

**Real Options:  
A Way To Deal With Market Uncertainty In Real Estate Development Projects**

by

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Submitted to the Department of Architecture in Partial Fulfillment of the Requirements for the Degree of  
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**Abstract**

The practice of applying options theory to real estate investments has only recently begun. In particular, options in real estate are called “real options.” Real options add value to real estate development projects by allowing developers to take advantage of positive aspects of the market and avoid negative conditions.

There has not been much effort to rigorously quantify the value of applying flexibility to real-world development projects. In this paper, I will attempt to examine the impact of applying real options theory to a mixed-use development project, the “Parc1 project,” which consists of two office towers, a hotel, and a retail mall to gain better understanding of flexibility. This project is being constructed all at once based on pre-determined assumptions about factors like rental rolls, sales price, and constructions costs. However, the deterministic model could result in a loss in case market conditions do not meet the assumptions set at the beginning. In this sense, applying real options such as phasing, deferring, and abandoning would be one of the ways to absorb the uncertainties in the market. This paper will try to figure out how much value real options can add to the project in terms of dealing with market conditions. For the analysis, the quantitative methods such as an engineering model and Monte Carlo simulation will be used.

Thesis Advisor David Geltner

Title Professor of Real Estate Finance

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# Chapter 1 Introduction

## 1.1. Introduction

Options as financial investment tools have been one of the most explored academic areas in Business Administration since mid 1990s and have been comprehensively used in real world. The basic concept of options theory is to provide flexibility. For an example, call options give us a right to buy stocks at a certain price called the “strike price.” If the stock price goes above the strike price, we exercise the call option. On the other hand, if the stock price goes down the strike price, we do not necessarily have to exercise the option, thereby avoiding losses. With this flexibility, the possibility of making profit usually increases.

However, applying options theory to real estate investments has not begun until recently. Options in real estate are called “real options.” Real options add value to real estate development projects by allowing flexibility according to market conditions. When developers initiate a development project plan, they first forecast the market conditions over the projected time period and use them as a basis for the project plan. The number of floors, property types, and target sales prices are determined based on these assumptions. For example, assume that an apartment with 100 units was built under a deterministic model that predicted all would be sold; however, the market turns out to afford only 80 units. The apartment was overbuilt and the developer gets a loss as a result of the incorrect forecast. Had the developer had an option to build 50 units first and then decide whether to build 50 more based on market conditions, the developer

could have adjusted the size of second phase realizing the forecast was not correct. In this sense, real options are effective in recognizing hidden values of a project by taking into account the uncertainties associated with the project.

This paper will attempt to apply real options to a development project, the Parc1 project, which is under construction currently in Seoul, Korea. It is a mixed-used development project that consists of two office towers, a hotel, and a retail mall and is being constructed under deterministic assumptions. This paper will try to determine how much value real options can add to the project by comparing the flexible model with the deterministic model. Real options include phasing, deferring, and converting uses from office to apartment<sup>1</sup>.

In this paper I will demonstrate a quantitative method which we call the “engineering model” approach to options analysis. The engineering model enables developers to incorporate various options and follow one of them according to market conditions. The engineering model differs from the economic-based models more prevalent in academic real estate literature in that it more simply and transparently models the decision-making process, and may be easier for decision-makers to understand and employ. The engineering model includes use of Monte Carlo simulation to incorporate uncertainties associated with market conditions. Given design or program that a developer decided to take on, there are risks about how the market will change. The Monte Carlo analysis deals with those uncertainties and shows the worst and best case results. Following this analysis, a final conclusion will be presented about how real

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<sup>1</sup> Baabak Barman and Kathryn E. Nash. *A Streamlined Real Options Model for Real Estate Development*, September, 2007, p2

options analysis can help decision-makers realize new possibilities for flexibility as well as whether and how much the real options have added value.

## 1.2. Real Options

In the field of finance, options theory was developed and is being widely used in real world investment practice. The purpose of options is to protect investors from or profit more from market volatility. Let's assume, for an example, we went long on a call option with a certain amount of an "exercise price." This contract means that we have the right to buy a stock at the exercise price on a certain date, but are not obligated to. If the market goes down below the exercise price, we do not exercise the call option and are, therefore, protected from the market downturn. On the other hand, if the market goes up, we do exercise the option and benefits from the difference between the stock price and the exercise price. To what extent we can hedge the volatility is determined by the factors like the stock price, the exercise price, the volatility of the stock price, the time to expiration, and the interest rate<sup>2</sup>. In addition, the option value is calculated based on these factors and it is backed up by how the market estimates the stock price volatility<sup>3</sup>.

Real options are also a way of dealing with uncertainties associated with physical or real estate assets as options is used in stock or bonds market to hedge risks<sup>4</sup>. In the past, companies used assumptions on certain factors for making new investment decisions. For an instance, when a company considers buying a new machine that is more efficient,

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<sup>2</sup> Bodie, Zvi, Alex Kane, and Alan J. Marcus. Investments. McGraw-Hill/Irwin, New York, p738

<sup>3</sup> Bodie, Zvi, Alex Kane, and Alan J. Marcus. Investments, p737

<sup>4</sup> Mun, Johnathan, Real options analysis: tools and techniques for valuing strategic investments and decisions 2<sup>nd</sup> ed. John Wiley & Sons, Inc., Hoboken, New Jersey, p. 89

they execute the investment if the benefit is greater than the costs. Moreover, assume that a factory is working at full capacity and the management forecasts that the product sales will increase beyond the current capacity. If the construction cost of a new factory or an expansion of the existing one exceeds the revenues from the additional product sales, the investment decision will be approved. However, note that those decisions are based on fixed assumptions. In the real world, things are a lot more complicated. What if the efficiency of a new machine doesn't turn out to be as much as expected? What if the sales increase doesn't reach the level that the management forecasted?

In order to incorporate the complexity into the decision making process, real options theory was introduced. It takes into account possible scenarios in the future. What are the possible scenarios you have? How do you value those options? Can you go back to the right condition, if you choose the wrong path? When is the optimal timing to execute the option that you chose? These are all associated with real options and you may need to answer these kinds of questions to reflect the flexibilities as much as possible.

Real options analysis can be used in a variety of industries including automobile and manufacturing, computer, airline, oil and gas, telecommunications, utilities, real estate, pharmaceutical research and development, high-tech and e-business, and merger and acquisitions industries<sup>5</sup>. All these industries require the expensive investment at an early stage with an uncertain expectation of outcomes in the future. Those investments may seem unreasonable or unfeasible when they are evaluated by traditional valuation methods. However, they can prove to be valuable when the uncertainties in the future

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<sup>5</sup> Mun, p. 35

business environment and flexibilities in management strategies are taken into account by real options analysis.

Examples of real options include:

- Option to abandon
- Option to wait and see
- Option to delay
- Option to expand
- Option to contract
- Option to choose
- Option to switch resources
- Option for phased stage-gate and sequential investments

### 1.3. Simple case

The following is a simple case study about applying real options to a real estate development project. This case was extracted from a thesis by Michel-Alexandre Cardin (2007).<sup>6</sup> He looked at a real estate development project that consisted of 430 apartment units along with relevant infrastructure such as landscaping, and its total gross floor area was 430,000 square feet. The project was to be built in five phases. The project information is in Table 1.1.

He attempted to evaluate the project by using both a static model and a real options model. One of the options he considered in his paper is the construction of the

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<sup>6</sup> Cardin, Michel-Alexandre, *FACING REALITY: DESIGN AND MANAGEMENT OF FLEXIBLE ENGINEERING SYSTEMS*, June 2007

park that accompanied the apartments. The initial plan of this project was to develop each phase of apartments with a proportionate amount of park to provide residents with a pleasant environment. On the other hand, if the entire park was built in the beginning of the project, it would generate higher sales prices for the apartments in the following phases. This, however, requires a lump sum cost at the first phase.

**Table 1.1 Project Information**

Phase	Type	SF	Units	Start	Completion
I	APT	50,000	50	1/07	1/09
II	APT	80,000	80	1/08	1/10
III	APT	90,000	90	1/09	1/11
IV	APT	110,000	110	1/10	1/12
V	APT	100,000	100	1/11	1/13
Total		430,000	430		

First of all, Cardin tried to estimate the deterministic value of the project. He deterministically assumed factors such as development costs and sales and ran the discounted cash flow (DCF) analysis based on these static assumptions as follows:

- The initial price of the property is \$350 psf and increases at 2.5% a year.
- Development costs are currently \$220 psf and increase at 2.5% a year.
- The park totaling 200,000 square feet is evenly divided into five phases and developed along with the five apartment development phases. The cost for each phase is \$200,000 million totaling \$1M as a whole.

The DCF analysis result shows that the project NPV is \$3.3 million<sup>7</sup>.

Next, a real option was incorporated to capture a possible favorable market condition. There were three decision rules in the option. First, the park would be built all at once at the first phase. Potential buyers tend to find more value in the properties with a park nearby. In this sense, developing the park at the initial stage would influence the market prices for properties of the next phases, even though it will cost a total amount of \$1 million upfront. Second, the decision to expand to the next phase would depend on the market condition. Only when the market value of the built property was greater than the development costs by a certain percentage, would the development of the next phase proceed. Lastly, the developer could hold the land for 20 years of projected time period and then sell it if the profit from selling vacant land were greater than that of developing it. As a result of these options, the value of the project under the options model turned out to be \$16.9 million.

Table 1.2 shows the comparison of valuation factors using the deterministic and real option model. For each factor, the real option model shows a better result: the value added using the options model is \$13.6M (\$16.9M - \$3.3M).

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<sup>7</sup> Cardin, Michel-Alexandre, p. 76

**Table 1.2 Comparison between inflexible and flexible model**

	Inflexible Model	Flexible Model	Which is better?
Initial Investment	\$ 27.3	\$ 21.4	Flexible
Expected NPV	\$ 3.3	\$ 16.9	Flexible
Minimum NPV	\$ 59.2	\$ -25.5	Flexible
Maximum NPV	\$ 77.9	\$ 90.0	Flexible
Value of Flexibility	N/A	\$ 13.6	

## Chapter 2 Real Options Valuation Methodologies

### 2.1. Canonical Model

A development project consists of phases like construction phase, lease-up phase and stabilized phase<sup>8</sup>. Each phase has a different level of risk associated with the characteristics of the phase. During the construction phase the property is built up and costs are paid out across the period as opposed to the upfront payment for buying a built-up property. When the project is completely leased-up and fully operational, the risk embedded in the project becomes the same as that of the existing building of the same characteristics.

We can find out the appropriate opportunity cost of capital (OCC) for a stabilized asset by observing existing buildings. The information on buildings currently under full operation is publicly available through an association such as NAREIT, National Association of Real Estate Investment Trust. Also, the OCC for construction costs can be approximated as risk-free rate because using debt financing for the construction is almost universal. Given these known values, the OCC for the development phase of a typical development project will be derived.

$$\frac{V_T - K_T}{(1 + E[r_C])^T} = \frac{V_T}{(1 + E[r_V])^T} - \frac{K_T}{(1 + E[r_D])^T} \quad (2.1)$$

---

<sup>8</sup> Geltner, David and Miller(2007), Commercial Real Estate Analysis & Investments, p. 780

Where:

$V_T$  = Gross value of the completed building(s) as of time  $T$ .

$K_T$  = Total construction costs compounded to time  $T$ .

$E[r_V]$  = OCC of the completed building(s).

$E[r_D]$  = OCC of the construction costs.

$E[r_c]$  = OCC of the development phase investment.

$T$  = The time required for construction.

Solving (1) for  $E[r_c]$  we obtain:

$$E[r_c] = \left[ \frac{(V_T - K_T)(1 + E[r_V])^T (1 + E[r_D])^T}{(1 + E[r_D])^T V_T - (1 + E[r_V])^T K_T} \right]^{(1/T)} - 1 \quad (2.2)$$

## 2.2. The Samuelson-McKean formula

The land ownership rights last forever and the right to develop a building on a land also is perpetual as long as it is not exercised. In this sense, the infinite lifetime of rights associated with land development should be taken into account. One of the most famous formula developed in the Economics field turned out to be useful for the land valuation. This formula, "Samuelson-McKean formula", was developed by the Nobel Prize winning economist Paul Samuelson and his partner Henry McKean<sup>9</sup> and used for

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<sup>9</sup> Geltner, David and Norman Miller, p. 744

pricing “perpetual American warrants<sup>10</sup>.”

The Samuelson-McKean formula needs three input variables: the built property cash yield rate ( $Y_V$ ), the volatility in the built property value ( $\sigma_V$ ), and the construction cost yield ( $Y_K$ )<sup>11</sup>. Given those three variables, we can measure the “option elasticity”,  $\eta$  by the formula (3).

$$\eta = \{y_V - y_K + \sigma_V^2 / 2 + [(y_K - y_V - \sigma_V^2 / 2)^2 + 2y_K \sigma_V^2]^{1/2}\} / \sigma_V^2 \quad (2.3)$$

The option elasticity explains how much the option value will change when the value of underlying property changes by 1%.

Besides the option elasticity, the vacant land value,  $C_0$ , is derived from current best possible project value,  $V_0$ , and the current construction and development cost,  $K_0$ . The variable,  $V^*$ , represents the “hurdle value” under which the land remains undeveloped<sup>12</sup>.

$$C_0 = (V^* - K_0) \left( \frac{V_0}{V^*} \right)^\eta$$

This hurdle value can be expressed as a function of the current construction cost and the option elasticity.

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<sup>10</sup> A perpetual call option that can be exercised at any time on a dividend-paying underlying asset

<sup>11</sup> Geltner, David and Norman Miller, p. 745

<sup>12</sup> Geltner, David and Norman Miller, p. 746

$$V^* = K_0 \eta / (\eta - 1)$$

In this formula,  $\eta / (\eta - 1)$  is the “hurdle benefit/cost ratio.” This formula implies that the hurdle value is a function of three variables: the built property cash yield rate, the volatility in the built property value, and the construction cost yield. It is independent of the project scale such as the land size.

### **2.3. Engineering methods**

There are two types of valuation approaches for evaluating real options. One is called the “economics-based” model and the other is the “engineering-based” model.

The economics based method puts more emphasis on valuations of the options and includes the binominal option valuation and the Samuelson-McKean formula. The binominal option valuation method uses the binominal trees by which up or down cases are designed step by step over the projected time period. The values are estimated at each node and the option values are calculated backward from each node. Given this way of calculating option values, this method needs a finite time period for the analysis.

However, the land development right is considered infinite as a perpetual American call option. In order to overcome this weakness of the binominal option valuation method, the Samuelson-McKean formula is recommended to be used. As was mentioned in section 2.2, this formula was originally developed for pricing perpetual American call

warrants.<sup>13</sup> Considering the infinite maturity of the land development right, the Samuelson-McKean formula can be appropriate for valuing the options for real estate development.

The economics based models may, however, not seem to be easy for practical professionals as it requires to understand the underlying finance theory. Realizing the need for more relatively easy and transparent ways to value options, the engineering based method is adopted in this paper. This method has been initially developed in the field of engineering systems for maximizing the value of engineering systems under uncertain conditions. It is based on the cash flow pro forma which is widely used for the financial analysis of real estate investments. It also uses simple and commonly available software like the Microsoft Excel spread sheet and provides the graphical explanation of how the outcome might be distributed. As a result, estimating real options using engineering method can appeal more easily to professionals in real world business. Basically, this model follows steps set up by de Neufville et al. (2006). First, analysts need to set up a cash flow pro forma. Next, uncertainty in variables will be recognized into the initial model. Lastly, sources of flexibility is incorporated and appropriate decision rules are set up by which the decision to exercise options is made.

Even though, the engineering based approach has some limitations that it may not be able to estimate the true land value due to the use of a single risk-adjusted discount rate, it can easily incorporate various sources of uncertainty, show the graphical presentation of the outcomes, and provides more transparent analysis results for decision makers. The

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<sup>13</sup> Masunaga, 2007, p.24

summary of advantages and disadvantages of two approaches are quoted in Table 2.1 from a thesis by Masunaga et al. (2007).

**Table 2.1 Merits and demerits of the economics-based approach and the engineering-based approach**

	<b>Economic-based approach</b>	<b>Engineering-based approach</b>
<b>Merits</b>	<ul style="list-style-type: none"> <li>– It can calculate the "true" real options price under the market equilibrium theory.</li> </ul>	<ul style="list-style-type: none"> <li>– The user does not need to understand advanced financial theory.</li> <li>– The analysis can be done with normal computational resources.</li> <li>– It has many ways to present the result graphically.</li> </ul>
<b>Demerits</b>	<ul style="list-style-type: none"> <li>– The user needs to understand the financial theory of real options.</li> </ul>	<ul style="list-style-type: none"> <li>– It is not always possible to calculate "true" real options value, mainly due to the arbitrary assumption of single risk-adjusted discount rate.</li> </ul>

Source: Masunaga (2007)

#### **2.4. Monte Carlo simulation**

Every analytical method seeks to reflect the real-world. Monte Carlo simulation is an analytical method that analyzes the effect of varying variables. It randomly generates values for uncertain variables as many as the analyst wants. The random value

is generated with a probability distribution that fits the analysis model. Some of them are normal, triangular, uniform, and lognormal distribution<sup>14</sup>.

Without a simulation, the analysis result may get flawed if it does not cover enough samples that could happen in a real world. For example, suppose we pick up a piece of paper in a basket that has one hundred pieces of paper with numbers ranging from one to one hundred written on it. After this trial is repeated one hundred times, the average can be calculated. This is the simple average for one set of one hundred trials. If thousands of sets of trials are executed, the distribution of the simple averages can be observed. The expected value of the simulation will be different from the simple average. This is called the flaw of averages.<sup>15</sup>

The Monte Carlo simulation can be applied to various purposes such as forecasting demand, cost, and any other variables that have uncertainty. There are several software programs for performing a Monte Carlo simulation. In this paper, the Microsoft Excel spreadsheet "Data/Table" function will be used for the analysis.

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<sup>14</sup> Mun, p.112 – p.113

<sup>15</sup> Mun, p.114

## Chapter 3 Case study: the Parc1 Project

The case that is going to be analyzed in this thesis is the Parc1 project currently being constructed in Seoul, Korea. It consists of two office towers, a hotel, and a shopping mall totaling 6,785,080 square feet. The developer of this project is Skylan Properties<sup>16</sup>, a British based real estate developer, and this is going to be one of the mega mixed-use development cases in Korea. In addition, it will be a pioneering attempt to look at the large scale project from a real options point of view and verify the usefulness of real options. The Parc1 project broke the ground in September, 2007 and is expected to be completed in May, 2011. The project specifics are shown in Table 3.1.

**Table 3.1 Parc1 Project Specification**

Developer	Skylan Properties (Y22 Project Financing Investment Ltd.)
Architect	Richard Rogers
Total project cost	\$1.5 billion
Total GFA	6.79 million square feet
Uses	- Office: two towers (69 and 52 floors) - Hotel: 350 rooms - Retail: 8 story shopping mall
Parking	2,737
FAR	7.99 <sup>17</sup>
GC	Samsung Corporation
Completion year	2011



<sup>16</sup> It has formed a kind of limited liability company, Y22 Project Financing Investment Ltd., for tax purposes.

<sup>17</sup> The underground area is included in FAR under the Korean regulations.

### 3.1. Office Market in Seoul

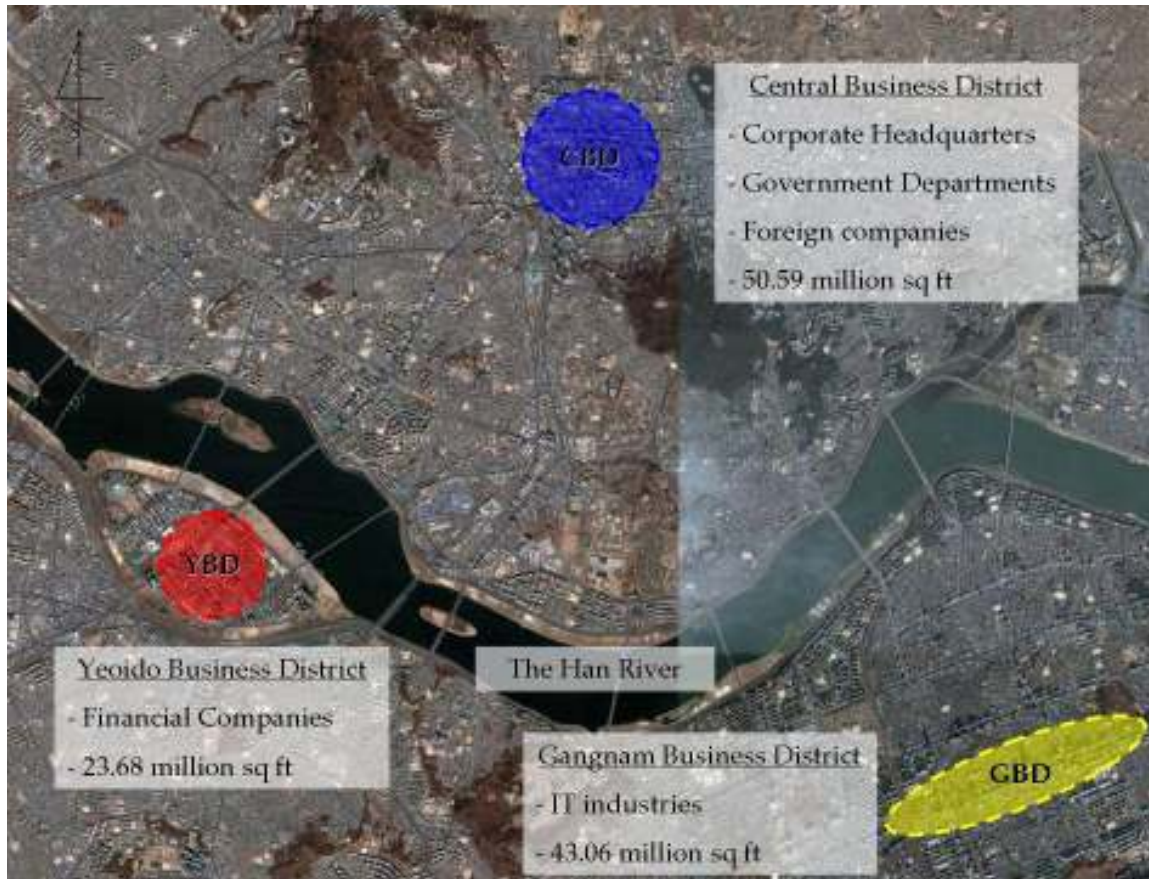
There are three Central Business District (CBD) areas in Seoul: the traditional CBD (CBD), “Yeoido” business district (YBD), and “Gangnam” business district (GBD). The CBD is where most of corporate headquarters, government departments, and foreign embassies are located. The CBD is a traditional business area that has been established along with the modernization of Korea, whereas the GBD was relatively newly formed business area that is represented mostly by IT industries. Recently, Samsung has built its new headquarters complex in the GBD. The YBD is represented as a financial business district where most of financial companies are clustering. All three business districts are easily accessible by both cars and public transit services such as subways and buses. The CBD is on the north side of Han River and the others are to the south. The map in Figure 3.1 shows the geographical location of three CBDs and Table 3.2 presents class A office stocks in them.

**Table 3.2 Class A Office Stocks in CBD, GBD, and YBD**

	CBD	GBD	YBD	Total
No. of Buildings	86	68	39	193
GFA (million sq. ft.)	50.59	43.06	23.68	117.33
% of Total	43.12%	36.70%	20.18%	100.00%

*Source:* Seoul Office Market Report, BHP-Korea, 1Q 2008

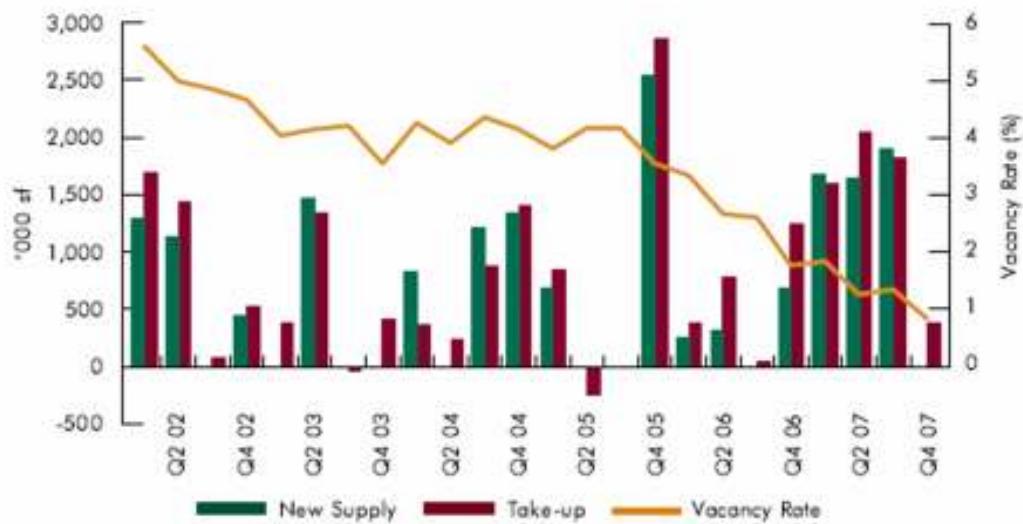
Figure 3.1 Geographical location of three business districts in Seoul



The office market in Seoul has been quite strong in terms of rental market and transactions since the mid 1990s. The demand for office spaces has remained strong due to the growing economy of the country and the new construction has not been fast enough to catch up the increasing office demand. The vacancy rate kept a down slope reaching a record-low of 0.84% in the fourth quarter of 2007<sup>18</sup> as shown in Figure 3.2. In the first quarter of 2008, however, it has increased slightly into 1.1%.

<sup>18</sup> Asia Pacific Office Market Review, 4Q 2007, CBRE p3

**Figure 3.2 Supply, Take-up and Vacancy in Prime Office Market in Seoul, Korea**



Source: Asia Pacific Office Market Review, CBRE, 4Q 2007

Regarding office rents, it has also kept gradually increasing since the late 1990s as shown in Figure 3.3. The average office rent in the CBD as of the first quarter of 2008 is \$29 per square foot being the highest among three districts. In the GBD, it is \$24, and in YBD, \$19. Traditionally, asking rents in the CBD have been the highest followed by the GBD and YBD. In addition to the literal rents, maintenance fees are collected separately and considered a part of rents. Total rental rates as of the first quarter of 2008 across three districts are shown in Table 3.3. Given the strong demand for the office space and the lack of new supply, the office rents are expected to rise for the time being.

The stable office market has drawn capital flows from both foreign and domestic investors and they competitively bought up class A office buildings, thereby raising sales

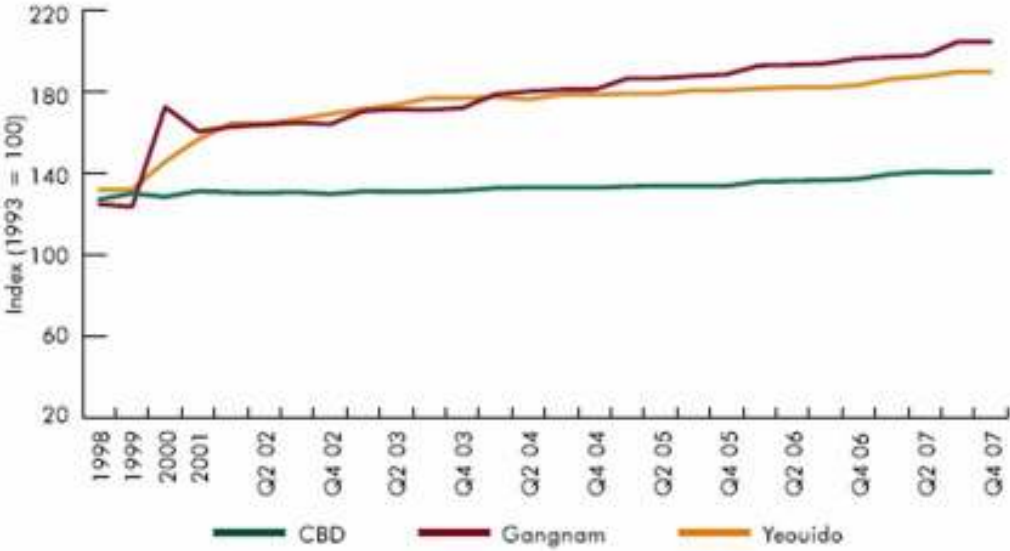
prices. Current transaction values in the GBD have reached \$618 per square foot and the initial yield on the class A office buildings is between 5.0% to 5.5%<sup>19</sup>. Although it seems to be relatively low compared to the average return level of class A office properties in major cities in the U.S., majority of investors expects high capital gains to compensate it.

**Table 3.3 Office Rental Rates, Seoul, 1Q 2008**

	Rents (psf)	Maintenance fees (psf)	Total (psf)
CBD	\$29.38	\$11.29	\$40.67
GBD	\$24.12	\$10.18	\$34.30
YBD	\$18.61	\$8.84	\$24.45

Source: Asia Pacific Office Market Review, CBRE, 4Q 2007; and Seoul Office Market Report, BHP-Korea, 1Q 2008

**Figure 3.3 Prime Office Rental Index, Seoul**



Source: Asia Pacific Office Market Review, CBRE, 4Q 2007

<sup>19</sup> Asia Pacific Investment Market Review, CBRE, 2H 2007, p12

### **3.2. Dealing with market uncertainty: Real Options**

One of the concerns associated with this project is that there is another competitive project, Seoul International Finance Center (SIFC), which is developed by AIG and will come on the market at the same time adding significant amount of new space stock to the market. Those two projects are located in the Yeoido Business District (YBD), one of three business districts in Seoul. In the YBD, the total stock of office space is around 24 million square feet. In Parc1 project, there is 4.28 million square feet of office space and SIFC has slightly more than the Parc1; 5.34 million square feet. The new supply from both projects, therefore, will increase existing office stock by 40.6% significantly impacting on the market in terms of rental and vacancy rate. Market conditions might not be as were assumed to be and this will affect the expected return on the project. This event cannot be avoided when it happens under the deterministic plan. In this sense, considering real options in the analysis of the project would help developers to figure out how to deal with uncertain market conditions.

The possible options would be phasing, deferring, changing property types, and abandoning. First, as for phasing, the project can be divided into two phases along with its two office towers. The decision for second building to be built will be made only when a certain criterion such as a vacancy rate goes below the average market rate. Second, this project could be deferred until overall market conditions become supportive. When the market recovers in terms of vacancy rate and rent rolls, the project can get started without phasing. Third, the conversion of the uses into other types such as residential could be one of the possible options to think of. Converting one of the office

towers into condos might turn out to be more feasible because the residential market has been strong over the last decades as well. This option, however, needs to reconsider the zoning regulations for the approval of converting uses. Lastly, if market conditions do not meet any criteria for a projected time period, the developer can wait and sell the raw land if the land price is higher than the profit from developing the land.

**Figure 3.4** Locations of the Parc1 and the SIFC project



The more options we take into account, the more exactly the analysis will present how much value real options add to the project. However, this paper will attempt to incorporate only a phasing option for the simplicity of the analysis.

## **Chapter 4 Option Valuation**

In order to estimate the option value, the engineering model will be used based on the Microsoft Excel spreadsheet. At first, this paper will derive the net present value (NPV) of the project under the static model in which key assumptions such as pre-lease rate and rent growth rate are fixed. These assumptions are very much close to those that were used by the developer. Therefore, the value under the fixed assumptions reflects the project value that was estimated by the developer as this project is currently being constructed under the static model. In addition, the canonical model by Geltner (2007) will be adopted to exactly ascertain the opportunity cost of capital for a development project and incorporate it into the analysis. Once the project NPV under the static model is estimated, another analysis will be made with sources of uncertainties: the pre-lease rate and rent growth rate. In order to incorporate flexibility, appropriate decision rules will be set up. Under this flexible model, only the first building will get started, and then, the decision to start constructing the second building will be made when market conditions meet the decision rules requirements. For example, the decision to build the second building will be made only when 90% of the first building is leased up. Also, the market rental rate will be considered for the decision rules. The Monte Carlo analysis will be done with two thousands samples by randomly generating pre-lease and rent growth rate with a certain percentage of uncertainty. This thesis will conclude comparing the performance of those two models.

#### 4.1. Key assumptions

Key assumptions such as the Gross Floor Areas (GFA), construction costs, exogenous variables like rent growth rate, general vacancy rate, and inflation rate, and Opportunity Cost of Capital (OCC) for various types are as follows.

**Table 4.1 Gross Floor Area (GFA) for each building**

	Square feet <sup>20</sup>	Square meters	Floors
Office one	2,455,277	228,105	69
Office two	1,825,034	169,553	52
Total	4,280,311	397,658	

**Table 4.2 Construction Costs<sup>21</sup>**

	Office one		Office two		Total	
	Amount	psf	Amount	psf	Amount	psf
Hard	539,723	219.82	396,786	217.41	936,509	218.79
Soft	243,773	99.29	187,127	102.53	430,900	100.67
Total	783,496	319.11	583,913	319.95	1,367,409	319.46

\* amount: \$ thousands

**Table 4.3 Exogenous Variables**

Projected rents in 2011 <sup>22</sup>	45.28 psf
Annul rent growth rate	3.00%
Inflation rate	3.00%
Vacancy (stabilized period)	3.00%
Terminal cap rate	5.50%

<sup>20</sup> 1 square meter = 10.7638 square feet

<sup>21</sup> \$1 = KRW 1,000

<sup>22</sup> Including maintenance fees

**Table 4.4 Opportunities Costs of Capital**

Risk free rate	4.50%
Risk Premium for construction costs	0.50%
Risk Premium for stabilized asset	2.00%
Risk Premium for speculative asset	4.00%

GFAs and construction costs are real numbers for the project. The projected rent in 2011 is the number assumed by the developer. As for the rent growth rate, it is based on the rent index by SAMS, one of the property management companies in Korea. The index shows the annual average increase rate of 3.59%. The inflation rate is assumed to be 3.0% as the CPI index<sup>23</sup> from the first quarter of 2000 and to the first quarter of 2008 shows the annual average increase rate of 3.3%. The historical data<sup>24</sup> of interest rates of three year Treasury bonds presents the annual average increase rate of 4.64% from January, 2003 to May, 2008. Therefore, the risk free rate is set up to be 4.5%.

#### **4.2. Static Model**

For the static model analysis, the typical ten year discounted cash flow (DCF) analysis is used under fixed assumptions. Construction costs are evenly distributed over four years of construction period; from 2008 to 2011. The main income source of real estate properties is rental income. Various components such as rent growth rate, vacancy, and initial lease up rate relate to the rental income cash flows, thereby affecting the return

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<sup>23</sup> National Statistical Office, Appendix

<sup>24</sup> National Statistical Office, Appendix

on the project at both property and entity level. Rents grow at a fixed rate of 3.0% over the projected time period according to the assumption. Also, vacancy rate is fixed at 3.0% from a conservative point of view although current vacancy in the YBD maintains below 1.0%. Regarding lease-up plan, interviews with a leasing agency for this project was conducted. According to the leasing agency, the initial pre-lease rate is 70% of total space at the end of 2011 when the project is completed. Within six months of the completion, it is expected to be fully leased-up and the average vacancy rate for the stabilized period will be applied afterwards. There will be 5% of turnover vacancy every three years.

On the expenses side, the operating expenses are expected to be 45% of the effective gross income. Typical structure of the leasing commissions in the Korean real estate market is that the equal amount of one month of the annual gross rental income is charged for any new leasing contracts. Expenses for tenant improvements are forty dollars per square foot and 0.5% of the NOI will be reserved for capital improvements of the building.

Resale value will be derived by applying 5.5% of terminal cap rate to the NOI of the eleventh year and sales cost is 2% of the price.

Figure 4.1 Rent Projection with 3.0% of Growth Rate under the Static Model

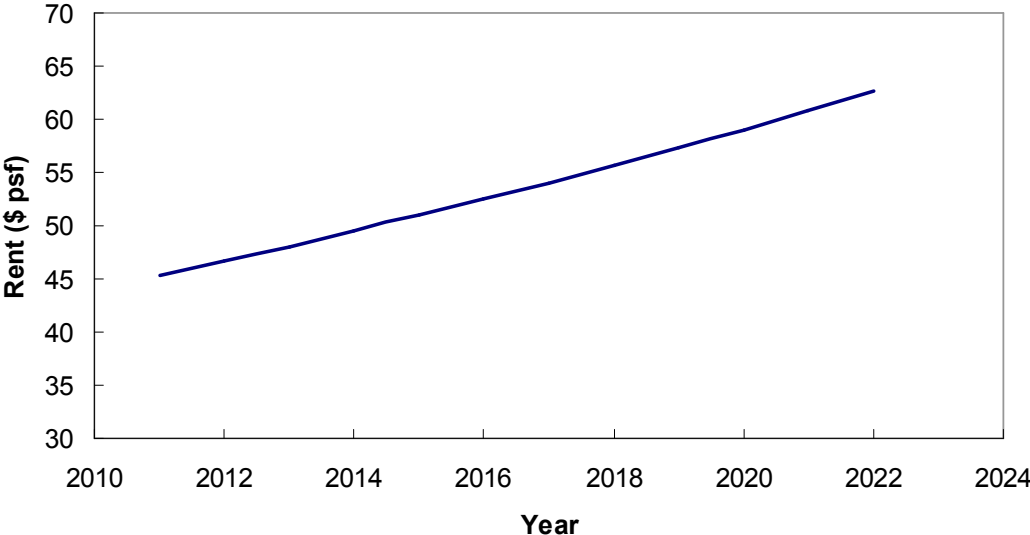
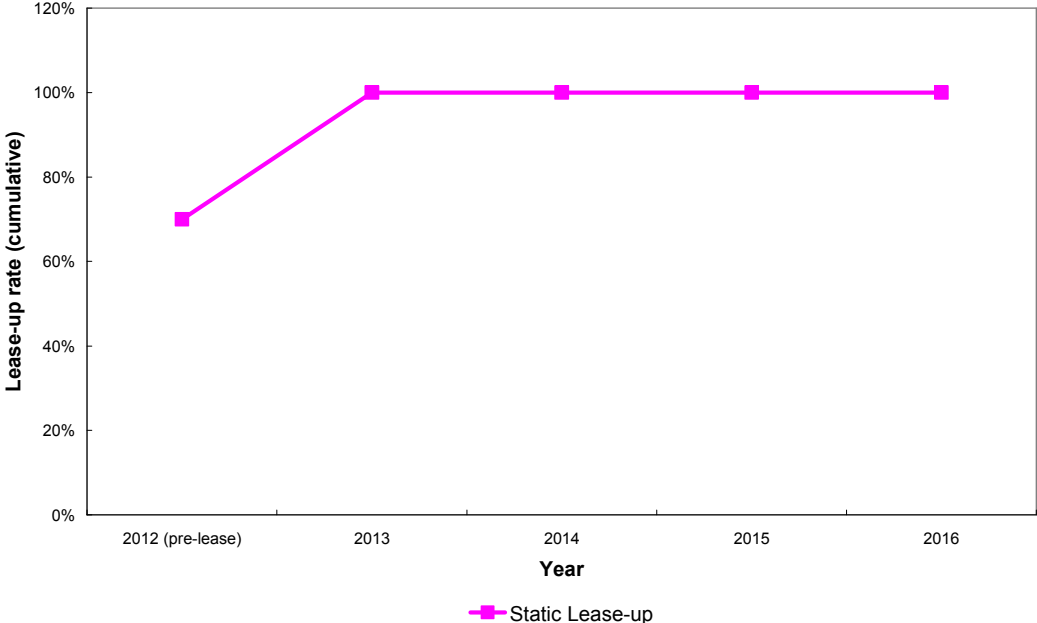


Figure 4.2 Lease-up Expectation under the Static Model<sup>25</sup>



<sup>25</sup> General vacancy and turnover vacancy rate will be applied to the lease-up expectation.

#### 4.2.1. Analysis result

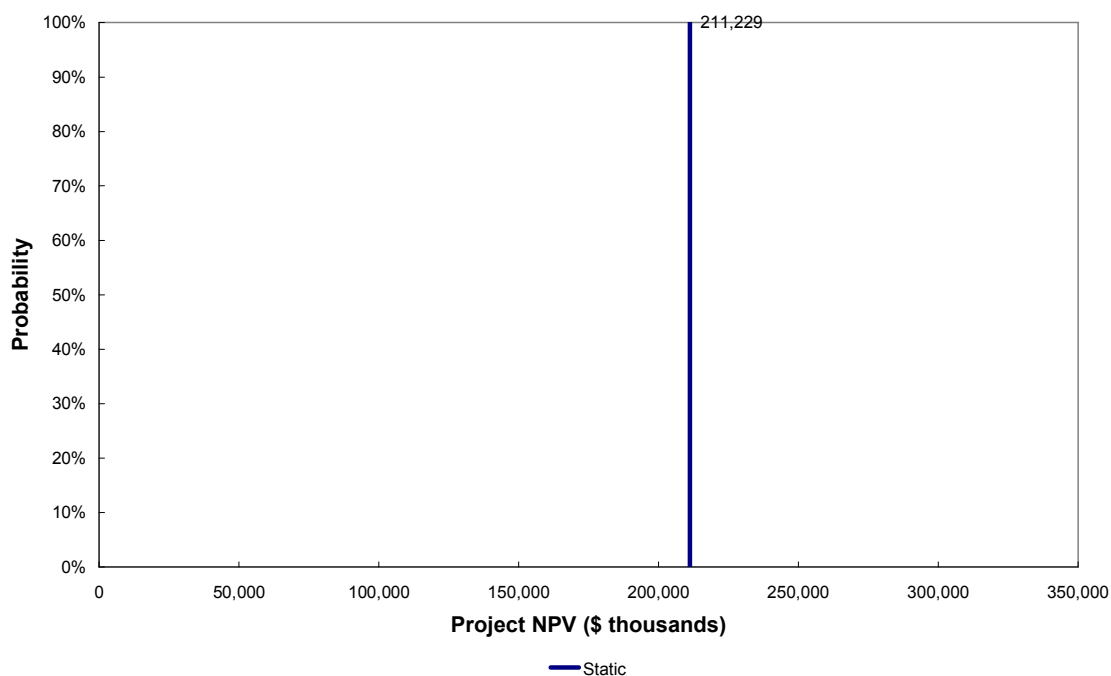
In order to recognize the risk associated with real estate development projects and decide the appropriate opportunity cost of capital for the development phase, the canonical formula by Geltner (2007) will be used. The end of year 2011 when the project is completed is set as time  $T$  and the beginning of year 2008 when the project got started is considered time zero. All the cash flows including the reversion from the stabilized period is discounted to time  $T$  at the discount rate for the stabilized properties. On the other hand, all the development costs are accrued to time  $T$  at a rate for the construction cash flows. Table 4.5 summarizes the values for each variable for the canonical formula. With those input variables, the appropriate OCC for the development phase is derived as 23.99%. Given that, the project NPV under the static model is \$211.23 million.

**Table 4.5 Summary for the Canonical Formula Analysis**

Inputs	Time T PV stabilized asset ( $V_T$ )	\$1,972,659
	Time T PV construction cost ( $K_T$ )	\$1,473,426
	Time T NPV: $V_T - K_T$	\$499,233
	OCC for stabilized asset	6.5%
	OCC for speculative asset ( $E[r_V]$ )	8.5%
	OCC for construction ( $E[r_D]$ )	5.0%
Outputs	OCC for development phase ( $E[r_c]$ )	23.99%
	NPV as of Time zero (2008)	\$211,229

\* \$, in thousands

**Figure 4.3 Cumulative Distribution Function: Project VARG - Static**



### **4.3. Inflexible Model**

There is no uncertainty in the static model. The result of the analysis totally depends on the assumptions. Even though the developer tried to predict market conditions as exactly as possible by using means such as leasing agencies, the outcome might not be as he had expected due to the realized market conditions. Considering all these, it is necessary to look into how the uncertainty in the market affects the project value. In order to study how volatile the project value is with varying market conditions, two thousands Monte Carlo simulations are made with varying conditions in the lease-up rate and rent growth rate. However, the inflexible model still does not have the flexibility in decision making process. The key assumptions are the same as in the static model.

#### **4.3.1. Uncertainty in lease-up expectation**

The initial pre-lease expectation was 70% at the completion and the rest of the space was expected to be filled up within six months of the completion. As was already mentioned in section 3.2, the impact that the new supply from this project will have is very huge. The Parc1 project itself will increase the existing office stock in the YBD by 18.1% when it is finished. Moreover, with the competitive project right next to the Parc1, the new office supply from both projects accounts for 40.6% of the current stock. The developer's argument is that the vacancy rate in the YBD is staying at near 1% and that the rental market seems to be able to maintain the strong momentum given the strong demand for the office space and lack of the new supply until the Parc1 is delivered to the market. In addition, they expect tenants' shifting from near buildings that favor newly built environment.

If all the favorable expectations by the developer turn out to be real, the realized pre-lease rate should reach or exceed the assumed rate of 70%. However, there also exist odds that market can go into a downturn. This necessarily does not mean that the static assumptions made in Parc1 project are wrong or too aggressive. They certainly tried their best to forecast the market as best as they can. Otherwise, the point is to demonstrate how the options analysis can be useful in a more general market rather than Yeoido. Therefore, it is natural that both positive and negative conditions are taken into account.

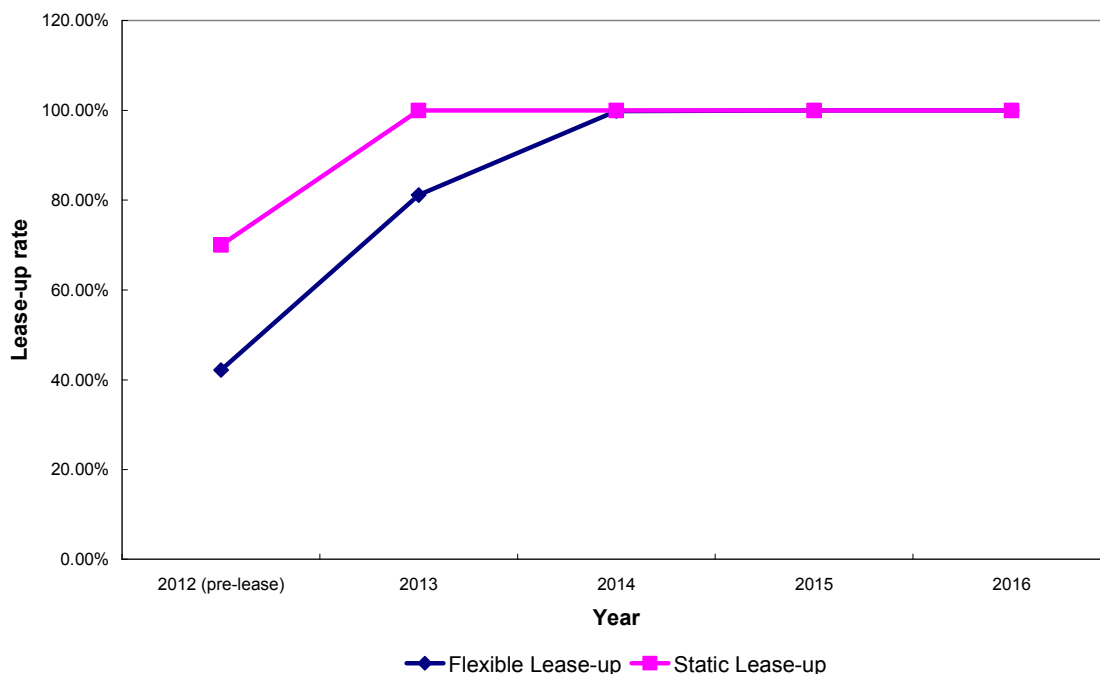
The lease-up expectation will fluctuate with 50% of uncertainty from the initial assumption. For example, the lease-up expectation for the first year is 50% as shown in

Table 4.6. 25% out of it is fixed and the rest of it fluctuates so that total lease-up expectation ranges from 25% to 75%. There is another uncertainty factor, “Market Parameter,” to make this model fit into a general market condition other than Seoul, Korea. If this market parameter is set to 100%, it means that the uncertainty level in the lease-up rate is fully realized as was assumed above to be 50%. On the other hand, if the market parameter is set at 30%, only 30% of the uncertainty assumption, that is 15%, will be recognized. By adjusting the market parameter, various market conditions can be applied to the model. At first, the lease-up expectation is set up for a general market. It is set up as 50% for the first year. In second year, it is going to be 30% and fixed at 20% for the rest of periods. For example, as for the lease-up expectation of the first year, the pre-lease rate, it will fluctuate with 50% of uncertainty so as to be centered at 50% ranging from 25% and 75%. In order to minimize the effect of the extreme cases, the triangular distribution method is used. The total lease-up rate will not exceed 100%, though. Figure 4.4 compares the static lease-up projection to randomly realized one with uncertainty. The blue line depicts the random realization.

**Table 4.6 Lease-up Expectation and Realized Lease-up**

	2012	2013	2014	2015	2016
Lease-up Expectation – static	70.00%	30.00%			
Lease-up Expectation – general market	50.00%	30.00%	20.00%	20.00%	20.00%
Random realized Lease-up	52.04%	35.23%	21.00%	18.19%	20.84%
Random realized Lease-up (cumulative)	52.04%	87.27%	98.27%	100.00%	100.00%
Uncertainty	50%				
Market Parameter	100.00%				

**Figure 4.4 Static and Randomly Realized Lease-up Projection**



Basically, the model was designed for a general market. Various market scenarios can be assumed by adjusting the market parameter, thereby changing the uncertainty level. In case of market downturn, more uncertainty could be assumed by increasing the market parameter. On the other hand, if the market is expected to be stable, less uncertainty could be recognized by reducing the parameter.

#### **4.3.2. Uncertainty in the rental rate**

Along with the lease-up expectation, the rental rate can be one of the sources of flexibility. Three uncertainties were recognized in the rental rate: rent growth rate,

volatility in the rent growth rate, and randomness in the realized rental rate.

First of all, the rent growth rate is fixed under the static model. It is assumed to increase at 3% per annum based on the past data. However, it might be different from the static increase rate. Over the past ten years, the office rent in CBD areas in Seoul has been in a gradually upward slope as seen in Figure 3.3. Given this, there will be much smaller uncertainty in the rent growth rate. It will fluctuate so that the mean is 3.0% ranging from 2.0% to 4.0%.

Next, there will be a volatility term in the randomized rent growth rate. The realized rent growth rate in any given period might be different from the randomized long-term average growth rate. It is derived by applying this volatility term to the growth rate obtained from the first step. This volatility term will be added to or deducted from the randomized growth rate. The amount added or deducted will be distributed so that the mean is zero and range is from -2.0% to 2.0%. The rent rate that is derived by applying this growth rate may be called "Trend Rent."

Lastly, the realized rental rate is calculated by adding another random term to the *level* of the trend rent. This reflects the fact that any specific lease negotiation for space in a specific building may differ from the general market rent level. The uncertainty in this random factor around the trend rent level is 5.0%. In other words, 95% of it will be fixed and the rest of it will fluctuate by a randomly generated number. The formula for the realized rental rate can be presented as in Formula 3.1. Figure 4.5 presents how the uncertain rent moves.

$$realizedrent(t) = (1 + rand(t)) \times trendrent(t - 1) \quad (3.1)$$

Where:

$$trendrent(t) = (1 + mu + sigma(t)) \times trendrent(t - 1)$$

$mu$  = randomized rent growth rate

$sigma(t)$  = volatility realization in the rent growth rate each period

$rand(t)$  = random term in the realized rent level each period

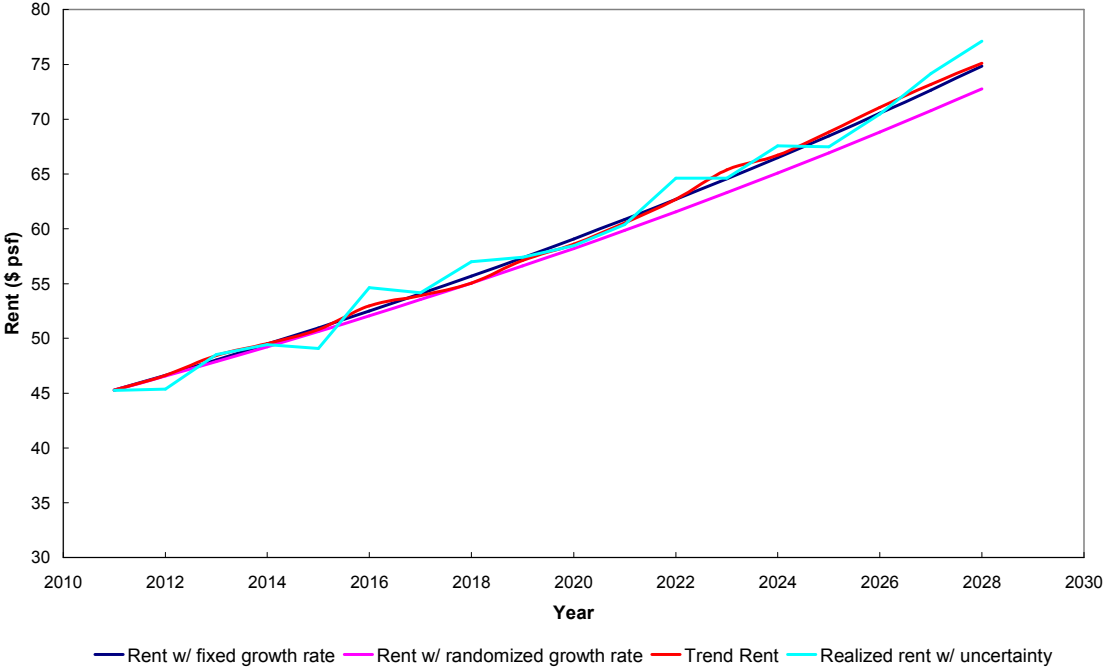
**Table 4.7 Variables for Uncertain Rent projection**

Fixed rent growth rate	3.00%
Randomized rent growth rate	2.83%
Realized rent growth rate with uncertainty	2.98%
Sigma(t)	±2.00%
Uncertainty in the realized rent	5.00%

**Table 4.8 Rent Projection (\$ psf)**

	2011	2012	2013	2014	2015	2016
Expected rent with fixed growth rate	45.28	46.64	48.04	49.48	50.96	52.49
With randomized growth rate	45.28	46.56	47.88	49.23	50.63	52.06
Trend Rent	45.28	46.62	48.43	49.52	50.80	52.98
<b>Realized rent with uncertainty</b>	<b>45.24</b>	<b>45.38</b>	<b>48.51</b>	<b>49.43</b>	<b>49.09</b>	<b>54.62</b>

**Figure 4.5 Rent Projection with a Random Realization**



**4.3.3. Analysis result**

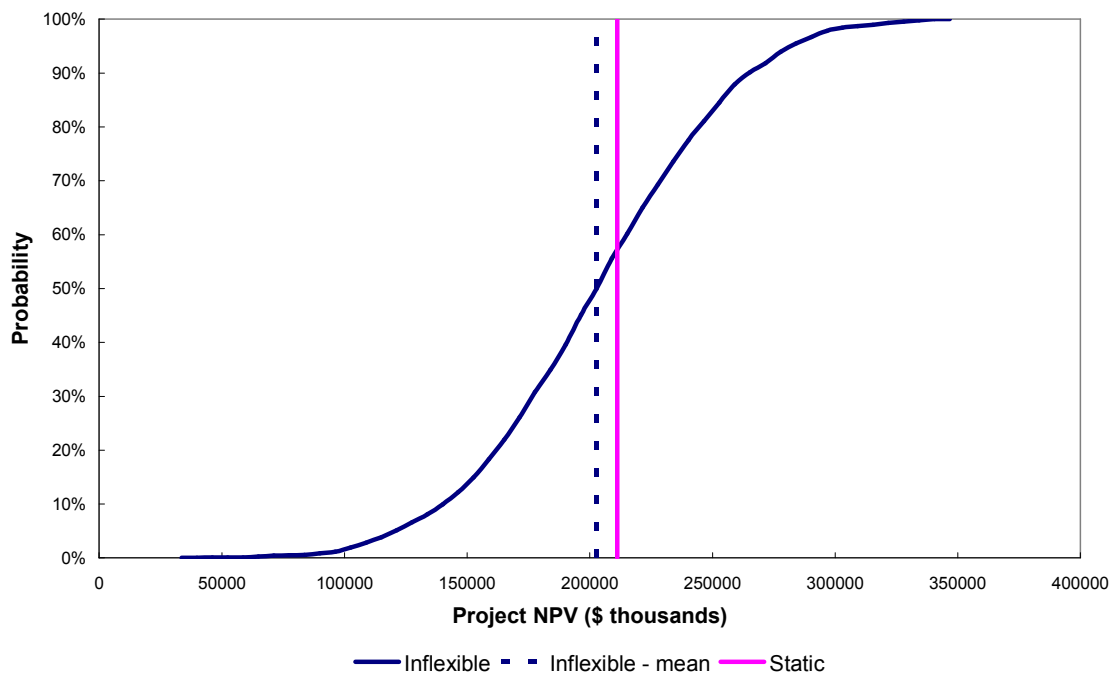
Two thousand Monte Carlo simulations that incorporate two kinds of uncertainty generate the analysis results with the maximum project NPV of \$340.45 million not including land cost and the minimum project NPV of \$33.62 million. The average project NPV is \$202.58 million. This result obviously shows that the project value varies according to market conditions and provides better understanding of how much the real value of the project might be. The possibility that the value might be less than the static NPV is close to 50%. If developers executed this project under the fixed assumptions, about half of them would earn losses from the project. From this point of view, it is

important for developers to be careful or conservative about making any assumptions related to the market.

**Table 4.9 Summary of Project NPV - Inflexible Model**

Maximum project NPV	\$340.45 million
Minimum project NPV	\$33.62 million
Mean	\$202.58 million

**Figure 4.6 Cumulative Distribution Function: Project VARG - Inflexible**



#### **4.4. Flexible Model – Property level**

In the flexible case, one of real options will be applied to the decision making process. Phasing of the development seems to be an realistic option (at the time of original program design) as there are two office towers in the project. Under the static and inflexible cases, the whole project is developed at the same time. If the project takes a hit from negative market conditions, there is no way to avoid it. The buildings should stand with large vacancy lowering the value of the property. In flexible case now to be examined, the project will be divided into two phases with one building in each phase. Only in a favorable market, the second building will be built to take advantage of the strong demand for office space.

At first, the building one is constructed as the initial plan. Then, the decision to start the construction of the second building will be made according to varying market conditions. There are two sources of flexibilities in the decision rules: lease-up rate and rental rate. The decision rules will be the combination of those two factors. For example, if the lease-up rate of the first building reaches 90% and the rental rate is not less than the expected level by the static model, it will trigger building the second office tower. Otherwise, we might still trigger the second building even with less lease-up of the first if the rental rates have grown enough above the baseline expectation. The specific decision rules are shown in Table 4.10. If market conditions do not meet the decision rules requirements until ten years after the building one is completed, the project is abandoned and the land is sold for the net value which the successful project value could have been.

**Table 4.10 Decision rule to trigger building the second office tower**

		Lease-up rate of the first building			
		Below 50%	70% to 50%	90% to 70%	More than 90%
Difference	More than 10%	No	Yes	Yes	Yes
from the	10% to 5%	No	Yes	Yes	Yes
expected	5% to 0%	No	No	No	Yes
rental rate	0% to -5%	No	No	No	No
by the static	-5% to -10%	No	No	No	No
model	Below -10%	No	No	No	No

Table 4.11 shows a case of decision making process given the condition of Figure 3.x and Table 3.x. Figure 3.x represents lease-up scenario and Table 3.x shows the rental rate. In the first year, 2012, the lease up rate turns out to be 74.50%, which does not meet the requirement of 90%. Therefore, the decision is postponed until next year since we also do not have at least 5% greater-than-expected rental growth. In 2013, the lease-up rate goes up to 91.57% satisfying the requirement. In addition, the rent is realized at \$48.85 psf, which is 1.69% more than the expected rent by the static model. Both conditions meet the decision rules requirement and, therefore trigger the construction of the second building.

**Table 4.11 Case of Applying Decision Rules**

		2012	2013	2014	2015	2016
Lease-up	More than 90%			Yes	Yes	Yes
	90% to 70%		Yes			
	70% to 50%	Yes				
	Below 50%					
Difference	More than 10%					
	10% to 5%					
	5% to zero	Yes			Yes	
	Zero to -5%		Yes	Yes		Yes
	Below -5%					
Decision					Start	

As in the inflexible model, two thousand Monte Carlo simulations are executed for the flexible model analysis. Table 4.12 shows the analysis result with the maximum project NPV of \$377.77 million and minimum project NPV of \$59.81 million. The average project NPV of two thousand simulations is \$210.29 million.

**Table 4.12 Summary of Project NPV – Flexible Model**

Maximum project NPV	\$377.77 million
Minimum project NPV	\$59.81 million
Mean	\$210.29 million

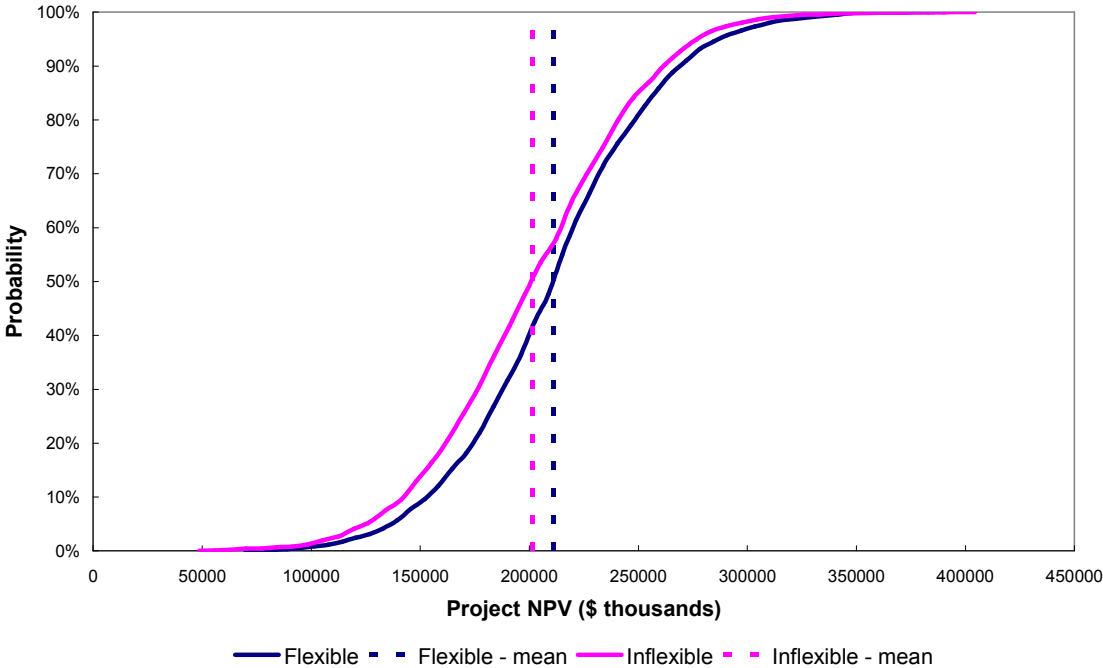
As a whole, the flexible model works better than the inflexible model. As shown in Table 4.13, across all categories: maximum, minimum, and mean project NPV, the flexible model performs best. The flexible model dominates the inflexible one over the all NPV range as presented in Figure 4.7. This means that the flexible model

relatively speaking avoids possible downturns of the market and is able to take advantage of the favorable market condition by making a decision to build the second building.

**Table 4.13 Comparison across static, inflexible, and flexible models**

	Static	Inflexible	Flexible	Best Case
Maximum	\$211.23	\$340.45	\$377.77	<b>Flexible</b>
Minimum	\$211.23	\$33.62	\$59.81	<b>Flexible</b>
Mean	\$211.23	\$202.58	\$210.29	<b>Flexible</b>

**Figure 4.7 Cumulative Distribution Function: Project VARG - Flexible**



#### 4.5. Flexible Model – Entity level

It was clearly found out that the flexible model produces better values at the property level. It is also worth looking at whether the flexible model adds value to the entity level. In order to analyze the project at the entity level, the information on the capital structure as well as the deal structure is needed. Those information is summarized in Table 4.14. It was impossible to secure all the real numbers for the project. Only the permanent loan amount and the share of the preferred equity are the real cases of the project. There are several participants in the preferred equity entity. However, it is not intended to go into the details for this analysis. This analysis intends to whether real options are valuable to equity investors, i.e. the subordinated equity in this case.

The simple deal structure is that the preferred equity gets 9.0% of the preferred return and that once it reaches that hurdle rate, the split goes 1.0% for the preferred equity and 99.0% for the subordinated. Considering 5.0% of preferred equity share, 1.0% of split for the preferred does not seem too low.

**Table 4.14 Capital Structure of the Parc1 project<sup>26</sup>**

Permanent loan	87.0%
Permanent loan interest	7.0%
Preferred equity	5.0%
Preferred return	8.0%
Residual split	1.0%

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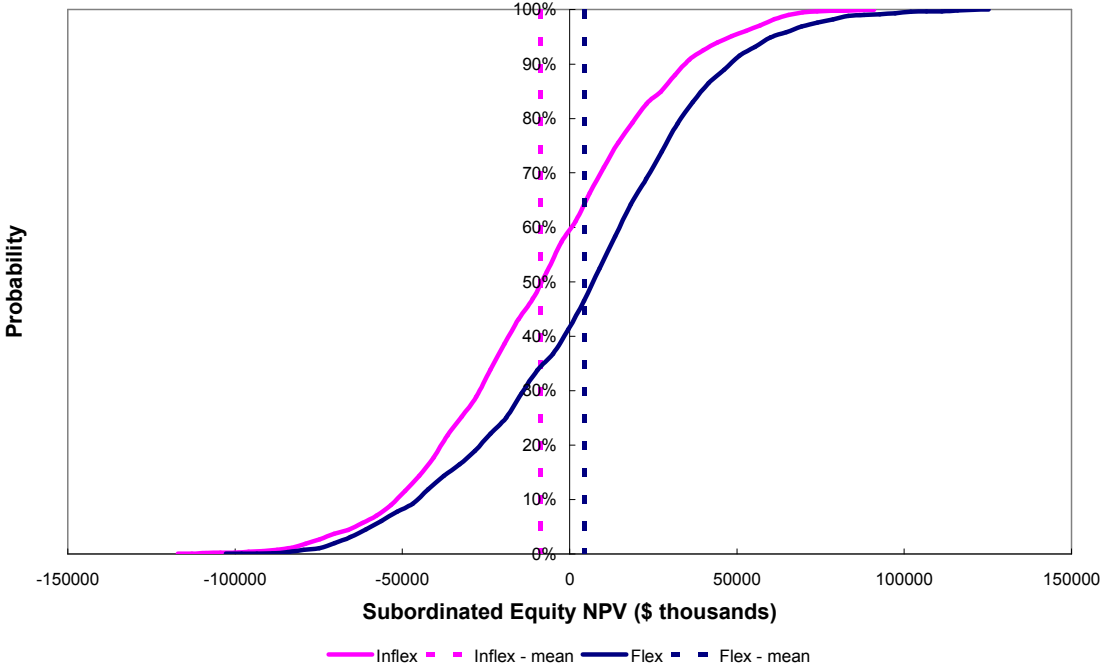
<sup>26</sup> Only the amount of permanent loan and the share of preferred equity reflect the real case of the project. Other information was not able to be secured and assumed appropriately base on the market rate.

For this analysis, the equity NPV will be estimated including the land cost that was valued under the static model. The land cost by the static model was \$211.23 million. Given this, the equity IRR for the whole project period of both the development and stabilized phase is 10.57%. This will be the OCC of the subordinated equity for analyses of the flexible and inflexible model. Using this OCC, the equity NPV will be calculated for the comparison. Two thousand Monte Carlo simulations will also be conducted to see the distribution of the NPVs. Table 4.15 shows the summary of the analysis. The flexible model performs better in all categories. In addition, Figure 4.8 shows that the flexible model dominates the inflexible model in a negative condition. These analysis results strengthen the fact that real options is an effective way to deal with a negative market condition.

**Table 4.15 Entity level NPV Comparison between Inflexible and Flexible model**

	Inflexible	Flexible	Which is better?
Maximum	\$90.90	\$125.23	<b>Flexible</b>
Minimum	-\$117.10	-\$102.73	<b>Flexible</b>
Mean	-\$8.85	\$4.31	<b>Flexible</b>
Std. Dev.	\$33.73	\$35.99	<b>Flexible</b>

Figure 4.8 Cumulative distribution function: Equity VARG - Flexible



In addition to the equity NPV analysis, the IRR split analysis for each entity for the whole period will be shown. The typical split pattern is well represented in Table 4.16 that the return on each entity gets enhanced from the project level to the subordinated equity level due to the deal structure.

Table 4.16 IRR Split Analysis for Each Entity

	Inflexible			Flexible		
	Project	Preferred	Sub.	Project	Preferred	Sub.
Maximum	9.53%	10.48%	13.07%	10.10%	10.78%	13.97%
Minimum	6.85%	9.03%	6.46%	7.16%	9.01%	7.23%
Mean	8.28%	9.76%	10.26%	8.62%	9.84%	10.66%
Std. Dev.	0.43%	0.24%	1.06%	0.45%	0.29%	1.079%

## Chapter 5 Conclusion

The purpose of this thesis is to verify that recognizing flexibility in a development project is an effective way to deal with market uncertainty and that it helps find out forgotten value. The Parc1 project was adopted here as a case study and flexibility in lease-up rate and rent rate was applied to the market where the Parc1 is located. For the analysis, market conditions were randomly generated as it were a general market rather than the YBD in Seoul. The analysis result shows clearly that the flexible model performs better than the inflexible one at both project and entity level. This means that recognizing the flexibility helps realize the hidden value in a development project.

This thesis also shows the simplicity and transparency of Engineering Method. Graphical charts that show the distribution of possible outcomes help decision-maker to understand and compare the performances of each model.

However, this thesis leave something more to be examined. The first building could even be postponed depending on market conditions, although it was determined to be built however the market might be. Converting types of the project is another possible source of flexibility for this analysis. Taking into account all these issues might generate different results. It might be a valuable try to make. However, the fact that real options were proven to be an effective way to avoid negative conditions and recognize value should be highly regarded.

## Exhibit A. CPI Index

Date	Seoul	Date	Seoul
2000 1Q	83.236	2004 2Q	97.038
2000 2Q	83.18	2004 3Q	98.184
2000 3Q	84.186	2004 4Q	98.296
2000 4Q	84.744	2005 1Q	99.5
2001 1Q	86.253	2005 2Q	99.8
2001 2Q	87.455	2005 3Q	100.3
2001 3Q	88.041	2005 4Q	100.4
2001 4Q	88.153	2006 1Q	101.3
2002 1Q	89.103	2006 2Q	101.9
2002 2Q	90.36	2006 3Q	102.6
2002 3Q	90.696	2006 4Q	102.5
2002 4Q	91.283	2007 1Q	103.4
2003 1Q	92.763	2007 2Q	104.6
2003 2Q	93.657	2007 3Q	105.2
2003 3Q	93.937	2007 4Q	105.9
2003 4Q	94.859	2008 1Q	107.1
2004 1Q	96.312		

*Source: National Statistical Office, 2008*

## Exhibit B. T-bond interest rate (APR)

Date(yyyy/mm)	1-yr	3-yr	5-yr	10-yr
2003. 01	4.79	4.96	5.15	5.43
2003. 02	4.63	4.73	4.89	5.15
2003. 03	4.72	4.78	4.94	5.2
2003. 04	4.6	4.6	4.77	5.03
2003. 05	4.3	4.27	4.41	4.68
2003. 06	4.28	4.07	4.19	4.46
2003. 07	4.27	4.37	4.63	4.95
2003. 08	4.15	4.62	4.93	5.26
2003. 09	4.07	4.25	4.46	4.77
2003. 10	4.11	4.28	4.53	4.87
2003. 11	4.47	4.77	5.08	5.35
2003. 12	4.67	4.87	5.13	5.43
2004. 01	4.6	4.88	5.16	5.42
2004. 02	4.42	4.83	5.13	5.43
2004. 03	4.25	4.58	4.88	5.26
2004. 04	4.13	4.54	4.88	5.25
2004. 05	4.07	4.39	4.75	5.16
2004. 06	4.12	4.28	4.58	5.01
2004. 07	4.06	4.19	4.47	4.88
2004. 08	3.73	3.82	4.01	4.33
2004. 09	3.5	3.59	3.75	4.14
2004. 10	3.48	3.54	3.67	4.05
2004. 11	3.34	3.42	3.53	3.96
2004. 12	3.28	3.28	3.39	3.85
2005. 01	3.48	3.65	3.89	4.42
2005. 02	3.48	4.19	4.47	4.88
2005. 03	3.82	4.04	4.29	4.77
2005. 04	3.71	3.86	4.11	4.69
2005. 05	3.6	3.71	3.89	4.42

**Exhibit B. T-bond interest rate (APR) (continued)**

Date(yyyy/mm)	1-yr	3-yr	5-yr	10-yr
2005. 06	3.66	3.79	3.97	4.46
2005. 07	3.77	4.12	4.39	4.89
2005. 08	3.88	4.33	4.67	5.08
2005. 09	4.19	4.52	4.81	5.15
2005. 10	4.44	4.81	5.06	5.36
2005. 11	4.57	5.1	5.39	5.68
2005. 12	4.67	5.06	5.33	5.6
2006. 01	4.62	5.02	5.29	5.58
2006. 02	4.57	4.87	5.03	5.28
2006. 03	4.57	4.93	5.13	5.42
2006. 04	4.61	4.95	5.16	5.45
2006. 05	4.59	4.78	4.93	5.2
2006. 06	4.7	4.89	5.03	5.25
2006. 07	4.82	4.89	5	5.16
2006. 08	4.76	4.77	4.83	4.94
2006. 09	4.68	4.69	4.76	4.89
2006. 10	4.64	4.62	4.67	4.79
2006. 11	4.7	4.72	4.79	4.91
2006. 12	4.85	4.82	4.88	4.95
2007. 01	4.98	4.97	5	5.04
2007. 02	4.96	4.91	4.94	5.01
2007. 03	4.89	4.79	4.82	4.94
2007. 04	4.97	4.94	4.96	5.07
2007. 05	5.11	5.1	5.13	5.22
2007. 06	5.15	5.24	5.35	5.48
2007. 07	5.29	5.35	5.43	5.52
2007. 08	5.3	5.28	5.33	5.42
2007. 09	5.39	5.39	5.44	5.52
2007. 10	5.34	5.42	5.49	5.56

**Exhibit B. T-bond interest rate (APR) (continued)**

<b>Date(yyyy/mm)</b>	<b>1-yr</b>	<b>3-yr</b>	<b>5-yr</b>	<b>10-yr</b>
2007. 12	5.6	5.89	5.9	5.82
2008. 01	5.47	5.44	5.51	5.56
2008. 02	5	5.06	5.14	5.28
2008. 03	5.05	5.15	5.2	5.36
2008. 04	5.06	4.98	5.02	5.17
2008. 05	5.07	5.28	5.36	5.5

*Source: National Statistical Office, 2008*

### Exhibit C. Office Rental Rate

Period	CBD	GBD	YBD
03 1Q	63,144	56,868	39,339
03 2Q	63,162	56,874	39,638
03 3Q	63,396	56,886	39,701
03 4Q	63,483	56,955	40,037
04 1Q	70,414	60,031	43,964
04 2Q	70,525	60,364	44,008
04 3Q	69,745	59,113	43,524
04 4Q	70,052	59,802	44,074
05 1Q	70,436	60,415	44,243
05 2Q	70,616	60,615	44,199
05 3Q	71,219	60,966	44,181
05 4Q	71,223	62,634	44,486
06 1Q	72,468	63,693	44,977
06 2Q	72,592	64,683	47,927
06 3Q	73,085	64,998	48,096
06 4Q	73,199	65,199	48,179
07 1Q	73,880	66,182	49,148
07 2Q	73,976	66,681	49,719
07 3Q	74,128	67,001	49,805
07 4Q	74,445	68,107	51,357
08 1Q	75,337	69,485	53,025

\* KRW per pyung (KRW 1 = \$1, 1 pyung = 0.2810 sq ft)

Source: [www.samsnet.co.kr](http://www.samsnet.co.kr)

**Exhibit D. Project Drawings**



**Exhibit E. Project Drawings - Office**



**Exhibit F. Project Drawings - Retail**



**Exhibit G. Project Drawings - Hotel**



## Exhibit H. Project Pro Forma – Static Model

	Construction 2008	2009	2010	2011	Stabilized 2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Hard cost	234,127	234,127	234,127	234,127											
Soft cost	107,725	107,725	107,725	107,725											
<b>TDC</b>	<b>341,852</b>	<b>341,852</b>	<b>341,852</b>	<b>341,852</b>	0	0	0	0	0	0	0	0	0	0	
<b>PGI</b>					199,617	205,606	211,774	218,127	224,671	231,411	238,354	245,504	252,869	260,456	268,269
turnover vacancy							-10,589			-11,571			-12,643		
less vacancy					-105,797	-6,168	-6,353	-6,544	-6,740	-6,942	-7,151	-7,365	-7,586	-7,814	-8,048
<b>EGI</b>			0	0	93,820	199,438	194,832	211,584	217,931	212,898	231,203	238,139	232,640	252,642	260,221
Operating Expenses					-42,219	-89,747	-87,675	-95,213	-98,069	-95,804	-104,041	-107,163	-104,688	-113,689	-117,099
<b>NOI</b>					51,601	109,691	107,158	116,371	119,862	117,094	127,162	130,977	127,952	138,953	143,122
TI							-8,561			-8,561			-8,561		
Leasing comission			-7,818		-8,801	0	-882	0	0	-964	0	0	-1,054	0	
Capital reserve					-258	-548	-536	-582	-599	-585	-636	-655	-640	-695	-716
<b>PBTCF (operations)</b>					42,542	109,142	97,179	115,789	119,263	106,984	126,526	130,322	117,698	138,258	142,406
Resale value@	6.00%														2,385,360
Resale cost	2.0%														-47,707
<b>PBTCF (reversion)</b>															2,337,653
<b>PBTCF</b>	<b>-341,852</b>	<b>-341,852</b>	<b>-341,852</b>	<b>-341,852</b>	42,542	109,142	97,179	115,789	119,263	106,984	126,526	130,322	117,698	138,258	2,475,911
<b>Canonical Procedure</b>															
Time T PV stabilized asset (2012)					1,972,659										
Time T FV construction cost (2012)					-1,473,426										
Time T NPV: V(T)-P(T)					499,233										
<b>OCC for dev. Phase</b>					<b>23.99%</b>										
<b>NPV Devlpt as of Time 0 (2008)</b>					<b>211,229</b>										

## Exhibit I. Project Pro Forma – Flexible Model (building one)

	Construction 2008	2009	2010	2011	Stabilized 2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
<b>First building</b>															
Hard cost	134,931	134,931	134,931	134,931											
Soft cost	60,943	60,943	60,943	60,943											
<b>TDC</b>	195,874	195,874	195,874	195,874	0	0	0	0	0	0	0	0	0	0	0
<b>PGI</b>					115,732	115,405	121,392	125,366	124,621	131,666	137,573	140,858	135,887	147,719	147,870
turnover vacancy							-2,428			-2,633			-2,718		
less vacancy					-58,979	-18,159	-3,642	-3,761	-3,739	-3,950	-4,127	-4,226	-4,077	-4,432	-4,436
<b>EGI</b>			0	0	56,753	97,246	115,322	121,605	120,882	125,082	133,446	136,632	129,092	143,288	143,434
Operating Expenses					-25,539	-43,761	-51,895	-54,722	-54,397	-56,287	-60,051	-61,484	-58,092	-64,480	-64,545
<b>NOI</b>					31,214	53,485	63,427	66,883	66,485	68,795	73,395	75,148	71,001	78,808	78,889
TI							-4,911			-4,911			-4,911		
Leasing comission				-4,729	-3,374	0	-202	0	0	-219	0	0	-226	0	0
Capital reserve					-156	-267	-317	-334	-332	-344	-367	-376	-355	-394	-394
<b>PBTCF (operations)</b>					27,684	53,218	57,997	66,548	66,153	63,321	73,028	74,772	65,509	78,414	78,494
Resale value@	6.00%														1,314,814
Resale cost	2.00%														-26,296
<b>PBTCF (reversion)</b>															1,288,518
<b>PBTCF</b>	-195,874	-195,874	-195,874	-195,874	27,684	53,218	57,997	66,548	66,153	63,321	73,028	74,772	65,509	1,366,932	

## Exhibit J. Project Pro Forma – Flexible Model (building two)

	Construction 2008	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
<b>Second building</b>			<b>1</b>												
<b>Decision to build</b>		<b>start</b>													
Hard cost	0	223,293	229,992	0	0	0	0	0	0	0					
Soft cost	0	105,307	108,466	0	0	0	0	0	0	0					
<b>TDC</b>	0	328,600	338,458	0	0	0	0	0	0	0					
<b>PGI</b>	0	0	0	97,868	102,260	104,701	101,006	109,802	109,914	116,375	115,629	119,602	124,507	130,839	
turnover vacancy	0			-1,957			-2,020			-2,327			-2,490		
less vacancy	0	0	0	-2,936	-3,068	-3,141	-3,030	-3,294	-3,297	-3,491	-3,469	-3,588	-3,735	-3,925	
<b>EGI</b>	0	0	0	92,975	99,192	101,560	95,956	106,507	106,616	110,556	112,160	116,014	118,281	126,914	
Operating Expenses	0	0	0	-41,839	-44,636	-45,702	-43,180	-47,928	-47,977	-49,750	-50,472	-52,206	-53,227	-57,111	
<b>NOI</b>	0	0	0	51,136	54,556	55,858	52,776	58,579	58,639	60,806	61,688	63,808	65,055	69,802	
TI	0			-3,650			-3,650			-3,650			-3,650		
Leasing comission	0	0	0	-163	0	0	-168	0	0	-194	0	0	-208	0	
Capital reserve	0	0	0	-256	-273	-279	-264	-293	-293	-304	-308	-319	-325	-349	
<b>PBTCF (operations)</b>	0	0	0	47,067	54,283	55,579	48,693	58,286	58,346	56,658	61,380	63,489	60,872	69,453	
Resale value@	6.00%										0	0	0	1,163,375	0
Resale cost	2.00%										0	0	0	-23,267	0
<b>PBTCF (reversion)</b>											0	0	0	1,140,107	0
PBTCF (abandoning)															
<b>PBTCF</b>		0	0	0	47,067	54,283	55,579	48,693	58,286	58,346	56,658	61,380	63,489	1,200,979	0

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