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Jackson, C.C., Crosby, F.N. and Orr, A. (2016) Refining the real estate pricing model. Journal of Property Research, 33 (4). pp. 332-358. ISSN 0959-9916

https://doi.org/10.1080/09599916.2016.1237539

Refining the real estate pricing model

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Abstract

Investment theory dictates that capitalisation (cap) rates for freehold real estate should be determined by the risk free nominal rate of return plus the risk premium (RP) less the expected growth rate, with an allowance for depreciation. However, importing the concept of the RP from the capital markets fails to guide investors through the complexities of the asset, or enable exploration of purchaser preferences and behaviour. A refined pricing model for real estate is proposed, based on a concept termed a risk scale, to distinguish between macro (market) and micro (stock) determinants of risk and growth within the RP.

This pricing model is estimated for a major global investment market, using a cross-sectional inter-temporal framework, with a dataset of 497 transactions in the London office sector over 2010Q2-2012Q3. Average cap rates are estimated at just over 5%, with asset-specific attributes dominating yield determination, with submarket quality and tenant covenant most important; and unexpired term insignificant, surprising during the “flight to safety” characterising the period. International investors bought at lower cap rates, despite the ongoing economic and financial instability of the study period. Improving understanding of pricing behaviour and market transparency is important and may be advanced through the pricing model.

Key words – Property investment, office market, London, capitalisation rates, risk premium.

Refining the real estate pricing model

1. Introduction

The nature and behaviour of commercial investors have radically altered in the wake of the globalisation and liberalisation of capital and investment markets during the second half of the 20th Century and the first few years of the 21st. A consequence of these changes has been that the ownership of larger, more valuable real estate has shifted from small local entrepreneurs to major real estate companies, financial institutions and funds, both national and international, with banks acting as a major source of finance for much of this change. Subsequently, commercial investment real estate pricing has developed within an increasingly sophisticated, analytical and global environment.

However, the relative lack of transaction volumes in the direct real estate market, and the fact that many transactions are not in the public domain, has restricted analysis of pricing and investor behaviour in the acquisition and sale process, in performance measurement and in bank lending decision-making. This is significant given that Gordon's (1959) pricing model, used within real estate markets, has been adopted from the capital markets and might struggle to cope with the unique and complex nature of the asset. The aim of this study is to redress this imbalance by revisiting and extending the theoretical pricing model to fully reflect both the complex characteristics of the real estate market and of the asset attributes that drive returns, to provide a framework for systematic asset pricing.

This new, explicit framework is operationalised in the second half of the paper, to provide an example of its utility by empirically estimating the perceived risk attached to specific real estate market and asset attributes. There have been very few empirical studies that have attempted to measure the importance of attributes in the pricing process. Most studies have investigated the determination of capitalisation (cap) rates using aggregated data (for example, Nourse, 1987; Ambrose and Nourse, 1993; McGough and Tsolacos, 2001). No published study has examined variation in the determination of cap rates on a cross-sectional basis in the UK, and here transaction data for the central London office market, one of the largest global real estate markets, are utilised. Operationalising the model in this way utilises highly disaggregated granular transaction data, not previously available for study, and provides new insights into the relative importance of investment attributes in the determination of cap rates and, further, investor pricing behaviour is explored.

2. The real estate pricing model

Pricing studies

Previous studies that have investigated real estate yields have tended to adopt one of three broad approaches. The first focuses on estimating cap rates as a function of macro-economic and capital market variables, for example Froland (1987), Evans (1990) and Chandrasekaran and Young (2000). Froland explained 86-95% of the variation in US cap rates between 1970 and 1986, although attracted criticism for his lack of theoretical foundations (Jud and Winkler, 1995) and for failing to allow for real estate sector differences or for the effects of time (Chandrasekaran and Young, 2000). Evans (1990) and Chandrasekaran and Young (2000) examine cap rates for residential/commercial real estate, concluding that real estate investors are slower to adjust their expectations than stock market investors in response to changes in the macro-economy, isolating the real estate market from the capital markets.

The second approach is dominated by the US Band of Investment framework, largely based on Modigliani and Millier's (1958) seminal work on corporate finance and weighted average cost of capital. Initially, Ambrose and Nourse (1993) modelled average cap rates as a fixed effects panel model. In this simple two-level hierarchical model, they derive a function of location and market factors and debt and equity components, as defined by the Band of Investment approach, to explain sector based cap rates. They conclude that a cross-section/time series panel approach provides parameters that are most consistent with *a priori* expectations of the Band of Investment model. However, they find that most of the variation is explained by real estate type, captured by the intercept terms, and argue for the need to account for the variation in yields by allowing for property-specific characteristics.

Jud and Winkler (1995) extend the work of Ambrose and Nourse by developing a model of real estate cap rates that complements traditional finance theory, drawing on Weighted Average Cost of Capital (WACC) and Capital Asset Pricing Model (CAPM) theories. They estimate cap rates as debt and equity spreads using contemporaneous and lagged spread variables and find that capital markets appear to drive the required returns on real estate. They also find that significant lag adjustments exist and that the structure of these depends on the real estate type and local areas.

Each of these first two approaches produces useful empirical evidence at a high level of aggregation but lacks the full theoretical conceptualisation needed to advance understanding of the determination of cap rates at the stock level, albeit the Band of Investment framework lays clear foundations. Thus, the third approach draws on and extends the work of Fisher (1930) and Gordon (1959), focusing on the now well-established pricing model:

$$k = RFR + RP - g \tag{1}$$

where k = cap rate, RFR = nominal risk free rate, RP = risk premium and g = growth. In some texts, the model has been extended to include depreciation *(d)*, important within the real estate sector.

Breaking the model down into its component parts reveals that some elements are well understood and represent little measurement difficulty. However, by contrast, others are less well researched or established, both in terms of the underlying determinants and the empirical estimation of the importance of each.

Risk Free Rate

Returns on individual stock vary in response to numerous factors across what could be termed a broad risk scale, determined by macro to micro levels of influence. Beginning at the macro end of the scale, as money searches for the best returns, the minimum that should satisfy is that available from a risk-free asset (RFR). Thus, drawing on Fisher (1930), Baum and Crosby (2008) set out that the RFR represents return to compensate the investor for expected inflation and time preference/impatience. Baum and Crosby discuss that the redemption yield on government bonds, matched to the term of the investment, provides an appropriate guide.

Hutchison *et al*. (2012) suggest that while this is a reasonable measure for the loss of liquidity and anticipated inflation, the relationship between real returns and expected inflation appears to have broken down in the aftermath of the financial crisis and the flight to safety, with real returns close to zero for bonds (Dimson *et al*., 2013). The debate on whether these new levels are temporary or are part of a changing dynamic in investment markets is important to understanding the level of target rates and risk premia. The traditional view of risk free rates is used here, but the uncertainty surrounding the basis of the risk free rate choice is noted. Baum and Hartzell (2012) go on to explain that, to avoid time-specific bias during unusual market periods, longer run averages may be used.

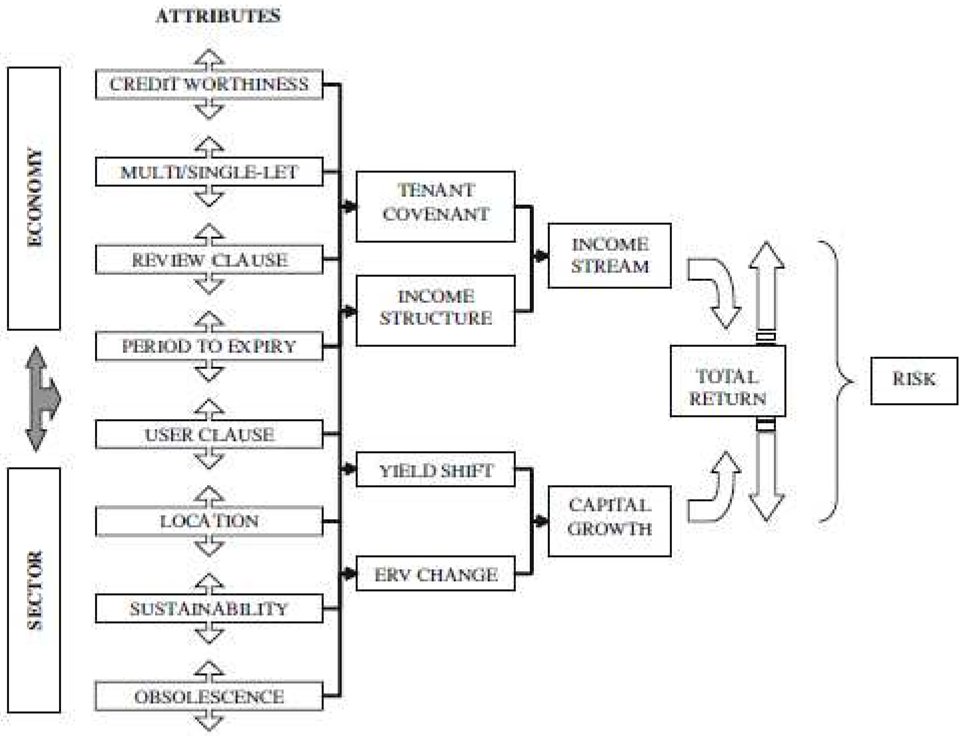
Risk Premium

Moving along the risk scale to the real estate market exposes the investor to risk, necessitating the risk premium (RP). Baum and Crosby (2008) break the RP down and discuss how it can be conceptualised and its sources disaggregated within the overarching RP. They set out three alternatives to help assess the appropriate level of the RP, but conclude that, at the individual stock level and due to definitional and data constraints, the two options provided by CAPM and WACC are of little use. They therefore focus on what they term the 'intuitive approach', drawing from Baum (2002). Thus, Baum and Crosby (2008) and Baum (2009) set out that the RP can be disaggregated into various components to include real estate market, sector, location and stock-specific factors, and each, in turn, can be seen as representing an increasingly micro level influence. The real estate market premium is stated to represent the differential risk associated with real estate compared to equivalent equity risk and, in addition, an amount to represent the sensitivity of the cash flow to economic shocks, especially in terms of volatility around rental growth and depreciation expectations which are set out explicitly in the amended Gordon growth model; illiquidity; and a catch-all group of other factors, including factors such as the impact on portfolio risk and the lease pattern. Conceptually, this is a little problematic given possible overlaps with other categories of drivers at more micro spatial scales and, therefore, more detailed specifications are sought within the conceptualisation and, of course, to enable the operationalisation of a real estate pricing model.

The sector and location components of the RP are given little attention in the literature and thus it seems sensible to continue with the idea of moving through the spectrum of spatial scales to guide conceptualisation. Thus, for example, demand and supply factors at the sector level, which drive vacancy rates and growth potential, should be included in the RP, while Baum and Crosby (2008) encourage investors to consider, within the location component, the local market and the local economic structure and catchment (and local competition) as relevant, especially in their contribution to market quality and, therefore, a sound and liquid investment opportunity at this sector/location scale.

The final component of the RP, the stock/asset premium, is disaggregated further by Baum and Crosby (2008), drawing on Baum (2002), to comprise tenant risk, lease risk, location risk and building risk – factors that underpin specific risk, each contributing to the risk and growth potential of individual stock. Jackson and Orr (2011) provide a review of studies of these stock-specific factors underpinning variation in return and risk levels, finding general consensus of the categories provided by Baum and Crosby. Drawing on these studies (for example, Wofford and Preddy, 1978; Dixon *et al*., 1999; IPD, 2000; Devaney and Lizieri, 2005; Blundell *et al*., 2005; Adair and Hutchison, 2005; Byrne and Lee, 2006), Jackson and Orr set out a conceptual model unravelling the chain of causal effects linking tenant, lease, location, building risk to asset returns and risk (Figure 1).

Figure 1. Real estate attributes, return and risk



Source: Jackson and Orr (2011)

Estimates of the Risk Premium

The level of the aggregate RP has been the subject of both empirical analysis and surveys of investors. Blundell (2009) considers the RP at the national level in the UK and that it will reflect a range of factors, such as illiquidity, expected earnings growth, default probability and so on. He estimated the risk premium on real estate over the period 1981-2008 as 3.1%. Using the equation ($k = RFR + RP - g + d$) which becomes ($RP = k - RFR + g - d$), his estimate includes the risk-free rate (as measured by the gross redemption yield on government bonds over the period) at 7.3% (*RFR*), 6.4% for the real estate initial yield (cap rate *k*), 6.3% for rental growth (*g*) and 2.3% for depreciation (*d*).. Previous empirical estimates of RP in the UK vary to include figures around 2% (Fraser, 1993, for prime real estate); 3% (Hoesli and MacGregor, 2000); an average of around 4% in the pre-crash period of 2002-06 (DTZ, annual); and at around a minimum of 3.5% in the post-crash period since 2008 (IPF/AREF, quarterly).[1] Hutchison *et al*. (2012) attempt to advance Blundell's work by modelling commercial risk premia within a time varying framework, reflecting market dynamics and cyclicality in returns. Their Markov regime switching model suggests that regime shifts are less important in the real estate market than in other investment and commodity markets. They found no evidence of

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[1] The Investment Property Forum quarterly survey of advisors and managers was taken over by the Association of Real Estate Funds in 2013 and is now available to members of AREF.

structural breaks in office risk premia, unlike other sectors, although warn that the aggregation of data may be masking structural changes, implying the need to examine risk premia at a more disaggregated level.

Growth and Depreciation

The final element of the Gordon pricing model set out in Equation 1 explicitly shows adjustments to the cap rate to reflect expected future growth, further influenced by real estate depreciation. Factors underpinning growth may be seen across the risk scale, such as the impact of the economy on the real estate market overall and variation in this across sectors and submarkets. Likewise, Crosby *et al.* (2013)'s findings on UK depreciation measurement and rates suggest that rental depreciation rates are also affected by factors across the risk scale; i.e. economic and local property market factors as well as specific property attributes. There are two possible approaches to growth expectations and depreciation. The first is to attempt to identify explicit variables for the measurement of each of these components, however in this paper we adopt a different approach and have wrapped them into the risk premium estimation, as set out below.

Most previous work does not disaggregate the components of the cap rate to the level of addressing the measurement of growth and/or depreciation across the risk scale. However, Jackson and Orr's (2011) conceptual model set out in Figure 1 traces the causes of variation in returns at the stock level back to the underlying attributes. This is important here – it is proposed that growth and depreciation expectations at the stock level are a function of the stock attributes and measurement of these attributes therefore reflects investor expectations and, therefore, pricing.

Refining the real estate pricing model

Table 1 provides a summary and conceptualisation of these complexities within a real estate pricing model. Crucially, it attempts to locate the distinct elements along a risk scale, showing a disaggregation of the components of the cap rate and causes of risk at distinct spatial scales. The final column sets out suggested variables to enable the operationalisation of the model.

Table 1. The cap rate and risk scale

Spatial Scale of Influence		Returns to Reflect	Drivers	Variables
Macro ↑	Investment and Capital Markets	RFR	Expected inflation, time preference	National level measures such as Treasury Bill rates, Gross Redemption Yields on government bonds, and actual and expected inflation rates.
	Real Estate Market	Risk and growth expectations	Performance and volatility of real estate relative to other assets	Macro-economic and industry estimates of income and capital returns and key drivers in asset markets at national, local and submarket levels.
	Sector		Market specific factors, economic/ catchment profile	
	Location			
	Stock/Asset		Tenant	Credit worthiness
			Lease	Multi/single-let, Review/user clause, Period to expiry/review
			Location	Micro location/ accessibility
↓ Micro			Building	Sustainability rating, Obsolescence

This conceptualisation allows Gordon's pricing model to be modified and extended for direct real estate by identifying the different components of the risk premium. Thus, if RP_{REM} is the part of the risk premium for exposure to the real estate market and RP_{STK} is the part of the risk premium for the stock/asset risk element attached to property-specific attributes, and, as above, if it is acknowledged that elements of these attributes influence growth expectations and depreciation, then equation 1 can be modified into:

$$k = RFR + RP_{REM} + RP_{STK} \qquad (2)$$

RP_{REM} and RP_{STK} can be refined further. Within RP_{REM}, there are the three components of RP_{mkt} (real estate market risk), RP_{sct} (real estate sector risk) and RP_{locm} (real estate market location risk). RP_{STK} is the part of the risk premium for the stock/asset risk element attached to property-specific attributes. This is composed of the four further elements of RP_{ten} (tenant risk), RP_{lse} (leasing risk factors), RP_{locs} (stock location risk) and RP_{bld} (building risk). Each of these seven distinct components of the RP reflects the elements of the risk, growth and depreciation attached to the individual stock, each derived from the various underlying market and stock-specific causes described above. Hence, this gives:

$$k = RFR + (RP_{mkt} + RP_{sct} + RP_{locm}) + (RP_{ten} + RP_{lse} + RP_{locs} + RP_{bld}) \quad (3)$$

Equation (3) provides a pricing model for real estate, based on Gordon's model, adapted and extended by explicitly disaggregating the risk premium, following the conceptualisation set out in Table 1.

3. Operationalising the model

Previous studies

Few studies have sought to undertake empirical analysis at the level of disaggregation proposed by equation (3), although some do offer important and useful findings. For instance, Sivitanidou and Sivitanides (1999) estimated US local level (metropolitan) office cap rates using local-fixed and time-variant components within a simple equilibrium adjustment framework, with time series/cross sectional versions. These local and time variant variables were found to have greater explanatory power for investors' required returns and income growth expectations than national factors, confirmed by Sivitanides *et al*. (2001) where fixed market characteristics create persistence differences in cap rates across markets, but national macro-economic forces account for some of the variation.

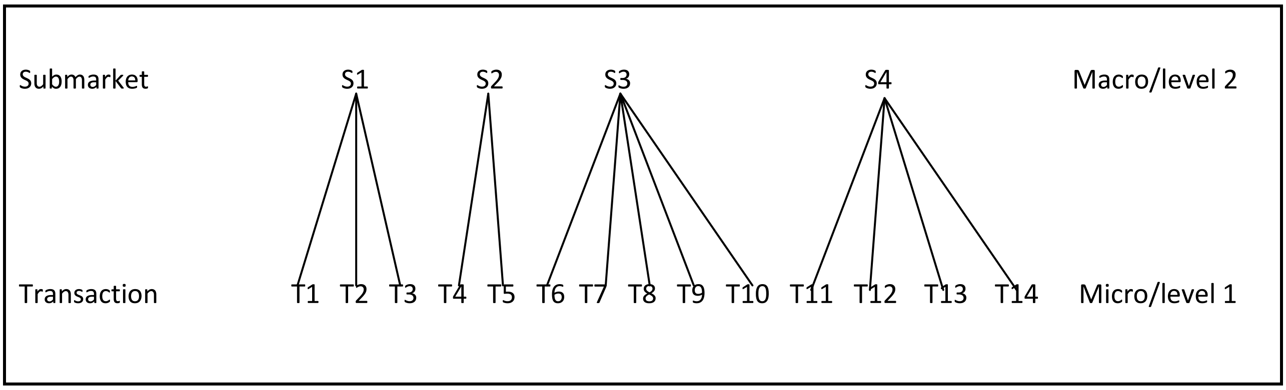
Hendershott and MacGregor (2005) apply an error correction framework to appraisal cap rates in prime UK locations and demonstrate that office and retail yields are inversely related to real expected rental growth and positively related (but insignificantly) to real dividend growth. Dunse *et al*. (2007) examine the determination of initial yields in nine provincial office markets in the UK relative to the City of London. They use the basic pricing framework and error correction panel model, with: the gross redemption yield on 15 year bonds to measure the nominal RFR; the RP is captured by the dividend yield on the FTSE 100 (proxy for the return on alternative investments) and the real value of financial institution transactions (capturing investors' perceptions of local market conditions); real rental growth (to proxy expected growth rates); with depreciation assumed to be constant. A further two variables, following the work of Hendershott and MacGregor (2005), are added to capture the deviations of rent and stock market dividend yield variables from the equilibrium.

Plazzi *et al*. (2008) and Plazzi *et al*. (2010) use transaction data for US Metropolitan Areas and build a set of simultaneous equations, derived from an extended Gordon framework, to examine the cross-sectional dispersion of rental growth and expected returns (in their 2008 paper) and time variation in expected returns, rental growth and cap rates at the area level (in their 2010 paper). They find that cap rates cannot be used to forecast expected returns and call for further work on identifying the determinants of real estate cap rates.

Current study

A framework for the estimation of the real estate pricing model developed here must recognise a number of challenges. First, the causes of disparities in cap rates can be masked by a range of real estate and transaction specific factors that operate across several spatial levels, and give rise to spatial autocorrelation. Following Orford (1993) and Leishman (2009), who used multi-level analyses when analysing local house prices to explicitly allow houses to be embedded within submarkets that are influenced by local and higher spatial level factors, a similar nested hierarchy exists within the commercial real estate market. Figure 2 shows how investment transactions can conceptually be represented as a simple two-level nested structure, where transactions are clustered within submarkets and that there may be shared influences from particular submarkets on transactions within those submarkets.

Figure 2. A unit diagram for a two level nested hierarchy



A multi-level framework, similar to the approach taken by Sivitanidou and Sivitanides (1999), will allow an exploration of the spatial variations in cap rates that are driven by submarket effects, while also measuring the variation generated by the characteristics of the real estate, its tenants, its purchaser and how wider macro-economic factors influence the expectations of purchasers with regards to individual investments. This modelling framework is suitable here as it explicitly captures the hierarchical structure of investment transaction outcomes when transactions are clustered within submarkets. Other statistical techniques, such as multiple regression, that ignore the effects of clustering, give biased standard errors which can result in random variation being mistaken for real effects.

Initially, a micro-level modelling framework is specified to capture the explanatory elements of, firstly, the impact of attributes specific to the transacted real estate in the determination of real estate cap rates achieved in each investment transaction and, second, as begun to be acknowledged in the literature above, the wider contextual and behavioural factors that can affect the outcome of the pricing decision, referred to here simply as transaction characteristics. This gives the level 1 Equation:

$$k_{ij} = \beta_{0j} + \beta_{i0} RFR + \sum \beta_{lj} RP_{STK_{lij}} + e_{ij} \quad (4)$$

where k_{ij} is the cap rate achieved in transaction *i* nested in submarket *j* and e_{ij} represents the variation in yields that cannot be explained by the real estate and transaction characteristics. This is extended from a regression model where β_{0j} accommodates the possibility of *j* intercepts as these can vary across submarkets. The risk-free rate and its parameter, and the explanatory variables and parameters, are represented by *RFR*, β_{i0}, $RP_{STK_{lij}}$ and β_{lj}, respectively. In theory there could be any number of explanatory variables within the underlying categories, but the sigma sign (∑) is used to give a concise expression for the sum of the variables that determine the cap rate in transaction *i* nested in submarket *j* and *l* represents the index of summation. These explanatory variables capture the specific real estate asset and transaction characteristics expected to impact on the return a buyer expects on a transaction, whereas the risk-free rate is expected to influence all transactions in much the same way regardless of submarket. An assumption underpinning this is that the residual term (e_{ij}) follows a normal distribution with variance equal to σ_e^2.

With reference to the conceptual framework in Table 1, investors' expectations about the performance of investments over the holding period are a function of macro/micro factors, beginning with conditions in the national capital markets and moving to real estate markets, to include market, sector and location factors which, taken together, are referred to here collectively as submarkets. Level 2 specifically captures the clustering of transactions within such submarkets, and the influence of the structural traits of the submarket (such as size, composition and quality of the market) which influence investors' risk perceptions. These effects should be common to all transactions in the same submarket so it is necessary to add an area-level error term that allows for variation between areas. Equation 5 allows for this by taking the intercept of Equation 4 (β_{0j}) and specifying it as:

(5)

$$\beta_{0j} = \gamma_{00} + \sum \gamma_{11} \mathrm{RP}_{\mathrm{REM\ lj}} + \mu_{0j}$$

This represents the macro-level equation. This equation assumes that a submarket's intercept varies around an overall average cap rate (γ_{00}) when all the predictors ($\mathrm{RP}_{\mathrm{REM}_{lj}}$) are equal to zero. $\sum \mathrm{RP}_{\mathrm{REM}}$ captures the submarket-level explanatory variables and μ_{0j} represents the deviation of submarket *j* from this average. This is also termed the submarket-specific effect. The combination of Equations 4 and 5 forms a simple two-level hierarchical framework that recognises the determination of cap rates as a transaction process nested within submarkets:

(6)

$$\mathrm{k}_{ij} = \gamma_{00} + \sum \gamma_{11} \mathrm{RP}_{\mathrm{REM}_{lj}} + \mu_{0j} + \beta_{i0} \mathrm{RFR} + \sum \beta_{lj} \mathrm{RP}_{\mathrm{STK}_{lij}} + \mathrm{e}_{ij}$$

This is a type of "fixed effect" multi-level framework and allows for two sources of random variation, at level 1 of the transaction process (e_{ij}) and at level 2 of submarkets *(* μ_{0j}). In keeping with analysis of variance models, the two variance components ($\mathrm{var}(\mathrm{e}_{ij}) = \sigma_e^2$ and $\mathrm{var}(\mu_{0j}) = \sigma_u^2$) need to be estimated along with the other parameters. The total variance is $\sigma_e^2 + \sigma_\mu^2$ and the proportion of the total variance attributed to submarkets can be estimated as $\sigma_\mu^2 / (\sigma_e^2 + \sigma_\mu^2)$ whereas the property-specific variance can be estimated as $1\text{-}(\sigma_\mu^2 / (\sigma_e^2 + \sigma_\mu^2))$. The clustering of transactions into submarkets induces a correlation between the cap rates of pairs of transactions ($\mathrm{cov}\left(\mathrm{R}_{\mathrm{er}_{ij}} \mathrm{R}_{\mathrm{er}_{i'j}}\right) = \sigma_\mu^2$) which are located within the same submarket and the size of this correlation, also referred to as the variance partitioning coefficient, should be the same as $\sigma_\mu^2 / (\sigma_e^2 + \sigma_\mu^2)$. In ordinary least square regression there should be zero correlations between the residual terms.

In Equation 6, submarket variation in cap rates is allowed for by the inclusion of fixed effects in the theoretical linear framework. This can be conceptualised as a series of submarket curves, each having different intercepts for each submarket but being similar in slope due to the same micro-level drivers having the same effects on the transaction process across all submarkets. However, it is possible that the effect of any micro-level covariate that determines cap rates will vary between submarkets, and Bailey *et al*. (2012) highlight the benefit of the hierarchical approach in that it allows for the existence of more complex patterns of variance to be investigated. This can be achieved by specifying an additional macro-level equation as:

$$\beta_{nj} = \gamma_{n0} + \mu_{nj} \tag{7}$$

Equation 7 now allows for variation in the slopes of the submarket curves where the common slope β_{nj} is replaced by another random effect. From this a random-intercept and random-slope model, including level-2 variables and cross-level interactions, is derived by substituting Equation 7 into 6 to give Equation 8.

$$k_{ij} = \gamma_{00} + \sum \gamma_{11} RP_{REM\ lj} + \gamma_{n0} RP_{STK_{nij}} + \beta_{i0} RFR + \sum \beta_{(l-n)\,j} RP_{STK_{(l-n)ij}} + \mu_{0\,j} + \mu_{nj} RP_{STK_{n1ij}} + e_{ij} \tag{8}$$

This is our theoretical mixed effect framework for operationalising our model of real estate cap rates. Within it, $\gamma_{00} + \sum \gamma_{11} RP_{REM\ lj} + \gamma_{n0} RP_{STK_{nij}} + \beta_{i0} RFR + \sum \beta_{(l-n)\,j} RP_{STK_{(l-n)ij}}$ represents fixed effects and $\mu_{0\,j} + \mu_{nj} RP_{STK_{n1ij}} + e_{ij}$ represents random effects which have two random effects at the submarket level. In a stepwise process, each of these stages in the model's development are estimated and examined to see how effective the inclusion of the fixed and random effects is in explaining cap rates.

4. Data

An exploratory estimation of the framework set out above, to operationalise the real estate pricing model, is undertaken using observed transactions in the global financial office market in central London. The analysis explores a dataset of 497 transactions in the central London office market over the period 2010 Q2-2012 Q3, representing every reported investment sale, after data cleaning and checking.[2] The data for the project are primarily provided by CoStar and comprise information on individual transactions relating to the characteristics of the occupation, leases, buildings and ownership. The building quality data from CoStar represent the first opportunity to fully explore the pricing of real estate attributes in the UK and that has driven the timescale of the analysis. The

[2] It is worth noting that this is significantly before the 2016 UK Referendum on EU membership was mooted in the 2015 Conservative election manifesto.

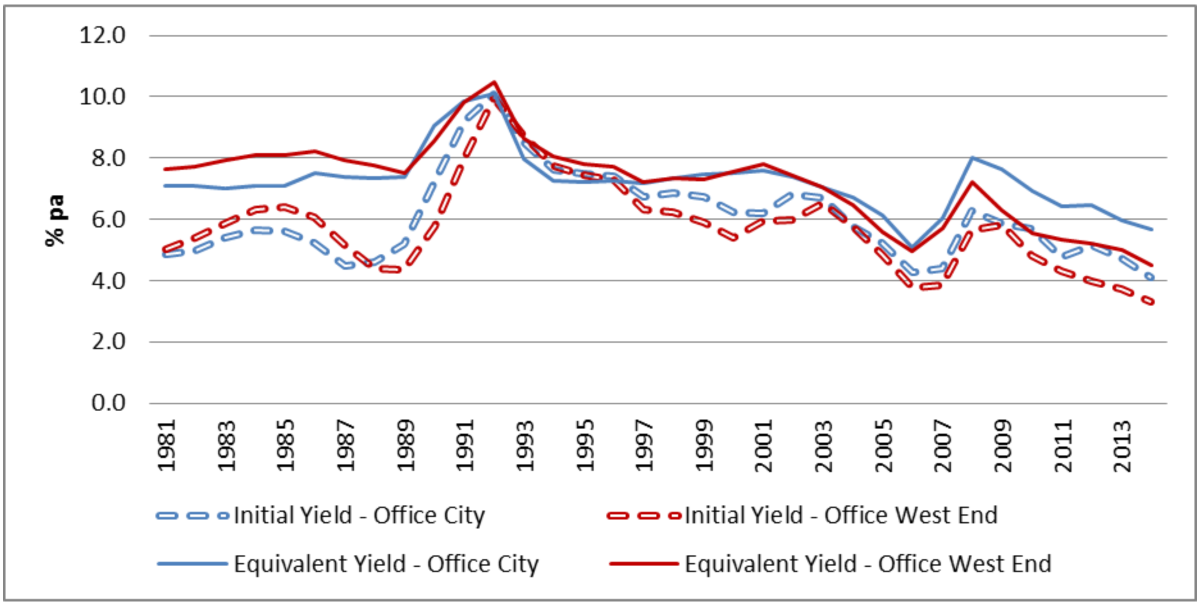
dataset is the most comprehensive available, but it has its limitations. Additional data were collated from CoStar, other sources such as EGi and provided by CBRE to both confirm and supplement the individual real estate data from CoStar. There are a number of observations that are available from multiple sources, for instance floorspace, and there were some discrepancies between sources. Prolonged and systematic data checking and validation was undertaken.

In terms of the dependent variable, the CoStar dataset only provides initial yields[3] for each transaction, necessitating calculation of the equivalent yield[4] required for the study. The equivalent yield is the preferred measure in the UK context as it takes into account not only the level of the initial rent, but also the reversion to a market rent (assuming current market levels) and the scheduled date for this change in income stream (i.e. at review or lease expiry). It is common in the UK that there are 5 years between changes in rental levels due to periodic review clauses in the lease and the lack of indexation between these periodic revisions. Thus, equivalent yields more fully reflect the level of cap rates in the UK market and are therefore the primary measure used within UK valuation and performance measurement systems (see, for example, Baum and Crosby, 2008). Figure 3 indicates the discrepancies between the two measures of initial and equivalent yield. It illustrates the London City and West End office markets between 1981 and 2015 and shows that, in the West End, apart from one year in the early 1990s when they were the same, equivalent yields were higher than initial yields, indicating positive reversionary potential (rent passing is lower than market rent). The data for the City office market illustrate that the post 1990 downturn created a period of over-renting (rent passing is higher than market rent) for four years. The main two reasons for equivalent yields being higher than initial yields for most of the period is that, normally, passing rents lag market rents and vacancies are not assumed to be infinite in the equivalent yield calculations.

[3] CoStar actually reports net initial yield which is purely the rent passing divided by the transaction price plus any purchaser's costs. Vacancies are therefore ignored causing properties with high vacancies to have low initial yields.

[4] The net Equivalent Yield is the IRR of the expected cash flow with the outlay being the transaction price plus purchaser's costs.

Figure 3: Initial and Equivalent Yields, London West End and London City Offices 1981 to 2014



Source: IPD Annual UK Property Index (MSCI)

Estimation of the equivalent yield requires some additional data, these being the market rent and the unexpired term to the next rent change.

Market rents have been determined by comparison to new lettings within the same building. Where these lettings are not contemporaneous with the transaction date, they have been updated using data from the CBRE Rent and Yield Monitor (CBRE, quarterly). The actual rent point valuations through time were given to the project confidentially and these were matched with the individual transactions within the transaction database.

The period to the next rent change was identified from the lease data collected for each transaction at the transaction date. Where a property was multi-tenanted, a weighted (by rent) average unexpired term was used. Not all lease expiry and rent revision dates were known for all leases within a transaction. Where they were not known across all leases in a property, a default of 2.42 years was used, being the average across the entire sample for those transactions where the next rent change was known.

Table 2 presents the summary descriptive statistics for the estimated cap rates in the form of equivalent yields over 13 contiguous submarkets as defined by market agents (those with very small sample sizes are merged into the neighbouring, most relevant, submarket). The skewness and kurtosis statistics above +2 or below -2 and additional distribution plots imply that the data do not fit with the normal distribution assumption and require transformation, using natural logarithms, to give a normal distribution for this, the dependent variable.

Table 2. Descriptive statistics for equivalent yields imputed for the sample of transactions across submarkets

Central London Submarket	Sample Size	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Bloomsbury	21	1.88%	12.34%	5.09%	.0236	1.492	.501	3.613	.972
City Centre	137	2.36%	28.15%	6.86%	.0347	3.175	.207	13.767	.411
City Fringe	62	0.84%	14.35%	6.50%	.0209	.770	.304	3.229	.599
Clerkenwell	24	1.57%	11.48%	6.10%	.0224	.068	.472	.392	.918
Covent Garden	38	1.15%	12.78%	5.48%	.0223	.813	.383	2.157	.750
Holborn	37	3.45%	8.69%	5.98%	.0113	.455	.388	.660	.759
Knightsbridge & Victoria	20	3.15%	15.18%	5.96%	.0313	1.981	.512	3.745	.992
Marylebone & Paddington	23	1.73%	7.43%	4.68%	.0130	-.241	.481	.206	.935
Mayfair	48	1.00%	10.01%	3.77%	.0198	1.434	.343	2.482	.674
Noho	28	2.55%	12.77%	5.13%	.0215	1.668	.441	4.705	.858
Soho	25	2.58%	10.40%	5.25%	.0223	.928	.464	.263	.902
St James	21	1.50%	10.92%	4.92%	.0218	.774	.501	1.434	.972
Westminster	13	1.46%	12.88%	6.88%	.0335	.360	.616	-.659	1.191
Total Sample	497	0.84%	28.15%	5.84%	.0274	2.434	.110	13.060	.219

The independent variables included in the analysis are largely derived from the literature, set out above. They are summarised in Table 3 and can be seen to follow the extended pricing model in equation (3) with the addition of variables to enable segmentation of the results for transaction characteristics, being the wider contextual and behavioural differences in transaction type, purchaser characteristics and time period. Two areas require expansion. Firstly, at the market level, the two components of real estate sector and location are, in effect, office submarkets, given the focus of the study on central London office markets. Thus, they are measured together using vacancy and rental variables to proxy the relative quality of each submarket, encapsulating additional factors identified as important, such as local economic structure and catchment. While the lagged vacancy data are straight-forward in their representation of perceptions of submarket quality, the differential rental measure used to indicate market quality is constructed from lagged rents, adjusted for inflation through the time frame of the project and centring around the average rent (grand mean) across all the submarkets included in the study. This allows us to interpret changes in this variable as a percentage adjustment to the average cap rate.

Table 3. Exploring the determinants of office cap rates: variables and data

Spatial Scale of Influence		Variable Group	Variable Name	Variable Definition	Data Source
		Dependent variable	Ln(EY)	Cap rate (Equivalent yield) net of purchasers' costs and in logs	Derived from transaction data on deals in Central London between Q2 2010 and Q3 2012
Macro		**Systematic Risks**			
	Investment and capital markets	Cross Market Drivers	LnNGRY	Risk free rate (R_{rf})	Quarterly average Gross Redemption Yields on 10 Years Gilts in logs (Source BoE)
			LnSPP1	Anticipated inflation	Services Producer price Index, lagged one quarter and in logs (Source NSO)
	Property market		LnDivYield	Return on alternative investments	Quarterly average dividend yields on FTSE-100 index (Source Datastream)
	Sector	Submarket Specific Drivers	SubInVac1	Submarket vacancy rate	Average submarket vacancy rate from Costar; lagged one quarter
	Location		SubLnRRent1_GC	Submarket quality	Real average rent in submarket, lagged one quarter, in logs and grand mean centred
		Asset specific risks			
	Stock/Asset	Tenant	Aver_TS	Weighted average tenant covenant strength	Measured as weighted average of covenant strength of tenants in the building; weighted by floorspace occupied. Tenant strength classified using Experian credit scores with 0=undisclosed/unknown, 1 = very low risk or government agency, 2 = below risk, 3 = normal risk, 4 = above risk; 5 high/maximum risk
		Lease	Multi	More than 1 tenant at the time of sale	Categorical variable 0=single or vacant; 1 = multi let
			Aver_Expiry	Weighted average term to lease expiry	Measured as weighted term to lease expiry in CoStar transactions in years, weighted by floorspace occupied
			Vacant	Vacant at the time of sale	Categorical variable 0=not vacant; 1 = vacant
		Location	CornerPosition	Property occupies a prominent corner site	Categorical variable 0= not on a corner; 1 = on a corner site
		Building	BuildRating	Quality of building, including extent of depreciation and obsolescence	Costar's building quality rating, which is a five point system that varies between 1 and 5. Lowest quality = 1 whereas highest equals 5
			NoResidential	Existence of a residential element in building	Categorical variable 0= residential use of part of building; 1= no residential use
Micro			NoRetail	Existence of a retail element in building	Categorical variable 0 = retail use of part of building; 1 = no retail use
		Transaction characteristics			
		Transaction traits	Type	Type of investment transaction	Categorical variable 0= long leasehold transaction; 1 =freehold
			PortSale	Property sold as part of a portfolio	Categorical variable 0=individual property sale; 1= part of a portfolio deal
			Partial	Proportional share of property sold	Categorical variable 0=100% deal; 1= proportional share in property
		Purchaser traits	IntExp	International experience of the buyer	Categorical variable 0=undisclosed purchaser; 1= purchaser appears to be UK and has no international real estate or experience of investing internationally; 2 = owner is either from abroad or has international real estate investment experience
			BuyReg	Continental region origin of buyer	Categorical variable 0 = undisclosed purchaser; 1 = buyer is either based or has major office in the UK; 2 = buyer located elsewhere in Europe; 3 = buyer located in Asia Pacific; 4 = buyer located in Middle East; 5 = buyer located in Africa; 6 = buyer located in Americas; 7 = offshore buyer
			BuyType	Type of buyer	Categorical variable 0 = unknown; 1= fund either based or has major office in the UK; 2 = fund from outside the UK; 3 = offshore fund; 4 = private (identify not revealed)
		Time	Time	Transaction period	Categorical variable to capture transaction year and quarter. 1 =2010 Q2; 2=2010 Q3; 3=2010 Q4; 4=2011 Q1; 5=2011 Q2; 6=2011 Q3; 7=2011 Q4; 8=2012 Q1; 9=2012 Q2; 10=2012 Q3

Secondly, following the derivation of the pricing model, the disaggregation of the RP into its component parts traces expectations of growth and depreciation to underlying causes at both market and stock levels. In terms of data requirements and modelling approaches, this represents advancement on previous studies that have struggled to find appropriate measures for growth and/or depreciation which have, in some instances, been ignored or assumed away as constants. Here, expected depreciation at the stock/asset level, is a function of location and building characteristics, captured by CoStar's measure of building quality, set out in detail in Table 4.

Table 4. CoStar building classification for offices

Building Rating	***Definition***	***Percentage in Sample***
1 Star	A very poor quality building with no tenant and little prospect of attracting a tenant because it is in very poor condition with substantial physical and structural defects and does not offer viable accommodation.	0.0%
2 Star	An older building, typically more than 20 years old, with the majority of the accommodation cellular. Poor quality reception areas with no lifts or old, poorly maintained lifts and generally poor maintenance with physical or structural defects. Rents will be substantially lower than for 3 Star buildings and close to the lowest levels achieved locally.	1.2%
3 Star	This is an older building that offers basic open plan accommodation and has been partly renovated but the interior has not been completely refurbished. Plant and other servicing likely to be outdated and inferior with some functional limitations although still reasonably well maintained.	39.2%
4 Star	A modern building, completed or renovated in the last 10 years, which offers good quality modern open plan space which is well maintained and managed. Externally less architecturally impressive than a 5 Star building. Offers good quality open plan office accommodation with raised floors, some form of air cooling system and adequate passenger lifts but is of a more basic design than a five star building.	47.6%
5 Star	A landmark building, either new built or extensively renovated within the last 5 years; to provide top specification accommodation and typically have a BREEAM rating of VERY GOOD, EXCELLENT or OUTSTANDING. If the building is older then the interior will be completely reconstructed with only the historical façade or structural frame remaining, and maintained and managed to the highest standard. Commands rents at or close to the top achievable rents in the local market.	12.0%

Source: CoStar (2013)

The CoStar building quality rating is a single categorical variable that measures the condition of the building through a grading of its specification, quality of maintenance, architectural quality, energy performance and prominence of its location. The building quality data are a new initiative and the ratings are collected by observation. Observers are given a set of criteria in order to grade each building and asked to rank over a five point scale. Many of the low quality buildings transacted were refurbishment/redevelopment opportunities and were excluded from the investment transaction dataset leaving the bulk of properties in grades 3, 4 and, to a lesser extent, grade 5.

5. Findings

Each stage of the model development is operationalised and the estimations, using a Restricted Maximum Likelihood (REML) method[5], are given in Tables 5 and 6. The analysis begins by testing Equation 6, the basic two-level framework. This is the same as $k_{ij} = \gamma_{00} + \mu_{0j} + e_{ij}$ where the explanatory variables and parameters (represented by $\beta_{i0} RFR$, $\sum \gamma_{11} RP_{REM_{lj}}$ and $\sum \beta_{lj} RP_{STK_{lij}}$) are omitted, leaving the intercept (γ_{00}) in the empty model (shown in Table 5 as Estimation 1) to represent the overall average cap rate. It is shown in natural logs (-2.9800) to create a normal, non-skewed data series and, when transformed back into percentage, gives an average cap rate of 5.08%.[6] Starting at this point in the analysis is useful as it allows us to then explore how cap rates differ due to submarket effects, stock-specific effects and transaction characteristics.

The intra-submarket correlation for the sample over the study period captures a significant proportion (85.45%) of the variation in cap rates around the estimated mean.[7] This conforms with *a priori* expectations, as previous studies show that specific risks contribute a large proportion of the investment risk attached to an asset and that default and void risks are primarily driven by the characteristics of the tenants, lease terms and property, as set out in the model by Jackson and Orr (2011).

It is noteworthy that the variance between transactions is 5.9 times larger than the variance between submarkets (see estimate of covariance parameters near bottom of Table 5). However, a not-insignificant 14.56%[8] of the differences in cap rates in the sample can be traced to submarket differences. Thus, both stock and submarket variables need to be investigated to fully explain cap rates. The relatively small size of the submarket-specific influence may surprise some analysts, but

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5 REML is one of two possible estimation techniques employed in most multi-level programs and selects the model parameter values that maximise the likelihood function that is calculated from a set of data that has been transformed to focus on the parameters of interest. This transformation is achieved by removing the effect of the fixed variables.

6 This average is the common average across all the submarkets allowing for between and within submarket variation and the bias generated by between submarket variations.

7 This is estimated as 1-(0.0285/(0.0285+0.1672)).

8 Calculated as (0.0285/(0.0285+0.1672)).

this could reflect the fact that many buyers are overseas and are seeking to buy in London as a perceived politically and financially stable international market, rather than very specific parts of London. Given the gap between cap rates in London and the rest of the UK (CBRE, quarterly), this London effect would be expected to be more noticeable if submarkets outside London had been included. The impact of overseas purchasers on cap rates is one of the factors tested subsequently.

Table 5. Results of empty multi-level models

Fixed Effects	Estimation 1	Estimation 2	Estimation 3	Estimation 4	Estimation 5
Intercept	-2.9800 ***	-2.9801 ***	-2.9026 ***	-2.9556 ***	-2.9801 ***
SublnRRent1_GC (Submarket quality)		-.3159 *	-.4638 **	-0.5465 ***	-0.3159 *
Time = 2010 Q2			-.0935		
Time = 2010 Q3			-.1189		
Time = 2010 Q4			-.0658		
Time = 2011 Q1			-.1005		
Time = 2011 Q2			-.1567 **		
Time = 2011 Q3			-.1643 **		
Time = 2011 Q4			-.0122		
Time = 2012 Q1			.0451		
Time = 2012 Q2			-.0901		
Estimates of Covariance Parameters					
Residual	.1672 ***	.1680 ***	.1676 ***	0.1723 ***	0.1680 ***
Intercept [subject = Submarket_id] Variance	.0285 **	.0181 *	.0158 *		0.0181 *
TIME [subject = Submarket_id] Variance				0.0143 **	0.0000
Model Fit Statistics					
-2 Restricted Log Likelihood	548.73	547.72	568.20	575.88	547.72
Akaike's Information Criterion (AIC)	552.73	551.72	572.20	579.88	553.72
Hurvich and Tsai's Criterion (AICC)	552.75	551.74	572.23	579.90	553.77
Bozdogan's Criterion (CAIC)	563.14	562.13	582.57	590.29	569.33
Schwarz's Bayesian Criterion (BIC)	561.14	560.13	580.57	588.29	566.33

*** significance at the 1% confidence level; ** at the 5% confidence level; * at the 10% confidence level.

The next stage of the analysis explores the influence of adding submarket variables as fixed effects to give Estimation 2. Here, we add the level-2 submarket variable SublnRRent1_GC to capture market quality. This mean-centred variable measures the change in the difference between average rental values across the central London area and in each submarket location. As set out in Table 5, while the average cap rate across all submarket locations remains at 5.08% (transformed from -2.9801 in natural logs), there is a clear improvement in explanatory power. Estimation 2 indicates that investors purchase at lower cap rates for better submarket quality: for every 1% the submarket location rental value rises above the change in average Central London rental value, the cap rate falls by 0.36% (transformed from 0.3159).[9] This is statistically significant and, thus, the unexplained variance between submarkets falls by 36.49%. The reduction in the Akaike's Information Criterion (AIC); Hurvich and Tsai's Criterion (AICC); Bozdogan's Criterion (CAIC) and Schwarz's Bayesian Criterion (BIC) also suggest an improvement in fit.[10] However, this improvement in fit is still relatively small with the Wald Z statistic testing[11] of the variance components in the covariance parameters suggesting that unexplained transaction variation still exists at the 1% confidence level. Although such tests can be unreliable (Snijders and Bosker, 1994), the fall in the Wald Z statistics to 1.786 for the unexplained submarket variation suggests (but only at the 10% confidence level) that a little variation exists between submarkets and the inclusion of the level 2 predictor does not remove all the submarket specific variation present in cap rates.[12]

The first of the wider contextual transaction characteristics is introduced in Estimation 3, where movements in the level of cap rates associated with the timing of the transaction are tested.[13] With only two exceptions (Q2 and Q3 in 2011) there are no significant differences over the study period, possibly implying that yield movements were static over the period of analysis. Market evidence supports this finding, with CBRE (various) indicating that prime yields in central London offices remained largely static for most of this analysis period. Statistically, the addition of the time variables fails to improve fit. When retested with time specified as random effects (Estimation 4) this results in higher information criterion statistics, suggesting the fit has been negatively affected by the inclusion

9 For example, if the rent in a submarket is £20 per square foot above the average central London rental value and that difference grows by 10% to £22, assuming all else remains unchanged, the cap rate will fall by 3.6%; i.e. from 5.08% to 4.9%.

10 Selection between alternative non-nested multi-level models can be made using goodness of fit statistics that are relative estimates of the information lost when a given model is used on a given set of data. The AIC, AICC, CAIC and BIC are variants of a goodness of fit test that use a likelihood function with either a penalty for the number of estimation parameters included in the model (AIC and BIC) or sample size (AICC and CAIC). The model with the lowest AIC, AICC, CAIC and BIC are preferred (Bozdogan, 2000).

11 The Wald test is a parametric statistical test that in this instance is used to test the significance of the null hypothesis that the difference between the estimated sample variance and the true variance is equal to zero. If the test rejects the null hypothesis then a statistical difference exists and this is assumed to be due to the model and its variance not capturing the true variance. The level of confidence in rejecting the null hypothesis is denoted by ***for the 1% confidence level; ** for the 5% confidence level and * for the 10% confidence level.

12 The influence of other submarket measures (absolute and grand mean centred submarket vacancy rates and actual rental growth, adjusted for inflation) in explaining cap rates were examined. None of these results are reported in the paper as they were insignificant and failed to improve explanatory power.

13 These relatively more complex estimations are referred to as growth models.

of a time random effect. Time, at least during this period of study, does not help explain the variation in cap rates.[14,15]

Estimation 5, the last in Table 5, checks for the possibility for time to be a third level of spatial influence where it affects multiple transactions over more than one submarket (as illustrated in Figure 4). This can be captured as a non-nested third level estimation. The level 2 and 3 random effects in Estimation 5 have been included as single identities.[16] A comparison of AIC and BIC statistics implies that the simpler 2 level hierarchical frameworks are a more relevant structure to adopt.

Figure 4. A unit diagram for a two level nested hierarchy and non-nested third level

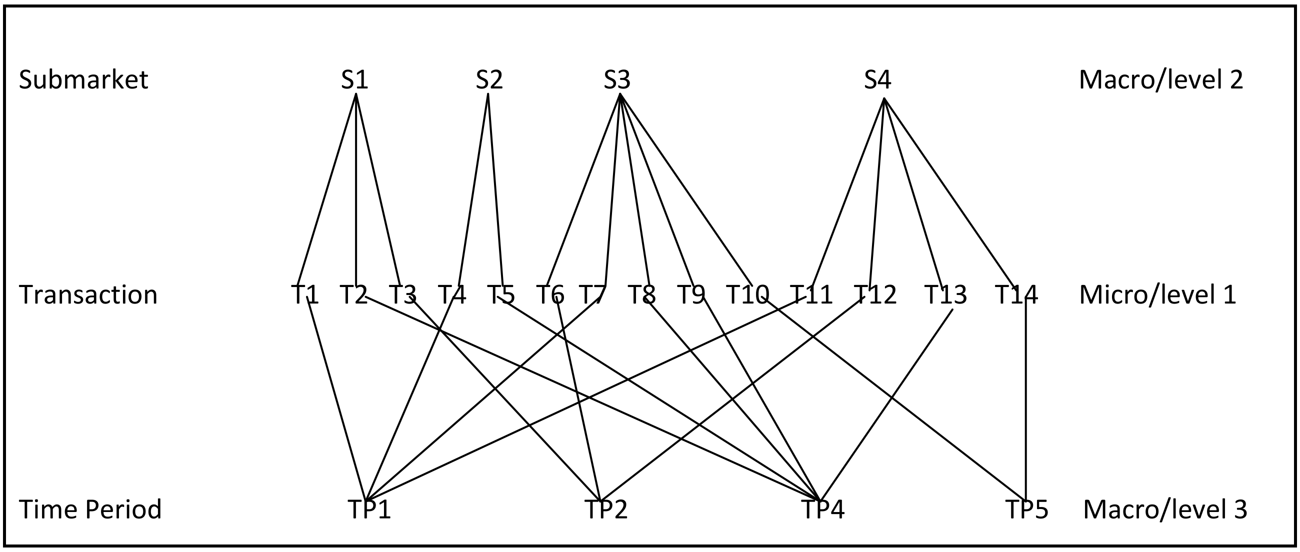

Table 6 presents the analysis when variables measuring the RFR rate are introduced, as are additional components of the RP, alongside the remaining wider contextual and behavioural factors relating to transaction characteristics, the latter as (level 1) explanatory variables. As detailed in Table 3, the variables run through the risk scale, starting at the macro end with the RFR: investor's

14 One concern was that there is not a sufficient number of observations in each time period across 13 submarkets; this was therefore reviewed across alternative submarket definitions (first the three City, West End and Mid-Town submarkets and, second, the merging of contiguous submarkets into seven groupings down from the original 13). In each of these iterations the time fixed effects and random effects remained insignificant, while the variation between submarkets became blurred and insignificant. The results are not, therefore, reported here.

15 Other random effects, tested in our mixed effects estimations as random slope effects, were absolute and grand mean centred submarket vacancy rates and actual rental growth, adjusted for inflation and grand centred submarket rents, adjusted for inflation. The addition of these variables as random effects did not improve explanatory power. The results are not reported in this paper.

16 More complex covariance structures were investigated but they failed to significantly improve goodness of fit.

expectation regarding the risk free rate of return and anticipated inflation; and, moving along the scale to the RP with additional real estate market factors, to include return on alternative investments; and, at the micro end of the risk scale: variables capturing the tenant, lease, location and building specific attributes of the asset. The rate of return expected on a risk free asset, the weighted average term to expiry and the weighted average of the tenants' credit scores are measured as continuous variables, with the remaining attributes captured through categorical variables. The intercept is removed to allow differentiation between the mean cap rate by type of transaction, with 0 denoting the purchase of a long leasehold and 1 representing a freehold.

Estimation 6 presents a detailed fixed effects model which contains possible predictors, as listed in Table 3, in an attempt to assess which individual variables contribute to London office cap rates but not all are significant. The majority of the properties in the sample are homogeneous in that they are occupied (Vacant=0), sold individually (PortSale=0) and sold as complete units (Partial=0), therefore these dichotomous variables are not significant in explaining differences in cap rates over and above the base model. In addition, the unit being on a corner site (CornerPosition=0) is also insignificant and, along with insignificant variables at the macro end of the scale that gauge anticipated inflation and dividend yields on shares as an alternative form of investment, these variables are removed in Estimation 7. This represents a more parsimonious fixed effects estimation[17] which yields lower AIC and BIC statistics and nearly all the fixed effects are significant at the 90% confidence level. The exceptions are average weighted tenants' credit score (Aver_TS), average weighted expiry term (Aver_Expiry), some CoStar building quality ratings (BuildRating), and the category for international experience that represents when this buyer information is unknown (IntExp=0). This estimation of the model specifies that the average cap rates for long leaseholds and freeholds based on a sample of the transactions where the buildings being transacted are rated as 5 star, top quality stock and bought by buyers with international experience are 3.52% (transformed from -3.3454) and 3.25% (exponent of -3.4254), respectively.

[17] This finalised estimation was derived in a stepwise process from Estimation 6, retaining the key risk drivers that influence cap rates as specified in the conceptual framework.

Table 6. Results of multi-level models containing property, buyer and transaction variables

Fixed Effects		Estimation 6		Estimation 7		Estimation 8	
SublnRRent1_GC	(submarket quality)	-.4657	**	-.5029	***	-.4882	**
LnNGRY	(RFR)	-.2344	**	-.1464	*	-.1512	**
LnSPP1	(anticipated inflation)	-.1023					
LnDivYield	(alternative investments)	-.5654	*				
Aver_TS	(ave. covenant strength)	-.0052		.0011		.0732	*
Multi=0	(single tenant/vacant)	-.0339					
Aver_Expiry	(term to lease expiry)	.0008		-.0001		-.0005	
Vacant=0	(property occupied)	.0340					
CornerPosition=0	(not a corner site)	-.0162					
CoStar Building Rating = 2 Star		-.2012		-.2495		-.7927	
CoStar Building Rating = 3 Star		-.1522	**	-.1718	***	-.4490	**
CoStar Building Rating = 4 Star		-.0596		-.0756		-.0641	
NoResidential=0	(some residential use)	.2390	***	.2217	**	.2246	**
NoRetail=0	(some retail use)	-.1004	**	-.1011	**	-.1060	**
Type=0	(long leasehold)	-2.8950	***	-3.3454	***	-3.4109	***
Type=1	(freehold)	-2.9555	***	-3.4254	***	-3.4984	***
PortSale=0	(individual property sale)	-.0090					
Partial=0	(whole property sold)	-.0262					
IntExp=0	(undisclosed purchaser)	.0016		-.0295		-.0297	
IntExp=1	(purchaser = UK only)	.0967	**	.1265	***	.1127	**
Buyer origin/experience unknown		-.5613	*				
Buyer is UK based/experience		-.4335					
Buyer is based in rest of Europe		-.5073	*				
Buyer is based in Asia Pacific		-.4499					
Buyer is based in Middle East		-.6477	**				
Buyer is based in Americas		-.3512					
BuyType=0	(buyer type not known)	.1582					
BuyType=1	(buyer/fund is UK based)	-.0038					
BuyType=2	(buyer/fund outside UK)	-.3968					
covenant strength * Submarket vacancy rate						-1.0906	*
Build Rating = 2 Star * Submarket vacancy rate						9.5509	
Build Rating = 3 Star * Submarket vacancy rate						5.2467	***
Build Rating = 4 Star * Submarket vacancy rate						.7985	
Build Rating = 5 Star * Submarket vacancy rate						1.0599	
Estimates of Covariance Parameters							
Residual		.1600	***	.1604	***	.1576	***
Intercept [subject = Submarket_id] Variance		.0129	*	.0135	*	.0139	*
Model Fit Statistics							
-2 Restricted Log Likelihood		589.21		561.96		532.52	
Akaike's Information Criterion (AIC)		593.21		565.96		536.52	
Hurvich and Tsai's Criterion (AICC)		593.24		565.99		536.55	
Bozdogan's Criterion (CAIC)		603.51		576.33		546.87	
Schwarz's Bayesian Criterion (BIC)		601.51		574.33		544.87	

*** significance at the 1% confidence level; ** at 5%; * at the 10% confidence level

At the macro end of the risk scale, Estimation 7 shows that the fixed effect for contemporaneous nominal risk free rates suggests that falling Gross Redemption Yields raise capitalisation rates. This is the same result even when lagged rates or alternative measures such as the Treasury Bill rate are used. Either real estate investors are slow to react to changes in the capital markets, as noted in the literature, or falling bond yields encourage investors to shift away from assets with the highest implied growth rates, especially if falling bond yields are a product of expected decreases in inflation that may impact on equity income flows.[18] Moving along the risk scale, Estimation 7 shows that mixed use within real estate assets impacts on cap rates. Where there is a residential component in the building, it seems that investors are pricing this as a risk and raising cap rates. In contrast, where offices have a retail component, this is perceived to lower risk and therefore lower cap rates.

The level of international experience of the buyer is also significant, with the results indicting that investors with international experience appear to buy at lower cap rates and, thus, higher prices, than home investors with no international experience.The origin of buyers has been removed from Estimation 7 as the inclusion of this variable failed to improve fit and multicollinearity appeared to exist between this variable and the definition used to categorise the international investment experience of buyers. Yet, when included, the results (see back to Estimation 6) confirm the finding that buyers' investment experience influences cap rates, suggesting that buyers from the Middle East and Europe transacted at lower cap rates than other regional buyers.

Estimation 8 specifies cross-level interactions to capture the possibility that our submarket measure of market quality may be linked to the quality of buildings. It also allows for the influence of historic vacancy rates in the submarket on investors' perceptions of void risk and how these are influenced by lease expiry terms. The results show a base cap rate of 3.30% for investors with experience in international markets buying long leaseholds with no retail or residential component in a top quality building (transformed from -3.4109). For a comparable freehold, the base cap rate is 3.02% (transformed from -3.4984). Key changes in the results given by Equation 8 include that the effect of tenant covenant strength now has a significant role in explaining cap rates, with rates increasing with increased covenant risk. The effect of building quality in explaining the differences in cap rates is inconclusive (even contradictory to expectations) although the positive and significant cross

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[18] For example, in the UK around the end of the millennium, falling inflation expectations caused a fall in medium dated Government bond rates from around a nominal 8% to 5% giving a significant increase in total returns within the bond markets. Reducing risk free rates were set against reducing nominal rental growth expectations causing little change in property cap rates over the same period and therefore lower total returns compared to bond markets.

interaction figures suggest that, in times of higher vacancy rates, cap rates are higher for buildings of poorer 3 star ratings than for buildings with higher ratings.

The significant variables driving transaction cap rates (in logs) are the risk free rate, type of real estate interest, existence of retail and residential space in the building, and tenants' covenant strength. Investment experience also has a significant influence, with experience in only UK markets resulting in upwards shifts in cap rates of 0.36% for freeholds and 0.39% for long leaseholds. The lower AIC and BIC tests suggest Estimation 8 is the better model, which is also confirmed by a Likelihood Ratio Test which describes the difference in deviance between Estimation 7 and 8, Estimations 1 and 8, and Estimations 2 and 8 and suggests Estimations 8 fits the data better.[19]

6. Discussion and Conclusions

The purpose of this study is to examine the pricing of direct real estate, focusing on the determination of cap rates and, more especially, the real estate attributes that determine the risk premium. Through this, a refined pricing model for direct real estate is proposed, extending previous understanding and reflecting the unique complexities of the asset and its context. Application of the model is demonstrated through the development of a spatially robust multi-level framework and subsequent estimation using observed cap rates for office properties in the central London global office markets.

The analysis of cap rates, focusing on the disaggregation of the risk premium, is developed from an analysis of the literature and uses the concept of a risk scale to identify the spatially distinct component parts of the risk premium. This, then, underpins the revised pricing model which reveals the complex components of the previously aggregated and opaque RP, with estimation of each subsequently demonstrated. Further, the catch-all categories of growth and depreciation are traced back to their causes, further enabling robust estimation and, importantly, avoiding potential endogeneity issues with these latent variables.

Operationalisation of the model is presented here through a cross-sectional inter-temporal analysis employing a dataset of real estate transactions in the central London office sector over a two and a half year period. The dataset contains asset-specific information not previously released by CoStar

[19] Tests show on the Level 1 residuals appear to follow a normal distribution. The residual histogram fits a normal distribution reasonably with a Skewness statistic of 0.321 although the Kurtosis statistic is a little high at 2.279.

and which was released to the research team prior to general release in 2013. The data have been enhanced and verified from other public domain or subscription-based sources as far as possible. The data have been transformed to provide equivalent yields, to represent more accurately investors' pricing than the initial yields reported within these datasets. The final dataset included 497 transactions within the time period Q2 2010 to Q3 2012.

Based on the inaugural case study estimates set out here, the unbiased average cap rate/equivalent yield across all transactions is just over 5%. The analysis period constitutes a time of stability in yields in the central London office market and therefore the finding that time generally does not influence the determination of the cap rate is not surprising.

However, although stable, the case study period was an unusual one in the capital markets, with central government and bank intervention taking place in the search for stability and recovery, in the aftermath of the global financial crisis that began a few years previously. Importantly, the results suggest that the relationship between returns on bonds and required returns on real estate has changed, as suggested in the literature (Dimson *et al*., 2013). Contrary to accepted investment theory and the Gordon growth model, where a fall in the RFR would lead to a fall in *k* if all other inputs remain stable, the results here suggest a negative relationship. The market interventions and returns on bonds approaching zero (amidst mounting speculation over the downgrading of the UK's credit rating which eventually happened in the first half of 2013) seem to have resulted in investor nervousness across markets, pushing up *k*. However, this negative causal relationship, although significant, is only slight. Thus, the response of real estate investors needs to be explored across the distinct components of the disaggregated RP, as set out in the pricing model. There is no simple explanation, with investors pricing the component parts of the RP according to their perceptions, as explored below. First, though, two concerns are noteworthy: despite the unusual economic and investment climate, real estate and bond yields were fairly stable over the period, making it difficult to determine statistically significant causality; and, further, this was an unusual period and so the findings here may not be the case in other periods.

At the level of the real estate market on the risk scale, the importance of the London submarkets on cap rate determination has been tested. Using the CoStar submarket divisions, the analysis has been undertaken across 13 submarket groupings[20] and the findings are as expected from the literature; that specific asset risks explain much more of the variation in cap rates than locational differences

[20] These are contiguous submarkets.

across submarkets. Around 15% of the explained variation in the cap rates is explained by the submarkets, against 85% by the asset-specific attributes. Within that, submarket location quality has a significant effect on the variation in submarket cap rates.

Real estate asset-specific characteristics figure prominently. There are differences in cap rates for mixed use assets: offices mixed with residential have higher cap rates, while offices mixed with retail tend to have lower cap rates. This mirrors historic relationships between retail and office yields with a number of commentators over a long period, such as Fraser (1984) and Baum and Crosby (2008), suggesting that the reduced depreciation rates for high street retail properties has kept their yields lower than offices. Higher quality tenant covenant strength also leads to lower cap rates. All these findings are as expected.

Asset-specific attributes that fail to significantly impact on cap rates include unexpired term to lease expiry. This is probably the most unusual finding, especially in a time of post financial crisis where the flight to safety and the search for “core” investments appears to have been a key driver of investor behaviour. It may be that this aspect is picked up in other measures. The other major surprise is the lack of influence on cap rates of building quality; here the analysis is inconclusive at best and, as with all disaggregated data, caveats are needed with reference made to the earlier discussion of the data source. However, notwithstanding this, it does appear that, in times of high vacancy, poorer CoStar-rated 3 star buildings have higher cap rates than higher quality 4 and 5 star buildings. This suggests that, in weaker occupier markets, the prime/secondary building quality price gap/cap rate adjustments increase but in better letting markets, when real estate vacancy rates are low, values of secondary assets rise as well. Further, it appears that investors are not distinguishing between the top two categories of building quality, perhaps being over-ridden by broader (London) market characteristics, especially as there are no spatial patterns discernible in the building quality data across submarkets. Other non-significant factors include single or multi letting, corner position and sales of mixed ownership properties. The building quality results need to be put into context. As indicated previously the data are a new initiative and the data collection has significant elements of subjectivity within it. The lack of distinction between cap rates on different CoStar quality rated buildings could be based on limitations of this immature dataset rather than any more fundamental reasons.

Finally the research investigated aspects of the transaction including the purchaser and the type of transaction. The principal finding is that buyers from the UK (and from overseas) with international investment experience appear to purchase at lower cap rates than UK investors with no international operations. In terms of transaction type, cap rates for freeholds are found to be lower than for those with long leasehold tenure. International investor behaviour does raise issues regarding the timing of the research. The rather surprising low impact of building quality, weighted average unexpired lease and submarket location on capitalisation rates could be explained by investor perceptions of the safe haven characteristics of the Central London market(s) during the study period with that factor having a larger than normal influence over market prices. For example, Middle East investors appeared to pay higher prices than most other overseas investors as well as home investors and also did not differentiate between different submarkets. But investors from mainland Europe also paid similarly high prices. There could be a safe haven argument here as London could be a safe haven from political and financial issues in the Middle East and a safe haven for Mainland European Investors during a period of uncertainty within the Eurozone. The data used in the study significantly predate any debate about the 2016 Brexit Referendum in the UK.

The differential between investors with a national and international focus could also be explained by the home investors not operating on the same scale as international investors and therefore not competing for the very high quality assets. Internationally active investors were more active in properties with the highest rental values and less active in transactions with lower rental values per square foot/metre. This raises the question of whether the specific measures used in the analysis fully reflect differences in building quality, especially the finer distinctions at the highest quality level, and that while international investors are identified as paying higher prices, it may be that they do so as they are purchasing the highest quality assets.

The research could usefully be repeated in a different period when the global financial crisis is a more distant memory (and before the next one), political turmoil in the Middle East has reduced, the European project more stable and the UK Brexit status more settled - to see what attributes take on greater or lesser significance.

Through the development of a real estate pricing model, and its subsequent exploratory estimation, this paper reveals evidence of investors' risk preferences and their perceptions of individual real estate asset attributes. This is important to practice and academia, not least because it employs a revealed preference method and a transaction based dataset that have not been used before to examine the pricing of commercial real estate investments. Furthermore, it has revealed the components of the "black box" RP within the traditional pricing model used for real estate. It has explicitly identified the multitude of risk factors, using the concept of a risk scale, to enable the robust classification of these factors, thus allowing a systematic estimation of their importance and significance in real estate pricing.

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