The spatial pattern of industrial rents and the role of distance

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Abstract

Purpose – The objective of this paper is to re-appraise intra-urban rent models in the context of a multi-nodal landscape. Primarily, the study focuses on the early work of Alonso and, more recently, Di Pasquale and Wheaton. Although the latter use a more sophisticated approach, both models lead to similar outputs, notably a declining rent gradient from the central business district (CBD). However, throughout the twentieth century there has been a considerable process of urban industrial change. Di Pasquale and Wheaton recognise this and argue that this has led to an almost flat industrial rent gradient.

Design/methodology/approach – To assess the current impact on industrial rents a hedonic rent regression model is applied which enables us to standardise for property characteristics.

Findings – The results support the hypothesis that the rent gradient from the CBD for a large city is still downward-sloping, albeit very shallow. More interesting is the significance of proximity to motorway junctions. The analysis supports the hypothesis of a multi-nodal rent surface. Proximity to a motorway junction is the most important locational variable with a much steeper and negative gradient than that to the CBD, albeit over a shorter distance.

Originality/value – These results imply that the draw of the CBD in terms of agglomeration economies and its accessibility to labour for a city the size of Glasgow still remains, but its attractions are much denuded with the development of a national motorway network.

Keywords Industrial property, Property finance, Socio-economic regions, Transportation

Paper type Research paper

Introduction

This paper reviews models of intra-urban rents (Alonso, 1964; Di Pasquale and Wheaton, 1996) and re-appraises them in the context of a uni-nodal urban landscape in which the assumptions underlying the bid rent curves for industrial property no longer hold. By re-examining the structure of spatial revenues and costs alternative forms of rent gradient will be postulated. This provides the framework for an examination of the intra-urban spatial pattern of rents of industrial properties. To test for the role of distance in the spatial variation of rents a hedonic regression model will be developed.

The focus of the empirical analysis is the city of Glasgow. The paper begins with an appraisal of intra-urban industrial location theory. This is followed by a review of the

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current literature applying hedonic analysis to industrial markets. This leads to a description of the case study area data and the research method. In the penultimate section we discuss our empirical analysis and the final section highlights the key findings.

Intra-urban industrial location theory

Intra-urban location theory of relevance originates with Alonso's land use model (Alonso, 1964) derived from von Thunen's model of an agricultural economy. It is based on a city located on a featureless plain where land use is allocated to the highest bidder in a competitive land market. In this uni-nodal city the central business district (CBD) is the point of maximum accessibility where business revenue is at a maximum and costs (other than land costs) are minimised. Differences in the optimum locations of industrial and commercial land uses relate directly to the responsiveness of revenue and costs to distance from the centre. It is presumed that revenues fall and costs rise with distance from the CBD. The local industrial property market is defined by those locations where industrial users outbid other land users.

Di Pasquale and Wheaton (1996) develop a more sophisticated approach. In their stylised nineteenth century city the CBD is replaced with a central shipment/transportation terminal. All firms are initially assumed to produce identical products and using the same production process, have equal outputs. There is no factor substitution so that the plot size and buildings are fixed for each firm, and output per acre is fixed.

In this theoretical model the rent for buildings is fixed but the land rent per acre varies with location. Revenue and production costs are spatially invariant and given a competitive land market land rents in equilibrium will exactly compensate for transport costs that rise with distance from the transportation terminals. In this way a rent gradient is formed. When the assumption of identical production processes is relaxed the model can be extended to groups of identical firms or land uses. This leads to a range of potential different rent gradients. The land market is presumed to be competition, allocating land use on the basis of the highest rent.

Both Alonso (1964) and Di Pasquale and Wheaton (1996) models above lead to similar outputs, notably a negative rent gradient from the CBD. A major distinction in their assumptions is that while Di Pasquale and Wheaton presume revenue is spatially constant Alonso has revenue decreasing with distance from the CBD. Logically, the Alonso model would lead to a steeper distance decay gradient but neither empirically tested their models.

During the twentieth century there has been a considerable process of urban industrial change. Three different processes have contributed to this – de-industrialisation, decentralisation and decongestion.

De-industrialisation is a consequence of traditional industries declining in the face of international competition and the globalisation of markets. Cities that had a high concentration of this type of industry have suffered severe economic decline. However, this structural explanation for decline will vary widely between cities, depending on the nature of their traditional industries.

Decentralisation involves the movement of manufacturing industries to better locations outside city core areas, and has become a worldwide phenomenon (Ingram, 1998). The reasons for this include lower inter-urban transport costs with the

introduction of new transport and delivery technologies and the increasing requirement for land due to changing production and storage requirements. This has encouraged industry to move to decentralised locations where there is plentiful supply of land and easy access to the national motorway networks. Other factors have also contributed to a decline in the requirement for industries to be close to core city areas. Technological change has weakened the agglomeration economies of many cities. Transport costs and the need for large pools of labour have also declined as a result of:

- miniaturisation of products;
- the introduction of new lightweight materials;
- a reduced number of moveable parts in machinery; and
- the increased use of electronics, as opposed to mechanical, parts and processes.

The globalisation of industry and markets has reinforced these trends further. The creation of large multi-national companies has helped to increase the average size of an industrial plant and therefore increase industrial land requirements (Coffrey and Polese, 1988).

Decongestion is the decentralisation of manufacturing industries to suburban locations or locations at the periphery of the city. Decongestion is distinct from decentralisation because it occurs strictly within the urban setting. It is a form of extended suburbanisation that involves an intra-urban move as opposed to an inter-urban move. It is however a consequence of the same forces that cause decentralisation.

How do these factors affect the theoretical models outlined above? Industry generally serves regional or national markets and hence revenue will not vary according to spatial location within a city. This is accordance with the Di Pasquale and Wheaton model rather than Alonso's. Industrial change means that the spatial structure of costs has changed over time. Distribution costs were originally minimised at central locations near rail and sea terminals. With the advent of the use of containers and trucks, together with the development of inter-urban road networks, distribution costs are now minimised at peripheral locations accessible to the national road network. Di Pasquale and Wheaton argue that this has led to an almost flat industrial rent gradient. However, with revenue constant throughout the city, and costs falling with distance from a central point, the rent gradient is logically upward sloping. However, this is perhaps intuitively an incomplete argument.

It is therefore necessary to return to the basic model. The general trends in transportation costs noted above can either be incorporated by changing the assumption about the transport cost distance function or by introducing additional nodal points of accessibility. These may or may not be subservient to the CBD node. This latter approach is more appropriate on a theoretical basis as it dissects the different influences.

The analysis so far has assumed production costs are constant across an industrial property market area. However, it is possible that labour costs could be lower at or near the CBD because this is an attractive location to potential workers who can benefit from the social agglomeration economies nearby and the use of an intra-urban

transport network centring on the CBD. Hence, labour turnover is lower and recruitment easier in central locations. Similarly, there are potential manufacturing agglomerations from a central location via access to business services and clustering (Henderson *et al.*, 1995; Gordon and McCann, 2000).

This study attempts to use the framework of comparative static models of the urban land use market to examine the actual spatial pattern of industrial property rents. Although these theoretical models are much criticised for their simplistic assumptions they can provide coherent insights into urban spatial structure (see for example Egan and Nield (2000)). By extending the intra-urban rent models with revenue spatially invariant to encompass accessibility nodes it is possible to postulate an industrial rent surface with a series of minor rental peaks. Specifically in this paper we test the hypothesis that the sign of the rent gradient is negative from the CBD and there is a positive impact of proximity to the motorway network on rents. The former recognises the traditional role of the CDB and the latter the influence of decentralisation and reduced transportation costs on the periphery of a city. We will now proceed to test this hypothesis using hedonic analysis, but first we will proceed to review this body of literature. There is no logical reason to presume any specific node should be dominant.

Industrial hedonic price studies

Hedonic theory represents an extension to urban location theory in the sense that, rather than conceptualising the stock in terms of location and different sized units of homogenous property, hedonic functions allow for stock heterogeneity and explicitly recognise the effect of physical characteristics and tenure rights on rental values (Evans, 1995). By controlling for typical building characteristics and lease terms, evidence from these hedonic studies has been used to determine the slope of the bid-rent gradient in metropolitan property markets and yield further information regarding the importance of physical attributes and legal rights of tenure on the level of rent.

There are only a limited number of hedonic price modelling of industrial property, and these have been confined to a few studies undertaken in the USA.

Hoag (1980) uses industrial property in an attempt to develop an index of real estate value and return. He uses a sample of 463 transacted prices spanning a five-year period between 1973 and 1978. The study tests the significance of property characteristics, national and regional economic indicators and location variables. Location variables were found to be significant, although the paper fails to define what these variables actually measure. Unusually, he discards these variables in the final model, despite their statistical significance, and retains the economic indicators instead.

Ambrose (1990) purely concentrates on property specific factors and ignores location variables. The data is located in a highly concentrated area of metropolitan of Atlanta and hence it is argued that there will be no location bias. The study tests a series of property characteristics which include; size, office space, ceiling height, number of drive-in doors, number of high docking doors, presence of a railway siding, presence of sprinklers and building age. Using a linear form all of these variables produced the expected sign and were significant at the 10 per cent level.

Fehribach *et al.* (1993) recognises the shortcomings of the work of Ambrose and Hoag. This study extends the work by taking account of location specific variables. The study area consists of two counties in the Dallas/Fort Worth area. The dependent

variable in this study is the sales price for the industrial building; this is regressed against 11 independent variables, which include physical attributes, economic and financial indicators and location variables. The two key location variables were the county the property was located in and the distance from the main airport. The results of the study highlight the statistical significance of these and other physical and economic variables.

Lockwood and Rutterford (1996), in line with earlier studies, test the effects on property value of physical characteristics, national market conditions, local market conditions, interest rates and location variables are undertaken. Again the study is based on Fort Worth, Dallas. However, this study extends the development of location measurements compared to the others. Four measures are tested; distance to the CBD, distance to the airport, distance to the nearest major road and access to the rail network. Despite the use of a different technique the results confirm the findings of the earlier studies. The major findings of this study indicate that local market conditions, physical characteristics and location of the property are the primary sources of value for industrial property. However, the location variable, distance to the CBD, was not significant.

Buttimer *et al.* (1997) also analyse the determinants of industrial warehouse rents in the Dallas/Fort Worth area. Independent variables are used to represent physical characteristics, location and market conditions. However in comparison to the Lockwood and Rutterford (1996) study, location is not measured through distance variables to key points of accessibility, but through the use of dummy variables to indicate submarket location. The conclusions reinforce the findings of earlier studies; rents are significantly impacted by physical characteristics, location and market conditions.

Jackson (2002) develops a hedonic model of industrial property located within the Southern California region to determine the impact that contamination has on sales price. The specification of independent variables is similar to earlier studies. Physical characteristics include, land and building size, office space and age. Date of sale is included to represent changes in market conditions and location is measured through a series of dummy variables. Finally a dummy variable is used to determine whether sold before, during or after the period of contamination remediation. Again, physical characteristics, date of sale and location proved to have a significant impact on value. Contamination had a significant negative impact, but did not prove to be persistent.

Overall these studies leave some confusion on the role of location, brought about partly because of the variation in the definition of locational variables and partly because of study area definitions are not clearly set within a mono-centric traditional core city. In addition to these studies Colwell and Munneke (1997) examine the spatial pattern of vacant industrial land prices in Chicago. They find that prices have a negative concave relationship with distance from the CBD, that the airport has a significant positive effect but only within three miles, and that price varies also with spatial sector of the city.

Study area and data

The chosen study area is Glasgow, which is Scotland's largest city situated on the west coast of central Scotland. It serves as a major provincial industrial, office and retail centre. Glasgow has experience considerable de-industrialisation and decentralisation

of industry over the last three decades. The city has suffered from a severe decline in shipbuilding and many of the dock areas have been redeveloped for housing and offices. Industry is now predominantly light engineering, electronics and other service industries. The local authority area of Glasgow City has approximately 2.3 million square metres of industrial floor space. There are approximately 2,700 industrial units giving an average size of 875 square metres[1].

The data used in this study is a subset of a commercial database maintained by the Scottish Property Network. This database comprises a comprehensive core of details of all individual industrial properties on all industrial estates in Scotland Property characteristics for each industrial unit include size, age, type, structure and condition. When such properties are on the market it incorporates information on asking rents. The focus of this study is 429 properties on the market in the industrial estates of the city over a five-year period, 1994-1998. Table I shows the distribution of transactions per year.. The data is augmented by the addition for each property of a range of distances linked to key points of accessibility is calculated. Overall, each data record has information on the transaction, physical and location characteristics that are described in Table II. Descriptive statistics are presented in Table III.

Table I.
Number of transactions per year

Year	Number of transactions
1994	78
1995	25
1996	77
1997	80
1998	169

Table II.
Variable description

Variable name	Description
LREN	Natural logarithm of asking rent per square metre
Y94-98	Year of transaction (1994 = 0)
Physical	
SIZEBAND	The data are classified into eight size bands; 0-99, 100-199, 200-499, 500-999, 1,000-1,999, 2,000-4,999, 5,000-9,999 and 10,000+
AGE (1 to 4)	Categorised into four age band dummy variables; (Before 1960 = 0), 1960-1969, 1970-1979, 1980-1989 and 1990 onwards
CONST (1 to 2)	Categorised into two types of dummy variables; (traditional construction = 0), steel portal frame and refurbished buildings
USE (1 to 2)	Categorised into two use dummy variables; (manufacturing = 0), workshop and warehousing
COND (1 to 2)	Categorised into two measures of condition; (good = 0), poor and new
Location	
GLASCEN	Straight-line distance in kilometres to Glasgow city centre
DIST2400	A measure of distance in kilometres to the nearest motorway junction within 2.4 km from the junction (see text)
NC	A dummy variable; North (1) and South of the River Clyde

Mean rent	£45.77 per m^2
Mean unit size	366.72 m^2
Mean distance from Glasgow city centre	4.8 km
Mean distance from nearest motorway junction	1.6 km
Per cent of observation constructed:	
Before 1960	16
1960-1969	9
1970-1979	14
1980-1989	40
1990 onwards	21
Per cent of observations of:	
Traditional construction	36
Modern construction	57
Refurbished	7
Per cent of observations primarily used for:	
Manufacturing	26
Workshop	32
Warehousing	41
Per cent of observations in:	
Good condition	87
Poor condition	3
New condition	10
Per cent of observations:	
North of the River Clyde	70
South of the River Clyde	30

Table III.
Descriptive statistics

The most modern and flexible construction forms are steel portal frames that are constructed of steel frames, which enable large unobstructed floor space. Traditional construction relates to buildings generally constructed in brick. This material does not allow large unobstructed floor plates to be constructed. As the floor area gets larger additional supports have to be added internally, effectively restricting the movement of plant and machinery within the unit. The final construction form is refurbished which refers to buildings of traditional construction modified in recent times to improve the internal layout and hence improve the internal accessibility of the unit. Warehousing is simply space primarily used for the storage and distribution of goods. Both manufacturing space and workshops are primarily used for the construction and manufacture of goods. The difference in the definition of these is primarily related to the size of the unit. Workshops tend to be small units supporting small businesses whereas manufacturing space is primarily occupied by medium sized to large businesses. In addition, workshops tend only to have manufacturing space whereas manufacturing units tend to have other areas, such as office suites and staff areas.

Location of each industrial unit is defined in three dimensions. First, by distance from a central point within the city of Glasgow and; second, the distance to the nearest major trunk road/motorway junction. The former is simply measured as the straight-line distance in kilometres from the city centre. The latter is more complex adopting an approach used by Colwell and Munneke (1997) and Colwell *et al.* (1998). This approach assumes that only occupiers who want to be located close to a

motorway junction will be willing to pay a premium for that benefit. It is assumed that distance from the nearest motorway junction only matters to industrial occupiers up to a maximum point. Beyond this point industrial occupiers are not actually interested in locating close to the motorway.

The distance within the boundary is defined as the maximum distance (D_{max}) less the straight-line distance (SD) ($D_{max} - SD$). If the industrial unit is located within the boundary it is given a dummy variable (D) of 1, if the unit is beyond the boundary it is designated a dummy variable of 0. Hence, the final distance variable is defined as $D^{*}(D_{max} - SD)$. However, theory does not dictate what this maximum distance should be. An algorithm is used that tests a series of maximum distance intervals of 800 metre (0.5 miles) around the nearest motorway junction. The criteria used to choose D_{max} is to estimate the variable ($D(D_{max} - SD)$) that minimises the standard error in the regression equation. Applying this algorithm gives a maximum distance of 2.4 km as the best measure.

Finally, a dummy variable (NC) is used to identify the location of each industrial unit relative to the River Clyde. The River Clyde is a natural barrier to movement around the city. To travel from one side of the city to the other a bridge has to be crossed and historically, it has been easier to access the city from the south, due to better transport infrastructure.

Overall, the independent variables comprise a comprehensive set of industrial attributes. While there are a few potential characteristics that are absent from our review of the industrial hedonic literature (for example, loading bay height) it is possible to argue that they are subsumed within the age, use and construction variables.

Analysis

The initial base model for the analysis, in linear form and without any transformations to the independent or dependent variables are specified as follows:

$$\begin{aligned} RENT_i = {} & \beta_0 + \beta_1 SIZEBAND_i + \beta_2 Y94_i + \beta_3 Y96_i + \beta_4 Y97_i + \beta_5 Y98_i \\ & + \beta_6 AGE\_1_i + \beta_7 AGE\_2_i + \beta_8 AGE\_3_i + \beta_9 AGE\_4_i + \beta_{10} USE\_1_i \\ & + \beta_{11} USE\_2_i + + \beta_{12}\mathrm{COND\_1}_i + \beta_{13}\mathrm{COND\_2}_i + \beta_{14}\mathrm{CONST\_1}_i \\ & + \beta_{15}\mathrm{CONST\_2}_i + \beta_{16}\mathrm{GLASCEN}_i + \beta_{17}\mathrm{DIST2400}_i + \beta_{18}\mathrm{NC}_i + + \varepsilon_i \quad (1) \end{aligned}$$

Functional form

The measurement of the implicit prices of the different attributes of the hedonic model raises questions about the correct model specification. Unfortunately, hedonic theory gives no indication of the best functional form to use and as noted by Dhrymes (1971), there is no theoretical a priori functional form of equation within hedonic regression analysis. In our analysis we choose between alternative models through a series of Box-Cox transformation and likelihood ratio tests (Box and Cox, 1964). The likelihood ratio tests are based on the theory that under the null hypothesis twice the difference in the logarithmic likelihood ($ln\ L$) between a null and alternative hypothesis is distributed as chi-squared (χ^2) with the number of degrees of freedom equal to the

difference in the number of unrestricted parameters (Halvorsen and Pollakwoski, 1981). The significance tests are based on the 95 per cent level of confidence.

Following Brennan *et al.* (1984) five functional forms are considered: log-linear, logarithmic, reciprocal, semi-log, and linear. It should be noted that log transformations could not be used for dummy variables and other independent variables that have possible magnitudes of zero. The procedure consists of an iterative search of a grid constructed for λ_L and λ_R. Following Brennan *et al.* (1984) a range of magnitudes from -1.5 to $+1.5$ based on increments of 0.01 was applied. The objective of this grid search is to find the combination of λ_L and λ_R that generate the maximum logarithmic likelihood (MLE). The results are presented in Table IV.

Based on the likelihood ratio test only the semi-log model ($\lambda_L = 0$, $\lambda_R = 1$) has a logarithmic likelihood that is not significantly different from the maximum logarithmic likelihood. Therefore it is concluded that the semi-log model is the most appropriate of the five models initially considered, on the basis of empirical evidence.

Hedonic results

A number of models are tested using stepwise regression procedures. This procedure is argued to be the most robust method of testing for the "best" equation. In the model being tested, the criteria used is that a variable is entered into the equation if it is significant at the 5 per cent critical value and is removed if the variables significance level falls below the 10 per cent critical value.

In total, 18 independent variables are regressed on the rent on the basis of a semi-log specification. Table V gives the results for the final model that was tested on the basis of this specification. An examination of the output produced by the stepwise procedure indicated that the regression coefficients remained stable throughout with no significant changes in sign or magnitude. The explanatory power of the model is reasonable, explaining 44.9 per cent of variation in rental value. In the "best" model all the variables are significant at the 95 per cent level and they all have plausible signs and magnitudes.

The constant represents the starting point of any examination of results produced by hedonic modelling. This term includes the influence of all attributes not included in the regression equation and is the base from which other variables are added. The coefficients generated in the hedonic model represent an implicit value of buying that attribute which is not included in the constant term. In this study the constant term

	ln L	χ^2_{calc}
Box-Cox	−1590.87	0.00
Log-log	−1673.54	165.33*
Log	−1671.13	160.51*
Reciprocal	−1601.34	20.93*
Semi-log	−1592.73	3.71
Linear	−1588.39	−4.96*

Notes: * Rejected at the 5 per cent significance level; Critical value = 3.84

Table IV. Results of Box-Cox transformations

Coefficient	B	*t*	VIF
(Constant)	4.101*	70.312	
SIZEBAND	−0.153*	−13.192	1.197
DIST2400	0.124*	6.285	1.323
AGE_1	−0.218*	−4.181	1.169
AGE_4	0.124*	3.563	1.113
COND_1	−0.190**	−2.328	1.069
GLASCEN	−0.01246*	−2.101	1.120
NC	−0.06573*	−1.972	1.281
Number of observations	429		
R^2	0.458		
Adjusted R^2	0.449		
Standard error	0.2804		
F-stat	50.734 (0.000)		

Notes: * significant at the 99 per cent critical value; ** significant at the 95 per cent critical value

Table V.
Results of the hedonic regression equation

represents a pre-1960s manufacturing unit of traditional construction, let in 1995, in good condition, and located at the city centre on the south side of the River Clyde.

An examination of the regression coefficients in the hedonic model emphasises the importance that location, size, condition and age have in explaining the variation in rent across industrial units. The results are now considered in more detail below.

Physical attributes appear to be less important in this model. Size band is the most significant variable indicating that rental values per square metre fall with increasing size of property. The results suggest that rent per square metre declines by 14.19 per cent per each incremental increase in the size band. This is a logical result given that there will probably be a quantum effect with increasing size.

Of the four age bands included in the model Age1 and Age4 are significantly different from the constant term. Age1 represents a 1960-1969 building; a period of building that is notorious, for all property types, to be least attractive in terms of aesthetic appeal and architectural quality. The analysis suggests that this age band suffers a reduction in rent per square metre of 19.6 per cent when compared to the constant. Age4 represents a 1990s building and attracts a premium of 13.2 per cent. Properties in poor condition (Cond_1) see a reduction of the rent per square metre by 17.13 per cent. Construction and use variables do not prove to be significant. However, many of these characteristics may well be subsumed into age band.

Location appears to have a major influence on the rent. All variables included are significant. The arguments for a negative rent gradient from the city centre are upheld. As the distance increases from the city centre rent reduces by 1.2 per cent per kilometre. However, the effect while significant suggests a very shallow rent gradient. The theoretical significance of distance to the nearest motorway junction is also upheld. This is the most significant location variable and second only to size band. The coefficient suggests that as the junction is approached from the boundary limit of 2.4 km the rent increase is 13.2 per cent per kilometre[2]. This is an entirely logical result since a location close to the junction will not only be more accessible but also more prestigious in terms of visibility from the road. A simulated rent gradient illustrating the significance of proximity to a motorway junction is shown in Figure 1.

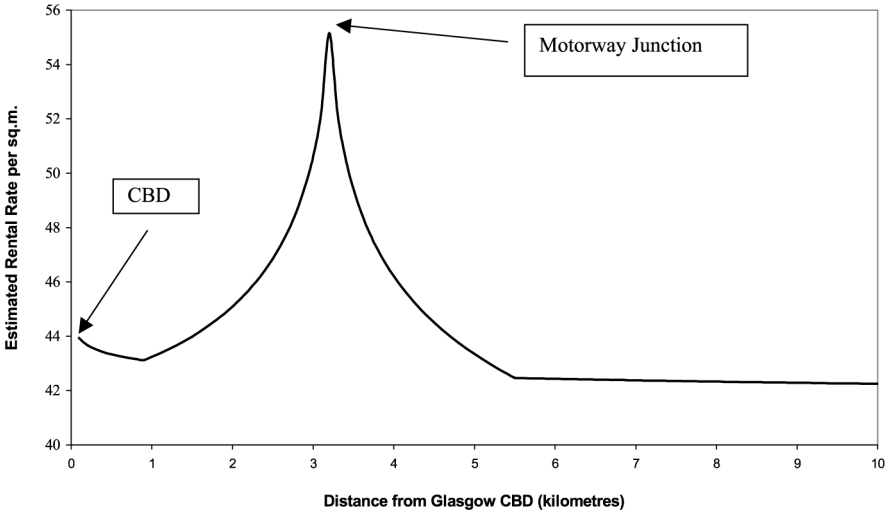

Figure 1.
Industrial rent gradients

Finally, the location relative to the River Clyde is also significant. Being located to the North of the River Clyde causes a reduction in rent by approximately 6.4 per cent. This result is as anticipated given the poorer transport links to the north of the city.

Technical robustness

In addition to the reasonable consistency with theoretical expectations of the signs and magnitudes of the estimated implicit values, the explanatory power of the model described above compares well with others reported in the literature. The *r*-squared of 0.458 and the adjusted *r*-squared of 0.449 are comparable with those studies reviewed earlier. Also the *F*-statistics are significant at the 1 per cent level, which implies that overall the equation is significant.

Multicollinearity is a common problem in hedonic models. Although it is impossible to completely eliminate it, the variable inflation factors (VIF) reported in Table IV indicate the problem of multicollinearity is minimised in the final model. A VIF of greater than ten indicates the presence of multicollinearity (Myers, 1990).

Ambrose (1990) and Can (1990) argue that there is good reason to expect the assumption of unequal variances to be violated in hedonic price models of real estate. Consequently, we use the Goldfeld-Quant test for heteroscedasticity. The test statistic was calculated to be 0.1308, which is less than the critical value of 1.29 at the 5 per cent level of significance. Thus, the null hypothesis that the residual variance is constant fails to be rejected.

Conclusions

The objectives of this paper is to re-appraise intra-urban rent models in the context of a mono-centric city with an accessibility landscape that encompasses multi-access points to inter-urban motorways, and to empirically test the role of distance. The starting point for the study is the theoretical uni-modal models of Alonso (1964) and more recently Di Pasquale and Wheaton (1996). Although the latter uses a more

sophisticated approach, both models lead to a similar theoretical output, notably a declining rent gradient from the CBD (neither undertake empirical tests). However, throughout the twentieth century there has been a considerable process of urban industrial change. Decentralisation has been partly brought about by the spatial structure of costs changing over time. For example, distribution costs were originally minimised at central locations near rail and sea terminals. However, with changed transport infrastructure peripheral locations are now more accessible. Di Pasquale and Wheaton recognise this and argue that this has led to an almost flat industrial rent gradient.

To assess the current impact on industrial rent gradients we applied a hedonic rent regression model, which enabled us to standardise for property characteristics. The general trends in transport costs can either be incorporated by changing the assumptions about the transport cost/distance function or by introducing additional nodal points of accessibility. This paper adopts the latter approach and hypothesises an industrial rent surface consisting of a series of peaks representing nodal points of accessibility within a declining rental gradient from the CBD (i.e. a mono-centric city).

The results support the hypothesis that the rent gradient from the CBD for a large city is still downward sloping albeit very shallow. More interesting is the significance of proximity to motorway junctions. The analysis supports the hypothesis of a multi-nodal rent surface. This is the most important locational variable with a much steeper and negative gradient than that to the CBD, albeit over a shorter distance. These results imply that the draw of the CBD in terms of agglomeration economies and its accessibility to labour for a city the size of Glasgow still remain but its attractions are much denuded with the development of a national motorway network.

Notes

1. Source: Scottish Property Network.
2. A simple measure of straight-line distance from the motorway junction was also tested in a separate model. This also proved to significant suggesting the rent per m^2 reduces by 6.5 per cent per kilometre as the distance increases from the motorway junction. Although significant this model specification gave slightly poorer results. The adjusted R^2 was 0.431 and the standard error 0.2847.

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