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Valuation of raw land in Hong Kong- A sequential compound option approach

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Reconciliation Statement

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Abstract: Various studies have tested the applicability of the well developed Real Option Pricing Model (ROPM) to the valuation of raw land and the related real options. Due to the unique characteristics of real estate, however, ROPM application has met with limited success. Recognizing the difference in land tenure between Hong Kong and other westernized countries, it is argued that the right to develop a piece of raw land in Hong Kong is in the nature of a sequential compound option and the value of raw land is the related option premium. We have calculated the value of the sequential compound options for four low rise residential properties and the outcomes are satisfactory, i.e. the estimated values of these four sites are closer to the actual transacted prices than the values estimated by traditional valuation methods. The land prices estimated by the model are between 11.44% lower and 0.86% higher than the actual prices paid. It is recommended that further research be undertaken in other market sectors such as high rise residential, commercial, and industrial for further testing of the validity of the model.

Key words: raw land, land tenure, valuation, sequential compound option

(180 words)

Introduction

Private vacant lands are typically held under freehold in most westernized countries. However, for various reasons, lands in some mature economies, such as Hong Kong and Singapore and in some emergent economy, such as mainland China, which are ripe for development, are leased out (normally under a long lease) and the ultimate ownership is retained by the state (central/ local government or statutory body). In other words, vacant lands in these economies are held under leasehold. This difference in tenure makes a big difference in the appraisal of vacant land. The Real Option Pricing Model (ROPM) has been used for the appraisal of vacant land held under freehold since the mid-eighties. However, applications of the ROPM to the appraisal of leasehold vacant landare next to none and research is needed to understand why this is the case and whether or not ROPM might be appropriate. This study is intended to answer these questions.

Land Administration System in Hong Kong

All lands in Hong Kong are held under lease except for the land on which St. John's Cathedral stands. The leasehold tenure in Hong Kong allows perpetual title of land to be held by the government as the owner of all lands. As land is scarce in Hong Kong, the Hong Kong Government, as the perpetual owner, imposes a number of positive and restrictive covenants (obligations) under the lease on the lessee, one of which is the Building Covenant (BC) clause. This ensures that the land is optimally developed within a certain period of time from the date of granting the lease and the leesee (developer) basically obtains a right to build and has to complete the development within a prescribed period; thereafter the developer can dispose of the finished unit to homeowners etc. In the event of non-performance, Government has the right to re-enter upon the land and re-dispose of the land to somebody else. This right to build corresponds to an "option to build", in the phraseology of finance.[1] In this case, the developer, after acquiring the land from government, has the option to build (produce) finished units at an exercise price (building cost of the finished units) on or before the BC expiry date. This analogy looks trivial but it does point the way towards an alternative way of appraising the subject vacant land. The following table shows the

[1] For the reader who may not familiar with option phraselogy, here is a brief description of option. There are two kinds of options, call and put option. A call (put) option gives its owner the right to buy (sell) stock (or other underlying asset) at a specified exercise price on or before a prescribed exercise date.

comparison of the relevant variables involved in the financial option model and the parallel build option model.

Financial Options	**Option to Build**
● Current stock price	● Present Value of the Completed Development
● Exercise price	● Construction cost plus building covenant extension fine
● Option premium (price)	● Land Premium (price)

Table 1 Comparison between the relevant variables involved in the Financial Option model and Option to build model

However, the BC period can be exteneded if good reasons are given. It can be extended on a yearly basis, the maximum extension period being 6 years on top of the original BC period. The extension of the Building Covenant period is subject to the payment of a premium (fine) in accordance with the prescribed rates as set out in Appendix I. Each yearly BC extension gives the developer an option to defer and build within the now extended time period, subject of course, to the payment of a BC extension fine. Thus the full option group consists of a total of seven options (one option to build and six options to defer and build) and their sum should reflect the market value of the subject vacant land.

From the angle of a developer, real estate development is a risky business. A developer may have to face both internal difficulties such as unpredictable site geology (hence unpredictable cost element) and external adverse conditions such as an economic downturn. The existing BC extension system does provide room for the developer to manourver, to catch the right time to sell the finished units for example. This provides incentive to developers to aggressively bid for vacant land when put up for sale by government.

Appraisal Method

The traditional methods of valuation, the Direct Comparison Method and the Residual Method, are generally adopted by the appraisal community in Hong Kong in the process of valueing vacant government land ripe for development. Occassionally, Discounted Cash Flow (DCF) technique may be adopted when complicated projects are involved. However, as pointed out by Leung and Hui (2002), even the DCF approach is inadequate to cope with the dynamics surrounding real estate development, and fails to capture the operation flexibilities that give the developer an option to revise his decision in response to unexpected market changes.

A consistent downward bias in appraised values has been observed for land vacant for development purposes in Hong Kong. This observation has prompted the valuation research community to look for a plausible explanation for the phenomenon. Yiu *et al.* (2006) point out that an eight percent systemic appraisal downward bias was found in appraisers' estimates against the final bid prices. They hypothesise that omission of the options value approach is one of the reasons for the under-estimate. Man & Ng (2007) provide further support for this view by observing that the estimated values of the auction sites made by public and private appraisers consistently differ from actual transacted price by 56% and 15% respectively. They suggest that the existence of the variance is because of the limitations of conventional valuation methods.

Recognising that the acquisition of a piece of vacant leasehold land in Hong Kong is equivalent to the purchase of an option to build plus six other options to defer and build, an opportunity is naturally provided to estimate the value of vacant land as the sum of the (prsent value of) seven options. This approach has never been tested empirically. If successful, a new valuation (appraisal) method will be added to the toolkit of valuers (appraisers).

In mathematical terms:

$$\text{Land Price} = O_B + \sum_{i=1}^{6} O_{tDB} \qquad \text{………………(1)}$$

where O_B represents the value of the option to build; and

$\sum_{i=1}^{6} O_{tDB}$ represents the sum of the six options to defer and build

The beauty of this approach is that vacant land sold by government can then be calculated by a real options pricing model. This, as far as we are aware of, is new to the field. This will exert a significant impact on the valuation of vacant land held under leasehold throughout the world. In the Hong Kong context, both Government and private developers could benefit from the more accurate valuation method in determining land value.

This paper consists of five sections. Section two covers the literature review whilst section three describes the methodology of valuing the option to build and the six options to defer and build. Section Four contains data analysis and interpretation. Section five is the conclusion of this study and policy implications are discussed.

Section II Literature Review

Scientific investigation of the application of the Real Option Pricing Model (ROPM) to real estate, more specifically, the appraisal of vacant land of freehold tenure was first carried out by Shilling *et al.* (1985). They first suggested that the real estate industry displays an option pricing behaviour: "A landowner agrees to sell property at a stipulated exercise price to a potential buyer (developer) within a specified length of time." But their study lacks transaction data in support. Shortly after, Titman (1985) explained when the optimal time for development was and why a piece of land was more valuable by deferring its development time. Williams (1991) posits that developing real estate is much like exercising an option and since freehold property is concerned, the options to develop in respect of time and density never expire. He then developed an option model for valuing these options; the value of these options depends partly on the stochastic evolution through time of the development cost and project value.

All the above theoretical developments are meant to identify and quantify, if any, the option embedded in **freehold** real estate. Grenadier (1995) evaluated the options embedded in commercial lease agreements. Buetor and Albert (1998) studied the pricing of embedded options in real estate lease contracts. It provides evidence that the real option pricing model conforms to financial intuition which provides support for the accuracy of the estimates. The findings of Bulan *et al.* (2009) lend support to the existence of a call option in the ability to delay irreversible investment. Novy-Marx (2005) showed that the value of an option to develop in the case of real estate would not be diminished by competition since the location of a development can never be perfectly substituted by another.

Trigeorgis (1996) suggested that there are altogether six different types of real options in real estate held under freehold in the development process. They are options to defer, expand, switch, contract, abandon and compound. All of them can be applied individually or in combination. The option to defer is particularly relevant to this study. The premium for a real estate development option is not explicitly revealed in any legally binding option contract, but is embedded in the land value (Sing and Patel 2001).

The empirical research of Quigg (1993) further examined the predictability of prices of freehold land by using the Real Option-Pricing Model (ROPM) with a large sample of market prices. It was the first study, based on the model of William (1991), which gave empirical support to the option-based valuation model to incorporate the option to defer for land development. It estimated the option premium for waiting to develop land in the Seattle area was approximately 6 percent on average, and ranged from 1 to 30 percent of the land price. The empirical testing of the 2700 land transaction data provided evidence that the option-pricing model has a certain value. There is a value for the option to wait which should not be neglected in valuation models.

Sing and Patel (2001a) estimated the premium for the option of waiting to develop for office sector at 28.78 percent, the industrial sector at 25.75 percent and for retail sector is 16.06 percent based on 2286 property transactions in the UK. Holland e*t al.* (2000), Bulan *et al.* (2009) have also examined the premium of land price over intrinsic value using a large sample of real estate data, whether irreversibility is an important factor for real estate investment, whether uncertainty delays construction, and whether competition among developers decreases the option value of waiting.

All the above studies concern **freehold** properties. This is understandable as most land in Western countries is held under freehold. Studies on leasehold land are very rare, though. In Hong Kong, the most recent review was carried out by Chiang *et al*. (2006), which concluded that there is an option value embedded in land auction prices with an average of 7.75 percent ranging from 2.33 percent to 69.1 percent under different market conditions. Their study however contains two drawbacks. The first is that the leasehold nature of lands has not been taken into consideration, and, secondly, the construction costs of the vacant lands were only based on the scale of the development and did not look at each case individually.

Section III Methodology

The core methodology is the Real Option Pricing Model (ROPM), more specifically, the Sequential Compound Option (SCO) pricing model, in discrete time formalism. The dynamic paradigm of real option incorporates decisions for whether to defer, expand, abandon or otherwise alter a capital investment. In the proposed study, the option to defer (OTD) aptly describes the situation of building covenant extensions and the number of OTD amounts to six and since they are sequential in nature, our chosen methodology is SCO pricing model.

The first step in the estimation process is to ascertain the value of the underlying asset, i.e.completed development. For this, use is made of the Hedonic Pricing Model (HPM) proposed by Rosen (1974. In Hong Kong, a completed development is normally the aggregate of a large number of finished units for a mix of users. Its value would be the sum of the values of the individual units. The individual units then become the components of the underlying asset.

In valuing individual units, and hence value of the completed development, it may be necessary to use multiple regression analysis. The value (price) of the individual unit is the regressor (dependant variable) and the relevant attributes such as area, aspect, age and conditions etc. are regressands (independent variables). The specification for the relevant Hedonic Pricing model normally takes the following form:

$$LnY = C + \beta_0 LnX_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \ldots + \beta_{(k-1)} LnX_{(k-1)} + \beta_k LnX_k + u$$

where Y is the predicted value; C is a constant , X_i is the quantity of the ith attribute, u is an error term to capture the unexplained variation in predicated vale and β is a coefficient.

When insufficient comparable sales data are available, it may be necessary to revert to the traditional Direct Comparison Method to ascertain the value of individual units and in turn, the value of the completed development.[2]

Monte Carlo Simulation is needed to model the volatility of the logarithmic return of the underlying asset. The evolution of the value of the underlying asset is a stochastic

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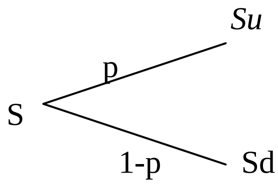
[2] Direct Comparison Method is one of the most common methods adopted by the valuation (appraisal) communities around the world. It is most easily understood as its underlying assumption is simply that as a commodity, real estate can be replaced or substituted and hence its value can be reasonably estimated from the sales of comparable properties.

process and we assume it follows a multiplicative binomial process over discrete periods.

In the study, rather than using the well known Black Scholes formula to estimate the relevant call options, the (discrete) binomial lattice method was employed instead, closely following the methodology proposed by Cox, Ross and Rubinstein (1979). A risk-neutral world is assumed where no arbitrage opportunities exist. The price movements of the underlying asset in time Δt under the binomial model is assumed as follows:



where p is the risk neutral probability and Su and Sd are the two possible prices of asset S at the end of time Δt. The three conditions imposed on p, u and din the proposed methodology of Cox, Ross and Rubinstein imply that:

$$p = \frac{a-d}{u-d} \qquad u = e^{\sigma\sqrt{\Delta t}} \qquad d = e^{-\sigma\sqrt{\Delta t}}$$

Where $a = e^{r\Delta t}$ and σ is the volatility of the underlying asset price, defined as the standard deviation of return on the asset in the time Δt.

A sequential compound option exists when a project has multiple phases, the later phases depending on the success of previous phases. The general procedure for calculating the sequential compound option includes ascertainment of the volatility of the logarithmic returns on the projected expected present value of future cash flows, generally with the help of Monte Carlo simulation. The static valuation of future profitability of the project using a discounted cash flow model is estimated using an appropriate market risk-adjusted discount rate.

For demonstration purposes, the calculation of a hypothetical sequential compound option consisting of two phases is now described. An asset value lattice for the underlying (asset) is first drawn up using the typical up and down factors of the binomial lattice method. Next the equity lattice of the second option (second phase) is calculated, with the exercise price of the second option (X_2) taken into consideration. The analysis first requires the calculation of the second option and then the first option because the value of a compound option is based on both options. Whether at the terminal, or an intermediate node, of the equity lattice, the general principle of calculating option value by finding the maximum between zero and the value obtained by exercising of the option is observed, always assuming a risk neutral world. A backward induction technique is used to back-calculate the entries of the equity lattice of the second option to the starting point to obtain the value.

As to the valuation of the first option, the equity lattice of the first option is drawn up by assuming that the first option is exercised at its exercise price (X_1) at the junction node with the second option. This will help us to calculate the value of the compound option. Lastly, we can then combine the option valuation lattices of the two options to get the value of the sequential compound option.

A numerical example is given as follows. The project has two phases, where the first phase costs \$500 million (X_1) and has one-year expiration. The second phase expiration is at three years and costs \$700 million (X_2). Using Monte Carlo simulation, the implied volatility of the logarithmic returns on the projected expected present value of future cash flows is calculated to be 20 percent. The rate for a riskless asset for the next three years is found to be 7.7 percent. The static valuation of future profitability using a discounted cash flow model (that is, the present value of the future cash flows discounted at an appropriate market risk-adjusted discount rate) is found to be \$1,000 million. The underlying asset lattice is shown in Figure 1. Figures 2 and 3 show the equity lattices for the second option and the first option. The final option (sequential compound option) value is also calculated in Fig. 3. Figure 4 shows the combined option valuation lattice of the two options.

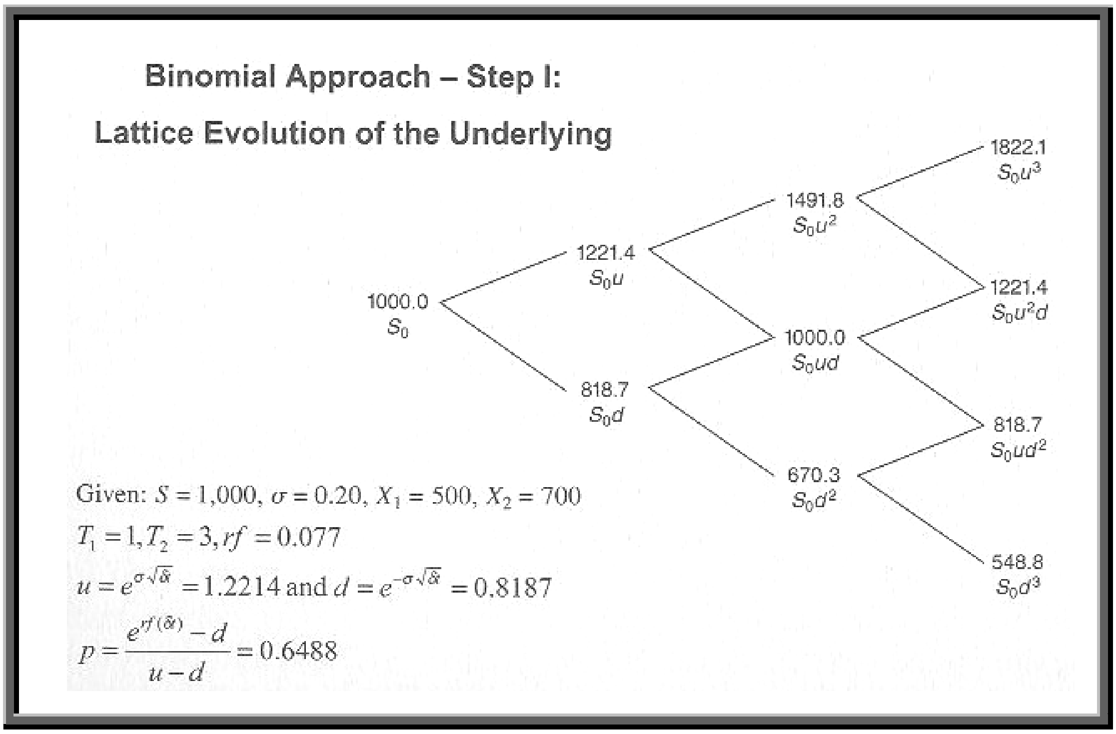


Figure 1 Sequential Compound Options (Underlying Lattice)

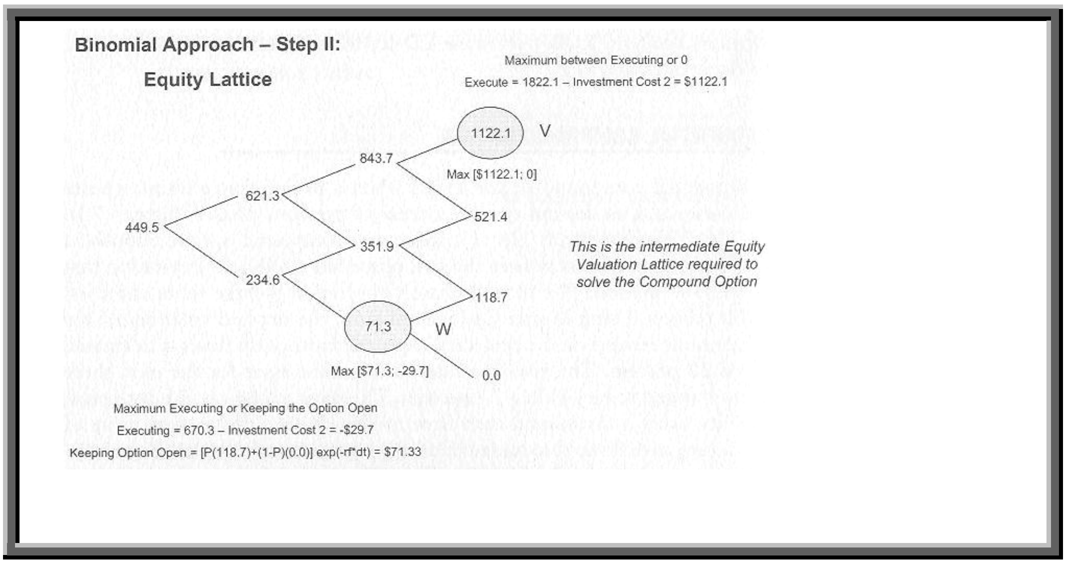


Figure 2 Sequential Compound Options (Equity Lattice)

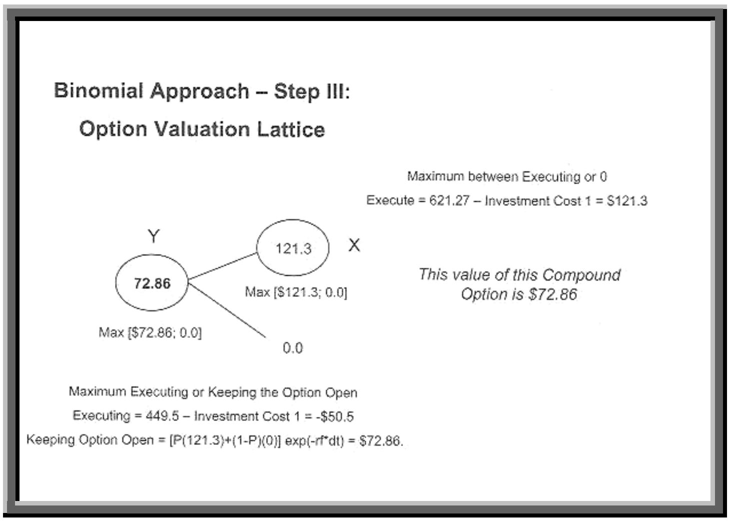


Figure 3 Sequential Compound Options (Valuation Lattice)

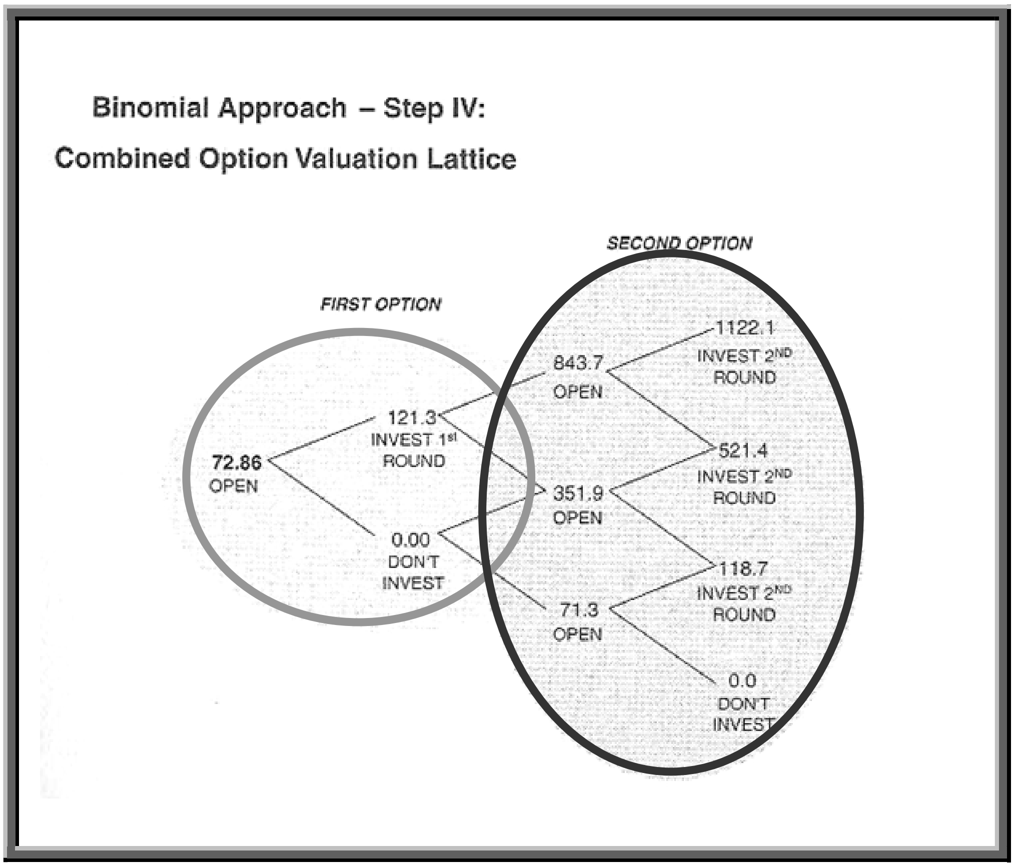


Figure 4 Sequential Compound Options (Combined Lattice)

Altogether seven options needed to be calculated. They are defined as Phase 1 to Phase 7. Phase 1 is the implementation of the project within the original building covenant period. Phase 2 is the implementation of the project with one year building covenant extension and so on. A developer has the sole discretion to decide if the next phase should be implemented or not. For example, if the project just moves into phase 3 (i.e. the project has already had two building covenant extensions) and the developer anticipates that it is still not the optimal time for the development, he can then choose to defer the completion of the development and moves into phase 4. Figure 5 below shows the sequential compound option decision process.

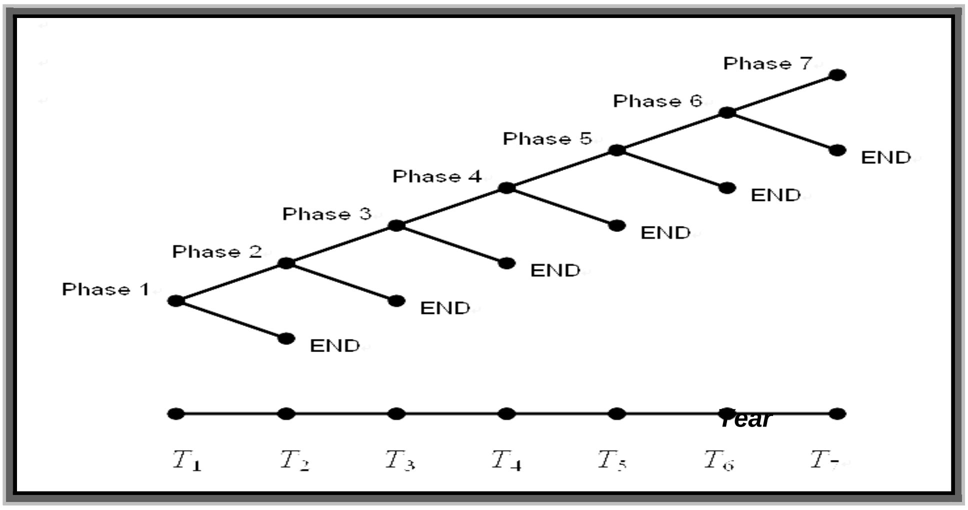


Figure 5 Sequential Compound Options decision

Section IV Date Analysis and Interpretation

In assessing whether the Real Option Pricing Model, or more specifically, the Sequential Compound Option (SCO) pricing model is applicable to the valuation of vacant land in Hong Kong, four low rise/ low density residential sites auctioned off by HKSAR government in the nineties have been chosen as our sample. The four chosen sites are in the different parts of the New Territories of Hong Kong.[3] The reason for chosing residential sites is that this sector is the most liquid in the property market and more transactions are available. Most, if not all, residential developmentsin Hong Kong are flatted developments. The four chosen sites are classified as luxurious housing, by Hong Kong standards, as the flats are all in excess of 100 m^2in area. A summary of basic information on the four sites is in Table 2.

	STTL 108	Lot 323 in DD213	TPTL 97	TMTL 355

[3] New Territories is the more 'rural' part of Hong Kong.

District	Kau To, Shatin	Sai Kung	Tai Po	Tuen Mun
Date of Auction	25/1/1995	30/3/1995	26/9/1995	15/1/1997
Land Premium (HKD)	$171,000,000	$30,000,000	$280,000,000	$258,000,000
BC period	3 years	3 years	4 years	3 years
Maximum years to expiry[4]	9 years	9 years	10 years	9 years
Type of Development	House Type	House Type	High Quality Finishes Apartments	High Quality Finishes Apartments
Maximum G.F.A. allowed	3,900 m^2 (41,980 sq.ft.)	540 m^2 (5,813 sq. ft.)	12,440 m^2 (133,903 sq.ft.)	6,604 m^2 (71,085 sq.ft.)
Area per flat	265m^2 – 355m^2	180 m^2	101m^2 – 117m^2	186m^2 – 205m^2
Class of Property	Class E	Class E	Class D	Class E
Number of comparable sales used in HPM	30	N/A	172	N/A

Table 2 Basic Information of the four sites

[4] Different parcel of lands may have to meet different development requirements. Their building covenants may also differ. The Particulars and Conditions of Sale for different parcel of lands of the three chosen sites are obtained from the Land Registry of the Hong Kong Government. By examining the said Particulars and Conditions of Sale, the relevant original Building Coveneant (BC) periods can then be identified. The maximum period of time to maturity is the original BC duration plus six years.

STTL 108

The first step in the calculation is to estimate the value of the underlying asset using a Hedonic Pricing Model (HPM). In the following, we will concentrate on the first site, i.e. STTL108. Thirty comparables[5] in the neighbourhood were collected with attributes similar to those of the subject development. The regression equation used was as follows:

$$LnPrice = C + \beta_0 LnArea + \beta_1 LnAge + \beta_2 TER + \beta_3 GDN + \beta_4 RF + \beta_5 FR + \beta_6 SWP + u$$

Descriptions of the variables, both dependant and independent, are shown in Appendix II. The value of the underlying asset (whole development), at the date of auction, equals the sum of all finished units and was estimated at around HKD$378 million.

The second step is to estimate the volatility of the underlying asset. The Crystal Ball fit-function was used in this exercise and the Student t distribution and Logistic distribution were chosen to represent the New Territories Class E averaged quarterly property price[6] and houses construction cost[7] respectively. The distributions are shown in Figure 6 and Figure 7. These two probability distributions are then incorporated into the Net Present Value of the underlying asset when running the Monte Carlo simulation. After 10,000 simulation runs, another distribution is generated, see Figure 8, and the forecast value of the standard deviation is shown in Figure 9. It happens to be a Logistic distribution with standard deviation of $52,735,991.43, which is 19.75% of the NPV. In other words, the volatility of the development is 19.75%.

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[5] Transaction records of the comparables are essential in estimating the value of the underlying assets. Data are mainly gathered from Economic Property Research Center (EPRC). A total of 30 transactions were collected for STTL 108 and 172 transaction records are collected for TPTL 97. For Lot 323 DD213 in Sai Kung and TMTL 355, we shall use direct comparative method to estimate the as there was a shortage of appropriate comparables.

[6] Averaged quarterly property prices of Class D residential and Chlass E residential between 1992 and 1997 were collected from the Rating and Valuation Department. The indexes of each quarter of the above year formulate part of the asset's volatility. There are 24 data collected in each data set since at least 15 data are required to run the fit-function of Crystal Ball.

[7] One more data is needed to complete the volatility estimation of the project – construction cost. Quarterly construction cost from 1992 – 1997 of the relevant type of housing, i.e. apartments with high finishes and house type development were collected from a reliable source. Again, there are 24 data in each data set were collected to meet the requirement of the fit-function of Crystal Ball of having at least 15 data to run.

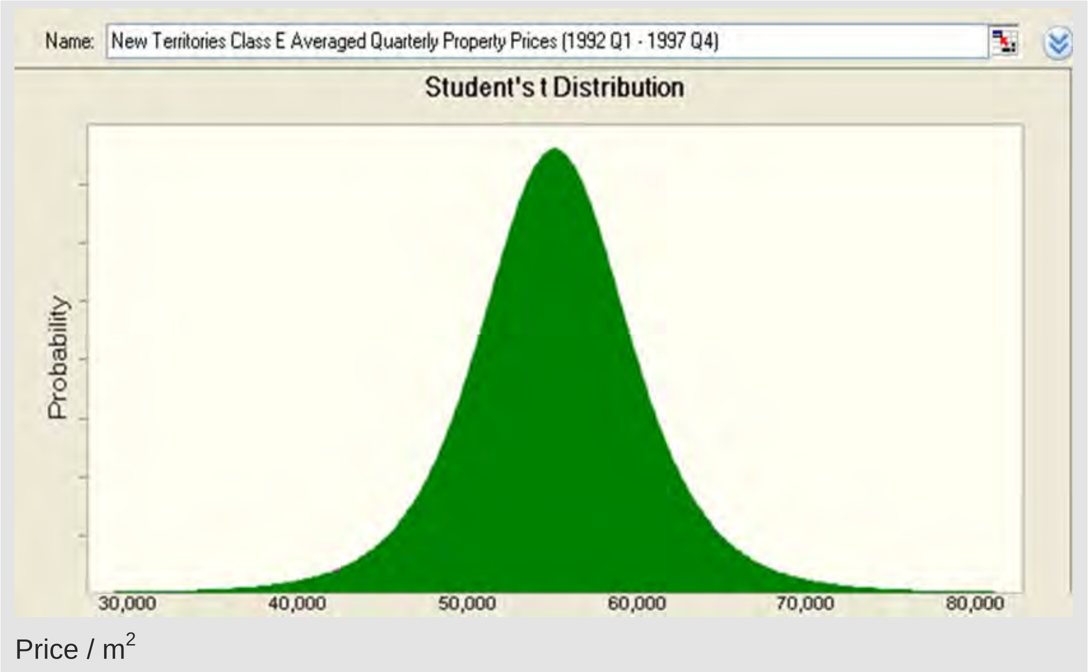

Figure 6 Probability distribution of Class E averaged quarterly property price in the New Territories from 1992 Q1 to 1997 Q4

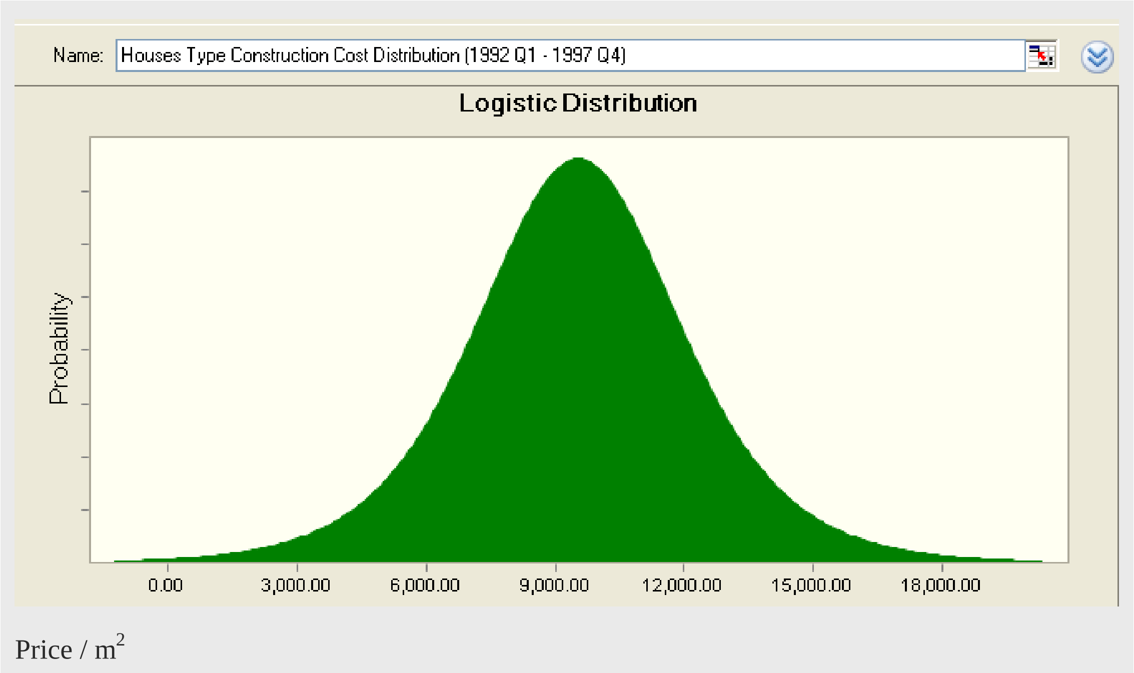

Figure 7 Probability distribution of the houses type construction cost from 1992 Q1 to 1997 Q4

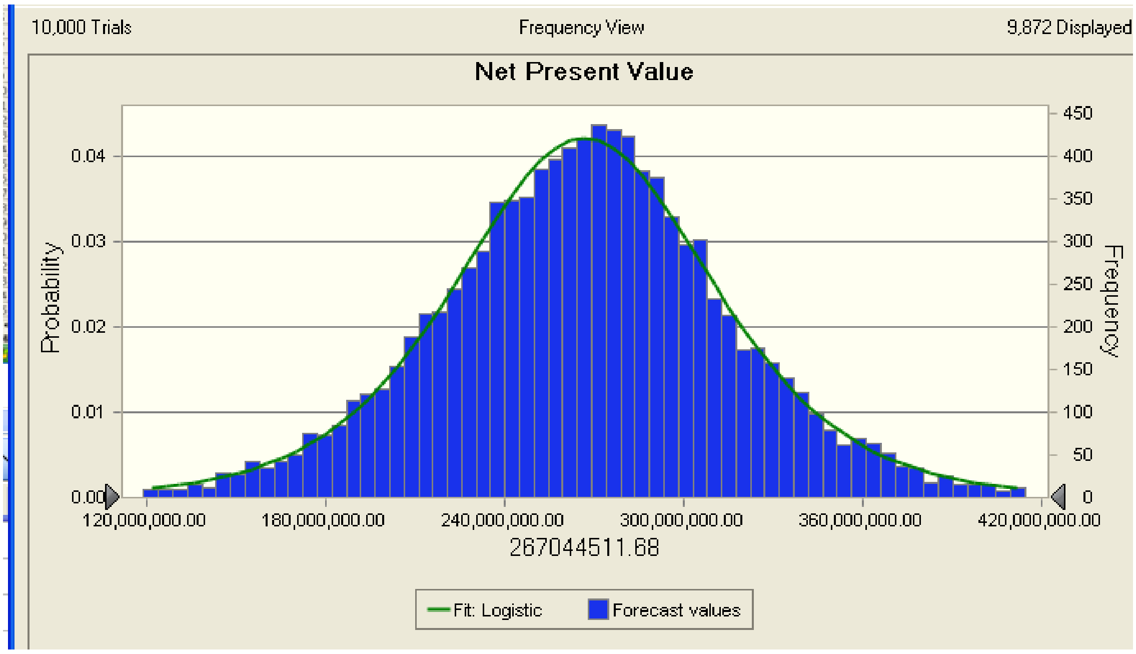

Figure 8 Probability distribution of NPV of the underlying asset – STTL 108

All the above variables, together with the discounted construction cost and the premium paid for BC extension are input to the Real Options Super Lattice Solver (SLS) to calculate the values of the individual Sequential Compound Option corresponding to the respective phases. The sum of the value of the option to build and the values of the six sequential options to defer and build is shown in Table 3 and gives the estimate of the STTL 108 land price.

10,000 Trials — Statistics View

Statistic	Forecast values
Trials	10,000
Mean	266,543,023.02
Median	267,249,486.65
Mode	---
Standard Deviation	52,735,991.43
Variance	2,781,084,792,520
Skewness	-0.0723
Kurtosis	5.57
Coeff. of Variability	0.1979
Minimum	-173,214,597.28
Maximum	614,443,258.76
Mean Std. Error	527,359.91

Figure 9 Statistical data for the underlying asset – STTL 108 after simulated for 10,000 trials

Phase[8]	Option Value
Phase 1	7,050,110.01
Phase 2	13,343,154.46
Phase 3	13,977,168.32
Phase 4	21,302,515.21
Phase 5	25,866,821.57
Phase 6	38,453,601.10
Phase 7	52,482,390.68
Total	**172,475,761.35**

Table 3 Value of the Option to Build and the six Options to Defer and Build for STTL 108

Table 4 below compares the values estimated by other valuers using traditional valuation methods and that estimated by ROPM.[9] It clearly indicates that the estimate produced by ROPM is comparable to, if not superior to, the traditional methods in this particular case.

Actual Premium	**Amount Estimated by Real Option Pricing Model**	**Amount Estimed By Apprasiers**	
$171,000,000	$172,475,761	$210,000,000	$230,000,000
Difference			
N/A	0.86% higher	22.8% higher	34.5% higher

Table 4 Comparison of values appraised for STTL108 under traditional methods and ROPM

8 Phase 1 = Option to Build; Phase 2 = Option to defer (1st time); Phase 3 = Option to defer (2nd time); Phase 4 = Option to defer (3rd time); Phase 5 = Option to defer (4th time); Phase 6 = Option to defer (5th time); Phase 7 = Option to defer (6th time).

9 Right before government auctions, some local private sector valuers typically announce their estimates of the vacant land to be auctioned and this information can be found in the press.

TPTL 97

Applying the methodology used for STTL 108 to TPTL 97, we have the following results:

Steps / Lot No.	TPTL 97
Step 1 – Option Values Calculation	
Value of the Underlying Asset at the Date of Auction	$517,590,024.13
Step 2 – Volatility Estimation	
Volatility	17.39%
Step 3 – Sequential Compound Options Calculation	
Phase	**Option Value**
Phase 1	11,926,173.84
Phase 2	22,661,089.27
Phase 3	23,490,650.46
Phase 4	26,493,374.06
Phase 5	42,786,878.72
Phase 6	57,526,204.31
Phase 7	93,816,274.21
Total	**278,700,644.87**
@ Risk-free Rate	5.76%

Table 5 Value of the Option to Build and the six Options to Defer and Build for TPTL97

The following table shows the estimated value of TPTL 97 using the ROPM and the traditional valuation methods used by other valuers. Again the ROPM forecast is superior.

Actual Premium	**Amount Estimated by Real Option Pricing Model**	**Amount Estimed By Apprasiers**	
$280,000,000	$278,700,645	$260,000,000	$300,000,000
Difference			
N/A	0.46% lower	7.14% lower	7.14% higher

Table 6 Comparison of values appraised for TPTL97 under traditional methods and ROPM

Lot 323 DD213 Sai Kung

There were some difficulties in the estimation exercise for Lot 323 DD213 in Sai Kung and TMTL 355. There were an insufficient number of comparable sales to allow a valid regression analysis. As an alternative, the Direct Comparison Method was relied upon. Although a large number of appropriate comparable sales were not available for the use of statistical methods for estimating purposes, a few good comparables did nevertheless exist, sufficient for determination of the value of the underlying asset. The results for the respective properties are as follows.

Steps / Lot No.	**Lot 323 DD213 Sai Kung**
Step 2 – Volatility Estimation	
Volatility	26.57%
Step 3 – Sequential Compound Options Calculation	
Phase	**Option Value**
Phase 1	644,523.04
Phase 2	1,268,359.73
Phase 3	1,433,228.15
Phase 4	3,223,067.93
Phase 5	4,445,574.86
Phase 6	6,810,812.67
Phase 7	11,947,490.76
Total	**29,773,057.15**
@ Risk-free Rate	6.07%

Table 7 Value of the Option to Build and the six Options to Defer and Build for Lot 323 DD213 Sai Kung

Table 8 shows the estimated value of Lot 323 DD213 in Sai Kung by the ROPM and those by the traditional valuation methods. Again the forecast made by ROPM is comparable to, if not superior to that of the traditional valuation method.

Actual Premium	Amount Estimated by Real Option Pricing Model	Amount Estimed By Apprasiers	
$30,000,000	$29,773,057	$17,000,000	$30,000,000
Difference			
N/A	0.76 % lower	43% lower	-

Table 8

Comparison of values appraised for Lot 323 DD213 Sai Kung under traditional methods and ROPM

TMTL 355

As for TMTL 355, we have the following results:

Steps / Lot No.	TMTL 355
Step 1 – Option Values Calculation	
Value of the Underlying Asset at the Date of Auction	$312,987,255
Step 2 – Volatility Estimation	
Volatility	22.74%
Step 3 – Sequential Compound Options Calculation	
Phase	**Option Value**
Phase 1	6,275,491.64
Phase 2	12,237,415.00
Phase 3	13,310,844.37
Phase 4	21,755,400.92
Phase 5	30,132,987.89
Phase 6	52,978,328.55
Phase 7	91,558,478.23
Total	**228,248,946.60**
@ Risk-free Rate	5.14%

Table 9

Value of the Option to Build and the six Options to Defer and Build for TMTL 355

Table 10 shows the estimated value of TMTL355 by the ROPM and by the traditional valuation method. Again the estimate produced by the ROPM is comparable to, if not superior to, that of traditional valuation method.

Actual Premium	**Amount Estimated by Real Option Pricing Model**	**Amount Estimed By Apprasiers**			
$258,000,000	$228,248,947	$163,000,000	$180,000,000	$213,000,000	$270,000,000
Difference					
N/A	11.54% lower	17.44% lower	30.23% lower	36.82 % lower	4.65% higher

Table 10 Comparison of values appraised for TMTL 355 under traditional methods and ROPM

The results above indicate that the predictive power of ROPM is superior to, or at least comparable to the traditional valuation methods. Hence ROPM should form part of the toolkit available to valuers when it comes to the appraisal of vacant land in Hong Kong, or more generally, when it comes to the appraisal of leasehold vacant land.

Section 5 Conclusions and related Implications

In this study, we made use of ROPM to value four (4) low rise, low density residential sites in rural parts of Hong Kong. A summary of the results is shown in Appendix III. Three of the cases studies were very satisfactory results, in that the differences between the actual land premium and the amount estimated by the Real Options Pricing model ranged between -0.76% and +0.86% only. The Tuen Mun case provided the greatest discrepancy of 11.44%. This might be due to the over-heated market conditions in the early 1997. All in all, based on these four cases, the land prices estimated by the ROPM can be said to give a comparable, if not a more accurate, result than do traditional valuation methods.

From this limited amount of empirical testing, the findings seem to indicate that the smaller the scale of the development, the higher the volatility and vice versa. Table 11 shows the relationship between the scale of the development and volatility. Among the three plots of lands auctioned in 1995, the site in Sai Kung is the smallest in terms of maximum permissible G.F.A., and a volatility of 28.36% was calculated. The volatility of the other three sites was much lower. It is argued that this may be due to the fact that a larger development has more leeway for its risk to be diversified or absorbed. For example, in the middle of the development, if it is found that market conditions are deterioating, the developer might reduce the pace of development in order to buy time. Smaller developments might not have the flexibility to dilute the effects of temporary setbacks in business and market conditions.

Case Study	**Year of Auction**	**Completion time under BC**	**Maximum G.F.A permissible (m^2)**	**Volatility**
STTL 108	1995	3 years	3,900	19.75%
Lot 323 in DD 213	1995	3 years	540	26.57%
TPTL 97	1995	4 years	12,440	17.39%
TMTL 355	1997	3 years	6,604	22.74%

Table 11 Summary of volatility of the four sites

The current Application List system adopted by the HKSAR government makes it imperative for Government valuers to estimate land values more accurately in order to safeguard Government revenue.[10] At the same time, potential purchasers (developers) of government land, in their own interests, are also desirous of estimating land value more accurately in order to avoid over-bidding. The valuation commuity, again in its own interests and to maintain its reputation and competitiveness should strive to sharpen its own core skills.

The ROPM has only been tested on a particular sector of the property market. To further test the validity of the ROPM and, hopefully, improve robustness of the model, additional testing in different sectors is essential. For example, ROPM must be tested on high rise/ high density residential properties, commercial properties and industrial properties.

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[10] Since the 4th quarter of 2002, the HKSAR government withholds regular vacant land auctions in order to ameriolate any possible adverse sentiment on market should no one buys the land put up for sale. Instead the application list system is adopted where the developers take the lead in the land sale process. If a developer is desirous of buying a certain piece of vacant government land in the so called ‘application list’, the developer has to propose a price for the land and make guarantee on buying the land at its proposed price during a subsequent auction. However, it does not guarantee that the developer who takes the initial action can get the land. The beauty of the new system is that every piece of land put up for auction will get a buyer at a minimum price known beforehand and government has a final say on the minimum price paid for each piece of land.

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APPENDIX I

Rates used for calculation
of BC Extension premia[11]

Period	Prescribed Rates
1st Year	2%
2nd Year	4%
3rd Year	8%
4th Year	14%
5th Year	22%
6th Year	32%

[11] Extracted from "Information Note (Issue No. 1/1985) for Authorised Persons, Chartered Surveyors and Solicitors issued by Land Administratio Office, Lands Department of the HKSAR Government

APPENDIX II

Dependent	LnPrice	Property Price
Structural	LnArea	Gross Floor Area
Structural	LnAge	Building Age
Structural	TER	Terrace (Dummy Variable) “0” = unit contains no Terrace “1” = unit contains Terrace
Structural	GDN	Garden (Dummy Variable) “0” = unit contains no Garden “1” = unit contains Garden
Structural	RF	Roof Floor (Dummy Variable) “0” = unit contains no Roof Floor “1” = unit contains Roof Floor
Structural	FR	Flat Roof (Dummy Variable) “0” = unit contains no Flat Roof “1” = unit contains Flat Roof
Neighborhood	SWP	Swimming Pool (Dummy Variable) “0” = unit contains no Swimming Pool “1” = unit contains Swimming Pool

APPENDIX III

Subject Lots	STTL 108	Lot 323 in DD 213	TPTL 97	TMTL 355
Land Premium on the date of auction	$171,000,000	$30,000,000	$280,000,000	$258,000,000
Averaged Land Premium estimated by appraiser before the date of auction	$212,000,000	$26,000,000	$287,000,000	$185,000,000
Averaged Land Premium estimated by estate agents before the date of auction	N/A	N/A	N/A	$270,000,000
Land Premium estimated by the Real Options Pricing Model on the date of auction	$172,475,761	$29,773,057	$278,700,644	$228,248,946
% difference between the actual land premium at the date of auction and the amount estimated by the Real Options Pricing Model	+ 0.86%	- 0.76%	- 0.46%	- 11.54%

Summary Table for the four sites