Valuing Flexibilities in Large-Scale Real Estate Development Projects

by

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Abstract

This thesis aims to develop a set of strategic tools for real estate development projects. The conventional tools such as the Discounted Cash Flow (DCF) method fail to incorporate dynamics of real estate development processes. As a result, their application to real world situation is quite limited. Two methods are introduced to deal with this inadequacy of the DCF method. Decision Tree Analysis (DTA) employs a management science approach to analyze flexibilities and corresponding strategies from management decision making perspective. Real Options Analysis (ROA) aims to apply theories of valuing financial derivatives to real assets and it allows investors to quantitatively analyze flexibilities. Each technique has advantages and shortcomings and should only be used for appropriate situations. DTA is suited for analyses of project specific risks that are not directly related to the overall market. ROA is a superior tool when risks are originated from the uncertainties of markets. Applying both tools in practice requires rather simplified assumptions, and it is crucial to understand them to make the analyses meaningful.

The thesis finds that incorporating flexibilities in decision making into an analysis is especially important for large-scale and multi-phase projects. The DCF method treats the later phase projects as if they are fully committed at the present time. This assumption of full commitment is rarely the case in the real world practice, and as a result, the DCF method systematically undervalues future phases in multi-phase projects. The case study of New Songdo City reveals that the value of flexibility is a critical factor for the analyses of large scale projects, especially when there is a lot of market uncertainties involved. Based on the conventional DCF method, New Songdo City has a hugely negative NPV and should not be pursued. However, the ROA and the DTA approaches show that it has a potential for creating enormous value by incorporating flexibilities of the project.

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Ch. 1. Introduction

> *We do ten-year pro-forma cash flow analysis but we don't really believe in them. Who knows what's going to happen down on the road?*[1]
>
> *Nobody really uses IRR or NPV within the development industry. It's just for institutional equity investors … [Therefore,] non-institutional investors are preferable for us. They are mostly interested in cash on cash returns.*[2]

Three methods mentioned above – Discounted Cash Flow (DCF), Net Present Value (NPV) and Internal Rate of Return (IRR) – have been widely accepted tools for any investment analysis. Yet, a number of anecdotal evidences suggest that real estate developers find these tools insufficient for the analyses of their development projects. The entrepreneurial nature of the development industry might have contributed to this lack of rigorous analyses: So called developers' gut-feelings sometimes become more important factors to the decision making process. However, it has been proven that DCF, NPV and IRR with a hurdle rate are fundamentally sound tools, and even within the real estate industry, these are standard methods for valuing income-generating institutional properties. In this sense, the relatively limited use of DCF based analyses in the development industry does not seem to be entirely due to developers' naïveté. The true reason for their limited use might be their failure to capture a part of everyday reality involved with typical development projects.

I believe that the inadequacy of conventional DCF, NPV and IRR for a development project analysis originates from their very static nature of underlying assumptions. On the contrary, the

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[1] From the presentation by the CEO of a leading New York development firm at MIT.
[2] From the class discussion with a guest speaker for the Design for Urban Development course at MIT.

essence of most development projects is their dynamic processes. Conventional methods give a single point estimates based on all the information available, and thus, it inherently implies that all the investment decisions are made as of now (time 0). Since most investment decisions for development projects are made in sequence over some time period, the conventional methods fail to incorporate flexibility of future decisions. This flexibility is all the more critical for large-scale urban mixed-use projects with multiple stages over time, and a static DCF based analysis would grossly misrepresent merits of such large scale projects.

The goal of the thesis is to evaluate and apply methods for incorporating flexibility into the analysis of large-scale real estate development projects. The first half of the thesis attempts to layout theoretical framework for evaluating complex development projects, first using NPV approach and later extending NPV analysis with Decision Tree Analysis and Real Options. The second half of the thesis is a case study applying the methods developed in the earlier chapter to the "New Songdo City (NSC)" project in Incheon, Korea. The NSC project is a highly complex new city development project that involves 100,000,000 square feet of building space and 12 year project schedule with 6 different phases. The rather simplified application of Decision Tree and Real Options analysis demonstrate the reason why the concept of flexibility and option is critical for such a large scale project with a high level of uncertainties, and at the same time, reveals some difficulties in applying options model to real world practices.

Ch. 2. Literature Review

The thesis deals with two methodologies – Decision Tree Analysis and Real Options Analysis – as tools for valuing flexibilities inherent in large-scale real estate development projects. Real estate development projects, unlike buy-sell decisions made for investing in pre-existing assets, require series of decision making over time, and for each future decision there are numbers of alternatives available. Therefore, it is important to identify what alternative courses are available and to plan ahead the best course of action given the flexibility. Decision Tree Analysis is a useful tool for laying out alternative courses of actions and their corresponding future payoffs. The use of Decision Tree was first advocated by J. Margee (1964) as a tool for corporate capital planning. Brealey and Myers (2003) introduced Decision Tree to illustrate how managerial flexibilities can create value for a capital project. They went one step further to propose a valuation technique under the Decision Tree structure. At the same time, they identified difficulties of determining a proper discount rate and probabilities. De Neufville (1990) proposed to use Decision Tree for finding optimal strategies for complex engineering projects. The application of Decision Tree Analysis to real estate projects has been limited, and there has been little research done for this purpose. However, the method is very relevant for real estate projects as demonstrated in the chapter 4, and it is safe to assume that it has been implicitly used for real estate decision makings.

Real Options, on the other hand, has been studied frequently and rigorously by academics, and there have been a number of researches done for its application to the real estate industry.

Recently, many academics and practitioners attempted to apply options valuation techniques to real world projects and investments. Arman and Kulatilaka (1999); Copeland and Antikarov (2001); and Mun (2002) promoted the use of the binomial tree approach in conjunction with Decision Tree to identify and value Real Options on real world projects in a practical manner. Dixit and Pindyck (1994) followed more theoretical approach by developing a series of mathematical models for the purpose of applying them in the real world.

Real Options Analysis is useful for the analysis of real estate projects due to the fact that various options are embedded in them. Titman (1985) first identified a vacant land as an option to buy a stabilized property at an exercise price equal to its construction costs. Through the application of the options theory, he explained the relationship between building activity and uncertainty. He argued that increased uncertainty led to a decrease in building activity in the current period. Williams (1991) constructed an options model of real estate development to analyze the optimal timing and the scale of a development. Capozza and Sick (1991) explained the difference in value between leased and fee-simple[3] property with a redevelopment options model. Based on their model, the discounts on leased properties are larger with high conversion efficiency, low interest rate, high growth rate or high uncertainty.

Flexibility in land use choice has been analyzed using the options valuation theory. Capozza and Helsley (1990) developed a land price model based on uncertain household income and land rent. This model predicted that the effect of uncertainty would delay the conversion of agricultural land to urban land; reduce expected city size; and impart an option value to agricultural land. Geltner et al (1996) examined the option that is present when a site for development has more than one allowable uses. Based on the authors' model that values the options to choose to construct one of two uses, they found that this option could add as much as 40% to the land value. This option to

[3] Fee-simple properties were considered properties with perpetual lease.

choose adds the most value when the cost of land is low relative to construction costs. The model also identifies that the conditions for optimal development of the land become more difficult to achieve, and furthermore, development would never occur when the two land use choices have equal value. Childs et al (1996) examined the options related to the mixed-use projects. They came up with a model that incorporates an option to mix two uses on a site and also a redevelopment option. Their model suggests that returns become less certain and uses less correlated as the option to redevelop increases in value. The model also predicts that mixed-use developments will be more common in markets that are more supply sensitive or when the project is large relative to the existing supply.

There have been many attempts made to explain aggregate level real estate market behaviors with Real Options framework. Williams (1993) pointed out the differences between financial options and Real Options in real estate projects, and modeled developers' behaviors. According to him, options on real estate differ from financial options in that each real asset produces goods or services with a finite demand elasticity; all options to develop cannot be exercised simultaneously due to the limited capacity of developers; and the supply of undeveloped assets is limited. Based on these assumptions, the model predicted that development is optimal at all values above a critical value. Thus, below this optimal value, no developer builds, and above the optimal value, all developers build at the maximum feasible rate. Grenadier (1955) studied overbuilding tendencies in real estate markets with an options model. He showed increase in construction time, cost of changing occupancy rates, or demand volatility would lead to overbuilding. Grenadier (1996) later went once step further to explain the overbuilding tendency by incorporating the game theory approach. He argued that the simultaneous exercises and development cascades might be resulted from the rational fear of preemption rather than irrational overbuilding. Li (1999) developed a model to explain land development in emerging markets where newly developed properties account for a substantial portion of the aggregate supply of such properties.

By incorporating demand elasticity, the model suggested that the value of land and developed properties in the emerging markets were much lower than the corresponding values in the markets with perfect demand elasticity. It also illustrated that the optimal intensity and the land value were most sensitive to market demand conditions when interest rates and construction costs were lowest.

There also has been some empirical research conducted to find evidences of real options pricing in real estate and other markets. Quigg (1993) examined land transaction data in Seattle and compared actual transaction prices with implied residual values of land. She found out that market land prices showed average 6% premium of optimal development over the residual value. This finding demonstrated that market participants indeed value options of waiting for optimal development. Holland, Ott and Riddiough (1999) proposed a model to test neoclassical versus option-based model of investment against US commercial real estate data. They found that the evidence favors the option-based model over the neoclassical model with respect to total uncertainty and thus irreversibility and delay are important aspects to investment decision-making. Another interesting result from their test was that short-run supply was inelastic with respect to changes in asset price but highly elastic to changes in price uncertainty. They suggested, in real asset markets, information regarding changes in price volatility might be more useful than information on changes in price levels.

Several empirical researches were also conducted for non-US markets. Yamaguchi et al (2000) applied a real options model similar to the one developed by Quigg to Tokyo real estate market data. They found out that the options premium for vacant land in Tokyo were average 18% over residual value. This was much higher than Quigg's estimation of 6% premium of the Seattle market, and it might be due to the high level of speculative activities in Tokyo. Bulan, Mayer and Somerville (2002) used data on condominium projects in Vancouver, Canada to empirically estimate the value of waiting for optimal development. Their study suggested that builders delayed development during times of greater uncertainty in real estate returns and when the exposure to market risk was higher. They also showed that competition significantly reduced the sensitivity of option exercise to volatility. Therefore, competitive firms were not able to capture the full benefits to waiting that a monopolist had. Based on their case studies on residential development projects, Yao and Pretorius (2004) argued that the Hong Kong government was undervaluing land that it provided to developers because the government used the conventional DCF valuation method. They suggested the Hong Kong government use the Real Options approach to increase revenue and alleviate its fiscal constraints.

The literature on developing Real Options model for real estate markets has been increased dramatically in recent years. The validity of options model in real estate was also tested and confirmed through empirical testing by academics, which some of them are mentioned above. However, the focus has been given to developing mathematical and statistical models, and there has been little attempt made to developing a Real Options method that could be easily applied by average practitioners. The concepts and procedures involved with the most Real Options models are beyond the scope of average practitioners' knowledge of the subject, and therefore, the application of Real Options Analysis to real estate development projects has been limited. The empirical studies, however, shows that the development industry implicitly takes advantage of the options inherent to development projects. Thus, It is crucial to strategically use options in real estate developments to become a successful developer. In this context, this thesis aims to implement practical methods to incorporate flexibilities and options inherent during real estate development processes, using Decision Tree and Real Options Analysis.

Ch. 3. Discounted Cash Flow based Analyses of Real Estate Development Projects

3.1. Fundamentals of Net Present Value and Internal Rate of Return Methods

Discounted Cash Flow (DCF) methods have traditionally been a fundamental principle in business decisions where money is invested now for yielding future returns. The basic principle of any DCF analysis is that expected future returns need to be "discounted" with an appropriate risk adjusted discount rate. Two of the most common DCF methods are Net Present Value (NPV) and Internal Rate of Return (IRR) (Hammond III, 1975).

The NPV analysis basically asks whether a project is worth more than its costs. Intuitively, if benefits of a project exceeds or is at least equal to its costs, the project is worth undertaking. The essence of the NPV analysis is estimating what benefits and costs are worth for investors. The conventional NPV analysis applies a discount rate, determined by the concept of opportunity cost of capital, to value costs and benefits in present terms (Brealey and Myers, 2003). For a simple investment that requires the initial cash investment of C_0 with T year life, the NPV for the project can be calculated as follows:

$$NPV = C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$$

Here, r is the opportunity cost of capital for the given project, which should reflect risks of future cash flows. Based on this framework, the following investment decision rules are applied for a NPV analysis (Geltner and Miller, 2001):

- *Maximize the NPV across all mutually exclusive alternatives.*[4]
- *Never choose an alternative that has a negative NPV.*

The IRR analysis is another version of applying the concept of NPV. The IRR is defined as the rate of return that makes the NPV of a project equal to zero. By solving the following equation, we can find IRR for a project that lasts T years and requires the initial investment of C_0 (Brealey and Myers):

$$NPV = C_0 + \frac{C_1}{1+IRR} + \frac{C_2}{(1+IRR)^2} + \ldots + \frac{C_T}{(1+IRR)^T} = 0$$

The actual calculation of IRR would involve trial and error. However, we can easily get the solution using IRR function in any common spreadsheet software. The IRR in itself is not as useful as the NPV analysis since it does not provide any information regarding the risk of the project. The IRR analysis only becomes useful when it is used in relation to the opportunity cost of capital – the required return of the project. Comparing the IRR with the required return is similar to the NPV analysis. That is, when the IRR is higher than the required return, the project would have a positive NPV. Following this method, the decision rule for the IRR analysis is (Geltner and Miller):

- *Maximize the difference between the project's expected IRR and the required return.*
- *Never do a project with an expected IRR less than the required return.*

[4] In principle, this rule should factor in all alternatives including flexibilities of delaying, abandoning, etc. Therefore, options value should be considered for NPV maximization (similar to the concept of eNPV that will be introduced in the chapter 4). However, in practice, NPV is only calculated using the static DCF procedure, and thus leaves out any potential value of flexibility. In this context, the thesis does not attempt to replace the NPV decision rule but rather aims to expand the conventional NPV procedure to incorporate the value of flexibility.

3.2. Application of DCF based analysis to Real Estate Development Projects

As illustrated in the previous chapter, the key element in the development of the NPV and the IRR methodology is the identification of *r*, known as discount rate or opportunity cost of capital. In theory, a discount rate should be same as the rate of return of equivalent investment alternatives in the capital market. Fortunately, the real estate industry has a very active market, and it is possible for investors to estimate a real asset's opportunity cost of capital by observing the market. Although the real estate market is not as efficient as the security markets due to the uniqueness of individual real assets and the infrequent trading, it is possible to find out the fairly reliable opportunity costs for a stabilized building investment. When applied to the investment analysis for a core stabilized asset, the NPV and the IRR have been proven effective.

In contrast to existing properties, the required return for development projects is not easily observable from the market. This might be one reason why the NPV approach is not as popular in the development industry. It is reasonable to assume that development projects are much riskier and thus require higher return. Furthermore, development projects are unique in that they involve multiple distinct phases. For instance, a development process typically involves buying an undeveloped land, permitting, construction, lease up, and stabilization. Each phase in a development process has a distinct level of risk. Therefore, to be consistent with the underlying theory, cash flows from each phase need to be discounted with its own risk adjusted discount rate.

Consider a development project for a land valued at $ 1,900,000. In addition to the land value, there is $ 40,000 of permitting related costs incurred at the time zero. The best use for the site is building an office building, and it is expected to generate an annual net operating income of $ 1,000,000. The lease-up is estimated to take about a year and it would generate $500,000 during the period. The cap rate of 8% and the opportunity cost of 10% are estimated for investing a similar office building that the developer proposed to build. For speculative buildings, the additional 1.5% of premium can be reasonably assumed based on the market analysis. The annual income growth is expected to be 2%. The construction is estimated to cost \$ 8,000,000 over two years with equal amount spent in each year. Figure 3.1 illustrates the annual cash flow of this development project.

In this example, there are two types of future expected cash flows. One is the construction cost cash flow and the other is the future income cash flow. As Brealey and Myers explained in their analysis of the Mark II investment, fixed future cash flows should be discounted with a risk free rate. On the other hand, the discount rate for the future incomes can be obtained from the market, and in this case, the lease-up phase discount rate of 11.5% can be used. Based on this information, the following NPV principle can be used for the development project:

$$NPV(Development) = PV_0(Benefits) - PV_0(Costs)$$

Assuming the building would be stabilized in the year 4, we can calculate the value of the building as of the year 3 with the stabilized discount rate of 10% and the long-term growth rate of 2%:

$$PV_3(Stablized - Office) = \frac{1{,}000{,}000}{0.1 - 0.02} = 12{,}500{,}000$$

Using the lease-up discount rate of 11.5%, the present value of benefits is calculated:

$$PV_0(Benefits) = \frac{500{,}000}{1.115^3} + \frac{12{,}500{,}000}{1.115^3} = 9{,}378{,}000$$

The present value of costs can be calculated in the same manner using the discount rate of 5% and the land cost at the time zero:

$$PV_0(Costs) = 1{,}011{,}000 + \frac{450{,}000}{1.05} + \frac{450{,}000}{1.05^2} = 9{,}378{,}000$$

Since the benefits and the costs are equal, the NPV of this development project is zero. Unless there are other opportunities with a positive NPV, the project is worth undertaking based on the NPV decision rule.

Figure 3.1: Simplified Development Project NPV and IRR Analysis

Cap rate (y)	8.0%				
Growth rate (g)	2.0%				
Spec Premium	1.5%				
Riskfree rate	5.0%				
	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Rental Income	0	0	0	500,000	1,000,000
Stabilized Property Value	0	0	0	12,500,000	
Construction Cost	0	4,500,000	4,500,000		
Land Cost + Fee	1,011,000				
Project Cash Flow	(1,011,000)	(4,500,000)	(4,500,000)	13,000,000	
PV of Benefit	$9,378,000				
PV of Cost	$8,367,000				
Residual Value	$1,011,000				
Market Land Price + Fee	$1,011,000				
NPV	$0				
IRR	16.8%				

The method presented above is a theoretically sound from the NPV perspective. However, it displays several disadvantages. The IRR of the project is 16.8% based on the cash flow projection in the figure 3.1. The IRR supposedly reflect higher risk of speculative development projects and indicates the risk premium of 6.8% over the required return of 10% for the stabilized buildings. However, it is hard to value the 6.8% premium because it is a blended rate of two distinct phases of construction, lease-up and stabilized operation. Therefore, in practice, it can be more helpful to identify the development period return in isolation. Geltner (2002) proposed a method to calculate the development required return based on the equilibrium across the markets related to the development industry. Since we already can reasonably estimate risks of stabilized assets and construction debts, we can calculate risks of development based on the other assets. That is, a development investment is equivalent to having a long position in the stabilized property and a short position in the construction costs at the same time. Assuming markets are efficient, this long and short position must be equal to the development project, and thus the following relationship can be assumed:

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

V_T = Expected value of stabilized property at time T
L_T = Expected balance due on construction loan at time T
$E[r_V]$ = Market required return on investments in a stabilized property
$E[r_D]$ = Market required return on construction loans

Based on this relationship, we can estimate the required return for the development period:

$$E[r_C] = \left[\frac{(V_T - L_T)(1+E[r_V])^T(1+E[r_D])^T}{(1+E[r_D])^T V_T - (1+E[r_V])^T L_T}\right]^{(1/T)} - 1$$

Using the proposed method, the development period return of 48.5% is calculated. This method identifies development risk as a separate risk regime by standardizing the development as a two period process and it can be more easily compared with other projects. Also, the required return here is calculated without knowing the value of the land, and as a result, it gives information as to what price investors should pay for the land for a positive NPV development project. Figure 3.2 illustrates the procedure to get the development return based on the analysis performed in Figure 3.1. This clearly shows that the project is NPV positive when the land can be acquired for less than $1,011,000.

Figure 3.2: Estimation of Two-Period Development Required Return

	Year 0	Year 1	Year 2	Year 3
Value of Stabilized Office at T=3				13,000,000
Value of Const. Cost at T=3				9,686,250
NPV at T=3				3,313,750
Residual Value at T=0	1,011,000			
Two Period Cash Flow	(1,011,000)	0	0	3,313,750
Devel. Period Req. Return	**48.5%**			

The two methods presented above provide a sophisticated analytical framework to analyze development projects based on NPV and DCF. However, the model's usefulness depends on how effectively it can help the real world decision making process. Development projects, unlike typical investments in pre-existing assets or securities, involve sequential cash outflows over time. Accordingly, valuing the cost side of the NPV becomes as important as the benefit side. In other words, in addition to the risks of receiving future incomes, development projects deal with the risks related to the costs, such as construction cost overruns and construction delays. Therefore the question is whether the previously used methods reflect all the risks related to the development stage. From the theoretical perspective, the development stage required return should capture these development risks. When applied in practice, the previous models exhibit a high degree of sensitivity to variations in underlying assumptions.

Figure 3.3: Project NPV and IRR Analysis with 2 year permitting delay

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Rental Income	0	0	0	0	0	520,000
Stabilized Property Value	0	0	0	0	0	13,005,000
Construction Cost	0	0	0	4,682,000	4,682,000	
Land Cost + Fee	1,011,000					
Project Cash Flow	(1,011,000)	0	0	(4,682,000)	(4,682,000)	13,525,000
PV of Benefit	$7,848,000					
PV of Cost	$8,907,000					
NPV	($1,059,000)					
IRR	14.7%					
Development 2-Period Return	**27.8%**					

Figure 3.3 shows changes in NPV and returns when there has been 2 year delay in permitting with otherwise identical cash flow as in Figure 3.1. These kinds of delays and changes are rather norm than exception in most development projects, and thus, it is fair to say the model's usefulness depends on its ability to deal with future changes. The 2 year delay in permitting as illustrated in Figure 3.3 result in 2.1% decrease in the going-in IRR and 20.7% decrease in the development two-period return. Also, as shown in Figure 3.4, 10% decline in the expected asset price would result in 7% decrease in the going-in IRR and 22.7% decrease in the development

return. The higher degree of development projects' sensitivity comes from the fact that they are levered positions on stabilized properties. That is, the upfront purchase of land brings with it the operating leverage, which is project exposure to fixed costs (Brealey and Myers).

Figure 3.4: Project NPV and IRR Analysis with 10% asset price decline

	Year 0	Year 1	Year 2	Year 3	Year 4
Rental Income	0	0	0	450,000	900,000
Stabilized Property Value	0	0	0	11,250,000	
Construction Cost	0	4,500,000	4,500,000		
Land Cost + Fee	1,011,000				
Project Cash Flow	(1,011,000)	(4,500,000)	(4,500,000)	11,700,000	
PV of Benefit	$8,440,000				
PV of Cost	$9,378,000				
NPV	($938,000)				
IRR	9.8%				
Development 2-Period Return	**25.8%**				

Figure 3.5 illustrates sensitivity of the exemple project in Figure 3.1 to the variation of the stabilized asset price. These example cases illustrate that, although the higher required return for development projects might compensate for their higher risks, the NPV and the required return based analyses does not help developers strategically dealing with the risks. To be sure, the NPV analysis is useful for avoiding bad projects and comparing with alternative projects with some standard measure. However, unlike investment decisions for stabilized assets, decisions regarding development projects are typically made over time, as cash outflow occurs over the time of the development. In this regard, for developers in practice, a tool to help them think ahead of future

Figure 3.5: Sensitivity of Development Returns to Change in Asset Prices

% change in Asset Price	Project Level IRR	Development Return (Rc)	NPV
20.0%	29.6%	80.2%	$1,875,000
15.0%	26.5%	73.3%	$1,407,000
10.0%	23.4%	65.9%	$938,000
5.0%	20.1%	57.7%	$469,000
0.0%	16.8%	48.5%	$0
-5.0%	13.3%	38.1%	($469,000)
-10.0%	9.8%	25.8%	($938,000)
-15.0%	6.1%	10.5%	($1,407,000)
-20.0%	2.3%	-11.0%	($1,875,000)

decisions and their impact on the project would be much more meaningful than the NPV analysis based on a decision at the time zero.

For large-scale projects with extended development period and multiple stages, the sensitivity of the NPV and the required return based analyses to underlying assumptions becomes magnified. Consider a mixed use development project with the following characteristics:

- Current market value of the land is $2,700,000. The upfront fee of $300,000 is required for design and permitting. Out of $3,000,000, $1,011,000 is attributable to the office component, and the remainder is attributable to the residential component.
- According to the current zoning regulations, one office building and one residential building can be built on site. The office building can be developed immediately. However, it would take up to 3 years for the residential building to break grounds due to the likely permitting complications.
- The construction of the office building is expected to take 2 years. The total cost is estimated to be $9,000,000, with two equal payments of $4,500,000 each year during the construction.
- The office building is expected to generate an annual income of $1,000,000, when stabilized in the year 4. The lease-up would take about one year with $500,000 generated during the period.
- The construction of the residential building is also expected to take 2 years. The total cost is estimated to be $19,500,000, with two equal payments of $9,750,000 each year during the construction.
- Based on the market research, the cap rates for the office and the residential properties are 8% and 7% respectively. For the appropriate discount rates, the growth rate of 2% and the spec premium of 1.5% will be added to the market cap rates.

Figure 3.6: Simple Mixed-Use Multi-Phase Development Project

Office Cap rate (y)	8.0%							
Residential Cap rate (y)	7.0%							
Long-term Growth rate (g)	2.0%							
Spec Premium	1.5%							
Riskfree rate	5.0%							
	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**
Land Cost + Fee	3,000,000							
Phase 1: Office								
Rental Income	0	0	0	500,000	1,000,000			
Stabilized Property Value	0	0	0	12,500,000				
Construction Cost	0	4,500,000	4,500,000					
Phase 2: Residential								
Rental Income	0	0	0	0	0	0	1,000,000	2,100,000
Stabilized Property Value	0	0	0	0	0	0	30,000,000	
Construction Cost	0	0	0	0	9,750,000	9,750,000		
Project Cash Flow	(3,000,000)	(4,500,000)	(4,500,000)	13,000,000	(9,750,000)	(9,750,000)	31,000,000	
PV Benefit	26,407,000							
PV Cost	24,028,000							
NPV	(621,000)							
IRR	18.2%							

Given the above information, it is possible to perform a NPV analysis of the project. Using the same method as in Figure 3.1 – Discounting costs with risk-free rate and benefits with risk-adjusted rate – , the resulting NPV of the project is negative $621,000 as shown in Figure 3.6. Following the NPV decision rule, the project should be rejected. Even though this multiple phased project has a higher project level blended IRR than the single asset development in Figure 3.1, it is quite inferior project based on the NPV. This result demonstrates that the longer development period and related uncertainties require higher return due the additional risks involved. Accordingly, the project's negative NPV seems well justified. However, given the sensitivity of the development project's NPV, the further test of the analysis should be granted.

Figure 3.7: Sensitivity of Multiple Phase Project to Change in Asset Prices

% change in Asset Price	Project Level IRR	NPV
20.0%	28.6%	$4,661,000
15.0%	26.1%	$3,340,000
10.0%	23.6%	$2,020,000
5.0%	20.9%	$699,000
0.0%	18.2%	($621,000)
-5.0%	15.3%	($1,941,000)
-10.0%	12.3%	($3,262,000)
-15.0%	9.2%	($4,582,000)
-20.0%	5.9%	($5,902,000)

The sensitivity analysis to the asset price change in Figure 3.7 shows that there are huge down sides from the base scenario and yet only 5% higher asset price would move the project into the positive NPV realm.

Since this project has multiple components in it, it is useful to analyze each component individually to identify which one loses (gains) most value. As shown in Figure 3.8, it turns out that the office component has zero NPV, whereas the residential component loses all the value mostly due to the fact that it is planned to begin construction three years later. That is, the negative impact on the NPV would be greater with later stage projects as costs are discounted with a much lower rate than benefits. In fact, if the construction can begin at the year 1, the residential component would generate $2,858,000 of positive NPV, which is much greater than the office component would generate. Due to the procedure that requires much higher discount rate for benefits than one for costs, the later projects are always less desirable compare to the earlier ones from the NPV standpoint, even if they are similar in all the other aspects. This might be one of the reasons why developers often times favor Cash-On-Cash return over NPV or IRR. From the example, the office building and the residential building each has 39% and 54%

Figure 3.8: NPV Breakdown of Multiple Phase Project

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Phase 1: Office								
Rental Income	0	0	0	500,000	1,000,000			
Stabilized Property Value	0	0	0	12,500,000				
Construction Cost	0	4,500,000	4,500,000					
Land Cost + Fee	1,011,000							
Office Cash Flow	(1,011,000)	(4,500,000)	(4,500,000)	13,000,000				
Office IRR	16.8%							
PV of Office Income Flow	9,378,000							
PV of Office Cost	8,367,000							
Office NPV	0							
Phase 2: Residential								
Rental Income	0	0	0	0	0	0	1,000,000	2,100,000
Stabilized Property Value	0	0	0	0	0	0	30,000,000	
Construction Cost	0	0	0	0	9,750,000	9,750,000		
Land Cost + Fee	1,989,000							
Office Cash Flow	(1,989,000)	0	0	0	(9,750,000)	(9,750,000)	31,000,000	
Office IRR	18.9%							
PV of Residential Income Flow	17,029,000							
PV of Residential Cost	15,661,000							
Residential NPV	(621,000)							

Cash-On-Cash return respectively.[5] Evidently, Cash-On-Cash return is not a theoretically sound measure because it does not account for any risks or time factor. However, the NPV analysis clearly penalizes later stage projects and discourages any long-term commitment on large-scale developments. This problem calls for improved analytical tools for valuing long-term development projects.

3.3. Shortcomings of Discounted Cash Flow based Analyses

As identified in the previous analyses, the NPV and IRR analyses work well for the valuation of a project based on a single fixed assumption. However, they are not as useful for real estate development projects, due to flexibility in subsequent decisions. Simply requiring higher returns for their higher risks does not help much in practice, although it might guide developers to weed out poor projects. The shortcomings of DCF based analyses originate from their fundamental assumptions. According to Copeland and Keenan (1998a), DCF techniques were developed to value investments such as stocks and bonds, and their basic assumption is that investors hold them passively. Thus, DCF based models like NPV overlook investors' capabilities of future decision making to alter the original course of a project in response to any future changes. In fact, they assume that investors make all the decisions based on their future expectations at the time, and then later they do not deviate from the initial decisions made.

De Neufville (1990) goes further to say that the conventional DCF analysis fails to recognize the fact that managers manage projects. According to him, this is the critical flaw of the DCF analysis.

[5] Cash-on-Cash return is calculated without any consideration for discount factor. It can formally expressed as: Cash-on-Cash return = (Built Asset Value – Construction Costs)/Construction Costs = Development Profit Margin / Construction Cost. For example, office Cash-on-Cash return = (12,500,000 – 9,000,000) / 9,000,000 = 38.9%.

The DCF procedures assume a single line of development for a project so that a project is carried through even if it fails. The analysis simply incorporates the probability of failure into the overall expectation of the project.

These flaws of the DCF based analyses are crucial to the analysis of real estate development projects, because the decisions related to development projects are spread over the entire development period and this give a greater degree of flexibility to adapt to any future changes. That is, large-scale development projects are rarely executed as they were planned initially. I would argue that the success of any development project depends heavily on the strategic use of flexibilities imbedded in the project.

Ch. 4. Valuing Flexibility in Real Estate Development Projects

4.1. Decision Tree Analysis (DTA)

Decision Tree Analysis (DTA) is one of the important tools available that takes flexibilities – left out from the NPV analysis – into account. It was first advocated by J. Magee in 1964 and has remained an important tool for capital investment decisions. DTA is basically a tool that can depict strategic future pathways an investor can take based on a number of different future outcomes. It shows graphically a decision road map of an investor's and manager's strategic initiatives and opportunities over time. DTA can be used when future outcomes are uncertain and investors have tool to react when new information is arrived in the future.

Prior to exploring DTA in detail, it is necessary to examine the concept of the expected return, which is basis of the conventional DCF analysis. According to Bodie et al (2002), the expected return of an asset is a probability-weighted average of its return in all future scenarios. Let Pr(*s*) be the probability of scenario s and *r(s)* be the return in scenario *s*, the expected return .*E(r)* can be expressed as:

$$E(r) = \sum_{s} \Pr(s) \cdot r(s)$$

For example, consider the return for a downtown office building that is sensitive to the overall regional economy. For the sake of the analysis, we can assume the following scenario for the next year:

	Bullish Economy	Bearish Economy	Economic Crisis
Probability	.4	.4	.2
Return	30%	10%	-30%

Applying these values to the formula defined above, the expected return of the office building is:

$$E(r_{office}) = (.4 \times 30) + (.4 \times 10) + (.2 \times (-30)) = 10\%$$

The conventional NPV method blindly uses this 10% as the basis of the investment analysis. However, it is critical to note that for actively managed investments like real estate development projects, managers can take action to prevent losses when the future outcome turns adverse. The main idea of DTA is to map out potential decisions so that it would enhance future outcome of a project. If an investor acquires an option to buy the office building, instead of buying the office immediately, she would not exercise option for a loss. Therefore, the investor's average return would be – without considering the option price and the lost time value of delaying the commitment:

$$E(r_{office.w.option}) = (.4 \times 30) + (.4 \times 10) + (.2 \times 0) = 16\%$$

As shown, the ability to make decisions when future outcome is known creates value to a project. DTA is designed to help investor to maximize the benefit of the sequential decision making.

Decision Tree Analysis incorporates the value of flexibility by explicitly laying out the structure of a project in such a way that all uncertainties and the potential decisions to be made on the uncertainties are represented as a tree form. According to de Neufville (1990), DTA leads to the following three results:

- Structures the problem, which otherwise would be very confusing due to the complexities introduced by uncertainty.
- Defines optimal choices for any period through an expected value calculation based on the consideration of the probabilities and the outcomes of each choice.

- Identifies an optimal strategy over many periods of time.

These benefits of DTA can be used to correct shortcoming of the DCF-based analyses as previously identified. DTA illustrates how future decisions could be made as uncertainties regarding a project reveal themselves over time. Therefore, it does not assume pre-committing all the decisions at the time zero. Unlike the NPV analysis, DTA assumes that investors will learn new information about the project and they have flexibilities to change course of action as the project proceeds.

Following de Neufville's approach, a Decision Tree is composed of three basic nodes:

- *Decision nodes (square)*, where possible decisions are contemplated and a decision made.
- *Chance nodes (circle)*, where outcomes are determined by events or states of nature. Chance nodes have probability of each chance happening, and the sum of the probabilities in each chance node equals one.
- *Terminal nodes (triangle)*, where a project is completed or abandoned. They are the end points of the decision tree branches, and they are typically accompanied by terminal value of the path.

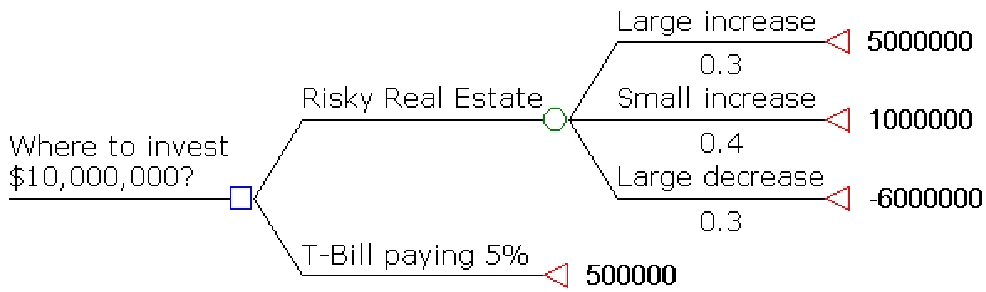
In its most basic form, a Decision Tree has series of decision nodes and chance nodes branching out to form a tree shaped structure. By assigning probabilities in chance nodes and terminal payoffs at the terminal nodes of each branch, it is possible to value the project at each decision node. Described formally, the expected value of a risky decision D_i is the outcomes weighted by their estimated provability of occurrence:

$$EV(D_i) = \sum_j P_j \cdot O_{ij}$$

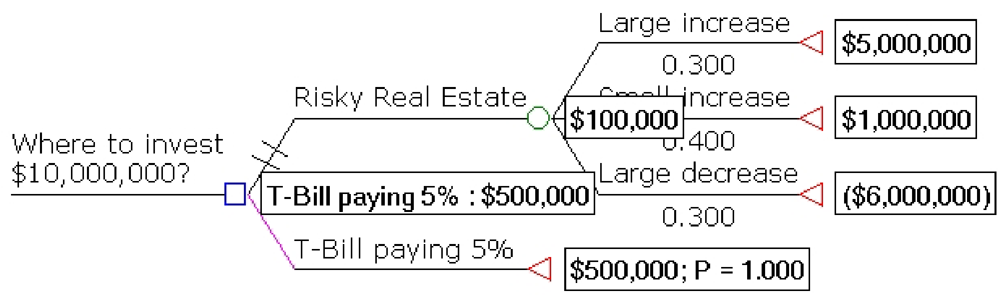
When there are a number of alternatives choices to be made, the decision rule in DTA is to choose the one that offers the best average value, defined as the expected value (*EV*) above. When multiples nodes and branches are involved, *EV* is calculated backwards from the terminal nodes to the initial node. The following is a simple example of the decision tree regarding an investment decision:

Figure 4.1: Simple Decision Tree Analysis of Investment Decision

4.1.1 Structuring of Decision Tree



4.1.2 Expected Values of Each Node



The simple analysis in Figure 4.1 identifies T-Bill as a superior investment than risky real estate, based on the expected value calculation[6]. This example is deterministic model in that it assumes all the future probabilities of outcomes are already known. It is possible to estimate probabilities and payoffs based on past data and experience, and it would not possible to know for sure in most cases. The real world application of Decision Tree Analysis would have much more complex form and involve numerous variables. The strongest virtue of DTA is that it exposes all the uncertainties and the accompanying flexibilities of a project wide open, which otherwise would have been treated as a "black box" that only gives a single value estimation.

[6] The example in Figure 4.1 does not account for discount rate and time, and therefore does not factor in investor's risk aversion. In this case, the expected value of investing in risky real estate is lower despite the potentially greater risks, and thus investing in T-Bill obviously superior to real estate. Another way to incorporate risks in this framework would be using a risk adjusted probabilities so that the probability of each outcome is adjusted for the risk. However, it would be hard to implement this approach in practice due to the difficulties of obtaining objective risk adjusted probabilities.

4.2. Application of Decision Tree Analysis to Real Estate Development Projects

As describe in the previous chapter, real estate development projects involve a sequential decision making as they progress. Therefore, they are ideal candidates for Decision Tree Analysis. A typical development project involves decisions on purchasing a piece of land, choosing a right program and capacity, choosing an optimal timing to build, etc. We can analyze office development project in Figure 3.1 using DTA. The previous analysis, fully committing to build an office building from the outset, resulted in zero NPV. It is important to note that the benefit side of the equation is highly uncertain, yet the costs side is relatively predictable. Thus, there is a value in waiting for higher benefits in the future. The current value of the asset to be developed is $9,378,000, which is the present value of future benefits. The cost of project is same as the current asset value, and it is composed of $1,011,000 of the land value and $8,367,000 of the construction costs. Figure 4.2 illustrates the decision tree that incorporates waiting up to 2 years[7] before committing for the construction based on the following assumptions:

- There are two discrete possibility of future outcome in the office asset prices based on up market and down market.
- During the good market, the asset price will increase 22.1%, and during the down market, it will decrease 18.1%[8].
- Probabilities of the up-market and the down-market are 60% and 40% respectively.
- Office would generate an annual income of 8% of its value. This would be lost income to the investor if she decides to wait for a better market.

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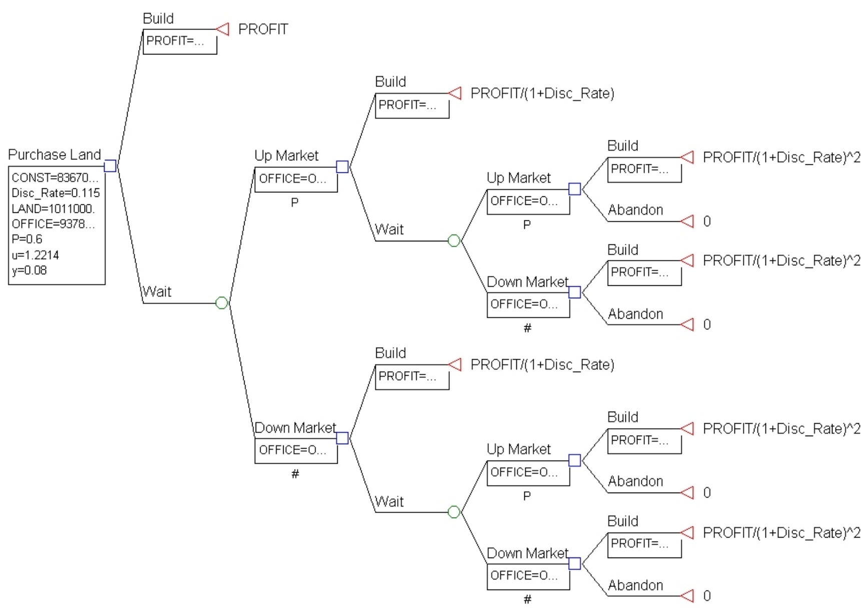
[7] Typical land development would have perpetual waiting option. However, this assumption is used for the purpose of this decision analysis. Perpetual option on land will be examined in the next chapter.

[8] Upward move and downward move of the asset price is estimated using the following formula based on 20% volatility of a typical real estate: $u = e^{\sigma\sqrt{\delta t}}$, $d = e^{-\sigma\sqrt{\delta t}}$.

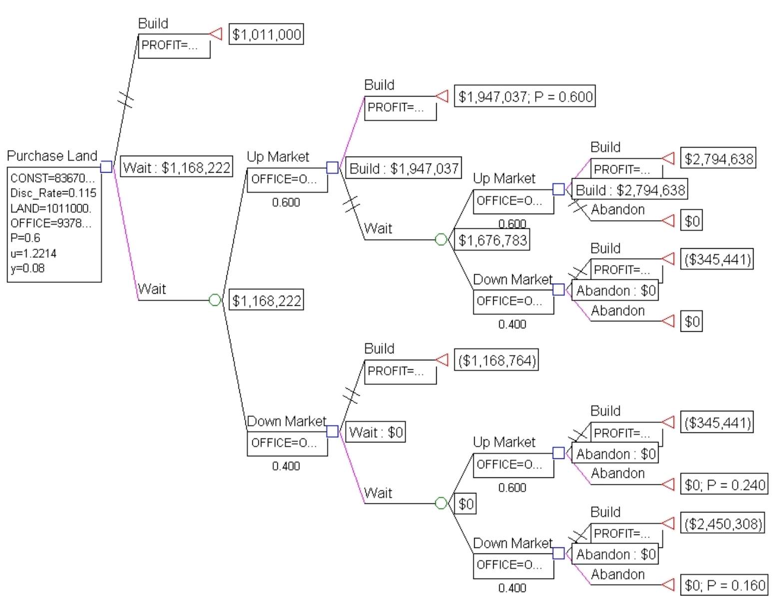
- An annual rate of 11.5% for an equivalent office building is used to discount future payoffs.[9]

Figure 4.2: Decision Tree Analysis of Development Project

4.2.1. Structuring of Decision Tree



4.2.2. Expected Value Calculation



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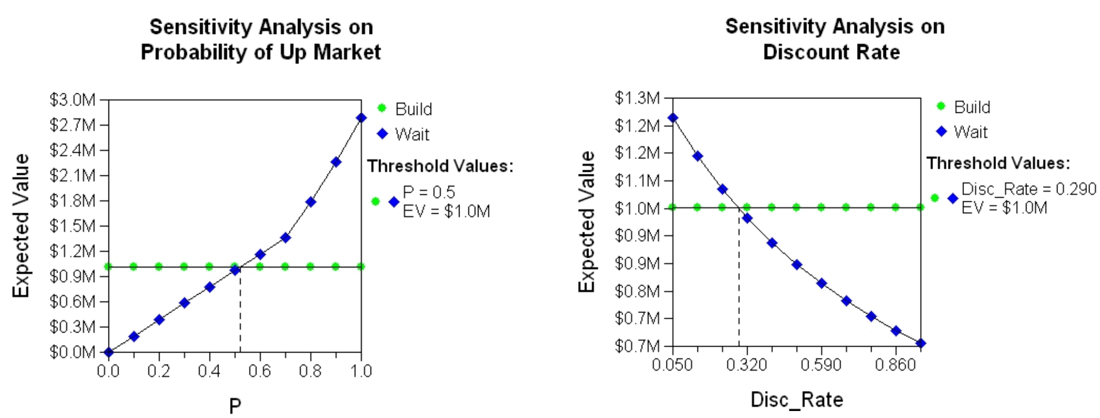
[9] This figure is for illustration purpose only and is not theoretically correct. Obviously, the discount rate for development project should be higher than this. Discount rates for Decision Tree Analysis are investigated further later in this chapter.

Bases on these assumptions, the DTA method reveals that there might be additional value in waiting for better outcome. However, the validity of this method is entirely dependent on the assumptions. More importantly, the probability and the discount rate are two most critical inputs in the model, yet entirely subjective numbers are used. Therefore, unless the assumptions are known for sure, a sensitivity analysis should be performed to see the robustness of the analysis and the boundaries of the decision rule. In figure 4.3, the lowest up-market probability for waiting decision to be optimal is 50% with the given discount rate. Also, with the 60% constant probability of up-market, the highest discount rate for waiting decision to be optimal is 29%. These results can be compared to the market data, other similar type of development projects, or developers' past experience to make more sensible judgment on the outcome of the analysis.[10]

Figure 4.3: Decision Tree Sensitivity Analyses



In the case of multiple-stage development projects, the decision tree analysis is even more useful due to the sequential decision nodes built in these projects. We can analyze the two-stage mixed use project from Figure 3.6 using DTA. Based on the previous NPV analysis, the project had the negative NPV of $621,000, and should be rejected based on the NPV decision rule. As the previous analysis revealed, the negative NPV was due to the second phase residential component,

[10] More rigorous way to identify probabilities and discount rates is possible by using DTA in conjunction with Real Options model. See the chapter 4.9 for details.

and the first phase, in fact, had zero NPV. Also the reason for the second phase's negative NPV was mostly due to the conventional NPV procedures that assume the full commitment of all the components of the project at the beginning. The following rather simplified assumptions are made for the sake of a DTA analysis:

- The first phase office component can be built any time between the first year and the third year, and when the developer made commitment to build the office, she would have a right to build a residential building in the third year. For the sake of simplicity, the analysis assumes that the developer will decide whether to build the residential component or not at the end of the third year (There is no more waiting option after the third year).
- Values of both office and residential properties are correlated with the market movement in that during an up-market asset price rises 22.1% and during a down-market, asset price falls by 18.1%.
- The office building would generate the annual income of 8% of its value and the lost income should be accounted for when the developer decides to wait for a better market.
- Probabilities of up and down-markets are estimated to be 60% and 40% respectively.
- 20% discount rate for the future profit is assumed by the developer.

Based on these assumptions, it is possible to map out the future market conditions and accompanying strategies for the developer as in figure 4.4. Then, the Expected Value of the tree can calculated moving backwards from the terminal nodes. The calculations performed in figure 4.5 gives the expected value of $4,337,000. Since the land was purchased for $3,000,000, the NPV of the project becomes positive $1,337,000, which would be high enough to compensate for the initial negative NPV of $621,000. In other words, the value incorporating flexibilities outlined above is 83% higher than the value without any flexibility. The sensitivity analysis performed in figure 4.6 illustrates that, if the upside potential is greater than 50%, there is some value in

Figure 4.4: Decision Tree Analysis of Multiple-Stage Development Project

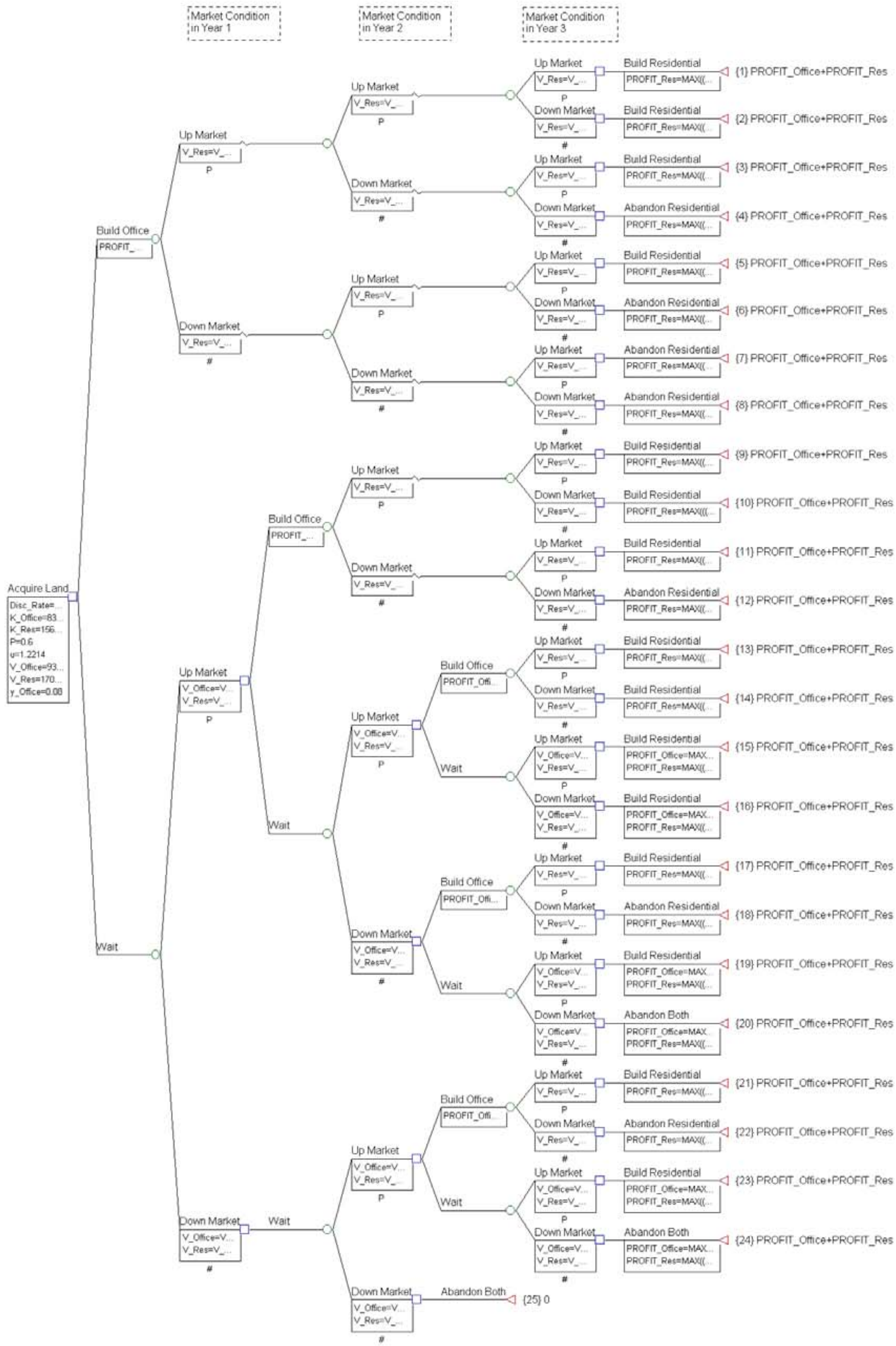
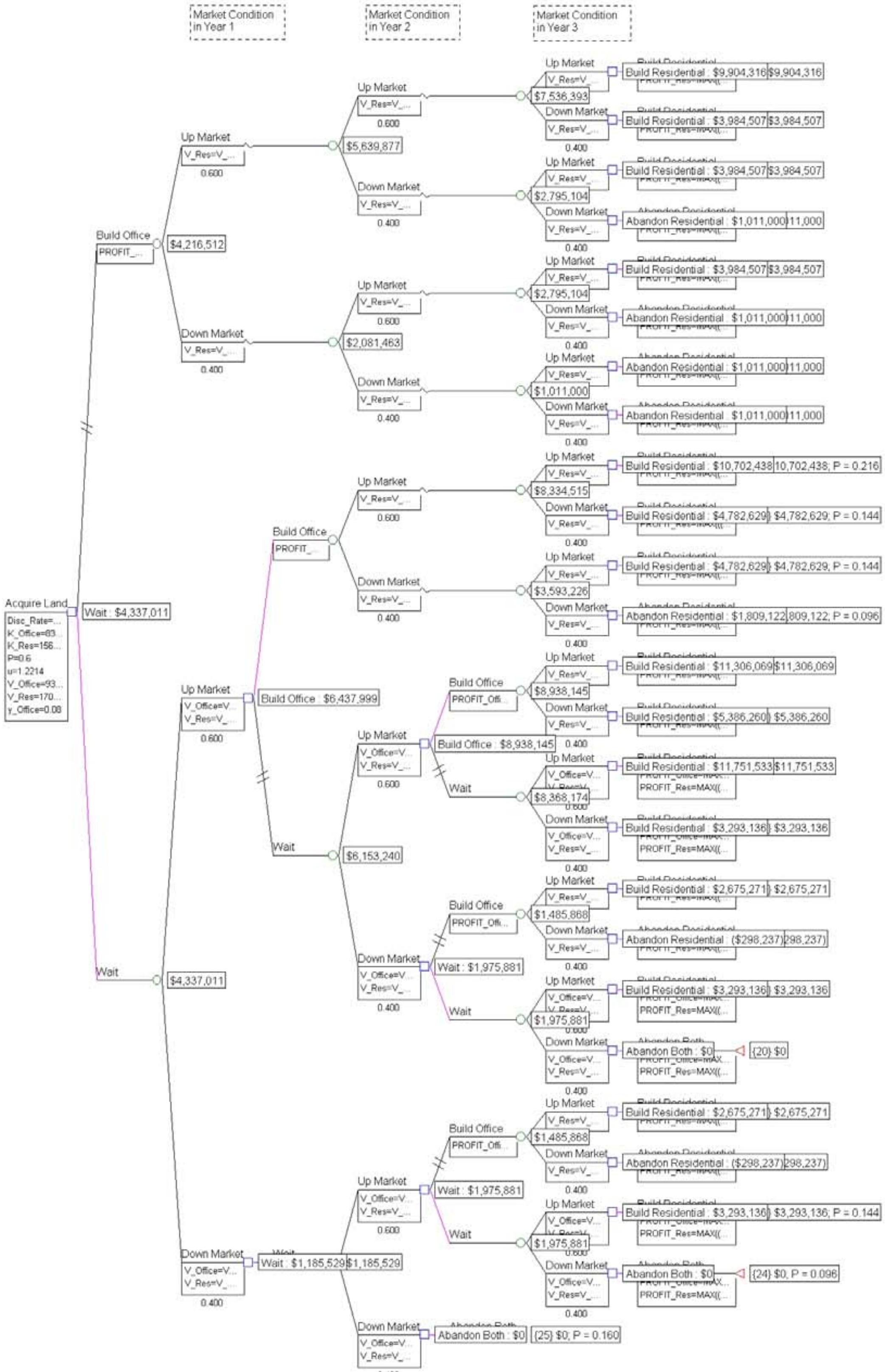
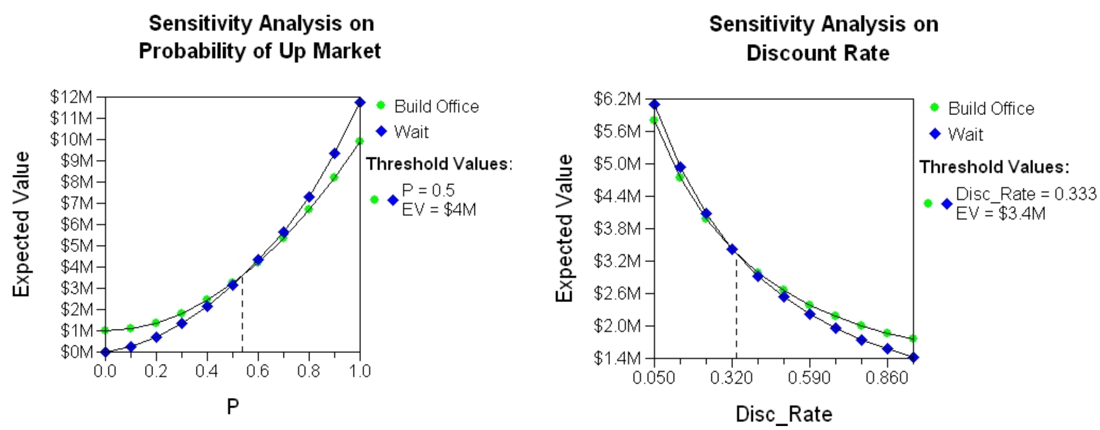


Figure 4.5: Expected Value Calculation of Multiple-Stage Development Project



waiting for better market conditions. Also, with the 60% probability of up-market, the flexible strategy would be optimal with a discount rate lower than 33.3%. Precise value of the flexibility would depend on the reliability of the discount rate and the probability assumption. However, this simplified example demonstrates that it is essential to incorporate flexibility into the analysis of large-scale and multi-phase projects.

Figure 4.6: Decision Tree Sensitivity Analyses



Another issue to be pointed out is related to the determination of the discount rate for each node. In this example, a single discount rate based on the developer's subjective experience was used. However, it is evident that as the project progresses, the risk characteristic of the project also changes. In other words, real estate development projects are in part a learning process in that some future uncertainties become known as time passes. For example, once the developer knows that there were two consecutive up-markets, the payoff in the year three would be much less risky than when it was valued from the first year. Therefore, all the nodes in a decision tree would have different risk levels, and they should have corresponding discount rates. In realty, it is close to impossible to calibrate discount rates for each node, and for most cases, some degree of subjective judgment is required.

As shown in the previous two analyses, Decision Tree Analysis corrects the analysis performed using the NPV method by incorporating flexibilities of future decision makings. DTA should be used in conjunction with the conventional NPV method whenever there are flexibilities built in a project, especially when the project involves multiple stages. The NPV analysis would systematically undervalue projects that have future phases of development, and without taking flexibilities into consideration, long-term projects would be rejected most of the time based on the NPV decision rule. However, DTA needs to be performed with much care to be an effective tool. Otherwise, it could lead to a distorted outcome and thus a poor investment decision. The following chapter will examine shortcomings of DTA to aware of, for a better implementation of DTA.

4.3. Shortcomings of Decision Tree Analysis

Decision Tree Analysis is a great analytical tool that complements weaknesses of the conventional Discounted Cash Flow based tools. Compared to the passive investment approach of the NPV analysis, DTA is much closer to the reality of actively managed real estate development projects. However, DTA has its own shortcomings and they should be clearly identified and understood by investors to be implemented for real world projects. The problems of applying DTA have been identified by many authors including Meyers (2002) and de Neufville (1990).

As Meyers points out, the difficulty of DTA's implementation comes from the sheer complexity of real world decision making processes. For any given future events, there would be a number of alternative actions mangers could choose for real world projects. Also there would be countless variables that would influence projects' outcome. If we start covering all the possible variables and choices, "*decision tree analysis*" would quickly become "*decision bush analysis*" as the number of paths increase geometrically with the number of decisions, outcome variables and number of states considered for each variable. This would make any analytic work challenging and time consuming. At the same time, investors would loose any insight on critical decisions for the success due to its complexity. For instance, the analysis performed in Figure 4.4 and 4.5 only involves three variables – possibility of up/down market and percentage increase (decrease) of the asset prices based on given market condition –, and it had only two states of market. Even then, the analysis was quite complicated. Therefore, to make DTA useful, it is important to identify critical variables and conditions for success, and focus on them. As Meyers puts it, "*decision trees are like grapevines: they are productive only if they are vigorously pruned.*"

One of the major simplifications is that decision trees require finite number of discrete alternatives. In the real world, there might be infinite number of outcomes and they might be continuous. Instead of a fixed percentage increase in an asset price, price change would span a range of values. This simplification can distort the outcome of the analysis, yet incorporating too many alternatives would make decision tree too complex to be useful.

Another related problem is that DTA eventually involves some degree of subjective judgment on input variables as well as resulting outcomes. If there are extensive data available for similar projects as the one being analyzed, this would not be too much of a problem. However, many new projects are unique and it would be difficult to come by a reliable data. In this case, the analysis should be performed based on subjective and most reasonable input assumptions, and verified with a rigorous sensitivity analysis. With help of software package such as TreeAge®, it is also possible to perform a Monte Carlo simulation.

In most cases, uncertainties are gradually removed as a project progresses, and this changes the risk of a project. Also, certain events change the risk characteristic of a project. For instance, if the underlying asset price drops during the development, the operating leverage of the project increases due to the fixed cost. This effectively makes the project riskier, and the opposite happens when the asset price rises. Due to the constantly changing risk levels of a project, using a single discount rate in each year is incorrect. This change in risk can be easily identifiable in a conceptual level. However, determining appropriate discount rate at every node would not be possible, due to the limited available data, and it would be practically unfeasible for complex decision trees. In other word, decision trees do not provide investors an appropriate tool to value future cash flows on the risk-adjusted basis.

It is also worth noting that Decision Tree Analysis is not a substitute of the conventional NPV analysis but it is a complementary method. The correct usage of DTA involves the application of Discounted Cash Flow method. If the initial DCF valuation is poorly done, the outcome of DTA would not be reliable.

Decision Tree Analysis can help investors identify the future strategic decision choices, and provide a clearer view of the future cash flows and risks of a project. However, due to the subjective assumptions required in most DTA procedures, it is challenging to use it as an objective valuation tool. More often than not, it would more useful as a strategic tool for future decisions than a precise valuation tool.

4.4. Real Options Analysis

Real Options is a method that uses the option theory to evaluate physical or real assets such as buildings and plants, as opposed to stocks, bonds and other financial instruments. Real Options was first advocated by Meyers (1977) in his analysis of corporate borrowings. Following the Copeland and Antikarov (2001)'s definition, Real Options is *"the right, but not the obligation, to take an action (e.g., deferring, expanding contraction, or abandoning) at a predetermined cost called the exercise price, for a predetermined period of time – the life of the option."* This definition is almost identical to that of financial options in that the only difference seems the type of assets that investors have options on. Accordingly, just like financial options, the value of Real Options depends on six basic variables: value of the underlying risky asset, exercise price, time to expiration, standard deviation of the value of the underlying asset, risk free rate and dividends rate if any (Copeland and Antikarov). Conceptually, both Decision Tree Analysis and Real Options are tools to value flexibilities of investments. However, the major benefits of Real Options is that it is much more robust valuation tool by accommodating techniques developed for the valuation of financial options. For instance, in contrast to DTA, Real Options can avoid guessing a correct discount rate for each future outcome by using the arbitrage free method and the risk neutral probabilities. In practice, Real Options can be used for largely two purposes: valuation of flexibility to complement the conventional NPV approach and formulation of proactive strategies to capture additional values, market shares, revenues, etc.

4.4.1. Real Options as Valuation Tool

Copeland and Weiner (1990) suggest that Real Option can be a remedy for problems of underinvestment resulted from the wide-spread use – often applied incorrectly – of the conventional NPV analysis:

> *A fascinating aspect of flexibility options is that in certain cases it is possible to estimate their value precisely. Often, the extra value added by flexibility is completely missing from such traditional valuation methodologies as net present value techniques. In fact, one contributing factors to underinvestment in the United States may be the slavish dedication of its MBA-trained mangers to NPV. Have you ever sat at a meeting and listened to a careful NPV analysis, known in your gut that the recommendation had to be wrong, but could not put your finger on the reason? The missing ingredient may be the value of flexibility.*

Real Options can be valued by finding out a financial option structure that is equivalent to the real world situation being analyzed. For instance, the option to expand a project when a favorable market condition arrives is similar to a financial "call" option. If the cost of expansion is fixed, it is equivalent to the strike price of financial options. When the payoff of the expansion is above the fixed cost, the expansion option would be "*in the money*." Following a similar approach, if Real Options in an investment can be clearly identified, it can be valued using techniques developed for financial options.

Most projects that involve sequential decision making process would have Real Options built in them. Without recognizing the value of Real Options, there would be the problem of underinvestment, and investors are likely to pass up investments with great potential returns. R&D projects are a popular example of the Real Options valuation. Most R&D projects usually do not make sense from the NPV standpoint. However, the most value of R&D is created when it become successful and opens up new market for a company. In other words, R&D is a right to acquire an exclusive and profitable market for the company at a cost incurred during the R&D process. As Copeland and Weiner (1990) put it, R&D situation is similar to *"paying to see the next card"* that provides an option to move forwards by investing more or abandoning the project. Real Options has a critical importance as a valuation tool because, prior to its introduction, a method that can value flexibilities inherent in many projects was not available. Investors and mangers had to either simply ignore any values of flexibilities or follow their subjective judgments.

The best feature of Real Options as a valuation tool is that it can be directly used in conjunction with the conventional NPV method. Mun (2002) proposed the concept of expanded net present value (*eNPV*), which is combination of the option value and the value from the conventional NPV method:

NPV = Benefits – Costs

Options Value = Benefits of Options – Costs of Acquiring Options

eNPV = NPV + Options Value

This approach can be applied to any valuation exercise. When a project is deterministic with no flexibilities, Options Value would simply be zero. The greatest advantage of the *eNPV* approach is that it forces investors to think about options in their investments or projects. Therefore, it can help investor recognizing value of flexibilities in projects, and at the same time, avoiding potential mistakes of underinvestment.

4.4.2. Real Options as Strategic Tool

Real Options is not only a conceptually superior valuation tool but also a strategic tool. According to Leslie and Michaels (1997), Real Options as a valuation tool deals with certain *"reactive flexibilities."* On the other hand, Real Options as a strategic tool identifies *"proactive flexibilities"* – the flexibility that can be strategically placed and built into projects. De Neufville and Neely (2001) regard this strategic use of options as *"Options in Projects"* as opposed to *"Options on Projects."* According to them, options in projects are options that involve a change in system design or underlying technology as uncertainty is resolved.

Real Options is particularly useful compare to other methods because it clearly identifies what drives values in projects with a flexible design. Based on the variables in financial options, Real

Options' basic variables can be structured in a way to maximize the potential value of a project. Using variables typical to financial options as the basis, Leslie and Michaels (1997) identifies six major variables that can strategically improve the options value in a project. The following is the list of variables in financial options and their implication for Real Options (Leslie and Michaels):

- Stock Price (S) – Evidently higher stock price would give higher value. For Real Options, it is hard to observe the market price of the underlying asset. Thus, the present value of expected cash flows is used instead. One major difference between financial and real options is that the owner of financial options cannot affect the value of the underlying assets. But, managers who operate real assets can raise its value and the value of Real Options at the same time (Copeland and Antikarov).
- Strike Price (X) – As the strike price of an option increases, the value of the call options decreases and the value of the put increases. In Real Options, the strike price is equivalent to the present value of all the fixed costs expected over the lifetime of the investment opportunity. Therefore, cutting costs by strategies such as leveraging economies of scale increases value of a project and its call-like Real Options at the same time.
- Uncertainty (σ) – Higher uncertainties increase the value of an option and this is critical difference from the NPV approach. Higher uncertainties would require higher discount rate and it will decrease the value from the NPV perspective. By placing options like features in a project, investors can put a limit on downside yet fully exploit the potential upside. For highly risky projects, options strategy can dramatically improve their values.
- Time to Expiration (T) – As time to expiration increases so does the value of an option. In Real Options, managers can extend the opportunity's duration using strategies such as acquiring renewable licensing.

- Dividends (δ) – Dividends are considered as costs incurred to keep an option afloat. Reducing the value lost by waiting is even more critical for Real Options, because the cost of waiting could be extremely high if an early entrant can preempt later followers. The lost of value by preemption can be minimized by discouraging others to exercise their options.
- Risk-free Interest Rate (r) – The risk-free rate is not something investor can change. However, it is worth noting that any expected increase in the interest rate raises option value, despite its negative effect on NPV, because it reduces the present value of the exercise price.

When strategically placing options features into projects, it is critical to identify which of above variables affect the options value the most. After that, they have to be carefully compared to the costs of placing or acquiring them. Options way of thinking can help investors understanding how options can create additional value for their projects, and what kinds of options should be acquired to maximize the potential of the project. The essence of strategic Real Options is that it fundamentally changes investor's attitude towards uncertainties. As opposed to the traditional strategy of avoiding uncertainties, Real Options strategy seeks gains from uncertainties and maximization of learning process during the course of a project (Leslie and Michaels). This new attitude will open up a wider range of possible actions and is crucial for any options thinking on real world projects.

4.4.3 Types of Real Options

Many authors have identified types of Real Options that can be found in real projects and come up with various ways to apply them in the real world (Trigeorigis, 1993; Mun, 2002, Copeland and Antikarov, 2001; Howell et al, 2001, Brealey and Myers, 2003; and Hull, 2003). The following is the list of Real Options that is most widely recognized and implemented. All of them are also applicable to real estate projects in different circumstances:

"Option to defer" captures the value of waiting when investors hold an option to buy valuable asset. For instance, one can wait to see if output prices justify constructing a building or plant, or developing a field. This is equivalent to a simple financial call option, and it captures time value of a call option to invest. It also leads to a useful decision rule of deferring exercise until the time value of waiting becomes zero. Typical real estate land development is a case of option to defer in that buying land is an option to build a property when its benefit exceeds its costs.

"Time to build option (staged investment)" is also called *"compound expansion option."* Staging investment as a series of outlays creates the option to abandon the enterprise in midstream if new information is unfavorable. Each stage can be viewed as an option on the value of subsequent stages, and valued as a compound option. Multi-stage real estate development projects can be considered as compound expansion option.

"Scaling Option (e.g., to expand; to contract; to shut down or restart)" is an option to change course of the project depending on market conditions. If market conditions are more favorable than expected, the firm can expand the scale of production or accelerate resource utilization. On the contrary, if conditions are less favorable than expected, it can reduce the scale of operations. In extreme cases, production may halt or start up again. When applied to real estate, an option to sublease the space can be interpreted as a contract option.

"Option to abandon" is a put option that values manager's option to shut down project and realize the resale value of the investment, when market turns sour. If the salvage value is reasonably high, the option to abandon can substantially cut down the negative effect of the

market downturn. Most development projects would have this option until it was built and leased-up.

"Option to switch" reflects the fact that mangers can switch inputs and outputs in response to the market fluctuations. If buildings are designed with flexibilities in mind, they can provide switch options to investors by offering to switch one use to another (e.g. office to residential) depending on the market condition.

"Growth option" is a crucial when early investment (e.g., R&D, lease on undeveloped land or oil reserves, strategic acquisition, and Information network/infrastructure) is a prerequisite or link in a chain or interrelated projects, opening up future growth opportunities. This is another version of sequential compound expansion option. Costs incurred for permitting during the development process can be regarded as an option to provide a growth opportunity.

" Rainbow option" is an option that depend on more than one type of uncertainty. Most real world cases are affected by a number of uncertainties such as output and input prices, demand quantities, interest rates, etc. Real estate development projects would be at least affected by uncertainties of construction cost and market demand.

As listed above, a majority of real world decisions in response to uncertainties can be model as a Real Options or combination of different types of Real Options. When applied to real world projects, even simple projects involve multiple options to choose from. Managers and investors often have to make strategic decisions on daily basis. To model this complex real world situation, it would crucial to identify uncertainties that matter the most. If investors can effectively mitigate some risks, options valuation should focus on the risks that they have to bear and would affect the project outcome in a meaningful way. Therefore, simplification without damaging integrity of analysis is one of the most important techniques for the Real Options Analysis.

4.5 Basis of Real Options Valuation

4.5.1 Stochastic Processes and Geometric Brownian Motion

One of the fundamental processes required for the valuation of an option is to model the uncertainties of underlying assets. Based on the assumption that the uncertainties of underlying assets is their randomness in price change, a mathematical model called Markov stochastic process is widely used to account for such uncertainties. The concept of Wiener Process, also referred to as Brownian Motion, is used to model stock prices' randomness and it is also applicable to a variety of other assets following similar patterns. Wiener Process is a type of Markov stochastic process with a mean of zero and variance of 1 per year (Hull, 2003). Wiener Process is formally expressed as follows:

$$\delta z = \varepsilon \sqrt{\delta t}$$

where, ε is a random drawing from a standardized normal distribution, and δz is the change during a small period of time δt. The value of δz for any two intervals of time δt is independent, and δz itself has a normal distribution with mean of $\delta z = 0$, standard deviation of $\delta z = \sqrt{\delta t}$, and variance of $\delta z = \delta t$.

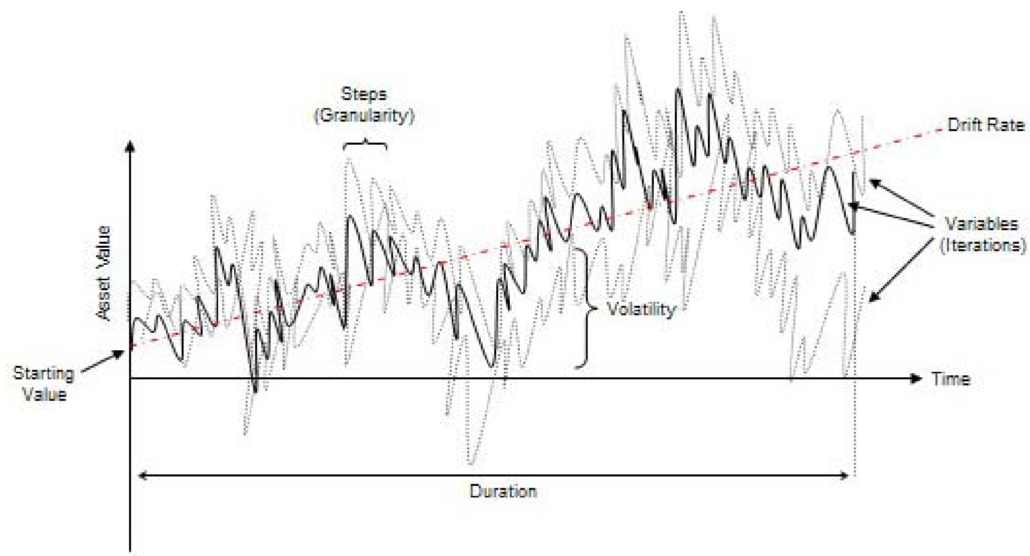
Based on Wiener Process, the process for change in stock prices is modeled as a process called Geometric Brownian Motion (Hull):

$$\frac{dS}{S} = \mu dt + \sigma dz$$

where S is stock price, μ is stock's expected return (drift rate), σ is the volatility of stock price and dz represents Wiener Process identified above. It is important to note that this process assumes constant rate of required return and volatility (Hull).

Dixit and Pindyck (1994) go one step further to introduce other kinds of stochastic processes including mean-reverting processes and jump-diffusion process. It is not crucial for average investors to manipulate these mathematical models to value Real Options. However, the assumptions that these models are based on have to be recognized since it is closely related to the interpretation of any Real Options Analysis that will be introduced in the next chapter.

Figure 4.7: Geometric Brownian Motion of Asset Price



Source: Crystal Ball Online Help, Decisioneering Inc.

4.5.2 Arbitrage-Free Pricing Method

Another break-through in options valuation comes from the concept of no arbitrage. Arbitrage opportunities occur when the same security or asset is traded in different prices, or when different assets with identical payoff and risk are traded in different prices. In theses cases, arbitrager can make risk-less profit buying an asset in one market and selling it in the other, or buying the under-priced asset and selling overpriced one. If we assume that markets are efficient, arbitrage opportunities would not occur, and even if it does, it would instantly disappear because rational investors would take advantage of the condition immediately. Hence, arbitrage-free pricing is based on the idea that assets or financial instruments with same payoff and risks should be priced same.

This idea provided a break-through in the options pricing because payoffs in options can be replicated with the combination of underlying assets and borrowing (or lending). For stocks and bonds, we can observe their prices very precisely, and thus prices of options on stocks and bonds can be calculated fairly accurately. Furthermore, when asset prices are already known, it is possible to use the concept of "risk neutral probability" in conjunction with the replicating portfolio method. Adopted from Brealey and Meyer (2003)'s Certainty Equivalent Cash Flow, the value of replicating portfolio can be discounted using risk-free rate – risk neutral probabilities are calculated based on the idea that certain cash flow should be discounted at a risk-free rate. Assuming that we know the range of future asset prices and the current asset price, the probability can be derived since it is the only remaining variable in the equation. This technique effectively avoids the problems of determining discount rate for each node when Decision Tree Analysis is used. The replication portfolio based on no-arbitrage assumption and the concept of risk neutral method are also basic assumption of the following options valuation method, and at the same time a source of the models' weaknesses.

4.6. Real Options Valuation Methods

Based on the two fundamental theories outlined in the previous section, there are a number of different methods that can calculate the value of an option. In this section, the four most recognized methods for options valuation are introduced and tested with the simple development example used in Figure 3.1:

4.6.1. Closed-Form Solutions

Closed-form solutions are mathematical equations that can be solved given a set of input assumptions. They provide the quickest and easiest way to value options simple enough to fit in one of the pre-established structures. The most widely used closed-form solution for options valuation is the Black-Scholes formula. The model was developed in the early 1970s by Fisher Black, Myron Scholes, and Robert Merton, and it was considered a major breakthrough in options pricing. The followings equations are the Black-Scholes formulas for the prices of a European call option on dividend-paying stock (Hull, 2003):

$$C_0 = S_0 \cdot e^{-qT} \cdot N(d_1) - X \cdot e^{-rT} \cdot N(d_2)$$

where,

$$d_1 = \frac{\ln(S_0 / X) + (r - y + \sigma^2 / 2)T}{\sigma\sqrt{T}}, \text{ and } d_2 = \frac{\ln(S_0 / X) + (r - y - \sigma^2 / 2)T}{\sigma\sqrt{T}}$$

N(·) represents the cumulative probability distribution function for a standardized normal distribution[11], *X* is the strike price, *r* is the risk-free rate, *y* is the dividend payout rate and *T* is the time to maturity. The office development example used in Figure 3.1 and Figure 4.2 can be easily applied to this formula. Following the same assumptions as the Decision Tree Analysis, current underlying asset value (S_0) is the present value of the office \$9,378,000; the strike price (*X*) is the present value of the construction costs \$8,367,000; the standard deviation of office prices (σ) is 20%; the time to maturity (*T*) is 3 years; and the risk-free rate (*r*) is 5%. For real estate application, dividend payout (*y*) should be equivalent to cap rate, and 8% cap rate for this example. Under these input assumptions, we can calculate the value of waiting to develop up to three years:

[11] It can be calculated using a normal distribution table, or the Excel function "NORMSDIST."

$$d_1 = \frac{\ln(9{,}378{,}000/8{,}367{,}000) + (0.05 - 0.08 + 0.2^2/2) \times 3}{0.2\sqrt{3}} = 0.24269$$

$$d_2 = \frac{\ln(9{,}378{,}000/8{,}367{,}000) + (0.05 - 0.08 - 0.2^2/2) \times 3}{0.2\sqrt{3}} = -0.10372$$

N(d_1) = NORMSDIST(0.24269) = 0.5959, N(d_2) = NORMSDIST(-0.10372) = 0.4587

$$C_0 = 9{,}378{,}000 \cdot e^{-0.08\times 3} \times 0.5959 - 8{,}367{,}000 \cdot e^{-0.05\times 3} \times 0.4587 = 1{,}092{,}000$$

Since the residual land value is \$1,011,000, the option value of the land is \$81,000[12] (1,092,000 – 1,011,000). In this case, the land as a call option has a higher value over the land as a residual value despite the potential loss of income. Starting to develop immediately based on the conventional NPV decision rule would be in fact a negative *eNPV*, when factoring in the option value of waiting.

Unlike the above example, most land developments do not have maturity. That is, once an investor acquires a piece of land, she has an option to wait until the value of the fully developed land is maximized – she can evidently wait forever. This is a type of perpetual call option, and it cannot be solved using Black-Scholes formula because it require *T* (time to maturity). Geltner and Miller (2001) introduced Samuelson-McKean formula[13] as the "Black-Scholes formula of real estate." The Samuelson-McKean formula is formally expressed as the following equations:

$$L = (V^* - K)\left(\frac{V}{V^*}\right)^{\eta}$$

where

$$V^* = K \cdot \frac{\eta}{\eta - 1}$$

[12] It is important to note that Black-Scholes formula is only capable of valuing European options. Therefore, this calcuted option value is based on the assumption that the developer cannot start to developer in the year one and two. Since the underlying asset is paying dividends, it is likely that early exercise will be optimal. Therefore, the option value is likely to increase, if we treat this optiona as a call. This is one of the weaknesses of using Black-Scholes formula.

[13] It was first developed by Paul Samuelson and Henry McKean for pricing perpetual American warrants.

$$\eta = \frac{y - r + \sigma^2/2 + [(r - y - \sigma^2/2)^2 + 2r\sigma^2)]^{1/2}}{\sigma^2}$$

and

V = Current Value of underlying asset

K = Strike price (cost of building asset)

σ = Volatility of underlying asset

y = Dividend payout ratio (Cap rate)

r = Risk-free rate

η= Option Elasticity

V*=Critical value of underlying asset at and above which it is optimal to immediately exercise the option.

We can analyze the same example used for Black-Scholes, except that there would be no maturity date:

$$\eta = \frac{0.08 - 0.05 + 0.2^2/2 + [(0.05 - 0.08 - 0.2^2/2)^2 + 2 \times 0.05 \times 0.2^2)]^{1/2}}{0.2^2} = 3.27$$

$$V^* = 8{,}367{,}000 \cdot \frac{3.27}{3.27 - 1} = 12{,}060{,}000$$

$$L = (12{,}060{,}000 - 8{,}367{,}000)\left(\frac{9{,}378{,}000}{12{,}060{,}000}\right)^{3.27} = 1{,}624{,}000$$

Without the maturity, the option value of the land becomes substantially higher as expected. More importantly, the Samuelson-McKean formula provides investors with other useful information, such as the optimal exercise price (*V**) and the hurdle benefit/cost ratio (*V*/K*)[14].

These ready-made formulas provide simple means to calculate the value of the land as an option. They are especially useful for straight forward land development projects. They provide the approximate value of land based on its inherent options structure, and also some guidance regarding their investment strategies.

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[14] For instance, based on *V*/K*, investors can find out the optimal profit margin for a development project, assuming they know the volatility and the yield of the asset.

4.6.2. Partial Differential Equation

According to Howell et al (2001), the partial differential equation is an equation that predicts how one variable (option value) would change if at least two other variables (underlying asset price and time) make small changes. Partial differential equations are typically derived from the mathematical model that simulates the behavior of the underlying asset, such as Geometric Brownian Motion, and solving this model with the concept of no arbitrage and the Ito Calculus (Dixit and Pindyck, 1994). Since partial differential equations only say changes in values, they do not provide a unique solution by themselves. It can only have unique solutions when some boundary conditions are determined (Howell et al). For instance, the previously introduced Black-Scholes formula is nothing but a solution of Black-Scholes partial differential equation:

$$rC = \frac{\partial C}{\partial t} + rS\frac{\partial C}{\partial S} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 C}{\partial S^2}$$

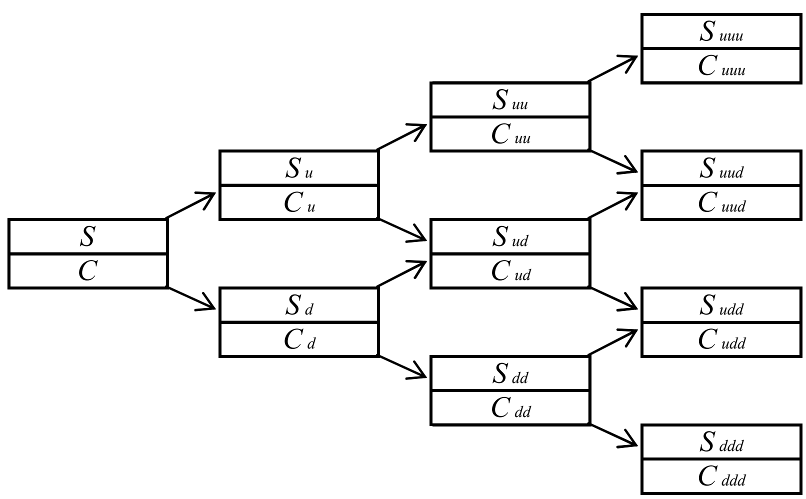
Black-Scholes formula for a non-dividend paying European call option is the solution to the above partial differential equation with the boundary condition $Max\{S_T - X, 0\}$.

Many academic researches on Real Options are dedicated to creating and improving models for different circumstances based on partial differential equation approach. Assuming input data are correct, this approach provides accurate values of an option, and it can model conditions that cannot be done in other methods. However, it involves such arcane mathematical skills as stochastic calculus and dynamic programming. Therefore, it is highly unlikely that average practitioner can have a handle on this procedure. Also in many cases, the resulting models do not provide analytical solutions. For these reasons, the partial differential equation approach is not going to be used for the analysis of the case and other examples in this paper.

4.6.3. Binomial Tree

Binomial tree method is a popular options valuation model due to its conceptual clarity and ease of use. This model is especially helpful for valuing Real Options due to the fact that it is flexible enough to be modified based on different structures and intuitive enough to be used by average practitioners. It graphically shows how future uncertainties unfold, and it is quite similar to Decision Tree in a way it incorporates flexibilities of future decisions. The concept of the risk neutral probability and no-arbitrage explicitly play crucial role in this approach. The same example is used to illustrate the binomial tree method. Instead of using European call options structure, the example in Figure 3.1 is valued as an American call with three years of maturity as shown below.

Figure 4.8: Binomial Tree with Asset Prices (*P*) and Call Option Payoff (*C*)



To solve the option value from the binomial tree, we need to find out up movement (u) and down movement of the asset prices, and risk neutral probability (q) of the up movement. The movements of asset prices can be estimated by their volatility, and the risk neutral probability can be calculated by solving for resulting probabilities when a risk-free discount rate is used instead of a risk-adjusted rate:

$$u = e^{\sigma\sqrt{\delta t}} \;, \qquad u = e^{-\sigma\sqrt{\delta t}} = \frac{1}{u} \quad \text{and} \quad q = \frac{e^{(r-y)\cdot\delta t} - d}{u - d}$$

where

σ = Volatility of underlying asset y = Dividend payout ratio (Cap rate)[15]

r = Risk-free rate δt = time steps[16]

Once we know these variables, we can layout evolving asset prices from the starting node to the terminal nodes.

$$S_u = u \cdot S_0, \quad S_d = d \cdot S_0, \quad S_{ud} = u \cdot d \cdot S_0, \; \ldots$$

On the other hand, options payoffs can be computed by starting from the terminal nodes and move backwards. The value at the starting cell becomes the price of the option. For instance, *Cuu* can be calculated as follows:

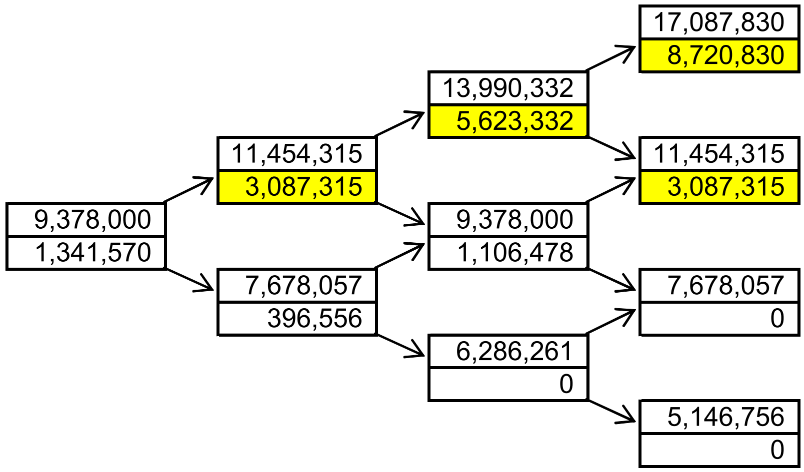
$$C_{uu} = Max\{e^{-r\delta t}[qC_{uuu} + (1-q)\cdot C_{uud}], S_{uu} - X, 0\}$$

Following this procedure, *u* and *q* is computed to be 1.2214 and 0.3768 respectively. With the underlying asset price of $9,378,000, the construction cost (strike price) of $8,367,000, 20% volatility and 5% risk-free rate, the value of the land as an American call option with three years to maturity can be calculated as in figure 4.9:

The resulting value of the land is $1,342,000[17] and it implies the option value of $331,000. This is much higher than the value of $81,000 calculated using the Black-Scholes formula because early exercises on shaded nodes in Figure 4.9 are optimal. It is however lower than the value from the Samuelson-McKean formula since longer maturity increases the value of an option.

[15] The risk neutral probability is calculated assuming continuous dividend payout of y.
[16] If an option has a one year maturity and the binomial tree has 10 steps, δt is 0.1.
[17] It is important to note that this value is only approximate solution, due to the assumption made to solve this options value.

Figure 4.9: Valuing Land as an American Call Option using Binomial Tree



*Shading indicates where an option is exercised.

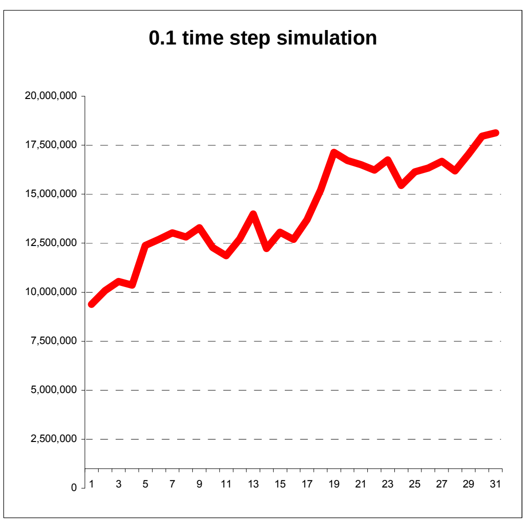
Many authors who advocate Real Options model in practice favor the binomial tree approach (Mun, 2002; Copeland and Antikarov, 2001; Arman and Kulatilaka, 1999). It is because the model is much easier to explain and implement, and at the same time, it provides a great deal of flexibility since analysts can customize payoffs and structures in each node. Also, when the early exercise is possible (i.e. American options), the Black-Scholes formula cannot be used and the binomial model can be an alternative. The greatest benefit of the binomial tree might be that it can be used in conjunction with decision trees. This “hybrid” approach is promoted by de Neufville and Neely (2001); and Copeland and Antikarov (2001). For example, from the overall Real Options structure, Decision Tree Analysis can be used instead only for the part that does not have reliable historical data.

4.6.4. Valuation by Monte-Carlo Simulation

Monte-Carlo can simulate real life price movements of underlying assets by randomly generating values for uncertain variables repeatedly. In Monte-Carlo simulation, variables had defined probability distribution. During a simulation, random numbers are drawn from the pre-defined probabilities. The simulation method is especially useful to value options with multiple variables, which are hard to be modeled in a binomial tree. European options can be easily calculated with simulation, but it is very hard to solve American options, when early exercises can be optimal[18]. For a European Option valuation, a series of forecast asset values are created typically using the Geometric Brownian Motion, and the mean of the option payoff at the terminal node is discounted back to the present using a risk-free rate. This value is equivalent to the option price.

Figure 4.10: Monte Carlo Simulations for a simple development option

Input Assumptions	
PV of Underlying Asset	9,378,000
PV of Cost (strike price)	8,367,000
Volatility of Underlying Asset	20.00%
Income Payout Rate	8.00%
Risk Free Rate	5.00%
Years to Maturity	3



0.1 Time Step Path-Dependent Simulation			
year	Simulate	step	Value
0.00			9,378,000
0.10	1.238677	1.076097	10,091,640
0.20	0.773311	1.044887	10,544,620
0.30	-0.204888	0.982202	10,356,947
0.40	2.903625	1.195592	12,382,682
0.50	0.473043	1.025231	12,695,109
0.60	0.493995	1.02659	13,032,676
0.70	-0.184916	0.983443	12,816,901
0.80	0.656493	1.037195	13,293,629
0.90	-1.171383	0.923962	12,282,803
1.00	-0.468523	0.965961	11,864,706
1.10	1.189311	1.072743	12,727,777
1.20	1.583583	1.099829	13,998,376
1.30	-2.0538	0.873809	12,231,903
1.40	1.106739	1.067155	13,053,338
1.50	-0.377257	0.971553	12,682,005
1.60	1.295821	1.079993	13,696,482
1.70	1.745272	1.111134	15,218,621
1.80	1.954272	1.125918	17,134,924
1.90	-0.303351	0.976105	16,725,477
2.00	-0.128216	0.986976	16,507,652
2.10	-0.193014	0.98294	16,226,030
2.20	0.578899	1.032118	16,747,174
2.30	-1.198501	0.922378	15,447,229
2.40	0.775888	1.045057	16,143,235
2.50	0.263231	1.011716	16,332,374
2.60	0.410292	1.02117	16,678,133
2.70	-0.3904	0.970745	16,190,220
2.80	0.8861	1.052367	17,038,053
2.90	0.919289	1.054578	17,967,961
3.00	0.222827	1.009134	18,132,086
Option Value			8,404,887

[18] There are several methodologies of using Monte Carlo simulation to value American options, suggested by a number of academics. However, it would require a complex programming to use them in practice. For details on these methods, see Hull (2003) pp. 474-478.

The following procedure is a simplified method for valuing European options with Monte-Carlo simulation (Mun, 2002). Figure 4.10 is an example of spreadsheet set up using Excel® and Crystal Ball® software, based on the development project in figure 3.1. The following is the procedure used for the simulation in figure 4.10:

1. Determine how many time steps to use. As in the binomial model, the finer time steps would result in more reliable outcome.
2. Based on the Geometric Brownian Motion, the behavior of the stock price movement can be modeled as,

   $\frac{dS}{S} = \mu dt + \sigma dz$, then $dS = S \cdot (\mu dt + \sigma dz)$

   when stock is paying dividends at a constant rate of y,

   $\mu = rf - y$, $dz = \varepsilon\sqrt{dt}$

   using discrete time steps,

   $\delta S_n = S_{n-1} \cdot [(rf - y) \cdot \delta t + \sigma\varepsilon\sqrt{\delta t}]$

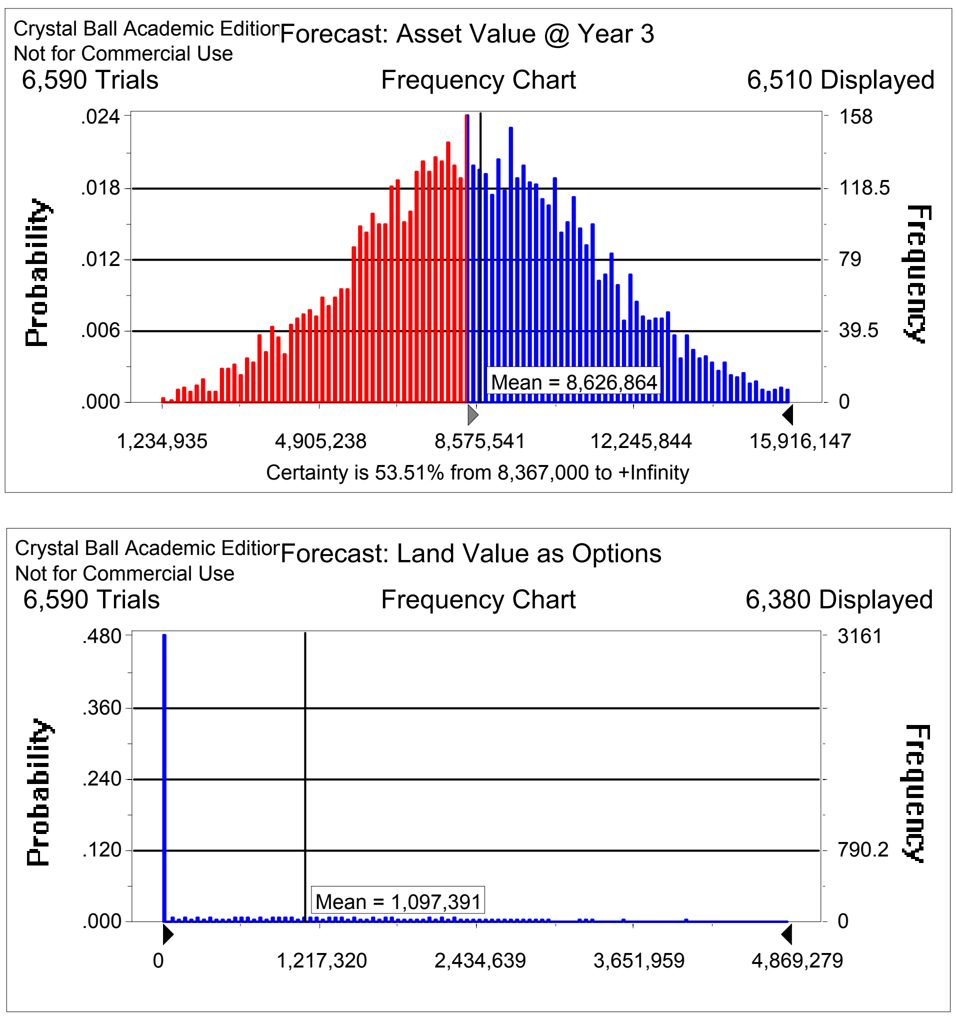
   hence,

   $S_n = S_{n-1} + \delta S_n = S_{n-1} + S_{n-1}[(rf - y) \cdot \delta t + \sigma\varepsilon\sqrt{\delta t})]$
3. Asset price in each time step can be set up as a above relationship. A software package such as Crystal Ball® can simulate these changes in asset prices repeatedly by generating random variable ε.
4. For a European call option, we can calculate payout as $C_N = Max(S_N - X,0)$, at the terminal asset value from each simulation. This value is discounted back to the present with the risk-free rate: $C_0 = C_N \cdot e^{-rf \cdot T}$

5. After a number of trials, the mean of all the trial values of C_0 is approximate value of the call option price.

The simulation values the European call option as $1,097,000, based on input variables from the example in Figure 3.1 and 4.9. The same option is valued at $1,092,000 based on the Black-Scholes formula and it demonstrates that simulation generates a fairly accurate value. A major advantage of simulations is that they generate a distribution of an underlying assets and options value, instead of a single value, as shown in Figure 4.11. For example, it is possible to estimate that the possibility of getting the asset value above the costs is approximately 54%.

Figure 4.11: Underlying Asset and European Call Value Distributions from Simulation



4.7. Application of Real Options Analysis to Large-Scale Real Estate Development Projects

As illustrated in the chapter three, valuing flexibilities is crucial for multi-phase long term development projects due to the conventional DCF procedure's tendency of systemically undervaluing later stage projects. A Decision Tree Analysis was previously used to address this problem but it had its own drawbacks. For instance, DTA becomes highly complicated even with a simplified assumption made in the example project in figure 4.5 – it only involved flexibilities of delaying the first phase up to three years and of abandoning the second phase at the third year if market turns unfavorable. The complex decision making flexibilities can be modeled as an option or a combination of several option. This approach would indeed value flexibilities more accurately if reliable data are available, and simplify the procedure of the analysis. For example, multi-stage projects can be valued as a sequential compound option.

In this section, the example project analyzed in figure 3.6 and 4.5 is valued with the binomial tree approach. The example had a negative NPV of 621,000 based on the conventional DCF procedure. The same assumptions and inputs are used except that the flexibility of delaying the second phase is incorporated into the analysis. Following is the list of input variable values:

> PV(office)=\$9,378,000; PV(office costs)=\$8,367,000; PV(residential)=\$17,029,000; PV(res. Cost)=\$15,661,000; σ_{office}=20%; $\sigma_{residential}$=25%; ρ=85%; office cap rate=8%; residential cap rate=7%; long term growth rate=2%; risk-free rate=5%.

The permitting structure is that the development right grants the developer an option to build an office building as a first phase within three years, and committing to build the office grants her a right to develop a residential complex until six years from now.

The project can be valued as a compound expansion option. For the purpose of the simplification, the underlying asset here is defined as a portfolio of two assets, which are not separable due to a unique permitting structure. In this way, the present value of asset is \$26,407,000 and the present value of costs is \$24,028,000. The volatility of this portfolio is then estimated by calculating the variance of the portfolio:

$$VAR_P = \sum_{I=1}^{N}\sum_{J=1}^{N} w_i w_j COV_{ij}$$

with two assets, variance of the portfolio becomes

$$VAR_P = w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1 w_2 \rho_{1,2}\sigma_1\sigma_2$$

where w_1 = 9,378,000/26,407,000 = 0.36 and $w_2 = 1 - w_1 = 0.64$, and then

$$VAR_P = 0.36^2 \times 0.2^2 + 0.64^2 \times 0.25^2 + 2 \times 0.36 \times 0.64 \times 0.85 \times 0.2 \times 0.25 = 0.0505$$

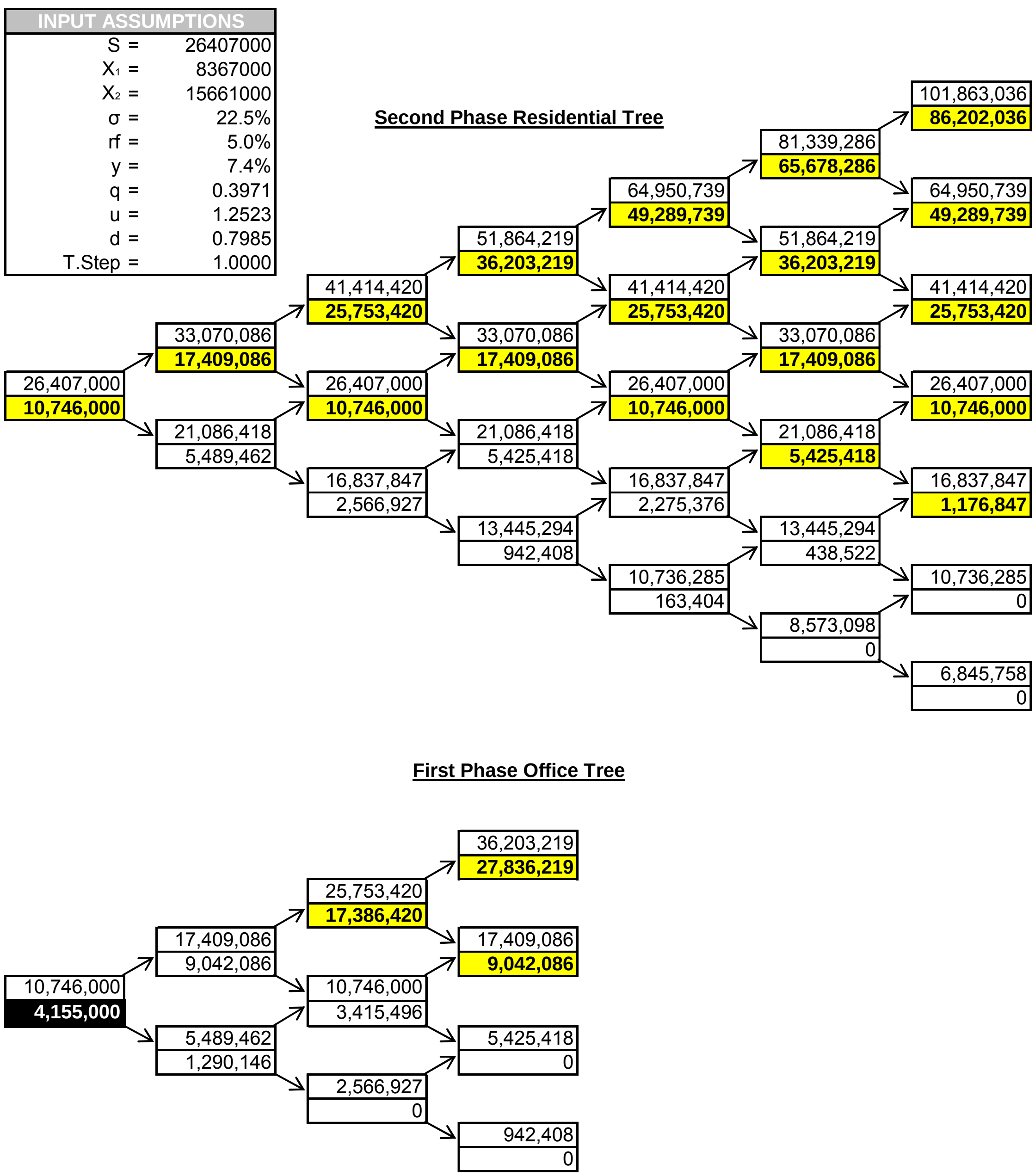
$$Volatility(\sigma_p) = \sqrt{VAR_p} = \sqrt{0.0505} = 22.5\%$$

The portfolio income yield rate is assumed to be the weighted average of cap rates:

$$y = 0.36 \times 0.8 + 0.64 \times 0.7 = 0.74 = 7.4\%$$

With these input variables in mind, the project is structured as an sequential compound option that has the first option (office) with the strike price of \$8,367,000 and 3 years to maturity, and the option to move onto the second phase (residential) with the strike price of \$15,661,000 and 6 years to maturity. The valuation of this option works backward in a way that first option payoff is dependent on the second option payoff. The binomial tree provides a convenient tool for this type compound expansion option. First, the underlying asset price movement can be mapped out using the volatility calculated above. Second, the option payoff for the second phase can be derived from the asset tree. Thirdly, the first option payoff is derived from the previous option payoff as if the second option payoff is the asset tree for the first option. Figure 4.12 is the illustration of this procedure. The resulting implied value of the land is \$4,155,000 which is worth \$1,779,000 more than the value calculated from the conventional DCF procedure. Also, since the land can be purchased at $3,000,000, it generates the positive NPV of $1,155,000. It is worth noting that the land value from the options approach is 75% higher than the value from the DCF approach just by accounting for the flexibilities of delay and abandonment. To be sure, the options value calculated here is only an approximate figure, and it depends entirely on the validity of the

Figure 4.12: Multi-Phase Development Project as Sequential Compound Option



*Shading indicates where an option is exercised.

assumptions made. Furthermore, it is unlikely that we can reduce real world development projects into such a simple options structure. However, it can help investors to avoid mistakes of rejecting the project because the conventional NPV showed up negative and this analysis can be used in conjunction with other types of qualitative and quantitative analyses.

4.8. Shortcomings of Real Options Analysis

Real Options as illustrated with previous examples can be an effective tool to value flexibilities of real estate projects. However, the examples used here are highly stylized to simplify complex real world situations, and yet it involves input variables that are not easy to estimate. To use this tool in a practical manner, it is important to know what underlying assumptions of Real Options models are and how they are related to the real world projects. By acknowledging and understanding its shortcomings, mistakes of blindly accepting results from Real Options models can be avoided, and at the same time, investors can put outcomes of the analysis in a appropriate perspective.

The major shortcomings of Real Options, when applied to real estate and other real assets, are originated from its most fundamental assumptions mentioned in the chapter 4.5. The first assumption is that the underlying asset price changes follow random walks, and their patterns can be modeled by stochastic processes. The most frequently used model is the Geometric Brownian Motion (GBM) and the most Real Options models are based on this assumption. The methods introduced in the chapter 4.6 – closed form formulas, Monte-Carlo simulation and binomial tree – are also based on the GBM model. However, whether real estate can be modeled with GBM is not evident. The GBM model works quite well for efficient markets such as the stock market but it is well known that the real estate market is not efficient and tends to be cyclical in nature. It is possible to use other stochastic processes such as mean reverting processes[19] described by Dixit and Pindyck (1994). However, the applicability of this model to real estate is not validated and the inefficiency in the real estate market would make testing difficult to do. More importantly, the typical procedures of using binomial tree, which is the most intuitive method for average practitioners, is based on approximation of the GBM model, and other more sophisticated models are challenging to implement within a binomial tree framework. In addition, the standard GBM model assumes a constant and known drift rate (required return of an asset) and volatility, and these assumptions might not hold true in real world situations. Therefore, to use Real Options as a quantitative tool, it is crucial to test the models against the real world market data. Academics have tried to perform empirical testing of Real Options models[20], and in most cases, confirmed a range of options value in the real estate market. Nevertheless, the accuracy of the real options value has not been yet validated.

The second fundamental assumption for Real Options valuation method is that there are no arbitrage opportunities and options payoff can be perfectly replicated by holding some portion of the underlying asset and borrowing (lending) at a risk-free rate. Then, the price for an option can be derived from the price and the volatility of the underlying asset. Use of risk neutral probabilities and risk-free rate as discount rate is applicable under this assumption. For financial options, this assumption holds fairly well since there are very well functioning markets for financial assets such as stocks and bonds. Thus, the accurate price for the underlying asset is readily observable and the volatility of the asset price can be easily estimated through the historical data. On the contrary, the typical underlying asset for Real Options, such as R&D project, does not trade in a market, and thus constructing replicating is not practically possible.

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[19] According to Dixit and Pindyck (1994), a simple mean-reverting process can be modeled as "$dx = \eta(\bar{x} - x)dt + \sigma dz$," where η is speed of reversion and $\bar{x}$ is normal level of x.

[20] See Chapter 2 Literature Review for the information regarding the empirical studies conducted by academics.

Options on real estate are somewhere in the middle of these two cases in that there is a functioning market for real estate and yet the market is not as efficient. Moreover, each real property is unique and there is no guarantee that the properties to be developed on the land are identical or perfectly correlated with other properties currently observable in the market.[21]

For typical real options, the problem of constructing a replicating portfolio is addressed in two ways. Arman and Kulatilaka (1999) suggested that the underlying asset of a real option can be replicated with a portfolio of traded investments. For instance, the replicating portfolio for the option to build a specific textile mill can be a portfolio of textile mill stocks. Also in real estate, an investment in a specific piece of vacant land can be replicated with a portfolio of public REITs. This approach would make constructing a replication portfolio of a real option efficient and practical. However, it suffers a huge conceptual flaw. That is, it is highly unlikely that financial instruments on similar business are perfectly correlated with a specific real asset. Therefore, this approach provides only a rough approximation of underlying asset value. Copeland and Antikarov (2001) proposed an alternative approach that uses the project value calculated with DCF method as the asset value. The volatility of the project is then estimated by performing a Monte Carlo simulation of project cash flows and their variability. This approach depends on the reliability of the original DCF valuation, and some degree of subjective inputs are required to estimate the volatility of the asset. The examples in the last chapter are based on the underlying asset value calculated from the conventional DCF procedure. This approach has a practical advantage because investors would use the conventional DCF method regardless, and thus it can present the Real Options valuation in a familiar context to most investors.

[21] In the case of stock options, the underlying asset (shares of stock) is identical to any other share of the same company, so that the perfect correlation is guaranteed. Even in this case, it is worth noting that Real Options method uses parameters from the past data to estimate future movement pattern of the stock, and if there is a fundamental shift in the company's business, the options valuation based on the past data can be misleading.

Even if we can construct a replication portfolio based on aforementioned methods, the "no arbitrage" principle should hold for conceptually realistic options valuation. To satisfy the condition of no arbitrage in theory, investors should be able to buy and sell any fractional shares of the underlying asset continuously or at least in a frequent interval and at little or no transaction costs. Most real assets would not satisfy this basic premise of no arbitrage and it is one the most critical conceptual difficulty that the Real Options method suffers. Brealey and Myers (2003) argues that we cannot rely on the arbitrage argument because of most real assets are not freely traded. In the context of real estate, since there is a functioning market, investors can hold a similar property to the one that is going to be developed. And thus, it is possible to construct an approximate replicating portfolio, although doing it in the real world would prohibitively costly. The point here is that, when valuing a piece of land as an option to build, it is important to acknowledge that the underlying property does not yet exist and a perfect replicating portfolio would not be possible due to the uniqueness of each property.

Besides these conceptual difficulties, there are other obstacles for applying Real Option in a real world project. Lander and Pinches (1998) summarized the reasons for the limited used of Real Options in corporate decision-making as follows:

- *The types of models currently used are not well known or understood by corporate managers and practitioners. Also, corporate managers, practitioners, and even many academics do not have the required mathematical skills to use the models comfortably and knowledgeably.*
- *Many of the required modeling assumptions are often and consistently violated in a practical real option application.*
- *The necessary additional assumptions required for mathematical tractability limit the scope of applicability.*

Technically difficulties mentioned stems from the difficulty of construction a replicating portfolios and the shortcomings of approximating them. The major obstacle for practical implementation seems that the concept of Real Options is not well known and intuitively comprehensible for average investors. Mathematical concepts behind the options models are too sophisticated to be used by most investors. Without the understanding of the underlying concepts, the existing Real Options models are "black boxes" for investors and it would not be possible for them to use these models in an analytical manner. On the other hand, the wide acceptance of the conventional NPV is partially due to its ease of use and manipulability. Even the binomial model, which is the most intuitive options model, requires the knowledge of the risk neutral dynamics and it is not something the majority of investors can understand intuitively.

4.9. Comparison of Underlying Values in Decision Tree and Real Options

Both Decision Tree and Real Options are useful tools for incorporating flexibilities into an investment analysis. In theory, if the structure of flexibility and the underlying assumptions are identical, both models should give same results. The major difference between two is that Decision Tree involves real probabilities – often subjectively determined – and risk adjusted discount rate and Real Options use risk-neutral probabilities – calculated based on risk-neutrality – and risk-free discount rate. Because of the similarity between two approaches, it is possible to get additional insights by comparing directly to each other.

Consider an example of real estate development project based on figure 3.1[22]. For the sake of simplicity, only one period is considered. Based on its 20% annual volatility, the up movement (*u*) of 1.2214 and the down movement (*d*) of 0.8187 is estimated.[23] Assuming the asset price in the next year would be reduced by the income paid, the one year asset price movement can be approximated as in figure 4.13. Based on this price movement, we can think of flexibilities both in Decision Tree and Real Options frameworks. For both approaches, the flexibility here is either

[22] The following input variables will be used as in Figure 3.1 except *T* and *y*: S = \$9,378,000; X = \$8,367,000; $\sigma = 20\%$; $T = 1$; $rf = 5\%$; $y = 8\%$.

[23] $u = e^{\sigma\sqrt{\delta t}}$, $d = e^{-\sigma\sqrt{\delta t}} = 1/u$.

to build now or to build in the next year only if the market is favorable. Since the structure and the underlying assumptions here are identical, both approaches should produce a same result.

Figure 4.13: One Year Asset Price Movement

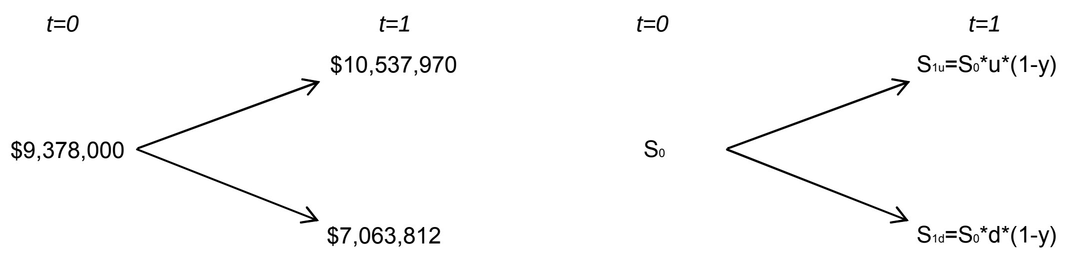


Figure 4.14 illustrates the framework of Decision Tree based on the asset price movement shown in figure 4.13. Here, the expected payoff in each decision can be easily estimated. When the property value drops below the construction cost during the down market, the developer simply would not build and thus the payoff equals zero. During the up market, the developer can realize higher profit by waiting one year. As mentioned in the chapter 4.3, the problem with Decision Tree is that it is difficult to estimate the probabilities of outcome (*p*) and the appropriate risk adjusted discount rate (r_c). Without knowing theses two values, it is not possible to know whether waiting creates higher value than building immediately. The value of immediate exercise – building now – is known and is $1,011,000. The value of waiting can be expressed as:

$$C_0 = e^{-r_c} \cdot [p \cdot Max(S_{1u} - X, 0) + (1-p) \cdot Max(S_{1d} - X, 0)]$$

Figure 4.14: Decision Tree Version of Development Option

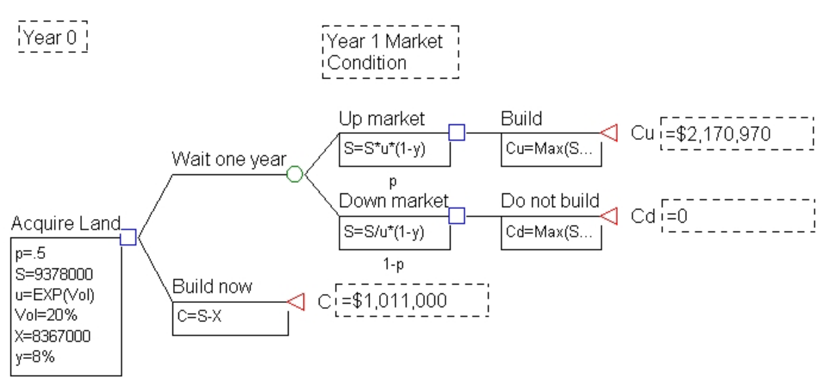
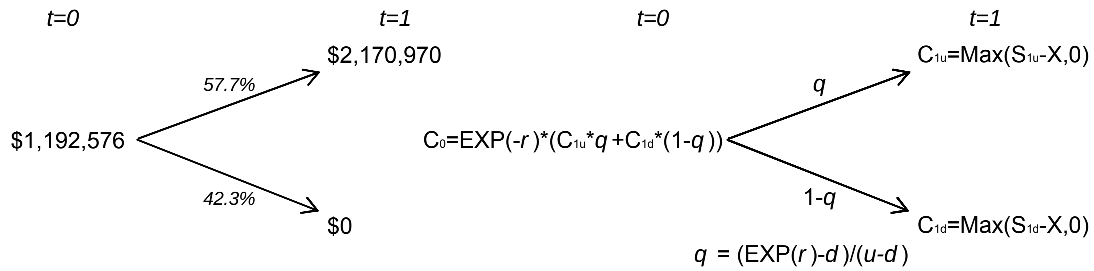


Figure 4.15: Real Options (Binomial Tree) Version of Development Option



On the contrary, the Real Options approach effectively eliminates guesswork regarding probabilities and discount rates by using risk neutral dynamics. Once the risk-free rate is known, the call option value can be calculated in a straightforward way:

$$C_0 = e^{-rf} \cdot [q \cdot Max(S_{1u} - X,0) + (1-q) \cdot Max(S_{1d} - X,0)]$$

where, $q = (e^{rf} - d)/(u - d)$

Between two formulas, we can see only difference is the probabilities and the discount rate. The two equations should give an identical result since they are valuing exactly same situation. By making this comparison, it is possible to gain further insights on the real world probability and risk-adjusted discount rate. As shown in figure 4.15, the option value of the land is $1,192,576 based on the binomial tree approach. The result from the decision tree should equal to this value. Now, since we already know the land value, there are only two unknown variables from the formulas from the decision tree. If the real probability (p) is known, it is possible to estimate the risk adjusted discount rate (r_c), or vice versa. For example, assume the real probability of up market is 60%:

$$C_0 = e^{-r_c} \cdot [p \cdot Max(S_{1u} - X,0) + (1-p) \cdot Max(S_{1d} - X,0)]$$

$$r_C = \ln \frac{[p \cdot Max(S_{1u} - X,0) + (1-p) \cdot Max(S_{1d} - X,0)]}{C_0}$$

$$= \ln \frac{(0.6 \times 2{,}170{,}970 + 0.4 \times 0)}{1{,}192{,}576} = 8.8\%$$

This result shows that if the real probability of up market is 60%, the discount rate[24] for the development project should be 8.8%.

In the context of real estate development projects, although it is hard to know real probabilities, it is possible to reasonably estimate the development period risk-adjusted discount rates. The methodology introduced in the chapter 3 is also relevant for valuing development option. The development period return from the chapter 3.2 reflects similar risks as in the land development option.[25] That is, they are both coming from the risks of achieving expected profit or payoff ($S - X$) when the land is developed. Therefore, the development required return formula can be restated as follows:

$$r_C = \left[\frac{(S_T - X_T)(1+r_S)^T (1+r_f)^T}{(1+r_f)^T S_T - (1+r_S)^T X_T} \right]^{(1/T)} - 1$$

$$= \left[\frac{\left(S(1+r_S)^T - X(1+r_f)^T\right)(1+r_S)^T (1+r_f)^T}{(1+r_f)^T (1+r_S)^T S - (1+r_f)^T (1+r_S)^T X} \right]^{(1/T)} - 1$$

$$= \left[\frac{S(1+r_S)^T - X(1+r_f)^T}{S - X} \right]^{(1/T)} - 1$$

where,

S = current value of underlying asset, S_T = underlying asset value @ T year,

X = current value of construction cost, X_T = construction cost @ T year,

r_S = discount rate for underlying asset, r_f = risk-free rate, and

T = time to construction completion.

[24] This discount rate reflects risks of getting the payoff (S-X) a year later, and it should not be same as discount rate for the underlying asset. The discount rate for the land as an option should be higher because options are inherently riskier and they are equivalent to a levered position on underlying assets.
[25] See page 21~22.

The formula presented above can capture shifts in risks as the asset price changes in the future, and thus it is appropriate to use within the Decision Tree framework. For instance, as the asset price increases, the risk level would drop due to the lower leverage, and the formula incorporates this change in risks accordingly. Using this method, the discount rate for the payoffs in the decision tree in figure 4.14 can be calculated[26]:

$$r_C = \left(\frac{9{,}378{,}000 \times 1.115^3 - 8{,}367{,}000 \times 1.05^3}{9{,}378{,}000 - 8{,}367{,}000} \right)^{(1/3)} - 1 = 48.5\%$$

Since the value of waiting is already known through the Real Options model, we can estimate the real probabilities of the up market:

$$C_0 = e^{-r_c} \cdot [p \cdot Max(S_{1u} - X, 0) + (1 - p) \cdot Max(S_{1d} - X, 0)]$$

$$p = \frac{C_0 \cdot e^{r_C} - Max(S_{1d} - X, 0)}{Max(S_{1u} - X, 0) - Max(S_{1d} - X, 0)}$$

$$= \frac{1{,}192{,}576 \times e^{0.485} - 0}{2{,}170{,}970 - 0} = 89.3\%$$

Assuming the discount rate of 48.5% for the land option, the true probability of the up-market should be 89.3%.

This process illustrates that it is possible to use the Decision Tree with less subjective input assumptions if investors can obtain information on either risk levels or real probabilities. More importantly, it can help investors avoid mistakes of using equal probabilities for all outcomes due to the lack of information. For instance, using 50% probabilities for the above example would undervalue the waiting option. Directly comparing Decision Tree and Real Options reveals the advantage of the Real Options approach more clearly. However, it is important to note that this advantage is only relevant where there is sufficient market information and the investment

[26] Time to construction completion (*T*) is assumed to be 3 as in the example in the chapter 3.

uncertainty comes from the market. When the uncertainty of a project is not market driven, the decision tree analysis would be more appropriate because it shows effects and flows of decision making in an intuitive manner. In the real estate development industry, the market risk such as the volatility of property values can be modeled more efficiently with Real Options. Project specific risks such as permitting and environmental risks can be analyzed though Decision Tree and other management science techniques.

Ch. 5. Case Study Background: New Songdo City Project

New Songdo City (NSC) is a massive public and private sector project based on the South Korean initiative to become an economic hub of the Northeast Asian region. The project also is the first-ever US-South Korean real estate joint venture, and ranks as the largest international real estate investment in South Korea's history with the estimated cost US $ 12.7 billion over 12 years (Muto, 2004).

The project involves a tremendous amount of risks especially due to the sheer size and complexities of the project. At the same time, it also presents a rare opportunity for the involved parties to create substantial profit as well as a brand-new world class city. I believe that the success of the project depends on the effective management and allocation of risks. Enormous amount of uncertainties related to the project requires the used of methods that incorporates flexibilities of future strategies, and this makes Decision Tree Analysis and Real Options Analysis all the more relevant.

The purpose of this chapter is first to understand the structure and background of the project, and secondly, to identify risks involved in the project and determine which on of them are most crucial to maximize value of the project. The following preliminary analysis is mostly based on the information regarding the first phase of the project.

5.1. Project Background

Shortly after the International Monetary Fund Bailout of South Korea in 1997, the City of Incheon and the Korean Central Government agreed to implement a long-term economic growth and development strategy for Korea which was based on turning Korea into a service and technology based global economy. Three major strategies were identified based on this initiative: a new international airport, a central place to house this new economy and substantial economic incentives to induce foreign investment to Korea.

In March 2001, the $5 billion Incheon International Airport opened. It is the 2nd largest airport in the world and is capable of handling up to 50 million passengers annually. After the first year, the air traffic count stood at 27 million passengers with 240,000 flights. It is designed to handle up to 50% of the world's air traffic flow by 2010. The Airport is connected to the mainland 5 miles away by an 8-lane bridge and commuter rail system to Seoul, which will be completed in 2005.

In the late 1990's, the City of Incheon began reclaiming approximately 3,000 acres of land along the southwest edge of the Incheon City coastline in order to create a platform for a new, world-class master planned community [See Figure 5.1]. This land would ultimately be developed by many international as well as domestic companies into a city of approximately 500,000 people and with services and amenities unlike any other city in the world. The goal of the city and the central government is to turn this land into “New Songdo City, the Hub of Northeast Asia".

In early 2001, the City of Incheon granted POSCO E&C (a subsidiary company of POSCO, the 2nd largest steel manufacturer in the world and one of the top companies in Korea) with a 6 month developer designation to act as the lead Master Plan Developer for the first 1,500 acres of reclaimed land at New Songdo City. This designation was subject to POSCO obtaining a foreign development partner with a majority interest in the venture. The purpose of that condition was to encourage foreign investment capital and user groups to New Songdo City, as well as to insure that this new city be designed and built above and beyond normal Korean standards.

Figure 5.1: New Songdo Reclamation

Source: The Gale Company

In April 2001, John Hynes and Stan Gale of The Gale Company in Boston traveled to Korea to meet with officials from POSCO and the Mayor of Incheon as well as to look at the real estate and begin to understand the dynamics of the marketplace. During this trip, The Gale Company found the following reasons to pursue this opportunity:

- The Project had the full and complete support and endorsement of the City, Central Government and South Korean President Kim.
- The land has all the necessary long-term fundamentals in place for real estate value: location, access to airport, access to public transportation, views, land that is easy to work with, utilities in place, streamlined approval process.
- The Land could be bought at 25% to 50% of the potential future market value.
- Phenomenal pent-up demand for housing and retail.
- Great potential for International demand.

- Blue-Chip Korean partner.
- Fee ownership.
- Government willing to create special Free Economic Zone designation for the area.

In July 2001, The Gale Company, POSCO E&C and the City of Incheon executed the Memorandum of Understanding (MOU) granting the development right and the land supply agreement to the newly formed joint venture company, New Songdo City Development LLC, between Gale and POSCO. Recognizing the importance of closing the land in order to start some construction activity soon, the City and NSC identified 94 acres of land out of the 1,376 acre parcel as an immediate development priority. As such, the 5.5 million square foot Convention Center Complex, with an estimated total cost of approximately $1.3 billion, was approved by the City and is now in the design-development phase.

The total cost of the 12-year build out is estimated to be approximately US $20 billion for roughly 100 million square feet of space and with $1 billion in land costs for the 1,000 net buildable acres. New Songdo City represents the single largest private development project ever. It is the largest land reclamation project outside of the Zuider Zee in the Netherlands. Through the 70/30 partnership with Posco E&C, The Gale Company becomes the first legal foreign owner of Korean soil.

5.2. Project Structure and Participants

5.2.1. The Project Company and Sponsors

<u>Project Company</u>

Although the selected project sponsors (The Gale Company and POSCO E&C) shared optimism regarding the project's success, their main goal of the project structure, especially for The Gale Company, is to make sure to shield the sponsoring firms from any economic or legal downfalls. As shown in the figure 5.2, The Gale Company created several layers of special purpose project companies for this purpose. It is also important to note that the sponsors created two separate companies, one for the development operations and the other for the equity ownership of the project. This separation can in fact work well for this type of the project, since each company can take on different and separable roles and risks: Gale International LLC would be responsible for developing and operational aspects of the project, and New Songdo City Development LLC would be the holding company of assets generated.

Managing Partner: The Gale Company

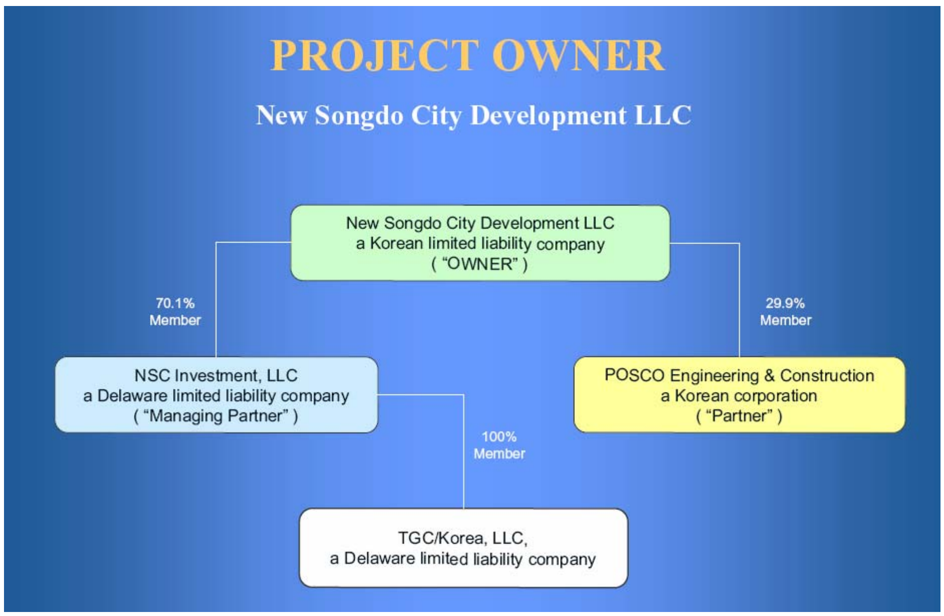
The Gale Company (Gale) is a real estate investment, development and service company headquartered in Florham Park, New Jersey with a portfolio exceeding 50 million square feet of commercial property. Since its inception, Gale has invested over $3 billion on behalf of its investment partners. The Gale Company has developed strategic relationships with several leading institutions and corporations, such as Morgan Stanley, UBS/PaineWebber, J.P. Morgan, Credit Suisse First Boston, Blackstone Real Estate Advisors, and The Principal Financial Group.

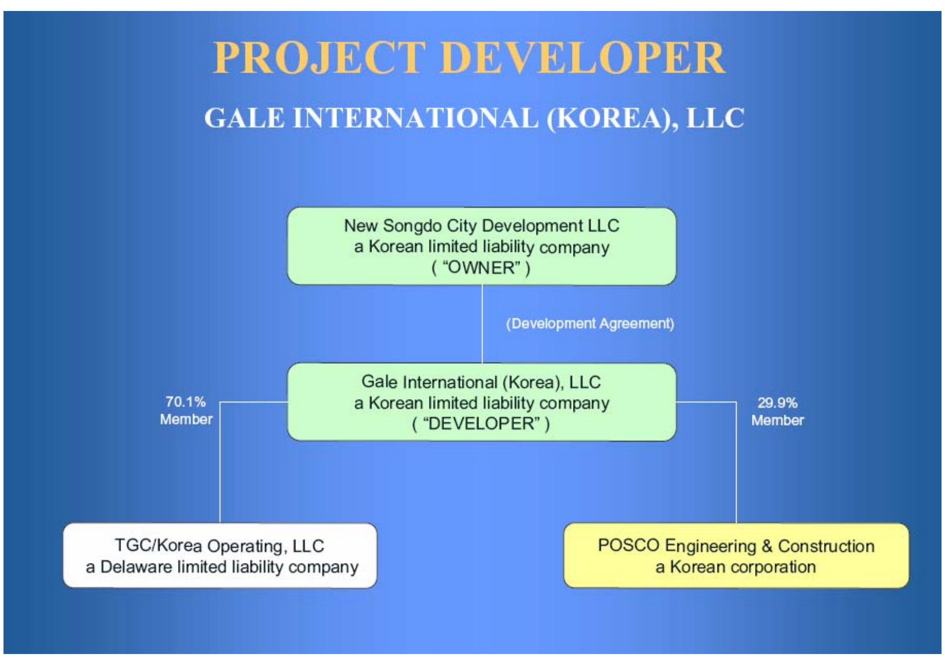
Besides the massive capital requirement, what the city of Incheon and POSCO E&C did not have was The Gale Company's extensive list of institutional investors and clients. Clearly, for Koreans, Gale's primary role in the project was attracting both foreign investors and tenants, so that the project becomes truly international in nature and thus would achieve the goal of an international economic hub.

Local Joint Venture Partner: POSCO E&C

POSCO E&C is a subsidiary of POSCO, which is the world's second largest steel producer. It is ranked 7th in terms of the construction revenue and also is the only Korean construction company that has a triple A credit rating from the local credit agency (Korea Rating, 2002). Larger construction companies, such as Hyundai Construction Company, went near bankrupt during the

Figure 5.2: Project Company Structure





Source: The Gale Company

late 90's currency crisis, and were still struggling to get out of the excessive corporate debt they accumulated for years (Yahoo Finance Korea, 2004).

POSCO E&C's revenue in 2002 exceeded US $ 1 billion and its assets are valued around US $ 962 million [see Figure 5.3]. For POSCO E&C, despite its decent size of balance sheet and sales revenue, it would not be possible for the company finance the entire project due to its sheer size. However, POSCO E&C jointly with POSCO Steel could contribute substantial amount of the equity capital, and thus play a role of managing partner. On the other hand, POSCO E&C's specialty is engineering and construction and it has limited expertise in international marketing, finance, and management. Naturally, POSCO E&C's major interest in the project would be construction contracts and the management fees.

Figure 5.3: Summary Income Statement and Balance Sheet of POSCO E&C

Summary Income Statement (in US $1,000)

YEAR	1999	2000	2001	2002
SALES	$706,653	$487,021	$735,381	$1,185,488
COST OF SALES	$613,497	$431,611	$638,501	$1,017,931
GROSS PROFIT	$93,155	$55,410	$96,880	$167,557
OPERATING INCOME	$51,161	$19,052	$50,485	$101,249
ORDINARY INCOME	$63,209	$25,482	$44,697	$61,741
NET INCOME	$37,978	$15,162	$34,004	$48,907
NET INCOME TO SALES(%)	5.4%	3.1%	4.6%	4.1%

Summary Balance Sheet (in US $1,000)

YEAR	1999	2000	2001	2002
TOTAL ASSETS	$925,528	$852,663	$823,237	$961,885
CURRENT ASSETS	$594,988	$544,494	$479,069	$641,300
NON-CURRENT ASSETS	$330,540	$308,169	$344,168	$320,585
TOTAL LIABILITIES	$387,026	$339,843	$306,201	$384,043
CURRENT LIABILITIES	$273,790	$266,651	$272,332	$350,441
LONG-TERM LIABILITIES	$113,236	$73,192	$33,869	$33,602
SHAREHOLDERS' EQUITY	$538,502	$512,821	$517,036	$577,841
COMMON STOCK	$299,895	$272,684	$259,016	$124,958
RETAINED EARNINGS	$238,607	$240,137	$258,020	$452,883

Source: www.poscoenc.com

5.2.2. The Korean Government

The New Songdo Project is a part of the government initiated plan to build three Free Economic Zones (FEZ) modeled after the success of those in Chinese cities such as Shanghai and Hong Kong's. Big part of this plan is to encourage as much foreign direct investment as possible through the provision of a set of incentives, such as income tax exemption for foreign workers and better services tailed to accommodate foreigners (Korea Ministry of Finance and Economy, 2004). Furthermore, the Korean government promises to deliver massive infrastructural facilities:

It plans to develop the FEZ-designated Incheon International Airport next to the Songdo Project as the mega-logistics hub of Northeast Asia. Incheon International Airport will have a cargo terminal expansion, duty-free district, 24 hour operation system, and entry/exit facilitation. World-class express couriers and other logistics are holding talks with the Korean government to establish their Asian regional headquarters in Incheon International Airport area (Oh, 2003). Their goal of attracting foreigners is even more ambitious. According to Kab-Won Oh, Deputy Minister of Free Economic Zone, the Korean government will actively support the FEZ infrastructure construction and host regional headquarters of the world's top 500 corporations. Five years from now, he assures, NSC will become the world's premier cosmopolitan city where everyone all over the world would want to live. It will be the magnet, the Hub of all Northeast Asia.

It is obvious that the success of New Songdo City depends heavily on whether the government can deliver its promises. NSC is the first one to be developed as FEZ, and the government has no previous track record of attracting foreign capital and companies to a single location in such a large scale. Specifically for NSC, the government committed to build a six-mile long, six-lane bridge connecting New Songdo City to the new Incheon International Airport, as well as roads making access easier to Seoul, 40 miles away (Sorohan, 2004). Without this infrastructure in place, any advantage that NSC might offer would be meaningless.

5.2.3. Financial Advisors

The most daunting task for the project sponsors is likely to be securing financing for the project. The cost for the first phase alone is estimated to be US $ 2.2 billions, and the entire cost for the 1,500 acre site is over US $ 12 billions (Incheon Free Economic Zone Authority, 2004). After the Asian Financial Crisis, the Korean government opened up its financial market to foreign firms.

Since then, the foreign banks market share in Korea has been rapidly rising [see Figure 5.4], and they have accumulated substantial know how of doing business in Korea. With help of Morgan Stanley, who had a long-term relationship with Gale for its US investments, Gale and POSCO was successful in getting first round financing of US $ 90 million for the initial land purchase and working capital needs. Woori Bank, a Korean local bank, was selected as a lead arranger together with Morgan Stanley and ABN AMRO. Woori said the US$90 million, a syndicate loan, came from US$50 million split by Woori and the state-run Industrial Bank of Korea, and US$40 million from Morgan Stanley, ABN Amro, the Bank of Nova Scotia and other investors. In addition to the first round financing, three banks – Woori, ABN AMRO, and Morgan Stanley – completed an agreement to act as financial advisors for the future financing of the project (Lee, 2004). Three advisors are currently planning to raise additional US $ 1 billion of construction financing for the first phase of the project (Woori Bank, 2004).

Figure 5.4: Top 10 Foreign Banks in Korea

	Total assets (Tril.won)		Net Profits (bil. Won)	
	2003	2002	2003	2002
City bank	11.3	11.9	56	96
HSBC	8.5	5.4	59	45
Deutsche	8.1	3.6	75	48
JP Morgan	5.4	3.8	33	27
ABN AMRO	4.9	2.8	21	8
SCB	4.7	3.8	18	28
ING	4.3	2.1	11	6
BNP Paribas	3.4	2.5	21	22
UBS	3.2	1.9	38	13
CSFB	3.2	2.9	6	-49
Total	**57**	**41**	**338**	**244**

Source: The Korea Times, March 2004

5.2.4. Project Designer: Kohn Pederson Fox PC

Kohn Pederson Fox (KPF) is New York based architecture and planning firm that specializes high end commercial buildings. KPF has designed high-rise towers and cultural centers in over 35 countries. It also has successfully completed several projects in Korean, including Dongbu

Kangnam tower and Rodin Museum. From the sponsor's perspective, KPF is an ideal planner to achieve a higher standard living environment that NSC is set out to provide Korean people.

5.3. Preliminary Analysis on Economics of Project

To evaluate profitability and return of the project, we have analyzed the economics of the project's first phase. One of the biggest incentives the Korean government provided to The Gale Company and POSCO was making the land available for substantially less than the prevailing market price of the region (The Gale Company, 2004). However, this incentive did not come free. In return, New Songdo City Development LLC (NSCD) had to build a new state-of-the-art convention center and assign it to the city of Incheon. Including the cost of the convention center, the total land acquisition cost would be still substantially less than the market value, and thus this structure would provide additional value to the sponsors when the project is completed and stabilized. In addition to the convention center, the first phase includes a new sixty story World Trade Center, high-rise residential towers, high-end retail spaces and hotels. Figure 5.5 shows the inventories of properties to be built for the first phase, with their costs and estimated benefits.

Figure 5.5: Phase 1 Project Inventories

	Building Area (Sq. Ft.)	Est. Const. Cost* (US $)		Cost per Sq.Ft. (US $)	Est. Const. Period (Quarters)	Est. Sales Rev. (US $)	Est. Ann. Income (US $)
Block 36							
Convention Center	300,000	92,048,000	5.1%	307	12	-	-
World Trade Center							
Office	648,000	112,072,000	6.2%	173	16	-	19,463,000
Residential	542,600	81,172,000	4.5%	150	16	154,871,000	-
Hotel	318,900	59,556,000	3.3%	187	16	-	7,598,000
Retail	500,700	68,406,000	3.8%	137		-	15,039,000
Hotel	700,300	130,726,000	7.2%	187		-	17,729,000
Parking Garage	1,850,000	107,516,000	5.9%	58		-	12,588,000
Block 35							
Residential	1,000,600	145,852,000	8.1%	146	8	246,755,000	-
Commercial	750,600	119,429,000	6.6%	159	8	-	21,042,000
Department Store	500,340	74,219,000	4.1%	148	8	-	12,655,000
Parking Garage	1,035,000	53,451,000	3.0%	52	4	-	6,780,000
Block 125							
Residential Towers	3,972,000	637,898,000	35.2%	161	8	952,190,000	-
Parking	1,659,800	127,398,000	7.0%	77	4	-	5,355,000
Total	$13,778,840	$1,809,743,000	100%	$131		$1,353,816,000	$118,249,000

Source: The Gale Company

It is important to note that the project involves two kinds of project. The first one is a collection of residential buildings to be sold as condominiums. According to the Gale Company's feasibility study, for-sale properties would generate profit margins in the range of 22 to 39 percent in a relative short period [See Figure 5.6]. The other portion of the project involves income producing properties such as retail, hotel, office and parking garage. This kind of properties generate around 9 to 14 percent annual income yield [See Figure 5.7]. This mix of properties gives the sponsors a flexibility that otherwise would be unavailable. For instance, it is possible to attract investors with short-term and long-term interest at the same time. More importantly, it could provide a financing flexibility using early cash flow as additional equity for the future development. We will discuss financing strategies using this early sales revenue in different ways in the later part of this paper.

Figure 5.6: For-Sale Properties Costs and Profit Analysis

PROJECT RECAP/KEY ASSUMPTIONS	**Trade Center Residential**	**Residential Towers**	**Residential**	**Totals**
Block Designation	36	125	35	
Total Building Area (Sq. Ft.)	542,600	3,971,489	1,000,600	5,514,689
Total Number Of Residential Units	145	2200	890	3,235
Residential Unit Average Size (Sq.Ft.)	3742	1639	1124	6,505
PHASE 1 Land Value Allocation	9.9%	32.6%	7.4%	49.9%
DEVELOPMENT COSTS				
Allocated Land Acqusition Costs	$36,000,000	$119,000,000	$27,000,000	$182,000,000
Subtotal - Allocated Land & Pre-Development Costs	$36,000,000	$119,000,000	$27,000,000	$182,000,000
Construction Costs per Sq. Ft.	*$129*	*$141*	*$129*	*$137*
Construction Costs	$69,890,584	$558,059,888	$128,884,111	756,834,583
Design & Supervision Costs	$4,500,000	$33,000,000	$6,200,000	43,700,000
Construction Management Costs	$2,096,718	$16,741,797	$3,866,523	22,705,038
NSC Development Overhead Costs	$3,522,098	$22,628,091	$5,188,654	31,338,843
Marketing Fees/Costs	$1,162,408	$7,468,017	$1,712,427	10,342,852
Subtotal	$81,171,808	$637,897,793	$145,851,715	864,921,316
Financing Costs	$3,753,540	$20,000,000	5292070	29,045,610
Subtotal - Development Costs	$84,925,348	$657,897,793	$151,143,785	893,966,926
TOTAL COSTS	$120,925,348	$776,897,793	$178,143,785	$1,075,966,926
Total Costs per Sq. Ft.	*$223*	*$196*	*$178*	*$195*
SALE PROFITABILITY ANALYSIS				
Sales Price per Sq.Ft.	*$293*	*$246*	*$253*	*$252*
Gross Sales Revenues	$158,842,237	$976,604,804	$253,081,528	$1,388,528,569
Sales Commissions/Closing Costs	($3,971,056)	($24,415,120)	($6,327,038)	($34,713,214)
Subtotal - Net Sales Proceeds	$154,871,181	$952,189,684	$246,754,490	$1,353,815,355
Less: Project Development Costs	($120,925,348)	($776,897,793)	($178,143,786)	($1,075,966,927)
NET SALE PROFIT	$33,945,834	$175,291,891	$68,610,704	$277,848,429
Sales Profit(Loss) per Sq. Ft.	*$62.56*	*$44.14*	*$68.57*	*$50.38*
Net Profit Margin	**28.1%**	**22.6%**	**38.5%**	**25.8%**

* Convention center development costs/sales revenues are included in land cost allocated to other portions of Phase 1.

Source: Author's assumption based on information provided by The Gale Company

Figure 5.7: Income Properties Costs and Return Analysis

PROJECT RECAP/KEY ASSUMPTIONS	Parking Garage	Retail	Hotel	Trade Center Office	Trade Center Hotel	Parking Garage	Commercial	Department Store	Parking Garage	Totals
Block Designation	36	36	36	36	36	125	35	35	35	
Total Building Area (Sq. Ft.)	1,850,000	500,700	700,300	648,000	318,900	1,659,800	750,600	500,340	1,035,000	7,963,640
Total Number Of Hotel Rooms	n/a	n/a	700	n/a	300	n/a	n/a	n/a	n/a	1000
Total Number Of Parking Spaces	4790	n/a	n/a	n/a	n/a	4890	n/a	n/a	2580	9680
PHASE 1 Land Value Allocation	2.70%	6.80%	8.20%	9.90%	4.90%	3.30%	6.30%	5.50%	2.50%	**50.1%**
DEVELOPMENT COSTS										
Allocated Land Acqusition Costs	$10,000,000	$25,000,000	$30,000,000	$36,000,000	$18,000,000	$12,000,000	$23,000,000	$20,000,000	$9,000,000	$183,000,000
Subtotal - Allocated Land & Pre-Development Costs	$10,000,000	$25,000,000	$30,000,000	$36,000,000	$18,000,000	$12,000,000	$23,000,000	$20,000,000	$9,000,000	$183,000,000
Construction Costs per Sq. Ft.	*$47*	*$117*	*$164*	*$152*	*$164*	*$70*	*$141*	*$129*	*$47*	*$94*
Construction Costs	$86,651,866	$58,630,526	$114,804,354	$98,642,610	$52,279,178	$116,614,676	$105,471,714	$64,447,208	$48,478,206	$746,020,338
Design & Supervision Costs	$1,600,000	$4,200,000	$6,000,000	$4,500,000	$2,500,000	$2,400,000	$5,000,000	$4,000,000	$1,300,000	$31,500,000
Construction Management Costs	$2,599,556	$1,758,916	$3,444,131	$2,959,278	$1,568,375	$3,498,440	$3,164,151	$1,933,416	$1,454,346	$22,380,609
NSC Development Overhead Costs	$3,131,516	$2,869,696	$4,870,149	$4,488,536	$2,412,106	$4,189,741	$4,355,665	$2,885,609	$1,903,225	$31,106,243
Marketing Fees/Costs	$519,323	$947,094	$1,607,310	$1,481,365	$796,075	$694,816	$1,437,513	$952,346	$315,626	$8,751,468
Subtotal	$94,502,261	$68,406,232	$130,725,944	$112,071,789	$59,555,734	$127,397,673	$119,429,043	$74,218,579	$53,451,403	$839,758,658
Financing Costs	$3,013,134	$5,120,000	$6,482,500	$6,034,600	$5,259,900	$4,450,100	$7,115,450	$4,854,000	$2,892,650	$45,222,334
Subtotal - Development Costs	$97,515,395	$73,526,232	$137,208,444	$118,106,389	$64,815,634	$131,847,773	$126,544,493	$79,072,579	$56,344,053	$884,980,992
TOTAL COSTS	$107,515,395	$98,526,232	$167,208,444	$154,106,389	$82,815,634	$143,847,773	$149,544,493	$99,072,579	$65,344,053	$1,067,980,992
Total Costs per Sq. Ft.	*$58*	*$197*	*$239*	*$238*	*$260*	*$87*	*$199*	*$198*	*$63*	*$134*
OPERATING ANALYSIS										
Rental/Use Revenues	$12,588,120	$15,830,242	$50,652,875	$20,487,311	$21,708,375	$5,354,550	$22,149,060	$12,655,088	$6,780,240	$168,205,861
Credit/Vacancy Factor	$0	($791,512)	$0	($1,024,366)	$0	$0	($1,107,453)	$0	$0	($2,923,331)
Subtotal	$12,588,120	$15,038,730	$50,652,875	$19,462,946	$21,708,375	$5,354,550	$21,041,607	$12,655,088	$6,780,240	$165,282,531
Operating Expenses	$0	$0	($32,924,369)	$0	($14,110,444)	$0	$0	$0	$0	($47,034,813)
General & Adminstrative Expenses	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL NET OPERATING INCOME (FFO)	$12,588,120	$15,038,730	$17,728,506	$19,462,946	$7,597,931	$5,354,550	$21,041,607	$12,655,088	$6,780,240	$118,247,718
Income per Sq. Ft.	*$6.80*	*$30.04*	*$25.32*	*$30.04*	*$23.83*	*$3.23*	*$28.03*	*$25.29*	*$6.55*	*$14.85*
Estimated Annual Net Income Yield	**11.7%**	**15.3%**	**10.6%**	**12.6%**	**9.2%**	**3.7%**	**14.1%**	**12.8%**	**10.4%**	**11.1%**

* Convention center development costs/sales revenues are included in land cost allocated to other portions of Phase 1.

Source: Author's assumption based on information provided by The Gale Company

Figure 5.8: Pro-forma Project Level Annual Cash Flow

(Figures in thousands of US dollars)

Year	Total	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Land Purchase	268,000	268,000									
Design and Construction Cost:											
Block 36											
Convention Center	92,048	4,602	7,364	18,410	24,853	23,012	13,807	0	0	0	0
World Trade Center:											
Office	112,072	5,604	16,811	22,414	31,380	24,656	11,207	0	0	0	0
Residential	81,172	4,059	12,176	16,234	22,728	17,858	8,117	0	0	0	0
Hotel	59,556	2,978	8,933	11,911	16,676	13,102	5,956	0	0	0	0
Retail	68,406	1,026	1,710	2,052	20,522	34,203	8,893	0	0	0	0
Hotel	130,726	1,961	3,268	3,922	39,218	65,363	16,994	0	0	0	0
Parking Garage	107,516	7,526	32,255	43,006	13,977	1,075	9,676	0	0	0	0
Block 35											
Residential	145,852	10,210	43,756	72,926	18,961	0	0	0	0	0	0
Commercial	119,429	8,360	35,829	59,715	15,526	0	0	0	0	0	0
Department Store	74,219	5,195	22,266	37,110	9,648	0	0	0	0	0	0
Parking Garage	53,451	3,742	16,035	26,726	6,949	0	0	0	0	0	0
Block 125											
Residential Towers	637,898	44,653	191,369	318,949	82,927	0	0	0	0	0	0
Parking	127,398	8,918	38,219	63,699	16,562	0	0	0	0	0	0
	207,774										
Total Cost	2,077,743	376,833	429,991	697,073	319,926	179,269	74,651	0	0	0	0
Residential Pre-Sales Revenue:											
Trade Center Residential	154,871	(1,858)	(1,239)	15,487	23,231	38,718	30,974	27,877	21,682	0	0
Block 35 Residential	246,755	(4,935)	74,027	78,962	98,702	0	0	0	0	0	0
Block 125 Residential Towers	952,190	(19,044)	285,657	304,701	380,876	0	0	0	0	0	0
	1,353,816										
Net Annual Rental Income*:											
Trade Center Office	357,524	0	0	0	0	0	0	9,926	16,199	20,654	289,676
Trade Center Hotel	118,599	0	0	0	0	0	0	3,875	6,324	8,063	92,112
Block 36 Retail	305,908	0	0	0	0	0	0	7,670	12,517	15,960	253,483
Block 36 Hotel	276,736	0	0	0	0	0	0	9,042	14,756	18,814	214,933
Block 36 Parking	257,448	0	0	0	0	6,420	10,477	13,358	13,626	12,588	187,353
Block 35 Commercial	471,833	0	0	0	0	10,731	17,514	22,330	22,777	21,042	354,663
Block 35 Department Store	283,768	0	0	0	0	6,454	10,533	13,430	13,698	12,655	213,300
Block 35 Parking	138,663	0	0	0	0	3,458	5,643	7,195	7,339	6,780	100,910
Block 125 Parking	109,520	0	0	0	0	2,731	4,457	5,683	5,796	5,355	79,701
Total Revenue	3,673,814	(25,837)	358,445	399,150	502,809	68,512	79,598	120,385	134,715	121,911	1,786,131
Net Cash Flow excl. Financing		(402,670)	(71,547)	(297,924)	182,883	(110,757)	4,948	120,385	134,715	121,911	1,786,131
Unlevered Project IRR	**15.44%**										

Source: Author's analysis based on information provided by The Gale Company

When we looked at the project cash flow in its entirety, the project level IRR was 15.4 percent [See Figure 5.8]. It is a respectable return compare to the average 6 to 12 percent annual return of US real estate properties. However, 15.4 percent return in itself does not confirm the financial feasibility of the project. Considering risks of a first-of-a-kind project, estimating a required return is a challenge. This return figure in fact provides very little margin for error. Cost overruns and failure to achieve the target revenue would wipe out any potential profit and likely put the project into bankruptcy. In addition, the project involves risks outside of the project, such as political and macro economical risks of South Korea. Also, given the absence of comparables, the expected revenue is hardly reliable. The expected sales price of condominium is about 30 percent above newly constructed housing nearby and is about 50 percent less than the comparables in Seoul (CB Richard Ellis, 2003). The expected annual lease for the office is about 40 percent below the market lease of Seoul CBD area. Considering the high-end nature of the planned properties, the figures look reasonable if not conservative. However, the bigger risk is whether the people would want to come and live in NSC at all. Therefore, focus should be given to the strategies for attracting future tenants and residents as well as minimizing risks in the project execution.

5.4. Identification of Project Risks and Uncertainties

5.4.1. Optimism

Although New Songdo City project involves different interests and issues among different parties, one thing shared in common was optimism and ambition regarding the project's success. The government firmly believes that the partnership with a foreign firm would warrant the success of the project. Mayor Ki-Sun Choi of Incheon stated that (Business Wire, 2002) "*We believe that this project will elevate the Republic of Korea as a leader of world trade and business. Together, government and the private sector hand in hand, we will make history and build one of the finest urban centers in the world.*"

Despite the fact that the scope of NSC is many times his firm's annual sales, Hak Bong Ko, president of POSCO E&C, believes that he can handle the entire construction within his company (Business Wire): "*With our strong financial condition and solid reputation in the construction field, we are very confident that we can execute, manage and complete the whole project in an efficient and satisfactory manner. We are proud to be playing this important role in this tremendous development.*"

John Hynes, president of the project comapny, goes even further to say that NSC will not only become "*most audacious piece of real estate in the world"* but also *"the world's most* *technologically advanced city*." He claims that the city will have canals of Venice, street scenes out of Paris, a waterfront on Chicago, schools inspired by the preps schools of New England, and a health service designed by Harvard (Piore, 2004).

Amongst all the optimisms, concrete strategies of how to achieve these ambitions seem still vague. I believe that the only way to get anywhere close to the ambitions laid out by NSC is to carefully align interests of different parties and effective allocate risks and benefits among involved parties.

5.4.2. Political and Policy Risks

The development plan for the Incheon free economic zone, which is the core strategy of the government to develop the area as the logistics hub in Northeast Asia, was introduced on October, 2003, during the national agenda meeting under the supervision of President Roh Moo-hyun (Incheon Free Economic Zone Authority, 2003). It is one of the nation's top priority projects and thus the Korean government would be the last one who would get in the way of building NSC. John Hynes' perception of the Korean government further confirms the positive involvement of the government. He said that "*What we found, which was unusual for a U.S firm, is not only New Songdo City a great piece of land, but the government is supporting us. Unlike the U.S., where you can run into barriers, here the Korean government is pulling us along* (Sorohan, 2004)."

For this project, the real problem arises from the government is that it may have promised too much. The related infrastructure projects alone are estimated to cost around US $ 7 billion [See Figure 5.9]. NSC's success is entirely dependent upon whether the government can deliver its promises. For instance, the initial failure of Canary Wharf, similar real estate development project in London, was largely due to the lack of transportation infrastructure (Poorvu and Segal, 2004). Also government's plan to finance 90 percent of all the development cost from abroad draws lots of skeptics. One government official admits that "*The financing plan is too vague. Unless the major portion of the required funds comes from the National Treasury, the success of the Incheon Free Economic Zone cannot be guaranteed.*"

One of the most critical mistakes the government and the sponsors of NSC made is that the government did not have a financial stake in the project itself. In fact, the toll bridge connecting between NSC and Incheon Airport is the only infrastructure project that secured a financing arrangement, and the government provided 50 percent of debt and equity under the structure of project finance.

In this context, NSC needs to convince the government to make a considerable direct investment in the project. Failing to do so would make its goal of attracting foreign investors very difficult and foreign investors would demand higher interest or return for their investment due to the

Figure 5.9: Incheon Free Economic Zone Metropolitan Infrastructure Plan

The 2nd Airport Bridge (to be complete by 2008)
Direct connection of Songdo to Incheon International Airport.
Project cost: US$ 774.8 million (909.4 billion Korean Won) (10.25 km, 6 lanes)
Developer: AMEC (UK)

The 2nd Seoul Belt Expressway (to be complete by 2008)
Initial opening between Songdo to Cheongna(21.5km)
Project cost: US$ 639 million (750 billion Won)
Developer: POSCO, E&C

The GyungIn Express Bridge (to be complete by 2008)
Direct connection of Songdo to southern part of Gyongki province.
Project Cost: US$ 448.3 million (526.2 billion Won)
Developer: The 3rd GyungIn Corporation.

Gyongin Expressway extension line (to be complete by 2008)
Direct connection of Cheongna to West Incheon IC.
Project Cost: US$ 218.1 million (256.6 billion Won)

Airport Railway (completed 38% of the 1st phase)
Phase 1: Incheon International Airport to Gimpo airport(to be complete by 2005)
Phase 2: Gimpo airport to Seoul Central Train Station.

enormous perceived risks. Furthermore, it would make a long term fixed rate financing virtually impossible. On the other hand, the current government's support does not warrant the same support from the next one. The next presidential election will be held in the year 2006, when the construction would be half way through. Koreans have had mixed responses toward foreign direct investment, and it is possible that a new government could change its direction completely. This change in the opposite direction is more likely to happen when the project goes bad, and government's investment in the project would be an insurance against adverse impact of the sudden change in the government policy.

5.4.3. Economic Risks

International Finance Corporation (2004) lists currency risks and interest rate risks as the two most important economic risks. There are many tools available to manage these two risks, and thus the exposure to theses risks can be minimized. However, the bigger risk for NSC would be the future growth of the Korean Economy. The scenario of NSC and Free Economic Zone is based on the assumption that Korea can maintain its high growth rate of the past by switching to a knowledge based economy. If this assumption does not hold, the long term prospects of NSC would be dismal at best.

<u>Currency Risks</u>

According to the International Finance Corporation (2004), any type of foreign exchange fund would involve some degree of currency risks. Korea has a very active currency swap market (Bank of Korea, 2004), and thus it provides most convenient way of mitigating currency risks. Also the degree of the inherent currency risks in the project can be reduced by capitalizing on the fact that NSC is to primarily attract foreigners. Current financing scheme involves 50 percent of local currency debt and 50 percent of US $ nominated debt. If NSC can attract similar proportion of local and foreign tenants and residents, NSC can receive the Korean currency revenue from locals and US $ revenue from foreigners. This is more feasible based on the government's plan to use all of US $, Euro, and Korean Won as a common currency. The Korean Won revenue will be used to service local debt, and US $ revenue to service foreign debt. In this way, NSC can effectively minimize currency risks without entering costly currency swap contract.

Interest Rate Risk

Interest Rate Risk is more problematic for the project than currency risk due to the difficulty of getting fixed-rate, long-term loans for high risk projects. According to the IFC (1999), floating interest rates are the norm rather than the exception for project financed loans. The best way to mitigate interest rate risks is to negotiate a fixed interest rate. Considering high risks of the project, it is entering long-term fixed rate contract is unlikely. In this case, NSC has an option of entering an interest rate swap contract. Although the Korean derivative market has been gaining liquidity in the recent years, fixed rate interest swap is only available up to three years and long-term contract is rarely available (AsiaRisk, 2004). Despite the current low rate environment, I believe that managing interest risk is important due to the size of future construction loan. For the loans from the foreign banks, NSC can use the international or the US capital market for interest rate swaps. And for the local loans, NSC can still enter short term local interest rate swap contract. In addition, NSC can rapidly amortize outstanding loans using early cash flows generated by for-sale properties, and thus reducing the interest rate exposure and the hedging cost over time.

5.4.4. Construction Risks

The current plan for NSC is that POSCO E&C will be construction manager overseeing all the construction process of the project. Although POSCO is a very highly rated local company with revenues of $1.1 billions in 2002, assigning all the risk to a company is a questionable strategy and warrants further investigation. POSCO may have the financial capacity to bear some of the construction risk for the general buildings, but not for the whole project. Further diversification of the construction risk may be necessary. It is important to note that the project involves multiple properties with different risk levels. For instance, the 60 story world trade center and convention center would involve much higher risk of cost overruns and delays than apartment buildings and parking garages. In this sense, it is possible to categorize risk levels and apply corresponding risk management strategies.

Figure 5.10: World Trade and Convention Center Complex

Source: The Gale Company

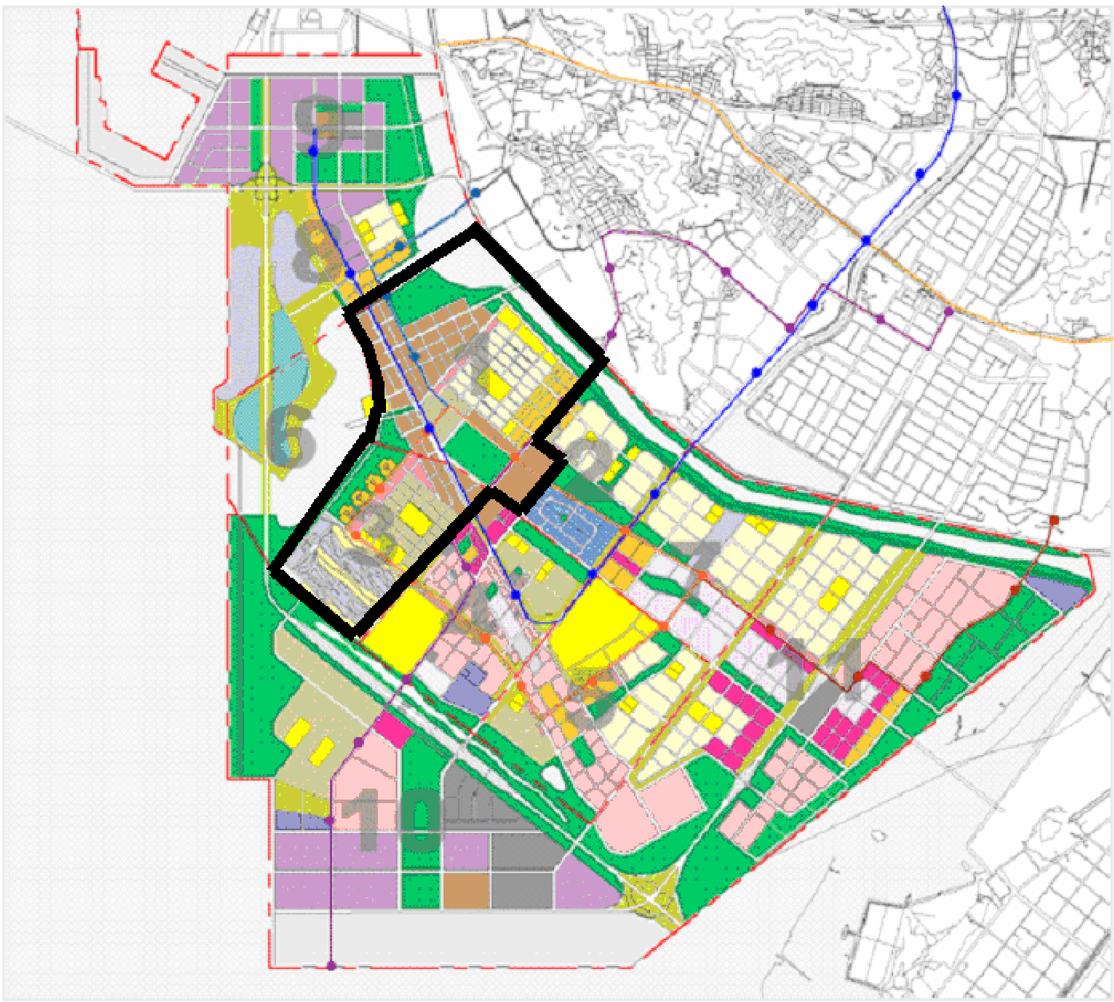
First, I believe that the first step for a risk mitigation was aligning participant's interests with appropriate risks so that there would be little agency conflicts. In this sense, the current scheme calls for a considerable revision. The using investment partner as a construction manager and contractor can be a proper strategy since any mistakes during the construction period would hurt itself as a equity investor in the project. However, POSCO's current stake in the project company is under US $ 10 million (Sorohan, 2004), and this is minuscule amount compare to the size of the construction contract. Therefore, the potential profit from the construction contract can compensate for any loss in its investment interest. To minimize the potential conflict of interests, I recommend NSC to require substantial additional equity investment from POSCO.

Secondly, even if it is POSCO's intention to achieve the highest quality of construction possible within the budget and the schedule, too much construction risk is in POSCO's hand, and it calls for some degree of diversification. For two most challenging properties – World Trade Center and convention center [See Figure 5.10] –, POSCO should be the lead contractor since it has most incentives to perform. Furthermore, we recommend bringing in high-profile contractors with convention center experience from abroad and forming a joint venture with POSCO. It will produce synergies of combining the foreign firm's state of the art construction technologies and POSCO's local knowledge and conventions. The remaining part of the projects such as the retail and residential buildings are relatively less risky. Therefore, NSC would enjoy the cost saving benefits of competitive bidding process among respected Korean construction companies. Independent supervisors play important role for the quality assurance. When using multiple contractors as suggested, the role of the supervisor is even more critical. In my opinion, NSC must hire a renowned foreign engineering firm as a supervisor to achieve the level of quality it aims to provide.

5.4.5. Market Risks

Among many risks presented here, the market risks are the hardest to estimate and mitigate, simply because the project is a city built up from a scratch. However, NSC is in fact only a small part of the entire Songdo redevelopment [see Figure 5.11], and the local housing development has already started a couple of years ahead. The Korean housing market has had rapid growth throughout the history of modern Korea, and it has been major source of the wealth creation for Koreans. The problem of the Korean housing market has been the fact it has been too good an investment. The rate of the growth in housing prices far exceeded the growth of the per capita income and housing affordability has been major social issues (Oh, 2003). Due to the rapid rise of housing prices, rental housing market has never taken off the ground, and Koreans thinks that rental housing is for the poor. Besides rare incidents, for-sale housing development has provided tremendous profit opportunities. Local housing development nearby NSC already signals a huge success of the project. According to Money Plus, all 5,000 housing units planned for the parcel next to NSC has been pre-sold, and these units are now being traded at 50 percent premium above the original sales prices. Local brokers cite the proximity to the NSC development site as a major reason for its success (Money Plus, 2004).

Figure 5.11: Development Map of New Songdo City
* Heavy line represents the boundary of New Songdo City (NSC) project



Source: Incheon Free Economic Zone Authority

In contrast to housing markets, the success of office, hotel, and other commercial spaces are still very much unknown. Government officials are hoping that in contrast to Seoul, where most foreign branch offices are located, NSC will attract Asian Headquarter offices. However, the city of Seoul already provided plenty of high-end office spaces for such tenants. Also, whether NSC can compete with the proven financial centers like Hong Kong is still up in the air.

I believe that NSC can use these two contrasting market segments to their advantage to mitigate the market risks. First of all, when the housing market is good, NSC should pre-sell as much housing units possible, and thus minimize risk of market softening. For the office portion, NSC should find a brand-name tenants and offer them with long-term leasing contract and at the same time attract them as equity investors. When the first couple of large companies jump in, often times, others follow.

It is clear that the market risk is the most critical factor for the success. Obviously, there is no sure way of taking this risk away. However, through a strategic investment partnership, coupled with the perfect execution of the project, this uncertainty in the market demand will go away in the future.

5.4.6. Financing Risks

Considering enormous capital requirements for the NSC project, there would be a huge risk regarding the financing of the project. Korean commercial banks have a limited ability to provide true long-term financing for real estate projects. Bank loans in Korea rarely exceed three to five years, including the construction period, whereas the Songdo development project requires at least fifteen years of amortization after the construction. As a result, the project sponsors would have to refinance after a couple of years with new loans, private placements or public bond issues with longer tenors. Through this "two-step" financing process, the sponsors would expose themselves to significant refinancing risks and unfavorable interest rate fluctuations (defined under financial risks) which may reduce the return on investment or even fail the overall project.

In the short term, the pre-sales mechanism of the Korean housing market provides greater flexibility in short term financing that otherwise would have been impossible. Figure 5.12 shows a typical condominium installment plan that was used for one of the residential complex near NSC. This early cash flow will enable the sponsors pay down construction loans quickly. More importantly, by reinvesting profits from the early stage housing sales, the sponsors can build up their equity in the project. By applying this strategy of early housing presales and sales proceeds reinvestment, the sponsors would require less than US $ 1 billion of construction, when total construction budget of the first phase was approximately US $ 2.2 billion. More interestingly, this would generate enough equity in the later phase income producing properties to support a permanent debt service coverage ratio of 1.6. This would in fact translate into around 50% of interest savings. Furthermore, banks would be more comfortable lending to the project, because of the diminishing default risk on the loan as the project progresses.

Figure 5.12: Typical Condominium Payment Schedule

		# 0f	Per SF	Per Unit	Down	Installment Payment						
Unit Type	Floor Level	Units	Sales $	Sales $	Payment	2004.4	2004.8	2004.12	2005.4	2005.8	2005.12	Final Pmt
32A	Ground Fl.	10	$133	$159,348	$15,934	$15,934	$15,934	$15,934	$15,934	$15,934	$15,934	$47,808
(1200 SF)	Middle Fl.	80	138	165,181	16,518	16,518	16,518	16,518	16,518	16,518	16,518	49,558
	Top Fl.	10	160	191,848	19,184	19,184	19,184	19,184	19,184	19,184	19,184	57,558
32B	Ground Fl.	12	135	162,103	16,210	16,210	16,210	16,210	16,210	16,210	16,210	48,633
(1200 SF)	Middle Fl.	186	141	168,770	16,877	16,877	16,877	16,877	16,877	16,877	16,877	50,633
	Top Fl.	12	163	195,770	19,577	19,577	19,577	19,577	19,577	19,577	19,577	58,733
40	Ground Fl.	4	168	234,501	23,450	23,450	23,450	23,450	23,450	23,450	23,450	70,351
(1400 SF)	Middle Fl.	70	176	245,751	24,575	24,575	24,575	24,575	24,575	24,575	24,575	73,726
	Top Fl.	4	201	281,168	28,117	28,117	28,117	28,117	28,117	28,117	28,117	84,351
46	Ground Fl.	8	173	277,060	27,706	27,706	27,706	27,706	27,706	27,706	27,706	83,119
(1600 SF)	Middle Fl.	137	181	289,143	28,914	28,914	28,914	28,914	28,914	28,914	28,914	86,744
	Top Fl.	8	203	325,393	32,539	32,539	32,539	32,539	32,539	32,539	32,539	97,619
55	Ground Fl.	4	175	349,963	34,996	34,996	34,996	34,996	34,996	34,996	34,996	104,992
(2000 SF)	Middle Fl.	72	183	365,379	36,538	36,538	36,538	36,538	36,538	36,538	36,538	109,617
	Top Fl.	4	201	402,463	40,246	40,246	40,246	40,246	40,246	40,246	40,246	120,742
67	Ground Fl.	2	177	425,617	42,562	42,562	42,562	42,562	42,562	42,562	42,562	127,685
(2400 SF)	Middle Fl.	36	186	445,200	44,520	44,520	44,520	44,520	44,520	44,520	44,520	133,560
	Top Fl.	2	202	483,950	48,395	48,395	48,395	48,395	48,395	48,395	48,395	145,185

Source: www.land4949.co.kr

The permanent loan financing will be harder to do in Korea because of limited long-term financing sources. For instance, the average maturity of the Korean corporate bond is somewhere around 3.5 years, and also there are no long term domestic commercial mortgages available in Korea. On the equity side, the sponsors might not have accumulated enough equity to support long-term financing and it is also possible that existing equity holders would want to realize their return by taking their equity out of the project. When such events happen, there would be substantial amount of new equity to be raised by the sponsors or they have to disposed all the assets and liquidate.

As a tool for a long term financing, the development of ABS market in Korea offers a unique opportunity. The asset-backed securitization market in Korea has been a haven for many projects struggling to borrow the kind of amounts that had previously made available through government loans or straight bond markets. In the wake of the Asian financial crisis, investors became comfortable with securitization issues, because deals carry extra credit enhancement and typically expose investors to only one asset (Giddy, 2000).

Figure 5.13: Short and Long-Term Financing Analyses for First Phase

(Figures in thousands of US dollars)

Year	**Total**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Development Expenditure	2,077,743	376,833	429,991	697,073	319,926	179,269	74,651	0	0	0	0
Net Pre-Sales Revenue		(25,837)	358,445	399,150	502,809	38,718	30,974	27,877	21,682	0	0
Net Rental Revenue		0	0	0	0	29,794	48,624	92,509	113,033	**121,911**	1,786,131
Construction Loan:											
Beginning Balance		0	392,670	449,557	647,941	573,654	769,706	885,753	0	0	0
Advances		392,670	21,547	157,924	0	144,423	46,774	0	0	0	0
Interest	334,735	0	35,340	40,460	58,315	51,629	69,274	79,718	0	0	0
Repayment		0	0	0	(132,602)	0	0	(965,471)	0	0	0
Ending Balance		392,670	449,557	647,941	573,654	769,706	885,753	0	0	0	0
Permanent Loan:											
Beginning Balance		0	0	0	0	0	0	0	965,471	955,816	946,258
Advances		0	0	0	0	0	0	965,471	0	0	0
Interest		0	0	0	0	0	0	0	67,583	66,907	66,238
Repayment		0	0	0	0	0	0	0	(77,238)	**(76,465)**	(75,701)
Ending Balance		0	0	0	0	0	0	965,471	955,816	**946,258**	936,796
DSCR @ Stabilization	**1.59 X**										
Equity:											
Equity Investments	200,000	10,000	50,000	140,000							
Sales Revenue Reinvestment		0	358,445	399,150	452,528	34,846	27,877	0	0	0	0
Cash Distribution to Equity			0	0	50,281	33,666	51,722	120,385	134,715	121,911	1,786,131
Net Cash Flow to Equity		(10,000)	(50,000)	(140,000)	50,281	33,666	51,722	120,385	134,715	121,911	849,335
Equity IRR after Financing	**39.46%**										

Source: Author's analysis based on information provided by The Gale Company

5.5. Basis of Further Analysis

As evidenced by the analyses in this chapter, NSC is an enormously complex project that involves a great deal of uncertainties from every direction of the project. It would simply be impossible to capture this complexity with a single model. However, the qualitative analyses in this chapter reveal that a large portion of the risks can be mitigated by better strategies and their implementations. The lesson from the tools introduced in the chapter 4 tells us that as uncertainties and resulting risks goes up, the potential value of flexibilities become higher. Therefore, it is essential to incorporate Decision Tree and Real Options analyses into the analysis of the New Songdo City project.

Due to its sheer complexity, the application of DTA and ROA would be a daunting task. DTA would quickly become “decision bushes,” and there would be too many variables and resulting options to be modeled with a conventional Real Options model. In this sense, both tools could not be used to value the project precisely in a practical manner. However, these models’ capabilities of valuing flexibilities would still have critical use for the investors and other related parties.

From the risks identified in the chapter 5.4, the market risk is a single most important risk that cannot be effectively controlled by the investors. Also other risks are correlated with the market risk in that if market turns out to be a good one, other related risks would decrease as well. Therefore, the following analyses would focus on the uncertainties of the market, which is interpreted as the volatilities in underlying asset prices. One of the most important procedures required for DTA and ROA is the simplification of the real world situations through the identification of critical uncertainties. The analyses in the chapter 6 reveal that the flexible strategies in response to the change in market conditions are the important value driver in the New Songdo City project.

Ch. 6. Case Study: Valuing Flexibilities in the development of New Songdo City

As identified in the chapter 5, New Songdo City involves a number of risks and the success of the project depends on the developer's strategies to deal with them. The methods presented in the chapter 4 illustrate that the value of the project is enhanced when there is flexible strategies available to developers. Especially, when the project involves a large amount of uncertainties, the value of flexibilities increases from the options perspective. Thus, it is evident that incorporating the value of flexibilities into the analysis is crucial, and the project is likely to be undervalued without doing so. In this chapter, the NSC project is first valued with the conventional Discounted Cash Flow method, and later the analysis is complemented with the Real Options and Decision Tree approaches.

6.1. Valuation of New Songdo City with the Discounted Cash Flow method

Although it leaves out the value of flexibility, the Discounted Cash Flow analysis is a correct method to value investments assuming there is no flexibility. Both Real Options and Decision Tree are based on the values calculated with the DCF procedures, and thus it is critical to thoroughly apply this method as a basis of the further analysis. In this section, each property type in the project is analyzed first, to identify necessary input assumptions that are required for the DCF procedure. Based on the assumptions identified, the property and the aggregate level DCF analyses will be performed. The project involves largely 10 property types as summarized in figure 6.1. Majority of properties are programmed for either housing (45.7%) or office (39.7%) and the focus is given to the analysis of these two properties.[27] Hospitals, schools, government buildings and other service related properties are assumed to be developed as fee based projects with clients' full commitment, and thus only nominal amounts of risks are involved. These properties are assumed to be zero or slightly negative NPV projects on this ground.[28]

Figure 6.1: Summary of Project Inventories (in SF)

PHASE	HOUSING	OFFICE	RETAIL	HOTEL	HOSPITAL	SCHOOL	GOV.	TOTAL	FAR
PHASE 1	5,515,220	648,000	1,751,640	1,019,200	0	0	1,000,000	9,934,060	2.8
PHASE 2	10,915,664	1,931,000	1,166,955	656,973	1,849,138	279,513	0	16,799,243	1.7
PHASE 3	5,650,451	0	340,000	0	0	0	0	5,990,451	0.4
PHASE 4	15,090,462	9,998,775	2,342,386	0	0	279,513	0	27,711,137	2.4
PHASE 5	5,289,300	13,711,970	2,004,071	0	0	0	0	21,005,341	4.7
PHASE 6	246,000	10,834,234	919,630	0	0	0	0	11,999,865	1.8
TOTAL	42,707,097	37,123,979	8,524,682	1,676,173	1,849,138	559,026	1,000,000	93,440,096	1.9
% of TOTAL	**45.7%**	**39.7%**	**9.1%**	**1.8%**	**2.0%**	**0.6%**	**1.1%**	**100.0%**	

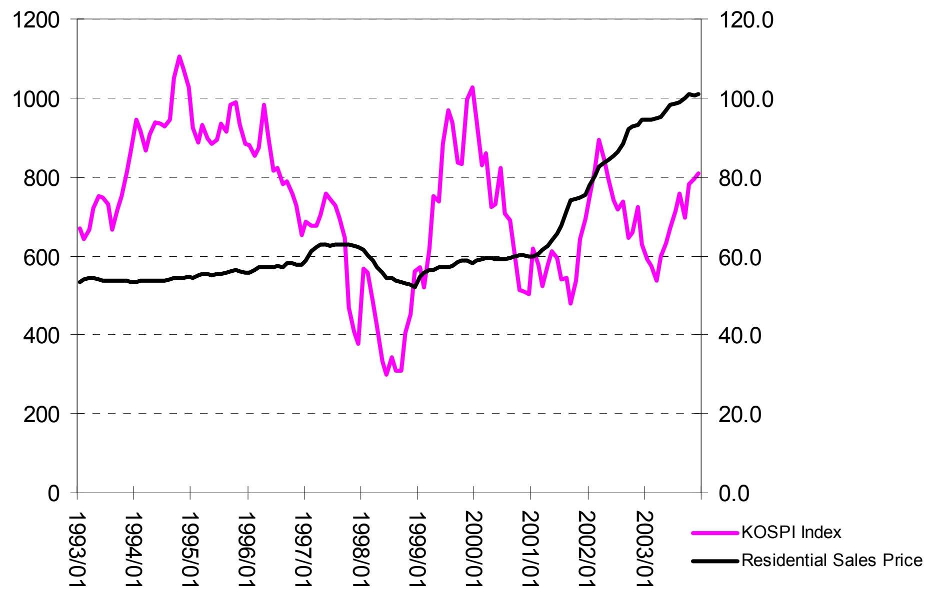
6.1.1. Residential Properties

In the chapter 5, residential properties are identified as the most promising component of the project. The high-end condominiums recently constructed nearby the NSC site have been sold out and the reason for their success is said to be due to the proximity to NSC. The housing market in Korea is dominated by for-sale high-rise condominiums, and the current plan for NSC is to take advantage of this situation. The housing rental market in Korea is largely marginalized and it is common conception that rentals are for the poor. The for-sales housing market has been a major source of wealth in Korea, and residential properties are the only asset class that has had consistent growth over the last ten years. The Korean stock market, in contrast, did not have much real growth despite its high volatility, and the underperformance of other asset classes has been another important reason for the success of for-sales condominiums as investments. Figure 6.2 compares Korean Stock Price Index (KOSPI) and housing sales index publicized by Kookmin Bank. It shows that the Korean stock prices did not exhibit a long-term growth and yet the

[27] See Appendix A for the detailed breakdown of programs in each phase.
[28] Also, they only account for 3.7% of the building area to be developed. As an overall plan, it is important to have these programs in place; however the profit of the individual building would not affect much on the overall return of the project.

housing prices have had a fairly consistent growth. Especially since the year 2001, the average growth rate of for-sale housing was an impressive 18%.

Figure 6.2: Korean Stock and Housing Market (1993-2003)



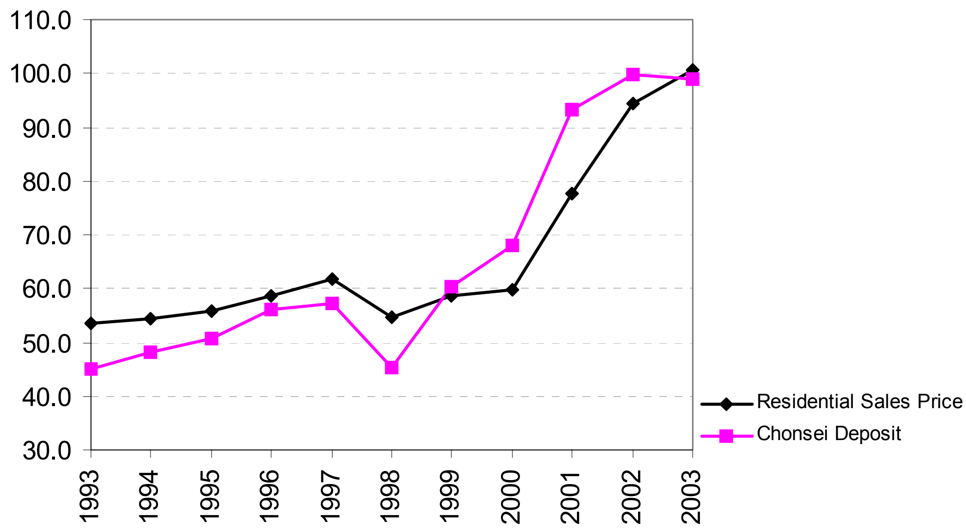
Source: The Bank of Korea, Kookmin Bank

Another unique aspect of Korean rental housing market is "*Chonsei*" system that has been the standard way of earning rental incomes.[29] *Chonsei* is a full lump sum deposit paid in advance to the lessor and is returnable at the end of the lease period without interest. Typical term for *Chonsei* is two years and the owner is supposed to earn interests on the deposit. In a way, it is similar to zero-coupon bonds. This practice is originated from the high interest environment in the past, when the typical consumer interest rate was above high teens. Also it was a form of consumer financing when the concept of personal and household credit did not exist. The deposit amount in the *Chonsei* system is ranges between 30% and 70%, and the rate is highly correlated with the change in the asset prices [see Figure 6.3]. In today's low interest environment, this system becomes problematic because the implied interest (rent) on the deposit is only about

[29] Monthly rentals are typically only available to low income households and foreigners. They accounts for last than 5% of the housing maket.

5~6%. Since the *Chonsei* deposit is average 50% of the property value, the yield on the asset becomes only about 2.5~3%.[30] However, the high growth in sales prices has more than compensated the lower income in the recent years.

Figure 6.3: Residential Sales Price and *Chonsei* Deposit Index (1993-2003)



Source: Kookmin Bank

Based on the sales trend in the nearby area, US$ 280 per square foot can be easily achievable for the residential properties in NSC. Considering higher standard of design and construction, it might be possible to sell housing units up to US$ 350 per square foot. As shown in Figure 6.3, the recent 10 year growth rate of for-sales properties is 7.3% per annum and for the past three years, the growth rate has accelerated to 18% per annum.

6.1.2. Office Properties

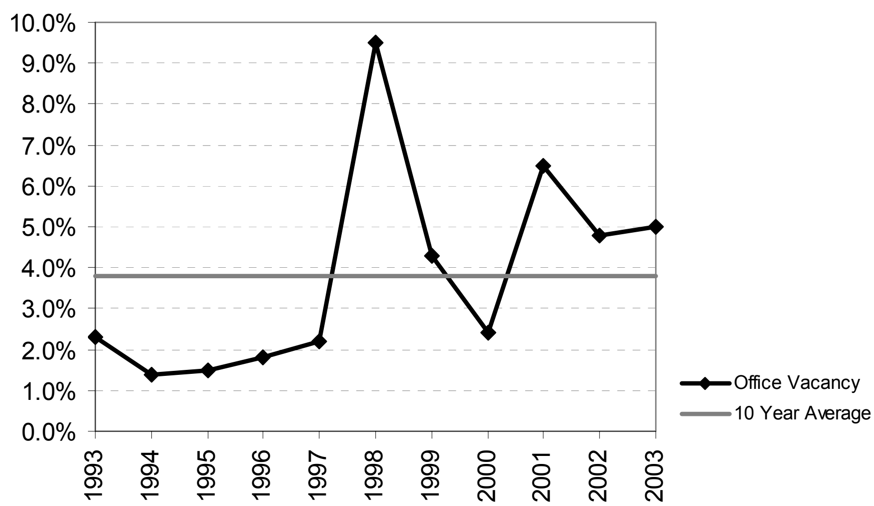
Unlike residential properties, it is challenging to estimate future values of office properties in NSC, due to the absence of comparables. City of Incheon does not have a central business district equivalent to the one to be created in NSC, and there is no current demand for such a large amount of class A office spaces in the area. The central business district of Seoul currently has 67

[30] Most people invest the Chonsei deposits in quite risky investments and aims to get above 10% returns on them. However, the risk free rate should be used to calculate the yield because the income should be cash equivalent.

million square feet of Class A and B office spaces, and yet NSC promises to deliver 37 million square feet of new office spaces.[31] In this sense, the success of the office properties entirely depends on the promises of the Free Economic Zone.

In the absence of direct comparables, the office market in Seoul is used as a basis of the analysis and fairly conservative assumptions are used. Seoul office market has had extremely low vacancies compared to other major cities in the world, and proves that there is healthy demands for high-quality office spaces [See Figure 6.4]. Good news for NSC is that office construction in Seoul has been tapering down since the mid nineties and there is few undeveloped lands left in its business districts (Vigers Korea, 2002). When there is necessary transportation infrastructure in place, a big portion of future demand can shift to NSC. The developer and the government are aware of this problem of uncertain demand and they planned the construction of office properties for later phases.

Figure 6.4: Office Vacancy Rates, Seoul (1993-2003)



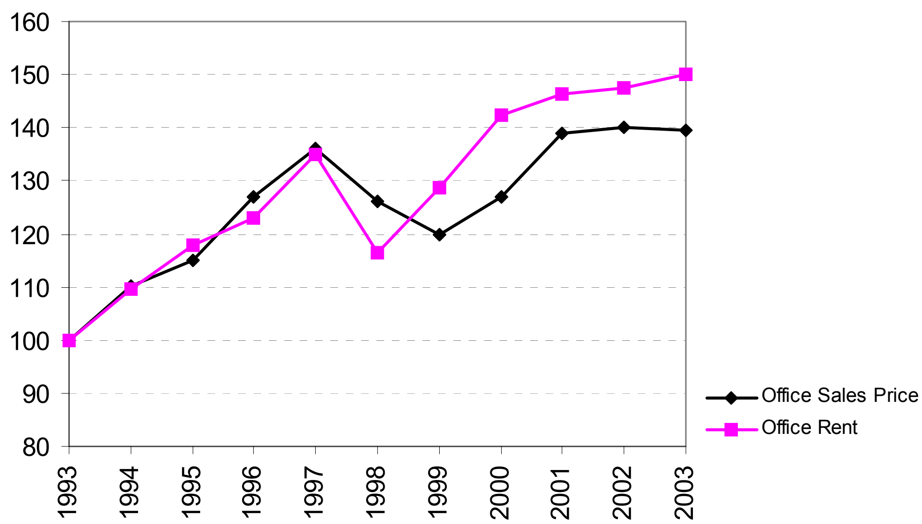
Source: BHP Korea

Unlike the housing market, the growth in value for office properties has been in line with overall rate of inflation. As shown in figure 6.5, both sales price and rents has been rising moderately at 3

[31] City of Incheon currently has about 10 million square feet of mostly class B and C office spaces.

to 5% per annum except during the period of the Asian financial crisis. The recent ten year average growth rate is 3.8% where the average CPI growth for the same period is 4.0%. According to Cushman & Wakefield (2004), the average net office rent in the central business district of Seoul is US$ 45 per square feet, and the average cap rate for the core office properties is about 9%. For the analysis of the office properties in NSC, the net office rent of US$30 per square feet is used, which is 33% below the current market rate in Seoul. The same cap rate and growth rate is assumed. However, three years of abortion period is used to partially account for the risks related to the uncertain demand.

Figure 6.5: Office Sales Price and Rent Index, Seoul (1993-2003)



Source: BHP Korea

6.1.3. Retail Properties

Considering the huge amount of new residential and office properties to be introduced, the retail component of the project that accounts for 9.1% of total area can be supported internally. Also, the nearby city of Incheon has over 2,000,000 residents and 8,000,000 households and yet the area currently does not enjoy diverse retail environment available to the other Seoul metropolitan areas. The retail element of the project consists of large regional malls and street retails. The demand for this retail would initially come from the city of Incheon itself, as there are little or no modern retail facilities. Modern retail facilities represented by department store has enjoyed more than 20% annual sales growth for the past decade, and other types of modern retails recently introduced, such as American style malls and discount store, are starting to expand rapidly (Vigers Korea, 2002). The growth rate of retail has been highly correlated with the growth in the Gross Domestic Product of Korea, and the analysis incorporates it as a base growth rate for the retail component. Accounting for both *Chonsei* deposits and monthly rents, the retail component is expected to generate the annual income of 12%, which is in line with other modern retail properties in the Seoul metropolitan area.

6.1.4. Luxury Hotels

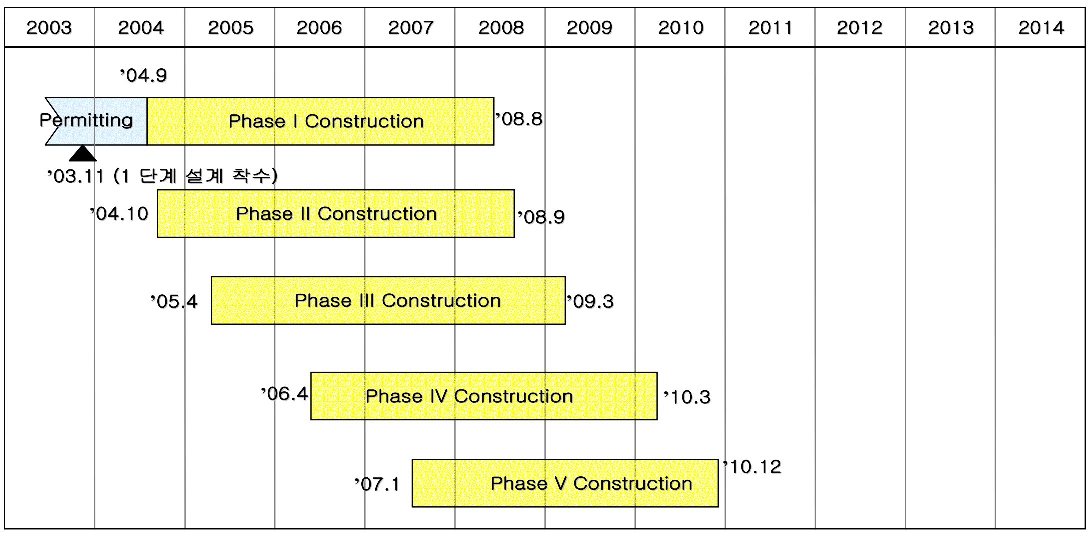
Hotels are planned for the second phases of the project, and it is an important to component of making the city as a world class business center. However, hotel demand would not pick up until the majority of office spaces are occupied and it would only happen in the later phase. For strategic reasons, however, it is important for developers to have them in place early on. Therefore, the analysis assumes that it would take 6 years until the hotel occupancy would reach a normal rate. The average daily rate of US$120 is used for the purpose of analysis.

6.1.5. Land Deal and Overall Project Schedule

One of the greatest merits of the project is the fact that the government is providing land in a low fixed price which is estimated to be much lower than the market values of the land in the region. Also as the project turn out to be a success, the land parcels would command much higher prices than ones nearby. Therefore, this land deal has enormous potential for the future value creation. The for the first three phases, the government agrees to provide land for US $700,000 per acre, which the government estimates as 25% of the fair market value, For the later phases, the remaining land can be bought for US $2,000,000 per acre.

The government and the Gale Company have a very aggressive schedule laid out for the construction of the project. They planned to commence the construction of each phase approximately one year apart, and in the year 2007, five phases will be fully committed, if things progress as planned. The schedule for the last phase is not yet determined, and is entirely optional as long as the previous five phases are started. Figure 6.6 illustrates the plans for construction phasing and durations.

Figure 6.6: New Songdo City Construction Schedule

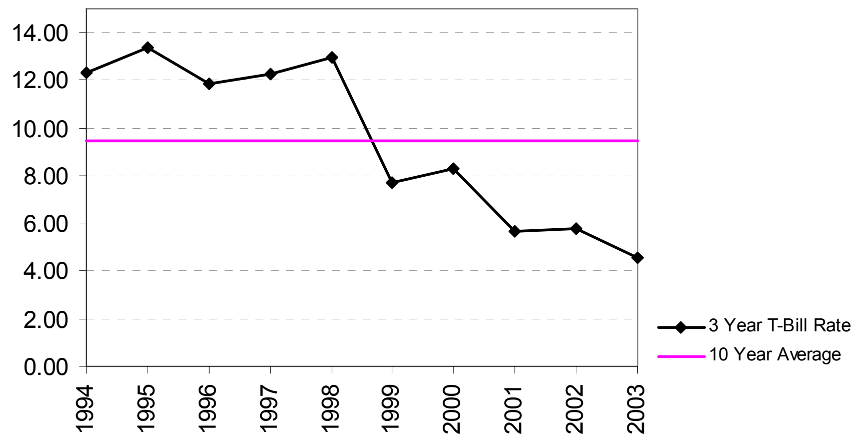


Source: New Songdo City Development LLC.

6.1.6. Discount Rate and other Assumptions

In addition to the previous analysis of each property type, it is crucial to determine discount rate for each stream of future cash flows. The construction costs are assumed to be fixed and are discounted with risk free rate. Korea has an active government bond market, and it gives guidance as to the determination of appropriate risk free rate. Figure 6.7 shows the trend in the Korean government bond rates during the past decade. It has steady downward trend and the currently rates are in fact lowest in the history. The current rate of 5.5% for the longest term, 10 year government bond is selected as the risk free rate, since it matches quite well the duration of the project.

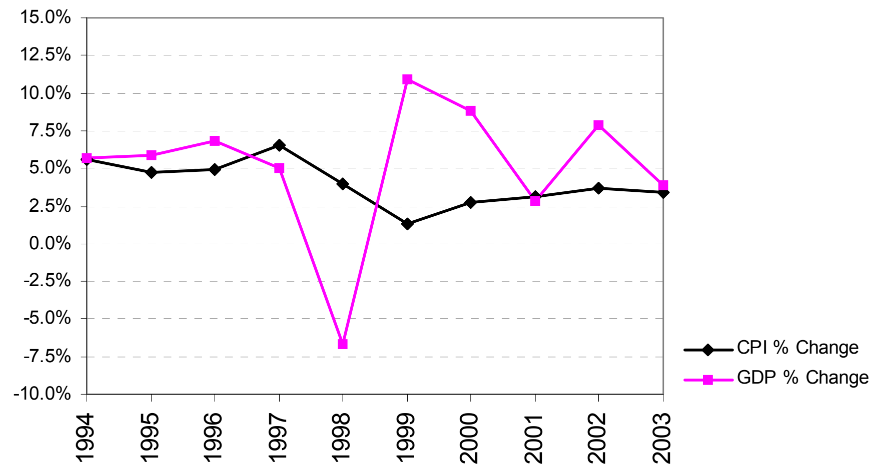
Figure 6.7: 3-Year Korean Government T-Bill Rates (1994-2003)



Source: Bank of Korea

For the overall growth rate, two sources are used for the base growth rates [see Figure 6.8 for recent trends]. The construction and other fixed costs are assumed to grow at the average 4.0% CPI growth rate of the past decade. Some other growth rates, such as retail sales and hotel rates are highly correlated with GDP and for them the average growth rate of 5.1% is applied.

Figure 6.8: Annual Changes in GDP and CPI (1993-2003)



Source: Bank of Korea

The discount rates for each property and other costs are determined based on the information analyzed in the previous chapter. In addition to the property level discount rate, a premium of 2% is incorporated to reflect the speculative nature of the project. Figure 6.9 summarizes input assumptions to be used for the basis of the DCF analysis:

Figure 6.9: Input Assumptions for DCF Analysis

Assumptions	Yield	Growth	Spec	Disc. Rate
Residential	3.5%	7.3%	2.0%	**12.8%**
Office	9.0%	3.6%	3.0%	**15.6%**
Retail	12.0%	5.1%	2.0%	**19.1%**
Hotel	8.0%	3.6%	3.0%	**14.6%**
Golf	5.0%	6.4%	1.0%	**12.4%**
Risk-Free Rate				**5.5%**

Assumptions	Housing	Office	Retail	Hotel	Hospital	School	Gov.	Golf	Park
DEVELOPMENT COST	**173**	**185**	**150**	**190**	**216**	**150**	**170**	**22**	**15**
SALES REVENUE	**285**	**-**	**-**	**-**	**238**	**165**	**187**	**16**	**-**
ANNUAL NET INCOME	**-**	**30**	**32**	**27**	**-**	**-**	**-**	**1**	**-**

* Figures here are US$ per SF in 2003 dollars.

6.1.7. NPV analyses based on DCF valuation

A pro-forma cash flow analysis based on the findings in the previous chapters is developed for each property type in each phase.[32] Figure 6.10 is the summary of results from the DCF valuation of the pro-forma cash flows:

Figure 6.10: Summary of NPV analysis based on DCF method (in thousand US $)

	PHASE 1	PHASE 2	PHASE 3	PHASE 4	PHASE 5	PHASE 6	TOTAL
Residential							
PV of Benefit	1,056,562	2,303,109	965,087	2,353,499	753,248	31,989	**7,463,495**
PV of Costs	769,435	1,648,993	833,368	2,172,905	743,569	33,763	**6,202,033**
Benefit - Costs	287,128	654,116	131,719	180,594	9,679	(1,774)	**1,261,461**
Office							
PV of Benefit	114,625	320,937	-	1,681,438	1,454,531	1,024,002	**4,595,532**
PV of Costs	99,699	311,944	-	1,539,610	2,061,335	1,590,126	**5,602,715**
Benefit - Costs	14,926	8,993	-	141,827	(606,804)	(566,125)	**(1,007,182)**
Retail							
PV of Benefit	128,448	138,448	34,885	207,847	153,788	61,031	**724,448**
PV of Costs	173,514	156,919	44,636	300,227	250,778	112,350	**1,038,424**
Benefit - Costs	(45,066)	(18,471)	(9,751)	(92,380)	(96,990)	(51,320)	**(313,977)**
Hotel							
PV of Benefit	73,679	130,816	-	-	-	-	**204,495**
PV of Costs	160,450	108,429	-	-	-	-	**268,879**
Benefit - Costs	(86,771)	22,388	-	-	-	-	**(64,384)**
Golf Course							
PV of Benefit	-	-	174,854	-	-	-	**174,854**
PV of Costs	-	-	188,170	-	-	-	**188,170**
Benefit - Costs	-	-	(13,317)	-	-	-	**(13,317)**
Hospital							
PV of Benefit	-	328,716	-	-	-	-	**328,716**
PV of Costs	-	341,707	-	-	-	-	**341,707**
Benefit - Costs	-	(12,992)	-	-	-	-	**(12,992)**
School							
PV of Benefit	-	38,771	-	32,203	-	-	**70,974**
PV of Costs	-	37,788	-	36,018	-	-	**73,806**
Benefit - Costs	-	983	-	(3,815)	-	-	**(2,832)**
Park, PV of Costs	-	39,760	27,964	35,560	6,745	49,173	**159,202**
Land, PV of Costs	256,550	149,975	214,380	468,408	68,361	237,750	**1,395,424**
TOTAL Benefits - Costs	**(86,333)**	**465,283**	**(133,693)**	**(277,743)**	**(769,221)**	**(906,142)**	**(1,707,848)**

[32] See Appendix B for the detailed pro-forma DCF analysis.

The result in figure 6.10 shows that the only property type that generates positive NPVs is residential property. This is somewhat expected since it was the only component with the verified high demand and the sales price level. Also, only the second phase has a positive NPV of $465 million, because it is the period of a extensive housing build up. Later phases have increasingly higher level of negative NPVs. The fact that the cash flows are coming from the later in the future and most office spaces are planned for later stages is two most important reasons for this accelerating level of negative NPVs. On the aggregate level, the NSC project has an IRR of 28.8% and yet it generates US$ 1.4 billion of negative NPV. The IRR alone seems quite attractive. However, the project involves much greater degree of risks based on the NPV rule and should be rejected if the developer must follow the planned course of the development (i.e. there is no flexibility of later stage decision makings).

6.2. Valuation of New Songdo City as Compound Expansion Option

As illustrated in the chapter 4, the projects, especially with multiple stages with high level of risks, have a potential to generate value far exceeding the one suggested by the conventional NPV approach. The one of the major source of uncertainties comes from the uncertainties of the market. Real Options approach is an appropriate tool, when valuing the flexibility related to the overall market risks. In this section, Real Options model is used to value options of waiting for the better market condition and abandoning the project when unfavorable market continues.

6.2.1. Structure of Options: Sequential Compound Option

The current agreement between the government and the Gale Company is inherently option-like, and it should be considered as such. The purchase of the land for the first phase and the commitment of building a new convention center and turning it over to the government can be considered as the purchase of an option to develop NSC in a sequential manner. The government granted an exclusive right to develop to the Gale Company in exchange for the convention center and the commitment to follow the mutually developed and agreed physical master plan.[33] As described previously, the government also gave the Gale Company right to purchase remaining parcels for the later phase for a predetermined price, which is assumed to be lower than their fair market value. Following this structure, the total amount of US$ 256,550,000[34] is the price paid for the purchase of the development option. Also, multiple phasing can be considered as a sequential compound option. The later phase projects can only be started once the previous phases are fully committed and started construction. The each phase has its own strike price equal to the development costs of the corresponding phase. The underlying asset is the collection of all the properties to be developed in NSC, and in each phase, some portion of them is assumed to be constructed based on the predetermined master plan.

6.2.2. Volatility of Underlying Assets

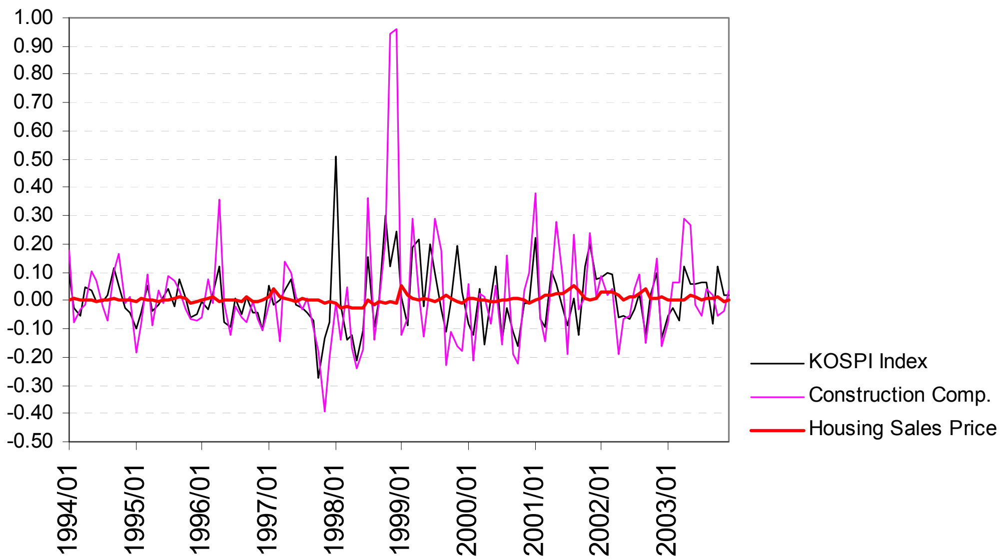
The most critical input assumption required for the options valuation is the volatility of the underlying asset. However, due to the scarcity and the unreliability of data, it is challenging to make a reliable estimate of the asset volatility. Several data sources are considered for this reason.

First, it is possible to estimate the volatility by finding out a "*twin security*" in the capital market, as suggested by Arman and Kulatilaka (1999). Construction companies in Korea are in essence merchant builders and developers, and their business is very similar to the large development project like NSC. Accordingly, it is possible to find the return data of such pubic companies and use their volatilities as guidance for the volatility of the assets to be built in NSC. A portfolio of the five largest construction companies is selected for the analysis with equal weighting. The monthly return data during the past decade is used for the analysis and figure 6.11 shows the

[33] See graphics and maps in Appendix D and E for details of the New Songdo City master plan.
[34] This amount includes the purchase price of the first phase land, costs related to predevelopment (feasibility study, costs related to setting up a project company, early stage overhead costs, etc.) and the development costs of the new convention center.

volatility of the monthly return of this portfolio. It turns out that the construction sector has been the most volatile sector in the Korean stock market, which in itself has exhibited excessive historical volatility. The portfolio of the construction companies has 63% annual standard deviation of its returns compared to 37% of KOSPI stock market index. The high volatility of the construction sector might be originated from the high leverage used by the construction companies, and also it is highly correlated with the overall stock market volatility. It is unlikely that the properties themselves exhibit such a high level of volatility, and thus it might not be appropriate to consider stocks of construction companies as "*twin securities*."

Figure 6.11: Monthly Return Volatility of Construction Companies and Residential Sales Prices (1993-2003)



Source: Bank of Korea

Second method to estimate the volatility of the underlying asset is to rely on the data from the direct asset market. The housing market in Korea has been notorious for its volatility due the high level of speculation. Prof. Lee of Korea University describes the Korean housing market as one similar to a gambling table (2002):

> *The economy, already suffering from unemployment and fluctuating prices, is now being plagued by rampant real estate speculation. This real estate speculation boom is an archfiend wielding terrible power, capable of blowing out the flickering signs of a hopeful economic recovery. In the Kangnam area, south*

of the Han River, outright acts of apartment purchase right speculation bear an uncanny resemblance to speculation in action at a bustling, lively gambling table. Dealers and owners are colluding to buy up purchase rights of newly built apartments in order to boost apartment prices after which they will walk away with enormous profits from trading.

Such anecdotal evidences suggest a stock market like volatility for the for-sale housing market. The reliable source for accurately estimating the property level volatility would be challenging due to the limited published data. Unlike the US and some other countries, Korea does not yet have real estate historical return index that can be used for the estimation for all property types. The housing market, however, fairly extensive documented sales and income data, and they can be a reasonable source for the estimation. The Housing and Commerce Bank of Korea, now merged to Kookmin Bank, has complied a housing sales price index since 1986, and it is considered the most reliable data available for the Korean real estate market. However, the index is compiled based on the survey of local brokers, and it is customary that brokers and sellers underreport the actual transaction prices most of the times. Therefore, the volatility estimated is likely to be somewhat understated. Based on this index, the annual return volatility of the housing market during the past year is 19.1%.

For other commercial markets, the only available source is from the broker's research reports. For example, the historical asset price level showed in figure 6.5 is from the brokerage firm BHP Korea, and it is based on the survey of 96 office properties in the business districts of Seoul. As a result, its data source is too limited to represent overall market, but it still provides a useful guidance. This data has a low annual return volatility of 7.9%, which is much lower than that of the housing market. Anecdotal evidences suggest that the low volatility in the office market compared to that of the housing market, and yet the degree of their disparity can be misleading considering their difference in the data source. For the other property types such as hotels and retails, there are virtually no historical return data available. However, the combined value of all the other assets account for less than 10% of the entire project valuation. Therefore, their influence on the overall volatility of the portfolio would not be substantial. For this reason, the volatilities of retail, hotel and other properties are assumed to be consistent with the overall property portfolio.

Even if the volatilities of 19.1% and 7.9%, for the housing and the office market respectively, are fairly accurate on the index level, individual properties would have higher degree of volatility due to the individual idiosyncratic risks involved. For example, the unsmoothed NCRIEF index in the US has only 6% volatility during the past decade, and yet the typical properties in the US have shown volatility in the range between 15% and 20% (Geltner and Miller, 2001). Initially, the volatility of the entire project as a portfolio is calculated based on the residential and the office market data. The portfolio weights of each property type are determined based on the present values from the DCF analysis. The present values of the residential and the office components are $7,463,495,000 and $4,595,332,000 respectively. Consequently, the residential and the office component have portfolio weights of 61.9% and 38.1% respectively. The correlation between two return data is 35.1%. With these variables, the portfolio volatility is calculated:

$$
\begin{aligned}
VAR_P &= w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2\rho_{1,2}\sigma_1\sigma_2 \\
&= 0.619^2 \times 0.191^2 + 0.381^2 \times 0.079^2 + 2 \times 0.619 \times 0.381 \times 0.351 \times 0.191 \times 0.079 \\
&= 0.01738
\end{aligned}
$$

$$
Volatility(\sigma_p) = \sqrt{VAR_p} = \sqrt{0.01738} = 13.2\%
$$

The resulting volatility of 13.2% could be used for lower bound estimate. As is in the case of the US, the project level volatility should be higher than the index level. In addition, the properties in the entirely new city are likely to be more volatile in the beginning than the properties in mature cities. Considering all the risks factors analyzed in this chapter, the base volatility of 25%, which is slightly higher than the range in the US market, will be used. To be sure, this estimate is, to large extent, a subjective estimate and thus it warrants sensitivity analysis around this value.

6.2.3. Sequential Compound Option Valuation using Binomial Lattice

Figure 6.12 illustrates the procedure used for the valuation of the sequential compound option structured in the previous chapter.[35] The current plan is that each stage of the project start a year apart and there is a tremendous political pressure to proceed as soon as possible. However, there is no contractual obligation to follow the plan precisely. Therefore, it is reasonable to assume that the Gale Company would have an option to wait at least two years before starting the next phase. The sequential compound option model used in figure 6.12 uses this assumption of 2 years of waiting time for each phase. Also, there is an abandonment option to stop the project any time during the process. For the modeling purpose, constant volatility (σ) and income payout rate (y) are assumed. This is obliviously a simplification because asset volatilities can change over time, and income level of real estate changes as evidenced by frequent cap rate changes in real estate markets. As a payout rate, 6% weighted average of cap rates for all the properties in the project is used. In realty, payout rate should be adjusted for each phase because each phase has different composition of property types. The variability of payout rate and volatility can be incorporated with more sophisticated programming. However, the above assumptions are made to simplify the modeling process.

The binomial tree method is used due to its simplicity and flexibility. As a first step, the asset price movement is modeled with one year time step. The risk neutral probability (q) and the upward movement (u) of asset price in each time step are calculated based on the constant volatility and dividend payout rate. With the base assumption of 25% volatility and 6% payout rate, the following values are derived:

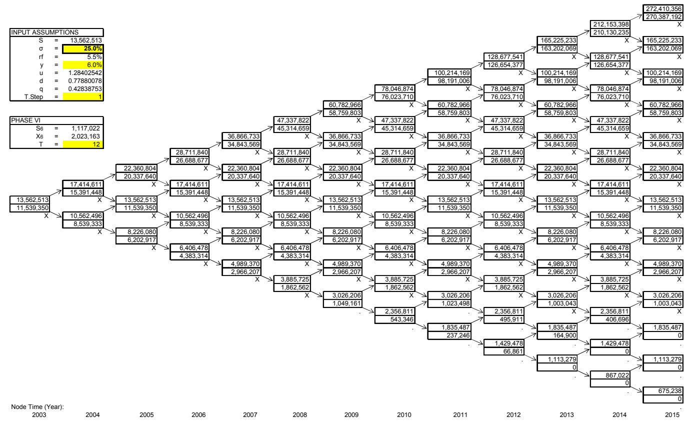
$$u = e^{\sigma\sqrt{\delta t}} = e^{0.25} = 1.284\,, \qquad d = 1/u = 0.7788$$

$$q = \frac{e^{(r-y)\cdot\delta t} - d}{u-d} = \frac{e^{(0.055-0.06)} - 0.7788}{1.284 - 0.7788} = 0.4284$$

[35] See Appendix C for detailed binomial model for the analysis.

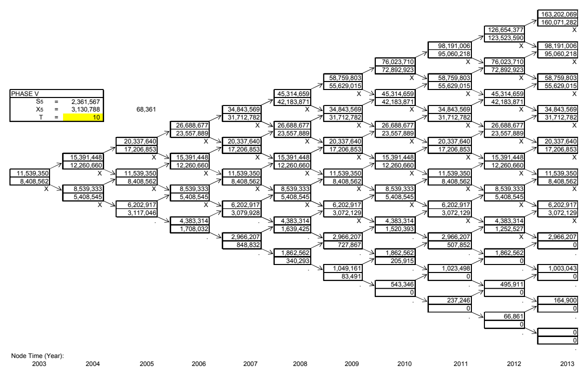
Figure 6.12: Valuing NSC as 6 Stage Sequential Compound Option

INPUT ASSUMPTIONS		
S	=	13,562,513
σ	=	25.0%
rf	=	5.5%
y	=	6.0%
u	=	1.28402542
d	=	0.77880078
q	=	0.42838753
T.Step	=	1

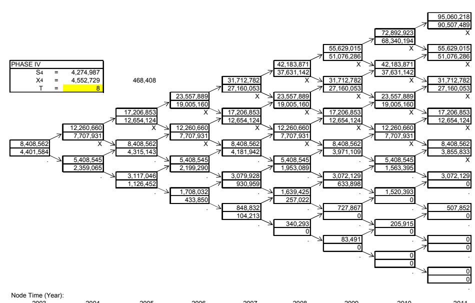


PHASE VI		
S_6	=	1,117,022
X_6	=	2,023,163
T	=	12

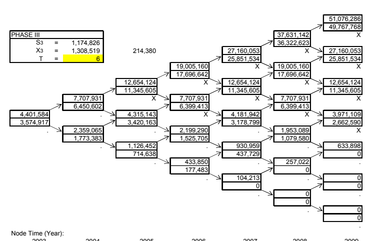
PHASE V		
S_5	=	2,361,567
X_5	=	3,130,788
T	=	10



PHASE IV		
S_4	=	4,274,987
X_4	=	4,552,729
T	=	8

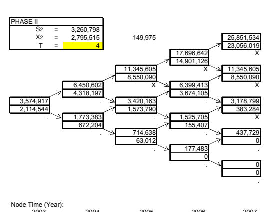


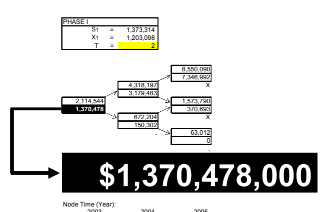
PHASE III		
S_3	=	1,174,826
X_3	=	1,308,519
T	=	6



PHASE II		
S_2	=	3,260,798
X_2	=	2,795,515
T	=	4

PHASE I		
S_1	=	1,373,314
X_1	=	1,203,098
T	=	2





Once the asset price movement is modeled based on the calculated input values, the option value is solved backwards starting from the sixth phase. Assuming two years of potential waiting period in each phase, the sixth phase has 12 years to maturity and later phase would have 2 years shorter maturity in each step. Since these options can be exercised anytime before or at the maturity, each option should be valued as an American Option.

With the base case of 25% volatility, the price of the option is US$1,370,478,000 based on the binominal model. Since US$ 256,550,000 was committed to purchase this option, net value created with the project is US$ 1,113,928,000. Compared to the negative NPV of US$1,707,848,000, the flexibility of waiting and abandonment generates US$ 2,821,776,000 of additional value. This result provides a completely opposite view towards the project and demonstrates the enormous potential value of flexibility for long-term large scale projects.

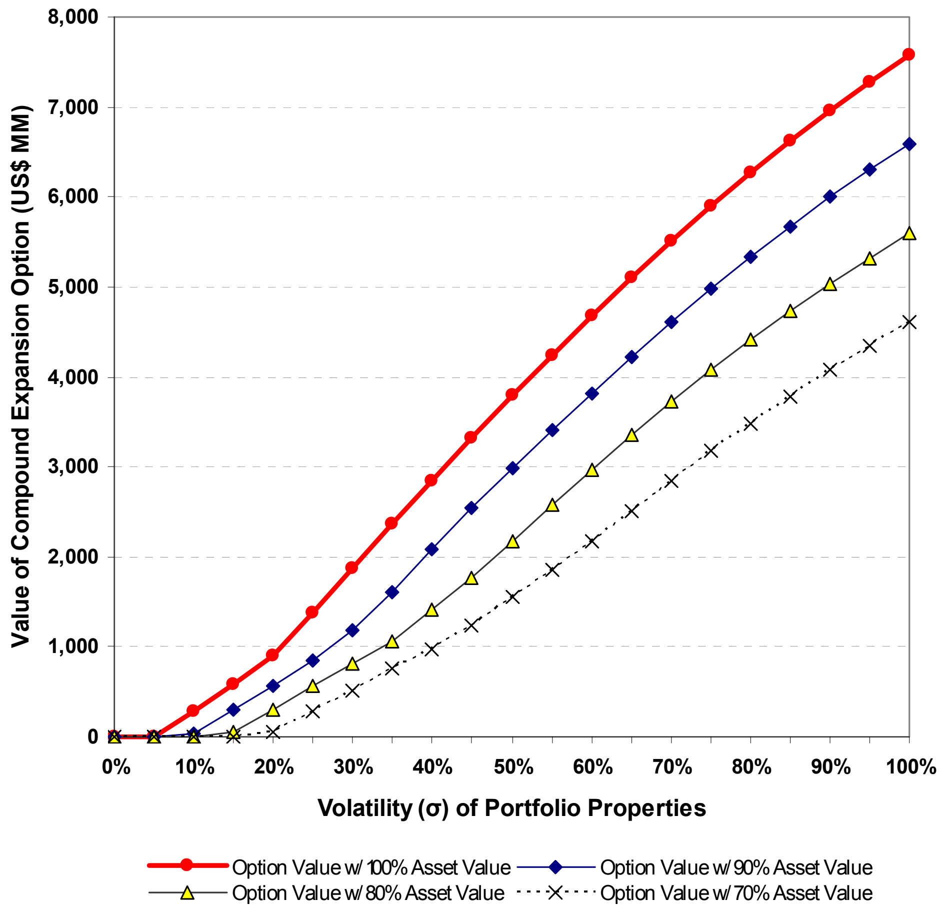
However, the resulting value should only be an approximation as a result of numerous simplifications made. Therefore, it warrants a sensitivity analysis to observe a range of potential values from the model. Figure 6.13 is the result of the sensitivity analysis, and figure 6.14 graphically shows the result of option value sensitivity in relation to volatility and initial asset prices. The result shows that there is little option value with the volatility level below 10% and the volatility of 15% and above is needed for the investor to reasonably accept the value of option beyond the purchase price of the option.

Figure 6.13: Sensitivity of Option Value on Volatility (σ) and Asset Value (S)

Volatility	100% Asset Value	90% Asset Value	80% Asset Value	70% Asset Value
0%	0	0	0	0
5%	0	0	0	0
10%	282,981,524	32,661,971	0	0
15%	588,862,922	293,560,160	60,291,639	0
20%	898,292,532	561,903,823	308,635,969	61,187,101
25%	**1,370,477,568**	840,232,791	559,779,171	290,014,520
30%	1,872,472,289	1,179,824,998	810,723,735	520,374,890
35%	2,365,944,011	1,615,390,127	1,060,030,749	751,471,874
40%	2,849,396,617	2,080,888,058	1,411,973,126	980,058,284
45%	3,323,823,271	2,535,492,061	1,762,571,879	1,230,389,633
50%	3,789,469,438	2,977,938,654	2,166,407,869	1,549,655,458

Figure 6.14: Option Value Sensitivity Graph

(*The shaded area on the graph indicates the most likely range of volatility (15~35%)



6.3. Application of Decision Tree Analysis to Project Specific Risks

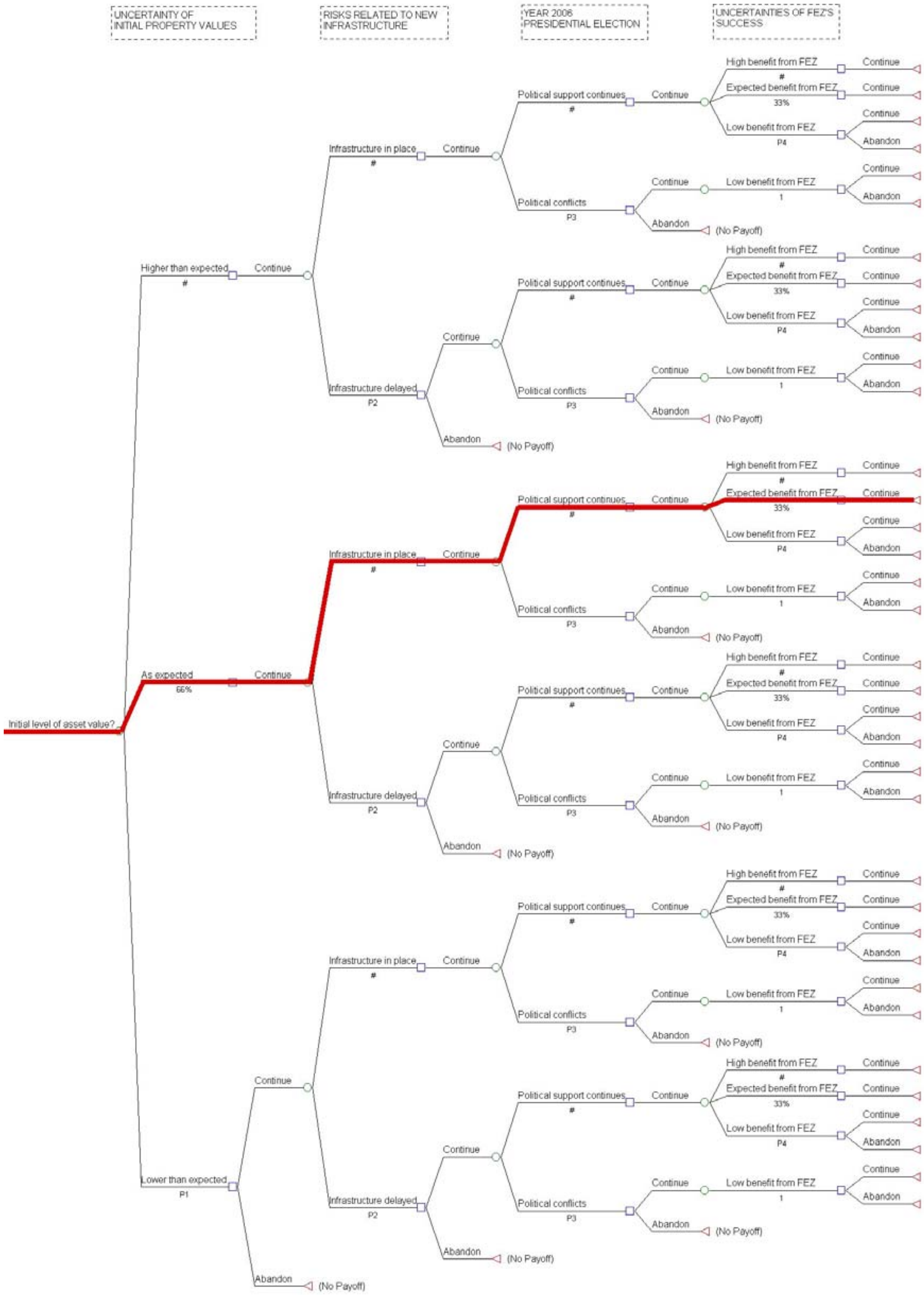
The Real Options analysis in the previous section reveals a huge value in the flexibility of the project. However, it is important to note that the real option analysis performed in the previous section only deals with the uncertainty in random changes of asset prices. Real Options model is only useful as regard to broad market based uncertainties, and yet there are many other risks specific to the project as identified in the chapter 5. Decision Tree Analysis is a more suitable tool for project specific risks and it can provide a useful framework for further analysis. In this section, Decision Tree is applied to account for a series of project specific risks. Decision Tree Analysis can be used in conjunction with the Real Options model. That is, Decision Tree would first layout uncertainties and corresponding flexibilities. Then the effect of the project specific uncertainties can be interpreted as a change in the input variables of the Real Options model. This approach would complement the shortcomings of DTA as a quantitative analysis tool.

The first project specific risk to be considered is the uncertainties of the initial asset prices. The Real Options model only accounts for volatility of asset prices and the current value of the asset is only a fixed input variable. The rent and sales price level was determined through the market research, and the future expected cash flow based on the research was discounted to determine the current value of assets. One of the unique characteristic of the NSC project is that it does not belong to any specific market because it is creating a brand new city from a scratch. Therefore, in what level the properties are going to be valued by investors are unknown, and this risk is project specific even though it is related to the market. Three possible scenarios of high, expected and low initial asset price levels are used to describe this uncertainty.

The other risks are also treated in a similar manner. Government's failure of providing promised infrastructure such as bridges and a mass transit system is another important risk. The initial pitfalls of the Canary Wharf project in London were primarily due to the delay in construction of the transportation infrastructure (Poorvu and Segal, 2004). The government's strong support for the project makes this event rather unlikely. However, there is a small possibility, given the massive investment required. The first stage project can still be supported with the existing infrastructure and any delay would affect the second stage and later ones. This risk again can be valued by downward adjusting asset and rent price levels.

The third project specific risk to be considered is coming from the possibility of government's abandoning its support when a new president is elected in the year 2006. The success of the

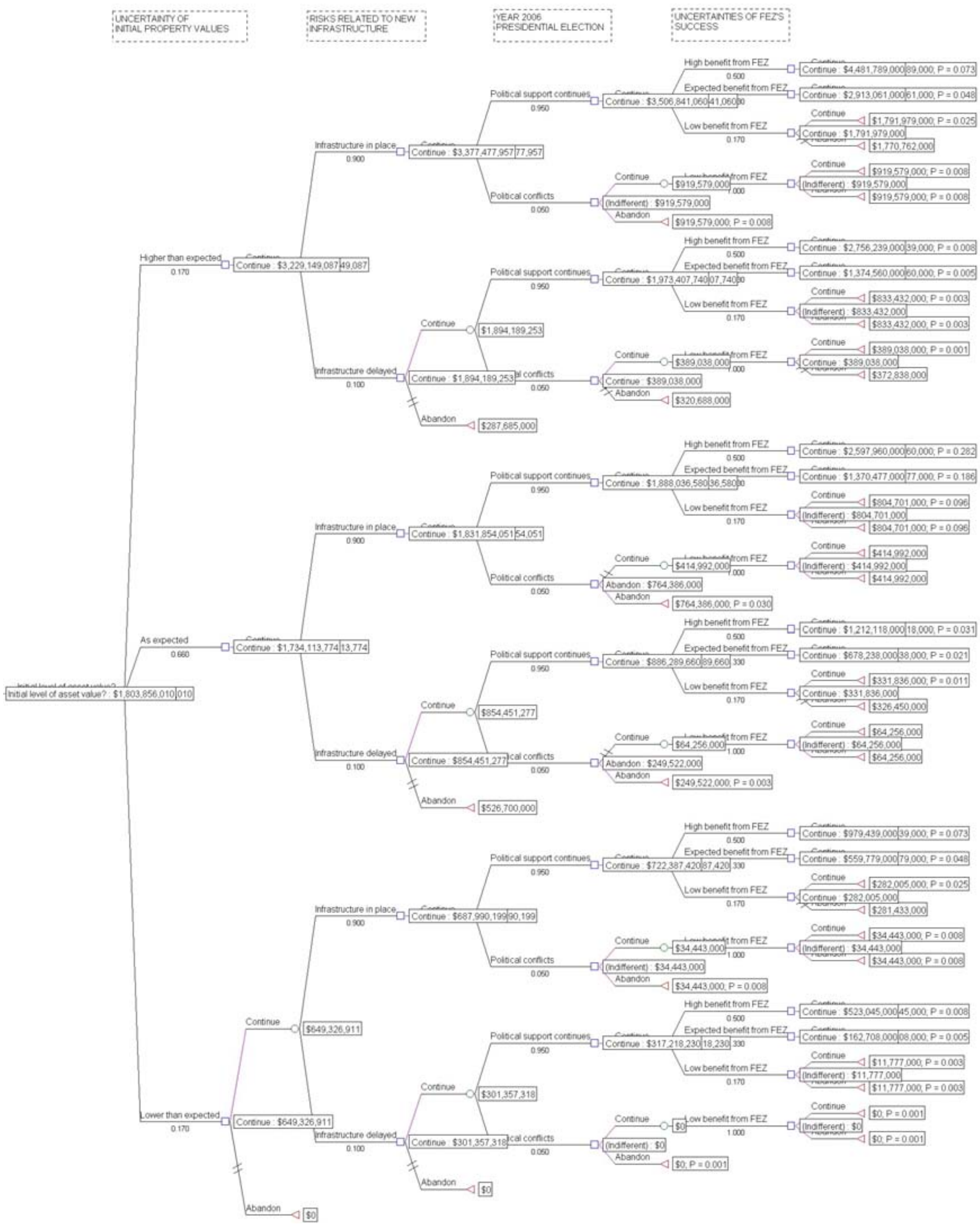
Figure 6.15: Structure of Decision Tree for Analysis of Project Specific Risks
(* Heavy line indicates the base scenario)



project is not achievable without the promised government supports and any potential change in the government's policy toward the Free Economic Zone would greatly affect the outcome of the project. Therefore, from the third phase, this risk is factored in by adjusting asset prices downward in the case of political conflicts. The last project specific risks is related the degree of success for the Free Economic Zone initiative, the later phase office spaces are dependent on its success. When it fails to attract global companies as it promised, it is unlikely that over 30 million square feet of office space can be filled. Also, if FEZ turns out to be a huge success, the property values would be much higher than the base value calculated under conservative assumptions. Figure 6.15 lays out the four risks considered in a sequential manner within the Decision Tree framework.

Using the Real Options model to calculated payoffs of each decision and chance path is much simpler than valuing within the Decision Tree. Also, it effectively avoids challenges of determining correct discount rates. As a base setting, upward or downward change of 20% in asset price with 17% probability of each extreme outcome is assumed for the analysis. Probabilities of negative effects from the delay in infrastructure and political conflicts are assumed to have 5% and a 30% drop in asset prices is assumed for these negative events. Based on these base assumptions, the resulting value of the option is US $1,804 million and it is US $434 million higher than the value of US$ 1,370 million obtained by only using the previous compound option model. This is due to the flexibility that allows cutting down the lower bound returns and at the same time capturing the asset price jumps in the case of the better than expected outcomes. Figure 6.16 illustrates the procedure to calculate the expected value of the decision and the risk structure laid out in figure 16.15. Given the entirely subjective nature of input assumptions, this value itself is not so meaningful. However, this exercise allows developers to see complex interaction of both project specific and market based uncertainties. By performing sensitivity analyses on the assumptions, developers can better understand the effect of individual risks on the overall project feasibility.

Figure 6.16: Expected Value Calculation for Decision Tree



Ch. 7. Conclusion

The issue of flexibility brought up in the thesis is a critical matter to real estate developers. Due to the absence of intuitive analytical method of valuing flexibilities, developers have relied on rudimentary tools such as cash-on-cash returns and sensitivity analyses. Even worse, developers often times have no choice other than entirely depending on their intuition for their critical investment decisions. Two tools introduced in the thesis, Decision Tree and Real Options can address the problem of valuing flexibilities.

The case study of the New Songdo City reveals that maximizing the value of flexibility is a key for a success in large-scale real estate development projects. It proves that Real Options and Decision Tree provide an effective analytical toolset for valuing such projects. However, the quantitative result of the analysis is not reliable enough to be used as precise value estimation due to the subjective and the incomplete assumptions made for the analyses. It is essential to understand this shortcoming to make an appropriate use of the analysis, and yet it should not stop developers applying these methods. The conventional DCF procedure would significantly undervalue long-term large-scale projects and relying on cash-on-cash return or intuition instead does not provide any analytical framework. In this regard, the further development of the presented method is crucial for the development industry.

Based on the approach used for the analysis of the New Songdo City project, the following procedure for valuing large-scale development projects is recommended:

1. Identify all the risks related to the development project, and determine the major source of identified risks.
2. Perform a DCF valuation incorporating the expected future cash flows and the risks identified, as if there is no flexibility in the project. A rigorous DCF analysis is critical because it is used as a basis of the later analysis.
3. Research market data for quantifiable risks, such as the volatility of underlying asset returns. If there is no reliable data available, a best subjective judgment has to be made.
4. Determine the structure of the option as to the identified risks. It is critical to know which options are valuable since real world projects would involve numerous options.
5. Once market based risks are identified and necessary input data are assumed, a Real Options model can be used to value the project's flexibility. The binomial tree approach is recommended because it is the most intuitive options valuation model and is easily customizable.
6. For project specific risks, the Decision Tree Analysis can be used. In most cases, there would be few data available for this type of risks. Hence, a degree of subjective judgment has to be used. The Decision Tree can help developers to understand interrelationship between different kind of flexibilities and uncertainties. When appropriate, DTA can be used in conjunction with Real Options. For instance, the payoffs in a Decision Tree can be calculated with the Real Options model by varying input variables.
7. Through sensitivity analysis must be performed. The single value estimate from the proposed model is not reliable enough to make base critical decisions. Sensitivity analyses would provide developers a range of values, and more importantly it would clearly show the relationship between input variables and the value of resulting flexibility.
8. Once the relation between the input assumptions and the value of flexibilities becomes clearer, developers should look for the opportunities to maximize the value by influence

the options structure with contract, negotiation with other parties, etc. This opportunity is unique to the real world options as opposed to financial options[36] and every effort must be made to take advantage of this opportunity.

It is obvious that the procedure recommended has a lot of room for further development especially in the area of modeling techniques. However, the advantage of this procedure is that it can be practically implemented with basic knowledge of options valuation, and it provides a analytical perspective of flexibility in development projects. For straightforward short-term development projects, this process itself might be too time-consuming and a simple method such as Samuelson-McKean model can be used instead. Large-scale projects with long-term multiple stages, however, should require a thorough analysis of flexibility similar to the recommended method. The potential value of flexibility is simply too large to be ignored. Successful developers must have intuitively learned to value and enhance flexibilities in their projects. This tool could provide a resource for developers to distinguish themselves from the average developer that only have a limited tool set available for them, and as a result, it could help increasing number of more exciting yet complicated projects becoming a reality.

[36] Financial options can be valued fairly accurately because most input variables are determined by the market. For this same reason, it is impossible for investor to alter underlying conditions. In the case of Real Options, investors often find opportunities to alter input variables in a options valuation model. The chapter 4.4.2 explains this possibility in detail.

Appendix A: New Songdo City Project Inventories

PHASE	BLOCK	LAND (sf)	LAND (acre)	HOUSING	OFFICE	RETAIL	HOTEL	HOSPITAL	SCHOOL	GOV.	GOLF	PARK	TOTAL	FAR
Phase 1	35	701,000	16.1	1,000,600		1250940							2,251,540	3.2
	36	1,680,000	38.6	542,620	648,000	500,700	1,019,200			1,000,000			3,710,520	2.2
	125	1,138,000	26.1	3,972,000									3,972,000	3.5
	SUB TOTAL	**3,519,000**	**80.8**	**5,515,220**	**648,000**	**1,751,640**	**1,019,200**	**0**	**0**	**1,000,000**		**0**	**9,934,060**	**2.8**
Phase 2	23	447,000	10.3	1,372,894		176,528							1,549,422	3.5
	24	83,000	1.9	166,000		83,000							249,000	3.0
	25	162,000	3.7	324,000		162,000							486,000	3.0
	26	170,000	3.9	340,000		170,000							510,000	3.0
	33A	3,772,000	86.6			58,800						3,017,600	58,800	0.0
	34A	101,000	2.3		101,000	50,500							151,500	1.5
	34B	225,000	5.2		675,000	112,500							787,500	3.5
	34C	385,000	8.8		1,155,000	192,500							1,347,500	3.5
	37A	408,000	9.4	1,253,111		161,126							1,414,238	3.5
	37B	271,000	6.2				656,973						656,973	2.4
	38	765,000	17.6						279,513				279,513	0.4
	40	367,000	8.4	1,357,900									1,357,900	3.7
	42	361,000	8.3	1,083,000									1,083,000	3.0
	48	350,000	8.0	1,295,000									1,295,000	3.7
	54	350,000	8.0	1,282,859									1,282,859	3.7
	60	367,000	8.4	1,357,900									1,357,900	3.7
	62	361,000	8.3	1,083,000									1,083,000	3.0
	112	901,000	20.7					1,849,138					1,849,138	2.1
	SUB TOTAL	**9,846,000**	**226.0**	**10,915,664**	**1,931,000**	**1,166,955**	**656,973**	**1,849,138**	**279,513**	**0**		**3,017,600**	**16,799,243**	1.7
Phase 3	27	170,000	3.9	340,000		170,000							510,000	3.0
	28	170,000	3.9	340,000		170,000							510,000	3.0
	44	361,000	8.3	760,737									760,737	2.1
	46	361,000	8.3	469,300									469,300	1.3
	50	361,000	8.3	760,737									760,737	2.1
	52	361,000	8.3	469,300									469,300	1.3
	56	361,000	8.3	760,737									760,737	2.1

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PHASE	BLOCK	LAND (sf)	LAND (acre)	HOUSING	OFFICE	RETAIL	HOTEL	HOSPITAL	SCHOOL	GOV.	GOLF	PARK	TOTAL	FAR
	58	361,000	8.3	469,300									469,300	1.3
	64	361,000	8.3	760,737									760,737	2.1
	66	361,000	8.3	469,300									469,300	1.3
	106	9,823,000	225.5	50,303							9,822,774		50,303	0.0
	121	1,090,000	25.0									1,090,000	0	0.0
	124	307,000	7.0									307,000	0	0.0
	SUB TOTAL	**14,451,000**	**331.8**	**5,650,451**	**0**	**340,000**	**0**	**0**	**0**	**0**	**9,822,774**	**1,397,000**	**5,990,451**	0.4
Phase 4	20	271,000	6.2		2,618,448	84,029							2,702,477	10.0
	67	131,000	3.0		1,137,242	40,619							1,177,862	9.0
	68A	37,000	0.9		301,244	11,473							312,717	8.5
	68B	148,000	3.4		725,889	45,891							771,779	5.2
	69	261,000	6.0		2,265,803	80,929							2,346,732	9.0
	70A	126,000	2.9		531,468	39,069							570,537	4.5
	70B	149,000	3.4		628,482	46,201							674,683	4.5
	71	365,000	8.4		1,790,199	113,176							1,903,375	5.2
	72	366,000	8.4	732,000		549,000							1,281,000	3.5
	73	232,000	5.3									232,000	0	0.0
	74	282,000	6.5	564,000		282,000							846,000	3.0
	75	215,000	4.9	430,000		215,000							645,000	3.0
	76	215,000	4.9	430,000		215,000							645,000	3.0
	77	206,000	4.7	412,000		206,000							618,000	3.0
	82A	1,035,000	23.8	2,689,462		414,000							3,103,462	3.0
	82B	2,156,000	49.5									2,156,000	0	0.0
	83	452,000	10.4	678,000									678,000	1.5
	87	366,000	8.4	915,000									915,000	2.5
	89	366,000	8.4	1,354,200									1,354,200	3.7
	91	452,000	10.4	678,000									678,000	1.5
	93	349,000	8.0	1,291,300									1,291,300	3.7
	95	452,000	10.4	678,000									678,000	1.5
	97	349,000	8.0	1,291,300									1,291,300	3.7
	99	452,000	10.4	678,000									678,000	1.5
	101	366,000	8.4	915,000									915,000	2.5
	103	366,000	8.4	1,354,200									1,354,200	3.7
	105	775,000	17.8						279,513				279,513	0.4
	123	415,000	9.5									415,000	0	0.0
	SUB TOTAL	**11,355,000**	**260.7**	**15,090,462**	**9,998,775**	**2,342,386**	**0**	**0**	**279,513**	**0**	**0**	**2,803,000**	**27,711,137**	2.4

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PHASE	BLOCK	LAND (sf)	LAND (acre)	HOUSING	OFFICE	RETAIL	HOTEL	HOSP.	SCHOOL	GOV.	GOLF	PARK	TOTAL	FAR
Phase 5	1	395,000	9.1	1,580,000		197,500							1,777,500	4.5
	2	162,000	3.7		794,554	50,232							844,786	5.2
	3	154,000	3.5		755,317	47,751							803,068	5.2
	4	362,000	8.3	1,629,000		181,000							1,810,000	5.0
	5	243,000	5.6		1,191,831	75,347							1,267,178	5.2
	6	221,000	5.1		1,083,929	68,526							1,152,454	5.2
	8	295,000	6.8	1,327,500		147,500							1,475,000	5.0
	9	210,000	4.8		1,029,977	65,115							1,095,092	5.2
	10	222,000	5.1		1,633,250	68,836							1,702,086	7.7
	11	226,000	5.2		1,330,142	70,076							1,400,218	6.2
	14A	303,000	6.9		1,486,110	93,952							1,580,062	5.2
	15	287,000	6.6		2,463,363	115,688							2,579,050	9.0
	16	263,000	6.0		1,754,297	81,549							1,835,846	7.0
	18	207,000	4.7	124,200	82,800	207,000							414,000	2.0
	19	266,000	6.1	159,600	106,400	266,000							532,000	2.0
	21B	96,000	2.2									96,000	0	0.0
	21C	134,000	3.1	469,000		268,000							737,000	5.5
	122	443,000	10.2									443,000	0	0.0
	SUB TOTAL	**4,488,000**	**103.0**	**5,289,300**	**13,711,970**	**2,004,071**	**0**	**0**	**0**	**0**	**0**	**539,000**	**21,005,341**	4.7
Phase 6	7	138,000	3.2		588,853	34,232							623,085	4.5
	12	295,000	6.8		1,374,529	91,471							1,466,000	5.0
	17	258,000	5.9		1,265,401	79,998							1,345,399	5.2
	107	246,000	5.6		1,085,890	76,278							1,162,168	4.7
	108	236,000	5.4		1,007,024	58,542							1,065,565	4.5
	109	246,000	5.6	246,000		246,000							492,000	2.0
	110	246,000	5.6		1,025,563	76,278							1,101,841	4.5
	111	236,000	5.4		902,849	43,906							946,755	4.0
	113	246,000	5.6		941,105	45,767							986,872	4.0
	114	236,000	5.4		902,849	43,906							946,755	4.0
	116	103,000	2.4		505,179	47,906							553,085	5.4
	117	88,000	2.0		474,771	27,286							502,057	5.7
	118	155,000	3.6		760,221	48,061							808,283	5.2
	120	353,000	8.1									353,000	0	0.0
	126	3,672,000	84.3									3,672,000	0	0.0
	SUB TOTAL	**6,755,000**	**155.1**	**246,000**	**10,834,234**	**919,630**	**0**	**0**	**0**	**0**	**0**	**4,025,000**	**11,999,865**	1.8
PROJECT TOTAL		**50,414,000**	**1,157**	**42,707,097**	**37,123,979**	**8,524,682**	**1,676,173**	**1,849,138**	**559,026**	**1,000,000**	**9,822,774**	**11,781,600**	**93,440,096**	**1.9**

End of Table

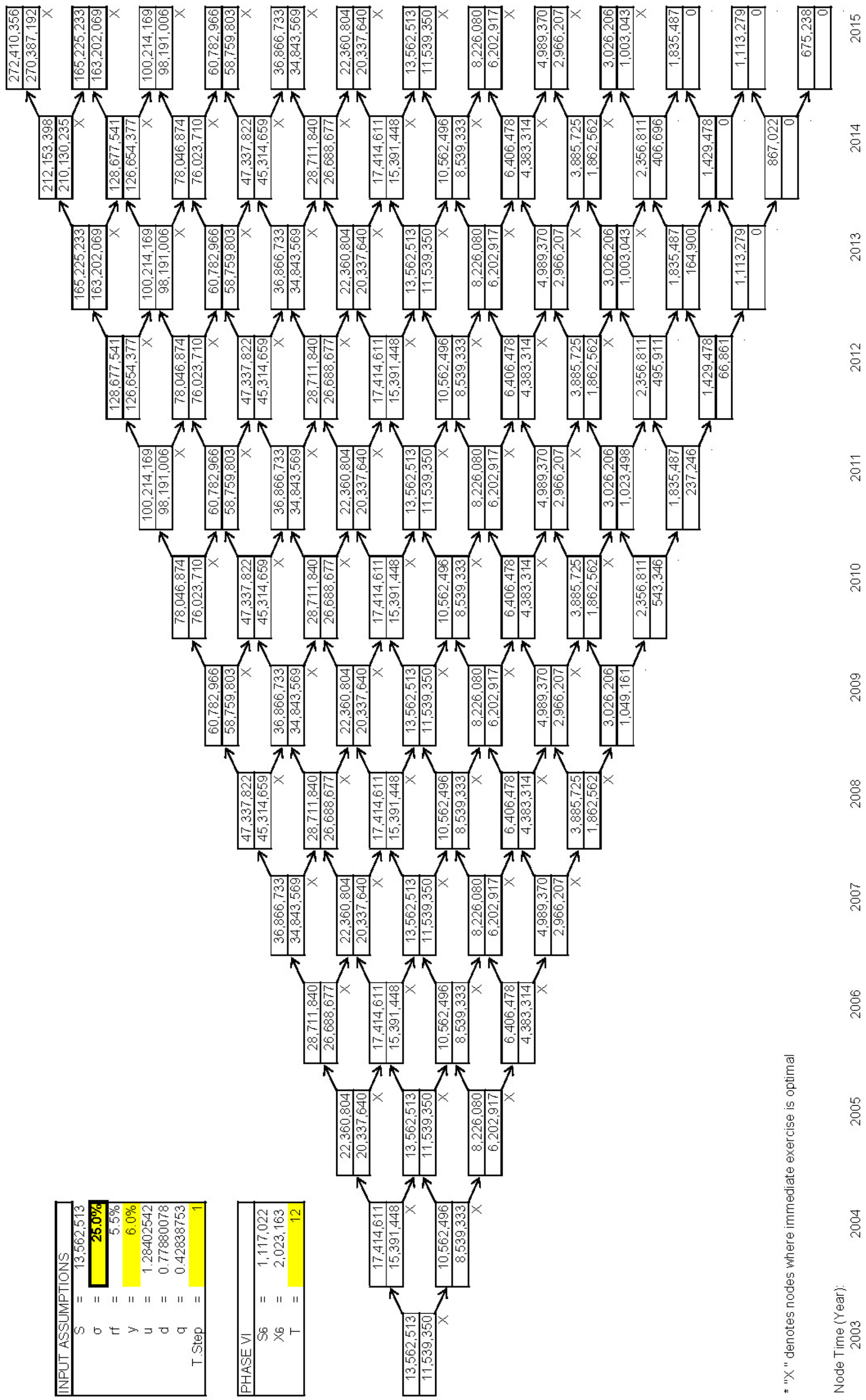
Appendix B: Pro-forma Discount Cash Flow Analysis

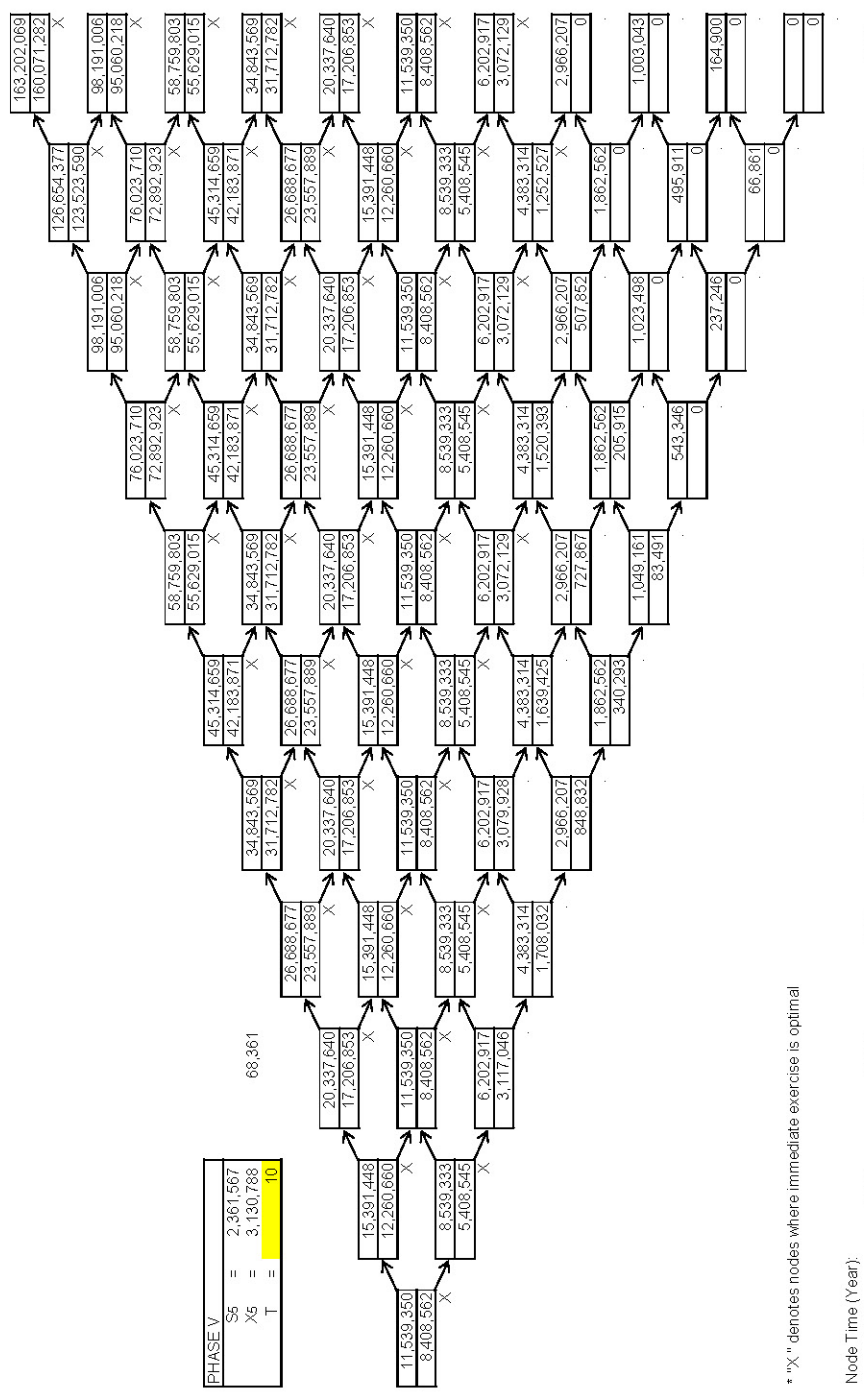
	Presnet Value	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PHASE I	**(86,333)**												
COST	**1,459,647**	**256,550**	**195,399**	**559,881**	**532,424**	**76,113**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Land + Fee	56,550	56,550											
Convention Ctr	200,000	200,000											
Residential	769,435	-	172,984	345,969	345,969								
Office	99,699	-	22,414	44,829	44,829								
Retail	173,514	-	-	131,027	65,514								
Hotel	160,450	-	-	38,056	76,113	76,113							
BENEFIT	**1,373,314**	**-**	**406,145**	**406,145**	**541,526**	**29,408**	**525,605**	**9,741**	**12,664**	**16,885**	**173,473**	**-**	**-**
Residential	1,056,562	-	406,145	406,145	541,526								
Office	114,625	-	-	-	-	5,839	229,880						
Retail	128,448	-	-	-	-	17,237	287,283						
Hotel	73,679	-	-	-	-	6,332	8,442	9,741	12,664	16,885	173,473		
PHASE II	**465,283**												
COST	**2,795,515**	**-**	**158,223**	**825,604**	**1,210,381**	**979,585**	**107,511**	**-**	**-**	**-**	**-**	**-**	**-**
Land + Fee *	149,975	-	158,223										
Residential	1,648,993	-	-	486,266	778,025	680,772							
Office	311,944	-	-	91,988	147,181	128,783							
Retail	156,919	-	-	72,118	108,177								
Hotel	108,429	-	-	32,142	38,571	57,856							
Hospital	341,707	-	-	102,849	102,849	102,849	102,849						
School	37,788	-	-	21,592	21,592								
Park	39,760	-	-	18,649	13,987	9,324	4,662						
BENEFIT	**3,260,798**	**-**	**-**	**434,688**	**1,075,547**	**1,063,334**	**1,122,607**	**1,157,993**	**9,135**	**12,789**	**411,084**	**-**	**-**
Residential	2,303,109	-	-	320,429	961,288	961,288	961,288						
Office	320,937	-	-	-	-	-	47,734	710,711					
Retail	138,448	-	-	-	-	11,539	23,078	351,294					
Hotel	130,816	-	-	-	-	-	-	5,481	9,135	12,789	411,084		
Hospital	328,716	-	-	90,507	90,507	90,507	90,507	90,507					
School	38,771	-	-	23,752	23,752								

	Presnet Value	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PHASE III	**(133,693)**												
COST	**1,308,519**	**-**	**116,112**	**116,112**	**372,612**	**579,703**	**403,682**	**-**	**-**	**-**	**-**	**-**	**-**
Land + Fee *	214,380	-	116,112	116,112									
Residential	833,368	-	-	-	259,265	414,824	362,971						
Retail	44,636	-	-	-	21,642	32,464							
Golf Course	188,170	-	-	-	91,705	114,631	22,926						
Park	27,964	-	-	-	-	17,785	17,785						
BENEFIT	**1,174,826**	**-**	**-**	**-**	**170,845**	**545,882**	**599,366**	**736,217**	**105,422**	**-**	**-**	**-**	**-**
Residential	965,087	-	-	-	170,845	512,535	512,535	512,535					
Retail	34,885	-	-	-	-	-	3,463	6,926	105,422				
Golf Course	174,854	-	-	-	-	33,347	83,368	216,756					
PHASE IV	**(277,743)**												
COST	**4,552,729**	**-**	**-**	**-**	**521,350**	**1,413,366**	**2,221,258**	**1,715,098**	**-**	**-**	**-**	**-**	**-**
Land + Fee *	468,408	-	-	-	521,350								
Residential	2,172,905	-	-	-	-	713,182	1,141,091	998,455					
Office	1,539,610	-	-	-	-	505,324	808,519	707,454					
Retail	300,227	-	-	-	-	153,575	230,363						
School	36,018	-	-	-	-	22,907	22,907						
Park	35,560	-	-	-	-	18,377	18,377	9,189					
BENEFIT	**4,274,987**	**-**	**-**	**-**	**-**	**469,958**	**1,435,072**	**1,459,644**	**1,690,512**	**1,072,174**	**5,514,705**	**-**	**-**
Residential	2,353,499	-	-	-	-	469,958	1,409,874	1,409,874	1,409,874				
Office	1,681,438	-	-	-	-	-	-	-	231,494	324,092	5,514,705		
Retail	207,847	-	-	-	-	-	-	24,572	49,144	748,083			
School	32,203	-	-	-	-	-	25,198	25,198					

	Presnet Value	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PHASE V	**(769,221)**												
COST	**3,130,788**	**-**	**72,121**	**-**	**-**	**-**	**1,110,223**	**1,762,460**	**1,359,746**	**-**	**-**	**-**	**-**
Land + Fee *	68,361	-	72,121										
Residential	743,569	-	-	-	-	-	257,474	411,958	360,463				
Office	2,061,335	-	-	-	-	-	713,774	1,142,038	999,283				
Retail	250,778	-	-	-	-	-	135,336	203,004					
Park	6,745	-	-	-	-	-	3,640	5,460					
BENEFIT	**2,361,567**	**-**	**-**	**-**	**-**	**-**	**169,665**	**508,995**	**530,648**	**783,796**	**983,328**	**5,514,705**	**-**
Residential	753,248	-	-	-	-	-	169,665	508,995	508,995	508,995			
Office	1,454,531	-	-	-	-	-	-	-	-	231,494	324,092	5,514,705	
Retail	153,788	-	-	-	-	-	-	-	21,654	43,308	659,237		
PHASE VI	**(906,142)**												
COST	**2,023,163**	**-**	**-**	**-**	**-**	**-**	**310,730**	**685,190**	**1,087,107**	**830,518**	**-**	**-**	**-**
Land + Fee *	237,750	-	-	-	-	-	310,730						
Residential	33,763	-	-	-	-	-	-	12,334	19,735	17,268			
Office	1,590,126	-	-	-	-	-	-	580,893	929,429	813,250			
Retail	112,350	-	-	-	-	-	-	63,966	95,949				
Park	49,173	-	-	-	-	-	-	27,996	41,995				
BENEFIT	**1,117,022**	**-**	**-**	**-**	**-**	**-**	**-**	**8,128**	**24,383**	**34,618**	**233,250**	**575,343**	**4,488,052**
Residential	31,989	-	-	-	-	-	-	8,128	24,383	24,383	24,383		
Office	1,024,002	-	-	-	-	-	-	-	-	-	188,398	263,757	4,488,052
Retail	61,031	-	-	-	-	-	-	-	-	10,235	20,469	311,587	
TOTAL													
COST	**15,270,361**	**256,550**	**541,855**	**1,501,597**	**2,636,767**	**3,048,767**	**4,153,404**	**4,162,747**	**2,446,854**	**830,518**	**-**	**-**	**-**
BENEFIT	**13,562,513**	**-**	**406,145**	**840,833**	**1,787,918**	**2,108,582**	**3,852,315**	**3,880,718**	**2,372,765**	**1,920,262**	**7,315,840**	**6,090,048**	**4,488,052**
CASH FLOW		**(256,550)**	**(135,711)**	**(660,764)**	**(848,849)**	**(940,185)**	**(301,089)**	**(282,029)**	**(74,089)**	**1,089,744**	**7,315,840**	**6,090,048**	**4,488,052**
IRR	**28.77%**												
NPV	**(1,707,848)**												

Appendix C: Valuation of Compound Expansion Options




PHASE V
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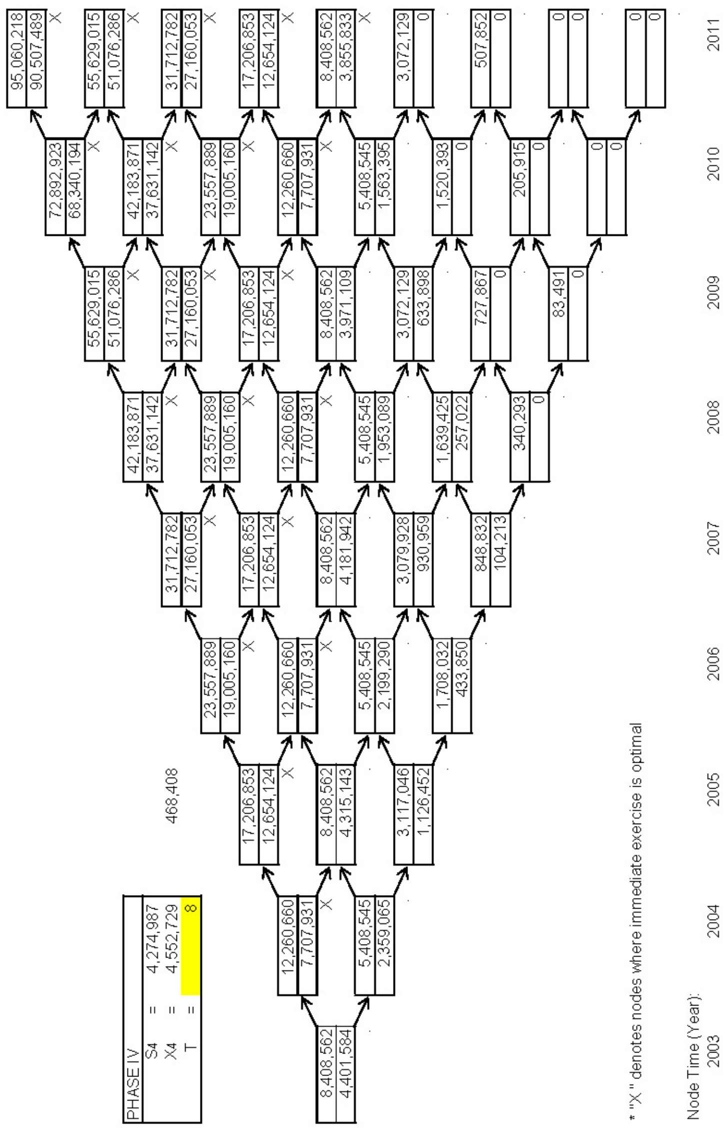
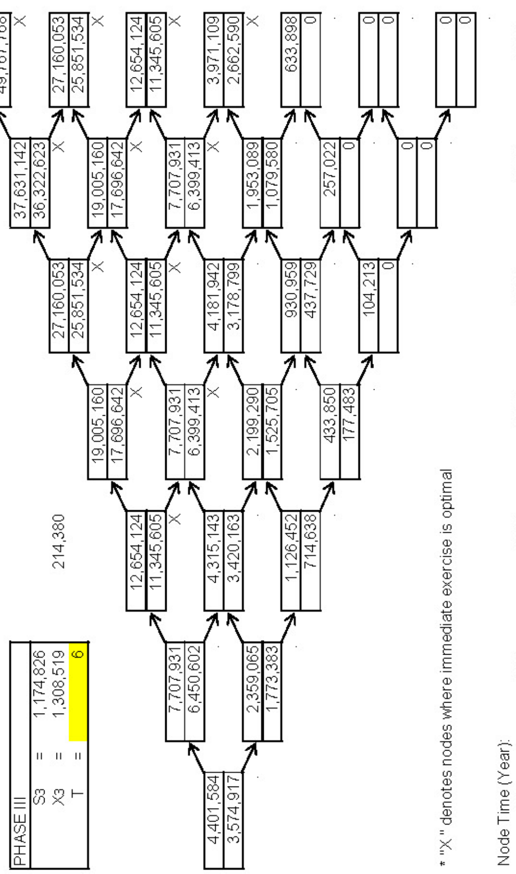
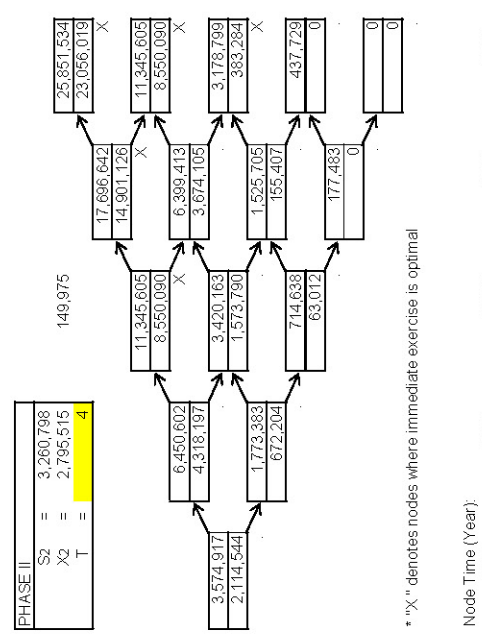
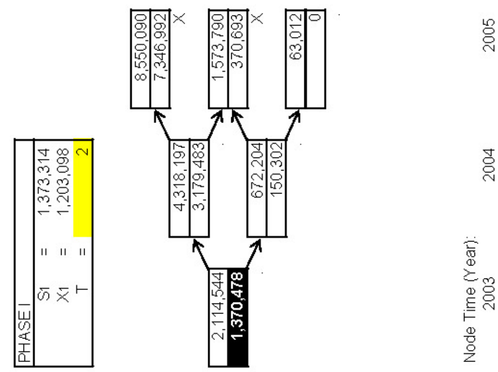
X5 = 3,130,788
T = 10
68,361
11,539,350 8,408,562 X
15,391,448 12,260,660 X
8,539,333 5,408,545 X
20,337,640 17,206,853 X
11,539,350 8,408,562 X
6,202,917 3,117,046
26,688,677 23,557,889 X
15,391,448 12,260,660 X
8,539,333 5,408,545 X
4,383,314 1,708,032
34,843,569 31,712,782 X
20,337,640 17,206,853 X
11,539,350 8,408,562 X
6,202,917 3,079,928
2,966,207 848,832
45,314,659 42,183,871 X
26,688,677 23,557,889 X
15,391,448 12,260,660 X
8,539,333 5,408,545 X
4,383,314 1,639,425
1,862,562 340,293
58,759,803 55,629,015 X
34,843,569 31,712,782 X
20,337,640 17,206,853 X
11,539,350 8,408,562 X
6,202,917 3,072,129 X
2,966,207 727,867
1,049,161 83,491
76,023,710 72,892,923 X
45,314,659 42,183,871 X
26,688,677 23,557,889 X
15,391,448 12,260,660 X
8,539,333 5,408,545 X
4,383,314 1,520,393
1,862,562 205,915
543,346 0
98,191,006 95,060,218 X
58,759,803 55,629,015 X
34,843,569 31,712,782 X
20,337,640 17,206,853 X
11,539,350 8,408,562 X
6,202,917 3,072,129 X
2,966,207 507,852
1,023,498 0
237,246 0
126,654,377 123,523,590 X
76,023,710 72,892,923 X
45,314,659 42,183,871 X
26,688,677 23,557,889 X
15,391,448 12,260,660 X
8,539,333 5,408,545 X
4,383,314 1,252,527 X
1,862,562 0
495,911 0
66,861 0
163,202,069 160,071,282 X
98,191,006 95,060,218 X
58,759,803 55,629,015 X
34,843,569 31,712,782 X
20,337,640 17,206,853 X
11,539,350 8,408,562 X
6,202,917 3,072,129 X
2,966,207 0
1,003,043 0
164,900 0
0 0
* "X" denotes nodes where immediate exercise is optimal
Node Time (Year): 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013


PHASE IV
S4 = 4,274,987
X4 = 4,552,729
T = 8
468,408
8,408,562
4,401,584
12,260,660
7,707,931
X
5,408,545
2,359,065
17,206,853
12,654,124
X
8,408,562
4,315,143
3,117,046
1,126,452
23,557,889
19,005,160
X
12,260,660
7,707,931
X
5,408,545
2,199,290
1,708,032
433,850
31,712,782
27,160,053
X
17,206,853
12,654,124
X
8,408,562
4,181,942
3,079,928
930,959
848,832
104,213
42,183,871
37,631,142
X
23,557,889
19,005,160
X
12,260,660
7,707,931
X
5,408,545
1,953,089
1,639,425
257,022
340,293
0
55,629,015
51,076,286
X
31,712,782
27,160,053
X
17,206,853
12,654,124
X
8,408,562
3,971,109
3,072,129
633,898
727,867
0
83,491
0
72,892,923
68,340,194
X
42,183,871
37,631,142
X
23,557,889
19,005,160
X
12,260,660
7,707,931
X
5,408,545
1,563,395
1,520,393
0
205,915
0
0
0
95,060,218
90,507,489
X
55,629,015
51,076,286
X
31,712,782
27,160,053
X
17,206,853
12,654,124
X
8,408,562
3,855,833
X
3,072,129
0
507,852
0
0
0
0
0
* "X" denotes nodes where immediate exercise is optimal
Node Time (Year):
2003
2004
2005
2006
2007
2008
2009
2010
2011

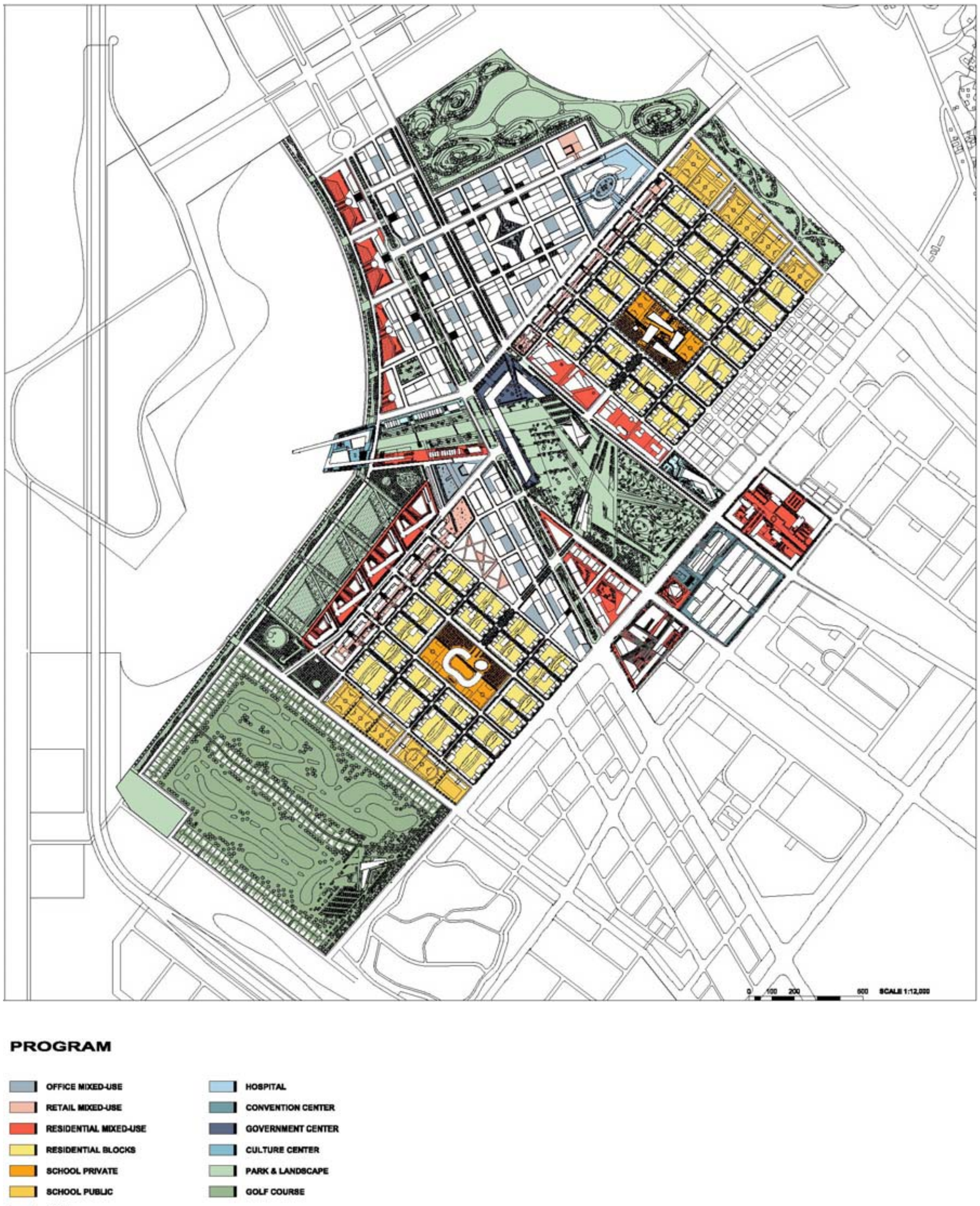

PHASE III
S3 = 1,174,826
X3 = 1,308,519
T = 6
214,380
4,401,584
3,574,917
7,707,931
6,450,602
2,359,065
1,773,383
12,654,124
11,345,605
X
4,315,143
3,420,163
X
1,126,452
714,638
19,005,160
17,696,642
X
7,707,931
6,399,413
X
2,199,290
1,525,705
433,850
177,483
27,160,053
25,851,534
X
12,654,124
11,345,605
X
4,181,942
3,178,799
930,959
437,729
104,213
0
37,631,142
36,322,623
X
19,005,160
17,696,642
X
7,707,931
6,399,413
X
1,953,089
1,079,580
257,022
0
0
0
51,076,286
49,767,768
X
27,160,053
25,851,534
X
12,654,124
11,345,605
X
3,971,109
2,662,590
X
633,898
0
0
0
0
0
* "X " denotes nodes where immediate exercise is optimal
Node Time (Year):
2003
2004
2005
2006
2007
2008
2009


PHASE II
S2 = 3,260,798
X2 = 2,795,515
T = 4
149,975
3,574,917
2,114,544
6,450,602
4,318,197
1,773,383
672,204
11,345,605
8,550,090
X
3,420,163
1,573,790
X
714,638
63,012
17,696,642
14,901,126
X
6,399,413
3,674,105
1,525,705
155,407
177,483
0
25,851,534
23,056,019
X
11,345,605
8,550,090
X
3,178,799
383,284
X
437,729
0
0
0
* "X " denotes nodes where immediate exercise is optimal
Node Time (Year):
2003
2004
2005
2006
2007

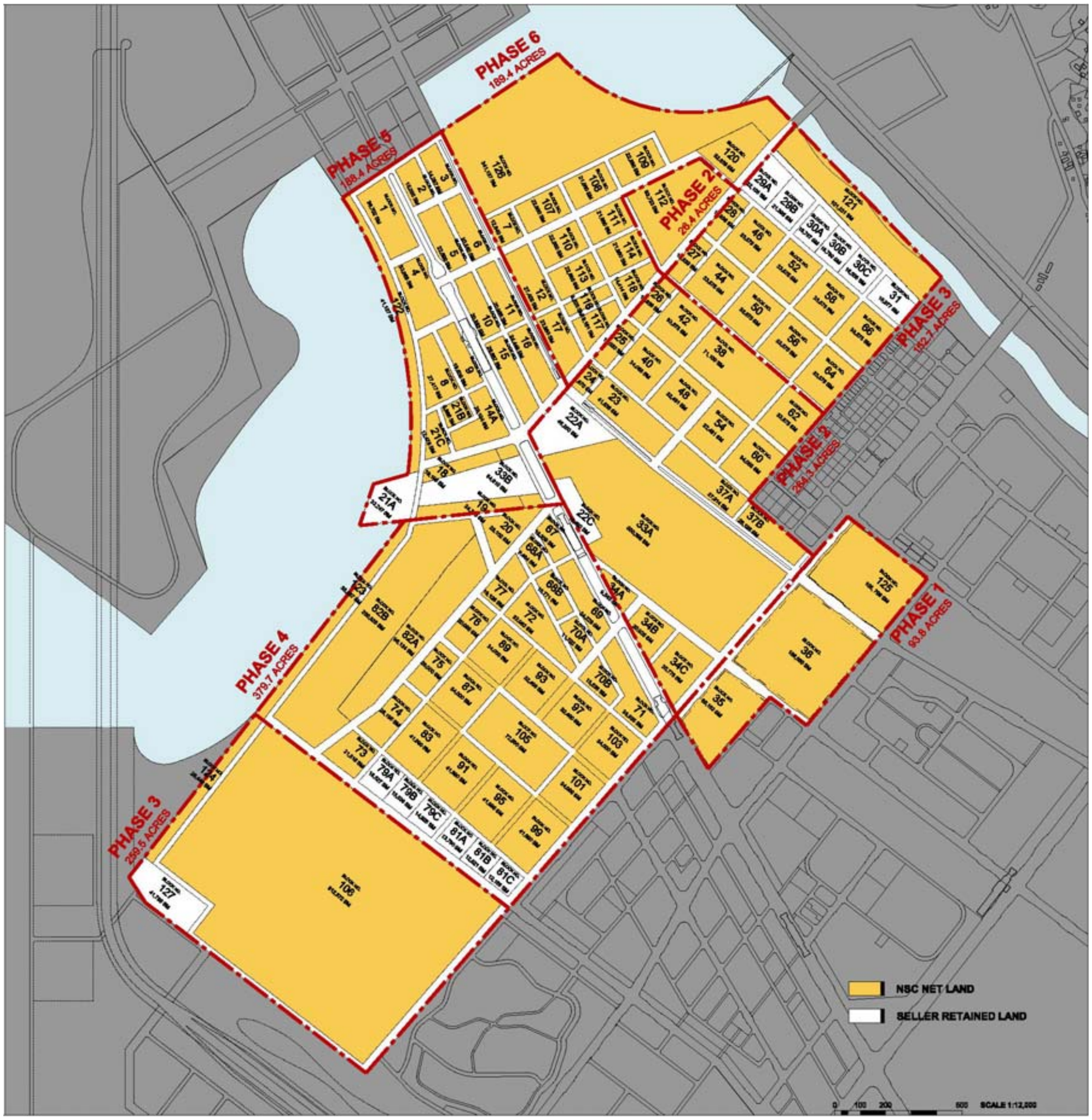

PHASE I
S1 = 1,373,314
X1 = 1,203,098
T = 2
2,114,544
1,370,478
4,318,197
3,179,483
672,204
150,302
8,550,090
7,346,992
X
1,573,790
370,693
X
63,012
0
Node Time (Year):
2003
2004
2005

Appendix D: New Songdo City Master Plan

a. OVERALL MASTER PLAN



b. PHASING AND BLOCK DIAGRAM



PHASE 1	(SM)	(ACRES)
GROSS LAND AREA:	379,715.0	93.8
NCS NET LAND AREA:	326,921.0	80.8
SELLER RETAINED LAND AREA:	52,794.0	13.0

PHASE 2		
GROSS LAND AREA:	1,176,826.9	290.8
NCS NET LAND AREA:	914,526.4	226.0
SELLER RETAINED LAND AREA:	262,300.5	64.8

PHASE 3		
GROSS LAND AREA:	1,536,592.7	412.2
NCS NET LAND AREA:	1,106,013.4	330.8
SELLER RETAINED LAND AREA:	430,579.3	81.4

PHASE 4		
GROSS LAND AREA:	1,536,764.0	379.7
NCS NET LAND AREA:	1,106,191.0	273.3
SELLER RETAINED LAND AREA:	430,573.0	27.0

PHASE 5		
GROSS LAND AREA:	762,556.3	186.4
NCS NET LAND AREA:	417,716.1	103.2
SELLER RETAINED LAND AREA:	129,094.8	85.2

PHASE 6		
GROSS LAND AREA:	766,475.3	189.4
NCS NET LAND AREA:	637,380.5	157.5
SELLER RETAINED LAND AREA:	129,094.8	31.9

TOTAL		
GROSS LAND AREA:	**6,290,352.2**	**1,554.3**

c. BUILDING TYPES AND PROGRAMS

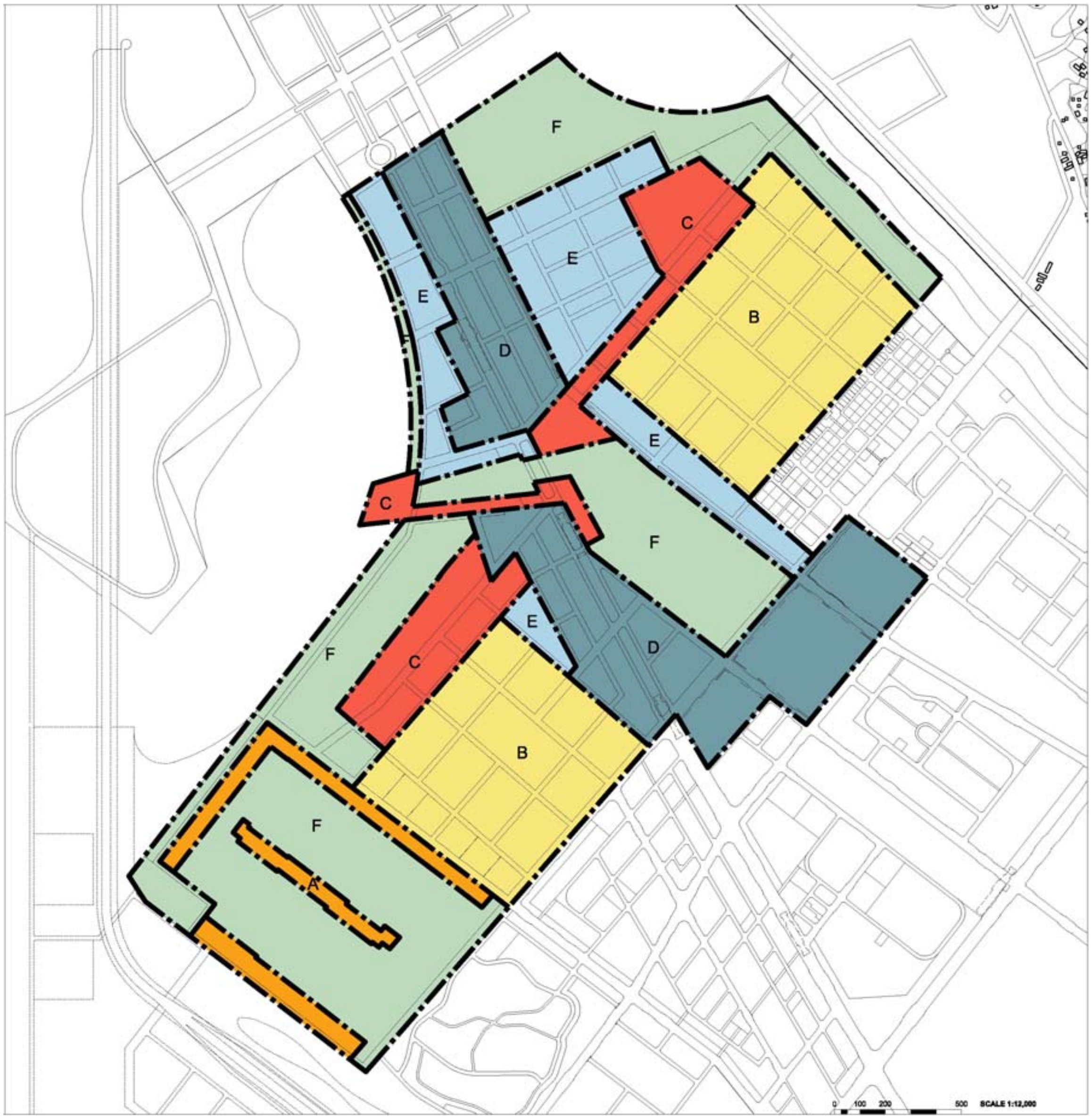
BUILDING TYPES

1 CONVENTION WITH RETAIL MALL
2 SIXTY-STORY HIGH-RISE TOWER
3 DEPARTMENT STORE
4 CENTRAL PARK + CAR-PARKING GARAGE
5 HOTEL
6 RESIDENTIAL MIXED-USE BLOCK
7 GOVERNMENT CENTER
8 MUSEUM
9 CULTURAL CENTER
10 OFFICE: MIXED-USE
11 STREET RETAIL
12 PRIVATE SCHOOL
13 TYPICAL RESIDENTIAL BLOCK (LOW FAR)
14 TYPICAL RESIDENTIAL BLOCK (HIGH FAR)
15 HOSPITAL
16 HIGH-RISE RESIDENTIAL MIXED-USE
17A GOLF COURSE CLUBHOUSE
17B GOLF COURSE VILLA
18 HIGH-RISE RESIDENTIAL MIXED-USE NEAR WATER

PROGRAM

- OFFICE MIXED-USE
- RETAIL MIXED-USE
- RESIDENTIAL MIXED-USE
- RESIDENTIAL BLOCKS
- SCHOOL PRIVATE
- SCHOOL PUBLIC
- HOTEL
- HOSPITAL
- CONVENTION CENTER
- GOVERNMENT CENTER
- CULTURE CENTER
- PARK & LANDSCAPE
- GOLF COURSE

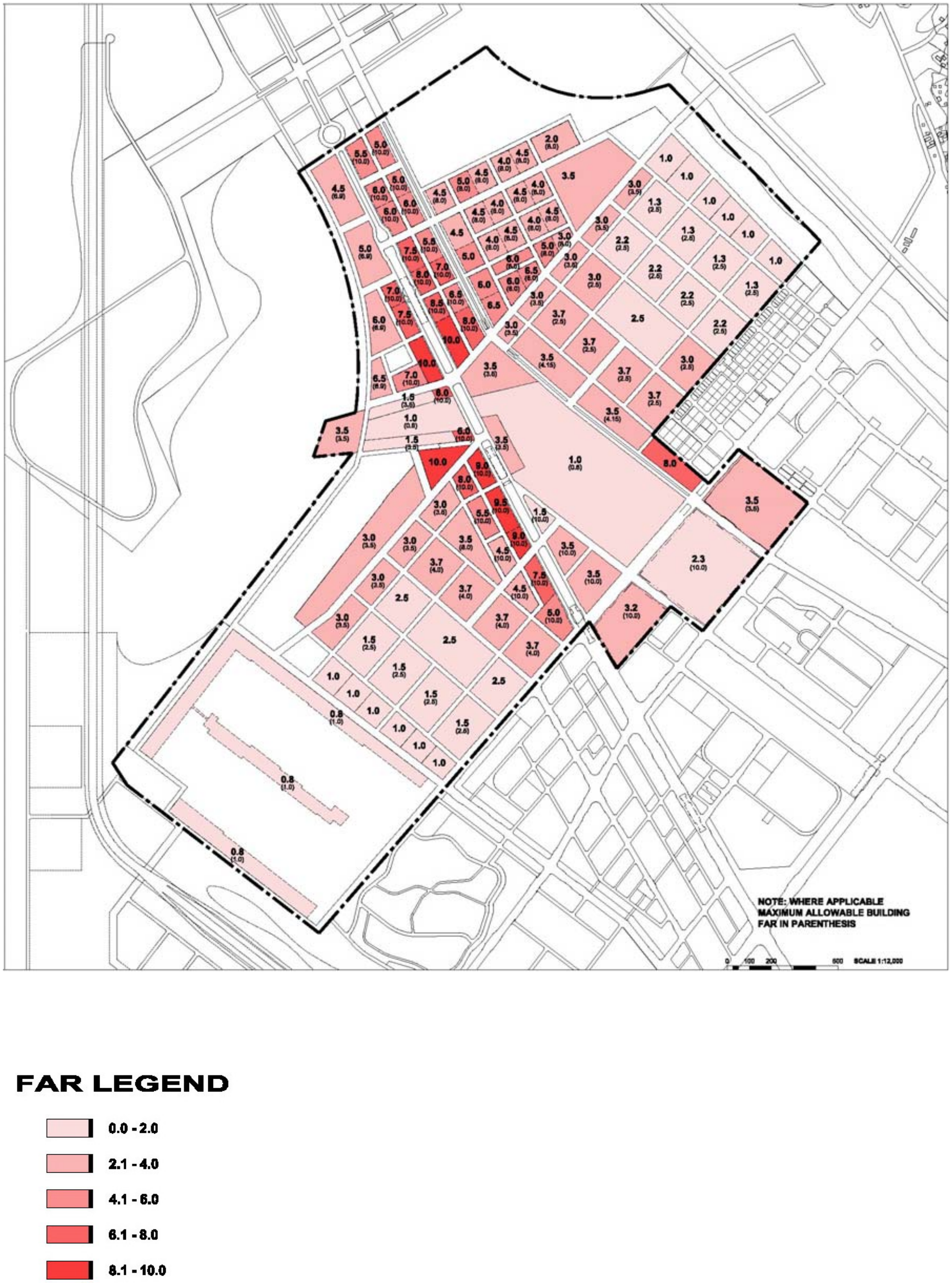
d. PROPOSED DISTRICT ZONING DIAGRAM



DISTRICT ZONING

- A RESIDENTIAL (TYPE 1)
- B RESIDENTIAL (TYPE 3)
- C SEMI-RESIDENTIAL
- D CENTRAL COMMERCIAL
- E GENERAL COMMERCIAL
- F NATURAL GREEN

e. PROPOSED BUILDING FAR DIAGRAM



Appendix E: New Songdo City Images

a. AERIAL VIEW OF NEW SONGDO CITY

b. CENTRAL PARK AND UNDERGROUND GARAGE

c. TYPICAL RESIDENTIAL BLOCK

d. HIGH RISE MIXED-USE BLOCK NEAR WATER

e. DEPARTMENT STORE

f. STREET RETAIL AND CANAL

g. HOSPITAL

h. GOLF COURSE AND CLUB HOUSE

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