A Real Options Analysis of a Vertically Expandable Real Estate Development

by

Anthony C. Guma

Bachelor of Design in Architecture, University of Florida, 1998

Master of Architecture, Massachusetts Institute of Technology, 2001

Submitted to the Department of Urban Studies and Planning
in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Real Estate Development

at the

Massachusetts Institute of Technology

September, 2008

Signature of Author____
Department of Urban Studies and Planning
July 31, 2008

Certified by____
Richard de Neufville
Professor of Engineering Systems and of Civil and Environmental Engineering
Thesis Supervisor

Accepted by____
Brian A. Ciochetti
Chairman, Interdepartmental Degree Program in
Real Estate Development

A Real Options Analysis of a Vertically Expandable Real Estate Development

by

Anthony C. Guma

Submitted to the Department of Urban Studies and Planning
on July 31, 2008
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Real Estate Development

Abstract

Like many great business ventures, grand successes in real estate development are often attributed to individuals with strong visions and talent, as well as a keen foresight on the future conditions which will ultimately decide the value of their projects. Even with the best forecasts and predictions, this type of a clear view of the future real estate market is typically difficult to bring into focus. By considering developments which provide the ability to react accordingly to the uncertainty of future forces, developers can better manage the risk associated with a potential weak market while also gaining the potential to benefit in a strong one. Flexibility of this type in real estate is generally known as a "real option."

Even in dense urban centers with a limited amount of developable land, market uncertainty may still exist. Therefore, flexibility in that type of environment could allow a developer to be better positioned should a market improve or decline. One way to provide this type of flexibility on urban sites is to develop a given quantity of space initially with the option to add more vertically in the future. Although rare, such vertical expansions are quite feasible and the real option is quantifiable.

This thesis investigates the value of providing a real option to vertically expand a structure in the future. Real option valuation is often regarded as a complex procedure and outside of typical real estate finance. This investigation will adopt a previously developed methodology based on familiar spreadsheet techniques and common valuation metrics such as net present value.

To explore the use of this methodology and the potential value of vertical expansion, the Health Care Service Corporation headquarters in Chicago, IL is the basis of an analysis. This structure represents an existing building with the built-in option to expand vertically to almost twice its initial height.

Thesis Supervisor: Richard de Neufville
Title: Professor of Engineering Systems and of Civil and Environmental Engineering

Acknowledgements

I would like to sincerely thank Professor Richard de Neufville for his guidance, insight, and dedication as the supervisor of this thesis. From the very beginning, his comments and enthusiasm were an inspiration to this work and his vast experience always provided the clearest advice. It was a pleasure to conduct this work as an interdisciplinary link between the Center for Real Estate and the Engineering Systems Division at MIT.

Professor David Geltner was essential to the success of this thesis. I am very thankful for his support along the way, his patience in working through the stumbling points with me, and for his introduction to Professor de Neufville. This thesis would not have existed without his discovery of the HCSC project and his help in developing a relationship with the team in Chicago. Also, his dedication to instructing finance at the CRE is unwavering and he was a valuable part of my experience over the past year.

Michel-Alexandre Cardin was an excellent resource for all aspects of this research. His lecture on flexibility and tutorial of the engineering-based methodology was a strong factor in cementing my interest in this topic.

Many thanks go to the HCSC Vertical Completion project team in Chicago for being terrific hosts, providing great information, and allowing us to share in a truly amazing project.

I would like thank my all of my fellow classmates, the faculty, and staff of the CRE for making this year such a great experience. Especially to Jason Pearson and Kate Wittels, two classmates who explored this fascinating topic and the HCSC project along with me.

To all of my great friends, thank you for being around when I needed distractions the most. Especially those who I neglected so often over the year.

Finally, I am utterly grateful to have the best parents and family imaginable and who always give me their unconditional support in so many ways... Over this year, and in all of my endeavors.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

1.1 Background

The real estate evaluation process involves a series of forecasts intended to provide an unbiased and realistic projection of a potentially uncertain future (Geltner et al, 2007). While a rigorous analysis of economic data and trends can form the basis for inputs which may ultimately fall close to expectations, a level of uncertainty will always exist. Given this reality, and in spite of best efforts, real estate must often take a passive position with respect to the external variables which play a determinate role in the value of the property. This context provides little in the way of actively responding to changes in market conditions, and typically the only choices may be efforts to sell the asset or some form of repositioning. If flexibility can be embedded in real property in a way which allows the investment to respond accordingly to favorable conditions in the future, or to avoid potentially negative outcomes, the asset may inherently be more valuable. Similar to options on financial assets, the greater potential volatility of the future results in a greater value of the flexibility itself.

Flexibility in real estate development comes from the ability to change the nature or course of a project as future events are revealed. These opportunities are referred to as 'real options' and are the right, but not the obligation, to different actions in capital budgeting in response to future knowledge or events (Brealey et al, 2006). When considering the value that flexibility brings to a real estate development, the traditional discounted cash flow (DCF) and net present value (NPV) approaches will typically ignore options available in the future. To effectively value this flexibility, a real options analysis (ROA) can be applied as an option based approach which integrates decision making opportunities at future points in time.

The option to expand or contract real estate over time is often seen in multi-phase development projects in which a parcel of land is strategically planned to accommodate a series of structures built sequentially (horizontally) across the site over time. A less frequently implemented and alternative strategy is to build the optionally into a singular structure allowing for an option to expand (vertically) under favorable conditions. While projects of this nature present interesting design, engineering, and project management challenges, the result of these efforts is a clear option in the scheme which may ultimately add the value of flexibility to developments which ordinarily stand statically.

This thesis analyzes and evaluates a real estate development project with this type of embedded vertical expansion flexibility. Specifically, this study is based on a downtown Chicago commercial office tower with the built-in option to expand vertically to almost twice its initial height. Through the use of a real options analysis, the value of the optional future investment opportunity will be determined and compared to inflexible base case scenarios.

1.2 Methodology

There are many documented real option valuation methodologies which range in levels of complexity and are demonstrated on a varied set of applications. The valuation model used in this thesis is based the notion that the application of an ROA to investment decisions can be most effective in the hands of managers in a way that limits the calculation complexities that are generally associated with the valuation of real options (Leslie and Michaels, 1997; Copland and Antikarov, 2001). Therefore, the valuation methodology applied in this thesis is an application of the simple spreadsheet analysis described by de Neufville et al (2006), and also referred to as an engineering-based approach. This approach uses Monte Carlo simulation techniques within Excel® to simulate possible future outcomes as a way to determine expected net present values (ENPV).

This engineering-based approach will be applied to a case study analysis of the Health Care Service Corporation (HCSC) headquarters in Chicago, IL (Figure 1.1) from and ex-post point of view by comparing a deterministic scenario of the development to a scenario which exercises the embedded flexibility in a strategic manner.

Figure 1.1: HCSC headquarters with vertical expansion / completion seen under construction, 2008 (Source: Author).

1.3 Objective

In applying the engineering-based valuation method to the HSCS headquarters, a current project with built-in flexibility, the objective of this thesis is to investigate the following:

- The reasons why a real options analysis is appropriate for a development project such the HCSC tower.
- The characteristics of a real estate development which make vertical expansion desirable and feasible.
- A real options analysis to determine the potential value of the flexibility in a vertically phased structure.

Chapter 2: Real Options Overview

The basic toolset at work when valuing a real estate development project includes a multi-year discounted cash flow analysis and decision based on a net present value. The NPV rule is commonly understood to provide a sound method for deciding between mutually exclusive opportunities by identifying the alternative with the greatest value. This method also allows for the rejection of any alternative which presents a negative NPV. This process inherently forces a decision based on a set of fixed forward looking assumptions and ignores the value achievable when flexibility is provided in a project. Real options analysis provides a means to quantity the value which flexibility brings to a project in its ability to respond appropriately to uncertainties in the future real estate market.

The concept of a real option is very broad and considerable information is available within financial literature describing various definitions, valuation methods, and applications. The underlying theories and applications are far reaching, and it is beyond the scope of this thesis to provide a comprehensive description of real options in a general way. It is the intent of this chapter to describe the basic concepts as they relate to real estate and in particular to the analysis of a vertically phased development project. This chapter also provides background and precedent information which positions the work within the greater literarily discourse on flexibility and real options in real estate.

2.1 Description of Real Options

In a simplified sense, a real option in real estate is the opportunity to make changes to a development project or other investment as previously unknown information is revealed. Different sources on the topic of real options all have slightly different definitions although the general sentiment is consistent. Also, in contrast to financial options in which value is derived from an underlying financial asset, real options derive their values from a tangible or real asset. A more formal definition relevant to the context of this study is that a "real option is the right, but not the obligation, to take an action (e.g., deferring, expanding, contracting, or abandoning) at a predetermined cost called the exercise price, for a predetermined period of time – the life of the option (Copland and Antikarov, 2001, p.5)." In all cases, the motivating factor in the decision making process is it to take advantage of a potential future upside to an investment, and to limit a potential downside. These characteristics of real options provide the benefit from flexibility in responding to the future uncertainties for which traditional underwriting and DCF analysis attempts to account for. Although the depicted real option model is not directly implemented in this thesis, Figure 2.1 represents a comparison between a traditional NPV analysis and an ROA.

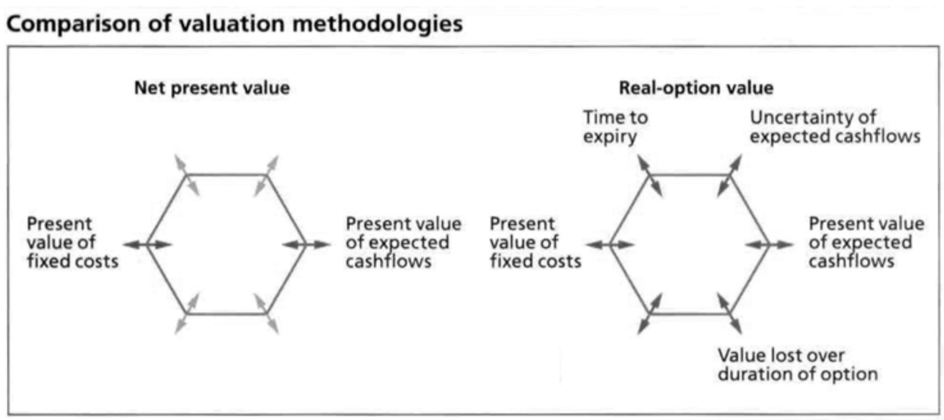


Figure 2.1: Comparison of NPV and Real Option Methodologies (Source: Adopted from Leslie and Michaels, 1997).

2.2 Real Option Types

While financial options generally provide the owner with the option to buy (a call option) or sell (a put option) an underlying asset at a specified price (exercise or strike price) for a specified amount of time, real options provide flexibility in several analogous ways. The general types of real options which are applicable to real estate development may be summarized in the following list:

- A deferral option – the right to delay a project.
- An abandonment option – the right to terminate a project.
- An option to expand/contract – the right to increase or decrease the scale of a development.
- A switching option – the right to change from one product type to another.

- A growth option – an option acquired through investing in the creation of future growth opportunities (e.g. new technologies or infrastructure).
- A compound option – a phased option in which an option is contingent on the prior exercise of a preceding option (an option on an option).

Based on a list defined by Brach (2003).

Given the focus of this study on a vertically phased development project, the compound option is the primary type investigated. As described in greater detail subsequently, the option to construct an additional series of levels above an existing building is contingent of the prior decision to exercise the initial option to develop the land originally.

2.3 Real Option Valuation Methods

Much has been written with regard to the shortcomings of DCF/NPV techniques when compared to real options analyses. This criticism is based on these models being unable to account for potential flexibility at the time of the investment decision. When the decision to invest is made irreversibly and without flexibility, the ability to react to the arrival of new information at a later date is lost. This value can been seen as an opportunity cost which is not a considered in a traditional DCF/NPV analysis. While incorporating this opportunity cost into the analysis can attempt to capture the value of the option, an alternative approach is to adopt option pricing models typically used in valuing financial assets to the investment opportunities of real assets (Dixit and Pindyck, 1994). In summary and with specific respect to real estate, Sirmans summarized this dilemma such that a:

> DCF model is not only incomplete, but may lead to costly errors. Investors must decide when to invest, how to modify operating plans during the life of the project, and when to sell the investment. Existing research shows the conventional DCF techniques can be poorly suited for investment valuation in the presence of 'real options.' If the NPV of a project is redefined to include the opportunity cost of exercising the option to invest, then the standard rule of 'invest if NPV is positive' is still applicable (1997, p. 95)

In recognition of the DCF/NPV limitations, the use of ROA has gained traction, slowly at first, in the context of capital budgeting since the term was introduced in the late 1970's. From the initial academic interest in the 1980's, the concepts and methodologies of real options began to take a foothold a among industry professionals when considering a range of corporate investment opportunities (Borison, 2005). Following from these beginnings, ROA have been applied within the real estate context for topics which include the determination of land value, the optimum time to switch from one use to another, the value of flexibility in a multi-phase development, and many other instances.

While the use of ROA has found a place among practitioners, the methodologies for conducting such analyses are diverse. The methods vary in complexity and range from quantitatively rigorous models based on financial option valuation, to procedures which use techniques and intuitions that real estate developers are familiar with. For example, although distinct in its ability to incorporate flexibility in investment decisions, in many cases the technical aspects of an ROA includes discounting cash flows and net present value calculations as integrated parts of the valuation (Copland and Antikarov, 2001). So in this sense, ROA does not act as a replacement to DCF, as a DFC analysis is often necessary to understand the value of the underlying asset (Brealey et al, 2006). This relationship places real options into the parlance of widely understood real estate finance (DCF analysis, NPV rule). When combined with methods which are implemented within the familiar tool of Excel®, ROA has the potential to augment common professional practices.

2.3.1 Real Options in Relation to Financial Options

To see the relationship between financial options and real options as well as the role of NPV as a link to real options analyses, one way is by looking at the framework and the associated description for "mapping the characteristics of the business opportunity onto the template of a call option" proposed by Luehrman (1998). Luehrman's framework begins with an identification of the option to be investigated and its properties such as expected cash flows, length of time to options can be deferred, and the projected costs to exercise the option. After this initial identification, the properties of the investment opportunity are then mapped on to the analogous requirements of a European call option (Figure 2.2).

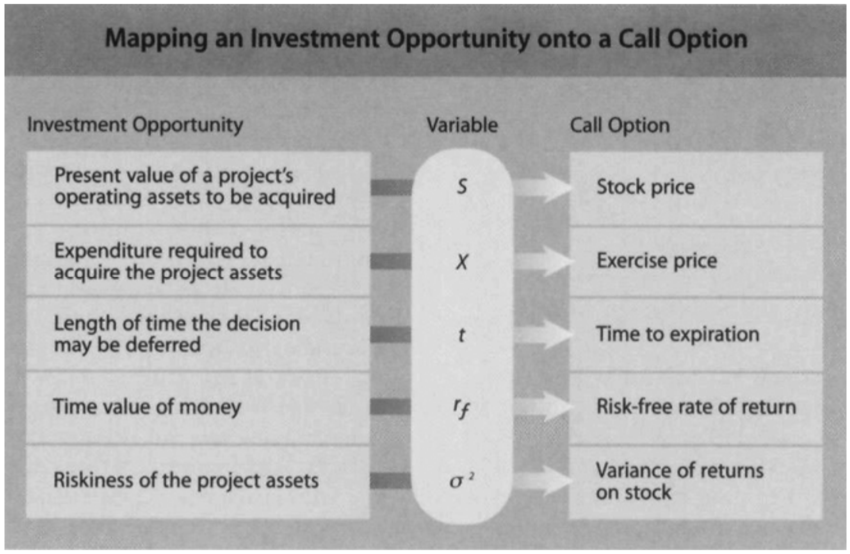


Figure 2.2: Mapping an Investment Opportunity onto a Call Option (Source: Luehrman, T. A., 1998).

The first two components of this mapping, the present value of the project (S) and the total cost (X), are provided by the same values calculated in a traditional DCF model and therefore a DCF analysis is the beginning point of considering the option. Given that traditional DCF calculations do not incorporate the added value that the option provides, the remaining factors in the mapping form the necessary components to value the flexibility. These factors include the length of time for which the option can be exercise (t), the interest which may be earned on the expenditure (r_f, the risk-free rate), and the riskiness or volatility of the real asset (σ^2).

Of all the variables in the above mapping, the volatility (σ^2) of the real asset is most difficult to define. For example, in engineering systems the historical volatility data is typically not available (de Neufville, 2002). At the same time, this variable is essential in that it is a measure of future uncertainty and the ultimate value of flexibility in a project is its ability to respond to the uncertainties of the future. For options on financial assets, this volatility can be defined as the standard deviation of a particular stock's annual returns based on information which is readily available. When considering this variable in an ROA, Luehrman recommends "taking a(n educated) guess" in the range of 30% to 60% percent per year when information is scarce, researching information on similar industries, and simulating a distribution of returns with computer based Monte Carlo simulations. When researching data, comparables to consider would be publicly traded stocks of businesses with investment opportunities which would be of a similar level of risk (Brealey et al, 2006). For real estate, the volatility of individual build properties is typically in the range of 10% to 25% per year (Geltner et al 2007).

Following this mapping of variables, the framework continues by determining the value of the call option through and application of the Black-Scholes formula using the mapped variables as inputs. Luehrman goes on to present this framework for a compound option in which the NPV of the flexible project equals the NPV of the first phase plus the value of the call option (NPV Flexible = NPV Phase 1 + Option Value Phase 2). This is facilitated by first separating the cash flows of the two phases and performing a DCF analysis for each.

2.3.2 Real Options Analysis in Real Estate

The preceding example describes how the valuation of real options can be understood in the context of financial options, and how the lexicon of real options is shared with the typical vocabulary of real estate finance. This introduction can be continued by looking at more specific methods of using real option analyses, or more generally, option valuation theory (OVT) in the context of real estate development. One application of this theory is the call option model of land value and related the value of land the development option it provides an owner (Geltner et al, 2007).

The following examples in this section summarize the examples presented by Geltner et al, (2007). The original text should be referenced for more detailed explanations.

An example of the option valuation theory as it relates directly to land value can be seen in a one-period binomial model of a one year deferral option to develop a structure. This model is based on acquiring the option to develop a building immediately, or to defer the development for one year. The following table summarizes the value of the land with the deferral option and the value of the option (Table 2.1). The "action" row of the table can be understood with a review of a typical call option which provides the owner the right, but not the obligation to buy an underlying asset. The option has a positive value when the current price of the underlying asset has a spot price (S) above the strike price (K), the price in which the underlying asset can be purchased for. In this case the spot price is analogous to the value of the developed property, and the strike price relates to the construction cost. The payoff of the call option can be expressed as $\mathrm{MAX}[(S-K), 0]$, and in this was payoff captures any potential upside and limits the downside exposure to the cost of purchasing the option. In this example in Table 2.1, the option is "in the money" when the value of the developed property is $113.21 and in turn, the value of the options is $23.21.

($ Millions)	Today	Next Year	
Probability	100%	30%	70%
Value of Developed Property	$100.00	$78.62	$113.21
Development Cost (Excluding Land Cost)	$88.24	$90.00	$90.00
NPV of Exercise	$11.76	-$11.38	$23.21
(Action)		(Don't Build)	(Build)
Future Values		0	$23.21
Expected Value of Built Property	$100.00	$102.83	
(Probability x Outcome)	(1.0 x 11.76)	(0.3 x 78.62) + (0.7 x 23.21)	
Expected Value of Option	$11.76	$16.25	
(Probability x Outcome)	(1.0 x 11.76)	(0.3 x 0) + (0.7 x 23.21)	
PV (Today) of Alternatives @ 20% Discount Rate	$11.76	$13.54 = (16.25/1.20)	
Land Value Today = MAX(11.76, 13.54) = $13.54			
Option Premium = $13.54 - $11.76 = $1.78			

Table 2.1: Option Premium Value Due to Future Uncertainty in Built Property Value (Source: Adopted from Geltner et al, 2007).

As the above table illustrates, the option premium is the value captured by the flexibility to develop the land in one year as opposed to immediately. This is based in the ability of the development flexibility to respond to the probability of the value of the built property having a 70% chance of increasing to $113.21 and a 30% chance of decreasing to $78.62.

While this one-period model presents a clear example of the value of flexibility, this scenario can be expanded to incorporate a series of future scenarios and each with an up or down outcome. The following binomial tree (Figure 2.3) is an expansion of the preceding example by dividing the one year period into 12 months.

Month:

0	1	2	3	4	5	6	7	8	9	10	11	12
												$184.73
											$175.52	
										$166.77		$165.11
									$158.45		$156.88	
								$150.55		$149.06		$147.58
							$143.05		$141.63		$140.22	
						$135.91		$134.57		$133.23		$131.91
					$129.14		$127.86		$126.59		$125.33	
				$122.70		$121.48		$120.28		$119.08		$117.90
			$116.58		$115.43		$114.28		$113.15		$112.02	
		$110.77		$109.67		$108.58		$107.50		$106.44		$105.38
	$105.25		$104.20		$103.17		$102.14		$101.13		$100.13	
$100.00		$99.01		$98.02		$97.05		$96.09		$95.13		$94.19
	$94.07		$93.14		$92.21		$91.30		$90.39		$89.49	
		$88.49		$87.62		$86.75		$85.89		$85.03		$84.19
			$83.25		$82.42		$81.60		$80.79		$79.99	
				$78.31		$77.53		$76.77		$76.00		$75.25
					$73.67		$72.94		$72.21		$71.50	
						$69.30		$68.61		$67.93		$67.26
							$65.19		$64.55		$63.91	
								$61.33		$60.72		$60.12
									$57.69		$57.12	
										$54.27		$53.73
											$51.05	
												$48.03

Figure 2.3: One Year Monthly Binomial Value Tree (Source: Adopted from Geltner et al, 2007).

From this expanded binomial tree the option value can be calculated by working in reverse from the terminal point using a certainty-equivalence DFC method. Also, a distribution of expected built property values can be generated to determine a more detailed view the development value (Figure 2.4).

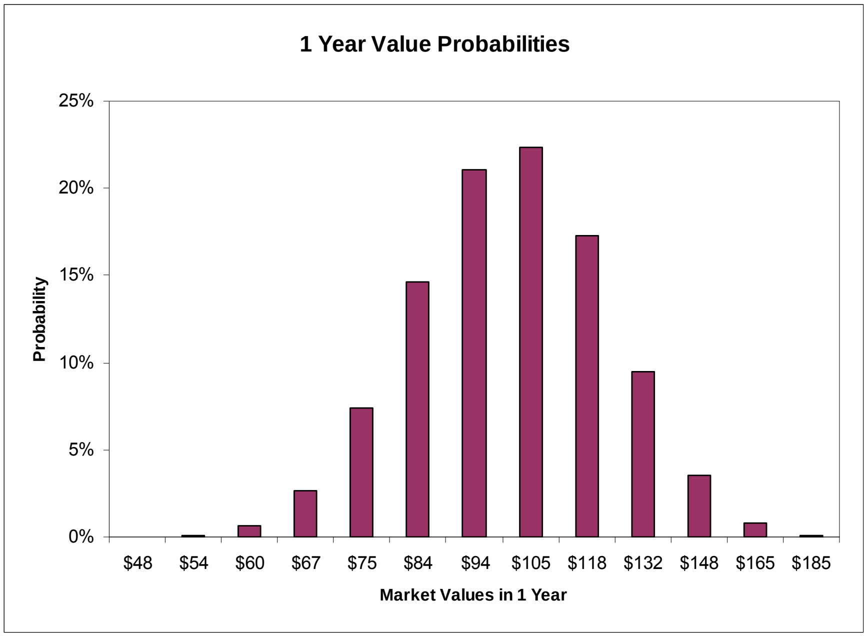


Figure 2.4: One Year Value Probabilities (Source: Adopted from Geltner et al, 2007).

While the binomial model provides and intuitive and reasonably realistic approach to land valuation I relation to development timing, there are two main drawbacks of this method. The first is that the model limits development timing to a finite span of time, such that the perpetual option of developing on land with fee simple ownership. Second, the model does not consider time as continuous matter, but as discrete steps. Both of these drawbacks can be overcome but an application of the Samuelson-McKean formula. Similar to the Black-Scholes formula widely used in corporate finance, the Samuelson-McKean formula provides a way to value a perpetual development option incorporating continuous time. This formula defines the value of land as:

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

Where η is the option elasticity, and V* is hurdle value of the land. Land values above this hurdle should be developed immediately, and below which development should be deferred. Where,

$$\eta = \left\{ y_V - y_K + \sigma_V^2 / 2 + \left[\left(y_K - y_V - \sigma_V^2 / 2\right)^2 + 2 y_K \sigma_V^2\right]^{\frac{1}{2}} \right\} / \sigma_V^2$$

and,

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

The inputs to the formula are the construction yield (y_K), $y_K = r_f - g_K$. Where r_f is the risk-free rate and g_K is construction cost growth rate. y_K is the cash yield of the built property, the cap rate (Net Operating Value (NOI) / Property Value). Also, σ_V is the volatility of the built property, and as mentioned in section 2.3.1, is typically 10% - 25%. K_0 is the current development cost and V_0 is the observable values of similar newly developed properties.

An application of Samuelson-McKean formula with the following inputs (Table 2.2) produces the option / land values represented in Figure 2.5:

σ_V	20%
y_V	7.0%
r_f	3.0%
y_K	1.0%
V_0	$200,000
K_0	$150,000
η	4.1213
V*	$198,057

Table 2.2: Samuelson-McKean formula variables.

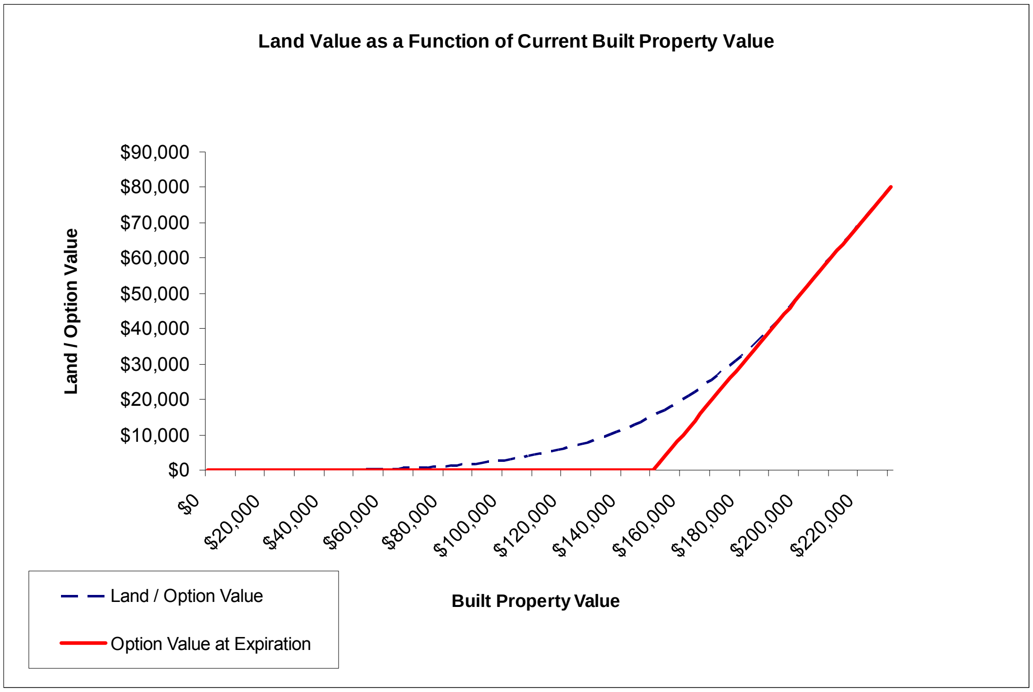


Figure 2.5: Land Value as a Function of Current Built Property Value (Source: Adopted from Geltner et al, 2007)

All three of these models relate the concept of options to the realm of real estate development, and each has individual strengths and weaknesses. None of these methods present overwhelming challenges in their ability to be understood, nor are the underlying concepts foreign to the discourse surrounding real estate professional practice. However, some of the concepts beyond that of uncertainty and flexibility are positioned outside of daily working methods and employ seemingly unusual techniques.

The binomial option valuation method and the perpetual, continuous time valuation method provided by the Samuelson-McKean formula employ rigorous economic theory to their methodologies and are referred to as the "economics-based" approach to valuing flexibility. Also, these components of option valuation theory are based on a concept that land, built property, and bonds exist in an equilibrium state such that risk and return per unit of risk are consistent. As a result, these methods may solve for true economic value, but at the expense of widely know and implemented metric of valuation.

2.3.3 The "Engineering-Based" Approach to Real Option Valuation

The series of points discussed in the preceding sections all point toward the conclusion that real option analyses are well suited with the real estate valuation process. A summary of these points includes the fact that (a) flexibility in the real estate development process intrinsically adds value in its ability to react to uncertainties, (b) discounted cash flow and net present value techniques fail to incorporate potential flexibility into valuations, and (c) methodologies for the application of real options are well established and are consistent with rigorous economic theory.

At the same time however, ROA is rarely used in the general practice of real estate professionals. The rationale behind this fact can be attributed to the perceived and possibly realistic assumption that option valuation theory is complex, and different from commonly employed techniques of real estate financial modeling. In an article discussing the use of real options with corporate business decisions, this attitude was expressed such that:

> We believe, however, that managers don't need to be deeply conversant with the calculation techniques of real-option valuation. Just as many investments are made by managers who have only a passing acquaintance with the capital asset pricing model (CAPM) and the subtleties of estimating the cost of capital and terminal values for NPV calculations, so the fundamental insights of real-option theory can be used by managers who have no more than a basic understanding of option-pricing models (Leslie and Michaels, 1997, p. 7).

Recognizing the value of flexibility, a methodology has been developed which provides a palatable technique for analyzing real options, and aimed at designers and managers. This technique uses familiar tools, common terminologies, and limits the need to thoroughly understand complex financial concepts and calculations. This more intuitive method of valuing real options is based on analyses carried out with spreadsheet techniques in Excel® and is referred to as the "engineering-based" approach. This methodology has been developed by de Neufville, et al (2006) as a way of integrating real option analyses into infrastructure and engineering systems, and particularly as a means for designers to recognize and value flexibility in fields which do not regularly utilize the financial theories related to real options and in which volatility is not easy to measure. The three primary merits of the spreadsheet technique are (a) the use of commonly understood spreadsheet software, (b) the use of information that is typically available in the field, and (c) valuation results which can be intuitively understood and related to others.

As described by de Neufville et al, this engineering-based approach is comprised of three main steps:

1) Evaluate a base case scenario without flexibility using traditional DCF and NPV techniques as a means of comparison.

2) Incorporate uncertainty into the base case scenario using a Monte Carlo simulation to arrive at an expected net present value (ENPV), as well as a cumulative distribution function of possible outcomes. These functions are represented by a value at risk and gain (VARG) curve. Value at risk (VAR) is the probability that losses will exceed a specified amount (Brealey et al, 2006). VARG is more appropriate terminology for the method as it incorporates the potential upside ultimately provided by the flexibility. The resultant VARG charts provide a clear and graphical way to evaluate the project and potential value created through flexibility and options.

3) Incorporate flexibility into the design or project based on decision rules which are based on capturing potential upsides, and limiting potential downsides. This is due to the asymmetric value which options provide (de Neufville, 2002). This asymmetry is derived from the fact options are a right, not an obligation, and in positive scenario the options can be exercised producing a gain; and in negative scenarios the option can simply "expire" with minimal or no loss. This allows for flexibility to gain more value under circumstances involving more risk and uncertainty. The results of the flexible case can again be represented intuitively by VARG curves.

While the true rigor of the economics-based approach may be perceived as absent from the engineering-based approach, the advantages are gained from its intuitive use of standard DCF/NPV techniques, clear graphical representations, and its ability to be more easily grasped by practicing professionals. Additionally, the engineering-based approach can incorporate multiple sources of uncertainty, be performed with standard computers, and can be used to easily test potential decisions.

2.4 Relevant Background Research on Real Options

In addition to the methodologies developed for the valuation of real options in real estate, an array of research has been conducted which investigates the overall sentiment toward flexibility in real estate developments, the contexts which make real options analyses an attractive considerations, and the results of the application of ROA methodologies.

2.4.1 Industry Perceptions

In efforts to gain an understanding of how the real estate community views flexibility, risk management, and the potential use of real options analysis; a study was carried by Barman and Nash (2007). Their research involved conducting interviews of real estate professionals with a goal of understating and documenting the typical sentiments toward these issues.

Their findings showed that real estate developers identified an extremely diverse range of potential uncertainties which form their notions of risk associated with a project. These risks range from unforeseen existing site conditions to overall uncertainty of future market conditions. Many of these risks are often mitigated by the expertise of the professional and ultimately, the identification of risks is distilled down and into "the value of the built asset." Through experience, the risks can be assessed and options for potential courses of action can be formulated. These options are based on looking at the potential risks and selecting options which best reduce downside exposure and possibly harness an upside. The identification of this process begins to prove that developers view risk and flexibility in an intuitive manner based on experience.

Additionally, the Barman and Nash interviews included questions regarding developer's typical valuation process when considering a project. The results show that the most common methods include static metrics such as return-on-cost and cash-on-cash, as well as internal rate of return (IRR) and NPV. The hurdle rates for these metrics were found to be based on "rules of thumb," but where also tailored to the individual specifics of a project. Also, it was found that as attitudes toward risk and return vary with respect to perceived uncertainty and potential flexibility, the professionals valuating real options in an "indirect" way. The sources of uncertainty most considered were rents, construction costs, cap rates, the timing of the project.

Lastly, the interviews revealed that some sensitivity analysis was employed to a degree, but with a bias toward reducing losses rather than capturing gains. With regard to real options analysis, interest does exist, but the perceived complexities of the process are seen as a drawback and that a straightforward tool would be preferred.

2.4.2 Economics-Based Approach and Engineering-Based Approach Compared

A thesis written by Masunaga (2007) compared the economics-based and engineering-based approaches to real option valuation. This comparison was based on a real estate development case study and Figure 2.6 summarizes the findings.

	Economics-based approach	Engineering-based approach
Merits	• It can calculate the "true" real optionsprice under the market equibrium theory.	• The user does not need to understand advanced financial theory. • The analysis can be done with normal computational resources. • It has many ways to present the result graphically.
Demerits	• The user needs to understand the financial theory of real options.	• It is not always possible to calculate "true" real options value, mainly due to the arbitrary assumption of single risk-adjusted discount rate.

Figure 2.6: Merits and demerits of the economics-based approach and the engineering-based approach (Source: Masunaga*, 2007).*

These results reiterate the differences between the two methods and also highlight the advantages of the engineering based approach with respect to professional practice, while qualifying this notion based on a singular risk-adjusted discount rate. Masunaga also concludes that the engineering-based approached could be used to present an investment opportunity to certain audiences, but backed-up by the results of the economics-based approach. This suggestion is derived from a discrepancy (8%) in the calculation of true land value between the methods.

Additionally looking at both valuation approaches within their research Barman and Nash (2007) concluded that a "hybrid model" incorporating aspects of the two techniques. Specifically, the Samuelson-McKean hurdle value was implemented as a factor in the flexibility decision criteria.

Although both conclusions recommend in some way that the engineering-based model be augmented with the economics approach, these conclusion may begin to detract from the straightforward nature of the spreadsheet analysis. Considering that the differences found between the two approached can be considered small, the engineering-based approach produces fairly accurate results when compared to rigorous economic theory. Also, when compared to a valuation method which might ignore flexibility all together, the strength of the model as a tool for practitioners grows significantly. Given these considerations and the real world applicability of analyzing the HCSC headquarters as a case study, the engineering-based approach was implemented in valuing the flexibility associated with vertical expansion.

Chapter 3: HCSC Headquarters

To investigate the potential of flexibility in real estate and the real options engineering-based approach to valuation, the Health Care Service Corporation tower in Chicago, IL will be analyzed as an examination of how these concepts can be applied to a conceived and executed development project.

The information presented in this chapter was gathering from interviews with Jim D'Amico, Joseph Dolinar, David Eckmann, Andrew Pini, Lou Rossetti, and Bud Spiewak; on-site observations by the author; and materials provided by the architect.

3.1 Project Description

The HCSC project and the ultimate decision to construct a tower with an embedded option to expand evolved out of the interactions of many contributing factors. These include the corporate goals of the HCSC, the space market of Chicago in general, and availability and characteristics of developable land in downtown Chicago.

3.1.1 History

In 1992, HCSC began to consider a plan for the future growth of the company and anticipated its associated space needs. At that time, the company was leasing approximately 500,000 square feet of office space in downtown Chicago to accommodate 3000 employees. The company projected their growth to reach 7200 employees over the following twenty-two years, and the appropriate means of expanding their facilities was thought to be an important factor to the successful future of their organization.

When beginning to assess the needs of the corporate growth and the potential options to satisfy them, the following three major options were formulated: (1) attempt to lease additional space in a building adjacent to the current facility, (2) lease (as a primary tenant) space in a speculative office development, and (3) build and inhabit an new building constructed to suit their specific needs.

Concurrently, the strategic motivations of the organization's growth were such that a long term consolidated central headquarters in downtown Chicago was considered to be a strong asset for the future culture and identity of the corporation. Additionally, the commuting patterns of a majority of their employees are centered on the current downtown location. This fact contributed to an early decision to not consider a suburban location seriously.

When comparing the options available for expansion to the motivating factors of the organization, the ultimate decision was distilled in the process. Leasing additional space in a neighboring building would not achieve their goals for a synergetic consolidation of business groups. Also, the availability of downtown Chicago office space of the scale required by HCSC at the time would have made assembling leasable space in an efficient manner challenging.

Acknowledging themselves as a singular large tenant, it was thought that adopting a speculative office development would not accommodate the specific and well established organizational structures of the company, and lead to potential inefficiencies (Figure 3.1). With these two conclusions and a concurrent investigation of potentially available and appropriate land underway, the decision to build for themselves was eventually reached.

	Typical Speculative Office Building	BCBS Requirements
Floor plate size	25 – 30,000 SF	36,000 sf +
Type of office space	Majority closed office	Majority open office
Density of people	225 usable SF/person	140 usable SF/person
Passenger elevators	Minimal interfloor traffic	Maximum interfloor traffic
Service elevators	Periodic use	Heavy daily use
Tenant modifications	Terms of lease	Almost yearly
Parking/loading	Minimal per zoning code	Exceed zoning requirement
Special functions	Minimal	Cafeteria for 900 Conference/training center
Security	Minimal – after hours	Maximum 24/7
Accommodate expansion	Minimal	100% over 10 years

Figure 3.1: Comparison of the typical speculative office building characteristics with the requirements of HCSC (BCBS) (Source: Goettsch Partners, 2008).

3.1.2 Site Characteristics

The site selected was a 100,000 square foot (SF) piece of land at 300 East Randolph Street, within a few blocks of the existing space leased by HCSC (Figure 3.3). Located at prominent destination in downtown Chicago, the site is across from Grant Park (and at the time the future Millennium Park), next to the Aon Center (formerly the Standard Oil Building), and close to several other large buildings and headquarters. Also, the site's proximate location to the existing facility allowed for a minimum impact with respect to the employees. The site, a portion of a much larger area of land, is located on a former rail yard (Figure 3.4) and designated as a planned unit development (PUD) by the zoning authorities of Chicago. A PUD is typically a single area designated for the development of a variety of complementary land uses which are often different from previous zoning decisions. Additionally, the development of a PUD allows for a modified negotiating process between developers and the municipality with efforts to benefit the goals of both parties. The developer can benefit from allowance of higher densities and synergetic relationships between uses which adds value to all of the smaller sites contained within. The benefit to the municipality is in achieving a specific economic and/or urban planning goal for a particular area of a city.

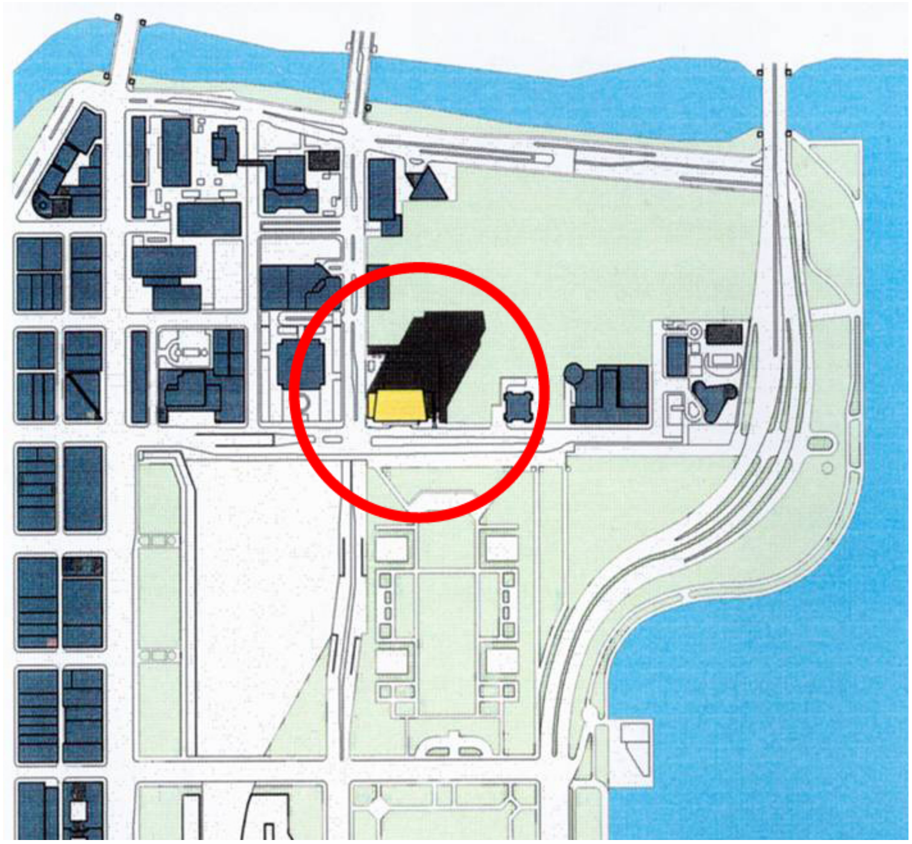


Figure 3.3: Project location plan, structure circled (Source: Goettsch Partners, 2008).

In the case of the PUD containing the HCSC site, the regulations allowed for a transfer of density, floor area ratio (FAR), between the individual parcels within the larger area. FAR is the ratio of the total floor area of a building(s), to the total area of the parcel of land it occupies. This is facilitated by purchasing the additional density from other parcels and adding it to a specific one. The 100,000 SF project site was originally zoned for density of 10 FAR. With the goal of building more area on the same size site, density was purchased to allow for building to an FAR of 18. Increased density on and urban site, like in Chicago, is typically considered more valuable intrinsically. With regard to HCSC, the increasing the density to 18 FAR was related to two particular factors. The first factor was their demand for enough density to satisfy the space requirements of the organization. The second factor was that the terms of the parcel within the PUD dictated that building at a density greater than 18 FAR would require the developer to also provide a park on the site at a significant cost. The land and additional density was purchased in 1994.

Figure 3.4: Former rail yard at site location (Source: Goettsch Partners, 2008).

3.1.3 Vertical Expansion Decision

As a component of the strategic planning for the growth of the company, a consultancy firm was hired to determine which business groups within HCSC were best consolidated at a single location, and which groups were best suited at an alternative site. The results of this assessment formed the base level of demand which the new structure should accommodate. This need translated into the minimum size of the building to be built.

With this minimum space requirement determined and the land acquired, a position had to be taken which balance the current needs of the company, the expected future growth requirements, and the role of the Chicago real estate market at the time. The initial question can be summarized as a decision to either build to accommodate the current area requirements, or build the minimum area plus additional space which would be available to address the future growth needs.

Any additional space beyond the amount taken by HSCS would be expected to lease in the market at rents which are high enough to justify the additional expense of constructing it. In 1995 when these decisions were being weighed, the office market in Chicago had been declining and it was thought that the possibility of leasing the extra office space at the required rents would be challenging. Recent history at the time would have encouraged a pessimistic view of the near future market conditions.

At the same time, HCSC anticipated growth internally and desired to keep their headquarters consolidated at the newly designated downtown site. The disconnect between planning for future growth at one location and lacking the ability to temporarily fill the additional space led to the idea of providing the potential to expand the project vertically at a point in the future.

An alternative strategy for increasing density to provide for future expansion is to purchase additional land. In this scenario the option for expansion is provided by land adjacent to the initially developed land. The assumption is that in the future when the demand is present, a second structure is built near the first. In the case of the HSCS development, the cost of purchasing the additional land was much greater than the cost of purchasing additional density (Figure 3.5). This type of horizontal phasing is not uncommon, but typically implemented in cases where optimistic future demand is expected and the site will be developed in phases to meet that demand. Similarly, it may be at locations where land is less expensive that in the downtown area of a major city. Neither optimistic near future demand, nor inexpensive land was present in the decision making process within HCSC building project.

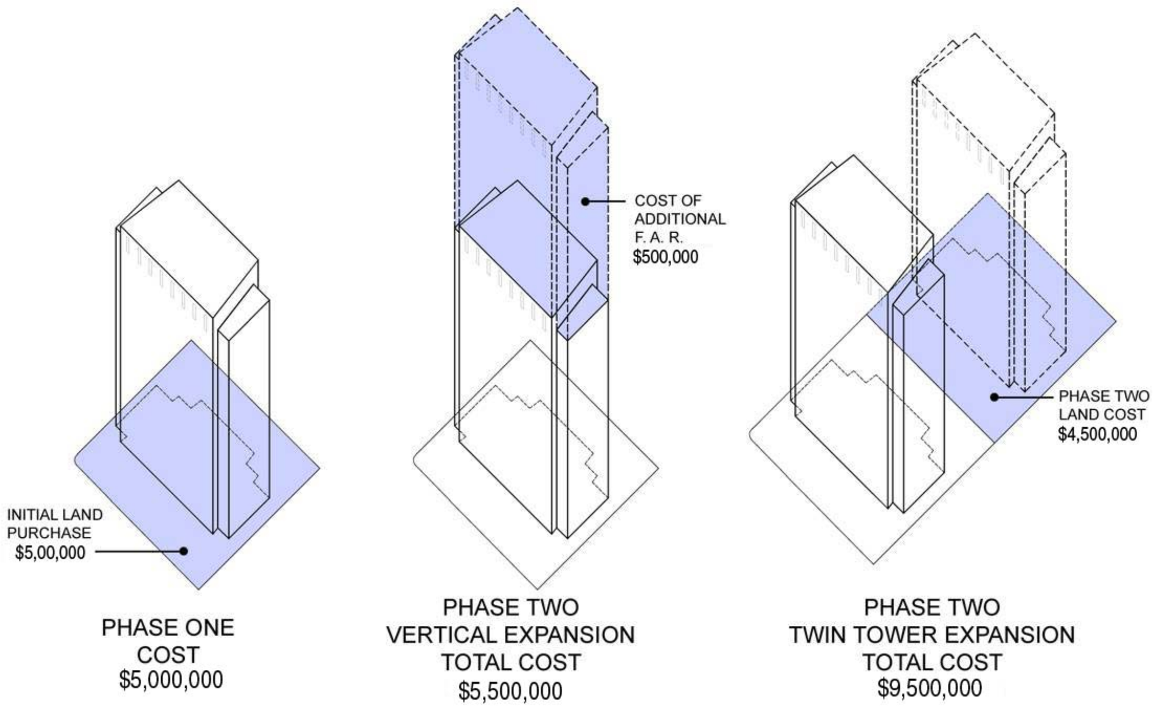


Figure 3.5: Land cost with respect to vertical or horizontal expansion options. Note: Actual dollar amounts were redacted (Source: Adopted from Goettsch Partners, 2008).

3.2 Project Timeline Summary

The overall development timeline for the project is summarized below:

- 1992 – Roadmap for growth was developed.
- 1993 – Options to satisfy space requirements considered.
- 1993 – Determination of which business groups required consolidation at a central location and which were best location off site.
- 1994 – Land purchased.
- 1995 – Phase 1 construction began.
- 1997 – Deadline to vacate leased office space. (September)
- 1997 – Phase 1 opened. (June)
- 2006 – Board approved vertical completion.
- 2007 – Phase 2 construction began.

3.3 Building Specifications

Following the decision to develop a vertically expandable structure, the overall building (Phase 1 and Phase 2 combined) was designed to maximize the allowable FAR assembled for the site. The scale of the first phase was based on accommodating the present HCSC needs, and the second phase was to occupy the remainder. The building occupies the corner of E. Randolph and N. Columbus (Figure 3.6) with a direct link to underground parking below Grant Park and easy walking access to mass transit nodes. With adjacencies to the park and the overall plan of the PUD, and situated in an intermediate position between shore of Lake Michigan and the heart of downtown Chicago; the building offers spectacular views in all directions.

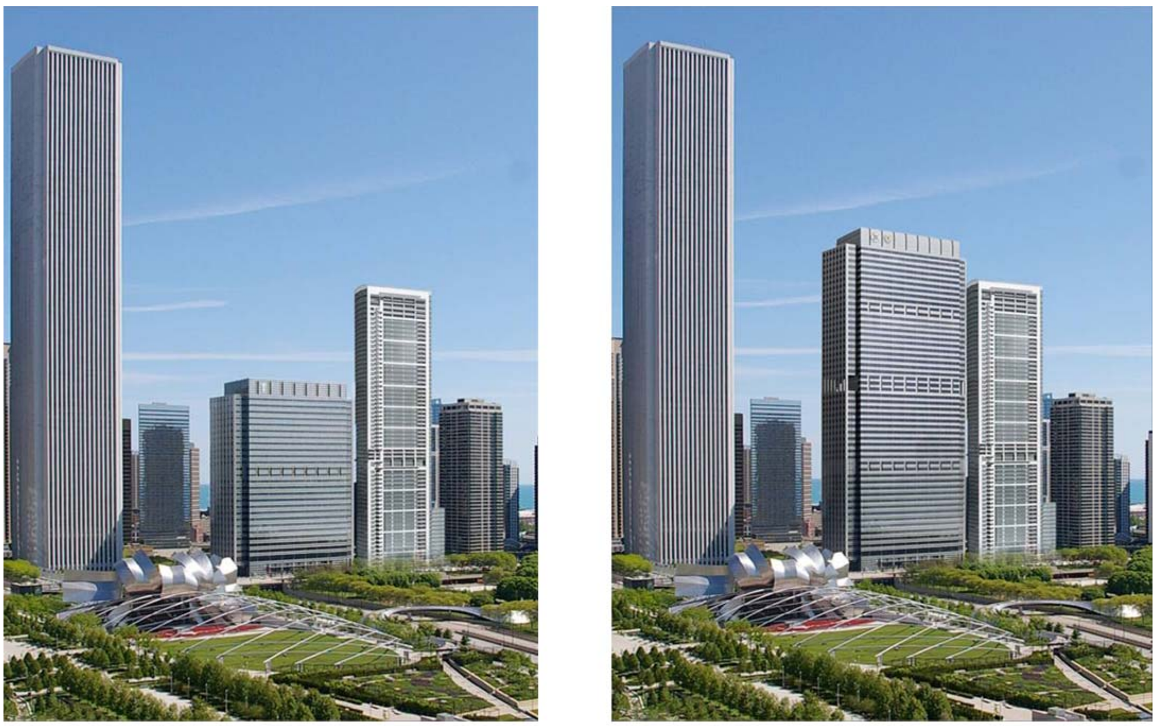
Figure 3.6: Site Plan (Source: Goettsch Partners, 2008)

The characteristics of the different phases are summarized in the following table (Table 3.1):

	Gross Area	Gross Area FAR	Rentable Square Feet	Levels (Above Grade)
Phase 1	1,430,718	1,343,677	1,047,822	29
Phase 2	883,453	798,526	704,717	25
Total	**2,314,171**	**2,142,203**	**1,752,539**	**54**

Table 3.1: Building space characteristics (Source: Goettsch Partners, 2008).

The building is a steel frame structure with lateral bracing provided by concrete shear walls for Phase 1 (levels one through twenty-nine), and cross bracing for Phase 2 (levels thirty through fifty-four). The exterior of the structure is clad in glass and natural stone. The aesthetic considerations of both phases were carefully articulated to achieve a very consistent visual appearance in the event that the expansion option was exercised (Figure 3.7).



Phase 1 Phase 2 (Phase 1 + Vertical Completion)

Figure 3.7: Architect's renderings of Phase 1 and Phase 2 (Source: Goettsch Partners, 2008).

3.4 Real Options "in" Projects

To provide the option for future vertical expansion or completion, the first phase of the project must be engineered and constructed to accommodate the expansion. An architectural design executed in the manner presents an example of a real option "in" a project, and in contrast to real options "on" projects (Wang and de Neufville, 2005). Wang and de Neufville discuss the differences between these two types of option, and the primary points are summarized in Figure 3.8.

Real options "on" projects	Real options "in" projects
Value opportunities	Design flexibility
Valuation important	Decision important (go or no go)
Relatively easy to define	Difficult to define
Interdependency/Path-dependency less an issue	Interdependency/Path-dependency an important issue

Figure 3.8: Comparison between real options "on" and "in" projects (Source: Wang and de Neufville, 2005).

As indicated in the Figure 3.7, real options "on" project are conceptually more closely related to financial options. The decision to exercise an option is dependent on the value derived from the project and irrespective of the technology or associated design (Wang and de Neufville, 2005).

The main idea behind real options "in" projects involves flexibility that is built directly into the design of a system or structure. A cited and clear example of this type of built-in flexibility can be seen in the Targus River Bridge in Lisbon, Portugal (Gesner and Jardim, 1998). Completed in 1966, the four-lane bridge was constructed with the included structural capacity to support future rail and automobile traffic, and the option was exercised in 1996. With respect to real estate development and embedded vertical expansion options, a handful of examples other than the HCSC tower can be identified and each with varying motivations and factors which led to the decision to embed flexibility (Pearson and Wittels, 2008).

3.4.1 Real Options "in" Real Estate Developments and the HCSC Tower

Real options "in" projects are based on an understanding of all the technical requirements associated with creating the flexibility. In regard to real estate developments, the technical requirements of building an option into a project can take on a range of possibilities. The differences in requirements can vary considerably based on particulars such as the project type (residents, office, industrial, etc.), the scale of the project, site characteristics, regulatory / entitlement processes, building codes, and any of the other forces that contribute to shaping a property development.

In order to build the flexibility to expand from twenty-nine to fifty-four levels, the HSCS headquarters had its own set of particular characteristics which had to be considered in the design. Some of the particulars are inherent in the vertical nature of the building and others related to the specific needs of the owner and the City of Chicago building code. Being a tall and complex structure, the technical considerations enabling flexibility in the HCSC tower range from large provisions in the overall structural design, to a plethora of smaller items such as a modified width dimension along egress routes with in anticipation of an updated life safety code. To describe them all would be lengthy and somewhat redundant. To gain a perspective on additional provisions built into the first phase of the project, specific aspects of the following four major building systems will be discussed: the structural design, the mechanical design (HVAC, plumbing, electrical), vertical circulation (elevators and stairs), and the exterior cladding.

Probably the first system to come to mind when imagining the concept of adding an additional twenty-four stories to an existing building is overall structure. In the HSCS tower at the most fundament level, the vertical structural members (columns) of the building had to be oversized to accommodate the additional gravity loads of the extension. Also, the building's foundations had to be sized for the additional load. The foundations of the structure are bell caissons at a depth of ninety feet, and incidentally the largest ones available at the time. In addition to providing adequate structural capacity in the first phase to accommodate the extension, the means to fasten the future columns to the exist one ones was essential. To allow for this future connection, the tops of the columns were extended through the slab and membrane of the first phase roof and waterproofed around (Figure 3.9).

Figure 3.9: Top of Phase 1 column extended through the roof slab and waterproofed to facilitate a connection for the Phase 2 expansion (Source: Goettsch Partners, 2008).

This detail allowed the new structure to be welded to the existing (Figure 3.10), and in a way which minimally impacts the existing roof which is beneficial given that construction of the expansion was always intended to occur over a fully occupied building.

Figure 3.10: Welded connection of the new and existing structure at the Phase 1 roof level (Source: Author).

In addition to the enhanced structure and foundations, the mechanical systems of the building required oversized provisions to accommodate the additional loaded in the future. Some of these provisions included space for extra sleeves in risers for future electrical cabling, larger pipes, and a fire sprinkler pumping strategy to accommodate the additional future spaces.

The vertical circulation system presented an interesting challenge for designers since the number of elevators would need to increase from sixteen to thirty-two. Planning for such an addition requires providing the necessary amount of physical space and in a way such that the logic of the circulation through the building remains practical and efficient. To accomplish this goal, the building was designed with a large full height atrium on the north side of the structure, flanked by the Phase 1 elevators. This arrangement allows for the future elevators to be installed in a portion of the atrium space while also leaving portion of space remaining for daylight to continue migrating through the core (Figures 3.11 and 3.12). Lastly, from an exterior aesthetic point of view, the materials of the cladding system were strategically designed. The stone selected for the façade was from a quarry with a seemingly sufficient supply to satisfy the demands of the future addition.

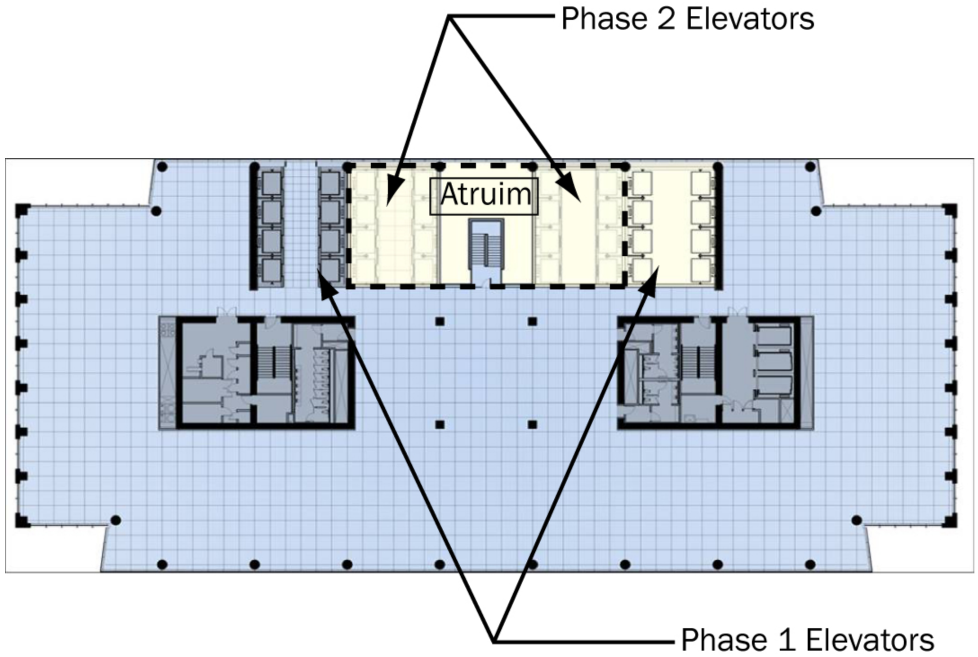
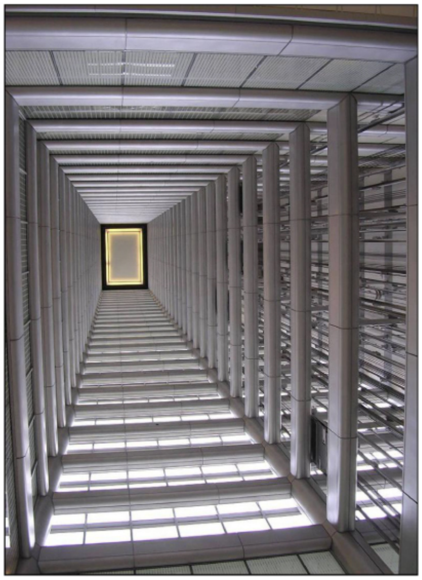


Figure 3.11: Typical floor place with Phase 1 and Phase 2 elevator arrangement indicated (Source: Goettsch Partners, 2008).



Phase 1 Atrium Space

Phase 2 Elevators Under Construction in Atrium Space

Figure 3.12: Phase 1 atrium and Phase 2 elevators under construction in provided space (Source: Goettsch Partners, 2008).

The technical enhancements to the first phase of the project were the result a strong forward thinking approach to the design, creative architectural and engineering solutions, and an overall commitment to the success of the potential future expansion. While this additional work was required to build-in the flexibility and did incur the cost of providing the option, the overall physical contribution to the project does not fall too far outside of typical design and construction for a structure of this type.

Chapter 4: Real Options Analysis of the HCSC Headquarters

This chapter describes the real options analysis based on the characteristics of the built-in option to vertically expand the HCSC tower. To reiterate, the "engineering-based" approach was selected as the valuation methodology based on the following points which link the real options analysis to traditional real estate finance:

- The implicit common language the two methods of valuation.
- The use of Excel® and standard spreadsheet modeling as a commonly understood tool.
- The transparency and similarity of the inputs.
- The intuitively understandable nature of the output metrics and clarity of the visual results.

4.1 Methodology

The main structure of the methodology is formed by the following steps:

1) Define the assumptions for the overall model.
2) Define the uncertain variables, and the decision making structure for the flexible case.
3) Valuation of the three different scenarios;
    a. Phase 1 (twenty-nine levels) only.
    b. Phase 1 and Phase 2 (fifty-four levels) as one complete structure.
    c. Valuation of a flexible design which incorporates the option to expand the structure vertically (from twenty-nine to fifty-four levels) under specified conditions.
4) Interpretation of the results using value at risk or gain (VARG) curves.

The three valuations will be simultaneously compared to determine the potential value that flexibility brings (or perhaps not bring) to the project. Expected net present values (ENPV) are simulated for each of these scenarios under the same conditions of uncertainty.

4.2 Assumptions

To provide the requisite inputs to the real options model, certain assumptions based on market conditions are made. Also, simplifications to the overall building design are incorporated to allow for a slightly more straightforward approach to the modeling. These simplifications to the structure involve assuming that the rentable areas of both phases of the project are the same (Table 4.1), or in other words, each phase comprises 50% of the entire potential structure.

	Gross Area	Rentable Square Feet
Phase 1	1,520,000	1,000,000
Phase 2	1,250,000	1,000,000
Total	**2,770,000**	**2,000,000**

Table 4.1: Simplified building program for analytical purposes.

The gross area is based on the relative proportions of rentable to gross areas as in the actual HCSC structure. The greater gross area of the first phase is based on the below grade spaces dedicated to the service needs of the building. The gross areas are used in the calculation of the total costs, and the rentable areas are the basis for revenue calculation.

Additional assumptions used in the analysis are the following:

- The analysis is from an ex-post perspective beginning in 1997, the completion date of Phase 1.
- Initial rents are $24 per square foot (based on historical data for 1997 Class A office rent in downtown Chicago).
- The risk free interest rate (r_f) is 4.85% (calculated from the 1997 average ten year U.S. Treasury rate, 6.35%, minus 150 basis points).
- The risk premium for stabilized Class A office space is 3.50%.
- The project discount rate is 8.35% (calculated as $r = r_f$ - + RP).
- Development cost growth is 1.50%.

- Operating expenses are $7.50 per square foot.
- Cap rates are 7.50% (based on 2007 average for downtown Chicago office properties).
- Development costs are $140 per square foot for Phase 1 and $124 for Phase 2. The additional cost per square foot to develop Phase 1 accounts for the cost of the land.
- Phase 2 construction time is 2 years.

4.3 Uncertain Variables and Decision Rules

To consider the uncertain nature of the future and its potential implications on the value of a real estate development, the model must incorporate measures indicative of possible future scenarios. To incorporate relevant uncertain variables into the analysis, factors were chosen to represent the varying nature of (1) future cash flows and (2) demand for office space. To represent these two variables, uncertainty in the projected future achieved rents (cash flow) and the future lease-up rates of the building (office space demand) are considered.

4.3.1 Projected Rent

To incorporate the uncertainty in potential future rent growth, the initial rent for Chicago in 1997 of $24 per square foot was subjected to a series of volatilities to simulate a wide range of potential future rent patterns. This base rent was expected to grow at 1% per year. This 1% growth rate is based on the fact that during the 1978-2004 period, the average annual growth of net operating income for institutional and commercial properties held in the NCREIF database was approximately 2% less than average annual inflation (Geltner et al, 2007). With inflation assumed to be 3% for the purposes of this analysis, 3% - 2% = 1%.

After this determination of a base rent and expected growth, volatilities were applied to provide a range of possible uncertainty for which the flexible case can react. The steps used in this model are the following:

1) The *Expected Rent* was calculated by growing the base rent at 1% (Eg) per year with a standard deviation of .35% (SDg) to determine a *Realized Rent.*

$$\textit{Expected Rent} = \text{Rent}_{(T-1)}\ (1 + \text{Eg})$$

$$\text{SGg Realized} = (\text{rand}() + \text{rand}() - 1)\ (2)\ (\text{SDg})$$

$$\textit{Realized Rent} = \text{Rent}_{(T-1)}\ (1 + \text{Eg} + \text{Sg Realized})$$

2) To determine a *Trend Rent*, a volatility which accumulates over time of 4% (σ) was applied to each year.

$$\sigma_{(T)} = (\text{rand}() + \text{rand}() - 1)\ (2)\ (\sigma)$$

$$\textit{Trend Rent} = \text{Rent}_{(T-1)}\ (1 + \text{Eg} + \text{SDg} + \sigma_{(T)})$$

3) To introduce potential volatility at each individual period *noise* of 8% was applied to each year to arrive at the *Achieved Rent*.

$$\textit{noise}_{(T)} = (\text{rand}() + \text{rand}() - 1)\ (2)\ (\textit{noise})$$

$$\textit{Achieved Rent} = \text{Trend Rent}_{(T)}\ (1 + \textit{noise}_{(T)})$$

For this analysis, the initial base rent of $24 per square foot was the approximate rate for downtown Chicago office buildings in 1997 and the expected growth rate was assumed to be 1%. The remainder of the variables which provide uncertainty and variability were selected to (1) provide a rich representation of potential future rent growth scenarios, (2) describe a methodology, and (3) demonstrate the value of flexibility with respect to uncertain conditions. Alternatively, the variables could be determined through a rigorous analysis of the historic rents for a given market.

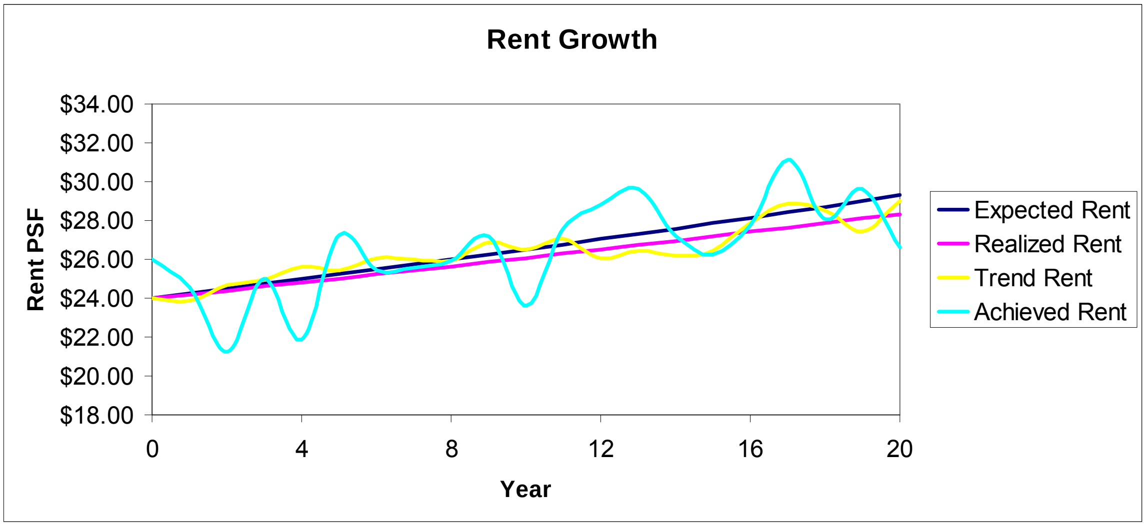


Figure 4.1: Example of possible achieved rent.

4.3.2 Lease-Up Simulation

The second source of uncertainty incorporated in the model is the expected lease up rate of the development. This simulated lease-up is based on leasing all of the potential space (Phase 1 and Phase 2) in the development over time. In the first year, the percentage of leased space is randomly generated (sampled from a triangular distribution) and can range from 30% and 70% of the entire potential structure. Given that each phase is 50% of the possible structure, the first lease-up of the first phase could potentially occupy less than, all of, or more than the space provided in the first phase. Following the first year, the lease–up in subsequent years can range from zero, to a maximum amount which falls between 25% and 75% of the total remaining available space each year. This amount is randomly generated and is consistent for all years of the analysis after the first. This sampling from a triangular distribution sets the average maximum lease-up of subsequent years to be approximately 50% of the space, with some years having a maximum lease-up of a bit more or less than 50%. This limiting factor on the lease-up of available space is taken from the pessimistic outlook for the Chicago real estate market in 1997. Figure 4.2 represents an example of one possible lease-up scenario.

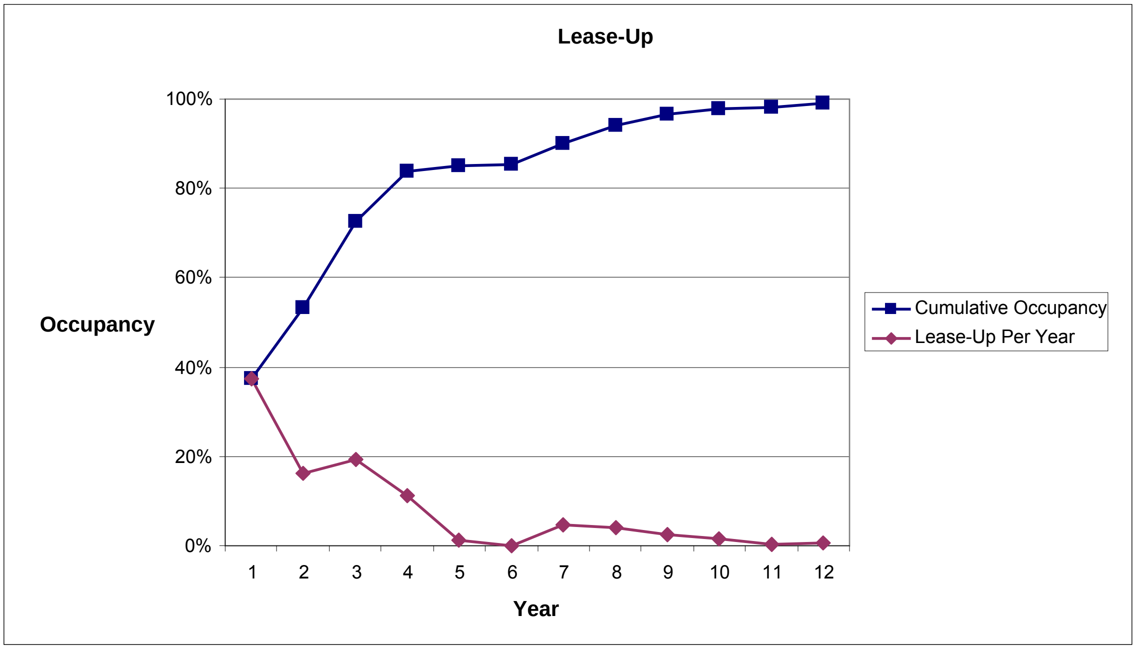


Figure 4.2: Example of a possible lease-up scenario.

The use of lease-up rate in the decision making aspect of a real options model was based on a similar strategy implemented in the analysis on a multi-phase development in Korea (Kim, 2008).

4.2.3 Option Decision Rule

Based on the potential uncertainties of future rent and lease-up scenarios, the decision to exercise the option to expand vertically can be based on a particular lease-up rate (1) and rent growth (2). To make the exercise decision, the model considers the following:

1) The lease-up rate of the entire structure will be estimated based on the procedure outlined previously. In doing so the model determines how much of the demand for space will be met by Phase 1 and any amount beyond the total space available in Phase 1 will be "captured" in the form of pre-leasing contracts for Phase 2. Pre-leasing contracts represent signed agreements between a future tenant and the owner of the building. This agreement specifies that the tenant commits to lease the space once the building is constructed and the space be made available. Once the pre-

leasing contracts amount to a designated percentage of the total space provided by Phase 2, the criterion to exercise the option is met. In other words, if each contract is placed in a folder after being signed, once the folder is thick enough; Phase 2 of the structure will be built. This process is diagramed in Figure 4.3. Although applying the concept of pre-leasing contracts in this manner may appear to be an abstraction from reality, the argument could be made that such leasing characteristics would be indicative of a strong office rental market in which the space might be leased even if such contracts are broken. Also, the amount of pre-leasing contracts deemed to be acceptable is somewhat subjective and based on the individual preferences of the developer.

2) The compound annual growth rate of the rent is calculated each year and compared to a specified hurdle. The hurdle should be determined by an assumed acceptable rent growth by which a developer would feel comfortable to use as basis for future rent.

The first year in which both of these two criteria are met will trigger the exercise of the option.

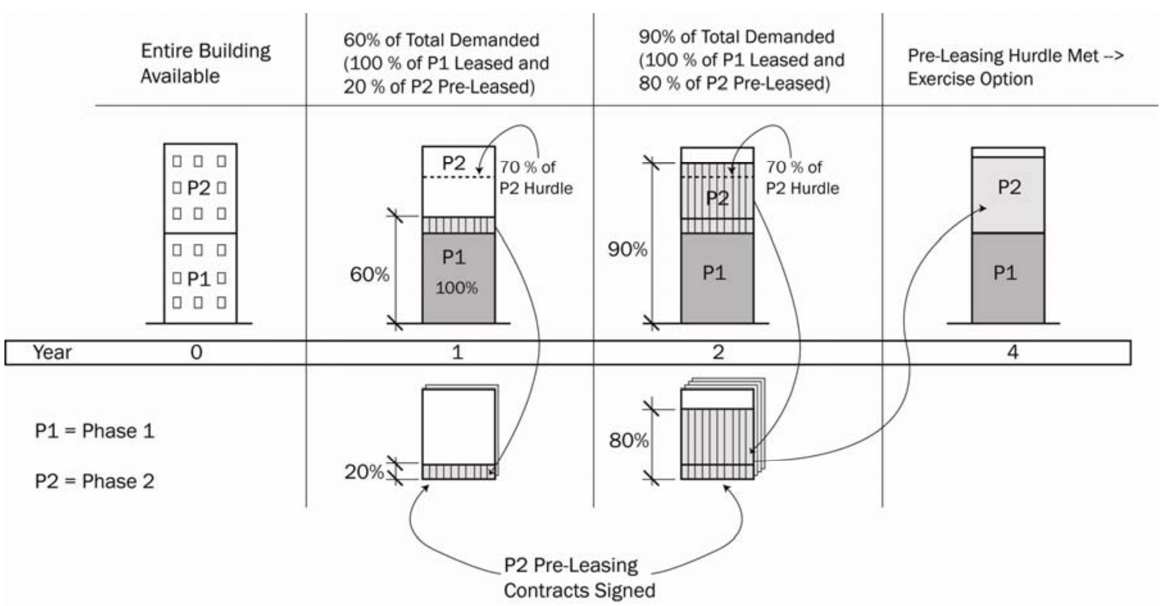
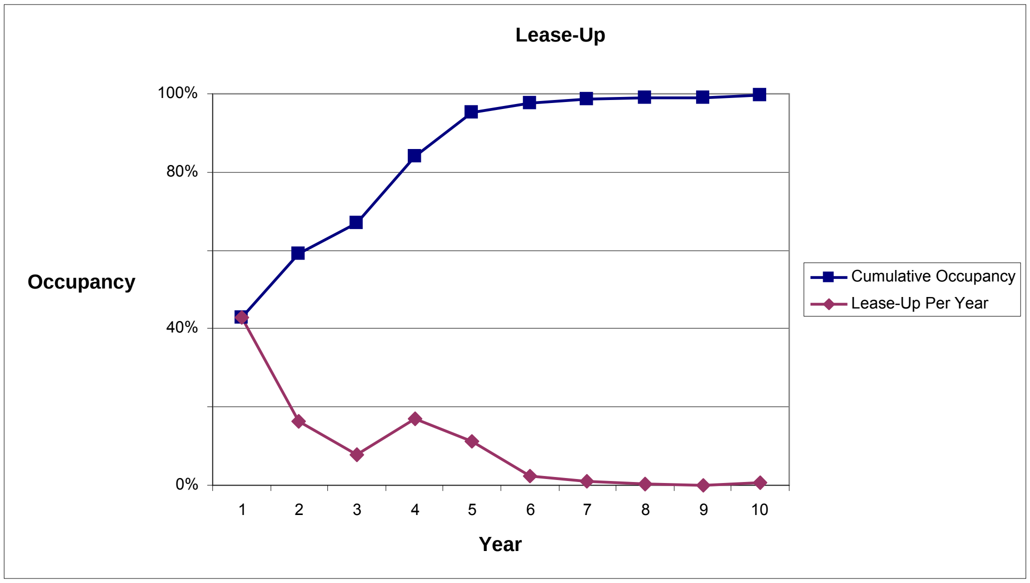
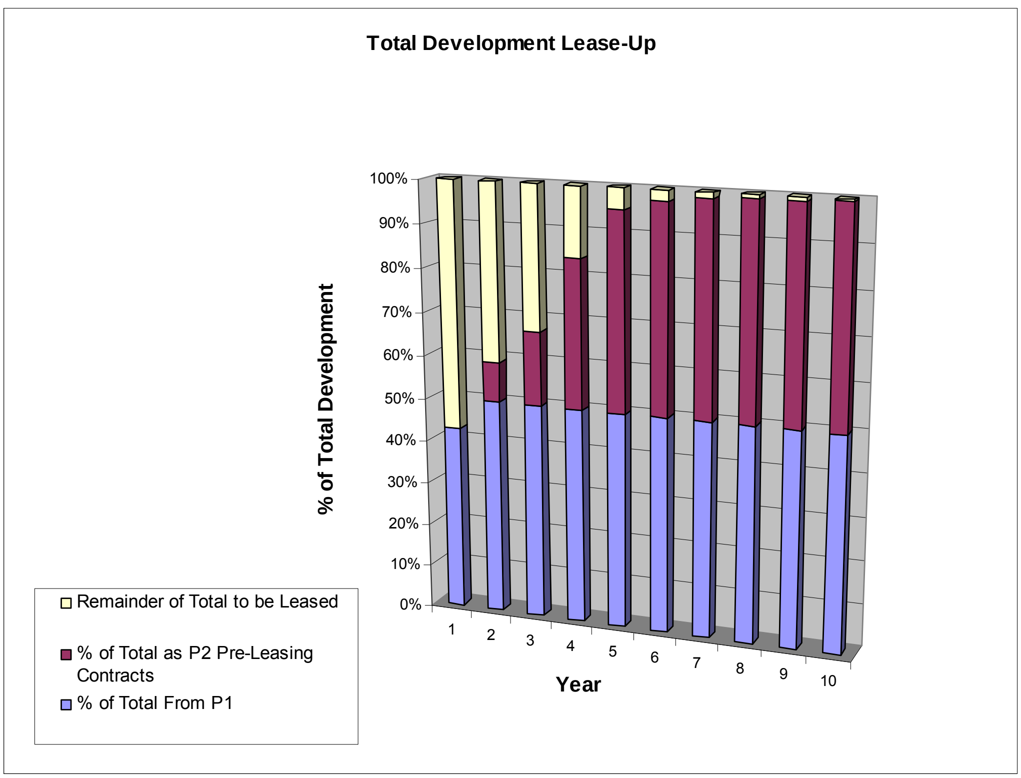


Figure 4.3: Decision rule diagram (Illustration by Author).

A numerical example of the simulated data that makes up the criteria for the decision to exercise the expansion option is represented in Figures 4.4 (A) and (B) below. Figure 4.4 (A) is the lease-up pattern of the entire structure which will determine the expansion decision. The graph in Figure 4.4 (B) represents the associated lease up pattern as it relates to the total structure, Phase 1, and the pre-leasing contracts for Phase 2.



(A) Lease-up rate.



(B) Cumulative total lease-up and lease-up per phase.

Figure 4.4: Example of a possible lease-up scenario.

Lastly, Table 4.2 represents an example of the exercise decision rule evaluation. In this particular example the first year total lease-up range is between 30% and 70%. The subsequent rent growth and Phase 2 lease-up hurdles are 1.0% and 70.0% respectively.

			Year 1 Range:	30.0%	70.0%		
	Year	1	2	3	4	5	6
	Lease-Up Per Year	40.6%	6.3%	3.2%	35.0%	8.6%	4.4%
	Cumulative Occupancy	40.6%	46.9%	50.1%	85.1%	93.7%	98.1%
	% of P1 Leased	81.3%	93.9%	100.0%	100.0%	100.0%	100.0%
	% of P2 Pre-Leased	0.0%	0.0%	0.2%	70.3%	87.4%	96.3%
Year		1	2	3	4	5	6
Rent Growth Hurdle: 1.0%	Rent CAGR:	8.0%	5.0%	2.7%	1.1%	1.1%	1.6%
P2 Pre-Leasing Hurdle: 70.0%	% of P2 Pre-Leased:	0.0%	0.0%	0.2%	70.3%	87.4%	96.3%
Exercise Decision Per Year		NO	NO	NO	YES	YES	YES
Exercise Year 4							

Table 4.2: Decision rule and determination of exercise year.

The decision to exercise the option to expand vertically is irreversibly and can only occur at one point in time. Since the model considers two factors, lease-up and rent growth, it is possible the decision rule may be “no” in a year after the first “yes.” This is due to the assumed uncertainty in the rent growth causing rents to fall in the future, and the growth to fall below the hurdle. At this point however, the decision to expand has already been made and the potential loss in revenue from the decline in rent in those cases is factored into the ENPV.

4.4 Simulation and Scenario Comparison

To determine the potential value brought to the project by the ability to expand the structure vertically, the three scenarios are evaluated and the results are compared. The ENPV’s of each case are calculated by performing a Monte Carlo simulation which produced 2000 realizations of potential future outcomes. Through this process an average, a minimum, and a maximum ENPV are generated can be used to differences in value between each. To arrive at the present value of the cash flows, a fifteen year DCF is performed for each case based on the assumptions in section 4.2.

- Scenario 1: The development of Phase 1 without the flexibility to expand built in. This scenario is based on the construction of only the Phase 1 of the total structure (See Appendix Table A.5)

- Scenario 2: The development of Phase 1 and Phase 2 as one complete structure. This scenario is based on the construction of the entire possible structure (See Appendix Table A.6).

- Scenario 3: The development a flexible design which incorporates the option to expand the structure vertically (from twenty-nine to fifty-four levels) under the conditions described in Section 4.2.3 (See Appendix Table A.7)

In this simulation the price of embedding the options is assumed to increase the development cost of Phase 1 by 12%. The assumed market conditions and decision making criteria are the same as the preceding numerical example with a first year lease-up between 30% to 70% of the whole building, a requirement for 70% of the potential second phase to be pre-leased, and a compound annual rent growth rate to be a minimum of 1.0%.

The remainder of the development characteristics and costs are summarized in Table 4.3 below.

P1 Cost Per Square Foot:	$140.00
P2 Cost Per Square Foot:	$124.00
Phase One Gross Area (Square Feet):	1,520,000
Phase One Rentable Area (Square Feet):	1,000,000
Phase Two Gross Area (Square Feet):	1,250,000
Phase Two Rentable Area (Square Feet):	1,000,000
Option Cost Premium:	12.0%
Phase 1 Cost **Without** Option:	$212,800,000
Option Price at 12% of Above:	$25,536,000
Phase 1 **With** Option:	$238,336,000
Phase2 Cost:	$155,000,000
Phase 1+2:	$393,336,000

Table 4.3: Development characteristics and costs for analysis.

The main intent of this analysis is to investigate the value that flexibility brings to project designed for vertical expansion. In this example the options was exercised in Year 4 of the analysis when Phase 2 of the development was 84.4% pre-leased and the compound annual rent growth was 1.9% (Table 4.4).

		Year 1 Range:		30.0%	70.0%		
	Year	1	2	3	4	5	6
	Lease-Up Per Year	44.6%	27.5%	12.5%	3.1%	4.4%	5.4%
	Cumulative Occupancy	44.6%	72.1%	84.7%	87.8%	92.2%	97.6%
	% of P1 Leased	89.3%	100.0%	100.0%	100.0%	100.0%	100.0%
	% of P2 Pre-Leased	0.0%	44.2%	69.3%	75.5%	84.4%	95.2%
Year		1	2	3	4	5	6
Rent Growth Hurdle: 1.0%	Rent CAGR:	-10.4%	-2.7%	-1.4%	0.4%	1.9%	-1.7%
P2 Pre-Leasing Hurdle: 70.0%	% of P2 Pre-Leased:	0.0%	44.2%	69.3%	75.5%	84.4%	95.2%
Exercise Decision Per Year		NO	NO	NO	NO	YES	NO
Exercise Year **5**							

Table 4.4: Simulation decision.

The results of this simulation are described in Table 4.4. It numerically displays how flexibility can affect the valuation of a development. In this example the flexible condition increased the ENPV by approximately $10 million (from 22,025 to 31,761 million) over simply building the first phase. This gain represents the exercising of the option at the appropriate time. Concurrently, the flexible design limits the potential downside loss associated with building the entirety of Phase 1 and Phase 2 initially by approximately $12 million in the worse case scenario (from -64,367 to -52,294 million).

	Scenario		
(x 1000)	Phase 1	Phase 1+2	Flexible
Initial Investment	$212,800	$393,336	$238,336
Expected NPV	$22,025	$40,011	$31,761
Maximum NPV	$78,379	$152,014	$119,019
Minimum NPV	-$37,222	-$64,367	-$52,294
Return on Investme	10.4%	10.2%	13.3%

Table 4.5: Analysis results.

The return on investment is based (ROI) on the initial investment and the expected NPV (Initial Investment / Expected NPV). The initial investment for the flexible case is slightly larger that Phase 1, as the cost to purchase the option represents the increase. While calculating the ROI in this way is a bit simplistic, it underscores the value created by incorporating flexibility in a development project. In this example, the return on the initial investment increases from 10.4% to 13.3% with the option to expand the structure vertically.

These same results are represented graphically by the VARG curves in Figure 4.5. In this graphic, the curve representing the flexible case is shifted to the right with respect to both the Phase 1 only and the Phase 1 + 2 scenarios. This relationship tells the same story as depicted numerically in Table 4.4 above.

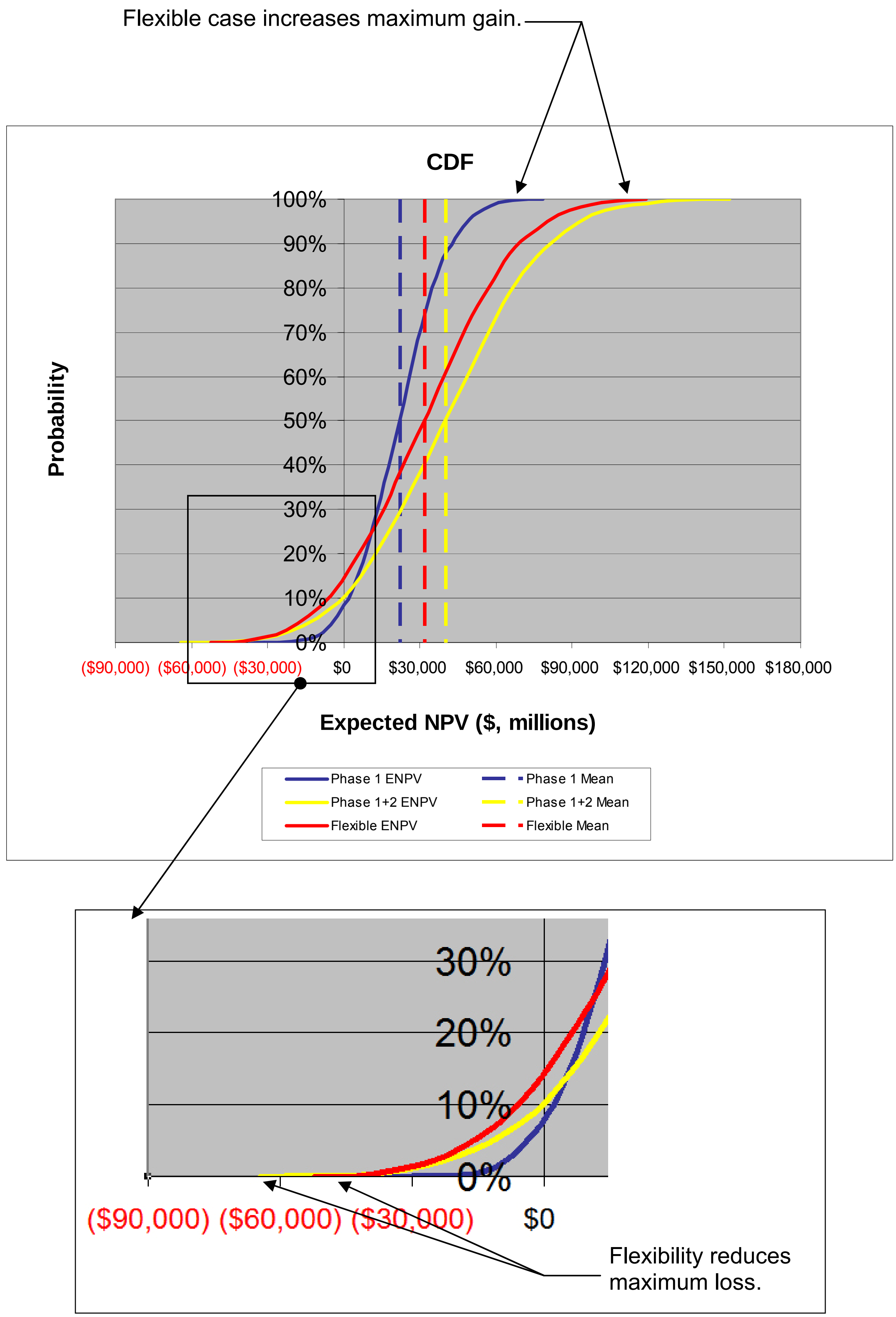


Figure 4.5: VARG (Value At Risk or Gain) curves base in the analysis results.

While it is clear that building flexibility into a real estate development can have positive implications on the overall value of the development, the outcome of the flexibility is sensitive to many factors. These factors can be related to anything from the design or the development costs, to the market and the preferences of the investor.

4.5 Analysis Observations

On the significant factors which could influence the value of the flexibility in a development project is the cost of the option. In the preceding analysis, the premium paid for the option increased the development cost by 12% and the resultant flexibility brought added value to the project. Figure 4.6 represents a range of option premiums and the related effect on the ENPV. The option premium is the additional cost of purchasing the option as a percentage of the base total development cost. From the graph it can be see that at around 17%, the price of the option prohibits the flexible case from adding value beyond that of the first phase. In other words, the benefit of the flexibility may not be worth the cost of acquiring it. While under the same conditions, the expected value of building the entire structure is still higher than the smaller Phase 1, the downside exposure would be greater.

The option cost premium in this graphic represents the additional expense required to construct Phase 2. For example, this expense includes the costs of providing greater capacity structural, mechanical and vertical circulation systems. The costs associated with these additional systems are required to provide the future option to expand vertically, but also are necessary in the construction of Phase 1 + 2 together. Therefore, as the cost of providing the option increases, the cost of building the Phase 1 + 2 scenario increases and the net present values of both cases declines.

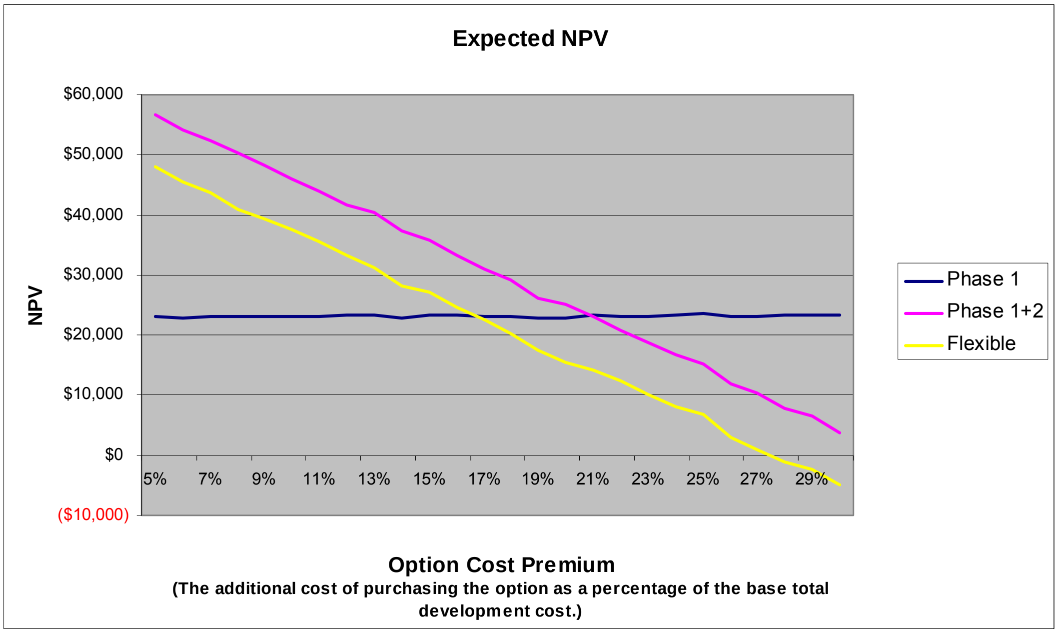


Figure 4.6: Expected NPV as a function of the price of flexibility.

A second point of sensitivity to the analysis could relate to the decision making process. In the preceding analysis, the factors considered in exercising the option were the lease-up rate of the potential second phase, and the rent growth over time. Buy changing the hurdles which must be met, the implications on the model can be observed.

In the simulation above, the pre-leasing obligation was set at 70%. But looking to either side of this a perspective on the analysis can be attained. For example, but setting the pre-leasing hurdle to a low value like 20%, the option is exercised early and the results of the flexible case look similar to constructing Phase 1 and 2 all at once (Table 4.6).

	Scenario		
(x 1000)	Phase 1	Phase 1+2	Flexible
Initial Investment	$212,800	$393,336	$238,336
Expected NPV	$22,010	$39,578	$35,803
Maximum NPV	$90,678	$174,738	$123,531
Minimum NPV	-$21,815	-$51,831	-$40,932
Return on Investme	10.3%	10.1%	15.0%

Table 4.6: Analysis results with 20% pre-leasing hurdle.

Alternatively, by looking at the results with a high pre-leasing hurdle like 90% (Table 4.7), the option is exercised at a rather late date and results are similar to the first phase but with a greater downside.

	Scenario		
(x 1000)	Phase 1	Phase 1+2	Flexible
Initial Investment	$212,800	$393,336	$238,336
Expected NPV	$22,165	$39,802	$22,686
Maximum NPV	$81,649	$157,887	$115,340
Minimum NPV	-$26,039	-$54,984	-$51,575
Return on Investme	10.4%	10.1%	9.5%

Table 4.7: Analysis results with 90% pre-leasing hurdle.

Chapter 5: Conclusion

Although uncommon, vertically expandable structures are occasionally developed. While the design, engineering, and construction process does present interesting and possibly unusual challenges, most can typically be resolved through relatively convention means. Proper planning and commitment to the ultimate long term goal of seeing the option realized is essential to the overall success of the project.

All of these characteristics of vertical flexibility can easily be foreseen and the expectation of a complex project would presumably be well anticipated. It is less clear however, what value the flexibility will bring to a project and what type of financial analysis a developer might use to quantify the potential value. The simple assumption is that efforts would be made to apply tradition underwriting methods to the deal. That process along with the keen expertise of an experienced developer might provide enough of feel for what the built-in flexibility is worth.

Concurrently, it is also easy to imagine that a seemingly more complex valuation methodology such a real options analysis would not be considered in a typical real estate practice. This may be true for a variety of reasons which range from a lack of understanding to a perception complexity. While all of these points may be true, this thesis has demonstrated that use of a real options analysis to value vertically expandable structures can be performed with tools and metrics that are familiar to most all real estate professionals. Additionally, applying these techniques to a vertically expandable structure can indeed demonstrate that the flexibility can provide additional financial gain while limiting the potential loss.

Flexibility in projects such as the HCSC headquarters does provide the ability to enhance the maximum gain, limit the worst case loss, or improve the expected value. These facts inherently point toward the idea that different types of investors have different preferences. Some may be more interested in maximizing the potential upside of the development, and others may be more interested in limiting downside losses. In the specific case of the HCSC tower, the flexibility to expand also includes an intangible value associated with a singular structure which can respond to the needs of a growing corporation.

Combining a tractable real option valuation methodology (spreadsheet analysis) with a development strategy that includes the ability to exercise and a future option (e.g. vertical expansion), the potential to match investor preferences to development projects becomes enhanced. In applying the described methodology to a project which incorporates flexibility the analytic expressions of interest to investors such as the value at risk, the expected and maximum net present values, and the different returns based on the initial capital investments are inherent products of the analysis. These metrics are valuable factors for developers considering possible investments, and omitted from conventional NPV or DCF analyses.

Bibliography

Worked Cited

Barman, B., Nash, K. E., (2007). *A Streamlined Real Options Model for Real Estate Development.* Unpublished Thesis S.M. in Real Estate Development --Massachusetts Institute of Technology Dept. of Urban Studies and Planning.

Borison, A. (2005). Real Options Analysis: Where Are the Emperor's Clothes? *Journal of Applied Corporate Finance, 17*(2), 17-31.

Brach, M. A. (2003). *Real Options in Practice*. Hoboken, N.J.: John Wiley & Sons.

Brealey, R. A., Myers, S. C., & Allen, F. (2006). *Principles of Corporate Finance* (8th ed.). New York, NY: McGraw-Hill/Irwin.

Copeland, T., & Antikarov, V. (2001). *Real Options: A Practitioner's Guide*: New York: Texere.

de Neufville, R. (2002). Architecting/Designing Engineering Systems Using Real Options, ESD-WP-2003-01.09. *MIT Engineering Systems Symposium on the Intellectual Foundations of Engineering Systems*. http://ardent.mit.edu/real_options/Real_opts_papers/ESD-WP-2003-01.09-ESD Internal Symposium.pdf

de Neufville, R., Scholtes, S., & Wang, T. (2006). Valuing Real Options by Spreadsheet: Parking Garage Case Example. *ASCE Journal of Infrastructure Systems, 12*(2), 107-111.

Dixit, A. K., & Pindyck, R. S. (1994). *Investment Under Uncertainty*. Princeton, NJ: Princeton University Press.

Geltner, D., Miller, N., Clayton, J., & Eichholtz, P. (2007). *Commercial Real Estate Analysis & Investments* (2nd ed.). Mason, OH: Thomson.

Gesner, G., & Jardim, J. (1998). Bridge within a Bridge. *Civil Engineering, 68*(10), 44-47.

Kim, K. (2008). *Real Options: A Way to Deal with Market Uncertainty in Real Estate Development Projects.* Unpublished Thesis S.M. in Real Estate Development --Massachusetts Institute of Technology.

Leslie, K. J., & Michaels, M. P. (1997). The Real Power of Real Options. *McKinsey Quarterly* (3), 4-22.

Luehrman, T. A. (1998). Investment Opportunities as Real Options: Getting Started on the Numbers. *Harvard Business Review, 76*(4), 51-67.

Masunaga, S., (2007). *A Comparative Study of Real Options Valuation methods: Economics-Based Approach vs. Engineering-Based Approach.* Unpublished Thesis S.M. in Real Estate Development --Massachusetts Institute of Technology Dept. of Urban Studies and Planning.

Pearson, J., & Wittels, K. (2008). *Real Options in Action: Vertical Phasing in Commercial Real Estate Development.* Unpublished Thesis S.M. in Real Estate Development --Massachusetts Institute of Technology.

Sirmans, C. F. (1997). Research on Discounted Cash Flow Models. *Real Estate Finance, 13*(4), 93-95.

Wang, T., & de Neufville, R. (2005). Real Options “in” Projects. *9th Real Options Annual International Conference, Paris*. http://ardent.mit.edu/real_options/Real_opts_papers/Real_Options_in_Projects-Tao-50217.pdf

Additional Reading

Cardin, M.-A., (2007). *Facing reality : design and management of flexible engineering systems.* Unpublished Thesis S.M. --Massachusetts Institute of Technology Engineering Systems Division Technology and Policy Program.

Childs, P. D., Riddiough, T. J., & Triantis, A. J. (1996). Mixed Uses and the Redevelopment Option. *Real Estate Economics, 24*(3), 317-339.

Cox, J. C., Ross, S. A., & Rubinstein, M. (1979). Option Pricing: A Simplified Approach. *Journal of Financial Economics, 7*(3), 229-263.

Coy, P. (1999). "Exploiting Uncertainty: The Real-Options Revolution in Decision Making “. *Business Week, 3632*, 118–124.

Ellingham, I., & Fawcett, W. (2006). *New Generation Whole-Life Costing: Property and Construction Decision-Making Under Uncertainty*. London, UK: Taylor & Francis.

Greden, L., (2005). *Flexibility in Building Design: A Real Options Approach and Valuation Methodology to Address Risk.* Unpublished Thesis Ph. D. --Massachusetts Institute of Technology Dept. of Architecture.

Greden, L., & Glicksman, L. (2004). Options Valuation of Architectural Flexibility: A Case Study of the Option to Convert to Office Space. *Real Options 8th Annual International Conference, Montreal, Canada*, 17–19. http://www.realoptions.org/papers2004/Greden_FlexibleDesign.pdf

Greden, L., & Glicksman, L. (2005). A Real Options Model for Valuing Flexible Space. *Journal of Corporate Real Estate, 7*(1), 34-48.

Hull, J. (2006). *Options, Futures, and Other Derivatives* (6th ed.). Upper Saddle River, N.J.: Pearson/Prentice Hall.

Myers, S. C. (1977). Determinants of Corporate Borrowing. *Journal of Financial Economics, 5*(2), 147-175.

Oppenheimer, P. H. (2002). A Critique of Using Real Options Pricing Models in Valuing Real Estate Projects and Contracts. *Briefings in Real Estate Finance, 2*(3), 221.

Rocha, K., Salles, L., Garcia, F. A. A., Sardinha, J. A., & Teixeira, J. P. (2007). Real Estate and Real Options -- A case study. *Emerging Markets Review, 8*(1), 67-79.

Trigeorgis, L. (1993). Real Options and Interactions with Financial Flexibility. *Financial Management, 22*(3), 202-224.

Interviews Conducted

D'Amico, Jim, The John Buck Company. In person interview. June 10-11, 2008. Interview conducted by the author.

Dolinar, Joseph, Goettsch Partners. In person interview. June 10-11, 2008. Interview conducted by the author.

Eckmann, David, Magnusson Klemencic. In person interview. June 11, 2008. Interview conducted by the author.

Pini, Andrew, Health Care Service Corporation. In person interview. June 12, 2008. Interview conducted by the author.

Rossetti, Lou, Walsh Construction. In person interview. June 10, 2008. Interview conducted by the author.

Spiewak, Bud, Cosentini Associates, Inc. In person interview. June 12, 2008. Interview conducted by the author.

Appendix

This section presents a description of the model which evaluates the real option to expand a structure vertically.

Table A.1 represents the first page of inputs which accounts for the characteristics of the property and the development costs.

Property Characteristics / Costs

P1 Cost PSF:	$140
P2 Cost PSF:	$124
Phase One Gross Area (SF):	1,520,000
Phase One Rentable Area (SF):	1,000,000
Phase Two Gross Area (SF):	1,250,000
Phase Two Rentable Area (SF):	1,000,000
Option Cost Premium:	12%
Phase 1 Cost Without Option:	$212,800
Option Price:	$25,536
Phase 1 With Option:	$238,336
Phase2 Cost:	$155,000
Phase 1+2:	$393,336

Table A.1: Property and cost inputs.

Table A.2 represents the second page of inputs which accounts for other costs and relevant rates.

Assumptions

Phase One Size (Rentable Area)	1,000,000	SF	
Phase Two Size (Rentable Area)	1,000,000	SF	
Total Size Rentable Area	2,000,000	SF	
Construction Cost Growth	2.0%		
Operating Expenses	$7.00	PSF	
Interest Rates			
10 Year US Treasury	6.35%	<==	1997 Average
Risk Free Rate	4.85%	<==	10 Yr Treasury Less 150 bps
Stabilized Class A Risk Premium	3.50%	<==	(Geltner et al, 200, p252)
Discount Rate (r = rf + RP)	8.35%		
Exit Cap Rate	7.50%	<==	Average 2007 Downtown Office

Table A.2: Other costs and relevant rates.

Table A.3 represents an example the page which simulates possible rent growth scenarios.

Rent(0)	$24.00	initial rent
Eg	1.00%	expected rent growth
SDg	0.35%	standard deviation of expected growth
sigma	4.00%	volitality
noise(t)	8.00%	noise
SDg realization	0.000484	
	0.300	mean reversion rate

Year	Expected Rent	Realized Rent	sigma(t)	Trend Rent	noise(t)	Achieved Rent	Trend Rent Mean Revert	Achieved Rent Mean Revert	CAGR
0	24.00	24.00		24.00	-0.0326	23.22	24.00	23.22	
1	24.24	24.25	2.15%	24.77	0.0506	26.02	24.77	26.02	12.07%
2	24.48	24.51	-4.51%	23.91	-0.0631	22.40	23.75	22.25	-2.10%
3	24.73	24.76	2.31%	24.71	-0.0543	23.37	24.77	23.42	0.29%
4	24.97	25.02	5.52%	26.34	-0.0271	25.62	26.39	25.68	2.55%
5	25.22	25.28	-5.55%	25.15	0.0156	25.54	24.77	25.16	1.62%
6	25.48	25.55	-5.07%	24.14	-0.0021	24.09	23.93	23.88	0.47%
7	25.73	25.82	-2.84%	23.71	-0.0550	22.41	23.96	22.64	-0.36%
8	25.99	26.09	0.56%	24.09	-0.1383	20.76	24.86	21.42	-1.00%
9	26.25	26.36	-0.20%	24.29	0.0349	25.14	25.42	26.31	1.40%
10	26.51	26.64	6.02%	26.01	0.0588	27.54	27.49	29.11	2.29%
11	26.78	26.92	-3.64%	25.34	0.0377	26.29	26.51	27.51	1.56%
12	27.04	27.20	-5.26%	24.27	0.0389	25.22	25.52	26.51	1.11%
13	27.31	27.49	-6.76%	22.89	0.0329	23.64	24.53	25.34	0.68%
14	27.59	27.77	0.74%	23.29	-0.1022	20.91	25.76	23.13	-0.03%
15	27.86	28.06	-0.86%	23.34	0.0732	25.04	26.37	28.30	1.33%
16	28.14	28.36	-0.85%	23.38	0.0934	25.57	26.90	29.41	1.49%
17	28.42	28.66	2.82%	24.29	-0.0617	22.79	28.35	26.61	0.80%
18	28.71	28.96	2.24%	25.09	0.0658	26.74	29.38	31.31	1.67%
19	28.99	29.26	4.48%	26.47	-0.0678	24.68	30.87	28.78	1.14%
20	29.28	29.57	-4.33%	25.61	0.0736	27.49	29.35	31.51	1.54%

Table A.3: Rent growth simulation.

Table A.4 represents an example the page which simulates possible lease-up scenarios.

		Year 1 Range:	**30.0%**	**70.0%**			Subsequent Year Mamimum of Remainder				48%	25%	75%		
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Lease-Up Per Year	46.63%	24.96%	0.03%	13.57%	6.13%	4.01%	2.09%	0.36%	1.06%	0.55%	0.29%	0.10%	0.02%	0.09%	0.05%
		53.37%	28.41%	28.38%	14.81%	8.68%	4.67%	2.57%	2.21%	1.16%	0.60%	0.32%	0.21%	0.20%	0.10%
		46.77%	0.09%	97.21%	41.40%	46.24%	44.85%	13.94%	99.20%	68.51%	91.95%	32.58%	8.12%	92.96%	86.86%
Cumulative Occupancy	46.63%	71.59%	71.62%	85.19%	91.32%	95.33%	97.43%	97.79%	98.84%	99.40%	99.68%	99.79%	99.80%	99.90%	99.95%
Vacancy	53.37%	28.41%	28.38%	14.81%	8.68%	4.67%	2.57%	2.21%	1.16%	0.60%	0.32%	0.21%	0.20%	0.10%	0.05%

Table A.4: Lease-up simulation.

Table A.5 represents an example of the Phase 1 valuation.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Rent	26.02	22.25	23.42	25.68	25.16	23.88	22.64	21.42	26.31	29.11	27.51	26.51	25.34	23.13	28.30	29.41
Cumulative Total Lease-Up	47%	72%	72%	85%	91%	95%	97%	98%	99%	99%	100%	100%	100%	100%	100%	100%
% of P1 Leased	93%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

PROJECTED NET OPERATING INCOME AND CASH FLOW FROM OPERATIONS
($ in Thousands)

Year	1995-1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Development Cost	(212,800)																
Potential Gross Income		26,021	26,021	26,021	26,021	26,021	23,876	23,876	23,876	23,876	23,876	27,514	27,514	27,514	27,514	27,514	29,413
Less Vacancy		(1,752)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Effective Gross Income		24,269	26,021	26,021	26,021	26,021	23,876	23,876	23,876	23,876	23,876	27,514	27,514	27,514	27,514	27,514	29,413
Operating Expenses		(6,529)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)
PBTCF		17,740	19,021	19,021	19,021	19,021	16,876	16,876	16,876	16,876	16,876	20,514	20,514	20,514	20,514	20,514	22,413
Reversion PBTCF																298,841	
Total PBTCF	(212,800)	17,740	19,021	19,021	19,021	19,021	16,876	16,876	16,876	16,876	16,876	20,514	20,514	20,514	20,514	319,355	

NPV	**32,116**

Table A.5: Phase 1 valuation.

Table A.6 represents an example of the Phase 1+2 valuation.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Rent	26.02	22.25	23.42	25.68	25.16	23.88	22.64	21.42	26.31	29.11	27.51	26.51	25.34	23.13	28.30	29.41
Cumulative Total Lease-Up	47%	72%	72%	85%	91%	95%	97%	98%	99%	99%	100%	100%	100%	100%	100%	100%
% of P1 Leased	93%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% of Total as P2 Pre-Leasing Contracts	0%	22%	22%	35%	41%	45%	47%	48%	49%	49%	50%	50%	50%	50%	50%	50%
% of Total From P1	47%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
% of Total as P2 Pre-Leasing Contracts	0%	22%	22%	35%	41%	45%	47%	48%	49%	49%	50%	50%	50%	50%	50%	50%
P1 + Pre-Leasing	47%	72%	72%	85%	91%	95%	97%	98%	99%	99%	100%	100%	100%	100%	100%	100%
Remainder of Total to be Leased	53%	28%	28%	15%	9%	5%	3%	2%	1%	1%	0%	0%	0%	0%	0%	0%
% of P2 Leased	0%	43%	43%	70%	83%	91%	95%	96%	98%	99%	99%	100%	100%	100%	100%	100%

PROJECTED NET OPERATING INCOME AND CASH FLOW FROM OPERATIONS
($ in Thousands)

Year	1995-1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Development Cost	(393,336)																
Phase One Potential Gross Income		26,021	26,021	26,021	26,021	26,021	23,876	23,876	23,876	23,876	23,876	27,514	27,514	27,514	27,514	27,514	29,413
Less Vacancy		(1,752)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phase One Effective Gross Income		24,269	26,021	26,021	26,021	26,021	23,876	23,876	23,876	23,876	23,876	27,514	27,514	27,514	27,514	27,514	29,413
Operating Expenses		(6,529)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)
PBTCF		17,740	19,021	19,021	19,021	19,021	16,876	16,876	16,876	16,876	16,876	20,514	20,514	20,514	20,514	20,514	22,413
Phase Two Potential Gross Income		26,021	26,021	26,021	26,021	26,021	23,876	23,876	23,876	23,876	23,876	27,514	27,514	27,514	27,514	27,514	29,413
Less Vacancy		(26,021)	(14,784)	(14,770)	(7,710)	(4,518)	(2,228)	(1,229)	(1,058)	(552)	(288)	(173)	(117)	(107)	(56)	(29)	(31)
Phase Two Effective Gross Income		0	11,238	11,251	18,311	21,503	21,648	22,647	22,818	23,324	23,588	27,340	27,397	27,406	27,457	27,484	29,382
Operating Expenses		0	(3,023)	(3,027)	(4,926)	(5,785)	(6,347)	(6,640)	(6,690)	(6,838)	(6,916)	(6,956)	(6,970)	(6,973)	(6,986)	(6,993)	(6,993)
PBTCF		0	8,215	8,225	13,385	15,719	15,301	16,007	16,129	16,486	16,672	20,384	20,426	20,433	20,472	20,492	22,389
Total PBTCF From Operations		17,740	27,236	27,246	32,406	34,740	32,177	32,884	33,005	33,362	33,549	40,898	40,940	40,947	40,985	41,005	44,802
Reversion PBTCF																597,364	
Total PBTCF	(393,336)	17,740	27,236	27,246	32,406	34,740	32,177	32,884	33,005	33,362	33,549	40,898	40,940	40,947	40,985	638,370	

NPV	53,754

Table A.6: Phase 1+2 valuation.

Table A.7 represents an example of the Flexible scenario exercise decision and valuation.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Rent	26.54	24.20	21.68	24.21	26.49	29.31	28.97	27.20	28.26	25.39	29.08	24.39	24.60	31.34	28.51	27.43	27.44
Cumulative Total Lease-Up		46%	81%	93%	95%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% of P1 Leased		92%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% of Total as P2 Pre-Leasing Contracts		0%	31%	43%	45%	48%	49%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
% of Total From P1		46%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
% of Total as P2 Pre-Leasing Contracts		0%	31%	43%	45%	48%	49%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
P1 + Pre-Leasing		46%	81%	93%	95%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Remainder of Total to be Leased		54%	19%	7%	5%	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% of P2 Pre-Leased		0%	61%	86%	91%	97%	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%

PROJECTED NET OPERATING INCOME AND CASH FLOW FROM OPERATIONS
($ in Thousands)

Year	1995-1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Phase 1 Development Cost	(238,336)																
Phase One Potential Gross Income		24,204	24,204	24,204	24,204	24,204	28,972	28,972	28,972	28,972	28,972	24,395	24,395	24,395	24,395	24,395	27,443
Less Vacancy		(1,823)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phase One Effective Gross Income		22,382	24,204	24,204	24,204	24,204	28,972	28,972	28,972	28,972	28,972	24,395	24,395	24,395	24,395	24,395	27,443
Operating Expenses		(6,473)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)	(7,000)
PBTCF		15,909	17,204	17,204	17,204	17,204	21,972	21,972	21,972	21,972	21,972	17,395	17,395	17,395	17,395	17,395	20,443
Phase 2 Development Cost	(155,000)	(158,100)	(161,262)	(164,487)	(167,777)	(171,133)	(174,555)	(178,046)	(181,607)	(185,239)	(188,944)	(192,723)	(196,577)	(200,509)	(204,519)	(208,610)	(212,782)
Exercise Option		NO	NO	NO	NO	YES	YES	NO	NO	NO	NO	NO	NO	YES	NO		
"YES" Count		3	3	3	3	3	2	1	1	1	1	1	1	1	0		
Phase Two Potential Gross Income				0	0	0	0	27,196	28,260	27,196	27,196	27,196	24,597	24,597	24,597	24,597	24,597
Less Vacancy				0	0	0	0	(210)	(79)	(55)	(51)	(18)	(15)	(14)	(5)	(3)	(3)
Phase Two Effective Gross Income				0	0	0	0	26,986	28,182	27,141	27,145	27,177	24,583	24,583	24,592	24,594	24,594
Operating Expenses				0	0	0	0	(6,946)	(6,981)	(6,986)	(6,987)	(6,995)	(6,996)	(6,996)	(6,999)	(6,999)	(6,999)
PBTCF				0	0	0	0	20,040	21,201	20,155	20,158	20,182	17,587	17,587	17,594	17,595	17,595
PBTCF From Operations		15,909	17,204	17,204	17,204	17,204	21,972	42,012	43,173	42,127	42,130	37,577	34,982	34,982	34,988	34,990	38,038
Reversion PBTCF																507,172	
Development Costs	(238,336)	0	0	0	0	(171,133)	0	0	0	0	0	0	0	0			
Total PBTCF		15,909	17,204	17,204	17,204	17,204	21,972	42,012	43,173	42,127	42,130	37,577	34,982	34,982	34,988	542,162	

PV of Development Costs	(352,937)	Phase 2 Cost	(171,133)
PV of Property	381,951		
NPV	**29,014**		

		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Rent Growth Hurdle: **1.0%**	Rent CAGR:	-8.8%	-9.6%	-3.0%	0.0%	2.0%	1.5%	0.4%	0.8%	-0.5%	0.9%	-0.8%	-0.6%	1.3%	0.5%
P2 Pre-Leasing Hurdle: **93.0%**	% of P2 Pre-Leased:	0.0%	61.2%	86.0%	90.6%	96.6%	98.8%	99.2%	99.7%	99.8%	99.8%	99.9%	99.9%	99.9%	100.0%
		NO	NO	NO	NO	YES	YES	NO	NO	NO	NO	NO	NO	YES	NO
Exercise Year	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0

Table A.7: Flexible case valuation.