Canary Wharf Case Analysis

1. Situation Brief

After the successful initial public offering in April 1999, Mr Johnson, CFO of Canary Wharf, was worried about the large difference between the book value of its properties from the valuers' assessment and its market capitalisation. According to the assessment, the book value of the shareholders' funds is one billion pounds less than its market value. A major reason for this difference is that the valuers had taken into account the option contracts with Citibank, in which Canary Wharf might lose some value. In other words, Canary Wharf has negative real option value in a series of option contracts (puts) with Citibank. Mr Johnson wondered whether the valuers should also take into account the real options Canary Wharf holds on its properties held for development, which may lift the figures in the assessment. And he suggested to consider the specific volatility of the property values and the construction costs, because he believes real call options are more valuable the higher the expected volatility of underlying assets. With regard to the real call options, he also thought about hedging the development option elements.

2. Data Analysis on Real Option Value

1) Real Option Evaluation

With the queries above, the first thing we should be evaluating is the real options on properties held for development.

Since the three separate phases of urban development (properties held for investment, properties under construction and properties held for development) at Canary Wharf were assessed:, some estimates about the development options can be made from the listing particulars of the assessment.

The first model that can be used is Samuelson's Perpetual American Call option, which is a basic model for a perpetual opportunity to convert land into buildings. The properties of

Canary Wharf held for development are assumed to be proprietary, with no other competitors able to take away the rights to develop. Canary Wharf can exercise the options at any time to nearly infinity without expiration, assuming that this firm never goes bankrupt. These assumptions are not perfect but make sense to some extent for this case. To fit in with the Samuelson model, the asset price, which is net development value in this case, needs to be assumed to follow a geometric Brownian motion with yield δ_V and expected volatility σ_V constant over time, while building costs, which is construction costs K in this case, is fixed. Net development value V in 2003 can be obtained from Exhibit 2 after taking into account the probability of giving up the development due to fear of wars and spread of e-business, etc. Construction costs were estimated at between £ 198.96 to 209.32 per square foot. For illustration purpose, £200/square foot is taken in calculation and assumed constant in the Samuelson model. Annualised standard deviation of continuously compounded daily return of Canary Wharf equity price from March 1999 to January 2003 is taken as the proxy of expected volatility σ_V of net development value. The averaged UK Treasury Bill rate (5%) in 1999 was taken as the interest rate for this case. Yield of V at completion was also estimated at between 6.25% and 7.25%, with 6.5% taken in this example. With all the inputs for the Samuelson perpetual American call gathered, real option value per square foot of properties held for development is calculated as £163.68 in Exhibit 3A. Since the valuers estimated that development programmes at Canary Wharf covered 6.3 million square feet (excluding properties under construction), total real option value on properties held for development can be obtained as £1,031,209,812.37, which is over one billion pounds. This seems to be consistent with Mr Johnson's query.

Following Mr Johnson's query, if we consider the specific volatility of the property values and the construction costs, we come to the two-factor Perpetual American Exchange option model. The difference between the Samuelson one-factor Perpetual American Call and the two-factor Perpetual American Exchange is that the latter allows both net development values (V) and construction costs (K) to be stochastic and divisible. Besides, there is some correlation between these two factors and the correlation may vary according to market structure and time. Apart from the figures obtained in the last model, yield and volatility of construction costs and the correlation between V and K need to be obtained. A common estimate of the yield δ_k is average dividend ratio of Canary Wharf after going public. And the expected volatility σ_k can be estimated by annualised standard deviation of continuously compounded daily return of Tarmac equity price from March 1999 to Jan. 2003. Tarmac is a large British construction company which has call options traded on London International Financial Futures Exchange, and thus reflects most of market expectation of construction cost volatility[1]. The correlation ρ is also estimated from the correlation between daily returns on Canary Wharf and Tarmac share prices during the period from March 1999 to Jan. 2003. δ_k and σ_k are assumed to be constant over time. As shown in Exhibit 3B, real option value per square foot is calculated as £180.37, and total option value for properties held for development is £1,136,311,874.73, which is about 10% (£105,102,062) higher than that obtained using the Samuelson Perpetual American Call model.

2) Real Option Implications and Limitations

Both option values above are consistent with Mr Johnson's prediction, with a value of slightly over one billion pounds. If valuers take into account the real options on properties held for development, it would increase the value of Canary Wharf and thus make up the gap between the book value of its properties assessed and its market capitalisation. And options which consider volatility of both development value and construction costs have higher value than options which assume construction costs constant.

Both real options calculated are in-the-money Perpetual American Call/Exchange option. The real option value consists of time value as well as intrinsic value. Since the options can be exercised by Canary Wharf at any time, if assessed by Net Present Value, the development programme should commence. But if the real option theory is taken seriously, both options, the Samuelson option and the two-factor American Exchange,

1 Howell, Stark, Newton, Paxson, Cavus, Pereira and Patel (2001) Real Options, p. 171.

should not be exercised now. The trigger value for the Samuelson model is V*=445.95, while current net development value is 356.25. The trigger value for the two-factor American Exchange Option is Z*=2.89, while current Z is $\frac{V}{K}$=1.78. Canary Wharf can wait a bit longer to develop those properties, but since Mr Johnson wants a stochastic world to be considered, in which both V and K follows geometric Brownian motion, nobody knows how long Canary Wharf is still going to wait for the exercise.

The results of these two models might give Mr Johnson some relief, but they have limitations. Firstly, the estimation of volatility of V and K is not guaranteed. There is no direct evidence which relates the volatility to that of continuously compounded return on Canary Wharf and Tarmac share prices. And there is no guarantee that the estimate of correlation is correct. Secondly, even though volatility of return can be used to estimate, we have no way of finding out share prices that have not happened. If we use past share prices, fixed volatility of return could not be assured either. Thirdly, yield of development value and development costs are assumed constant, which might not be true in real world. Caused by change in dividend ratio of construction companies, change in the yields may affect the real option value.

3. Sensitivity Analysis

Sensitivity analysis may help to understand the impact of assumption relaxations on the real option value. In the calculation of both real option values, net development value V was set in 2003 after considering the probability of dumping the option to develop. It was also assumed that the development programme took three years to complete from the end of 1999. Besides, the estimated high uncertainty of V may also need our attention. Figure 1 is generated from Table 2.1, Table 3.1 and Table 3.3 in the Excel, featuring the sensitivity of Net Present Value per square foot, American Perpetual option value and Perpetual American Exchange option value on development value. As development value increases by £10 from 435 to 515, given other terms fixed, NPV/SF forms an upward straight line with a constant slope 0.5, which is smaller than the slope of the other two lines at the beginning of the line, respectively 0.587 and 0.557. With a close look at Table 3.1, we actually find that the American Perpetual Call option value is concave, which increases at a growing rate. We can also find in Table 3.3 that the American Exchange real option value is concave. In the range considered, the value of the American Exchange real option is always higher than that of the American Perpetual Call option because the volatility of K is considered in the former. And the two option values are much higher than (about four times as much as) NPV per square foot, and the difference is increasing as development value grows. Even though they are discounted by three years, the option values are still much higher than NPV. It can be concluded from Figure 1 that option values are more sensitive to changes in development value than NPV of the development programme. We can also say that the value of a real call or exchange option is positively correlated with property values that will be purchased. In the decision-making of Mr Johnson, the higher the property value, the stronger impact the real option has on whether to develop or not.

Figure 1

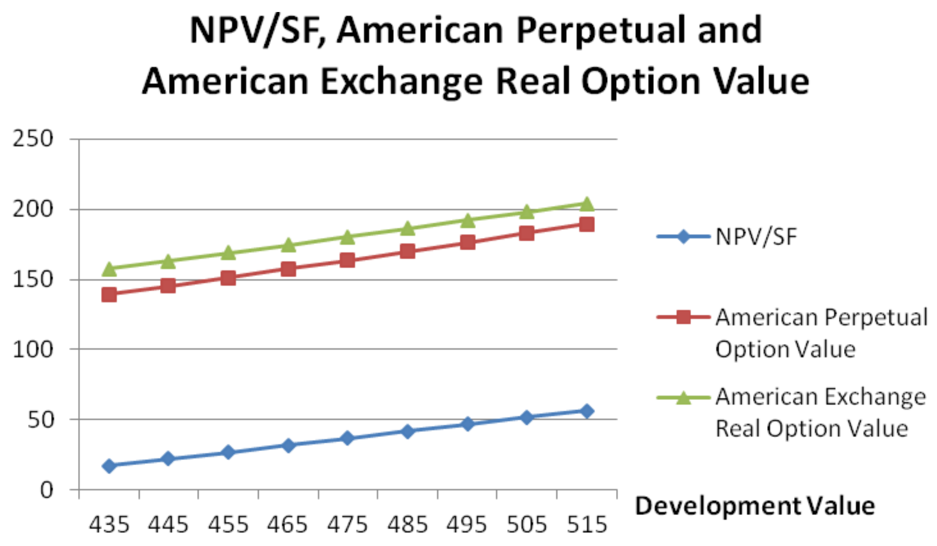


Figure 2 (from Table 3.2) tells some sensitivities of American Perpetual Call option to volatility of V, when volatility ranges from 12.36% to 52.36%. Increase in volatility leads to higher trigger value V* and higher option value F(V), while trigger value reacts more to volatility increase. Sensitive trigger value indicates that when there is large uncertainty in the development value of assets, Canary Wharf is likely to wait longer for commencing a programme before development value reaches trigger value. It can be noticed that option value F(V) remains constant at low volatility, and begins to increase at higher volatility. Before 27.36% volatility, option value equals the difference between V and K, which is intrinsic value of the call option. At 27.36% volatility, the American Perpetual Call option gains some time value, and as volatility continues growing, time value grows. If we look at Figure 3, we can find Delta of the option maintains 1.0 before 27.36% volatility and begins to decrease afterwards, while it is uneasy to observe in Figure 2. Decline in Delta indicates that less short position in underlying assets is needed to hedge a real call option with a higher volatility.

Figure 2

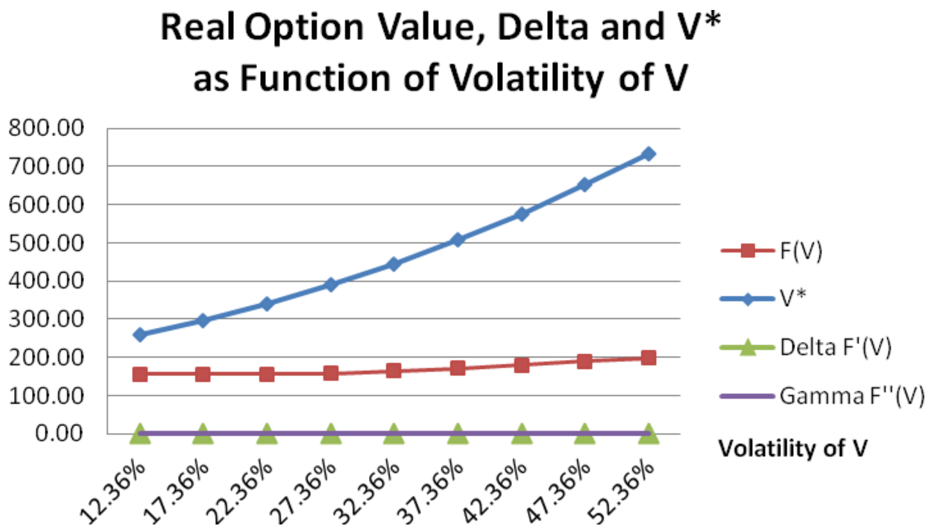


Figure 3

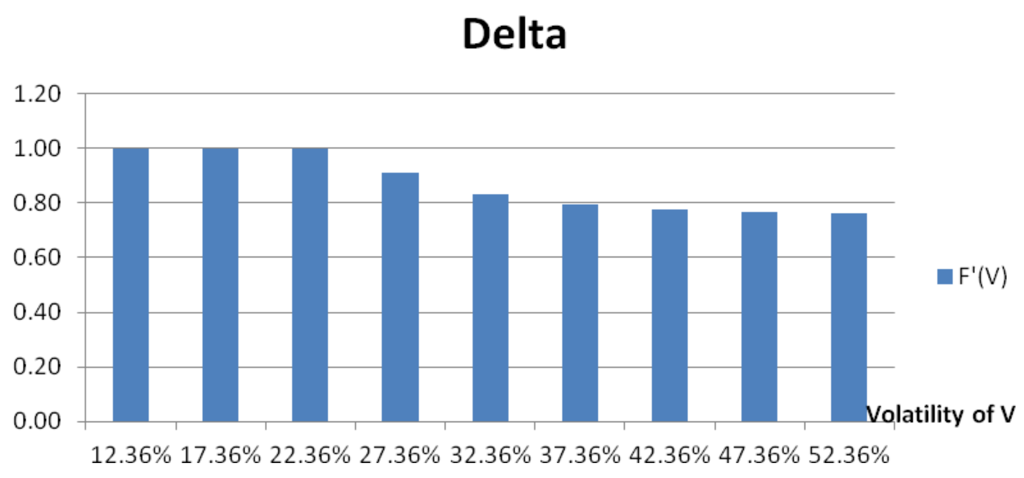
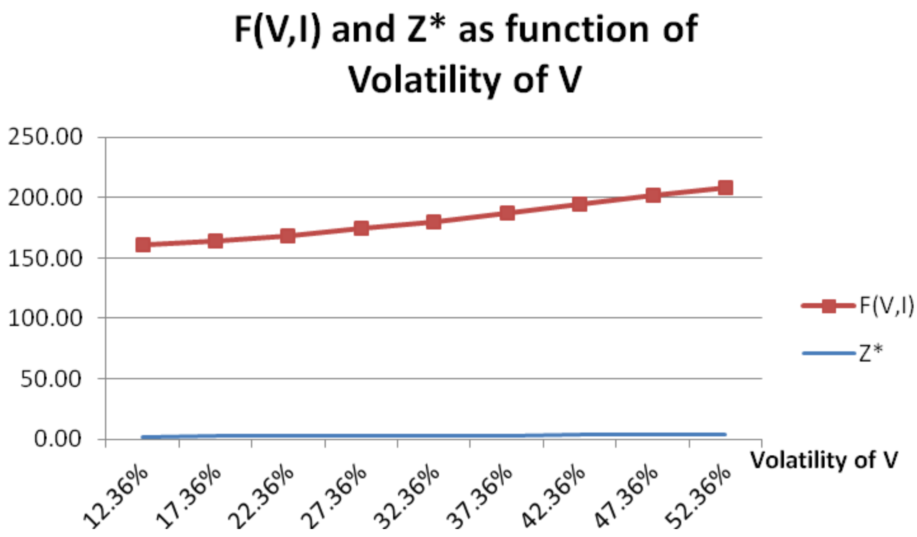


Figure 4 checks the sensitivity of Perpetual American Exchange option value and its trigger value to changes in V volatility. In the same range of volatility of V, the value of Perpetual American Call option increases by 26.5% and that of Perpetual American Exchange option increases by 29.4%. The two-factor American Exchange model is a little more sensitive to volatility change than Samuelson model. Like V* in Figure 2, trigger value Z* is also increasing with volatility, but in a less sensitive way because Z* is decided by two stochastic factors, V and K.

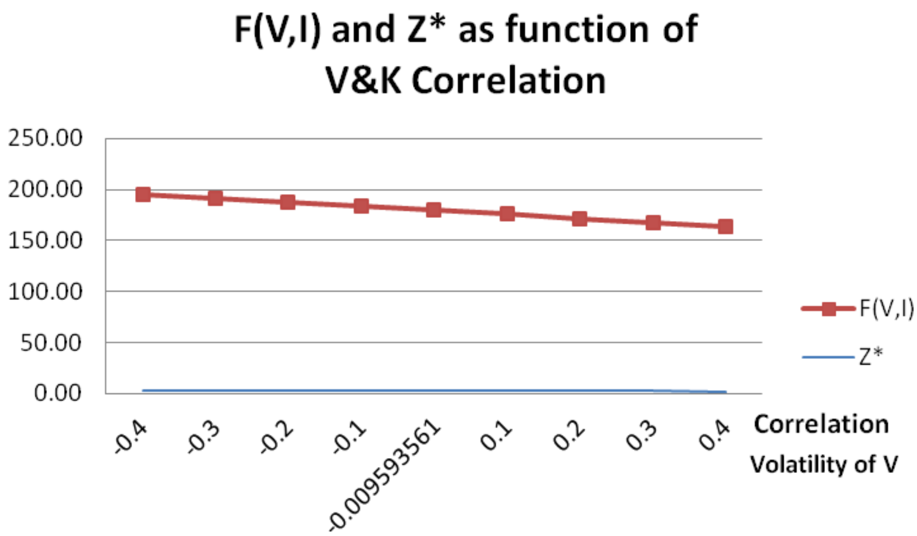
Figure 4



Generated from Table 3.5, Figure 5 looks at sensitivity of Exchange option value and its trigger value on future correlation between net development value and construction costs.

Correlation in the Perpetual American Exchange model is an uncertain estimate from future share price returns of two companies, so real option value can be severely affected if Mr Johnson wants specific volatilities of V and K to be considered. He would be happier to see a negative correlation of V and K, because higher assessment value of Canary Wharf could be gained by taking into account its development options. But intuitively, a positive correlation of V and K is more likely to happen in the real world. In contrast to Figure 4, trigger value Z* decreases in Figure 5 with correlation increasing. It can be inferred that if Mr Johnson spots a positive correlation between V and K, he might be willing to exercise the development option with further concession, at a lower V* or higher K*.

Figure 5



4. Hedge a Perpetual American Call

Regarding Mr Johnson's query on hedging Canary Wharf's development option, a simulation of delta hedging using the Perpetual American Call option is illustrated in this part. The delta (Δ) of an option is defined as the rate of change of the option price with respect to the price of the underlying asset[2]. The delta of a real call option is usually

2 John C. Hull (2009). Options, Futures, and Other Derivatives, p. 360

expressed as $\Delta = \frac{\partial F}{\partial V}$, where F is the value of the option and V is the value of the underlying asset. To hedge a call option one-for-one on asset V, Mr Johnson needs to short Δ V in the underlying asset. For a period of time, if delta (Δ) changes, rebalancing on the short position is required. Short selling of buildings needs to be assumed to be allowed, because usually shorting selling of properties is not allowed. And to short sell exact Δ V building(s), we have to assume buildings are perfectly divisible, e.g. in forms of contracts. No riskless arbitrage opportunities exist. Transaction costs on short selling and rebalancing can be ignored. A period of five years from 1999 to 2003 is considered with the assumed changes in property value V. It is also assumed that construction costs and volatility of V hold in the five years. As we can see in Table 4.1, delta of the option changes each year and rebalancing is needed at the end of each period.

Table 4.1 HEDGING A PERPETUAL AMERICAN CALL[3]

YEAR	1999	2000	2001	2002	2003
INPUT					
V	356	315	380	400	356
K	200	200	200	200	200
σ	32.36%	32.36%	32.36%	32.36%	32.36%
r	0.05	0.05	0.05	0.05	0.05
δ_V	0.07	0.07	0.07	0.07	0.07
OUTPUT					
F(V)	163.68	130.95	184.00	201.94	163.68
HEDGE (Position in V)	-296.79	-237.43	-333.63	-366.15	-296.79
ALTER HEDGE		-24.99	47.20	14.96	-29.31
GAIN ON F(V)		-32.73	53.05	17.93	-38.25
GAIN ON SHORTING Δ V		34.36	-48.99	-17.56	40.05
NET GAIN		1.63	4.06	0.37	1.79
CUM GAIN		1.63	5.69	6.07	7.86
V-K	156.25	115.00	180.00	200.00	156.25
F'(V) (Delta)	0.83	0.75	0.88	0.92	0.83
V*	445.95	445.95	445.95	445.95	445.95

3 Modified from Dean Paxson (2010), Real Option Value

A	0.00	0.00	0.00	0.00	0.00	
$\beta 1$	1.81	1.81	1.81	1.81	1.81	
PDE	0.00	0.00	0.00	0.00	0.00	
F''(V)	0.00	0.00	0.00	0.00	0.00	
F'(V*)	1.00	1.00	1.00	1.00	1.00	
F(V*)	245.95	245.95	245.95	245.95	245.95	
V*-K	245.95	245.95	245.95	245.95	245.95	
						RISK
RISK ROV		-20.00%	32.41%	10.96%	-23.37%	**26.56%**
RISK ROV HEDGED		1.00%	2.48%	0.23%	1.10%	**0.94%**

RISK ROV is the change in the F(V) of each year divided by the F(V) of 1999, reflecting fluctuation of option value. RISK ROA HEDGED is the change in NET GAIN of each year divided by the F(V) of 1999, reflecting fluctuation of hedged option value. RISK in the last column is the standard deviation of respective rows. From the last column we can see that volatility of real option value changes is reduced significantly from 26.56% to 0.94% by delta hedge.

5. Suggestions

Risk reduction is large, but there is still not enough reason for Mr Johnson to hedge the development option elements of Canary Wharf. Besides the impracticality of delta hedge on properties and transaction costs as well as large labour costs on rebalancing, if the premium of the development option is small enough, the option can be dumped without being exercised in the case of dramatic fall of V. As it is a perpetual American option, perpetual rebalancing on the short position in underlying asset is far more costly than the option premium. And with a highly volatile V, Mr Johnson has endless time as well as confidence to wait for the development value to re-bounce up to trigger value if development permission is made proprietary to Canary Wharf.

What's more, regarding the several complex puts with Citibank, at the time V falls, Canary Wharf loses in the development call option value, but gains from the put option value, because decrease in development value leads to a decrease in call option value, but an increase in put option value. The calls and puts are hedging each other on their own, so no more redundant hedge needs to be added.

In a word, delta hedge is effective, especially for extremely risk-averse managers, but not efficient enough to be used in Canary Wharf's case.

References

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Paxon, D.A., 2003. Real R&D options, Oxford: Butterworth-Heinemann.