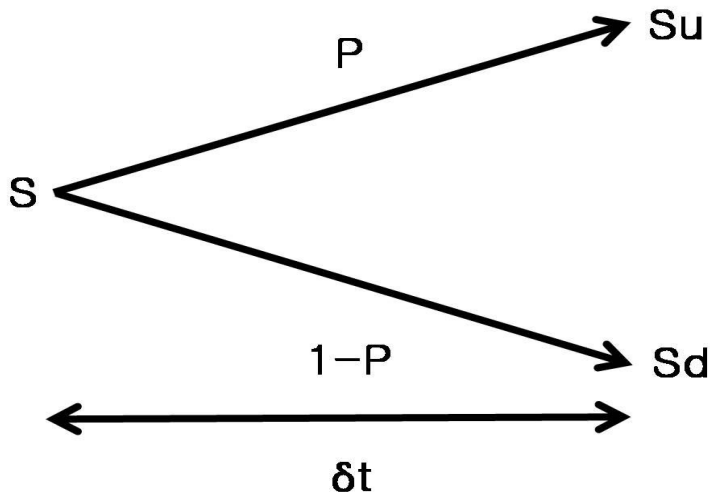

Figure 1-1 Movement of Underlying Asset Price After the Time Interval δt

Binominal Option is a model that displays price distribution of option's underlying asset using a stochastic process, which assumed to follow log normal distribution. Binominal Option model is most frequently used because it can calculate option price more easily than Black-Scholes Model and the margin of error is not that big when the option price is compared to that of calculated by Black-Scholes Model. To apply Binominal Model, the definition of input variables is needed and those variables are stated on the table below.

Table 4-1 Binominal Option Input Variable and Option Parameter

Input variable		Option parameter	
S	Present Value of investment project	% change of when S goes up	$u = e^{\sigma\sqrt{\delta t}}$
X	Exercise Price (project investment costs)		
σ	volatility	% change of when S goes down	$d = e^{-\sigma\sqrt{\delta t}}$
r	Risk Free Interest		
δt	Time Step	Risk Neutral Probability	$p = \frac{e^{r\delta t} - d}{u - d}$
T	Exercising Period(term)		

Percentage change of when S goes up and Percentage change of when S goes down are formulae which can be also called as rate of rise of value and rate of fall of value, respectively. The former shows how much the value of Underlying Asset is increasing, while the latter shows the reverse. Risk-Neutral Valuation is a method using Risk-Neutral probability which do not require risk premiums. For example, there are two situations. In the first situation, there is a 100% of chance to be given 1000 won for free and in the second one, there is a 50% of chance to be given 2000 won or 0 won. People who want to avoid risk are liable to choose the first situation and can be said

as having inclination toward Risk-Averse. On the other hand, people who accept risk to take much money although the chance or probability is low can be said as having inclination toward Risk-Taker. Risk-Neutral people see two situations as the same things because they both have same Expected Value.

To calculate project option value using Table 4-1 variables, Percentage change of when S goes up and Percentage change of when S goes down is multiplied by Present Value of Investment Project and then Basic Binominal Lattice Model is calculated by means of Rolling Backward Process, which is shown below Table 4-2.

Table 4-2 Basic Binominal Lattice Model

j \ i	0	1	2	3	4	5
0	Su	Su	Su^2	Su^3	Su^4	Su^5
1		Sd	Sud	Su^2d	Su^3d	Su^4d
2			Sd^2	Sud^2	Su^2d^2	Su^3d^2
3				Sd^3	Sud^3	Su^2u^3
4					Sd^4	Sud^4
5						Sd^5

Based on the model, Call Option Value can be calculated. After assuming Input Variable as following; S = 100 won, Exercise Price = 110 won, Annual Volatility σ= 11.41%, Risk Free Rate r = 5%, Five- year Exercise Period and Time Step δt= 1 year, Option Parameters u, d, p can be calculated by using this Input Variable, which is shown in the formula below.

$$u = e^{\sigma\sqrt{\delta t}} = e^{0.1141\sqrt{1}} = 1.1202 \quad (2)$$

$$d = e^{\sigma\sqrt{\delta t}} = e^{-0.1141\sqrt{1}} = 0.8921 \quad (3)$$

$$p = \frac{e^{r\delta t} - d}{u - d} = \frac{e^{0.05} - 0.8921}{1.1209 - 0.8921} = 0.6957 \quad (4)$$

Option Value can be calculated by using Underlying Asset Price which is turned into Binomial Model by calculated effect of Option Parameter based on Table 4-1 variables, and the following formula.

$$V_{T,j} = MAX\{Su^{T-j}d^{j} - X, 0\}, j = 0,1,2 \ldots, n \quad (5)$$

$$V_{i,j}^{c} = Max\{e^{-r\delta t}(pV_{i+1} + (1-p)V_{i+1,j+1}), 0\} \quad (6)$$

Using formula (5), the value of underlying asset ,Su^5, at the maturity is 176.94 then option value can be calculated by subtracting exercise value 110 from 176.94. At the maturity, However, Underlying Asset Price calculated by an intersection point between Su^2d^3 is 89.20 won and becomes negative number if subtracted by 110 won of Exercise Price, which could be a loss, when investing. Consequently, Option Value of this intersection point becomes 0 won. For instance, when one hundred million won of an apartment sale price, 110 millions won of investment and 5- year term are assumed, the apartment sale price is about 176.94 millions, taking volatility(σ = 11.41%) into account. 110 millions of investment subtracted from that value is 66.94 millions of Option Value, which can lead to investment in remodeling project.

In the same way, to calculate final Call Option Value, formula (6) is backwardly used along with Risk-Neutral Assessment Method and Risk Free Rate, which is shown below figure 4-2.

(unit: million)
(Up : Underlying value)
(Down : Option value)

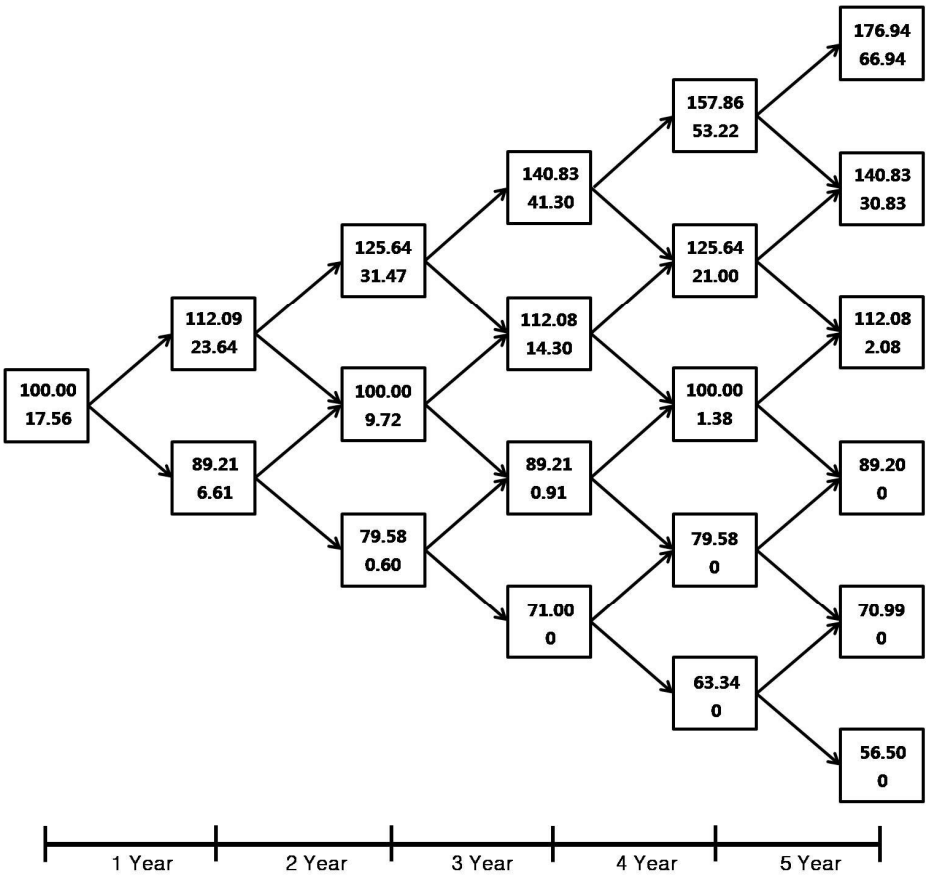

Figure 4-2 Binominal Model and Option Value

4.3 Summary

In this chapter, out of many value evaluation methods of real option, basic binomial lattice model that is needed to assess feasibility of remodeling was deducted using binomial model.

First, Dynamic NPV which is a concept that expands basic NPV by adding option value is defined. In order to find option premium which is the component of Dynamic NPV, input variable and option parameter of binomial model was prescribed. Then, using all the variables, basic binomial lattice model was calculated. This will be used as a basic model to calculate delay option and abandonment option.

Chapter 5. Application and Verification

To verify validity of Apartment Remodeling Feasibility Review Model already presented, the research chose an apartment complex, located in Yeondeungpo-gu, Seoul and completely constructed by S company and fully-occupied, as an application case. The model is Binomial Lattice Model among the Real Options and a procedure to evaluate Deferral Option Value and Abandonment Option Value. To evaluate them, NPV is firstly needed to be calculated by using total incomes and expenses which occurred in project. Next, volatility is estimated by using Proxy Variable and then Option Value is calculated by Basic Binominal Lattice Model, based on the value calculated above.

5.1 Outline of Project

The application of Apartment Housing used for the research is a successful application with Remodeling Union. And outline of the application is summarized on the Table 5-1 below. This project, that deals 3 units, 284 households apartments which 32 years elapsed since it had been built in 1978(based on 2010), was taking 6 years and 3 months promoting business period. The detail is shown on Table 5-2. Ground floor was built by pilot and special steel plate reinforcement was done with pillar and wall. By the construction, the first single-story vertical extension took effect in domestic

market. And by using horizontal extension technique, area was increased by 20~33m^2 per each household. Two-story underground parking lot was added.

Table 5-1 Outline of Application

Name	remodeling construction of D-dong Yeongdeungpo-gu, Seoul		**Period**	08.07.16 ~ 10.07.15
Classification	**before remodeling**		**after remodeling**	**Note**
Gross floor area	25,376 m2		Three dongs (11~13floor)	Newly-organized 2 floor basement car park Extension of 1floor piloti and 1floor
Floor space index	175%		243%	
Parking capacity	58 cars on ground (no basement		a total of 285 cars	a total of 227 cars
The number of households per pyeong	A-dong	17-pyeong	21-pyeong	Extension 4-pyeong / 12-household
		20-pyeong	25-pyeong	Extension 5-pyeong / 12- household
		34-pyeong	41-pyeong	Extension 7-pyeong / 84- household
	B-dong	22-pyeong	28-pyeong	Extension 6-pyeong / 84- household
		25-pyeong	32-pyeong	Extension 7-pyeong / 12- household
	C-dong	28-pyeong	34-pyeong	Extension 7-pyeong / 70- household
		30-pyeong	37-pyeong	Extension 7-pyeong / 10- household
	total number of households			7 kinds of pyeong, a total of 284-household

The cost of construction per pyeong is about 2.96 million won (2.88 million won of construction cost + 0.08 million won of union fee) which is acquired by the value of multiplying the cost of construction per pyeong by the gross construction contract area and then being divided by construction contract area per pyeong of each generation. The cost of construction consists of relocation expense, construction expense, option expense, related taxes and financial interest, and so forth. Interest rate is calculated by applying 6.26% on the basis of March 25th, 2008. The proportion of Operating Union expenses per year is calculated in the same way of the loan of Union working expenses.

Table 5-2 Progress of Promoting Project

Classification	**Safety diagnosis**	**Union Establishment Approval**	**Construction Review**	**Action Approval**	**Date of the start of construction work**	**Inspection before using**	**Date of the completion of move**
Date	04.7.30	05.7.28	06.04.13	06.08.23	08.7.14	10.07.08	10.10.30
Period		36 months (3 years)			24 months (2years)		

5.2 Feasibility Evaluation By Using Net Present Value

To analyze Real Option, NPV is calculated based on cash flow which occurred in the promotion of project, which is shown below Table 5-3.

Table 5-3 Financial Analysis by Using Discount Cash Flow

Big classification	Small classification	t = 0 (2005)	t = 1 (2006)	t = 2 (2007)	t = 3 (2008)	t = 4 (2009)	t = 5 (2010)	Total
Total income (+)	Loan of Union Working Expenses(borrowing)	54,480,914	384,445,916	549,498,171	540,140,479	417,122,128	318,314,029	2,264,000,000
	Loan of Operating Union Expenses (borrowing)	82,000,000	122,000,000	95,000,000				299,000,000
	Operating Union Expense				269,092,805	496,786,728	269,093,026	1,034,972,559
	Interest income, etc.						17,265,253	17,265,253
	Interest of additional relocation expense						15,818,794	15,818,794
	Support fund for vice administrative building		24,000,000					24,000,000
	Expenses for handing and taking over administrative buildings					41,165,425		41,165,425
	Union allotment expenses					1,431,826,366		1,431,826,366
	Sub total	136,480,914	530,445,916	644,498,171	809,233,284	2,386,900,647	620,491,102	5,128,048,397
Total	Operating Union Expense	9,684,630	68,339,831	97,679,540	96,016,390	74,148,416	56,584,102	402,452,909

expenditure	Union Working Expenses							
	Supervising expenses				276,760,000	363,000,000	181,592,282	821,352,282
	Expense for appointing a lawyer. Stamp tax and	68,981,280	45,255,770	38,118,370	64,767,268	9,800,000	23,709,000	250,631,688
	Registration cost, acquisition tax, registration tax etc				41,764,000		25,720,800	67,484,800
	Additional relocation expense				105,000,000	-25,000,000	-80,000,000	
	Deposit expense of purchasing price			747,790,000	590,100,100		121,000,000	1,458,890,100
	Associated costs of General meeting				5,969,100	2,841,960	4,102,130	12,913,190
	Loan of Working expenses interest					60,560,444	79,327,453	139,887,897
(-)	Electricity income cost of KEPCO, Gas facilities burden charge					12,874,360	11,066,630	23,940,990
	Sending signs, labor costs, Deposit of option-chosen household					6,969,180	5,180,750	12,149,930
	Real estate tax, residence tax etc					1,203,250		1,203,250
	Office supplies and printer toner, External audit			185,950		343,400	2,000,000	2,529,350

	Cost of substituting another price for Purchasing price and interest				145,396,970			145,396,970
	Subtotal	78,665,910	113,595,601	883,773,860	1,325,773,828	506,741,010	430,283,147	3,338,833,356
Net operating profit		380,667,423	409,737,732	-411,440,527	-679,347,690	1,840,370,842	249,227,259	
Cash Flow (discount rate 3%)		3,334,090	397,803,623	-387,822,158	-621,699,372	1,635,145,656	214,985,623	
NPV		**1,241,747,463**						

5.3 Feasibility Evaluation By Using Real Option

To evaluate the business value of Apartment Housing Remodeling having used Real Option, the research estimate volatility which is the most important variable, and Deferral Option and Abandonment are calculated by Basic Binominal Lattice Model made by using all defined variables based on the estimated volatility.

5.4 Estimating Volatility

Real Option has a difficulty in calculating volatility because it is not easy to obtain the past Cash Flow of Underlying Asset from the project compared to Financial Option which can obtained by using accumulated historical data(Park, 2009.) To solve this problem, there are some methods to calculate volatility of Real Option such as using historical data, Proxy Variable, subjective estimate of experts, Monte Carlo simulation and so forth.

The research aims to calculate volatility by using Transaction-based Sales Price Indices for the Apartment Housing Market, one of the indices for representing apartment asset value which is most sensitive part of Apartment Housing Remodeling. Volatility can be estimated through standard deviation of Seoul Metropolitan city, the southwest of Seoul and small-size, small-medium size and large-size of Seoul apartments required by using Transaction-based Sales Price I ndices. This process is summarized below Table 5-4.

Table 5-4 The calculation of Volatility by Transaction-based Sale Price Indices for the Apartment Housing Market

Classification	Seoul	The southwest of Seoul	Small size	Small-medium size	Medium-Large Size	Large size
Number of samples	77	77	76	76	76	76
Total	10096.6	10415.7	10523.7	10295.3	9525.6	8552.5
Average	131.12	135.27	138.47	135.46	125.34	112.53
Standard Deviation	**11.41%**	**11.54%**	**16.49%**	**12.98%**	**8.39%**	**5.91%**
Variance	130.28	133.18	272.04	168.5	70.34	34.91
Minimum	100	100	100	100	100	95
Median	134	138.1	145.05	139.9	127.7	113.25
Maximum	145.3	149.6	158.9	150.2	135.7	121.9

*: <Transaction-based Sales Price Indices For the Apartment Housing Market, http://www.kreic.co.kr/kreic/index.jsp>

The base point is January, 2006 and 6 of volatility can be calculated according to the size criteria of Transaction-based Sale Price Indices for the Apartment Housing Market and its criteria are like this; small-size below 60m^2, small-medium size 60m^2~85m^2, medium-large size, 85m^2~135m^2 and large-size over 135. The possession area of the real apartment complex ranges from 56m2 (before Remodeling) to 135m2 (after Remodeling), which meets the requirements above, so that 6 of volatility is calculated.

5.5 Basic Binominal Lattice Model

All variables for making Basic Binominal Lattice Model are calculated based on the volatility above, and this process is illustrated in Table 5-5.

Table 5-5 Variables of Basic Binominal Lattice Model

Variables		**Project of Ssangyong Yega-Classic in Dangsan-dong**	
Present Value	**S**	4,675,745,029 won	
Exercising Price	**X**	3,056,664,234 won	
Annualized Volatility	**σ**	Seoul	11.41%
		The southwest of Seoul	11.54%
		Small size	16.49%
		Small-medium size	12.98%
		Medium-Large Size	8.39%
		Large size	5.91%
Risk Free Interest	**r**	5.0%	
Time Step	**δt**	1 year	
Maturity	**T**	5 years	
% change of when S goes up	**u**	The Whole of Seoul	1.1209
		The southwest of Seoul	1.1223
		Small size of Seoul	1.1793
		Small-medium size of Seoul	1.1386
		Medium-Large Size of Seoul	1.0875
		Large size of Seoul	1.0609
% change of when S goes down	**d**	The Whole of Seoul	0.8921
		The southwest of Seoul	0.8910
		Small size of Seoul	0.8480
		Small-medium size of Seoul	0.8783
		Medium-Large Size of Seoul	0.9195
		Large size of Seoul	0.9426
Risk Neutral Possibility	**p**	The Whole of Seoul	0.6957
		The southwest of Seoul	0.6929

		Small size of Seoul	0.6136
		Small-medium size of Seoul	0.6645
		Medium-Large Size of Seoul	0.7846
		Large size of Seoul	0.9186

Present Value is that of total income calculated by financially analyzing real example. Exercise Price is calculated by using Present Value of total expenses. Time Step is 1-year and Risk Free Rate is applied 3.13% on the basis of the average of Government Bond Interest Rate which was valid from January 2012 to August 2012. The Table 4-2 below shows Basic Binominal Lattice Model made by using volatility of Seoul Metropolitan City and the process is the same as Table 5-6.

Table 5-6 Basic Binominal Lattice Model of first volatility
(The Whole of Seoul)

(unit: million)

j \ i	0	1	2	3	4	5
0	4,675	5,241	5,874	6,584	7,381	8,273
1		4,171	4,675	5,240	5,874	6,584
2			3,721	4,171	4,675	5,240
3				3,319	3,720	4,170
4					2,961	3,319
5						2,641

The Option Value in Table 5-6 can be calculated by Rolling Backward Process, using formula (5) and (6). The result is shown in Table 5-7 below. The calculated 21.71 billion of Option Value added to 12.41 of previous NPV

Value becomes 34.12 billion of Dynamic NPV. This value is the project value taking Option Value into consideration.

Table 5-7 Calculation Structure of Option Value

(unit: million)

j \ i	0	1	2	3	4	5
0	2,171	2,664	3,216	3,818	4,473	5,216
1		1,409	1,852	2,381	2,966	3,527
2			632	956	1,445	2,183
3				0	0	0
4					0	0
5						0

5.6 The Calculation of Deferral Option Value

To calculate Deferral Option Value, calculation Option Value is needed, which can be calculated by using formula (5) and (6) after making Basic Binominal Lattice Model made by using all variables. For example, 1-year Deferral Option Value of first volatility is calculated as in Table 5-8 and the formula is specified below (7), (8), (9) and (10).

Table 5-8 Basic Binominal Lattice Model of First Volatility
(The Whole of Seoul)

(unit: million)

j \ i	0	1	2	3	4	5	6
0	2,174	2,283	2,760	3,295	3,895	4,569	5,322
1		1,146	1,502	1,903	2,356	2,866	3,439
2			500	796	1,131	1,510	1,939
3				0	156	432	746
4					0	0	0
5						0	0
6							0

$$V_{6,0} = MAX\{Sd^j - X * (1 + r_d) - \delta, 0\} \quad (7)$$

$$V_{6,1} = MAX\{Sd^5u - X * (1 + r_d) - \delta, 0\} \quad (8)$$

$$V_{5,1}^c = e^{-r\delta t}\left\{\begin{matrix} p * (Su^6 - X * (1 + r_d) - \delta) \\ +(1 - p) * (Su^5d - X(1 + r_d) - \delta) \end{matrix}\right\} \quad (9)$$

$$V_{0,0} = V_{1,0} / (1 + R) \quad (10)$$

In the same way, Deferral Option Value per Volatility during five years can be calculated. The lowest is that of large-size and the highest is that of small-size. Also, it is analyzed that the more delayed the business is, the more increased the value is. And Deferral Option Value calculated by 6 of Volatility is shown below Table 5-9. Consequently, Option Values rises in proportion to the increasing Term and Volatility.

Table 5-9 Calculating Deferral Option Value per volatility

(unit: million)

	11.41%	**11.54%**	**16.49%**	**12.98%**	**8.39%**	**5.91%**
Option Value	2,275	2,274	2,275	2,274	2,275	2,274
1 Year Delay	2,175	2,197	1,324	2,461	1,676	1,315
2 Year Delay	2,351	2,377	3,531	2,684	1,780	1,372
3 Year Delay	2,525	2,554	3,886	2,905	1,880	1,426
4 Year Delay	2,697	2,729	4,247	3,125	1,977	1,477
5 Year Delay	2,865	2,902	4,615	3,345	2,070	1,525

5.7 The Calculation of Abandonment Option Value

In promoting Apartment Housing Remodeling project, if project value turns out to be useless by the investor based on certain steps, the investor will abandon the project halfway. The steps mentioned above can be given three hierarchical categories; first step is to permitting establishing Union. If Union is organized, project cannot be promoted at all. Second step is to permitting action, which is like the concept of approving business. However, currently a written permission is separately required regardless of Union Establishment Permission, which becomes difficulty in promoting project. The last step is about move and construction. If this step is passed, Union members begin to move and construction begins, which makes project not abandoned.

Abandonment option value can be calculated as follows : the first step is to make Basic Binominal Lattice Model by using all variables of 5.5. For instance, the maximum is Basic Binominal Lattice Model of small-size apartment in Seoul, whose volatility is 16.49% is shown below Table 5-10.

Table 5-10 Basic Binominal Lattice Model of Third volatility
(Small size of Seoul)

(unit: million)

j \ i	0	1	2	3	4	5
0	4,655	5,490	6,474	7,635	9,003	10,618
1		3,947	4,655	5,490	6,474	7,635
2			3,347	3,947	4,655	6,490
3				2,838	3,347	3,947
4					2,407	2,838
5						2,041

Second step is to set expenses, which occur in first, second and third step of promoting project as Exercising Price, and then to calculate Abandonment Option Value by Rolling Backward Process in the first stage of each step, using formula (5) and (6), like Table 18, 19 and 20.

Table 5-11 Calculation Structure of Abandonment Option of third volatility

(unit: million)

j \ i	0	1	2	3	4	5
0	4,594	5,425	6,406	7,563	8,929	10,539
1		3,883	4,587	5,418	6,399	7,556
2			3,279	3,876	4,580	5,411
3				2,767	3,272	3,869
4					2,332	2,760
5						1,962

Table 5-12 Calculation Structure of Abandonment Option of third volatility

(unit: million)

j \ i	0	1	2	3
0	2,692,	3,426	4,304	5,354
1		1,884	2,486	3,209
2			1,178	1,667
3				557

Table 5-13 Calculation Structure of Abandonment Option of third volatility

(unit: million)

j \ i	0	1
0	2,584	3,312
1		1,770

Abandonment Option Value is calculated as 25.84 billion and if 12.4 billion of previous NPV is added to it, which becomes 38.24 billion of Dynamic NPV. This value considers danger factors which can occur in promoting business

and then adds value of project abandonment to previous NPV. Therefore, it is thought that the investor can learn to use this project abandonment value as an index, whether to invest or not, knowing this value in the first stage of investment.

This Abandonment Option takes on Bermudan Option which is an intermediate form between American Option always available to Exercise Option and European Option only available to Exercise Option on expiration date. And calculated Abandonment Option Value added to previous NPV, Dynamic NPV is in Table 5-13.

Table 5-14 Calculation of Abandonment Option Value per volatility

(unit: million)

	11.41%	11.54%	16.49%	12.98%	8.39%	5.91%
First step	4,613	4,613	4,614	4,967	4,614	4,613
Third step	2,712	2,712	2,712	2,712	2,713	2,713
Second step (Option Premium)	**2,604**	**2,604**	**2,604**	**2,604**	**2,605**	**2,605**
NPV + Option Premium	3,845	3,845	3,845	3,845	3,846	3,846

The change of Abandonment Option Value is so small, compared to that of 5.6. This is because time interval is set shortly.

5.7 Summary

Generally, Remodeling Feasibility Review begins after Commission for promotion is organized. However, remodeling project is not only delayed for procedural problems but also canceled if project value proves to be useless by the investor. Thus, possibilities above should be considered at the point of Remodeling Feasibility Review. After considering Deferral and Abandonment cases, Remodeling Feasibility needs to reflect these values.

For this, 12.4 billion of NPV is calculated by Discounted Cash Flow, which is a conventional method. However, uncertainty which can occur in project promotion is not considered in this value. To complement the problem, Option value considering uncertainty of Deferral and Abandonment examples is needed.

First, according to calculated Deferral Option, among other Standard Deviations, the maximum value is about 46 billion which appeared in volatility of Seoul small-size when project is delayed for 5 years. The result means that project value is highest when invested at the expiration date of option. However, Deferral Option Value including Dynamic NPV is similarly calculated as about 38 billion, compared to Deferral Option Value which shows clear differences depending on time sections. Time sections are shortly set, when calculating Abandonment Option Value, which makes effect of volatility small.

The Abandonment Option Value includes a right to abandon project in Union Establishment Approval step, Action Approval step and Relocation and Construction step.

As a result, Deviation per volatility and time appeared largely because effect of volatility is larger than time value in Deferral Option Value, while the reverse in Abandonment Option Value.

These values reflects Option Values which were overlooked in previous NPV in the first stage of project, so that investors and union members can decide whether invest or not, based on these values.

Chapter 6. Conclusion

A project like Apartment Remodeling which takes prolonged period with clear phased business characteristic must be carried forward with considering uncertainty or market change in that period. But traditional Discounted Cash Flow, usually applied in existing Apartment Remodeling Feasibility Review, has a defect of analyzing the business value by determining parameter, uncertainty or cash flow which will occur in future at this stage

6.1 Results and Discussions

The results of the research are below

(1) The research recognize the problem as referring previously, reviewing the feasibility by applying Bermudan Option and European Option type which supplement Remodeling Feasibility Review that consists of traditional discounted cash flow. Based on cash flow of actual case, NPV is calculated. And comparing with calculated NPV on the basis of business delay or abandonment which occurs often in Apartment Remodeling Business by using Binomial Lattice Model in various technique type of real option for calculating the Deferral Option Value and Abandonment Option Value,

(2) Above all, the NPV of project was calculated with traditional Discounted Cash Flow. And Deferral Option and Abandonment Option are calculated

with 6 units of volatilities which are extracted from Transaction-based Sale Price Indices for the Apartment Housing Market of Ministry. The value of Deferral Option Value and Abandonment Option Value added to previous NPV is regarded as realistic, in that it reflects flexibility and uncertainty of future in promoting project. Therefore, investors learn to use Dynamic NPV as an index in deciding when to invest and whether to invest or not, because Dynamic NPV includes calculated Option Values in the point of feasibility review.

(3) The research, that uses real option theory, has a significant meaning for developing apartment remodeling feasibility review which complement NPV embraces most part of feasibility study in domestic currently.

This research is judged to have difference from current research in following ways: feasibility review considering uncertainties and risk which can occur during actual public housing remodeling business, unlike current research that only used one option for feasibility review, this research used two different options for the feasibility review; it is more realistic feasibility review of public housing that only used current BPV to judge by suggesting value range of the project using methodology other than NPV.

6.2 Further Study

This research has major limitations: failure to verify through various case studies, using only one case study to verify, calculating variability using only data since 2006, and failure to consider all the real uncertainties and risk that can occur during projects. Thus, considering these limitations and in order to make more realistic and valid further study, variability estimation method that considers remodeling business situation and all other possible elements will be studied. Based on this, research that combine integration with other options (including delay and abandonment option) will be studied.

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국 문 초 록(In Korean)

글로벌 금융위기 이후 국내 건설산업이 급격하게 침체된 가운데 건축물 리모델링 시장에 점점 초점이 맞춰지고 있다. 건축물 리모델링은 주거환경을 크게 개선시킬 뿐만 아니라 각 세대별 전용면적 증가, 여유공간 내 수평 또는 별동 증축, 대형 평수의 세대분할을 통한 세대 수 증가 및 일부 분양 가능 등 많은 장점을 가지고 있다. 그러나 국내 공동주택 리모델링 시장의 경우 각종 법규 및 사업추진 절차상의 문제점 때문에 리모델링 대상 물량이 적지 않은 수치임에도 불구하고 사업이 지지부진한 곳이 태반인 실정이다. 또한 공동주택 리모델링 사업 추진여부를 결정하는 사업성 검토 단계에서 대부분의 수익성 판단 모델로 사용되고 있는 순현재가치법은 리모델링 사업이 가지고 있는 단계별 특성과 미래의 불확실성을 고려하지 않은 단점을 가지고 있다. 이에 본 연구는 전통적인 가치평가방법인 순현재가치법의 문제점을 개선하고, 사업이 진행됨에 따라 일어날 수 있는 불확실성을 고려한 실물옵션 이론 중 이항모델을 활용하여 기존 사업성 검토에서 쓰이는 NPV를 보완하였으며, 공동주택 리모델링 실제 성공사례를 바탕으로 연구를 진행하여 보다 현실적이고 타당성 있는 사업성 검토를 하였다. 본 연구는 국내 공동주택 리모델링 시장 발전의

토대를 제공하고, 기존의 사업성 검토 및 경제성 평가의 문제점을 개선하여 그 타당성을 향상시킬 수 있을 것으로 기대된다.

주요어: 리모델링, 실물옵션, 경제성평가, 공동주택, 도시재생

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