CASE STUDY: UNDERSTANDING RISK AND OPTIMAL TIMING IN A REAL ESTATE DEVELOPMENT USING REAL OPTIONS ANALYSIS

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Consideration of risk and its management is key in most real estate investment and development opportunities. Recognition of this, particularly in recent years, has led to various financial techniques being employed, including simulation analysis and Value at Risk (VaR), to assess various proposed transactions. The U.K. Investment Property Forum has sought to establish a real estate sector standard for risk. This standard for risk has provided a greater insight into the risk structure and returns on investments for management to review. Notwithstanding these approaches, they have nevertheless largely relied on traditional deterministic appraisals as a basis for assessing risk and return.

An addition to understanding the risks and returns of a project is to apply a real options analysis (ROA). In commercial real estate, the application of an ROA to date has largely been academically driven. While this has provided a strong theoretical base with complex numerical and analytical techniques employed, there has been limited practical application. This lack in some respects is surprising, given that real estate contains a multiplicity of embedded real options due to its intrinsic nature and that the sector operates under conditions of uncertainty. In particular, real estate development provides flexibility in deferring, commencing, or abandoning a project, which in turn are options that convey value.

This case example, which focuses on a large site in the town center of Croydon, 20 minutes from central London in the United Kingdom, highlights the differences of an investment's risk structure and average return when comparing a static net present value (NPV) to an ROA approach. It also illustrates the apparent irrationality of why land is left undeveloped in downtown locations despite the apparent redevelopment potential, an issue that has been the subject of several seminal real option real estate papers (see Notes at the end of this case).

The ROA approach for this example initially formed the basis for advice to the Council (local authority), which was working closely with an investor developer. For this case study, the analysis is from the perspective of the investor in seeking to understand the optimal timing for development and its associated risk structure. In order to maintain confidentiality and simplify certain steps, prices and issues referred to have been adapted.

The right or flexibility to develop (i.e., construct) land is a real option and this often comes in the form of an American call option. This case study utilizes a binomial lattice approach and methodology. The call option is combined with an American put to sell the site either to the Council at open market value (OMV) or as a result of compulsory purchase order (CPO). Therefore, the strategic decision is whether to defer, sell (i.e., abandon), or develop. This flexibility conveys value, which is not captured by a conventional deterministic or NPV appraisal.

A five-step ROA approach was adopted and comprised:

Stage I	Mapping or framing the problem.
Stage II	Base scoping appraisal (deterministic).
Stage III	Internal and external uncertainty inputs.
Stage IV	Real options quantitative analysis.
Stage V	Explanation and strategic decisions.

Three quantitative variations using a lattice approach were considered: a binomial lattice; state pricing; and a binomial lattice with two volatility variables. The reasoning for this approach is explained later. A Monte Carlo analysis was undertaken at both the deterministic analysis (Stage II) and with the ROA (Stage IV), which further illustrates the risk profile comparison between real options and NPV.

The lattice approach allows for decisions to be taken at each node. This features provides an investor with the ability to determine the optimal timing with respect to development, or to defer, or to abandon (disposal of the property).

The basic simplified details of this case study are as follows:

- An undeveloped town center site of approximately 2.43 ha (6 acres) adjacent to a major public transport interchange.

- A comprehensive mixed-use scheme has been granted planning permission comprising: a supermarket (7,756 sq m, 83,455 sq ft); retail units (6,532 sq m, 68,348 sq ft); restaurants and bar (7,724 sq m, 83,110 sq ft); health club and swimming pool (4,494 sq m, 48,355 sq ft); night club (3,718 sq m, 40,006 sq ft); casino (2,404 sq m, 25,867 sq ft); offices (12,620 sq m, 135,791 sq ft); and a car park (500 spaces).
- A Fund acquired part of the site (in a larger portfolio acquisition) at a book (accounting) cost of £8m, reflecting the development potential. It also inherited option agreements with other adjoining landowners in order to assemble the entirety of the site, which would result in a total site acquisition cost of £12.75m, thereby enabling the implementation of a comprehensive scheme.
- The costs of holding the site and keeping the options open with the other landowners are £150,000pa. Income from a car park on the site is £50,000pa. Therefore, net outgoings are £100,000pa (totaling £500k over 5 years, that is, this is assumed to be an intrinsic sunk cost in developing the site).
- The Council wishes to see the site comprehensively developed for the scheme and have granted permission. They also have a long-held objective of developing a sports and entertainment arena in the center of Croydon. Under an agreement with the investor in conjunction with granting the planning permission, the Council has said it would acquire the land at OMV (i.e., equivalent to the book cost) at any time up to 5 years from grant of planning permission should the investor wish to sell and not implement the scheme. Thereafter, the Council would acquire the site using CPO powers (a statutory procedure) if comprehensive development has not been started. The case for granting a CPO is believed to be given, among other reasons, due to the fragmented ownership and that this high-profile site has lain undeveloped for many years. Compensation from the Council to the Fund in acquiring the site via a CPO based on a *no scheme* world (i.e., ignoring any development potential) has been calculated at £5m.

Stage I: Mapping the Problem

Three basic real options were identified that conveyed *flexibility* in terms of optionality in real estate development. They were the option to abandon (i.e., sell), the option to defer investment, and the option to execute (i.e., implement the development). Any of these should be exercised prior to the expiration of 5 years given that the site would be compulsorily acquired at what the Fund estimated as being at subbook value under a CPO. In addition to these options, the option to alter the planning permission subject to market circumstances could also be added. While this would often occur in

practice, it is not examined in this instance. The optionality of achieving an optimal tenant mix could also be considered.

As indicated earlier, these options are American (two calls and one put), although the decision just prior to the expiration of 5 years or the CPO could be considered a European put and therefore should be calculated as such.

The Croydon market was considered uncertain in terms of occupier requirements and rental levels, which were sensitive to general real estate market movements for both offices and retail. The ability to attract a supermarket operator and a major office pre-let were seen as key prerequisites prior to implementation of construction. The scheme would not be developed speculatively.

An ROA strategy matrix was prepared. Table 14.1 provides a simplified summary. It is evident from Table 14.1 that even in applying a qualitative

TABLE 14.1 ROA Development Strategy Matrix

Strategy/ Approach	Type of Development	Market Factors	Planning Issues	Timing	Embedded Option Appraisal
Pessimistic	Comprehensive Development	Poor office market; uncertain retail requirements	Reduce office content; reconfigure retail	3–5 yrs	Defer or sell
Cautious		Occupiers require 50% of offices; anchor retail tenant but at low rent gain	Consider phasing offices and retail (review planning obligations)	2–4 yrs	Defer or develop/ expansion option
Optimistic		Major office pre-let; quality anchor retailers secured; demand is high for all uses in the scheme	Consider increasing office content	1–3 yrs	Develop and expansion option

analysis, values may evolve asymmetrically. There could be a considerable upside relative to the downside. It was a characteristic of the Croydon office market, for example, that other competitor office schemes if implemented could encourage office sector activity and upward pricing of space with a high probability of occupier relocations. In this instance the investor did not have other real estate holdings in the town center. If the investor did, implementation of the scheme may also be considered a strategic (growth) option and could be analyzed as such.

Stage II: Base-Scoping Approach

A cash-flow residual development appraisal was produced, with key value drivers of the scheme being the supermarket and office components accounting for 47.15 percent of the expected capital value of the entire project. An overall blended yield of 7.8 percent was expected, which in market terms was considered cautious. An office rent of £215 per sq m (£20 per sq ft) was applied, although this was considered to have underperformed London's (and United Kingdom) office growth as illustrated in the two graphs in Figure 14.1. Total office returns also underperformed London (and the United Kingdom), which is in line with historic patterns for Croydon.

Costs comprised land acquisition, construction, professional fees, other agents' fees and costs, and finance (rolled up interest on costs). Land and construction costs excluding profit totaled £90.48m. The gross development value (GDV) of the scheme was £105.76m. It was considered by the investor that, for a project of this scale, a developer's profit on cost of 17.5 percent would be required (although profit on land was acceptable at 10 percent). The scheme on this basis outlined previously was marginally producing a total profit of £15.28m; in other words, a deterministic (NPV) measure of development profit. The next stage was to consider the project risks in a state without strategic flexibility.

A Monte Carlo simulation analysis was undertaken based on key input variables of supermarket and office rents and yields and office construction costs (a fuller analysis with other variables was initially undertaken and then narrowed down to key variables together with preliminary sensitivity and scenario analysis). The results are shown in the frequency chart in Figure 14.2.

Figure 14.2 shows a mean total profit return of £13.7m (90 percent certainty range of £8.3m to £19.0m) against a minimum required return of £14.7m (assuming 10 percent and 17.5 percent profit on land and construction cost, respectively). These returns can be compared with the ROA and explanation that incorporate a simulation of the option values in Figure 14.7 and Table 14.3, which appear in a later section. It should be noted that the project risk testing and use of simulation analysis, as illustrated earlier, is in itself a complex area, as highlighted earlier in this book.

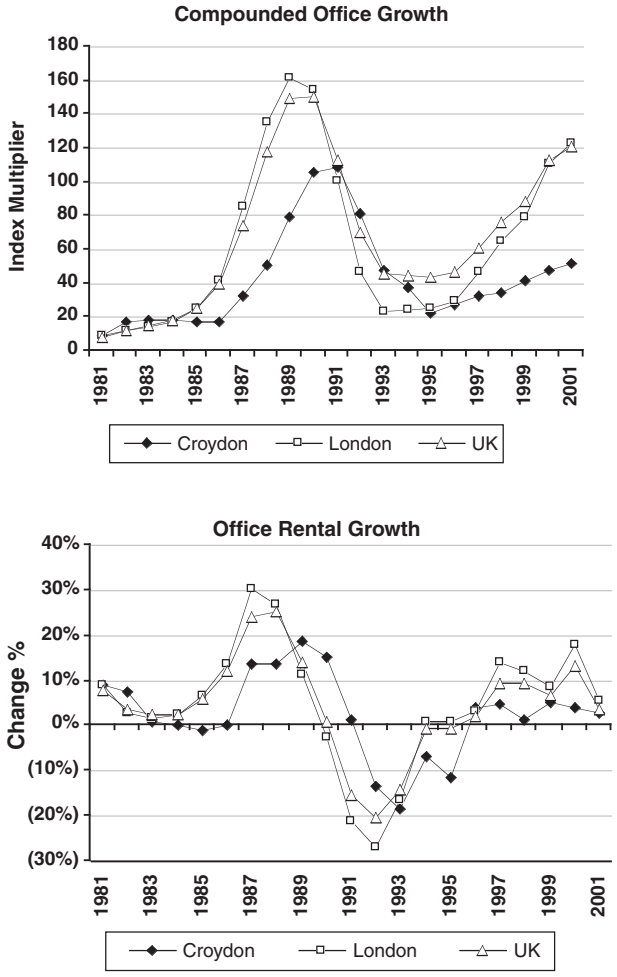

FIGURE 14.1 Croydon office rental and compounded growth. (*Source:* Data from IPD 2001)

Stage III: Internal and External Uncertainty Inputs

The base scoping provided a useful measure of the financial internal uncertainties and their interdependencies. In addition, it was necessary to regard specialist reports concerning construction constraints, cost variables, and programming. These also aided the simulation analysis in Stage II.

An ROA requires an assessment of volatility, a key input into the risk-neutral framework of real options pricing. In this instance, state pricing was

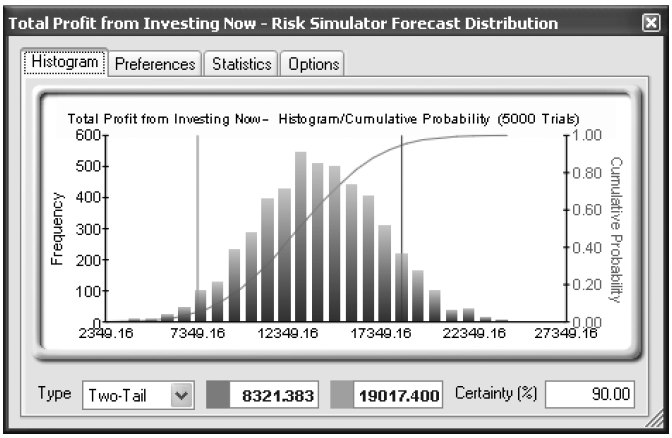

FIGURE 14.2 Base scoping Monte Carlo analysis.

also used. An assessment of the magnitude of the upside and downside within an underlying lattice in order to capture the likely asymmetry of the Croydon market was therefore undertaken.

As volatility is key to ROA, research and subsequent analysis are critical in obtaining suitable input data and then reviewing the resultant computations in Stage V. Indexes, as outlined later, are based on professional valuations as opposed to market transactions. Academic papers have highlighted the potential for what is known as valuation "smoothing" within the indexes with the result that volatility of real estate may be understated. Various techniques and data sources have been used for backing out true, historic, implied, and expected volatility in real estate over alternative time frames. However, this remains a significant area of research. The following approach has been simplified for practical reasons in obtaining appropriate volatility rates for this case study.

The U.K. Investment Property Databank (IPD) data on office and retail rental growth and total returns for Croydon, London, and the United Kingdom between 1981 and 2002 were analyzed. As investment performance is judged on total returns, these volatility figures were used with respect to the underlying asset value. Volatility of total returns for office and retail for three periods—1981–2002(1); 1991–2002(2); and 1995–2001(3)—are shown in Figure 14.3. Both graphs show volatility decreasing over the three periods from a range of 8.6 percent to 12.1 percent (offices) and 6.4 percent to 8.7 percent (retail) to 2.4 percent to 3.3 percent (offices) and 1.15 percent to 3.4 percent (retail). These appear to be low volatility rates compared to empirical research.

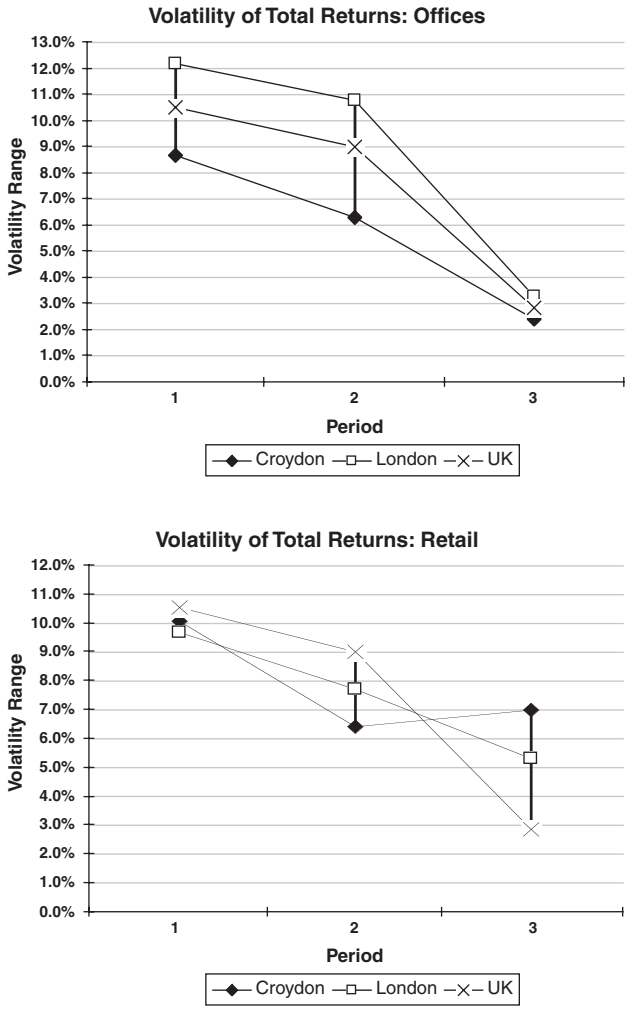

FIGURE 14.3 Croydon retail and office volatility of total returns. (*Source:* Data from IPD 2001)

Another way of considering the volatility over this period for offices and retail is on a 5-year rolling basis as shown in the two charts in Figure 14.4.

From Figure 14.4 we see that the Croydon office market showed an average volatility of 8.95 percent (range 2.2 percent to 14.7 percent), which was below both London (average 11.39 percent, range 4.1 percent to 24.1 percent) and the United Kingdom (average 10.12 percent, range 2.6 percent to 10.9 percent). For retail (except in Croydon) the volatility levels were

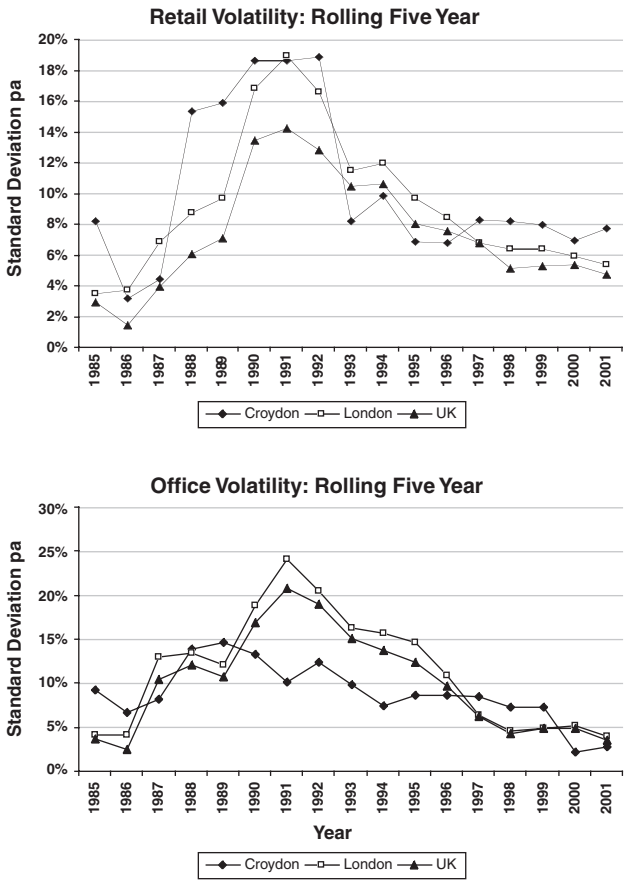

FIGURE 14.4 Croydon retail and office returns—5-year rolling volatility. (*Source:* Data from IPD 2001)

generally lower than for offices, with the Croydon market showing an average of 10.27 percent (range 3.2 percent to 18.9 percent) compared with a London average of 9.29 percent (range 3.5 percent to 19 percent) and the United Kingdom average of 7.46 percent (range 1.5 percent to 14.3 percent).

It is necessary for the underlying asset to arrive at a single volatility, that is, combining retail and offices. Further research and analysis in practice was undertaken, including cross correlations. For the purposes here, a figure of 10 percent with an analysis range of between 5 percent and 35 percent is utilized, taking account of sector empirical studies and desmoothing of base indexes.

So far as the price probability falls under the ROA analytical approach state pricing, this has regard to compounded growth in capturing the asymmetry of future underlying asset changes. Again, further research in practice was undertaken. Indeed, an alternative approach in option pricing would be via a jump-diffusion whereby an initial jump (i.e., upside) could be followed by a reversion to appropriate volatility levels. Nonrecombining lattices or multiple recombining lattices with changing volatilities could also achieve similar results. For state pricing, the upstate was assumed at 15 percent and downstate 5 percent. See Johnathan Mun's *Real Options Analysis, Second Edition* (Wiley, 2005) for technical details.

So far as costs were concerned, cost inflation was set at 5 percent and cost volatility at 5 percent. The latter was considered low in comparison to empirical examples and therefore was analyzed within a range of 5 percent to 25 percent. U.K.-published construction cost indexes have been criticized as not reflecting the true volatility found in the sector. This criticism has again led to other alternative measures and proxies being sought and analyzed, including traded call options of construction companies.

Stage IV: Real Options (Quantitative) Analysis

The three lattice approaches together with the inputs and assumptions outlined earlier were computed. The cost of implementation input excluded profit on cost and land in order to directly compare the option price to development profit. The value input was that derived from the deterministic appraisal. Under each approach, the lattices were as follows:

- An underlying asset pricing lattice, the price evolution.
- An underlying cost lattice, the cost growth or evolution.
- The value of exercising the development, in simple terms the NPV in each moment of time of making an investment.
- A valuation lattice, where the value would be the maximum of price less cost; the option to defer less the intrinsic sunk costs; or the offer to be acquired by the Council. The termination boundary (year 5) would be the maximum of the underlying price less costs or the offer to be acquired by the Council.
- A decision lattice, which was based on the valuation lattice in determining at each node whether to defer, sell, or develop.

Option values were calculated under each of the three approaches, which were then compared to the development profit of the deterministic approach, as shown in Table 14.2. In each case the value (profit) of the option to defer (i.e., now or later) is higher than the current or expected profit of investing immediately. The difference in the real option values results from the evolution of the lattice and risk-neutral pricing of each approach.

TABLE 14.2 A Comparison of Real Option Values with NPV

	ROA		
NPV (£m)	Binomial (£m)	State Pricing (£m)	Binomial (Dual Volatility) (£m)
15.28[a]	18.13	18.09	23.77
Additional Value Created by ROA	2.85	2.81	8.49

[a]This amount represents the total profit of investing now of which £14.7m would be the minimum required return.

Stage V: Explanation

The option price takes into account all possible future outcomes under the three ROA approaches that were not captured by the deterministic analysis. It was, however, necessary to consider the sensitivity of the inputs, particularly with respect to volatility (price and cost) and price probabilities under state pricing as well as the impact on the decision lattice at the different nodes. The decision lattices in Figure 14.5 (with time in years in bold) are set out for comparative purposes.

Taking an overview with regard to all of the approaches, development should probably be deferred in years 1 and 2; deferral or selling were the dominant options in year 3; and development should only probably be envisaged in years 4 or 5. This scheme essentially provided an analytical underpinning for a professional judgment and decision framework. The surface graphs in Figure 14.6 illustrated the sensitivity for each approach. Figure 14.6 clearly indicated the effect and interaction of volatility on the option price (OP), which again emphasized the importance attached to establishing base volatility inputs as discussed earlier in Stage II. This analysis in practice was analyzed and reported on further. A Monte Carlo analysis of each option price was undertaken and the frequency charts are set out in Figure 14.7 together with a certainty level of 90 percent. These charts can be compared to the base-scoping frequency chart (Figure 14.2) and illustrate the narrowing (particularly with state pricing) of the risk structure and higher average return.

It was notable that the risk structure range's downside of the three approaches was relatively similar, being between £16.2m and £18.6m (see Table 14.3). In this particular instance, the downsides provided useful benchmarks to the minimum required return of £14.7m under an NPV approach, as an alternative measure to comparing average returns. Notwithstanding this NPV result, the upsides under the three approaches were significant.

The investor, as a result of an ROA, could clearly form a strategy in terms of optimal timing or whether to invest at all. The flexibility of this

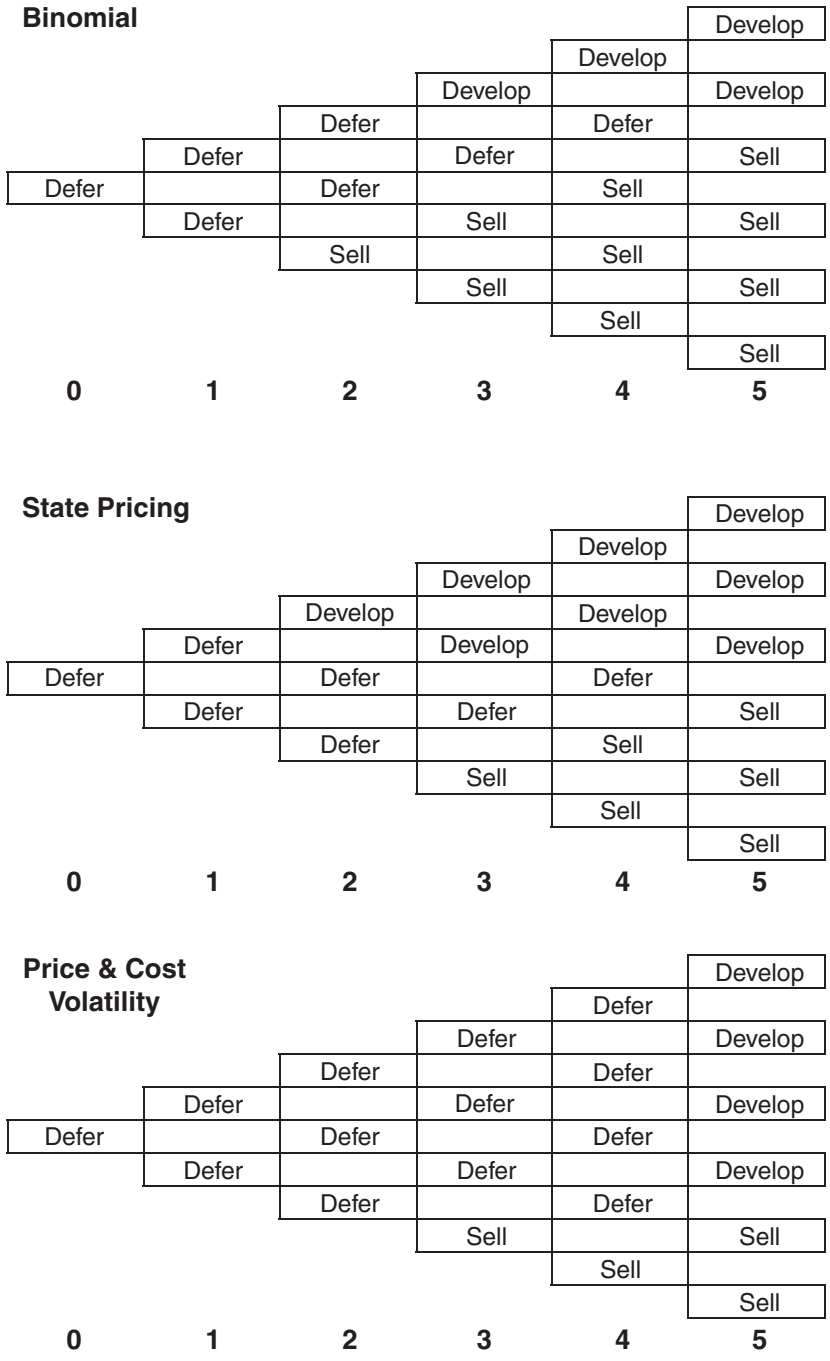

FIGURE 14.5 Binomial lattices.

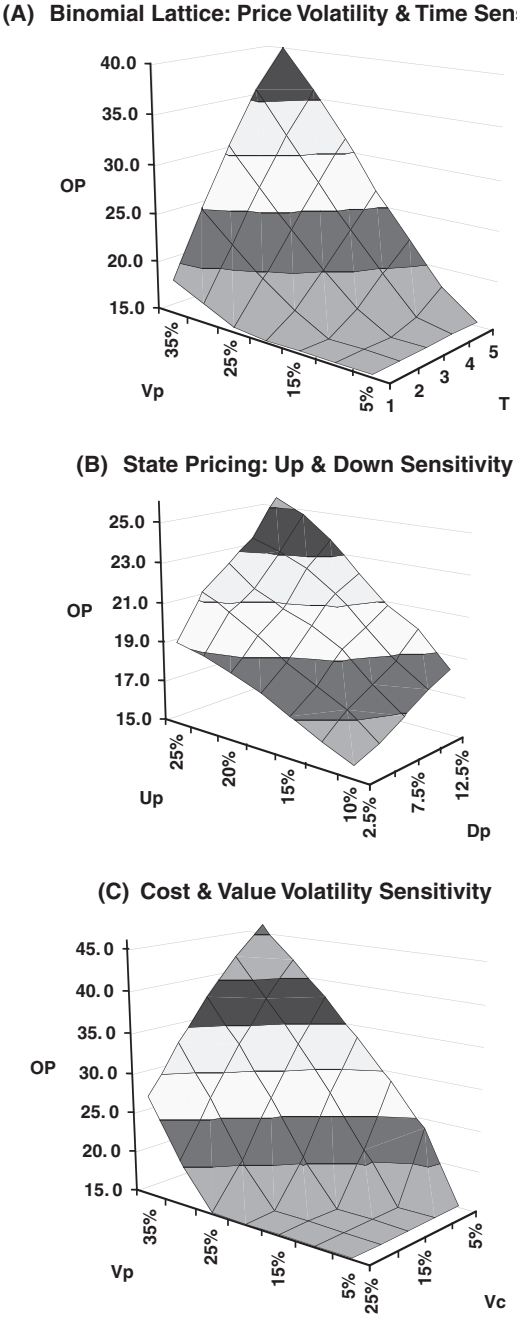

FIGURE 14.6 Croydon ROA sensitivity graphs.

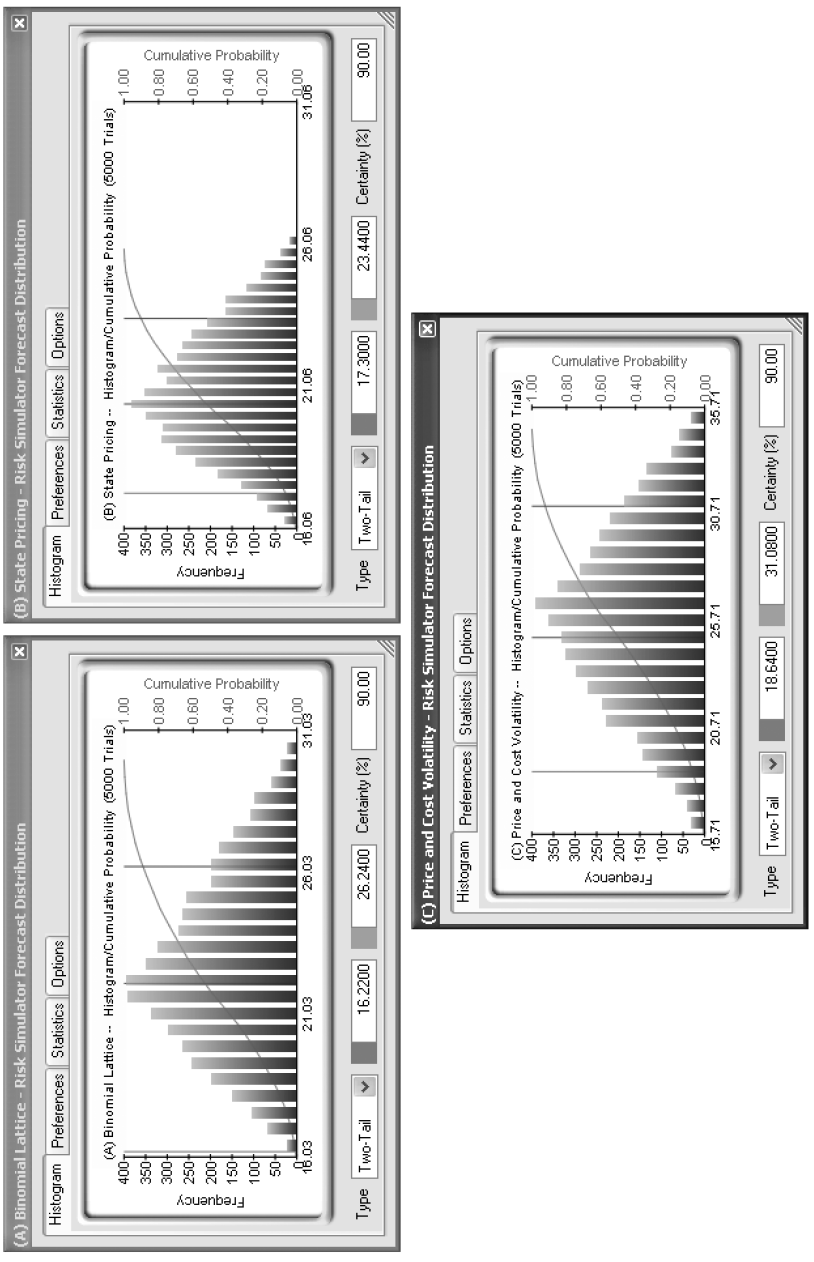

FIGURE 14.7 ROA Monte Carlo application.

TABLE 14.3 Simulated NPV and Option Values Croydon (Average and Range)

	Average Return (£m)	Risk Structure Range 90% (£m)	Percentage Above Required Return (£m)
NPV	13.7	8.3–19.0	(6.8)
Binomial Lattice	21.1	16.2–26.2	43.5
State Pricing	20.6	17.3–23.4	40.0
Binomial (Cost/Price Volatility)	25.1	18.6–31.1	70.7

decision created additional value over and above a conventional valuation of the development. This additional value would perhaps be incorporated within a price, if the investor were to dispose of the opportunity to a third party at the beginning of the period.

The real option paradigm when applied to real estate potentially highlights, on one hand, the seemingly intuitive action of investors and, on the other hand, undervalued investment opportunities and suboptimal decisions. As such the ROA, as illustrated previously, therefore provides another approach and valuable layer to the risk analysis and potential returns of real estate investment and development.

Notes

The following papers provide further reading on the subjects of investment risk, volatility measures, and real options in real estate development.

Brown, G., and G. Matysiak. *Real Estate Investment, A Capital Market Approach*. London: Financial Times Prentice Hall, 2000.

Grenadier, S. "The Strategic Exercise of Options: Development Cascades and Overbuilding in Real Estate Markets." *Journal of Finance* 51, no. 5 (1996): 1653–1679.

Quigg, L. "Empirical Testing of Real Option-Pricing Models." *Journal of Finance* 68, no. 2 (1993): 621–639.

Sing T. "Optimal Timing of Real Estate Development under Uncertainty." *Journal of Property Investment & Finance,* Special Issue: Real Options, 19, no. 1 (2001): 35–52.

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