Pricing the options inherent in leased commercial property: the impact of rental growth volatility

Professor Andrew Baum
Department of Real Estate and Planning
University of Reading Business School

Dr Frank Brown
Oxford Property Systems

With acknowledgements and thanks to Neil Crosby and Patrick McAllister

Pricing the options inherent in leased commercial property: a UK case study

Professor Andrew Baum
Department of Real Estate and Planning
University of Reading Business School
UK

Dr Frank Brown
Oxford Property Systems

1. Introduction

This paper is one of a series setting out the findings of a group of research and development projects carried out at the Department of Real Estate and Planning at the University of Reading and at OPS (Oxford Property Systems, a software development company) over the period 1999–2006. The projects have several aims. These are: to identify the fundamental drivers of the pricing of different lease terms in the UK property sector; to identify key issues in pricing cash flows derived from leases with different lease lengths and other terms; to develop a model for return estimation and pricing of these cash flows under a variety of lease variations; and to use the model to draw conclusions about the market pricing of lease cash flows.

Although it is possible to model quantitatively both landlords' and tenants' positions, the complexity of the legal issues that influence the rental impact of lease terms makes a solution to pricing challenging. The approach of valuers and funding criteria also add complexity to the issue and add an institutional dimension to the problem, impeding the adjustment towards rational pricing. The intricacy of these issues possibly explains the conservatism of many market participants towards flexi-leases. However, it also provides a potential opportunity to market participants with the ability to accurately price flexibility in lease terms.

The research uses data derived from major databases maintained by IPD and the Valuation Office, interviews and workshops with over 50 market participants (owners, letting and investment agents, valuers and rent review surveyors) and a questionnaire survey carried out in 2006. The OPS software development work was based on the outputs of this research.

A key conclusion of this study is that the relative stability of lease terms in the retail and office sectors reflects a widespread mutuality of interests between landlord and tenant in the status quo. Long leases provide important benefits for most retailers in terms of security of trading position and adequate write-off periods, and the fit-out costs for an office user can also encourage longer leases than might otherwise be optimal.

From the landlord's perspective, the main factors driving the required 'compensation' for a lease term amendment include expected rental volatility, expected probability of tenant vacation, and the expected costs of tenant vacation. These data are used in conjunction with simulation technology to measure the value of options inherent in certain lease types to explore the required rent adjustment. The resulting cash flows have interesting qualities which illustrate the potential importance of option pricing in a non-complex and practical way.

Finally, the introduction of a new variable, rental growth volatility, into systems for modelling and pricing property cash flows has important and perhaps surprising implications.

2. Factors affecting the value effects of lease variations

2.1 Rental valuation

The landlord perspective

Flexible leasing creates uncertainty in the cash flow. The long lease with upward only rent reviews on full repairing and insuring terms has the essential advantage of minimising cash flow uncertainty. Modelling the impact of flexible leases introduces the need to deal with uncertain cash flows.

Where break clauses are relevant, the key variable is the probability of the tenant exercising the break and vacating. Where short leases are relevant, the key variable is the probability of lease renewal. In each case, void lengths, empty property costs and re-letting costs are relevant. Data availability has been limited: there is little empirical evidence of the probability of breaks and lease renewals and void periods. However, even if available, the value of mean figures will be limited since individual features of properties and tenants will affect the propensity of the tenant to vacate, as will the economic environment.

It is apparent that the probability of tenant vacation will be influenced by the nature of the specific tenant, lease, market sector and building as well as market factors. The expected costs and probability of tenant vacation can be specified as a function of many factors. These include:

- the length of the notice period
- the amount of the financial penalty
- the expected cost of dilapidations
- the estimated amount spent fitting out premises
- the availability of alternative premises
- the estimated costs of relocation
- growth/contraction in the tenant's business
- expected rental growth

The estimated probability of letting termination is the first key variable used in calculating the expected cost of tenant vacation. The second key variable is the expected length of the void period. The expected costs of a void will be a function of the estimated probability of costs being incurred and the amount of these costs. In addition, there is a possibility of a downward rent review.

The probability of the rent passing exceeding rental value at rent review is dependent upon the expected level of rental growth, the time to rent review and the volatility of rental growth. Hence, in the absence of reliable transaction evidence involving comparable leases, investors' pricing adjustments should be based upon

- expected rental volatility
- expected probability of tenant vacation
- expected costs of tenant vacation
- expected rental growth
- time to rent review

The tenant perspective

Interviews with practitioners suggest that the economic value put on short leases was variable between tenants. The general impression given was that a majority of retail tenants

placed a higher value on securing a trading position than on obtaining flexibility. This is less true of office and industrial tenants.

Tenants who perceive a high degree of risk in a venture or a location will tend to place a high value on a short lease for two main reasons. Firstly, they perceive a need for a certain exit strategy. Secondly, long leases can decrease the project IRR from the tenant's point of view.

However, fit-out costs can be an important variable. Tenants with substantial fit-out costs place little value on short leases since they may need 10-15 year write-off periods to maximise IRR. It was estimated by interviewees that average required write-off periods were 7-8 years.

Expected rent impacts

The point was strongly made that retailers will not pay a premium rent for flexible leases. The retailer's business plan is very short term. At the same time, landlords will protect investment value: for many of them, successful investment is perceived to be about protecting long income streams, high headline rents and low capitalisation rates. It is not surprising, therefore, that leases shorter than 10 years are rare for prime space in this sector. The main exception to this is the use of rent free periods and capital incentives, each of which will have a direct effect on rent.

In the retail market, rent is typically the first thing agreed. After that, it is a matter of give and take on lease terms. Several interviewees suggested that it will be useful to use a pricing model to examine the rent implications of lease variations in comparable deals done.

Generally, it can be difficult to obtain strong views concerning the rent impact of lease variations as there can be a strong desire to protect the headline rent and to use other lease terms (rent frees, inducements) to compensate for variations. The source of this attitude, which exists at the expense of NPV or IRR maximisation, is a matter of interest connected with valuation practice. Nonetheless, interviews picked up a large amount of opinion and transaction-based evidence of likely rent variations for typical lease alternatives.

Table 1 reports the average expected rent impacts of lease variations across all eight market sectors. This based on workshops held at the offices of the OPRent sponsors, assuming a standard lease of 15 years without breaks on upward only rent reviews every five years with 3-6 months rent free. The impact varies from sector to sector and is depended upon building and location quality. Nonetheless, some patterns emerge. Short leases, for example, are widely regarded as more damaging than short term break clauses.

Table 1: expected mean rent impacts

Lease variation	Mean rent impact
Review 1 break	10.45%
Review 2 break	6.60%
All review break	17.00%
5 year lease	15.23%
10 year lease	7.00%
10 year lease, 5 year break	16.40%
3 year reviews	-3.79%
Two way reviews	6.25%
RPI lease	5.80%

Rent review/lease renewal

Lease length is an issue in setting rents at rent review. Where the hypothetical lease in the rent review clause has a lease term that is 20-25 years, this tends to be regarded as onerous. As a result, established through precedent and negotiation, discounts of 2.5%/3% are common for hypothetical unexpired terms in excess of 15 years. However, it is clear that where the unexpired term in the hypothetical leases is 'short' – say five years – landlords are unable to achieve an uplift in rent.

Although the logic of such an uplift is accepted, landlords arguing this point are generally unable to identify evidence of premium rents. Consequently, practitioners were unaware of any precedents establishing an uplift. It is instructive that the only occasion that a break clause is rent sensitive at rent review is when *the landlord* has an option to determine the lease. In this case, there is evidence of rent discounts at rent review.

In the high street, long leases may lead to rent discounts: 10 years is the minimum needed to maintain ERV, but a hypothetical term of 25 years will produce a discount at review.

Although there is no absolute certainty that tenants will get what they want, the courts will generally be strongly influenced by the existing lease length in setting new leases. They will also take into account market norms and the preferences of the tenant. However, a key point is that tenants who obtain a short lease at lease renewal do not pay a rent premium. There are no precedents of landlords being awarded inflated rents to reflect a break clause/short lease. Conversely, as with rent reviews, there is lots of precedent to suggest that where the landlord has the advantage of a break clause, this can lead to substantial discounts in rent (15%-20%).

2.2 Capital valuation

"Valuers have a great and excessive impact" (interviewee).

The importance of valuers and valuation methodology is illustrated by the fact that the required rent effect of a lease variation is often calculated by reference to the yield (valuation) impact of that variation. Say a property let on standard terms is valued by reference to a rental value of £10 and a yield of 10%. The valuer may be asked to estimate the yield impact of a change from a 15 year lease to a 5 year lease. Assume that the yield moves out to 12%. This leads to a fall in value of 15%. It can be put right by a 15% rent increase, and this is where many will end their analysis.

This is not true value maximisation: it is based on likely selling prices, not on cash flows, and is therefore a mechanism based on very short term analysis.

Due to similar considerations, it can be difficult to obtain strong views concerning the rent impact of lease variations, as there can be a strong desire to protect the headline rent and to use other lease terms (rent frees, inducements) to compensate for variations. The source of this attitude is again the protection of the short term valuation rather than the optimisation of the longer term cash flow. Nonetheless, the valuation process is not wholly ignorant of future cash flows.

Discussions with valuers suggest that for properties with short leases, break clauses and imminent lease expiries the main valuation adjustment is the incorporation of a void allowance in the valuation. Generally this is the case for leases of less than five years unexpired. However, it was pointed out that the void allowance did not reflect the 'true'

expected costs of a void. Rather it was moderated to reflect the fact that the tenant would probably not break. Where it was certain that the tenant would break, then a full void allowance was included in the valuation.

With regard to break clauses it was stated that notice period and penalty would be factored into the valuation so that a long notice period and substantial rent penalty could neutralise the void allowance. For shopping centres with short leases a valuer would build in a running void assumption into the cash flow based on expected average void rate and expected average void period.

Flexible leasing may lead to faster lettings and less rent free periods. The rental increase available may easily compensate for the risks of voids and re-letting costs. Valuation methodology does not naturally assist in examining this problem, which is regarded as an investment appraisal challenge left for owners and consultants rather than valuers.

Interviewees noted this tension between valuation and investment appraisal approaches. This can lead to different advice being given to lessors by two different departments of the same property consultant – and this is not surprising, because one approach is based on short term sale price protection while the other is based on long term cash flow protection.

Funding

Funding criteria are often critical to the pricing strategies of private investors. Given that the banks place great importance on unexpired lease terms in their risk management procedures, short leases are undesirable from the landlord's perspective.

The observed capitalisation rate damage that can be observed for leases with less than 10 years unexpired - or 15 in some sectors - can be seen as a rational outcome of financing criteria.

Liquidity

One consequence of the valuation process may be that short leases tend to be less liquid. Practitioners commented that it was rare to see a property on the market that had less than five years unexpired. Landlords tended to follow one of two strategies. Firstly, they could simply wait until the lease had expired and a new lease negotiated before disposal. Alternatively, they could restructure the lease.

Few landlords appear to be prepared to take on what would be a normal challenge in many other markets, namely to provide a level of customer service and the resulting continuation of a customer relationship. This may be the result of the market's excessive reliance on the valuation process accompanied by a lack of faith in its use where there is abnormality and little or no comparable evidence.

The portfolio effect

Landlords will be more flexible on multi-let schemes than on stand alone leases, partly because of the influence of valuers who will penalise the capitalisation rate for a short lease on a single investment but take the 'tone' of lease lengths for the yield on a multi-let estate.

In addition, lenders may be more relaxed about lending against properties let on short lease terms where the property is multi-let, and on schemes including several assets let on flexible lease terms, due to the portfolio effect. However, this is not easily modelled in a lease

pricing system. It therefore represents an advantage for larger owners able to exploit the risk reduction explained by standard portfolio theory.

The price impact of flexible leases will also be affected by the portfolio effect: a department store or anchor store has much greater impact on a shopping centre than other tenants, so the rent impact of a break is much bigger.

Lessor options

Flexible lease pricing provides the parties with more options both in the standard sense and in the financial sense. Lessee options are most obviously introduced by tenants' break clauses. They have a value to the tenant based on the occupation alternatives they provide: remain, move, close down. They have a cost to the lessor based on the potential interruption to cash flow and the associated cost of running and re-letting an empty property. While it is difficult to estimate their value to a tenant using pure financial variables they can be valued by reference to the landlord's costs.

Interviewees found it relatively easy to find examples of break clauses and to comment on the likely rent impact. Typical were expectations such a 15% premium for a 5 year break; a 7.5% premium for 10 year break; and 15% plus for both.

Tenants' break options may be countered by lessor options to break, which may cancel any price impacts. Less obviously, the grant of a lease outside the Landlord and Tenant Act 1954 removes a tenant option to stay and grants a lessor option to remove the tenant.

The value of these lessor options is less easy to model than the lessees' options. The financial cost of exercising a lessor break can be modelled using financial variables – namely the cost of running and re-letting an empty property - while the benefits of the option (which may include re-development options, or the opportunity to re-locate other tenants to free up space that be re-let at a higher rent and many others) are less easily priced.

Volatility

Rental growth volatility was not mentioned as an input variable by a single valuer or market participant interviewed. It is clear that this variable is not used explicitly in market pricing.

3. Developing a model for pricing cash flows

3.1 Introduction

It is apparent that there is a wide variety of factors affecting the financial implications of short leases and break clauses. Valuers are faced with the task of reflecting the rental and capital value implications of this diversity within their appraisals. It is well documented that when faced relatively novel lease structures, valuers tend to adopt conservative practices. Indeed there are rational grounds for such an approach. Consistent with other appraisal approaches to 'anomalies', the initial research on this topic found that valuers tend to use rather ad hoc adjustments to reflect the effects of break clauses (Lizieri and Herd,1994).

Although it may be argued that any application of generalised risk adjustments by market participants to account for break options should also be used by valuers in assessing market values, previous research has shown that established rules-of-thumb in valuation practice are often at odds with activities in the market or that there is diversity of application within the market (O'Roarty et al, 1997). Further, given the combination of asset heterogeneity, confidentiality and 'thin' trading, the usefulness of direct comparison methods of valuation will be limited. For break clauses, this drawback will be further exacerbated by the diversity of break clauses.

3.2 Simulation approaches

In this method of analysis, the distribution of possible outcomes is generated by a computer using randomisation based on specified probability distributions. Lizieri and Herd (1994) used simulation as a method of pricing break clauses. They examined approaches to the problem by practitioners and found a notable lack of consistency between valuers and in the internal logic of their assumptions.

They developed a simulation approach to formally account for the probability that tenants may exercise the right to prematurely determine the lease and found evidence of inconsistency in the application of yield adjustments as a remedy for the impact on value of break options. Indeed they concluded that in general valuers tended to adopt a conservative approach (presenting an opportunity for arbitrage trading). Their model derived the probability of tenant vacation from evidence about an 'average' rate of non-renewal by tenants.

However, given the diversity in the structure of break clauses and the heterogeneity of tenant circumstances, the applying 'average' probabilities is just as likely to fail to account accurately for the implications of break clauses and its application also to produce arbitrage possibilities. There is information available that can enable an estimation of the probability of tenant vacation.

3.3 Analytical approaches – using option pricing theory

Although simulation can be used to price financial options, specific mathematical equations have been proposed which generate similar outputs. There has been considerable interest in the potential application of option pricing techniques to property investment and development decisions (see Grenadier, 1995; Ward et al 1998; Patel and Sing, 1998 and Rowland, 1999). If the option to vacate is viewed from a typical option perspective the limitations of such methodologies can be seen.

In a typical option product the investor acquires the right to buy (call option) or sell (put option) an underlying asset before or at a pre-agreed date. In this case, since the problem is

concerned with options to vacate, the similarity is with a European put option where the tenant has the right to vacate (sell) at a pre-agreed date. The value of the option is a function of movement in the price of the underlying asset. Logically, the price volatility of the underlying asset is a key determinant of the value of the option with increasing volatility producing higher option values. Although mathematically complex in derivation, the operation of option pricing models is relatively simple. The key variable – volatility – is either estimated from analysis of historic price data or is obtained by analysing implied volatility in transactions.

It can be recognised how the volatility of property rental and yield series can impact of the financial implications of an option to vacate. Where the rental value at the point of potential letting termination is lower than the rent passing, the right to vacate may act as a downward rent review. This point is further analysed below. However, reliable application of these pricing models is, therefore, predicated on reliable historic time series and/or adequate transaction data. There are well documented problems with both these requirements in the commercial property market. Moreover, even in markets which are relatively deep, mis-estimation of volatility is a problem in valuing options (Hodges, 1990).

A good example of the limitations of the application of option pricing models to break clauses is Ward (1997). He presents an approach derived from the binomial option pricing model. Ward identifies volatility in rents as the primary factor affecting value making assumptions about the circumstances in which the tenant will vacate. Pricing outcomes are presented on the basis of a range of assumptions about rental volatility. Moreover, the focus on future rental levels (and associated volatility) ignores the role of other issues such as tenant circumstances and break clause structure. The emphasis on volatility as the primary determinant of option value will be more appropriate where there is uniformity in the structure of the option but may be problematic where there is heterogeneity in the probability of exercise. In a typical European option, the rational investor will always exercise the option when they are 'in the money'. However, in the property market we have seen that each break option is unique in terms of structure of the option and the tenant attitude to exercise.

It is illuminating to contrast this study with the case of pricing upward/downward rent reviews (Ward and French, 1997). In this case, the rationale for the application of option pricing models seems more appropriate. Where the open market rental value is below the rent passing, the rent will always fall in the case of a non-upwardly only rent review: the option will be exercised since it is 'in the money'. Ward's break option pricing model assumes that this rule also hold for break clauses. In reality, tenants may choose to exercise the break whether rents have fallen or not and in some cases may be unwilling to use the 'threat' of break to lower the rent. Moreover, in the case of downward rent reviews also, the pricing implications are dependent upon the volatility assumption and Ward and French (1997) demonstrate the relatively wide range of possible volatility-dependent pricing outcomes (see 4.5 below).

It is clear that both option pricing and simulation approaches can provide similar solutions to lease pricing issues. However, simulation seems more suitable in this context for a number of reasons.

- It can be carried out using spreadsheet-compatible analytical systems such as Crystal Ball or @RISK.
- The outputs can be integrated into conventional spreadsheet models.
- It is flexible enough to cope with non-standard or unusual situations/assumptions.
- It is relatively transparent and permits the analyst to identify the key determinants of the outputs.

3.4 OPRent: the system

OPRent is a simulation based system which is now being adopted in the UK property market. It uses the above research and theory to change the way in which property owners think about income streams, moving from a deterministic approach to a probabilistic approach. OPRent works by a statistical evaluation of risk through the modelling of the cash flows associated with a range of different elements of flexibility that could be incorporated into a lease. OPRent compares the likely cash flow from a standard lease with that expected from a lease. A technical specification is available.

Two illustrative examples of OPRent outputs are used here.

Simulation 1: Moving from a 15 year lease with 5-yearly upward-only rent reviews to a 10 year lease with a 5 year break

Assumptions

Rental value on a standard lease: £100,000 with one year rent free
Lease renewal probability: 20%
Lease break probability: 25%
Expected void: 3 quarters
Void volatility: 3 quarters
Empty property costs: £10,000 a year
Re-letting costs: £25,000
Expected rental growth: 1%
Rental growth volatility: 4%
Target return: 9%

Result

The required year 1 rent increases by 36% (see Table 2).

Table 2: Simulation 1 outputs (shorter lease with break)

Year	Cash flow: standard (£)	Cash flow: flexible (£)
1	0	0
2	100000	135900
3	100000	135900
4	100000	135900
5	100000	135900
6	108100	82492
7	108100	87969
8	108100	104576
9	108100	107424
10	108100	107484
11	115908	25200
12	115908	53931
13	115908	104907
14	115908	113256
15	115908	113256

Explanation

The higher cash flow for the flexible lease acts as compensation for the owner, but can be lost at the first review where a break operates. At this point there is a 25% chance of a break being exercised, and the system assumes a 100% chance of any tenant using the break to bring the rent back down to the market level.

After the break, there is a chance of a void and associated costs. The probability of a void falls, and the cash flow improves with every passing quarter.

At the lease end in year 10, the chance of a lease renewal is very small and the cash flow recovers only as the probability of a re-letting after an expected void period rises with passing time.

Simulation 2: Moving from a 15 year lease with 5-yearly upward-only rent reviews to a 15 year lease with rent reviews which operate in either direction

Assumptions

Rental value on a standard lease: £100,000 with one year rent free
Lease renewal probability: 20%
Lease break probability: 25%
Expected void: 3 quarters
Void volatility: 3 quarters
Empty property costs: £10,000 a year
Re-letting costs: £25,000
Expected rental growth: 1%
Rental growth volatility: 8%
Target return: 9%

Result

The required year 1 rent increases by 6% (see Table 3).

Table 3: Simulation 2 outputs (moving from upward only reviews)

Year	Cash flow: standard (£)	Cash flow: flexible (£)
1	0	0
2	100000	105712
3	100000	105712
4	100000	105712
5	100000	105712
6	114288	112322
7	114288	112322
8	114288	112322
9	114288	112322
10	114288	112322
11	126996	119580
12	126996	119580
13	126996	119580
14	126996	119580
15	126996	119580

Explanation

The key here is to compare the expected rental value using 1% rental growth (£112,322 at year 6 and £119,580 at year 11) with the expected cash flows under these two leasing options. The two-way rent review picks up exactly these values, which represent the mean cash flow where rental growth can be higher or lower than expected. The upward-only rent review picks up a higher value, which is defined as the mean cash flow where rental value growth has an expected value and a positively skewed distribution, with zero being the lowest possible value.

In many ways, the more interesting questions raised by this paper are to do with the possibility that the result of this technology will be accepted by market participants with a traditional view of property income. This impacts on lease pricing but also has implication for capital values and valuation/pricing/appraisal.

3.5 Valuation

The implications for pricing are best illustrated by using an example.

Assume the rental value of a property let on a standard lease is £100,000. The market capitalisation rate that would be applied is 7%, and a valuation of £1,428,000 would result.

In DCF terms, a required return or target IRR of 9% might be decided as appropriate. If the price of £1,428,000 is 'correct' the implied perpetuity rental growth rate required to deliver the return is 2.29%. A DCF analysis using these inputs would confirm a present value of the expected income stream of £1,428,000.

Now rental growth volatility of 8% is added to the problem. The value of the standard lease is impacted by this variable, as it includes upward-only rent reviews which create a prism through which effective cash flow growth is magnified. The greater the volatility, the greater the value of the lease with the upward only review. The following question arises: does the market value of £1,428,000 reflect the impact of rental growth volatility? If so, how can that market price be de-constructed and explained?

A required return of 9% and expected market rental growth of 2.29% produces a value of £1,428,000 only if rental growth volatility takes a value of zero.

If we accept that the price is the result of efficient market pricing, and that the market understands the impact of rental growth volatility, one of the inputs must change. This has to be either the IRR, which will be lower in a world which recognises volatility (8%), or alternatively volatility-adjusted rental growth must be lower (1.1%).

If we do not accept that price is the result of efficient market pricing, and that the market may not understand the impact of rental growth volatility, then we may assume that the 9% IRR and the implied rental growth values are fixed. The valuation then rises to £1,575,000 to take account of volatility. This is a matter for further exploration.

4. The impact of rental growth volatility on pricing and returns

In the following section, we report the results of a set of 720 OPRent simulations and the making explicit of the implicit relationships between these key variables: rental growth; capitalisation rate; IRR; and rental growth volatility. What impact do changes in rental growth volatility have on the delivered IRR? What impact do changes in rental growth volatility have on the rate of rental growth required to deliver a required return or IRR? What impact do changes in rental growth volatility have on the appropriate capitalisation rate for pricing a property cash flow to deliver a required IRR?

Results are shown in Figures 1, 2 and 3 and Tables 5-19 (Appendix). A standard 15 year lease with upward only rent reviews is used in all 720 simulations.

Figure 1: rental growth volatility and IRR

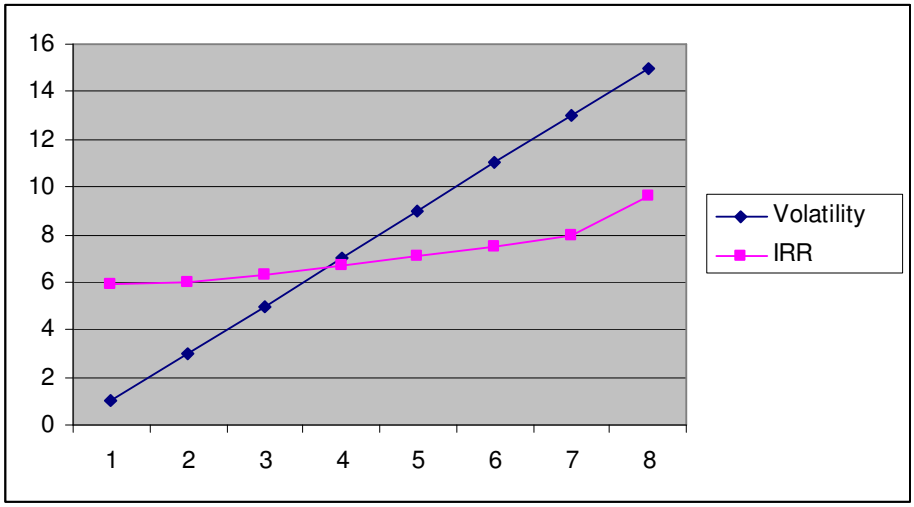


Figure 1 shows that IRR increases exponentially with rental growth volatility. Full results are reported in Tables 5-9. If market pricing models ignores volatility, as our research has established, then delivered IRRs are likely to be higher than those modelled by the market. Given a market average of close to 5% (see Table 4) the delivered IRR could be underestimated by more than 1%.

Table 4: rental growth volatility

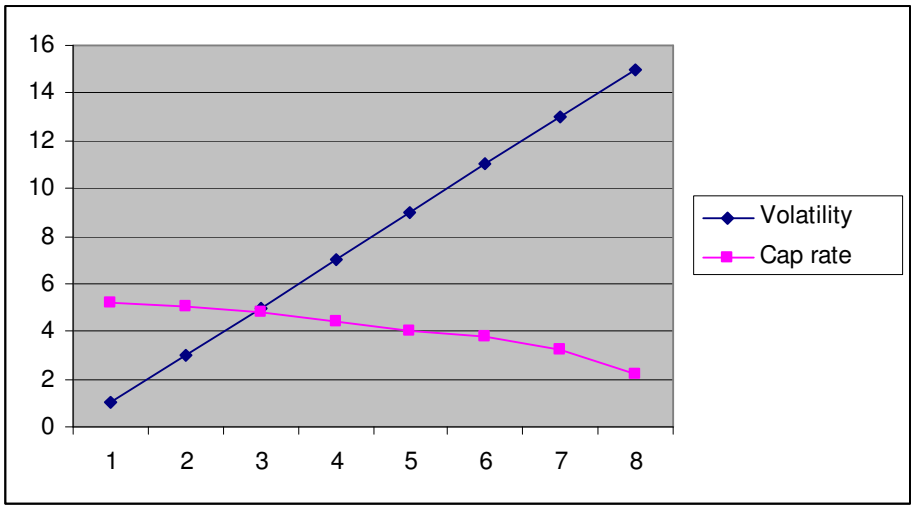
High Street Shops	4.7
Shopping Centres	3.7
Retail Warehouses	6.4
Business Parks	3.3
City & Mid Town Offices	6.9
West End Offices	8.1
Rest of London & Provincial Offices	4.7
Industrial	3.1
All Property	4.8

Source: IPD

Figure 2 shows how capitalisation rates to deliver the required return fall at an increasing rate as rental growth volatility increases. Full results are reported in Tables 10-14. Again,

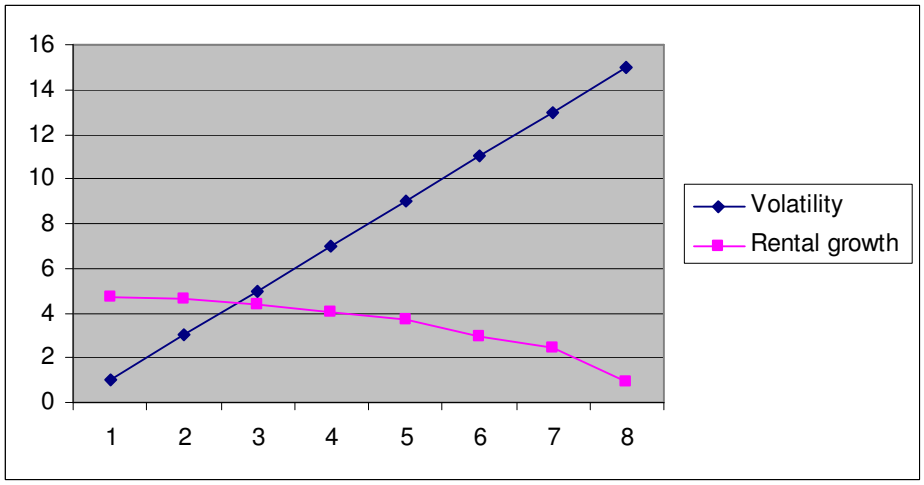
capitalisation rates which are used to value upward-only rent reviews in models which ignore rental value volatility can undervalue by using capitalisation rates which are as much as 1.5% too low at 5% market average rates of volatility.

Figure 2: rental growth volatility and capitalisation rates



Finally, Figure 3 shows how the rate of rental growth required to deliver the required return fall at an increasing rate as rental growth volatility increases. Full results are reported in Tables 15-19. Less rental growth is needed to deliver the required IRR when rental growth volatility is above zero.

Figure 3: rental growth volatility and required rental growth rate (%)



These findings have very significant implications for the pricing of UK property investment, especially those subject to upward-only rent reviews. We suggest that:

- Delivered returns will, all things being equal, exceed the returns modelled in conventional DCF appraisals.

- Capitalisation rates should be lower than those used in the market, and both traditional and DCF valuations fail to price the options inherent in the upward only rent review.

- The rental growth rates required to deliver required returns are lower than market participants believe to be the case.

For a given set of inputs regarding the required IRR, expected rental growth rates and an upward only rent review pattern, then as long as rental growth volatility is expected to exceed zero, **buyers can pay more than they think they can afford for property investments**.

References

Baum, A (2003): *OPRent Research Report 2003*, Reading, OPS.

Baum, A., Crosby, N. and McAllister, P. (2001) *Pricing Lease Terms in the Retail Sector*, University of Reading: Department of Land Management Working Paper.

Corporate Intelligence Group, (1993) *Market Research Survey,* reported in DoE Consultation Paper on Commercial Property Leases: Response by IPF, London, Investment Property Forum.

Crosby, N., Murdoch, S. and Markwell, S. (2000) *Monitoring the Code of Practice for Commercial Leases,* London: Department of the Environment, Transport and the Regions, 2000,152pp + App 236pp.

Crosby, N. and Murdoch, S. (1997) *The influence of procedure on rent determination in the commercial property market of England and Wales,* Paper delivered at RICS 'Cutting Edge' Research Conferences, Dublin, 1997.

Crosby, N., Lizieri, C and Murdoch, S. (1998) *Changing Lease Structures in Real Estate Office Markets,* Paper delivered at ERES/AREUEA conference, Maastricht.

Drivers Jonas (1997) *Commercial Leases - A Permanent Revolution*, Drivers Jonas Research.

Grenadier, S. (1995) *Valuing lease contracts: A real-options approach,* Journal of Financial Economics, Vol .38, pp. 297-331.

Grenadier, S (2003) *An Equilibrium Analysis of Real Estate Leases*, National Bureau of Economic Research Working Paper 9475

Hodges S D (Ed) (1990) *Options: Recent Advances in Theory and Practice*, Manchester University Press, 1990.

Lizieri, C. and Herd, G. (1994) *Valuing and appraising new lease forms: the case of break clauses in office markets,* Proceedings of RICS The Cutting Edge property research conference, September, 1994.

Lizieri, C. (for the Business Space Research Team) (1997) *The changing market for business space: occupier requirements, market response and valuation impacts,* Paper delivered at RICS 'Cutting Edge' Research Conference, Dublin, 1997.

McAllister, P (2000). *Pricing short leases and break clauses using simulation methodology,* University of Reading: Department of Land Management Working Paper.

McAllister, P. and O'Roarty, B. (1998): *The legal and valuation implications of break clauses: a behavourial perspective,* Paper delivered at RICS Cutting Edge conference, de Montfort University, 1998.

McAllister P. and O'Roarty, B. (1999): *Pricing break clauses: a fundamental approach,* Paper delivered at the RICS Cutting Edge conference, Cambridge.

O'Roarty, B., McGreal, S. and Adair, A. (1997): *The impact of retailers' store selection criteria on the estimation of retail rents,* Journal of Property Valuation and Investment 15 (2) pp 119-130.

Patel, K. and Sing, T.F. (1998): *Application of Contingent Claim Valuation (Real Option) Model for Property Investment Analysis,* Paper delivered at RICS 'Cutting Edge' Conference, de Montfort University, 1998.

Reynolds, K. (1997): *Can Tenants Use Break Clauses to Re-negotiate Rents Downwards?,* in Proceedings of Henry Stewart Conference Studies, Break Clauses, London.

Rowland, P. (1999): *Pricing lease covenants: turning theory into practice,* Paper delivered at PRRES conference, Kuala Lumpur.

Slessenger, E. and Ballaster, R. (1994): *Tenants' break clauses*, Estates Gazette, Issue 9446, pp.196-7.

Ward, C. (1997): *Risk neutrality and the pricing of specific financial aspects of UK leases,* Paper delivered at RICS 'Cutting Edge' Research Conferences, Dublin, 1997.

Ward, C., Hendershott, P. and French, N, (1998): *Pricing Upwards Only Rent Review Clauses: An International Perspective,* Journal of Property Valuation & Investment, 16(5), 1998, 447-454.

Ward, C. and French, N. (1997): *The Valuation of Upwards Only Rent Reviews: an Option Pricing model*, Journal of Property Valuation & Investment 15(2), 171-182.

www.OPRent.com

Appendix

Table 5: rental growth volatility and IRR (%): 1

Observation	Rental growth	Cap rate	Rental growth volatility	IRR
1	1	5	1	5.881
2	1	5	3	6.025
3	1	5	5	6.295
4	1	5	7	6.7
5	1	5	9	7.1
6	1	5	11	7.524
7	1	5	13	7.976
8	1	5	15	9.646
9	1	7	1	7.855
10	1	7	3	8.02
11	1	7	5	8.26
12	1	7	7	8.563
13	1	7	9	8.969
14	1	7	11	9.475
15	1	7	13	10.375
16	1	7	15	11.446
17	1	9	1	9.825
18	1	9	3	9.994
19	1	9	5	10.317
20	1	9	7	10.567
21	1	9	9	11.107
22	1	9	11	11.712
23	1	9	13	11.826
24	1	9	15	13.111
25	1	11	1	11.795
26	1	11	3	11.979
27	1	11	5	12.273
28	1	11	7	12.549
29	1	11	9	12.981
30	1	11	11	13.597
31	1	11	13	14.214
32	1	11	15	14.485
33	1	13	1	13.77
34	1	13	3	13.949
35	1	13	5	14.214
36	1	13	7	14.545
37	1	13	9	14.943
38	1	13	11	15.359
39	1	13	13	15.943
40	1	13	15	16.573
41	1	15	1	15.747
42	1	15	3	15.916
43	1	15	5	16.174
44	1	15	7	16.54
45	1	15	9	16.923
46	1	15	11	17.269
47	1	15	13	17.805
48	1	15	15	18.318

Table 6: rental growth volatility and IRR (%): 2

Observation	Rental growth	Cap rate	Rental growth volatility	IRR
49	3	5	1	7.621
50	3	5	3	7.697
51	3	5	5	7.937
52	3	5	7	8.224
53	3	5	9	8.713
54	3	5	11	9.327
55	3	5	13	10.137
56	3	5	15	10.652
57	3	7	1	9.539
58	3	7	3	9.631
59	3	7	5	9.821
60	3	7	7	10.167
61	3	7	9	10.455
62	3	7	11	11.13
63	3	7	13	11.756
64	3	7	15	12.802
65	3	9	1	11.456
66	3	9	3	11.542
67	3	9	5	11.745
68	3	9	7	12.034
69	3	9	9	12.368
70	3	9	11	12.873
71	3	9	13	13.338
72	3	9	15	14.282
73	3	11	1	13.379
74	3	11	3	13.455
75	3	11	5	13.644
76	3	11	7	13.97
77	3	11	9	14.348
78	3	11	11	15.078
79	3	11	13	15.589
80	3	11	15	16.58
81	3	13	1	15.3
82	3	13	3	15.387
83	3	13	5	15.57
84	3	13	7	15.823
85	3	13	9	16.298
86	3	13	11	16.758
87	3	13	13	17.12
88	3	13	15	17.544
89	3	15	1	17.223
90	3	15	3	17.308
91	3	15	5	17.485
92	3	15	7	17.734
93	3	15	9	18.095
94	3	15	11	18.629
95	3	15	13	19.15
96	3	15	15	19.825

Table 7: rental growth volatility and IRR (%): 3

Observation	Rental growth	Cap rate	Rental growth volatility	IRR
97	5	5	1	9.37
98	5	5	3	9.441
99	5	5	5	9.615
100	5	5	7	9.795
101	5	5	9	10.291
102	5	5	11	10.92
103	5	5	13	11.22
104	5	5	15	11.652
105	5	7	1	11.238
106	5	7	3	11.32
107	5	7	5	11.477
108	5	7	7	11.747
109	5	7	9	12.106
110	5	7	11	12.602
111	5	7	13	13.245
112	5	7	15	14.296
113	5	9	1	13.108
114	5	9	3	13.184
115	5	9	5	13.367
116	5	9	7	13.615
117	5	9	9	14.031
118	5	9	11	14.577
119	5	9	13	15.296
120	5	9	15	15.643
121	5	11	1	14.979
122	5	11	3	15.052
123	5	11	5	15.171
124	5	11	7	15.436
125	5	11	9	15.756
126	5	11	11	16.461
127	5	11	13	16.935
128	5	11	15	17.305
129	5	13	1	16.851
130	5	13	3	16.931
131	5	13	5	17.074
132	5	13	7	17.319
133	5	13	9	17.769
134	5	13	11	18.214
135	5	13	13	18.716
136	5	13	15	19.192
137	5	15	1	18.727
138	5	15	3	18.79
139	5	15	5	18.951
140	5	15	7	19.173
141	5	15	9	19.563
142	5	15	11	19.87
143	5	15	13	20.148
144	5	15	15	20.806

Table 8: rental growth volatility and IRR (%): 4

Observation	Rental growth	Cap rate	Rental growth volatility	IRR
145	7	5	1	11.123
146	7	5	3	11.192
147	7	5	5	11.376
148	7	5	7	11.688
149	7	5	9	12.187
150	7	5	11	12.333
151	7	5	13	13.163
152	7	5	15	13.503
153	7	7	1	12.947
154	7	7	3	13.024
155	7	7	5	13.191
156	7	7	7	13.534
157	7	7	9	13.723
158	7	7	11	14.142
159	7	7	13	14.689
160	7	7	15	15.454
161	7	9	1	14.773
162	7	9	3	14.852
163	7	9	5	15
164	7	9	7	15.22
165	7	9	9	15.613
166	7	9	11	15.956
167	7	9	13	17.012
168	7	9	15	16.987
169	7	11	1	16.599
170	7	11	3	16.66
171	7	11	5	16.804
172	7	11	7	17.018
173	7	11	9	17.408
174	7	11	11	17.945
175	7	11	13	18.205
176	7	11	15	18.836
177	7	13	1	18.424
178	7	13	3	18.488
179	7	13	5	18.673
180	7	13	7	18.853
181	7	13	9	19.176
182	7	13	11	19.657
183	7	13	13	20.091
184	7	13	15	20.737
185	7	15	1	20.255
186	7	15	3	20.314
187	7	15	5	20.458
188	7	15	7	20.692
189	7	15	9	21.004
190	7	15	11	21.514
191	7	15	13	21.84
192	7	15	15	22.364

Table 9: rental growth volatility and IRR (%): 5

Observation	Rental growth	Cap rate	Rental growth volatility	IRR
193	9	5	1	12.882
194	9	5	3	12.981
195	9	5	5	13.144
196	9	5	7	13.396
197	9	5	9	13.643
198	9	5	11	14.331
199	9	5	13	15.09
200	9	5	15	15.326
201	9	7	1	14.666
202	9	7	3	14.74
203	9	7	5	14.874
204	9	7	7	15.193
205	9	7	9	15.465
206	9	7	11	15.854
207	9	7	13	16.417
208	9	7	15	16.982
209	9	9	1	16.447
210	9	9	3	16.527
211	9	9	5	16.673
212	9	9	7	16.911
213	9	9	9	17.195
214	9	9	11	17.598
215	9	9	13	18.194
216	9	9	15	19.095
217	9	11	1	18.231
218	9	11	3	18.306
219	9	11	5	18.459
220	9	11	7	18.678
221	9	11	9	18.838
222	9	11	11	19.383
223	9	11	13	19.811
224	9	11	15	20.216
225	9	13	1	20.016
226	9	13	3	20.083
227	9	13	5	20.203
228	9	13	7	20.397
229	9	13	9	20.65
230	9	13	11	21.057
231	9	13	13	21.468
232	9	13	15	22.257
233	9	15	1	21.803
234	9	15	3	21.87
235	9	15	5	21.988
236	9	15	7	22.165
237	9	15	9	22.5
238	9	15	11	22.836
239	9	15	13	23.287
240	9	15	15	23.788

Table 10: rental growth volatility and cap rate (%): 1

Observation	Rental growth	IRR	Rental growth volatility	Cap rate
241	1	6.06	1	5.18
242	1	6.06	3	5.032
243	1	6.06	5	4.789
244	1	6.06	7	4.439
245	1	6.06	9	4.01
246	1	6.06	11	3.765
247	1	6.06	13	3.241
248	1	6.06	15	2.205
249	1	8.06	1	7.212
250	1	8.06	3	7.037
251	1	8.06	5	6.799
252	1	8.06	7	6.478
253	1	8.06	9	6.097
254	1	8.06	11	5.59
255	1	8.06	13	4.978
256	1	8.06	15	4.26
257	1	10.06	1	9.237
258	1	10.06	3	9.066
259	1	10.06	5	8.782
260	1	10.06	7	8.421
261	1	10.06	9	8.022
262	1	10.06	11	7.392
263	1	10.06	13	6.896
264	1	10.06	15	6.329
265	1	12.06	1	11.265
266	1	12.06	3	11.086
267	1	12.06	5	10.83
268	1	12.06	7	10.461
269	1	12.06	9	10.049
270	1	12.06	11	9.594
271	1	12.06	13	9
272	1	12.06	15	8.517
273	1	14.06	1	13.293
274	1	14.06	3	13.103
275	1	14.06	5	12.776
276	1	14.06	7	12.51
277	1	14.06	9	12.093
278	1	14.06	11	11.513
279	1	14.06	13	11.156
280	1	14.06	15	10.688
281	1	16.06	1	15.32
282	1	16.06	3	15.131
283	1	16.06	5	14.869
284	1	16.06	7	14.582
285	1	16.06	9	14.123
286	1	16.06	11	13.73
287	1	16.06	13	13.117
288	1	16.06	15	12.393

Table 11: rental growth volatility and cap rate (%): 2

Observation	Rental growth	IRR	Rental growth volatility	Cap rate
289	3	6.06	1	3.377
290	3	6.06	3	3.283
291	3	6.06	5	3.038
292	3	6.06	7	2.829
293	3	6.06	9	2.395
294	3	6.06	11	1.765
295	3	6.06	13	1.319
296	3	6.06	15	0.857
297	3	8.06	1	5.458
298	3	8.06	3	5.369
299	3	8.06	5	5.146
300	3	8.06	7	4.83
301	3	8.06	9	4.249
302	3	8.06	11	3.947
303	3	8.06	13	3.208
304	3	8.06	15	1.877
305	3	10.06	1	7.542
306	3	10.06	3	7.455
307	3	10.06	5	7.256
308	3	10.06	7	6.906
309	3	10.06	9	6.499
310	3	10.06	11	6.005
311	3	10.06	13	5.572
312	3	10.06	15	4.734
313	3	12.06	1	9.626
314	3	12.06	3	9.526
315	3	12.06	5	9.29
316	3	12.06	7	8.948
317	3	12.06	9	8.619
318	3	12.06	11	7.948
319	3	12.06	13	7.554
320	3	12.06	15	6.94
321	3	14.06	1	11.709
322	3	14.06	3	11.628
323	3	14.06	5	11.391
324	3	14.06	7	11.148
325	3	14.06	9	10.777
326	3	14.06	11	10.367
327	3	14.06	13	9.745
328	3	14.06	15	7.919
329	3	16.06	1	13.793
330	3	16.06	3	13.712
331	3	16.06	5	13.498
332	3	16.06	7	13.158
333	3	16.06	9	12.816
334	3	16.06	11	12.306
335	3	16.06	13	11.924
336	3	16.06	15	11.247

Table 12: rental growth volatility and cap rate (%): 3

Observation	Rental growth	IRR	Rental growth volatility	Cap rate
337	5	6.06	1	1.464
338	5	6.06	3	1.367
339	5	6.06	5	1.149
340	5	6.06	7	0.792
341	5	6.06	9	0.507
342	5	6.06	11	-0.172
343	5	6.06	13	-0.784
344	5	6.06	15	-1.345
345	5	8.06	1	3.601
346	5	8.06	3	3.514
347	5	8.06	5	3.323
348	5	8.06	7	3.012
349	5	8.06	9	2.274
350	5	8.06	11	2.137
351	5	8.06	13	1.176
352	5	8.06	15	0.957
353	5	10.06	1	5.741
354	5	10.06	3	5.649
355	5	10.06	5	5.486
356	5	10.06	7	5.167
357	5	10.06	9	4.741
358	5	10.06	11	4.116
359	5	10.06	13	3.941
360	5	10.06	15	3.299
361	5	12.06	1	7.88
362	5	12.06	3	7.798
363	5	12.06	5	7.629
364	5	12.06	7	7.296
365	5	12.06	9	6.956
366	5	12.06	11	6.363
367	5	12.06	13	5.867
368	5	12.06	15	5.165
369	5	14.06	1	10.018
370	5	14.06	3	9.934
371	5	14.06	5	9.724
372	5	14.06	7	9.388
373	5	14.06	9	9.116
374	5	14.06	11	8.687
375	5	14.06	13	8.117
376	5	14.06	15	7.408
377	5	16.06	1	12.154
378	5	16.06	3	12.089
379	5	16.06	5	11.866
380	5	16.06	7	11.619
381	5	16.06	9	11.265
382	5	16.06	11	10.939
383	5	16.06	13	10.389
384	5	16.06	15	9.719

Table 13: rental growth volatility and cap rate (%): 4

Observation	Rental growth	IRR	Rental growth volatility	Cap rate
385	7	6.06	1	-0.546
386	7	6.06	3	-0.644
387	7	6.06	5	-0.813
388	7	6.06	7	-1.128
389	7	6.06	9	-1.809
390	7	6.06	11	-2.082
391	7	6.06	13	-2.762
392	7	6.06	15	-3.599
393	7	8.06	1	1.643
394	7	8.06	3	1.54
395	7	8.06	5	1.354
396	7	8.06	7	1.091
397	7	8.06	9	0.629
398	7	8.06	11	-0.071
399	7	8.06	13	-0.728
400	7	8.06	15	-1.463
401	7	10.06	1	3.835
402	7	10.06	3	3.737
403	7	10.06	5	3.527
404	7	10.06	7	3.311
405	7	10.06	9	2.855
406	7	10.06	11	2.221
407	7	10.06	13	1.791
408	7	10.06	15	1.024
409	7	12.06	1	6.028
410	7	12.06	3	5.94
411	7	12.06	5	5.754
412	7	12.06	7	5.47
413	7	12.06	9	5.136
414	7	12.06	11	4.466
415	7	12.06	13	3.944
416	7	12.06	15	3.368
417	7	14.06	1	8.22
418	7	14.06	3	8.132
419	7	14.06	5	7.966
420	7	14.06	7	7.657
421	7	14.06	9	7.244
422	7	14.06	11	6.836
423	7	14.06	13	5.936
424	7	14.06	15	5.719
425	7	16.06	1	10.412
426	7	16.06	3	10.329
427	7	16.06	5	10.157
428	7	16.06	7	9.958
429	7	16.06	9	9.501
430	7	16.06	11	9.033
431	7	16.06	13	8.574
432	7	16.06	15	7.661

Table 14: rental growth volatility and cap rate (%): 5

Observation	Rental growth	IRR	Rental growth volatility	Cap rate
433	9	6.06	1	-2.651
434	9	6.06	3	-2.747
435	9	6.06	5	-2.944
436	9	6.06	7	-3.283
437	9	6.06	9	-3.829
438	9	6.06	11	-4.437
439	9	6.06	13	-4.898
440	9	6.06	15	-5.493
441	9	8.06	1	-0.409
442	9	8.06	3	-0.535
443	9	8.06	5	-0.756
444	9	8.06	7	-1.082
445	9	8.06	9	-1.517
446	9	8.06	11	-2.013
447	9	8.06	13	-3.048
448	9	8.06	15	-3.736
449	9	10.06	1	1.831
450	9	10.06	3	1.729
451	9	10.06	5	1.514
452	9	10.06	7	1.293
453	9	10.06	9	0.845
454	9	10.06	11	0.202
455	9	10.06	13	-0.506
456	9	10.06	15	-1.478
457	9	12.06	1	4.075
458	9	12.06	3	3.971
459	9	12.06	5	3.801
460	9	12.06	7	3.481
461	9	12.06	9	3.018
462	9	12.06	11	2.576
463	9	12.06	13	1.66
464	9	12.06	15	1.163
465	9	14.06	1	6.319
466	9	14.06	3	6.229
467	9	14.06	5	6.055
468	9	14.06	7	5.691
469	9	14.06	9	5.377
470	9	14.06	11	4.722
471	9	14.06	13	4.547
472	9	14.06	15	3.376
473	9	16.06	1	8.565
474	9	16.06	3	8.485
475	9	16.06	5	8.313
476	9	16.06	7	8.064
477	9	16.06	9	7.64
478	9	16.06	11	7.083
479	9	16.06	13	6.559
480	9	16.06	15	5.932

Table 15: rental growth volatility and required rental growth rate (%): 1

Observation	Cap rate	IRR	Rental growth volatility	Rental growth
481	5	5	1	-0.026
482	5	5	3	-0.253
483	5	5	5	-0.58
484	5	5	7	-1.234
485	5	5	9	-1.551
486	5	5	11	-2.429
487	5	5	13	-2.847
488	5	5	15	-3.377
489	5	7	1	2.226
490	5	7	3	2.1
491	5	7	5	1.809
492	5	7	7	1.381
493	5	7	9	0.795
494	5	7	11	0.335
495	5	7	13	-0.549
496	5	7	15	-1.237
497	5	9	1	4.401
498	5	9	3	4.289
499	5	9	5	4.111
500	5	9	7	3.722
501	5	9	9	3.158
502	5	9	11	2.588
503	5	9	13	2.076
504	5	9	15	0.691
505	5	11	1	6.567
506	5	11	3	6.453
507	5	11	5	6.233
508	5	11	7	5.881
509	5	11	9	5.422
510	5	11	11	4.982
511	5	11	13	4.251
512	5	11	15	3.299
513	5	13	1	8.717
514	5	13	3	8.613
515	5	13	5	8.414
516	5	13	7	8.032
517	5	13	9	7.667
518	5	13	11	7.089
519	5	13	13	6.202
520	5	13	15	5.493
521	5	15	1	10.851
522	5	15	3	10.742
523	5	15	5	10.497
524	5	15	7	10.083
525	5	15	9	9.618
526	5	15	11	9.346
527	5	15	13	8.895
528	5	15	15	7.798

Table 16: rental growth volatility and required rental growth rate (%): 2

Observation	Cap rate	IRR	Rental growth volatility	Rental growth
529	7	7	1	-0.06
530	7	7	3	-0.345
531	7	7	5	-0.708
532	7	7	7	-1.18
533	7	7	9	-1.702
534	7	7	11	-2.483
535	7	7	13	-3.519
536	7	7	15	-4.431
537	7	9	1	2.306
538	7	9	3	2.189
539	7	9	5	1.874
540	7	9	7	1.544
541	7	9	9	0.805
542	7	9	11	0.187
543	7	9	13	-0.62
544	7	9	15	-1.766
545	7	11	1	4.557
546	7	11	3	4.446
547	7	11	5	4.26
548	7	11	7	3.913
549	7	11	9	3.367
550	7	11	11	2.654
551	7	11	13	1.645
552	7	11	15	1.149
553	7	13	1	6.787
554	7	13	3	6.689
555	7	13	5	6.45
556	7	13	7	6.087
557	7	13	9	5.626
558	7	13	11	4.961
559	7	13	13	4.398
560	7	13	15	3.643
561	7	15	1	8.998
562	7	15	3	8.891
563	7	15	5	8.682
564	7	15	7	8.442
565	7	15	9	7.912
566	7	15	11	7.21
567	7	15	13	6.444
568	7	15	15	5.874
569	7	17	1	11.193
570	7	17	3	11.073
571	7	17	5	10.905
572	7	17	7	10.529
573	7	17	9	10.279
574	7	17	11	9.425
575	7	17	13	8.93
576	7	17	15	8.028

Table 17: rental growth volatility and required rental growth rate (%): 3

Observation	Cap rate	IRR	Rental growth volatility	Rental growth
577	9	9	1	-0.087
578	9	9	3	-0.446
579	9	9	5	-0.919
580	9	9	7	-1.541
581	9	9	9	-1.893
582	9	9	11	-2.748
583	9	9	13	-3.795
584	9	9	15	-4.753
585	9	11	1	2.385
586	9	11	3	2.284
587	9	11	5	2.004
588	9	11	7	1.408
589	9	11	9	0.89
590	9	11	11	0.401
591	9	11	13	-0.451
592	9	11	15	-1.524
593	9	13	1	4.717
594	9	13	3	4.619
595	9	13	5	4.405
596	9	13	7	4.04
597	9	13	9	3.685
598	9	13	11	2.953
599	9	13	13	2.418
600	9	13	15	0.957
601	9	15	1	7.017
602	9	15	3	6.911
603	9	15	5	6.745
604	9	15	7	6.493
605	9	15	9	5.986
606	9	15	11	5.37
607	9	15	13	4.742
608	9	15	15	3.256
609	9	17	1	9.293
610	9	17	3	9.18
611	9	17	5	9.016
612	9	17	7	8.687
613	9	17	9	8.309
614	9	17	11	7.815
615	9	17	13	7.191
616	9	17	15	6.287
617	9	19	1	11.544
618	9	19	3	11.438
619	9	19	5	11.26
620	9	19	7	10.909
621	9	19	9	10.596
622	9	19	11	9.802
623	9	19	13	9.392
624	9	19	15	8.749

Table 18: rental growth volatility and required rental growth rate (%): 4

Observation	Cap rate	IRR	Rental growth volatility	Rental growth
625	11	11	1	-0.122
626	11	11	3	-0.557
627	11	11	5	-0.988
628	11	11	7	-1.686
629	11	11	9	-2.339
630	11	11	11	-2.971
631	11	11	13	-4.245
632	11	11	15	-5.198
633	11	13	1	2.473
634	11	13	3	2.345
635	11	13	5	2.065
636	11	13	7	1.529
637	11	13	9	0.896
638	11	13	11	0.179
639	11	13	13	-0.511
640	11	13	15	-1.595
641	11	15	1	4.884
642	11	15	3	4.798
643	11	15	5	4.543
644	11	15	7	4.228
645	11	15	9	3.772
646	11	15	11	3.219
647	11	15	13	2.286
648	11	15	15	1.362
649	11	17	1	7.252
650	11	17	3	7.153
651	11	17	5	6.956
652	11	17	7	6.602
653	11	17	9	6.013
654	11	17	11	5.579
655	11	17	13	5.128
656	11	17	15	4.251
657	11	19	1	9.596
658	11	19	3	9.492
659	11	19	5	9.322
660	11	19	7	8.998
661	11	19	9	8.554
662	11	19	11	7.983
663	11	19	13	7.186
664	11	19	15	6.776
665	11	21	1	11.908
666	11	21	3	11.812
667	11	21	5	11.591
668	11	21	7	11.265
669	11	21	9	10.865
670	11	21	11	10.428
671	11	21	13	9.488
672	11	21	15	8.515

Table 19: rental growth volatility and required rental growth rate (%): 5

Observation	Cap rate	IRR	Rental growth volatility	Rental growth
673	13	13	1	-0.162
674	13	13	3	-0.617
675	13	13	5	-1.152
676	13	13	7	-1.719
677	13	13	9	-2.428
678	13	13	11	-3.675
679	13	13	13	-4.22
680	13	13	15	-5.376
681	13	15	1	2.564
682	13	15	3	2.458
683	13	15	5	2.128
684	13	15	7	1.663
685	13	15	9	1.126
686	13	15	11	0.49
687	13	15	13	-0.461
688	13	15	15	-1.392
689	13	17	1	5.056
690	13	17	3	4.959
691	13	17	5	4.788
692	13	17	7	4.361
693	13	17	9	3.972
694	13	17	11	3.305
695	13	17	13	2.663
696	13	17	15	1.961
697	13	19	1	7.505
698	13	19	3	7.424
699	13	19	5	7.193
700	13	19	7	6.856
701	13	19	9	6.511
702	13	19	11	5.945
703	13	19	13	5.411
704	13	19	15	4.228
705	13	21	1	9.909
706	13	21	3	9.804
707	13	21	5	9.613
708	13	21	7	9.372
709	13	21	9	8.825
710	13	21	11	8.361
711	13	21	13	7.888
712	13	21	15	6.798
713	13	23	1	12.282
714	13	23	3	12.176
715	13	23	5	12.016
716	13	23	7	11.722
717	13	23	9	11.251
718	13	23	11	10.791
719	13	23	13	9.792
720	13	23	15	9.217