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AN ANALYSIS AND EVALUATION OF HEDONIC PRICE VALUATIONS IN LOCAL LEASEHOLD OFFICE MARKETS

Jonathan Sayer and John Moohan

Jonathan Sayer is a Surveyor with Gadsby Orridge, 99, Friar Gate, Derby, DE1 1EZ, UK

John Moohan is Professor of Surveying Education in the School of Architecture, Design and the Built Environment, Nottingham Trent University, Burton Street, Nottingham, NG1 4BU, UK

ABSTRACT

This research aims to analyse and evaluate the application of the hedonic method of price determination to office rental valuations in a local commercial property market in the East Midlands, United Kingdom.

Previously published theory and empirical evidence has been reviewed and evaluated in the context of both residential and commercial property markets mainly in the UK and USA. To date the vast majority of studies have been applied to residential property markets, largely as a consequence of data availability and assumed market conditions. The array of office market studies can be classified in different ways but include time series based rental indices, habit persistence theory, hedonic rent indices, cross sectional hedonic studies and behavioural studies. Statistically the primary determinants of office values and transaction (or asking) rents in hedonic studies appear to be various indicators of size of property, quality and location. It is common for asking rents to be used as a surrogate dependent variable or a proxy for actual rents.

In this cross sectional hedonic price study of 58 commercial properties in Derby for the summer of 2004 there was no significant difference between asking rents and actual rents at the 95% level of significance. Asking rents were shown to be a reasonable proxy for transaction rents, which is consistent with Mills (1992).

A correlation matrix was constructed which revealed problems of interdependence between the presence of suspended ceilings and comfort cooling, and double glazing and category II lighting respectively. A parsimonious least squares linear regression model was developed that statistically explained 94.2% of the variation in asking rents. Size of property and double glazing were identified as explanatory variables at the 95% level of significance. These findings were similar to Dunse and Jones (1998). But in contrast to other research (Mills 1992; Dunse and Jones, 1998) proximity to a railway station, location in a business park, presence of parking, and a full repairing and insuring lease were not significant explanatory variables at the 95% level of significance. These differences between models may be explained by local influences such as the nature of the study area, the size and characteristics of the commercial property market, its economic structure, the number of observations in the model and the date at which the model was tested.

The authors also tested the predictive power of the model. The model was validated by removing six observations from the data set, recalibrating the model and predicting the asking rents for the six properties. There was a tendency to significantly overestimate asking rents for relatively low rental properties. Generally the model showed poor predictive power.

Asking rents per square foot were calculated and shown to have a wide dispersion around the mean. 36% of the variation in asking rents per square foot was explained by double glazing, on property parking and location on a business park development at the 95% level of significance. Whilst the explanatory power of the model could be improved in various technical ways, it may also be improved by adopting a pluralist approach to the explanation of commercial rents by combining quantitative and qualitative research methodologies that seek to verify and validate the behaviour of valuers.

Keywords: Characteristics theory of value; Hedonic price studies; Leasehold office valuations; Stepwise regression analysis; Economic methodology

INTRODUCTION

The primary purpose of the research is to analyse and evaluate an application of the characteristics theory of value to a local commercial property market using a review of the relevant literature and a case study of a commercial property market in the East Midlands Region of the United Kingdom (UK). Hedonism is generally understood as the doctrine that pleasure is the chief good. In this context the hedonic principle is that a property's value (or rent) depends on its characteristics, a principle that is core to the main approaches to valuation (Ambrose, 1990). The traditional comparable approach to property valuation has been described as naïve and flawed (Wiltshaw, 1991) and subjective (Dunse and Jones, 1998). The hedonic price method utilises a system of equations to estimate the implicit prices of the individual attributes that comprise 'property' and can be used to predict the value of a property. The lack of transaction information in property markets makes finding alternative ways of estimating value and rent of crucial importance (Diaz, 1999).

The literature reviewed encompassed both residential and commercial property markets because most published work relates to house prices and to a lesser extent rents. There is less evidence in terms of the determinants of office rents (Bollinger, 1998). Regarding office markets, studies from the USA numerically dominate but there are some for the UK (Gardiner and Henneberry, 1988; Gardiner and Henneberry, 1992; Dunse and Jones, 1998; D'Arcy et al, 1999; Dunse and Jones 2002; Orr and Jones, 2003; and Orr et al, 2003). Inevitably results show differences between studies but the main determinants of office values and rents are typically size of the property, indicators of quality and indicators of location. In most hedonic studies of commercial property markets property size is a key explanatory variable.

Hedonic price models typify orthodox neo-classical economics and econometric modelling, which has been the dominant academic approach to both property market research and the pedagogy of property and construction market education. But this normative framework based in efficient market theory has been applied in property and construction markets characterised by market imperfections that include heterogeneous markets, imperfect costly information, differentiated products, time-lags and lumpy illiquid assets. Rather than assume profit or utility maximisation by rational decision makers, behavioural theory suggests a need to examine what people intend to do and how they actually behave (Moohan and Royston, 2006). A pluralist methodology could lead to a greater understanding of commercial property markets.

There are a variety of methodological options available. These include time series analysis and index based models that focus on forecasting rental prices and habit persistence theory based on the premise that:

> " the rent bid for office accommodation by a prospective occupier may be based not on the current level of demand for floor space, which is directly related to the current level of activity of his/her business, but on the expected or trend level of demand" (Gardiner and Henneberry, 1992, p. 216)

Hedonic rent indices models that calibrate the estimated rent of an attribute over time have also been developed in the USA, Eire and the UK.

Contemporaneous with the development of a burgeoning literature regarding the application of cross sectional hedonic studies of office markets in both the USA and the UK, behavioural studies that investigate the process of property valuation have become increasingly common. These approaches may be regarded as competing methodologies by some observers but the current authors contend that they have a variety of purposes and different strengths and weaknesses, which this paper will consider.

A cross sectional hedonic price model has been developed and applied by the current authors to the commercial property market in the City of Derby, East Midlands, UK. The model is described, calibrated using the usual statistical tests and evaluated. The intention is to suggest that statistical modelling may not be sufficient by itself to provide a fundamental explanation of the determinants of rental values. In other words a pluralist approach may provide a superior explanation of real world market performance and behaviour and consequentially improve predictive power.

ECONOMIC STUDIES OF OFFICE MARKETS

Time Series Analysis – Index Based Models

Much of the academic research published relating to office rental prices has focussed upon the forecasting of rental prices via time series analysis and index based models (Gardiner and Henneberry, 1988; Gardiner and Henneberry, 1992; Wheaton and Torto, 1994; Webb and Fisher, 1996; Bollinger et al, 1998; Chaplin, 1999; D'Arcy et al, 1999; Orr and Jones, 2003). Gardiner and Henneberry (1988) developed a time series model to predict indices of office rents in eight regional areas of England using regional Gross Domestic Product (GDP), floor space and rent as a percentage of the national average as explanatory variables over the period 1979-1984. The coefficient of determination (R squared) varied from 0.40 in the East Midlands to 0.97 in the Yorkshire and Humberside region. But the forecasting error for 1985 ranged from 0.51% in the South East region up to 13.7% in Yorkshire and Humberside, the larger error being attributed to the 1984-85 miners' strike by the authors. The primary purpose of this genre of model is office rent trend analysis and prediction rather than the valuation of individual properties

Time Series Analysis – Habit Persistence Theory.

A further development of time series models is represented by habit persistence theory, the general nature of which is described by Gardiner and Henneberry (1992, p. 216) above. For example, when Gardiner and Henneberry (1992) integrated habit persistence theory into their 1988 model the coefficient of determination varied from 0.38 in the South West region to 0.97 in the North region. Unsurprisingly the predictive power of the model deteriorated over time. As a summary the model produced relatively accurate forecasts in declining regions but in expanding regions the results were not significant. This approach was not designed to aid the valuation of individual properties.

Time Series Analysis – Hedonic Rent Indices

Hedonic rent indices models have been estimated for a large number of cities in the USA, but there are relatively fewer in Eire and the UK. Wheaton and Torto (1994) conducted a hedonic rent indices study for five US cities from 1979 to 1991. The number of observations for each centre ranged from 533 (Cincinnati) to 2,523 (Houston) with the models generating a score for the coefficient of determination varying between 0.39 (Cincinnati) and 0.57 (Washington). The explanatory variables significant at the 95% confidence level included unit size, length of lease, number of storeys, whether the building is new and location. Wheaton and Torto (1994) recognised that with a time series approach, if the dataset is updated as current observations become available, the model may alter to enhance its level of explanation requiring the recalibration of historical values for the index. Webb and Fisher (1996) estimated a hedonic price index for effective rental rates (taken at the time the lease was completed) for Chicago from 1985 to 1991. Thirteen out of nineteen explanatory variables were significant at the 95% confidence level and the coefficient of determination for the model was 0.44. They found that whilst effective rents fell by 50% from 1985 to 1988, with only a slight increase in effective rents from 1988 to 1991, asking rents remained constant during the period. Bollinger et al (1998) investigated spatial variations in office rents, controlling for building characteristics and lease terms, using a hedonic time series model over the period 1990 to 1996 for Atlanta, USA. Sample observations for each year varied between 658 and 907 and the coefficient of determination for four models varied between 0.626 and 0.634 with up to thirteen significant explanatory variables. Nearly 40% of the variation in office rents remained unexplained by the models. Chaplin (1999) examined fifteen predictive models for the period 1985 to 1994 concluding that statistical tests do not necessarily improve the selection of best predictive model, a disappointing missive for those in the property profession who advocate reliance on predictive models.

D'Arcy et al (1999) investigated the determination of office rents in Dublin, Eire, over the period 1970 to 1997 using regression analysis. Their preferred model gave a coefficient of determination of 0.49. When forecasted index scores were tested against actual index scores errors of 3.6% and 3.0% were noticed for 1996 and 1997 respectively. Orr and Jones (2003) developed a time series model for the office centres in Edinburgh and Glasgow for the period 1979 to 2000. A weak reduced form price equation was generated for both centres. They showed that differences in supply-demand balances can impact on the determination of office rent and that urban centre analysis was to be preferred to a regional approach. But again the focus of these studies was on the descriptive analysis of rental statistics and not on identifying the key determinants of property value.

Cross Sectional Hedonic Price Studies

The founding fathers of cross sectional hedonic price studies applied to property are widely acknowledged as Lancaster (1966) and Rosen (1974). The hedonic approach assumes that a property can be decomposed into a number of attributes, Z_1, ……,Z_n. The price of a property can be expressed as:

$$P(Z) = Z(Z_1,\ldots\ldots,Z_n)$$

P(Z) is differentiated with respect to each individual attribute and an equilibrium condition is established. For practical implementation primary and secondary real estate data and related information is required as proxy or actual measures of their theoretical constructs. The implicit price of each attribute is estimated using multiple

regression analysis. Equations can be linear or non-linear but based on very strong assumptions in either case. Generic assumptions include a perfectly competitive market with a complete absence of monopoly power, a market that tends towards equilibrium, no government intervention that distorts the market, and utility maximising behaviour by actors in the market place. These actors are able to make marginal adjustments to their purchase or rental decisions.

To date most models have been applied to transaction prices, asking prices, transaction rents and asking rents for residential property. (See for example Adair et al, 1996(a); Adair et al, 1996(b); Des Rosier et al, 1996; Gallimore, 1996; Hoesli et al, 1997; So et al, 1997; Wolverton, 1997; Adair et al, 1998; Henneberry, 1998; Fletcher et al, 2000; Din et al, 2001; Yang, 2001; Tse, 2002)

Cross Sectional Hedonic Price Studies of Office Markets in the USA.

Most cross sectional hedonic studies of commercial property markets have taken place in North America. Clapp's (1980) study of a sample of 105 high-rise buildings in Los Angeles metropolitan area produced a coefficient of determination varying between 0.52 and 0.66. Distance from the Central Business District (CBD) was one of the main factors in determining value. Cannady and Kang (1984) produced a log linear model for Champaign-Urbana, Illinois, that had an R squared value of 0.78, based on only 20 observations. In a relatively small urban area age of property and distance away from the quadrangle of the University of Illinois had negative impacts on rental value. In a study of the Chicago CBD office market Hough and Kratz (1983) used a sample of 139 properties to produce a coefficient of determination that varied from 0.60 to 0.66, which is unacceptable for valuation purposes. Key explanatory factors for office rents included radial distance from the CBD, proximity to commuter transportation, measures of the responsiveness of the building to tenant needs, building amenities and architectural quality. Following Hough and Kratz (1983), Brennan et al (1984) achieved an R squared value of 0.93 based on a log linear model of 29 observations of actual transactions in Chicago from 1980 to 1983. The most important explanatory variables were property unit size, service charge cap, the relationship between the lease and the consumer price index, vertical location of the unit within the building, total size of building, base year escalation and location with respect to the CBD. Wheaton (1984) conducted a multiple regression analysis of 200 office rental prices for Boston in 1980 reporting a coefficient of determination of 0.78. Locational characteristics were the primary determinants of the value of accommodation, whilst tax variables, the main target of the research, were not significant. Frew and Jud (1988) estimated a log linear model for Greensboro, North Carolina, that produced an R squared value of 0.58. The key variables explaining rents were vacancy rate, building age, number of floors and highway location. Glascock et al (1990) applied regression analysis to 675 observations of marketed office buildings in Baton Rouge, Louisiana, achieving an R squared value of 0.85 in the linear form of the model. They found spatial variation in rental levels, whilst the class of building impacted on rental level. Mills' (1992) study of 543 offices in Chicago produced a coefficient of determination of 0.40, with locational factors having the greatest significance for rents. One perspective is that the market analysed was too large and that a more localised market analysis could have produced a greater level of explanation. Shilton and Zaccaria (1994) applied the hedonic price model to freehold office prices from 1980 to 1990 within Manhattan, New York. The explanatory power was 84% for a cubic transformation

of their model – key explanatory variables were the size of the property, the time of sale, the height of the building and proximity to landmarks. Sivitanidou (1995) analysed 1462 observations of property rentals in Los Angeles and produced a coefficient of determination of up to 0.59. Rents appeared to be explained by access, worker amenities such as education quality and levels of crime, commercial land availability, density limits and limited growth.

Three general observations on these American studies may be made. The first is that the explanatory power achieved in the models tends to be too low for valuation purposes, though it does seem to improve in smaller well defined geographical areas. Secondly the explanatory power of a model as measured by the coefficient of determination can be improved by varying the functional form of the equation, though sometimes these variations are devoid of theoretical justification. The third is that the relative importance of property size, qualitative characteristics of the property and locational influences in explaining office market values and rents varies from study to study, place to place and time to time.

Cross Sectional Models of Office Markets in the UK

These cross sectional models of office markets in the USA may be seen as forebears for the application of the approach in the UK. In the UK there has been a locus of work on the office market in Scotland using data from the University of Paisley's property monitoring initiative, the Scottish Property Network. One of the first studies was Dunse and Jones' (1998) study for Glasgow through which the asking rents for 477 office suites set between 1994 and 1995 were analysed. Up to 25 independent variables were analysed and a coefficient of determination of 0.60 achieved, providing an explanation of 60% of the variation in asking rent, similar to the findings of Hough and Kratz (1983). The principal determinants of asking rents were age and location, though the former may be a surrogate for other factors such as the quality and condition of premises. Dunse et al (2001) used principal component analysis and cluster analysis to assist in the identification of commercial sub-markets. Subsequently Dunse and Jones (2002) tested for the presence of office sub-markets using the hedonic price method using a sample of 430 office rents in Glasgow. A linear model produced the most plausible and theoretically consistent outcome with an R squared value of 0.58. Age, location and quality were the most important variables in determining office rents. They also examined different ways of segmenting the market with the coefficients of determination varying from 0.31 for 'property type' up to 0.96 for segmentation by 'statistical analysis'. However in terms of 'best' segmentation measured by the reduction in the standard error, sub-markets produced by 'real estate agents views' and 'property type' produced the better indicators. Orr et al (2003) conducted a hedonic study using Scottish Property Network data to determine the influence of time on the market and commercial property prices using 103 office properties, 110 retail properties and 120 industrial property prices from 1994 to 1998. The R squared value was 0.55 with the key determinants of value being the estimated annual rental growth at the regional level, the year of transaction, the construction type of the property, the layout of the property and the location in terms of Unitary Local Authority. The study did not find evidence of a direct relationship between the length of time the property was on the market and the transaction rent, speculating that non-price incentives such as rent free periods of time, break options or fitting out costs may be used to achieve faster lettings rather than discounting the transactional rent. As in the USA these hedonic

studies have identified a cocktail of quantitative, qualitative and locational attributes as the significant determinants of asking rents and property values. There are important differences between American and British studies. Office premises in America generally appear to consist of suites in multi-storey buildings, whereas in the UK the buildings are generally lower in height whilst not having the same level of amenities within the buildings.

Behavioural Studies

Hedonic studies of property markets have been challenged. Neo-classical methodology makes strong assumptions that do not correspond with the reality of property markets. Property markets may not be efficient. Real estate agents and imperfect information can influence prices as can the psychology of buyers and sellers. Large tracts of good quality data are required and may be scarce. A concentration on quantitative factors can lead to the neglect of important qualitative considerations and become reflected in low measures of explanatory power such as the coefficient of determination. The assumed independent explanatory variables may in fact be highly inter-correlated leading to difficulties in separating their influence on value or rent. The technique may not be sufficiently accurate in predicting values or rents, say within plus or minus 5%. Dissatisfied with the hedonic neo-classical paradigm, some researchers have sought to avoid some of these difficulties invoking other methodologies sometimes based in behavioural studies.

Behavioural studies in property research focus on the process of property valuation rather than statistical measures of the outcome. Northcraft and Neale (1987) questioned 67 respondents, 28% of whom were deemed by the researchers to be property experts (they were real estate agents rather than qualified valuers). The researchers found that listing prices can play the most significant role in biasing estimation results. These agents may not have formal training in the valuation of real estate. Diaz (1990) undertook an investigation of twelve expert valuers during the appraisal process and concluded that the actual behaviour of expert appraisers deviated significantly from the normative prescribed appraisal process leading to possible bias. Gallimore (1994) analysed a survey of 498 general practice surveyors in the UK and, from a 50% response rate, concluded that valuers anchor by placing greater weighting on more recent information. Gallimore (1996) followed the work of Diaz (1990) with a similar survey of 400 general practice surveyors in the UK. From a sample response rate of 43%, Gallimore was unable to conclude that the case for confirmation bias was proven, but there was evidence to indicate that valuers made early value judgements and then sought evidence to support their opinions. Diaz (1997) conducted an experimental test of 58 appraisers, of whom 48% were apprentices, in Atlanta, Georgia USA. He was unable to conclude that valuers were influenced by anonymous expert value judgements. It was only when valuers leave familiar markets that they may anchor decisions based on anonymous expert opinion (Diaz and Hansz, 1997). The role of anchoring was much more subtle. Gallimore and Wolverton (1997) investigated samples of sixteen valuers in each subset in the USA and the UK concluding that knowledge of impending sale price can adversely affect a valuer's decision on comparable choice and impact on actual value estimate. Diaz and Wolverton (1998) demonstrated the phenomenon of valuation smoothing whereby in repeat valuations valuers tended to 'anchor' new valuations to information in historical reports. Wolverton and Gallimore (1999) investigated the

impact of client feedback upon the appraisers' perceptions of their role in the loan underwriting process. 377 (31.8%) usable responses were received from a questionnaire survey of 1186 appraisers. The researchers concluded that appraisers who experience a high level of environmental perception of coercive feedback from clients are more likely to see themselves as 'validators' of client requirements to support sale price and lender-client's performance criteria. Thus clients can affect the valuation process and the behaviour of the valuer.

Overview

Collectively the studies are indicative of a tendency for behavioural studies to examine valuation processes whilst hedonic approaches tend to ignore the valuation process and focus on the quantification of attributes that have the potential to influence the value or rent of property. The objectives of the approaches are different and they have a variety of strengths and weaknesses. This may suggest that studies of commercial property markets could benefit from pluralist approaches to analysis and evaluation.

ANALYSING AND EVALUATING THE MARKET FOR RENTED OFFICE PROPERTY IN DERBY, UNITED KINGDOM

The authors applied a cross sectional hedonic model to the determination of asking rents per marketed office property in Derby in full cognisance of the strengths, weaknesses and controversy surrounding the neo-classical paradigm.

The Study Area

The City of Derby is situated in the East Midlands region of the UK, 130 miles north of London, 16 miles west of Nottingham, which is normally regarded as the regional capital. At the time of the 2001 Census, the City of Derby had a population of approximately 222,000 (Focus, 2005). Its office stock includes converted former residential properties, refitted post-World War II premises and newer office accommodation with a good level of occupier fit-out. Derby is heavily influenced by the manufacturing sector with 51% of the working population employed in the manufacturing industries. Derby has 14.4% of all employees in the Banking, Finance and Business Services sector compared with an average for Great Britain of 17.7% - Derby falls below the national average by about 18% (Focus, 2005).

The Data Set

Primary research data was compiled by obtaining leasehold marketing literature from commercial property agents operating within the study area in the summer of 2004. A total of 58 properties were available for occupation. Design and build projects that were not yet ready for occupation were excluded. Where specific data was missing agents were contacted directly to complete the data set. Other observations, not available from agents' marketing details, such as distance from the railway station, were obtained from a web site, www.upmystreet.co.uk.

A complete set of transaction rents was not available to the researchers. Resort was made to using asking rents as the dependent variable. Asking rents had previously been shown to produce as plausible regression coefficients as the actual value of a

lease (Glascock et al, 1990; Mills, 1992; Sivitandiou, 1995; Dunse and Jones, 1998; Dunse and Jones, 2002). This data is publicly available information and avoids issues relating to confidentiality and lease terms. The analysis was restricted to rentals to ensure that the demand for office accommodation was from the same consumer base, occupiers. Transaction rents were obtained for 22 of the 58 subject properties. The transaction rent was less than the asking rent for five of the properties by 2 to 4% of the asking rent. For the remaining seventeen properties asking rents and transaction rents were identical. The correlation coefficient, between transaction rents and asking rents, was calculated, and using the t-Test, shown to be highly positive and significant at the 99% level of significance. Thus there is evidence to support the hypothesis that asking rent is a suitable surrogate for transaction rent, though this proposition would require re-testing for other time periods or locations.

The full data set for the hedonic model may be described as follows:

> Asking rent (RENT) was a numeric variable measured as the asking rent of accommodation in £ per annum.
>
> Office area (SIZE) was a numeric variable measured as the net internal area of accommodation in sq. ft. as per the RICS Code of Measuring Practice (RICS, 2001).
>
> Distance to Derby railway station (DIST) was a numeric variable measured by distance from the subject office accommodation to the train station measured in miles. (This access indicator was tested because Derby railway station is physically dislocated from the centre of the city.)
>
> Parking (PARK) was a dummy variable that indicated whether or not parking was included with the property.
>
> Comfort cooling (CC) was a dummy variable that indicated whether or not a property had comfort cooling.
>
> Service charge (SeCh) was a dummy variable that indicated whether or not a service charge was applicable to a property.
>
> Data network cabling (DNC) was a dummy variable that indicated whether or not data network cabling was fitted in the property.
>
> Category II lighting (CAT2) was a dummy variable that indicated whether or not category II lighting was fitted in the property.
>
> Double glazing (DG) was a dummy variable that indicated whether or not central heating was fitted in the property.
>
> Central heating (CH) was a dummy variable that indicated whether or not central heating was fitted in the accommodation.

Suspended ceiling (SC) was a dummy variable that indicated whether or not a suspended ceiling was fitted in the property.

Lift (L) was a dummy variable that indicated whether or not there was a lift in the property.

Communal access (CA) was a dummy variable that indicated whether or not the accommodation had communal access.

Full Repairing and Insuring (FRI) was a dummy variable indicating whether or not a property was taken on a full repairing and insuring lease.

Business park development (BPD) was a dummy variable that indicated whether or not a property was situated in a business park location.

Asking rent (RENT) was divided by office area (SIZE) to calculate a numeric variable (RENTSQFT).

The Hedonic Model

Principally the model contained measures of size, quality and location of accommodation together with indicators of a range of internal services and amenities. The model to be tested by empirical study was:

$$RENT_i = f(SIZE_i,, DIST_i, PARK_i, CC_i, SeCh_i, DNC_i, CAT2_i, DG_i,$$

$$CH_i, SC_i, L_i, CA_i, FRI_i, BPD_i, X_i)$$

where $_i$ is the $_i$th property and X_i is an unknown variable.

In hedonic modelling office accommodation is taken as a 'composite good' and as such its demand is related to the demand for its component attributes. The foundation theory is that:

> "….goods are valued for their utility-bearing attributes or characteristics. Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them." (Rosen, 1974, p. 34)

The researchers contend that it is essential to understand the epistemology and ontology of the model prior to application. In addition whilst there is no theoretical limit to the number of explanatory variables contained within a model, there are empirical restrictions in terms of access to data, collection of data and the number of independent variables. In many previous UK studies data has been taken from a pre-existing data set. Data has to be suitable for regression analysis, including assumptions that the data is normally distributed and on a continuous scale. Skewed data may be transformed mathematically and dichotomous or dummy variables used for non-continuous data respectively. There are also technical statistical problems relating to multi-collinearity (interdependence between the assumed independent

explanatory variables) and heteroscedasticity (the error variance is not consistent over the observations). These problems may be tackled by examining the correlation coefficients between the independent variables and examining the characteristics of the data respectively. For a treatment of heteroscedasticity within property data see Fletcher et al (2000).

The explanatory power of any model is subsequently tested using the coefficient of determination whilst seeking to avoid the statistical problems outlined above. To combat the desire to improve the model by simply increasing the number of explanatory variables, the adjusted R squared statistic is used (Leishman, 2003), which imposes a penalty for adding independent variables that add little or nothing to the explanatory power of the model. Two further tests were used. The first was the t-Test designed to ensure that each explanatory variable included within the model was statistically significant at the 95% confidence level. The second was the F-Test designed to test the statistical significance of the model as a whole.

Intuitively office rents may depend on a large number of characteristics. Hypotheses and null hypotheses were developed. The explicit hypotheses developed for empirical verification were:

1. The size of the accommodation will have a positive impact upon the rental value of the office accommodation.

2. The distance from the railway station will have a negative impact upon the rental value of the property.

3. If the accommodation comes with parking there will be a positive impact upon the rental value of accommodation.

4. If the accommodation is fitted with comfort cooling, this will have a positive impact upon the rental value of the property.

5. If the accommodation is subject to a service charge, this will have a negative impact upon the value of the property.

6. If the accommodation is fitted with data network cabling, this will have a positive impact upon the rental value of the property.

7. If the accommodation is fitted with Category II lighting, this will have a positive impact upon the rental value of the property.

8. If the accommodation is fitted with double glazing, this will have a positive impact upon the rental value of the property.

9. If the accommodation is fitted with central heating, this will have a positive impact upon the rental value of the property.

10. If the accommodation is fitted with a suspended ceiling, this will have a positive impact upon the rental value of the property.

11. If the property is fitted with a lift, this will have a positive impact upon the rental value of the property.

12. If there is communal access to the accommodation, this will have a negative impact upon the rental value of a property.

13. If the lease is a full repairing and insuring (FRI) lease, this will have a negative impact upon the rental value of a property.

14. If the accommodation is situated at a business park address, this will have a positive impact upon the rental value of a property.

Statistical Analysis

Descriptive statistics were calculated for each of the variables in the data set. The size of the accommodation in the sample ranged from 281 sq.ft. to 13,765 sq.ft. Asking rents ranged from £3,120 per annum to £165,935 per annum. The properties were located between 0 and 3.6 miles from the railway station. The frequency of the presence of each of the dummy variables was calculated and ranged from 90% of properties being offered on a full repairing and insuring lease to 19% of the properties having a lift. Thus there was some variation between properties for the variables within the data set.

Prior to undertaking the hedonic analysis, the set of independent variables was tested for multi-collinearity commencing with the estimation of a correlation coefficient matrix (Mark and Goldberg, 1988). The matrix revealed that caution must be applied when interpreting the results of the regression analysis where the variables suspended ceiling and comfort cooling (0.62), double glazing and category II lighting (0.68) are included. The respective correlation coefficients are shown in brackets.

Using stepwise regression analysis a total of fourteen independent variables were regressed against the independent variable, asking rent. The model took the functional form of a linear specification. Model A summarises the outcome of the process.

Regression Analysis Model A

Variable	**Regression Coefficient**	**'t' Value**	**Sig.**
Constant	-2938.581	-1.910	0.061
SIZE	9.808	27.741	0.000
DG	5661.115	3.078	0.003
n	58		
R	0.970		
Rsq.	0.942		
Rsq.adj.	0.940		
F Stat.	443.698		0.000

Model A indicated that size and the presence of double glazing had positive impacts on asking rents at the 95% level of significance. The remaining variables were not

statistically significant at the 95% level of significance. The model exhibited two main problems. The first is that the constant term is not significant at the 95% level of significance. The second is the possibility of multi-collinearity between size and double glazing (r=0.266). Model A provided the 'best', most parsimonious statistical explanation and plausible model of asking rents for office property in Derby in the summer of 2004. In summary:

1 Each additional square foot of net internal area added £9.81 to asking rent.

2 The presence of double glazing added £5,661 to asking rent.

For the remaining twelve potential explanatory variables null hypotheses were accepted. In terms of independent variables deemed to be insignificant such as distance to the railway station, whether the office is located on a business park development, presence of parking, comfort cooling, and a full repairing and insuring lease, the findings run contrary to previous studies (Mills, 1992; Dunse and Jones, 1998). But Derby is much smaller than either Glasgow (Dunse and Jones, 1998) or Chicago (Mills, 1992). And as such the differentiation of asking rent per unit area may not be as great spatially. The insignificance of whether the lease is drawn on full repairing and insuring terms may be due to this being the industry standard in the UK whilst in the USA repairing obligations are usually shared between tenant and landlord (Hoesli and MacGregor, 2000).

The explanatory power of the model as measured by the value of R squared adjusted (0.94) appeared to compare well with previous office rental valuation models in a linear form including Cannady and Kang (1984) 0.36; Hough and Kratz (1983) 0.61; Brennan et al (1984) 0.83; Frew and Jud (1988) 0.50; Mills (1992) 0.385; and Dunse and Jones (1998) 0.61. Nevertheless 6% of the variation in asking rents was not statistically explained by the model.

The researchers also caution that although the model appears to be relatively successful as an explanatory model it does not perform well as a predictive tool. To demonstrate this proposition Model A was recalibrated by first ranking the properties by asking rent and then omitting the first, eleventh, twenty first, thirty first, forty first, and fifty first observations. Thus Model B was estimated with fifty two observations. The regression analysis is shown in Model B. The remaining six observations were used to test the predictive power of the model.

Regression Analysis Model B

Variable	**Regression Coefficient**	**'t' Value**	**Sig.**
Constant	-2614.861	-1.637	0.108
SIZE	9.812	26.466	0.000
DG	5441.629	2.740	0.000
n	52		
R	0.972		
Rsq.	0.944		
Rsq.adj.	0.942		
F Stat.	416.057		0.000

The results of the application of Model B to the estimation of asking prices are summarised below:

Property number	Asking rent	Estimated asking rent	Estimated asking rent/Asking rent	Percentage difference
One	**3120**	**5584**	**1.780**	**+78%**
Eleven	**11000**	**19252**	**1.750**	**+75%**
Twenty-one	**18960**	**26605**	**1.404**	**+40%**
Thirty-one	**23000**	**19105**	**0.831**	**-17%**
Forty-one	**29500**	**24217**	**0.821**	**-18%**
Fifty-one	**41000**	**43605**	**1.064**	**+6%**

Clearly the predictive power of the model is weak especially for properties with lower asking rents. The mean difference between estimated and actual asking rent was 39%. Hence Model B that has a relatively high explanatory power (94%) also has a weak predictive power.

The reasons for this were subjected to further investigation. First for the 58 observations contained in Model A asking rent per square foot of space (RENTSQFT) was calculated. The minimum value was £4.94 and the maximum was £15.00 per square foot. The arithmetic mean was £9.99 and the standard deviation was 2.67. Given the proposition that the relationship between RENT and SIZE may not be monotonic and the relatively wide dispersion of RENTSQFT around the mean the researchers examined the relationship between RENTSQFT and SIZE. The simple correlation coefficient was estimated to be nearly zero and was insignificant at the 95% level of significance. Therefore the research sought to determine the significant factors affecting RENTSQFT. This was done by means of a stepwise regression of RENTSQFT as the independent variable and the list of independent variables (pp. 9-10 above). Model C below describes the outcome.

Regression Analysis Model C

Variable	**Regression Coefficient**	**'t' Value**	**Sig.**
Constant	7.209	11.502	0.000
DG	1.418	2.018	0.049
PARK	1.933	2.474	0.017
BPD	1.505	2.054	0.045
n	58		
R	0.629		
Rsq.	0.396		
Rsq.adj.	0.362		
F Stat.	11.785		0.000

All three significant independent variables were dummy variables – DG (double glazing). PARK (the presence of parking on the property) and BPD (location on a business park development). The model explained 36% of the variation in RENTSQFT (asking rent per square foot) – 64% of the variation in RENTSQFT was not explained by the model. The remaining independent variables tested were insignificant at the 95% level of significance.

Evaluation

Model A identified net internal floor area (a measure of size) and the presence of double glazing (a measure of quality) as statistically significant determinants of asking rents at the 95% level of significance. Unlike previous research (Hough and Kratz, 1983; Brennan et al, 1984; Cannady and Kang, 1984; Mills, 1992; Dunse and Jones, 1998) locational variables were not significant. But model C showed that asking rents per square foot were positively affected by the presence of parking on the property and location within a business park development, as well as double glazing. Further research could analyse the impact of other locational variables such as travel time, access to other public transport services and distances to major arterial routes on rents.

The researchers acknowledge that the modelling process was based on relatively few observations (58) compared with many other studies as previously cited above. A larger data set could be obtained by either expanding the size of the market to say the East Midlands as a whole or by widening the timeframe for the collection of data. Either approach has issues because the structure of local markets may be different and can change over time. Other independent variables could also have been tested such as age of the building, whether or not a building is listed, sub-market location, and lay-out and floor level within a multi-storey building. Inclusion of these variables would have required an extended data set not immediately available to the researchers. In addition the quality of the data in this study depends on the accuracy and veracity of data provided by agents. Whilst the researchers had no reason to question this, it was not verified through independent inspection of properties. Alternative functional forms could also be tested such as log linear and semi-log linear models. Hedonic rent indices are unlikely to be the same across markets and property types and are likely to change over time, requiring frequent re-calibration and testing of any model. The study area did not feature in the Jones Lang Lasalle (2005) 50 Office Centre Rent, a research guide presenting top rents and rents achieved within major office centres within England. The analysis could be extended to take on a multi-centre approach in a hierarchy or continuum of office centres.

These are potential technical improvements and adjustments to the modelling process and need to be set in the context of the underlying methodology and paradigm of neo-classical economics. Research could also take a pluralist approach to understand the negotiation process and the determination of rents in commercial property markets because the various approaches have a variety of different purposes, methodologies and an array of strengths and weaknesses. No single methodology is likely to be sufficient by itself.

CONCLUSION

The researchers aimed to analyse and evaluate the determinants of office rental valuations in the local commercial property market of Derby, UK. In a linear hedonic model based on 58 asking rents set in the summer of 2004 (Model A), size measured by net internal floor area and the presence of double glazing explained 94.2% of the variation in asking rents at the 95% level of significance. Asking rents were found to be a reasonable proxy for transaction rents in the study. The explanatory power as measured by R squared adjusted was relatively high compared with other similar linear models. This may be explained, in part, by the size and nature of the study area. The locational variables tested in the model (proximity to the local railway station and location in a business park) were not significant determinants of asking rents. Intuitively and in line with the findings of hedonic prices studies of other commercial property markets, this may not be the case and requires investigation of other locational variables. The researchers are aware of a variety of further technical adjustments that could be tested in the modelling process.

The predictive power of the hedonic modelling process was shown to be weak in Model B. There were large and significant prediction errors for asking rents. On further investigation asking rents per unit area showed large dispersions around the mean as measured by the range and standard deviation. Although asking rents per unit area are not correlated with size as measured by net internal floor area, Model C showed that they could be explained partly by the presence of double glazing, on site parking provision and location on a business park development. But 64% of the variation in asking rent per unit area remained unexplained.

The outcome of this model, further adjustments to the model and any other hedonic model are fundamentally dependent on the underlying methodology. Neo-classical hedonic models have been criticised both generically and specifically in terms of particular applications. Classically behavioural theorists have challenged the epistemological and ontological condition of neoclassical hedonic models. The researchers are aware of this catalogue of criticisms. However, their review of the literature leads them to conclude that no single methodology is likely to be sufficient by itself. A pluralist approach is advocated, which recognises the strengths and weaknesses of different methodologies. Rather than enter into a potentially arid debate about the virtues or sins of methodologies, they would prefer to triangulate between the evidence produced by using an array of quantitative and qualitative approaches. This means that the analysis and evaluation of commercial property markets would benefit from a simultaneous examination of valuation processes (such as the behaviour of property professionals, negotiation and interaction with and between clients) and quantitative measurement of the determinants of asking rents, transaction rents and property values. This pluralist approach will form the methodological basis of forthcoming research into the determination of commercial property rents.

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