REAL OPTION ANALYSIS: A SWITCHING APPLICATION FOR MIXED-USE REAL ESTATE DEVELOPMENT

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ABSTRACT

In real estate development, properties are developed irreversibly in an uncertain economic environment. The uncertain environment for rents or occupancy may jeopardize the return on investment. In this paper, to mitigate the risk, we use a real option valuation analysis to find the optimal strategy for developing a mixed-use property. A mixed-use real estate project under construction in Denver incorporating apartments, retail, and parking is used as an example. We adopt a switch-option valuation analysis to compare the return on investment for building as planned or switching to a different property mix conforming to allowable zoning codes. We then examine the use of various option models for optimizing when to switch the property mix.

Keywords: real option, switching option, mixed-use, hotel, decision tree, Black- Scholes

INTRODUCTION

An option is a right without an obligation and describes a variety of management decisions in business investment (Zeng and Zhang 2011). In 1973, Fischer Black and Myron Scholes published their paper "The Pricing of Options and Corporate Liabilities" in the Journal of Political Economy. Their paper develops a mathematical model applied to financial markets. The core of the model is a Partial Differential Equation (PDE), now referred to as the Black-Scholes Equation. This equation determined the price of the options at any period in time. The development of the Black-Scholes Model initiated the trading of financial and exotic options by creating a pricing mechanism to allow for trading. This created a worldwide market as well as markets such as the Chicago Board Options Exchange. In later years, the application of option theory for business decision-making evolved and has come to be known as real options.

Real Options

S.C. Myers (1977) is noted for developing a new concept called a "Real Option". He defined a real option as an alternative or choice that a firm has with the decision making process for an investment. A real option is used for proactively developing strategic flexibility to recognize and capture values hidden in dynamic project uncertainties (Ford et al 2002). Real options assume that because of the uncertain economic environment in the future, investors are not capable of making every decision prior to investing. Consequently, they may choose to invest more upfront to acquire the right to alter the investment at a future date in order to maximize profits on the investment. The real options embedded within the investment allow managers to exercise their discretion based on the changing environment. This discretion can be exercised on both future investment decisions and on on-going investments. The core concept of the real option method is to allow investors to make informed choices in the future, with situational changes, to determine when the optimal timing is and what they should choose to heighten their return, prior to making an investment.

This discretion can be defined as start time and deferring. In terms of on-going investments, this discretion includes altering, expanding, abandoning, or switching. Decision trees, real option pricing formulas and simulation analysis are the three commonly applied methods to solve the real option problem and help managers incorporate embedded option values into their decision-making. Trigeorgis (1993) outlined seven types of real options based on different applications of the theory. The seven types are categorized as follows: Option to Defer, Staged Investment Option, Option to Alter Operating Scale, Option to Abandon, Option to Switch, Growth Option, and Interacting

Option. From this point in the literature, scholars devoted their research to the study of each option type and the application of real option theory to various fields and industries.

In terms of real estate, Titman (1985) was the first to consider a property investment or investor's development decision as an option. Later Quigg (1993) analyzed historical data (1976 - 1979) of real estate transactions in Seattle, and discovered that the average value of undeveloped land was 6% higher than the value of developed land. She stated that undeveloped land can be treated as an American-style call option using the same partial differential equations (PDEs) that Black-Scholes used in their option-pricing model. Most recently, Clapp et al (2012) proposed that the use of an option to redevelop needs to be incorporated in hedonic pricing models. Ross (1995) criticized the application of the traditional NPV method for calculating value, since the NPV method fails to consider the follow-up investments or options to invest. Sirmans (1997) followed by criticizing the traditional DCF method because it failed to consider that options are embedded in the investment as a result of the right, but not the requirement, to invest in the future. Many scholars, including Teisberg (1995), Lander (1995) and Pinches (1998), developed methodologies to include the valuation of (real) options to the traditional NPV valuation methods.

Hodder and Riggs (1985) developed the concept of a dynamic NPV to demonstrate how a project's discount rate changes as the project's success or failure increases over time. This allows a manager or investor to make decisions that could over time add value to a project. Tiesberg (1995) extended Hodder and Riggs by laying out conditions for the Dynamic Discounted Cash Flows (DDCF) model. Using a DDCF an investor can use a decision tree with branches at each point in time where an opportunity to invest exists, thereby altering the project and increasing its potential value. The DDCF is widely accepted as an alternative to traditional NPV methodology. It goes beyond the traditional DCF method, not only requiring users to set the discount rate, but also requiring them to consider future choices (such as dynamic discount rates) that may influence the valuation process. This was first pointed out by Fama (1977) who argued that traditional DCF suffers from misapplication in that DCF needs to be applied with more than one discount rate. The cash flows at each point in time using this method include the value of the real options, creating more flexibility than the traditional NPV by allowing the analyst to review the dynamics of the investment scenario at selected points in time and alter the decisions and the level of risk.

The remainder of this paper is divided into the following sections. The next section is a description of the different types of real options with the two major categories being real options prior to launching the investments and real options after launching the investments. The following section describes the switching option that includes both input switching and output switching, then the next section illustrates an option after investment (land) has launched using a switching option applied to a mix-use property in the City of Denver. The final section presents the concluding remarks.

TYPES OF REAL OPTIONS

Real options are separated into two groups, depending on whether the real option occurs prior to or after the investment. The former group includes staged investment, timing and operating options. The latter group consists of growth, shutdown, abandonment and switching options.

Real Option Before Investment

Prior to making an investment, both managers and investors need to address timing issues and determine when to invest based on the economic environment. This creates the options to start, develop or build. Williams (1991) provided a model that illustrated both the time and scale of options investors would consider in terms of real estate development projects. His assumption was that the changing environment may delay the actual development of the land but may also increase the scale of it once the investors decide to start. Williams (1997) later extended his previous model by allowing developers to redevelop their properties. Traditionally studies of real estate development applications focus on these types of real options thereby linking the option value to the value of the land prior to development. In these situations the value of waiting, staging or switching is incorporated into the value of the land or cash flow zero (CF0). This is primarily the case because these options exist prior to the land being developed, these are not options typically associated with a project under development.

Staged Investment Options

Many investments, and in particular venture capital (Botteron and Casanova 2003), are staged. The embedded staged investment option gives the manager flexibility to choose whether to invest in the next stage, given a favorable economic environment, or abandon the existing investment if market conditions prove unfavorable. An example of staged investment options in real estate is the acquisition of unimproved land. The acquisition or option to purchase land gives the investor the option to improve the land in the future if they discover favorable market conditions. Once an investor is satisfied to believe that the expected output value of the improvement meets or exceeds their investment requirements the land can be improved based on the market information. The initial investment of this stage can be valued as the cost of all options for the sequent stage.

Timing Options

Timing options provide the investor with the ability to change or postpone the dates of the investment. If an investor is holding a parcel of land, and the market forecast is unfavorable for improvement, timing option models may lead the investor to postpone the investment until such time that the return can justify exercising the option. Within real estate development, Titman (1985) was the first to treat vacant lots of land as a timing option to wait to develop. Titman uses a simple binomial model to explain why lots remain undeveloped and interprets an option to wait as an American call without dividends. Titman draws the conclusion that an option to wait contributes significantly to the value of land. However, what if the decision to develop was previously decided?

Operating Options

Operating options bring flexibility to investors and managers to react to the uncertain environment. By structuring the investment to incorporate flexibility they are able to respond to market changes and make the investment environment more valuable. These options are prevalent within real estate but not within the real estate literature. We present a few potential applications of options to real estate in each section below. However, as Lucius (2001) noted there are a limited number of quantitative studies regarding the valuation of real estate projects using real options methodology, and emphasized that practical valuations have yet to be comprehensively developed.

Real Option After Investment

Following an investment, managers and investors need decision making tools to value operational issues such as growth, shutdown, abandonment, and switching.

Growth Options

Growth options, also called strategic options, allow investors and managers to expand their operations after the initial investment. The expansion includes both scale expansion (increasing volume), and scope expansion (implementation of follow-on steps). Taking real estate improvement as an example, once land is improved (a building built); growth options provide managers the flexibility to expand the existing improvement with further construction by increasing the number of floors, adding square footage, or constructing more buildings. In addition, they can even invest in different types of improvements that contribute to the overall investment plan. Prior work by

Childs et al (1996) focused on a redevelopment option. They analyzed the effect of sequential investment on property value by evaluating a sequence of American calls (options to wait) without dividends. They conclude that with relatively low costs to conversion, flexibility with respect to mixed uses and redevelopment contributes significantly to the value of the built property or undeveloped land.

Shutdown or Temporary-Stop Options

During bad economic times, stopping production or operations can significantly reduce losses for investors. Therefore, the ability to shut down or temporarily stop the business and halt investment is valuable. The shutdown option allows managers to restart operations after market recovery when business operations once again become profitable. An example is Pindyck (1993) who analyzes the optimal utilization of a two reactor nuclear plant using option theory to determine when each reactor is shut down or operating. While typically applied to industry, thereby giving a manufacturer the option of shutting down a production line or stopping operations due to low prices there are many examples within real estate where firms have imitated industry. For example, a housing developer may choose to stop constructing new homes in a development. Several large tract homebuilders (KB Homes, DR Horton, etc.) put this policy in place following the U.S. housing crash of 2007. In addition, the World Trade Center in NYC has seen work stop on several buildings within the project.

Abandonment or Termination Options

Some businesses may currently be unprofitable but are forecast to recover in the near future. Other businesses are not expected to be profitable at anytime in the future. Abandonment or termination options provide the flexibility to analyze abandonment of the current businesses or investments permanently and sell or close them. The value of this option depends on both the current profits the business is making, and the salvage value of the assets the investors can receive. This real option occurs commonly in the extractive (oil, gas and mining) industries. Once a project starts should its success rate decline, it is common to decide to abandon or terminate drilling and mining operations (Smith and McCardle 1999). Many applications to real estate do not appear in the literature. During the recent housing recession, several builders choose to stop constructing new homes in a development and sell off developed lots.[46] Other examples include office, hotel and casino projects that were abandoned due to the economic recession in the USA and elsewhere.

Switching Options

Switching options give the flexibility to change either the input or output of a business or investment based on the economic changes of the market conditions. With embedded switching options, investors and managers are able to realize the smallest input and most profitable output. Switching options are typically associated with manufacturers or utilities. An example for a manufacturer includes the ability to produce different cars and/or SUVs on the same production line. For a utility, it is the ability to switch between different energy sources (oil, coal, gas) to produce power from the same plant. Within real estate development (including engineering, construction and redevelopment) there are examples of switching from an apartment building to condominiums, a warehouse to apartments or as we propose switching several apartment units into a hotel.

SWITCHING OPTIONS

Switching options are divided into both input and output models. The difference being whether the input or the output component is altered to maximize returns.

[46] Several large tract builders including Lennar, K.B. Homes and Richmond American sold off developed lots for future phases and some abandoned operations in the state of Colorado.

Input Switching

The input switching option is associated with process flexibility. This embedded option provided by extra investment in advance, results in outputs realized by using the least expensive sets of different inputs under current market conditions. Input switching is also traditionally associated with industry, where different feed stocks (materials, energy or other items) can be switched or changed in the inputs to make it possible to either produce items or reduce their cost (or weight). For the auto industry, it is meeting CAFE standards for energy efficiency by using more aluminum instead of steel. Other examples include burning different fuels in a power plant depending on input costs or for the tech industry replacing rare earth minerals from China with either different minerals or different sources that are more reliable.

Within real estate development, input switching provides price flexibility to adjust decisions regarding building components that comprise the structure. For many buildings, this can entail the use of steel, concrete or wood for structural integrity, and stone, brick, concrete or glass for the outer skin. The resulting building can then be built to budget, without sacrificing architecture or functionality by using the least expensive but suitable components. This concept was incorporated in the construction of the Metro State University's Marriott Suites Hotel in Denver. The concept of switching material inputs to build the building resulted in saving several million dollars thereby allowing the project to be built both to budget and on schedule.

Output Switching

An output switching option is associated with product flexibility, which varies in terms of the mix of final products or services. Managers are able to alter the combination of output with this built-in option resulting from the initial investment. Examples typically come from manufacturers and industry. As mentioned earlier the ability to switch production between cars and SUVs proves valuable for a car manufacturer.

Within real estate, we are illustrating that a developer of a mixed-use project, that includes apartments, may make an initial investment to allow for the flexibility to switch some of the apartments into hotel rooms to minimize the effect of low occupancy based on market need for additional apartment units and the corresponding lower rental rates for apartment units. The new output, combining both apartment and hotel services, is compared during construction and lease-up to the original concept to determine the most profitable output mix. By doing so, the property investment can be dynamically maximized.

Switching Literature

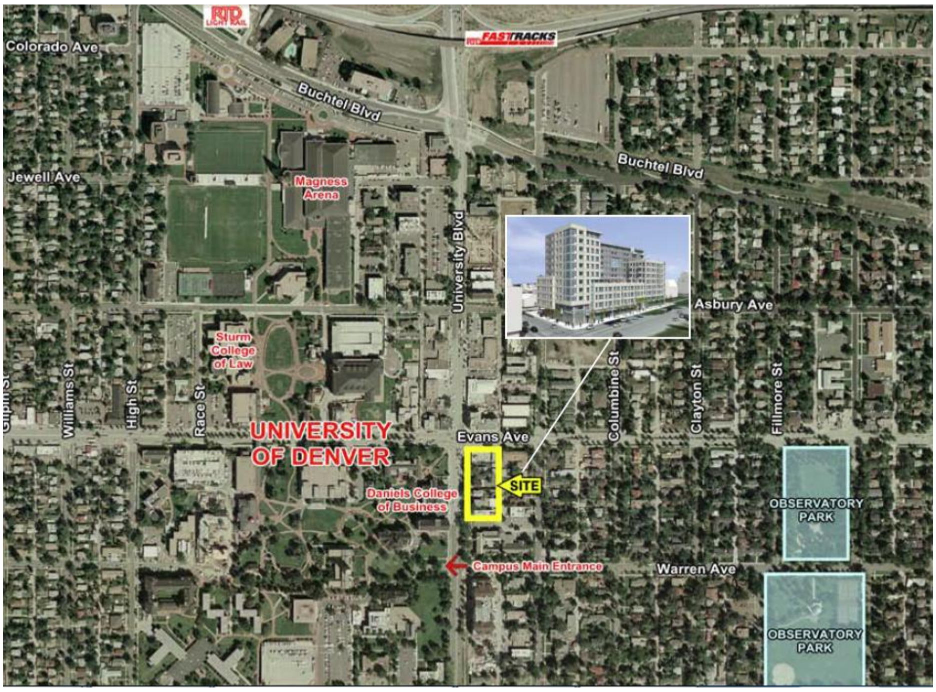
There is a limited set of prior work addressing switching options. These examples are found in industries other than real estate development. Sødal et al (2008) illustrate in the shipping industry an example of the possibility of shipping two major types of goods, those being dry bulk and liquids (oil for example). The tanker sector ships are used to ship oil while the dry bulk sector ships are designed to ship dry bulks such as grain, ores and coal. To combine the two categories of goods based on market need, a combination carrier was invented to carry both types of goods. Consequently, the shipping companies have switching options that allow them to adjust the input to maximize their profits. Johnson (2010) explores the impact of switching options on natural gas hedging strategies for Independent Power Producers (IPP’s). He suggests that the volume uncertainty associated with the switch option of purchased electricity led to the ineffectiveness of most of the natural gas hedges. The results suggest that while hedging natural gas price exposure is intuitively appealing, the volume risk of the switch option can lead to over and under-hedged positions. However, the switch option has value and this value should be taken into consideration when making hedging decisions. A real estate example is a developer switching from apartments to condominiums or vice versa depending on market economics.

The remainder of this paper is a practical demonstration to close the gap in research between theoretical option pricing and application in real estate development. The concept of an output switching option for real estate development that can be utilized during the construction and lease-up period is under explored. This option can be viewed as a hedge against economic uncertainty. We will use a mixed-use project under development in Denver, Colorado to illustrate this concept.

CASE STUDY: A MIXED-USE PROJECT IN DENVER, COLORADO

History

An 11-story, mixed-used building with 25,000 sq ft of retail and 213 apartment units is under construction in the city of Denver. The construction site is located at 2100 S. University Blvd, the corner of S. University Boulevard and E. Evans Avenue. Directly across the street is the University of Denver. Four blocks away to the north is a light rail station. The site is located near two major thoroughfares with major bus lines. The site is also the mid-point between Downtown Denver and the Denver Tech Center. (See Exhibit A). The concept is to attract tenants who want access to transportation, including light rail, as an alternative to living in Downtown Denver.



Site Location
Source: Google Earth
Exhibit A

The site area is approximately 1.2 acres with a standard rectangular shape assembled by seven (7) lots. (See Exhibit B) The site was zoned R-3, which is a high density residential zoning that does not permit retail. The development company, Urban West Group, applied to rezone the site from R-3 to RMU-30, which the city council of Denver approved in 2008. RMU-30 is a residential mixed-use district that allows higher density multiple unit dwellings of a density appropriate to the center-city and other activity centers such as light rail transit stations and supports commercial development. This type of zoning allows for retail, apartment, restaurants and hotels without land minimums.[47] The construction started in early 2011 and is expected to finish in 2014. The total

[47] Of note is that no zoning change is required to switch from apartment to minimum service hotel use.

development cost is estimated at US$85 million, including the land.[48]

Site View: Prior to Demolition
Source: Google Earth
Exhibit B

The mixed-use building is 11 stories and 120 feet high. (See Exhibit C) The net leasable area is approximately 216,047 sq ft. The building incorporates "Green" as it has energy efficient exterior window glass, programmable thermostats, dual-flush low-flow toilets, daylight dimming system and direct metering of heat and hot water, and Energy Star appliances.

Building Rendering
Source: Urban West Group
Exhibit C

[48] Data from developer Urban West Group. The land was acquired at a cost of US$3 million including the cost of removing existing buildings. The value of the previous going concern businesses is estimated to be US$3.8 million.

The first floor is designated for retail use. The retail plans consists of restaurant, specialty, and grocer space. It has 22 feet maximum height ceilings and separate entrances to each retail space. Floors 2 through 4 are parking dedicated to those renting apartments. Also included are 300 parking spaces exclusively for residents. The remaining floors (5-11) presently consist of 213 apartment units with washer and dryer, granite countertops and high-end cabinetry for each unit. The gross building area is 460,855 sq ft including the structured parking. The retail area is approximately 25,000 sq ft with 103 below-grade parking spaces exclusively for retail users. These parking spaces will be metered for day and night use.

Current Issues And Switching Option Proposal

Under RMU-30, the property is mixed-use and currently incorporates a mix of retail and apartment units. This apartment concept is new for the area as it targets upscale students and young professionals who want to commute from a light rail station. The light rail station is a 15-minute walk, making the location marginal in terms of "Transit Oriented Development". The property concept of young professionals selecting the location as an alternative to downtown living and amenities is unproven. The developer's projected rent for the apartments is set at US$1.97 psqft, exceeding current market rents for the area estimated at US$1.68 psqft based on data from Costar.[49]

SHOPS & APARTMENTS AT OBSERVATORY PARK UNIT MIX

	Quantity	Avg SF	% of units	Avg. rent/unit	Avg rent/SF
Studio	36	641	15.4%	$ 1,262.77	
1BR/1BA	91	787	38.9%	$ 1,550.39	
1BR/1BA+	40	956	17.1%	$ 1,883.32	
2BR	63	1255	26.9%	$ 2,472.35	
2BR+	4	1356	1.7%	$ 2,671.32	
Total/Avg	234	923	100.0%	$ 1,818.31	$ 1.97

Projected Rent for the Subject Property
Source: Urban West Group
Exhibit D

Within the local apartment market, there is a fierce (price) competition among apartment managers in this area. Eight pre-existing apartment complexes are located within a 1-mile radius of the subject site. Several of them went bankrupt with ensuing sales during the past year. This calls into question the absorption capacity for this area, which may be insufficient to support the projected occupancy of the new project. There is therefore considerable market risk that the developer will either not achieve projected occupancy levels (at current rental prices) or will need to significantly reduce rents based on current market fundamentals of competition, supply and an untested concept of target renters. In either case, revenues would be less than projected by the developer.

The real option proposal is to hedge against potential market risks by being able to switch the property mix from seven floors of apartments to three floors of apartments and four floors of limited service hotel units. This is proposed to create optimal flexibility and to hedge against an ill-

[49] Data from Costar comps, www.costar.com

conceived project concept or unexpected market conditions.

Cost to Switch
The top four floors of apartment units require the flexibility to switch (be converted) to a limited-service hotel. There are 102 one-bedroom units and 28 two-bedroom units on these floors. The estimated cost for switching a one-bedroom apartment unit to a one-bedroom hotel unit is about US$8,000 per unit.[50] The estimated cost for switching a two-bedroom unit to a two-bedroom hotel unit is approximately US$9,000 per unit.

The first option concept illustrated for switching is “switch as is” which means switch (convert) a two-bedroom apartment to a two-bedroom hotel unit, and one-bedroom apartment to one-bedroom hotel unit. The total estimated cost for converting the apartment units into hotel units is estimated to be US$1,068,000.

A second option for switching illustrated is “switch to one-bedroom hotel units” which means converting every two-bedroom apartment unit into two one-bedroom units. The extra cost for switching a two-bedroom apartment unit to two one-bedroom hotel units is approximately US$18,000. Therefore, the total cost for converting apartment to hotel units using this option is estimated to be US$1,320,000. In this case, there will be 158 one-bedroom units for the hotel.

Income from Four Floors After Switch
For the projected income of the hotel, the ADR (Average Daily Rate) is estimated to be US$120 per day for a one-bedroom unit and US$180 per day for a two-bedroom unit.[51] Also according to the data from “Host 2011”, the estimated occupancy rate is 68% for the projected hotel and the operating expense is assumed to be 52% of the effective rental income (Effective Rental Income = Gross Rental Income – Vacancy Loss).

For the option “switch as is”, there are 28 two-bedroom units and 102 one-bedroom units. The base rental income is about US$6,092,797 pa. The net operating income is about US$2,358,893 pa.

For the option “switch to 1 bedroom hotel units”, there are 158 one-bedroom units for the hotel. The base rental income is estimated at US$6,292,945 pa. The net operating income is estimated at US$2,588,230 pa.

Income from Four Floors Before Switch
According to the prospectus given by Urban West Group, the rent for a two-bedroom unit is US$2,472 per month and the rent for a one-bedroom unit is US$1,550 per month. Their projected occupancy is 85% and their operation expense is estimated to be 20% of the effective rental income.[52] After calculating, the net operating income for the four floors of apartments is US$1,854,899 pa.

Static NPV model
We use the following assumptions.

Assumptions:

1. An 11% discount rate for the building after switch and a 10% discount rate for the building before switch[53]

[50] Based on a local General Contractor’s estimate
[51] Based on a review of Host data and local hotel market room rates
[52] Based on a review of data provided by Host data and local hotel market room rates
[53] Based on a review of data provided Host data and Hospitality Investment Survey

2. Rent growth is 3% pa based on historic local rates
3. Total cost for building before switch is US$85,086,102. (Given by Urban West Group)
4. Total cost for building after switch = Total cost before switch + Cost to switch = US$85,086,102 + US$1,068,000 = US$87,938,102[54]
5. Net Operating Income for building before switch is US$5,889,025. (Given by Urban West Group)
6. Net Operating Income for building after "switch as is" = Net Operating Income before switch – Income from 4 floors before switch + Income from 4 floors after switch = US$5,889,025 - US$1,854,899 + US$2,058,670 = US$6,092,797
7. Net Operating Income for building after "switch to one bedroom hotel units" = Net Operating Income before switch – Income from 4 floors before switch + Income from 4 floors after switch = US$5,889,025 - US$1,854,899 + US$2,588,230= US$6,292,945

NPV for building before switch:

$$\text{NPV} = \text{PV*} - \text{Initial Cost} = \sum_{n=1}^{50} \frac{\$5,889,025}{(1+10\%)^n} - \$85,086,102$$

= **US$19,827,239**

*Present value of cash flows

NPV for building after "switch as is":

$$\text{NPV} = \text{PV} - \text{Initial Cost} = \sum_{n=1}^{50} \frac{\$6,092,797}{(1+11\%)^n} - \$86,154,102$$

= **US$11,062,001**

NPV for building after "switch to one bedroom hotel units":

$$\text{NPV} = \text{PV} - \text{Initial Cost} = \sum_{n=1}^{500} \frac{\$6,292,945}{(1+11\%)^n} - \$87,938,102$$

= **US$12,471,544**

Land cost prior to development was US$3 million, which included the cost of removing existing buildings.

Summary

As the result shows, if the building can achieve the projected occupancy rate (85%), it is more profitable to keep the current plan, in other words, not to switch.

Sensitivity Analysis

As we discussed before, the apartment rent charged by the owner (US$1.97 psqft), is much higher than the average submarket level. Therefore, it may be unrealistic for the owner to achieve an 85% occupancy rate. In order to determine the threshold of the occupancy rate that makes the option "switch to hotel" become a better choice than keeping the current plan, we run a sensitivity analysis in Excel. After analysis we find that if the expected occupancy drops below 82%, then it is better to "switch to one-bedroom hotel units" and if the expected occupancy for the apartments is below 74%, then it is better to "switch as is".

Dynamic DCF model for NPV comparison

In order to analyze the NPV for the building before a switch, a Dynamic Discounted Cash Flow (DDCF) model is also used for calculating the NPV. The DDCF model requires the consideration of

[54] The costs include the value of land.

all possibilities in the future. Instead of analyzing the cash flows along a predetermined scenario, it can assess risk as the project progresses. As described earlier, a DDCF utilizes a decision tree and dynamic programming methods. All the data used in DDCF comes from similar project outputs. In this model, different discount rates are applied to discount every year's cash flow back. Due to the unpredictability of the future and increasing risk of lease up, the risk to project occupancy is higher in the future. We estimate the discount rate will increase by 0.5% for every year.

New NPV for building before switch:

$$\text{NPV} = \frac{CF_1}{{(1+r_1)}^1} + \frac{CF_2}{{(1+r_2)}^2} + \ldots\ldots + \frac{CF_{50}}{{(1+r_{50})}^{50}} - CF_0$$

$$= \frac{\$5{,}889{,}025}{(1+10\%)^1} + \frac{\$5{,}889{,}025}{(1+10.5\%)^2} + \ldots\ldots + \frac{\$5{,}889{,}025}{(1+34\%)^{50}} - \$\ 85{,}086{,}182$$

= **- US$4,099,029**

Summary

By using the DDCF model to address the issue of optimistic rent, we obtain a more objective NPV of the building before switch. Using this NPV (-US$4,099,029) compared with the NPV of the building after the switch to one bedroom hotel units calculated prior (US$12,471,544), we can conclude that it is profitable to switch the top four floor apartments to a hotel.

Real Option Valuation Model

The Black-Scholes model assumes that options have a fixed maturity date, can only be exercised at the maturity date, and that the underlying investment has no cash payouts.

For our example, we are introducing an infinite life option-pricing model to value the option. The formula, developed by McDonald and Siegel (1986), is based on assumptions similar to those of the Black-Scholes formula, except for the fact that it assumes cash payouts for the underlying investment and the option can be exercised at any time.

The formula of the Infinite Option Pricing Model is as follows:

$$\text{Real Option Value (ROV)} = (V^* - I) * \left(\frac{V}{V^*}\right)^{\beta}$$

where:

$$V^* = \frac{\beta}{(\beta - 1)} * I$$

$$\beta = \frac{1}{2} - \frac{r_f - \delta}{\sigma^2} + \sqrt{\left(\frac{r_f - \delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r_f}{\sigma^2}}$$

Terms are defined as follows:

- V^* is the minimum value of the underlying investment that "triggers" exercising of the real option
- I is the initial cost of making the investment
- V is the current value of the underlying investment
- r_f is the risk-free rate of interest

δ is the cash flow yield (discount rate)
σ is the standard deviation of the rate of return of the underlying investment[55]

Value for the option "switch as is":

I = cost for switching +Total Cost = US$87,938,102
V = stabilized first year's Net Operating Income/ Market Cap Rate[56]
= US$6,092,797 / 7.5% = US$81,237,293
r_f = 10 years treasury rate = 1.86%
δ = chosen discount rate = 11%[57]
σ = standard deviation of the projected IRR = 20%

$$\beta = \frac{1}{2} - \frac{r_f-\delta}{\sigma^2} + \sqrt{\left(\frac{r_f-\delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r_f}{\sigma^2}} = \mathbf{5.74}$$
$$V^* = \frac{\beta}{(\beta-1)} * I = \mathbf{US\$106,490,444}$$
$$\text{Real Option Value (ROV)} = (V^* - I) * \left(\frac{V}{V^*}\right)^{\beta} = \mathbf{US\$3,923,123}$$

Value for the option "switch to one-bedroom unit":

I = cost for switching +Total Cost = US$88,654,102
V = stabilized first year's Net Operating Income / Market Cap Rate[58]
= US$6,292,945 / 7.5% = US$83,905,933
r_f = 10 years treasury rate = 1.86%
δ = chosen discount rate = 11.5%
σ = standard deviation of the projected IRR = 20%

$$\beta = \frac{1}{2} - \frac{r_f-\delta}{\sigma^2} + \sqrt{\left(\frac{r_f-\delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r_f}{\sigma^2}} = \mathbf{5.98}$$
$$V^* = \frac{\beta}{(\beta-1)} * I = \mathbf{US\$106,456,131}$$
$$\text{Real Option Value (ROV)} = (V^* - I) * \left(\frac{V}{V^*}\right)^{\beta} = \mathbf{US\$4,288,141}$$

Analysis
Based on the above stated assumptions, including an 85% occupancy rate, the calculated results show that exercising either option today to switch from apartments to hotel rooms would be a money-losing proposition. Since for both options, their current value (V) is smaller than their Cost (I). However, the owner has the right to build it in the future that provides possibilities for the owner to maximize his profit at a certain point in time.

As shown in the formula of the infinite option-pricing model, the V^* stands for the value that triggers the owner to exercise his option, in other words, how high the value must be before it makes sense to commence conversion.

The calculation results indicate that for the option "switch as is", we should not begin conversion until the projected value of the property is higher than US$106,490,444. Same for the option

[55] We used the Quartile range of returns from comparable sales shown in Korpacz (PWC)
[56] Data from Hospitality Investment Survey
[57] We used the yield (discount) returns from comparable sales shown in Korpacz (PWC)
[58] Data from Hospitality Investment Survey

“switch to one-bedroom units”, when the projected property value reaches US$106,456,131, the option to switch should be exercised. Thus the result is a “waiting to switch” to the hotel units.

Lastly, for the value of the option, the calculated value shows how much the option is worth today. Comparing the two options, the second option “switch to one-bedroom unit” has a higher value than the option “switch as is” and shorter time of waiting (V^* is lower for option 2). It shows that, without the constraint of the budget, the second option is the optimal choice for the owner.

These positive results for the value of the real option also show that if a developer needs to spend additional dollars upfront for construction to provide the possibility of a potential “switch” later it is worth doing. For instance, the expense of specialized elevators for separating hotel occupant's access and apartment dwellers that costs US$500,000 can be justified because the value of the option to switch is much greater.

The value of the option to switch is shown to be equivalent to land value for this project. (Approximately US$3 million dollars or US$6.8 million if including going concern businesses). Since the land was acquired at market prices one can say that the value to switch was ignored by the developer and not priced into the market.

CONCLUSION

We have shown that the use of real options for real estate development can enhance risk management by considering the uncertain economic environment and evaluating alternative outputs. The use of a switching option to analyze apartments in comparison to hotel utilization illustrates the alternatives to make the project become more profitable by means of product output selection and option exercising timing selection. The use of NPV comparisons and an Infinite Option Pricing Model provides us with an objective analysis to mitigate the risk in the process of real estate development.

The ability to recognize the embedded real options in mixed-use development property can provide investors with the opportunity to consider various designs before launch of investments and scenarios of actual investments. With utilization of these options models, investors and managers can maximize development profits based on a changing economic environment.

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