GLAECONOMICS

Working Paper 42

Valuing housing and green spaces: Understanding local amenities, the built environment and house prices in London

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Transport for London

LONDON DEVELOPMENT AGENCY

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Greater London Authority
September 2010

Published by
Greater London Authority
City Hall
The Queen's Walk
London SE1 2AA
www.london.gov.uk
enquiries **020 7983 4000**
minicom **020 7983 4458**

ISBN: **978-1-84781-390-9**

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GLA Economics provides expert advice and analysis on London's economy and the economic issues facing the capital. Data and analysis from GLA Economics form a basis for the policy and investment decisions facing the Mayor of London and the GLA group. The unit is funded by the Greater London Authority, Transport for London and the London Development Agency.

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1. Executive Summary

This report is an update of a previous GLA Economics study- 'Valuing Greenness: Green spaces, house prices and Londoners' priorities'- published in 2003. The previous study used a hedonic modelling approach to assess how the amount of green space within wards in London affected house prices, whilst taking into consideration other influential factors such as transportation accessibility and housing density. The hedonic pricing method is based on the theory that the value of a good is based on the combination of the many attributes the good possesses. In the case of housing this includes domestic facilities, access to services and so on. The value of individual attributes can be inferred from the hedonic model, and thus it is a useful method for estimating the value of attributes that influence house prices, particularly where markets do not exist such as for green spaces. This research builds on the original study with better green space data and a wider range of built environment and locational factors analysed at a more detailed spatial scale.

The most important factors influencing house prices were found to firstly relate to physical built environment housing qualities, particularly house size and age, with larger older housing being much more desirable. This supports arguments emphasising the value of family housing in London, and of the continuing appeal of historic high heritage value neighbourhoods. The most important locational factor in the model was unsurprisingly distance from Central London. Green space was most strongly related to house prices through the high attractiveness of detached housing with large private gardens. The total green space area within the locality (distance of 1km) was also found to boost house prices, though to a lesser extent than calculated in the previous Valuing Greenness study.

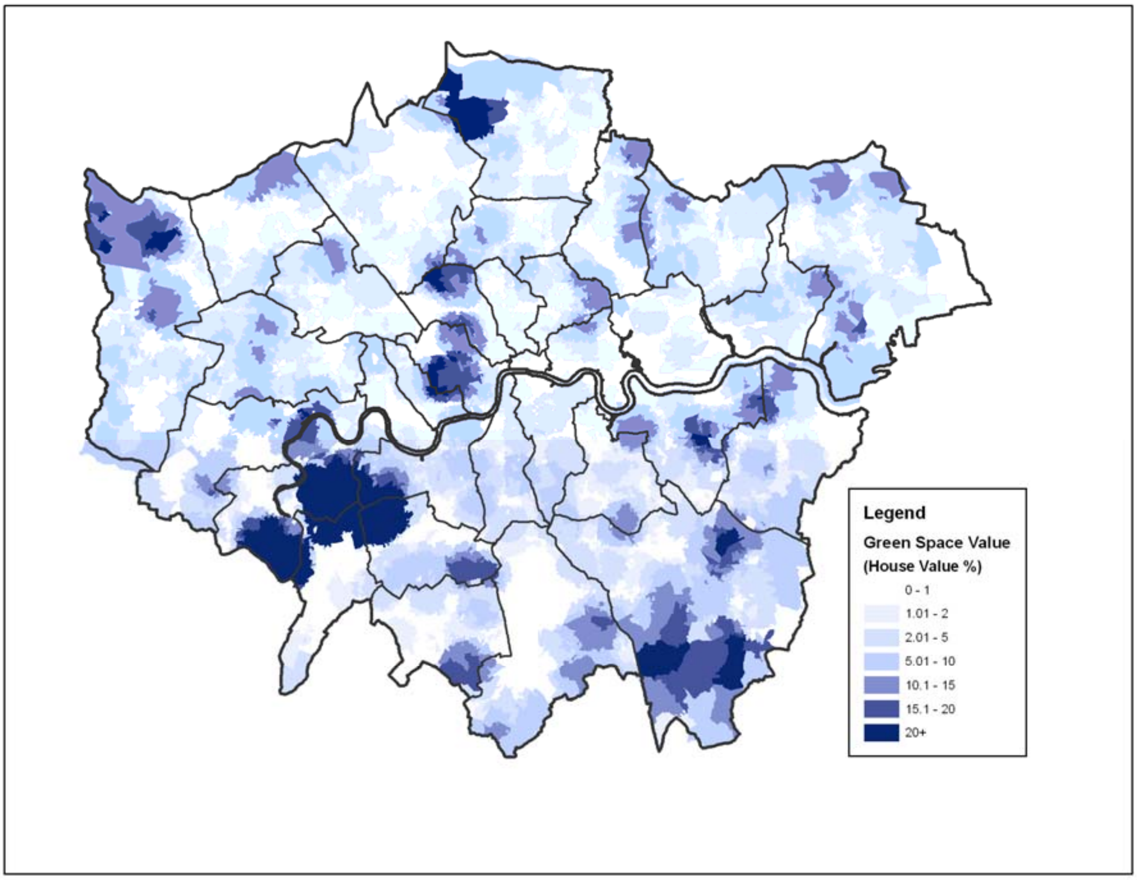
Several versions of the model are developed in this research, each version adding a greater number of attributes to explain house price variation and increasing the explanatory power of the model. Access to parks is correlated with built environment factors, such as housing type and size, and is negatively correlated with deprivation. The inclusion of socio-economic and built environment variables in the model reduces the strength of the correlations between green space and average house prices. The headline figures given here are from Model 2, which included green space, built environment and locational factors, but did not include socio-economic attributes. The reason for excluding socio-economic attributes is that they are strongly correlated with income and are therefore more of a reflection of housing market outcomes than a causal factor in determining property value.

From Model 2, the approximation of green space value is that each hectare of park space within 1km of housing increases house prices by 0.08% (Table 1). Additionally the presence of a regional or metropolitan park within 600 metres was found to add between 1.9% and 2.9% to total house value. Note that these values fall when income related deprivation variables are included in the model. It is also possible to express the estimated contribution of the green space attributes to housing value in the form of a map (Figure 1). This shows the connection between high green space access and several affluent housing areas in London, such as Richmond and around Hyde Park, as well as many areas of relatively lower park access both in Inner and Outer London. Note that types of open space other than formal green space, such as metropolitan open land, are not included in Figure 1.

Table 1: Model 2 Green Space Attribute Values

Green Space Attribute	Modelled House Price Value
Park Area within 1km	0.077-0.083% per hectare
Regional/Metropolitan Park within 600m	1.9-2.9%

Figure 1: Model 2 Estimated Green Space Value (% increase in house value)



A weakness with the analysis is the lack of green space quality information beyond general type classifications. The modelling approach is to calculate a single value of green space area applicable across Greater London. There is likely to be spatial variation in the relationships between green spaces and house prices, with quality and prestige factors making a number of parks highly desirable, while some less attractive green spaces will have a reduced influence on the local housing market. These issues are explored in this paper by mapping the residuals of the model predictions to estimate where prices are being over and under estimated. This highlights the attractiveness of high prestige royal parks, and the appeal of west and north London. Future research would benefit from better data sources of green space quality.

2. Overview

This report is an update of a previous GLA Economics study- 'Valuing Greenness: Green spaces, house prices and Londoners' priorities'- published in 2003. The previous study modelled how the amount of green space within wards in London affected house prices, whilst taking into consideration other influential factors such as transportation accessibility and housing density.

The comprehensiveness and accuracy of models depend significantly on the range and quality of data available, and there were a number of data limitations in the 2003 research. In the intervening years improvements have been made in the digital representation of green spaces in London, as well as for other spatial data sets such as those representing the built environment. Therefore this research improves on the original study with a wider range of factors considered at a more detailed spatial scale.

Built environment factors in particular are focussed on, as these are anticipated to significantly influence house prices. These factors include housing size, housing type (such as detached or terrace) and proxies of housing age. As expected these data items are amongst the most influential in the final model.

Note that the house price data used is derived from Land Registry housing sales, and therefore describes the owner occupation and mortgage housing markets. Rental housing markets are not considered within this framework.

2.1 The Value of Green Spaces

Accessible green spaces provide a range of amenities to residents, including space for recreation, children's play areas and aesthetically appealing spaces to enjoy nature. Green spaces also have a number of important environmental roles in relation to biodiversity, minimising urban heat island affects and mitigating flooding. These environmental roles may not necessarily be directly valued by the public and reflected in house prices, though are no less significant for this.

As stated in the London Plan 2008-

"London's open spaces include green spaces, such as parks, allotments, commons, woodlands, natural habitats, recreation grounds, playing fields, agricultural land, burial grounds, amenity space, children's play areas, including hard surfaced playgrounds, and accessible countryside in the urban fringe. Civic spaces, such as squares, piazzas and market squares also form part of the open space network. The variety and richness of London's open spaces, that include historic parks and gardens, contribute hugely to its distinctive and relatively open character.

Open spaces play a vital role: they provide a valuable resource and focus for local communities, can have a positive effect on the image and vitality of areas and can encourage investment. They provide a respite from the built environment or an opportunity for recreation. They promote health, wellbeing and quality of life. They are also vital facilities for *developing children's play, exercise and social skills. They play a crucial role in adaptation to and mitigation of climate change, protecting and enhancing biodiversity, reducing flood risk and contributing positively to urban micro climates."*

2.2 Modelling Approach

The modelling approach used is the hedonic pricing method, where the value of a house is assumed to be the result of the combination of many factors that can be inferred from linear regression analysis. This is the same as the previous valuing green spaces research. The log of house prices is taken as the dependent variable to minimise the influence of extremely high prices that are found in certain London sub-markets.

The spatial scale of the model has been increased to the most detailed census geography, known as output area level. This is a significant change, increasing the number of zones in Greater London from 640 wards to over 24,000 output areas. This is intended to increase the accuracy of the model and be able to represent the fine grained mix of housing types that often characterises London. Additionally local access to green spaces should also be better represented. On the other hand increasingly the spatial scale will highlight more unique and atypical combinations of variables that would be averaged out at larger spatial scales. Therefore, it is not guaranteed that increasing spatial scales increases the statistical accuracy of the model, though in this case of this research it does bring a significant improvement.

2.3 The Dynamics of Residential Location

Cities are often described as complex systems in scientific literature, which refers to the interdependence of many factors in urban processes, and the relatively unpredictable ways these interact over time. In the case of residential location, a great number of social, economic and built environment considerations affect residential location decision making. Furthermore the cumulative effects of population movement and urban development mean that residential communities do not stand still, and are constantly shifting through processes such as urban decline, regeneration and gentrification.

The nature of complex systems has important implications for the type of linear regression methods used in this study. The first is that multi-collinearity is likely. There are techniques to measure the extent of cross-correlations between variables. Multi-collinearity also makes it more difficult to assume causality in correlations between variables.

3. Green Spaces Analysis

3.1 Green and Open Space Data

The dataset used to represent green and open spaces is the Greenspace Information for Greater London (GIGL) data. GiGL is an open space and biodiversity records centre set up in 2006 and hosted by London Wildlife Trust. The dataset provides a higher level of comprehensiveness and detail to green space information in London. In addition to representing parks, GIGL includes many other types of open space such as squares, cemeteries, and vacant land. These are discussed further in the next section. The dataset does not at present include private household gardens.

3.2 Classifying Green and Open Spaces

Clearly the type of green space has important implications for how useful and valuable it is to residents. In addition to formal green spaces such as parks and gardens there are a great variety of public and private open spaces that add, or in some cases detract, from the environmental amenity of a neighbourhood. These spaces include rivers, canals, sports fields, cemeteries, vacant plots and industrial land. Many of these spaces are recorded in the GIGL data. To simplify the modelling of these open spaces, they have been classified into general amenity groups: formal green spaces, general open spaces, and unattractive open spaces. These vary from high amenity to negative amenity in terms of how they are expected to influence house prices. Their amenity value is assumed to be correlated to area. For instance large parks are assumed to higher value than small parks.

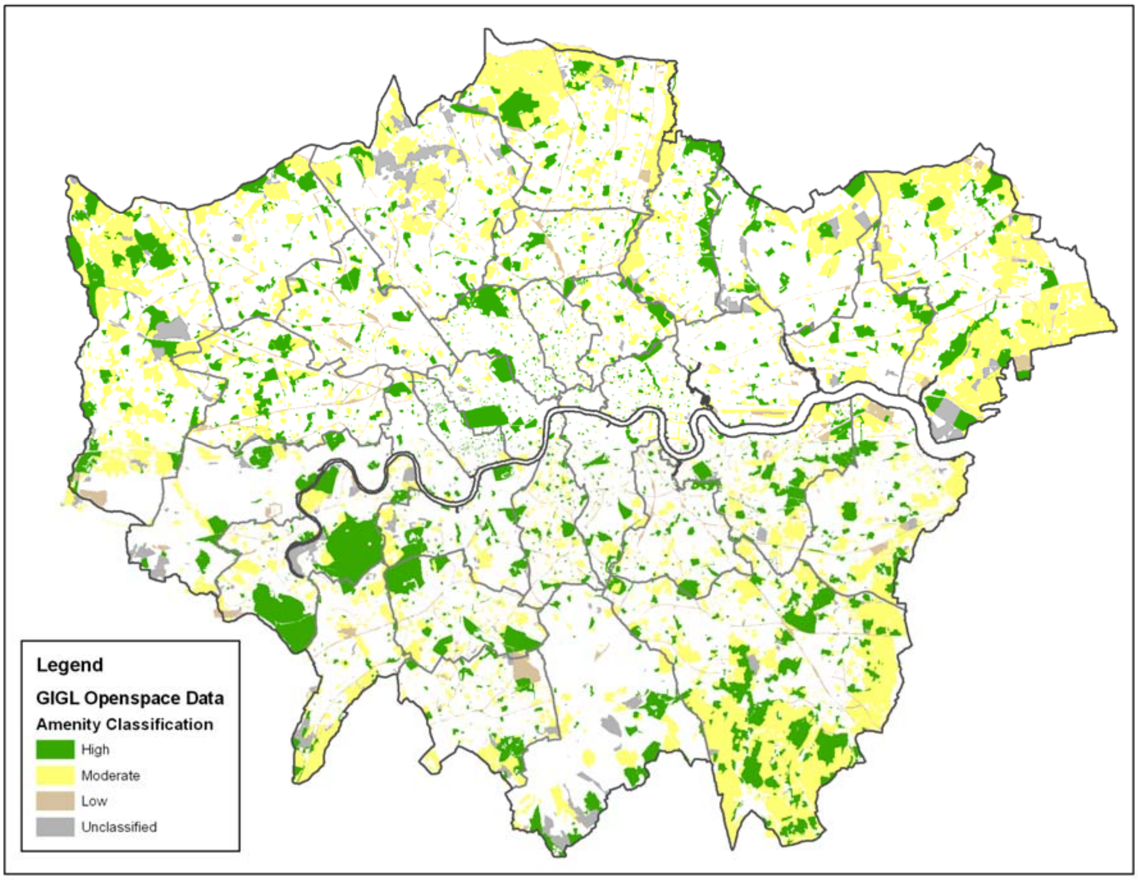
In addition to these general categories, several open space variables are modelled independently as binary factors, where their amenity is either present or absent (rather than being correlated to area). These include the River Thames, other rivers and canals, and regional parks (note that regional parks are therefore included both in an area based measure and as a binary measure).

Table 2: Open Space Amenity Classification

Amenity General Class	Expected Amenity Value	Amenity Sub Class
Formal Green Space	High	Public Gardens; Parks (all kinds); Square; Wilderness Park/Heath
General Open Space	Moderate	Agriculture; Allotments; Cemetery, Church; Greenbelt; Landscaping around Buildings; Metropolitan Open Land; Public Institution Grounds; Recreation, Sports; Reservoir;
Unattractive Open Space	Low / Negative	Industrial; Prison; Sanitation; Transport; Vacant; Wasteland
Additional Independent Variables	High	River Thames; River/Canal; Regional Park

The map of the open space classification groups is shown in Figure 2. The largest areas of General Open Space are found near the GLA boundary on the suburban fringe, where metropolitan open land and agricultural land is prominent. Within the formal open space category there is an intricate network of green spaces of various sizes spread across London. The largest parks are found to the west, particularly around Richmond and Wimbledon. The low amenity open space category is far less prominent, and relates mainly to railway lines and sewage works. We can assume therefore that most industrial land is not included in the GIGL data.

Figure 2: Classified Open Spaces in GIGL Data



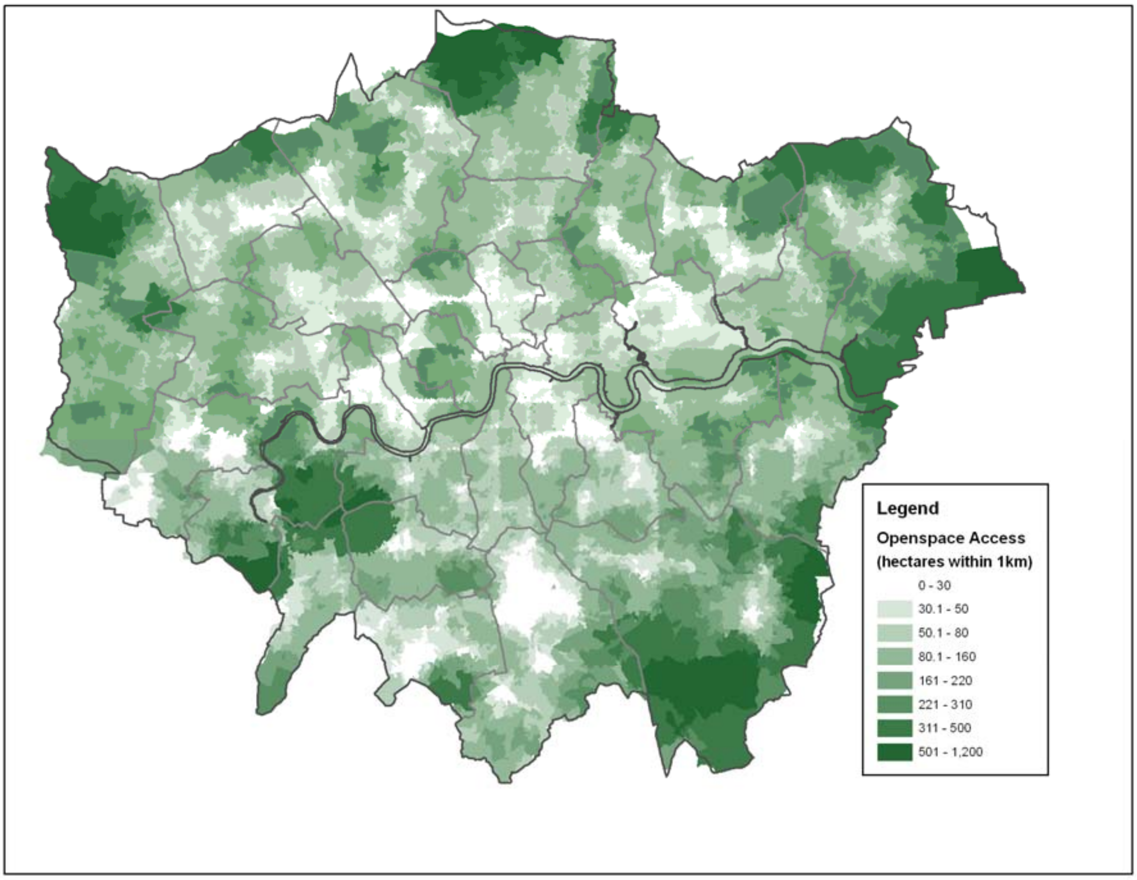
It would have been useful to extend the green space typology to model different kinds of parks independently, using the categories defined in the London Plan green space hierarchy. This hierarchy describes green spaces by area and type, from regional parks to small local spaces. The London Plan categories are not however included in the GIGL data. Furthermore including the 6 level classification in the hierarchy would have greatly increased the number of variables and reduced the clarity of the green space value results for this research.

3.3 Accessibility to Open Space

The green space data can be used to measure the total area of green space accessible within a particular distance of neighbourhoods. Figure 3 maps the total formal green space and open space (as defined in the previous section) accessible within a 1 km threshold of output areas, calculated using GIS software. By this measure the majority of London has access to at least 50 hectares of open space within 1 km. The geography of open space access is uneven however, and there are areas of notably lower open space access. In addition to the unsurprisingly low access in Central London, low values are also found in several inner-city areas, including Shepherd's Bush and parts of Southwark, Lewisham and Newham. Note that the situation in North West Newham will be improved with the creation of the Olympic Park.

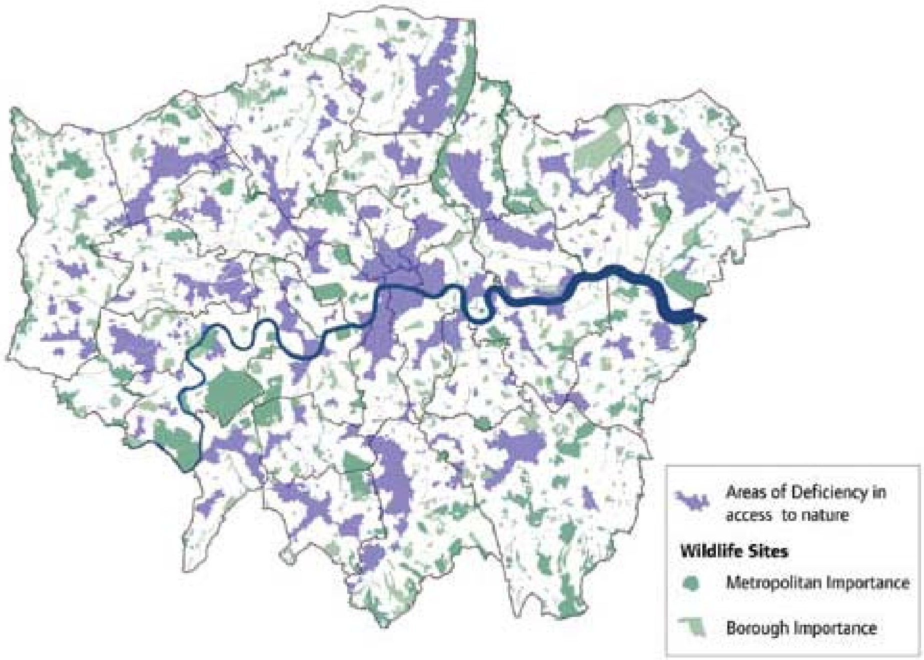
Generally Outer London has better access to open space by this measure due to large areas of metropolitan open land and some agricultural land. There is the exception of North Croydon which has a large area of low open space access. Total open space access is lower here due to a lack of a regional park. This result is also partly due to incomplete small parks data for this borough in the GIGL database. Note that as the GIGL data only covers the Greater London area, there will be a boundary effect for those zones at the very edge of Greater London.

Figure 3: Open Space Area within a 1km Distance (open space defined in Section 3.2)



The access to open space indicator has similarities to the analysis from the London Plan Improving Londoner's Access to Nature Implementation Report (2008), which measured areas of deficiency in access to nature (Figure 4). The different emphasis to the results compared to Figure 3 is a result of firstly the inclusion of all types of open space in this study compared to the wildlife focussed typology in the access to nature study, and secondly by the area-based measure used here.

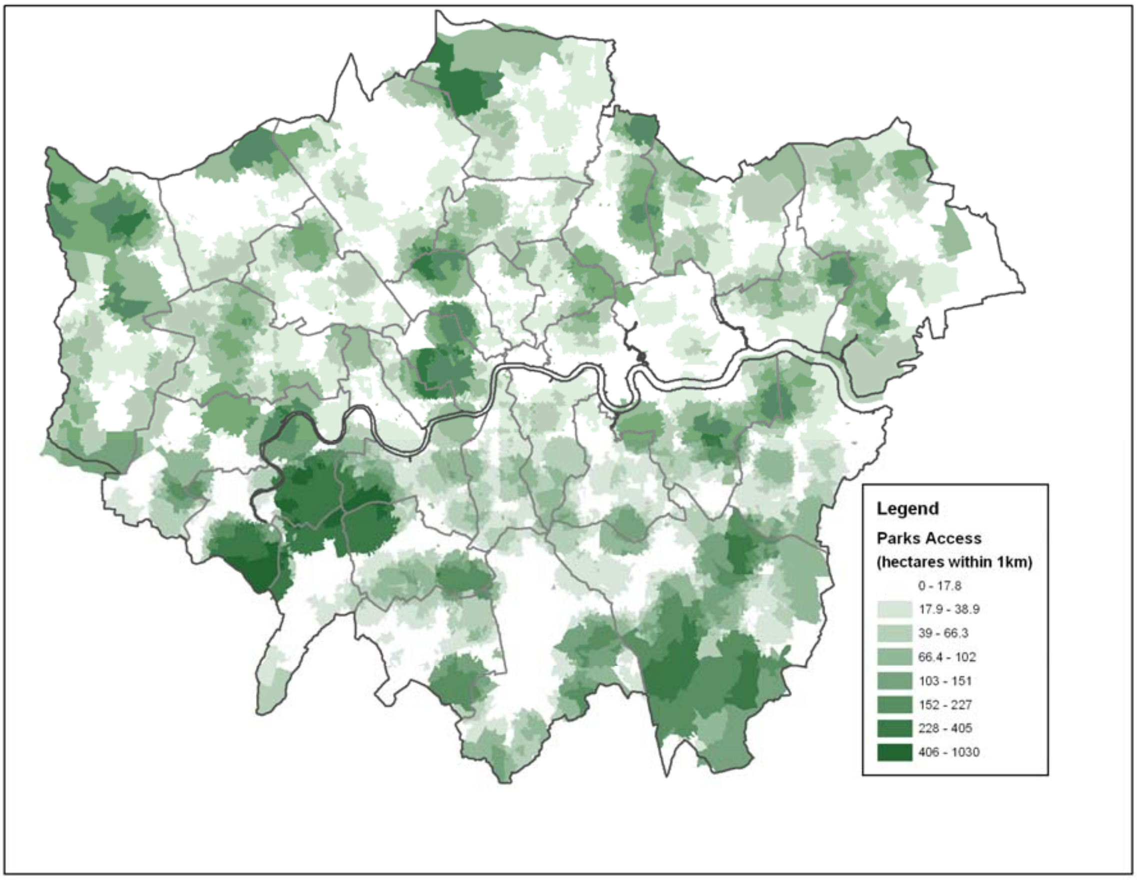
Figure 4: Areas of Deficiency in Access to Nature



(Source: Improving Londoner's Access to Nature, 2008)

The same measure can be applied to formal green space (i.e. park) access (Figure 5) as defined previously in Section 3.2. The results show some significant differences to the open space access analysis, with lower results in Outer London and strong concentrations around the royal parks to the west. There are a number of connections between areas of high park access and high house prices, and these are discussed further in Section 4.

Figure 5: Park Area Access within 1km Distance (park area defined in Section 3.2)



The connections between high quality green space access and desirable residential areas have produced associations between lower green space access and deprivation in London. The average park access for the most and least deprived lower super output areas (LSOAs) in Greater London are shown in Table 3, with the most deprived areas nearly 25% below the London average. The association between these variables is very minimal in regression analysis however. This is because a wide range of socio-economic factors contribute to deprivation and it cannot be explained by a single variable.

Table 3: Park Area Access and Deprivation

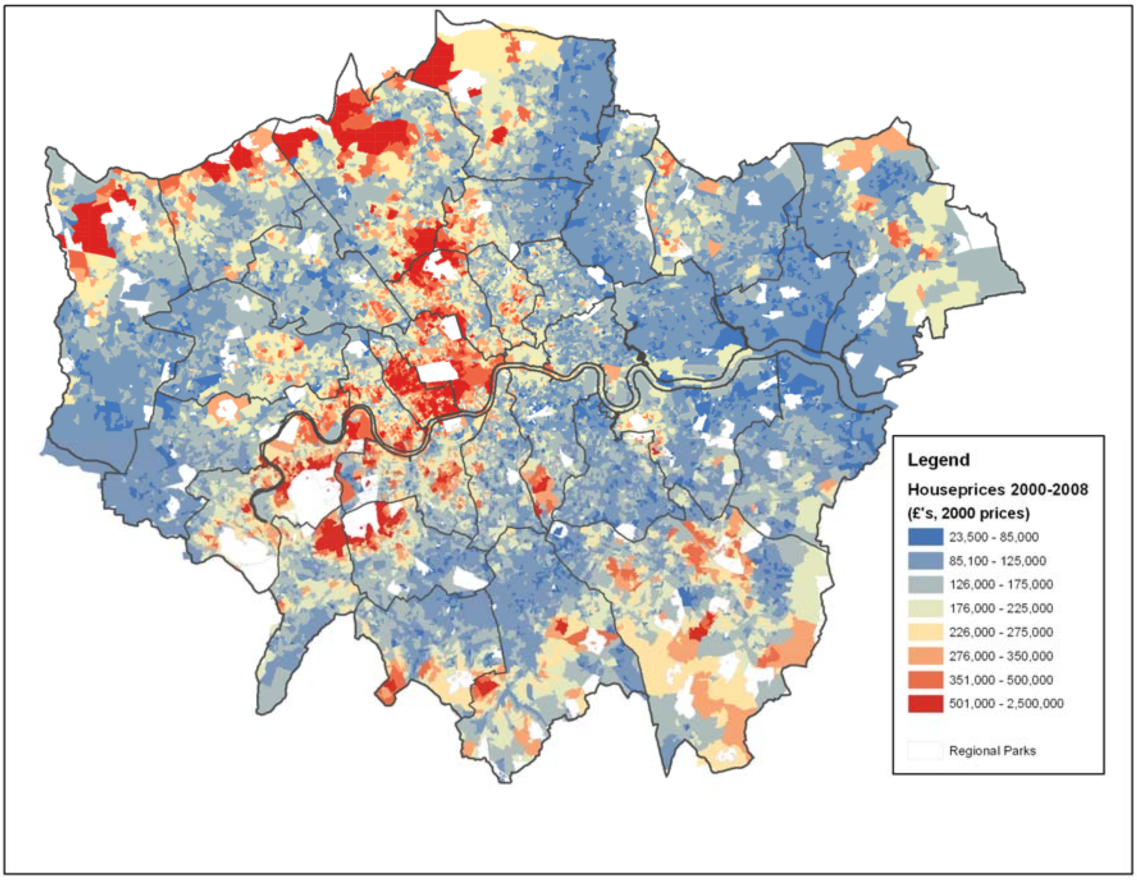
Group	Average Park Area Access 1km (hectares)
Greater London Average	48.3
20% least deprived LSOAs	62.6
20% most deprived LSOAs	36.2

4. The Geography of House Prices

Housing sub-markets within Greater London are highly polarised, including many of both the richest and the most deprived neighbourhoods in the UK. A map of average house price sales using 2000-2008 Land Registry Data, adjusted to 2000 prices, is shown in Figure 6. (The method for calculating average price is detailed in Appendix A). It is clear from Figure 6 that areas of high prices are strongly clustered, and that this clustering occurs at multiple scales, from small pockets of high prices to large districts and corridors extending over multiple boroughs.

There is no simple relationship (e.g. proximity to Central London) which can comprehensively explain the spatial pattern of house prices in London. Two corridors of very high prices extend from Westminster: one running South-West through Hyde-Park, Kensington-Chelsea to Richmond and Wimbledon; and the second running north though Regents Park to Hampstead and Highgate. These are all areas of high quality extensive parks, and these green spaces have very likely played a role in the development of these highly affluent neighbourhoods. Two large areas of high prices in Outer London can also be seen. To the north-west a corridor of high prices run through Barnet, Stanmore and Northwood. This pattern is also repeated to the south-east, with moderately high prices in the low density areas around Biggin Hill, Orpington and Warlingham. As will be shown later, these are areas of relatively large detached houses with gardens.

Figure 6: Average House Price Sales in London 2000-2008



Source: Land Registry

Areas of low prices extend widely across East London, north around Tottenham, west around Heathrow and Wembley, and much of South London. This is connected to many factors including social deprivation, industrial/ex-industrial areas, relatively poor quality council housing, and negative amenity infrastructure such as Heathrow airport. Many of these areas have been made priorities for regeneration in the various London Plans. Recent changes in prices in regenerating areas (such as at Stratford and the Olympic site) will not be reflected in the eight year average prices shown. The affects of previous regeneration schemes, such as in Docklands, can be seen with moderately high prices in these areas.

5. Housing Attributes Modelled

In this study we explain house prices through three types of attributes: physical built environment attributes, locational neighbourhood attributes, and socio-economic attributes. Built environment attributes relate to physical properties of housing, such as house size and type. Locational attributes describe neighbourhood amenities, such as green space access and public transport access. Socio-economic attributes describe the demography of the neighbourhood, such as deprivation and the quality of schools. There will be many connections and cross-correlations between these various factors.

An important question relates to the causality of these factors in determining house prices. Built environment and locational properties can generally be thought of as having a direct one-way relationship with the housing market. It is possible for some feedback loops to occur, where processes of gentrification and urban development respond to market signals and change the built environment, leading to further price increases.

The most problematic data to use in relation to the question of causality is socio-economic data. Low incomes and deprivation are as much a result of socio-economic segregation caused by the market restricting choices for less affluent households as they are a determinant of house prices. Therefore socio-economic datasets have to be used with caution as a predictor or determinant of house prices.

The following sections look in detail at the built environment, locational and socio-economic factors used in the model.

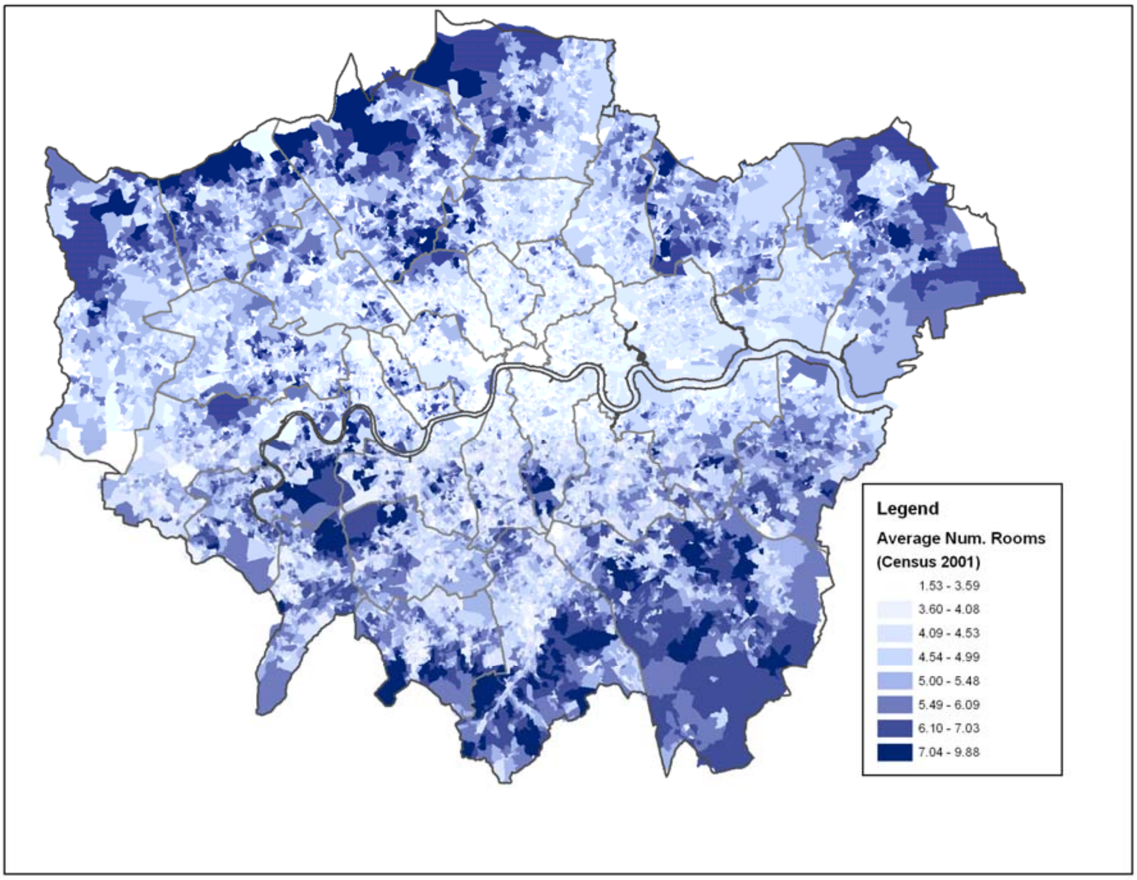
5.1 Built Environment Attributes

We define built environment factors here as the physical housing variables, such as housing size, type, density and age. These will have a strong influence on prices and are independent of the locational aspects of housing attractiveness, such as green space access.

Housing Size

Several studies have found property size to be the most influential variable in determining house price. In higher density areas such as London where housing sizes are on average smaller, this is likely to place an even greater emphasis on the value of large houses. Unfortunately there is no comprehensive dataset of house size for London. A proxy measure of the average number of rooms recorded in the 2001 census is used here (Figure 7). This will of course not include room size, but this is likely to be correlated with the number of rooms as well as other built environment variables such as housing type and age. A visual comparison between Figures 6 and 7 indicates that there are strong relationships between the number of rooms and house prices, with a number of high price areas strongly highlighted, and indeed this is confirmed later in the analysis section with number of rooms being the second most strongly correlated variable.

Figure 7: Average Number of Rooms



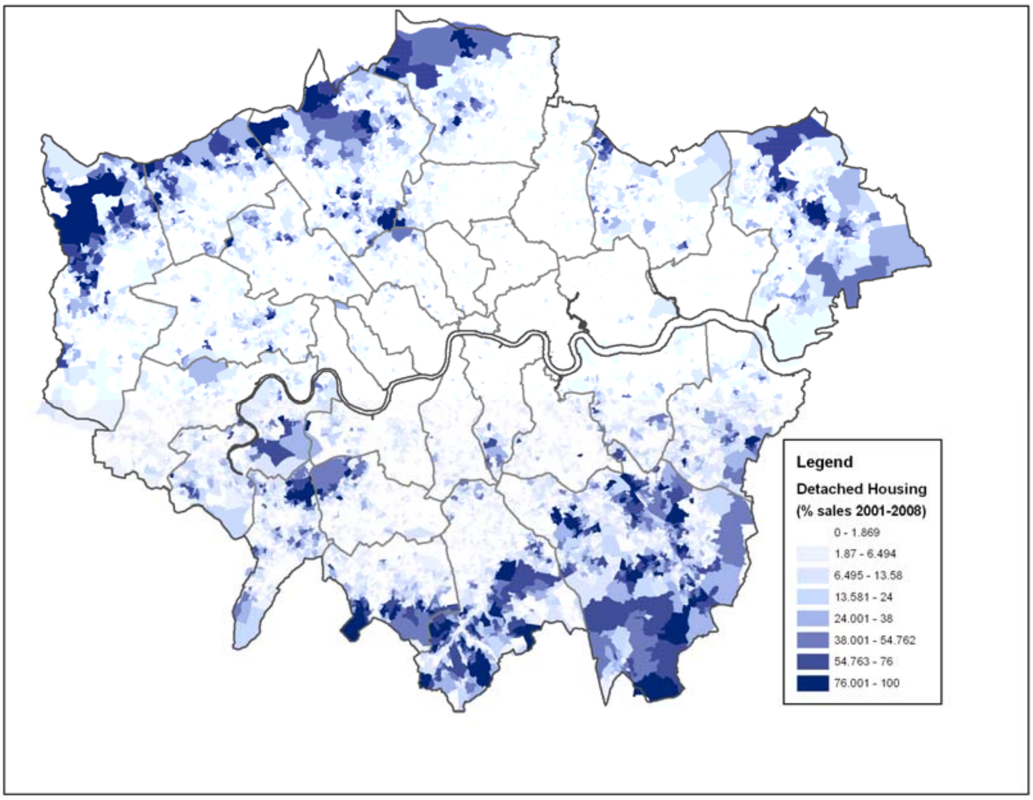
Source: Census 2001, accessed via CASWEB[1]

Housing Type

Basic classifications of house types into detached, semi-detached, terraced and flats can be found in the 2001 census data and in the Land Registry housing sales data. These types are related to a number of factors influencing prices such as density, the presence of private gardens, and often to house size. London generally has a density gradient of housing type, with high density flats in the centre shifting to terraced then semi-detached and detached housing as you move towards suburbs and urban periphery. Figures 8 and 9 show the two extremes of this relationship with detached housing confined to the boundaries of the GLA and only the most affluent inner areas, whilst flats dominate all of Central and Inner London. Note the close similarities between areas of detached housing and high average numbers of rooms.

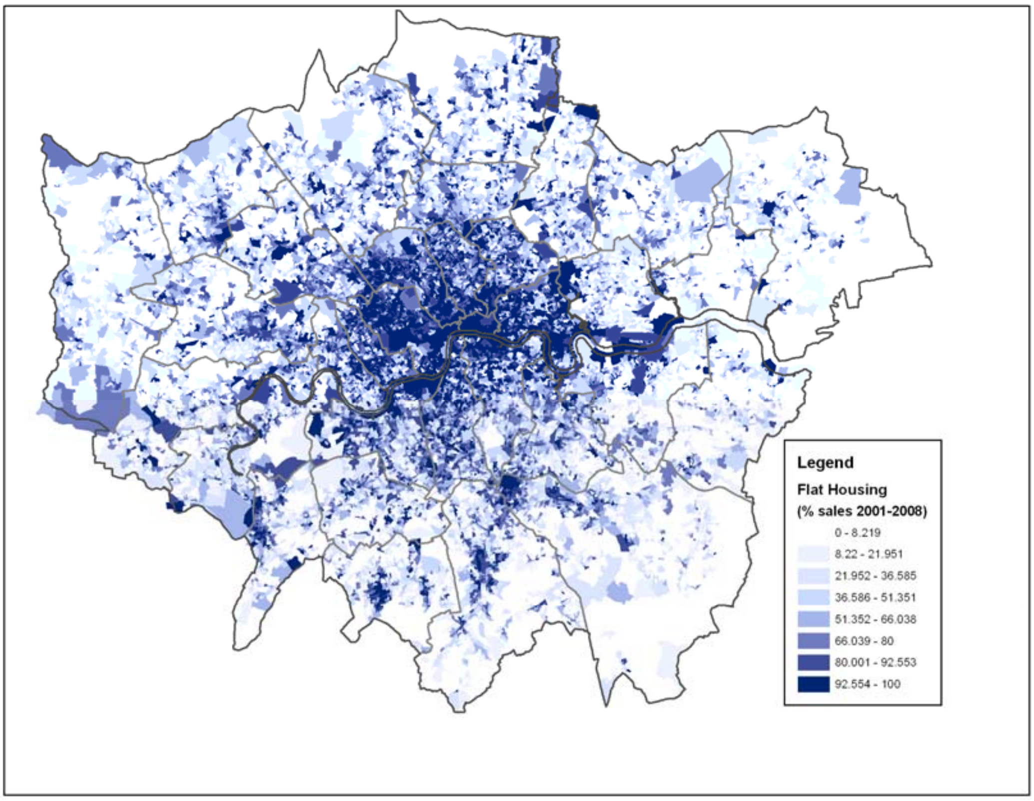
[1] http://casweb.mimas.ac.uk/

Figure 8: Detached Housing Proportion



Source: Land Registry Sales 2000-2008

Figure 9: Flat Housing Proportion

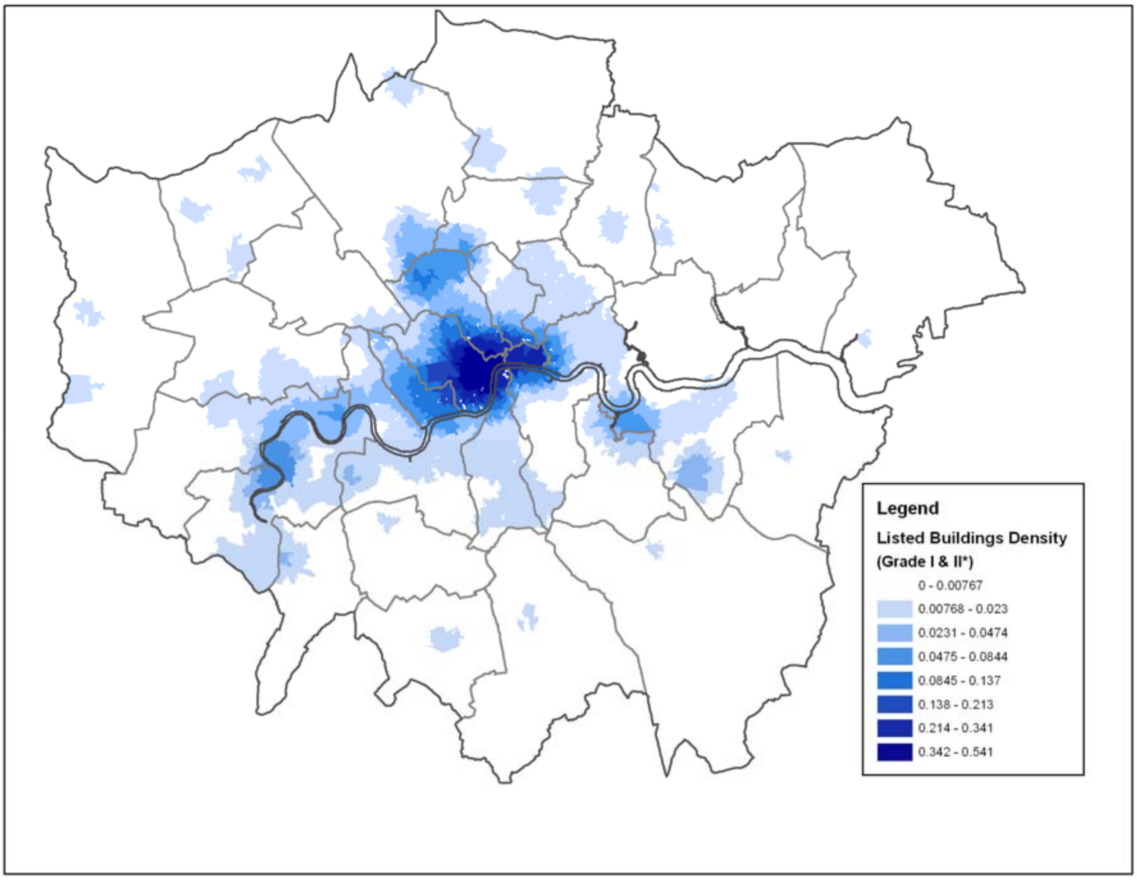


Source: Land Registry Sales 2000-2008

Housing Age/Listed Buildings

Older housing generally has a number of positive associations including aesthetic quality, durable materials, and prestige, as well as often being of larger size in terms of floorspace and ceiling heights. Again there is no universal data describing housing age across Greater London. Data on listed buildings (provided by English Heritage) can be used as a proxy of the general age and the heritage quality of an area. The density of Grade I and Grade II* buildings is shown in Figure 10, with church building listings removed to focus on housing. The distribution is strongly focussed on Central London and the West End, as well as other historic centres such as Greenwich.

Figure 10: Density of Listed Buildings

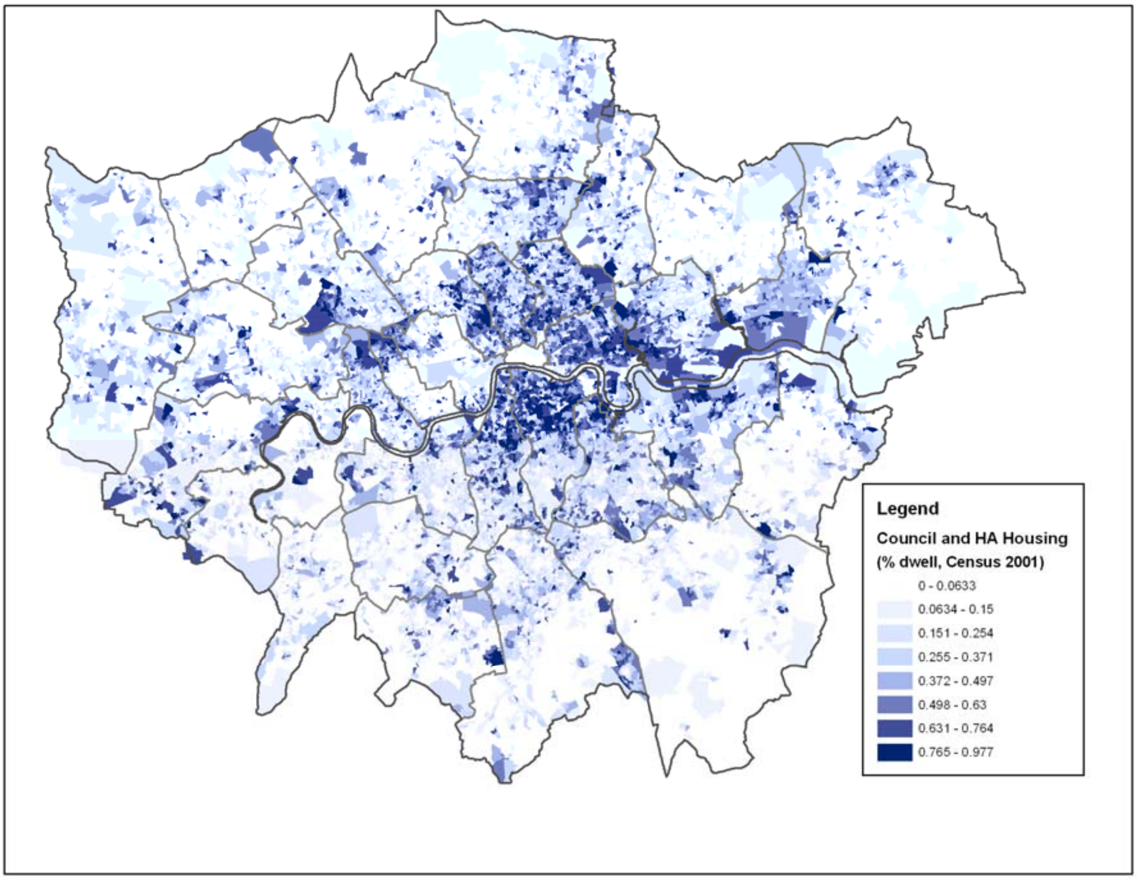


Source: English Heritage

Local Authority and Housing Association Housing

In general the bulk of local authority housing in London is mass produced relatively low quality buildings developed from the 1950's onwards. These are concentrated in Inner London and East London, with smaller pockets spread across the city. It is anticipated that this variable will be associated with lower prices, although there is considerable variation within the local authority housing stock so the strength of the relationship may be limited. There are also issues in relation to cross-correlations with socio-economic deprivation.

Figure 11: Council and Housing Association Housing Proportion

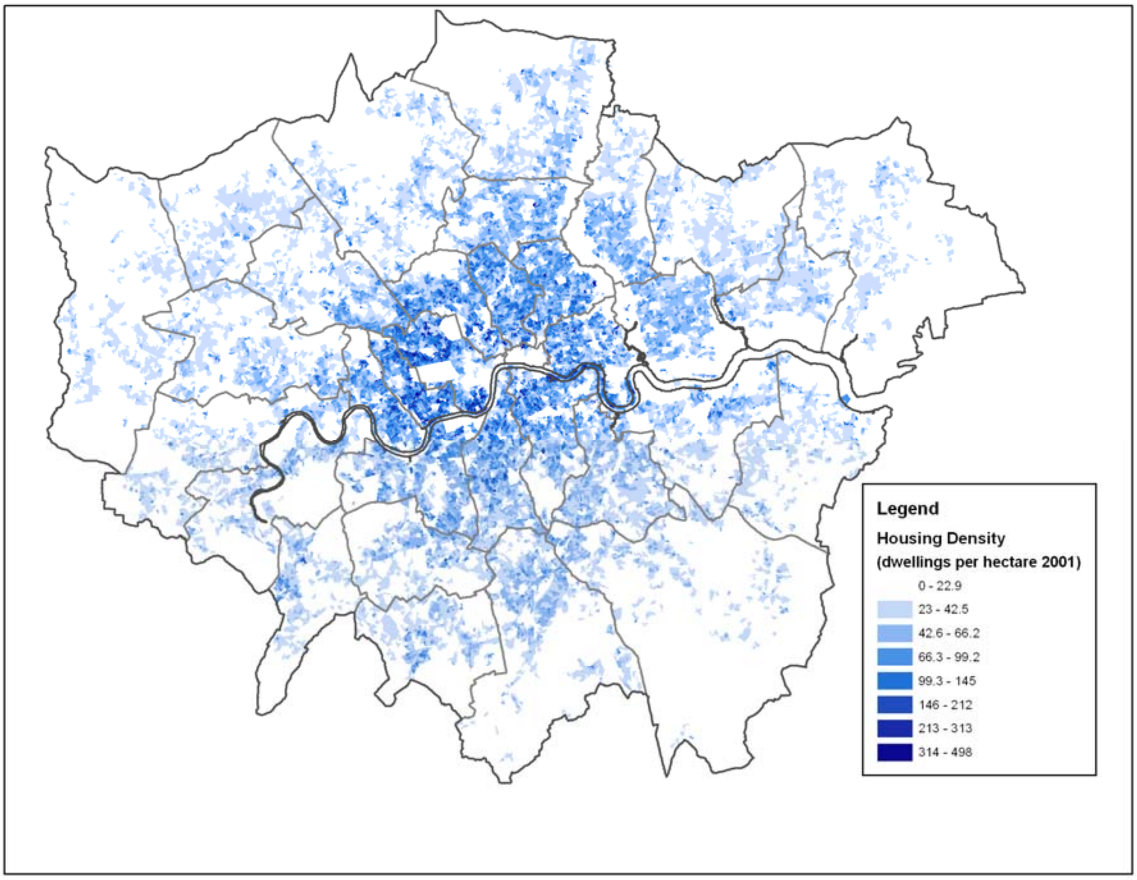


Source: Census 2001

Residential Density

The housing type data has already considered some aspects of density, and there will be further density variation within the housing type classes. Therefore it is worth including a density measure quantifying the number of dwellings per hectare at output area level (Figure 12). There is a clear density gradient from Central to Outer London. There is a problem with areas such as the City of London being measured as low density due to their dominant commercial functions. Fine scale data is advantageous here as particular estates (e.g. the Barbican) should be measured relatively accurately rather than being distorted by conditions in the wider district.

Figure 12: Dwelling Density



(Source: Census 2001)

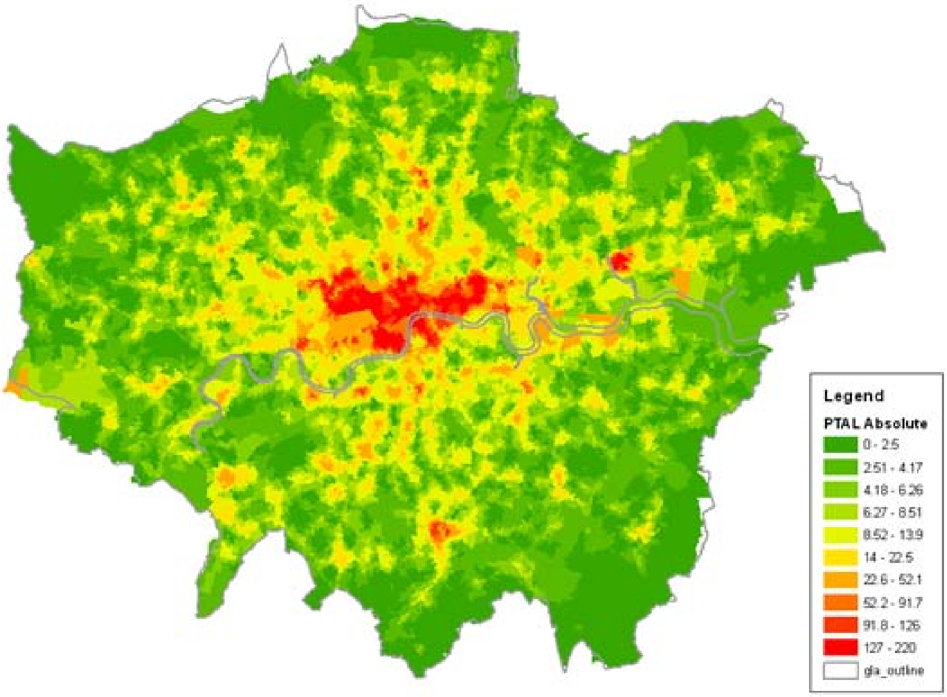
5.2 Locational Attributes

In addition to the properties of buildings themselves, the value of housing is derived from the access provided to local services, facilities and employment. The primary interest in this study is in the value provided by access to green spaces, which has been discussed earlier in Section 3. Here we look at other locational properties such as transportation accessibility, local service accessibility, air pollution and river proximity.

Public Transport Accessibility

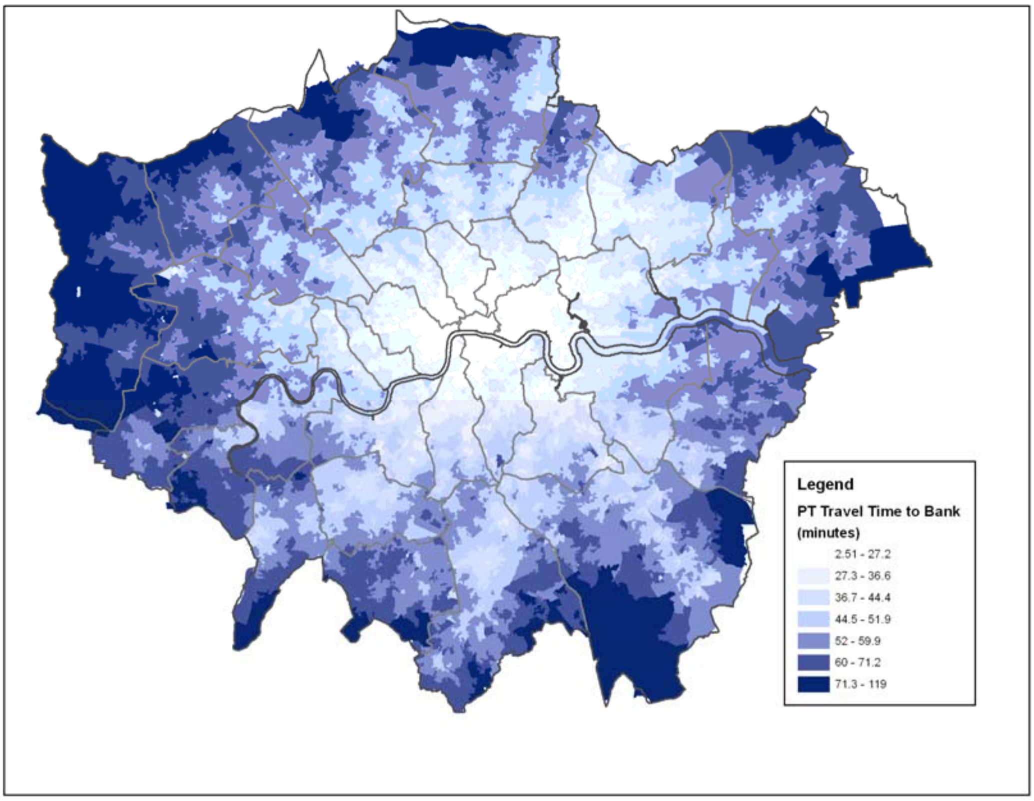
Access to public transport brings many mobility benefits in accessing facilities, population and employment across London. Accessibility can be measured in several ways including access to public transport services (such as TfL's frequently used PTAL measure shown in Figure 13) and access through public transport networks (such as the journey time to Central London measure shown in Figure 14). Both of these measures have been tested in the model. A simple straight-line distance indicator from Charing Cross has also been included.

Figure 13: Public Transport Accessibility Level 2008



Source: Transport for London

Figure 14: Travel Time to Bank 2006

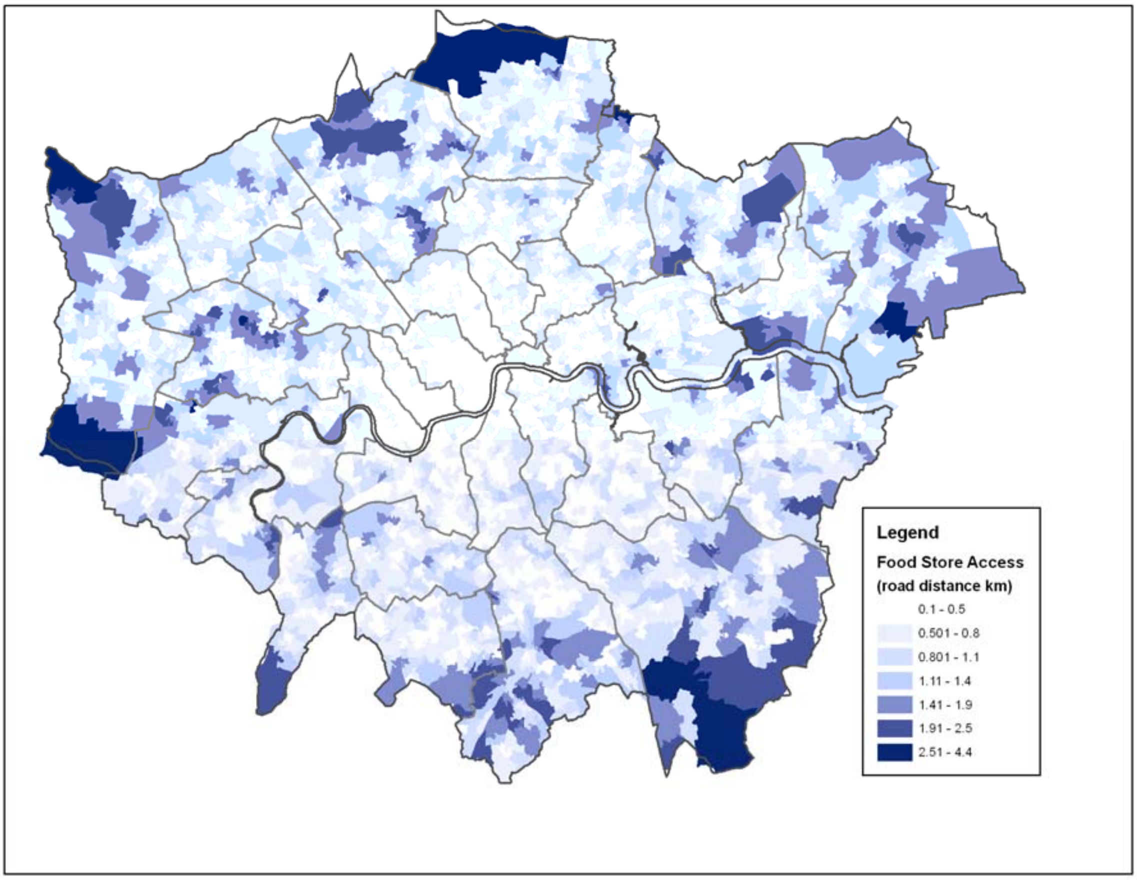


Source: Transport for London

Local Service Access

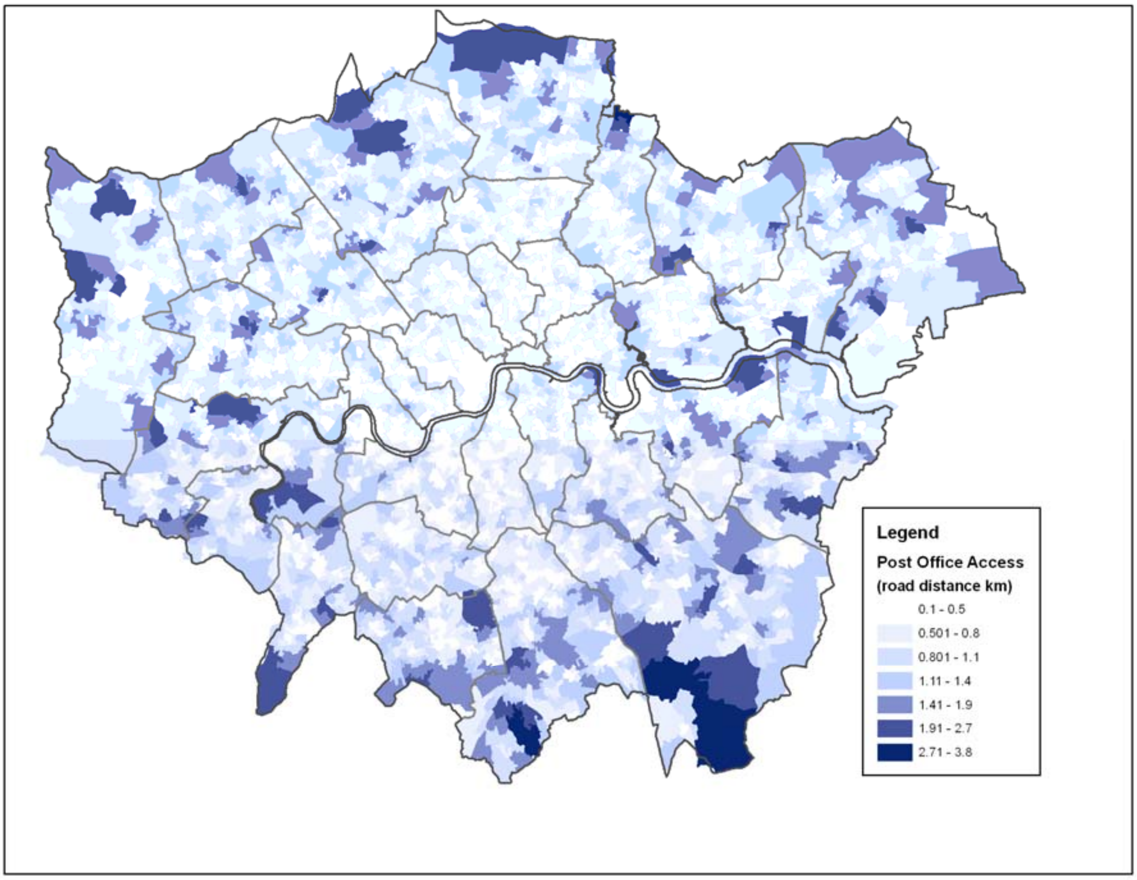
Access to local services such as food stores and public services is likely to have a modest impact on house prices. The calculation of indicators for the Index of Multiple Deprivation 2007 included calculating road distances to food stores, post offices, GPs and primary schools at LSOA level. The results for the different services tend to be similar as they often clustered together in local town centres. As shown in Figures 15 and 16 there are pockets of low service access in Outer London.

Figure 15: Distance to Food Store



Source: Indices of Deprivation 2007, Communities and Local Government

Figure 16: Distance to Post Office



Source: Indices of Deprivation 2007, Communities and Local Government

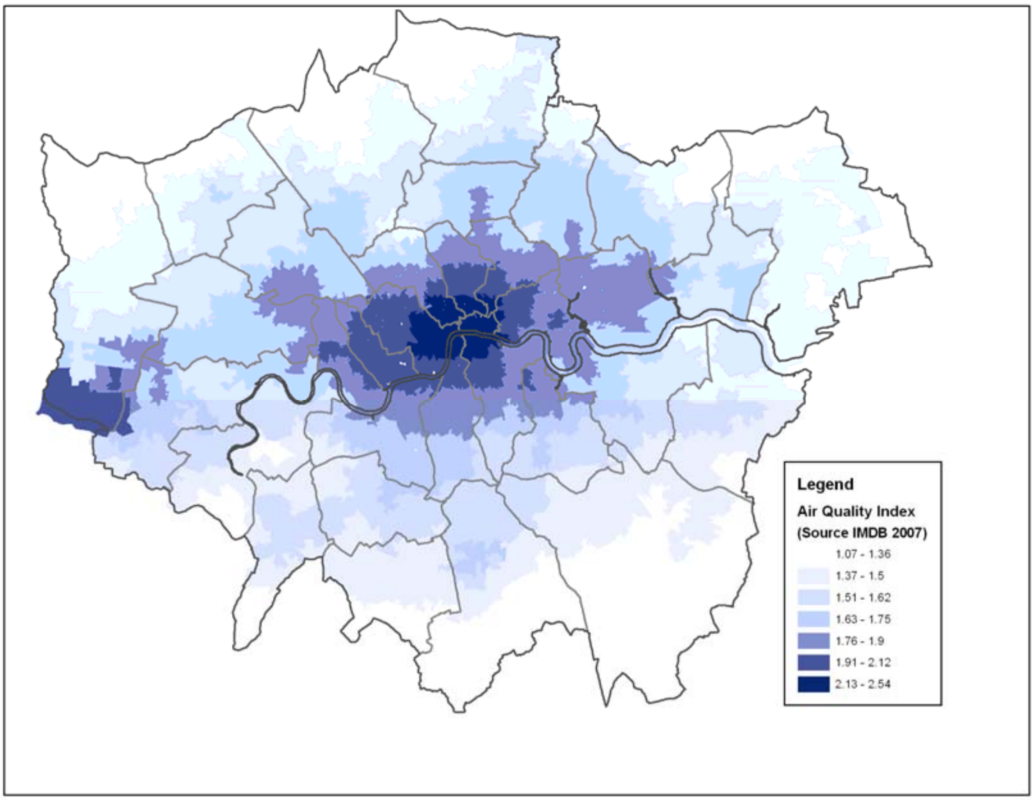
Air Pollution

Air quality in terms of the concentration of nitrogen dioxide and particulates is lower in Central London and around Heathrow Airport (Figure 17). This measure is also likely to be correlated with the related negative externality of noise pollution from vehicles and aircraft.

Rivers and Canals Proximity

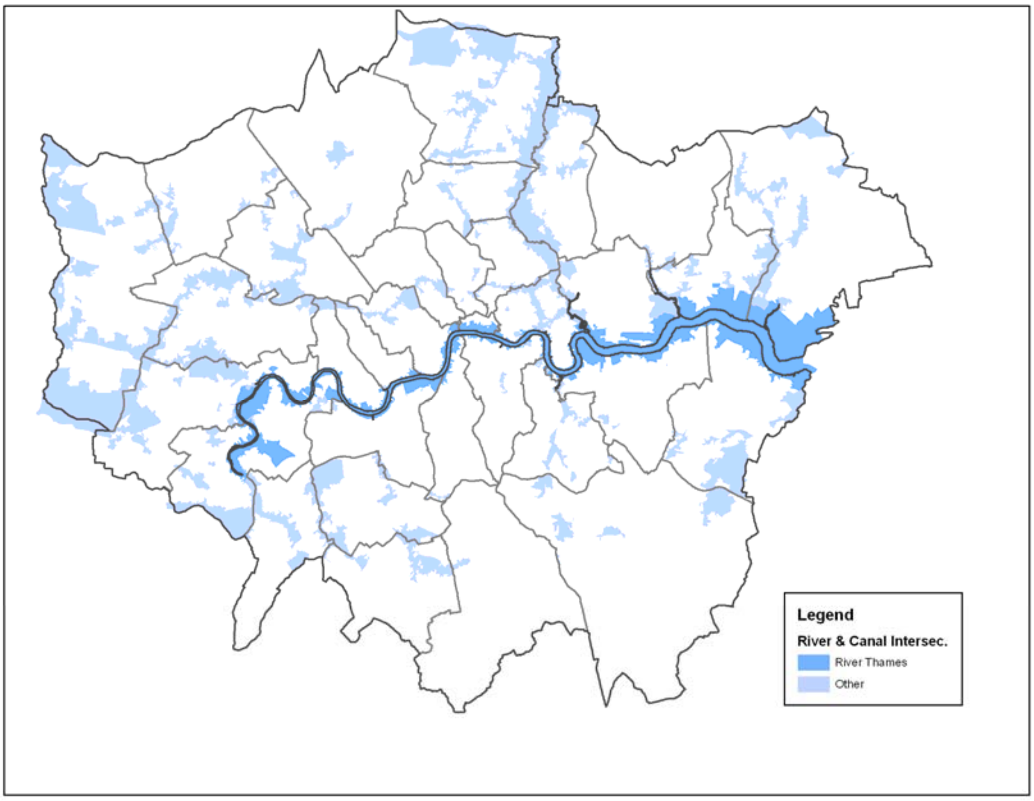
Rivers and canals are often attractive areas for housing. The River Thames is particularly significant in London and has been considered as a separate variable in the model so that any additional benefits of the Thames can be incorporated.

Figure 17: Combined Air Quality Index



Source: Indices of Deprivation 2007, CLG

Figure 18: River adjacency



Source: Ordnance Survey Mastermap 2008

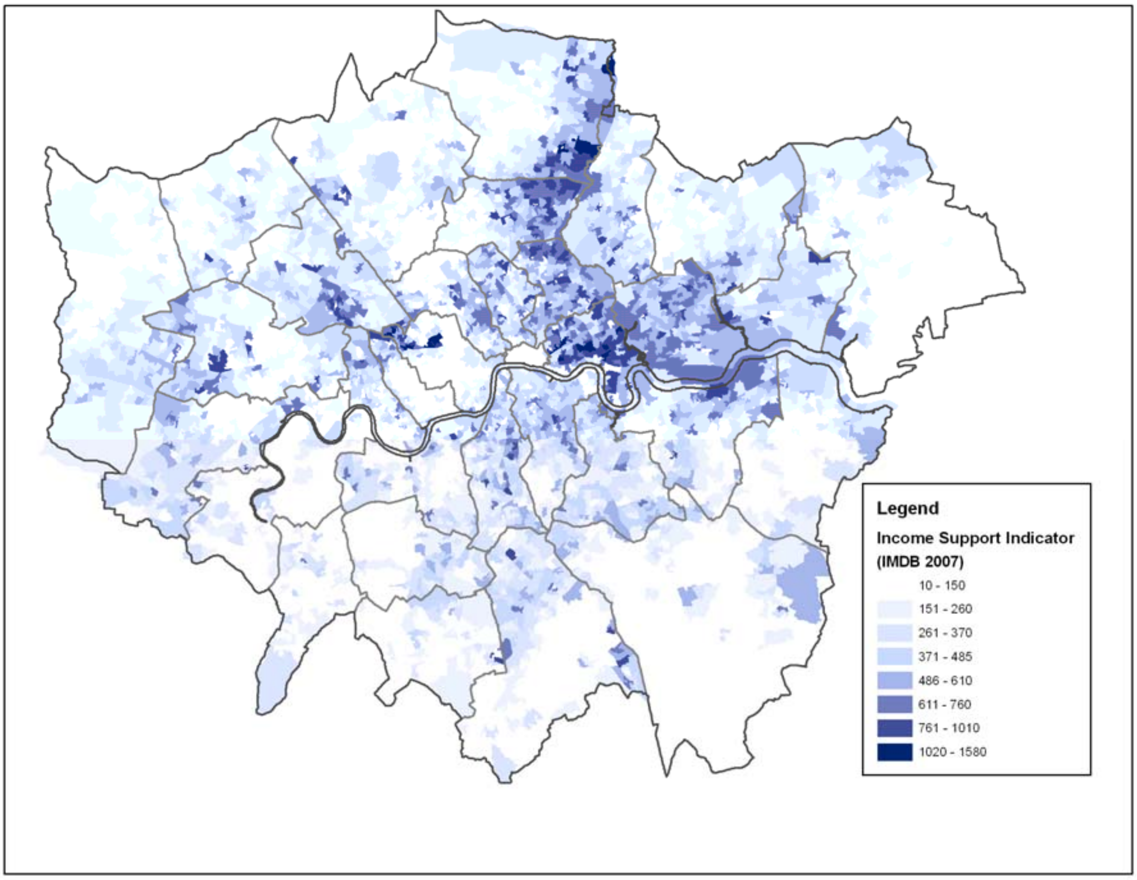
5.3 Socio-Economic Attributes

Residential segregation by socio-economic attributes is a near universal characteristic of cities in market economies. This is a result of income polarisation and of the preferences of many households to live in neighbourhoods with similar social and economic class characteristics to themselves. Core socio-economic characteristics are considered here in relation to income deprivation and education.

Deprivation Indicators: Income support and Higher Education Participation

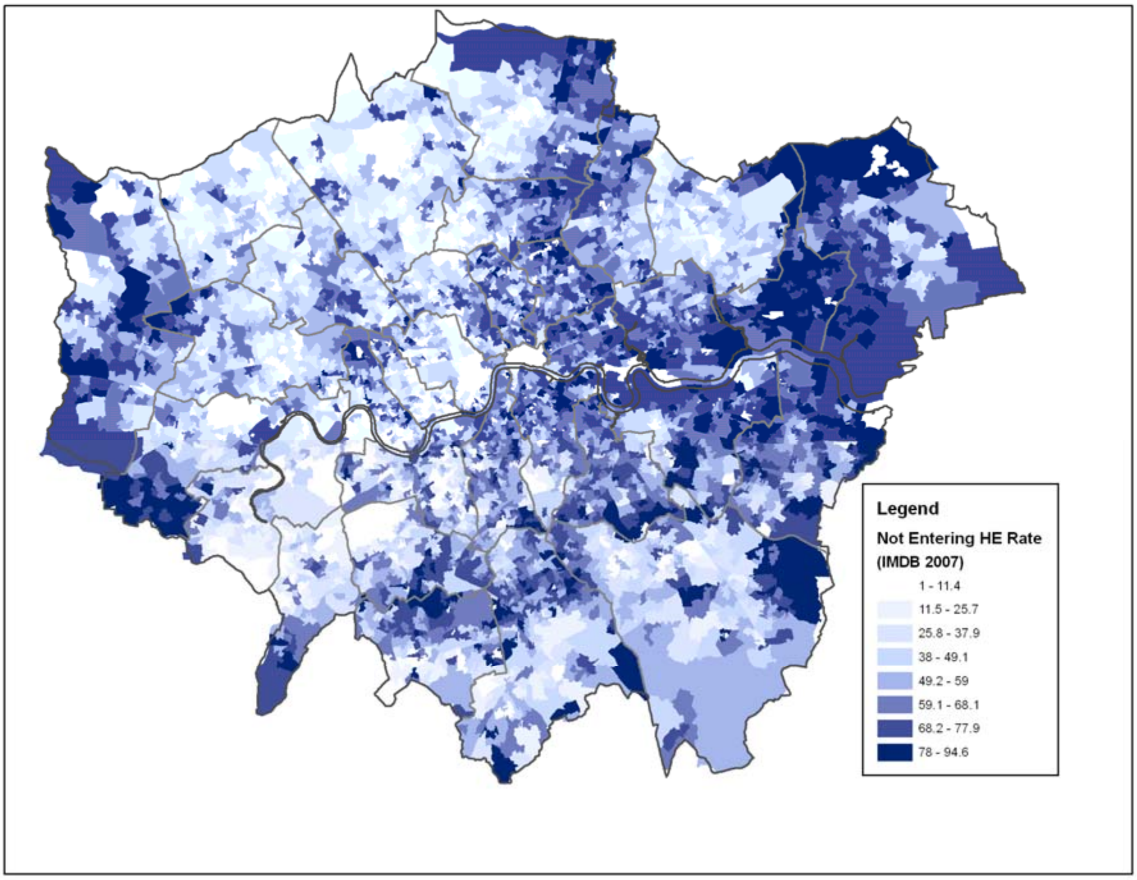
The level of income support claimants is an effective general indicator of deprivation. Claimants are concentrated in East London and in a corridor running north through Tottenham. The distribution is as expected closely related to the distribution of council housing. The level of non-participation in higher education has a similar East London emphasis but is more widely distributed across the region, and is likely to highlight lower income families who are not at the level of requiring income support.

Figure 19: Income Support Proportion



Source: Indices of Deprivation 2007, Communities and Local Government

Figure 20: Higher Education Non-Participation Rate

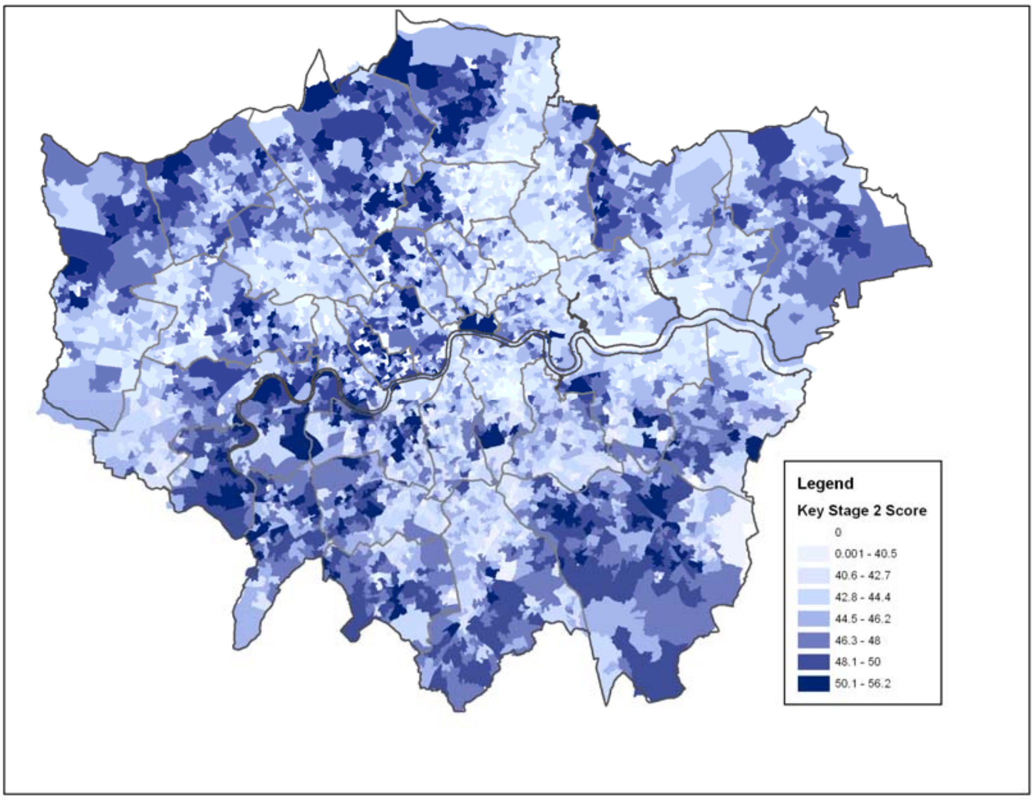


Source: Indices of Deprivation 2007, Communities and Local Government

Education Results (Schools Quality)

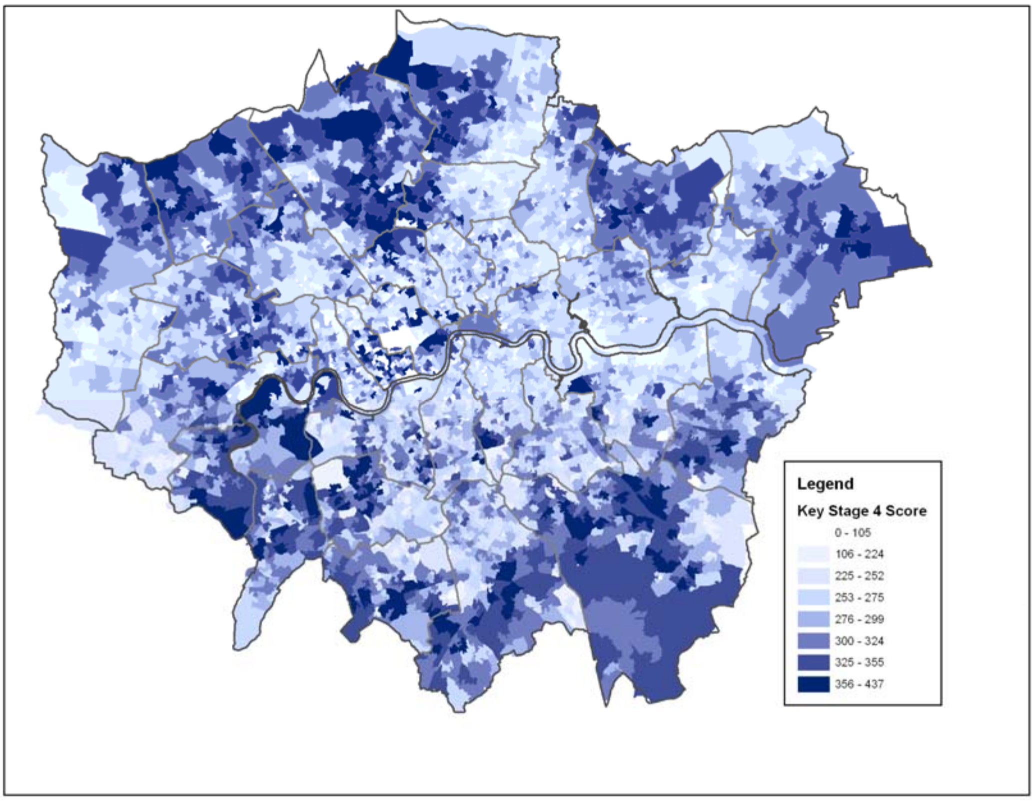
It has been widely recorded how the catchment areas for high quality schools have a significant influence on house prices. It would be a considerable effort to spatially model all London school catchment areas, so here we have used the proxy of education results by household. As this will include results from private schools, there will be relationships with affluence. Results from Key Stage 2 and Key Stage 4 were found to be the most influential in the model.

Figure 21: Key Stage 2 Score



Source: Indices of Deprivation 2007, Communities and Local Government

Figure 22: Key Stage 4 Score



Source: Indices of Deprivation 2007, Communities and Local Government

6. Analysis

6.1 Model Specification

The analysis method applied is a hedonic modelling approach. This is essentially a linear regression method combining all the input variables to predict the dependent variable, in this case average house prices. The extreme variation in house prices, particularly with a small number of very high price areas, means that the hedonic approach is most effective by taking the log of house prices as the dependent variable. This is known as a semi-log model.

There are a great number of variables to test, and those variables that are not found to be statistically significant are removed in the modelling process. The following sections describe different versions of the model, each adding more variables to explain the house price distribution. Model 1 considers green space measures in isolation from any other variables. Model 2 adds built environment and locational data to the analysis. Model 3 then adds socio-economic data. And the final model, Model 4, considers a prestige variable to capture the influence of very high value housing sub-markets.

6.2 Model 1 – Green Space Only

This model analyses the green space and open space variables in isolation, to measure the strength of general relationships between green space and house prices before considering the complexities of multi-collinearity with other built environment and socio-economic variables.

For the green space and open space accessibility, it is not known at what distances relationships will be strongest and so multiple distances have been tested, at 150m, 300m, 600m and 1km. It is possible for more than one distance to be significant, for example being adjacent to a park brings aesthetic benefits, while the benefits of pedestrian access to the park will extend over longer distances.

The summary of Model 1 is shown in Table 4. By this analysis method green space variables in isolation are a weak predictor of house prices, returning an R Square value of .083, i.e. the model only explains approximately 8% of the house price variation, with over 90% left unexplained.

Table 4: Model 1 Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.289	.083	.083	.440

The coefficients from Model 1 are shown in Table 5. It can be seen that the variables at distances of 1 kilometre proved to be the most effective at explaining average house prices. The total park (formal green space) area within 1 km has the highest beta value. According to the model each additional hectare of park space within 1km adds approximately 0.14% to house prices. The other types of open space, classified as moderate and low/negative amenity produced negative beta values. It is likely that, since the moderate open space is located at the urban periphery, it is correlated with distance from Central London, thus producing the negative result.

The only significant variable at a distance other than 1km was regional park access at 150m, which indicates the aesthetic benefits of being directly adjacent to a large park. The beta value is however rather low for this attribute. It appears that the model has largely been unable to capture the very local benefits of being directly adjacent to smaller green spaces. This is likely a question of scale- that this variation is occurring at scales smaller than output areas, and so is not comprehensively represented in this model.

Table 5: Model 1 Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	11.918	.005		2410.731	.000
Parks Area 1km	1.384E-3	.00005	.179	24.042	.000
Negative Area 1km	-4.963E-3	.0002	-.134	-20.648	.000
Moderate Area 1km	-1.256E-3	.0001	-.153	-19.978	.000
Regional Park 150m	.132	.020	.043	6.664	.000

6.3 Model 2- Green Space, Built Environment and Locational Attributes

By adding built environment and locational attributes to the model, a much greater proportion of the house price variation can be statistically explained. The R Square value for Model 2 is equal to .63.

Table 6: Model 2 Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.792	.627	.626	.281

The coefficients table and ranking list detail the most influential attributes in the model. Distance from Central London was by far the most strongly correlated variable, with a beta value of -.561. The negative value denotes that prices decrease as the distance from Central London (Charing Cross) increases, as one would expect. It is interesting that this simple Euclidean distance measure was more strongly correlated than more sophisticated travel time and PTAL indicators.

Many of the built environment indicators are strongly correlated with average house prices. The average number of rooms is the second most highly ranked attribute, whilst the proportion of council housing, detached housing and the density of listed buildings are 3rd, 4th and 5th respectively. Essentially the size and quality of housing is of central importance to explaining house prices.

Access to parks at 1km remains an important attribute in this model. The beta value has fallen compared with Model 1 to a value of .108, indicating that park access is partly cross-correlated with other variables such as average room size and detached housing. Each additional hectare of green space within 1km adds only approximately 0.08% to house prices with this model, in addition to the presence of a regional park within 600 metres adding 1.9-2.9%. The high result for detached housing and moderately high result for semi-detached housing does indicate the premium given to having a large private garden. Another highly valued open space amenity is access to the River Thames, which at a distance of 600 metres was associated with approximately a 9% rise in house prices. The other open space attributes from Model 1 have become much less prominent. Negative amenity open spaces within 1 km remains significant, but at a much lower beta value. The moderate amenity open space variable is no longer significant.

The service access locational variables proved to be significant, though with modest beta values. Average house prices fell with lower access to post offices and food stores. Curiously house prices increased with distances from primary schools. This is probably due to a cross-correlation with density.

Table 7: Model 2 Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
(Constant)	11.644	.019		616.492	.000
Average Num Rooms	.179	.003	.350	53.218	.000
Distance from Central London	-4.433E-2	.000	-.561	-100.120	.000
Density of Listed Buildings	2.420	.053	.212	45.527	.000
Council Housing %	-.005	.000	-.274	-54.431	.000
Detached Housing %	.009	.000	.247	48.016	.000
Parks Area 1km	.00083	.00003	.108	25.699	.000
Semi-det Housing %	.002	.000	.089	16.864	.000
River Thames 600m	.089	.006	.060	14.789	.000
Negative Area 1km	-.002	.000	-.051	-12.652	.000
Primary School Dist	.071	.007	.049	10.714	.000
Post Office Dist	-.030	.005	-.026	-5.545	.000
Food Store Distance	-.027	.005	-.024	-4.965	.000
Regional Park 600m	.024	.005	.019	4.699	.000

Model 2 Factors Ranked by Beta Value-

1. Distance from Central London (-)
2. Average Number of Rooms
3. Council Housing % (-)
4. Detached Housing %

5. Listed Buildings Density
6. Parks Area 1km
7. River Thames 600m
8. Semi-Detached Housing
9. Primary School Distance
10. Negative Area 1km
11. Post Office Distance (-)
12. Food Store Distance (-)
13. Regional Park 600m

6.4 Model 3 – Addition of Socio-Economic Attributes

This model adds the socio-economic factors to the variables entered for Model 2. The addition of these factors increases the R Square value by about 0.1 to .716, indicating that over 70% of the variation is explained by this model version.

Table 8: Model 3 Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.846	.716	.715	.245

Two of the socio-economic attributes prove to be strongly related to house prices. These are income support and the higher education participation rate, ranked 3rd and 5th respectively. Key Stage 2 results were also significant, though at a lower beta value. The addition of socio-economic attributes does not change the general dominance of the built environment factors, though their ranked order has shifted. The proportion of council housing is no longer an important variable (due to cross correlations with the deprivation indicators) whilst average number of rooms, detached housing proportion and listed buildings density remain influential attributes.

The park area and River Thames attributes have lower beta values compared to Model 2. These variables therefore have some correlation with the deprivation indicators. This brings us back to the earlier question of causality in relation to socio-economic variables; i.e. the degree to which socio-economic factors are a cause or a result of housing market outcomes.

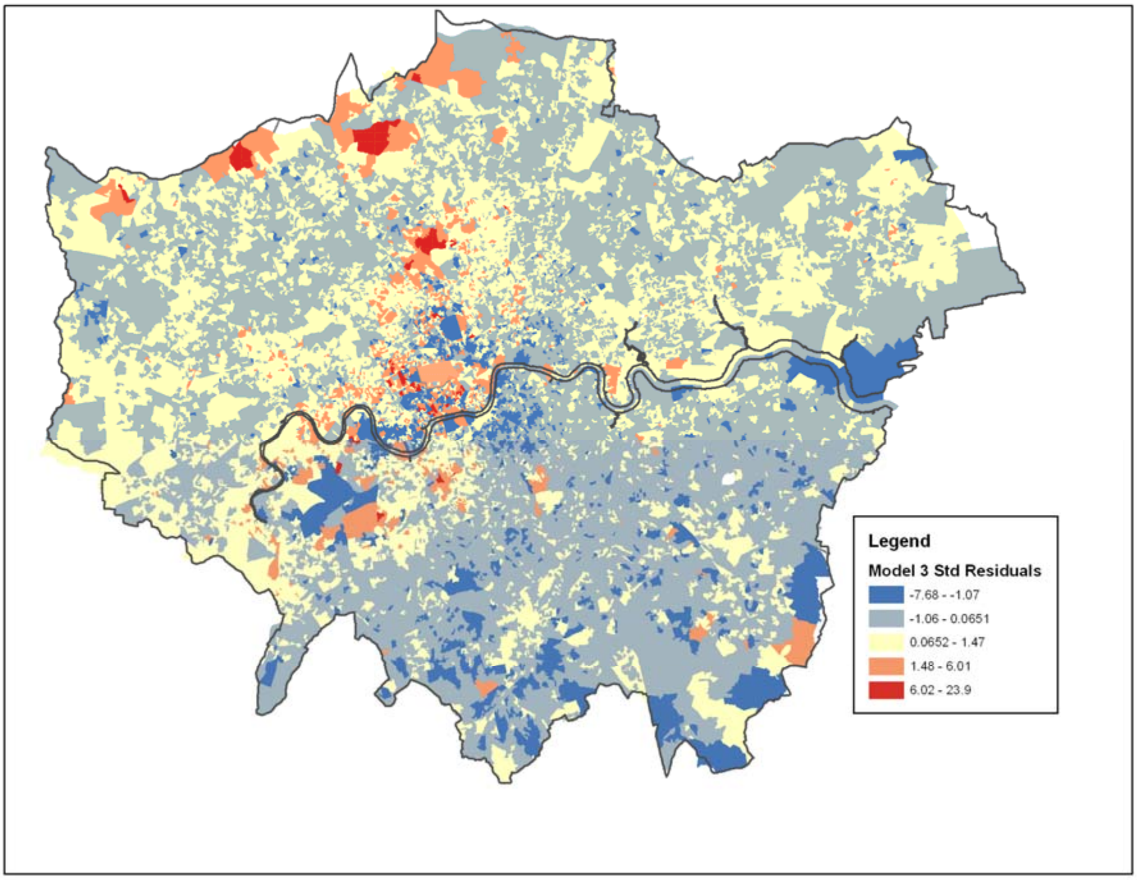
Table 9: Model 3 Coefficients

Model	Unstandardised Coefficients		Standardised Coefficients		
	B	Std. Error	Beta	T	Sig.
(Constant)	11.711	.035		330.688	.000
Not Entering HE	-.004	.000	-.178	-37.775	.000
Average Number of Rooms	.156	.004	.305	43.558	.000
Distance from Central London	-4.003E-2	.000	-.506	-92.711	.000
Income Support	.000	.000	-.210	-35.844	.000
Listed Buildings Density	2.014	.050	.176	40.584	.000
Detached %	.007	.000	.196	40.671	.000
Parks Area 1km	.0006	.00003	.077	19.741	.000
River Thames 600m	.066	.006	.045	11.895	.000
Semi-det %	.001	.000	.050	10.052	.000
Council Housing %	-.001	.000	-.059	-10.093	.000
Negative Area 1km	-.001	.000	-.039	-10.288	.000
Key Stage 2 Score	.006	.001	.042	9.591	.000
Flat %	.000	.000	-.056	-9.346	.000
Road Traffic Accident Rate	.016	.002	.029	7.468	.000
Post Office Distance	-.034	.005	-.029	-7.176	.000
Regional Park 600m	.024	.005	.020	5.098	.000

Model 3 Factors Ranked by Beta Value-
1. Distance from Central London (-)
2. Average Number of Rooms
3. Income Support (-)
4. Detached Housing %
5. Not Entering Higher Education (-)
6. Listed Buildings Density
7. Parks Area 1km
8. Flat Housing % (-)
9. Council Housing % (-)
10. Key Stage 2 Score
11. River Thames adjacent
12. River Thames 600m
13. Post Office Distance (-)
14. Road Traffic Accident Rate

By mapping the difference between the predicted house price values from the model and the actual house price values it is possible to look for spatial patterns in the model predictions and identify where the model is most and least accurate. This discrepancy between predicted and actual value is known as the residual, and the residuals from Model 3 are mapped in Figure 23. Dark blue areas show where the model is over-predicting while dark red areas show where the model is under-predicting. It is clear from Figure 23 that the predictions are weakest in the most expensive high prestige areas, such as Kensington and Hampstead. This is addressed in Model 4, which uses a dummy prestige variable to represent the atypical market conditions in these very high value areas.

Figure 23: Model 3 Standard Residuals



6.5 Model 4 Results

The addition of a prestige variable increases the R Square result to .767.

Table 10: Model 2 Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.876	.767	.767	.222

Table 11: Model 4 Coefficients

Model	Unstandardised Coefficients		Standardised Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	11.520	.033		352.333	.000
Not Entering HE	-.003	.000	-.152	-34.839	.000
Prestige	.614	.009	.243	66.116	.000
Average Number Rooms	.140	.003	.274	42.455	.000
Distance from Central London	-3.751E-2	.000	-.474	-92.547	.000
Income Support	-.0004	.000	-.167	-30.762	.000
Detached %	.008	.000	.202	45.466	.000
Listed Buildings Density	1.635	.046	.143	35.536	.000
Key Stage 2 Score	.009	.001	.069	17.008	.000
Semi-detached %	.001	.000	.067	14.440	.000
Parks Area 1km	.0004	.00003	.049	13.554	.000
Council Housing %	-.001	.000	-.065	-12.187	.000
River Thames 600m	.052	.005	.035	10.141	.000
Flat %	-.0007	.000	-.058	-10.447	.000
Negative Area 1km	-.001	.000	-.029	-8.398	.000
Post Office distance	-.035	.005	-.030	-7.625	.000
Road Traffic Accident	.013	.002	.025	6.994	.000
Regional Park 600m	.026	.004	.021	5.950	.000

The prestige dummy variable is strongly correlated, becoming the 3rd most important attribute in the ranked coefficients. The addition of a prestige variable also affects the beta values of some the other attributes. The Park area attribute falls to a beta value of 0.03. This indicates that the high prestige high value market areas also have high park access, as these variables are correlated. It also implies that varying levels of quality of green space may play a large role in their perceived value, as the value of these particular green spaces appears to be disproportionately high.

The importance of the listed buildings density also falls (but remains the 7th most important factor), indicating the connection between heritage buildings and very high value property sub-markets.

Model 4 Factors Ranked by Beta Value-

1. Distance from Central London (-)
2. Average Number of Rooms
3. Prestige Factor
4. Detached Housing %
5. Income Support (-)
6. Not Entering Higher Education (-)
7. Listed Buildings Density

8. Key Stage 2 Score
9. Semi-detached %
10. Council Housing % (-)
11. Flat Housing %
12. Park Area 1km
13. River Thames 600m
14. Post Office Distance (-)
15. Negative Area 1km
16. Road Traffic Accident Rate
17. Regional Park 600m

7. Conclusions

Overall the fine scale modelling approach worked effectively, returning R Square values between 0.63 and 0.77 depending on the version of the model used.

The most important factors influencing house prices were found to firstly relate to physical built environment housing qualities, particularly house size and age, with larger older housing being much more desirable. This supports arguments emphasising the value of family housing in London, and of the continuing appeal of historic high heritage value neighbourhoods. The most important locational factor in the model was unsurprisingly distance from Central London.

Green space was most strongly related to house prices through the high attractiveness of detached housing with large private gardens. The total green space area within the locality (distance of 1km) was also found to boost house prices, though to a lesser extent than calculated in the previous Valuing Greenness study. Access to parks is correlated with built environment factors, such as housing type and size, and negatively correlated with deprivation. The inclusion of these variables in the model reduces the strength of the correlations between green space and average house prices.

Additionally there is a significant spatial variation in the relationships between green spaces and house prices, with quality and prestige factors making a number of larger regional and metropolitan parks highly desirable, while some less attractive green spaces appeared to have only a minimal influence on the local housing market. It is therefore problematic to place an absolute value on green space applicable across Greater London. The best approximation from this research is that each hectare of formal green space within 1km of housing increases house prices by approximately 0.08% to house prices with this model, in addition to the presence of a regional park within 600 metres adding 1.9-2.9%. (using the values from Model 2). These values fall when income related deprivation variables are included in the model.

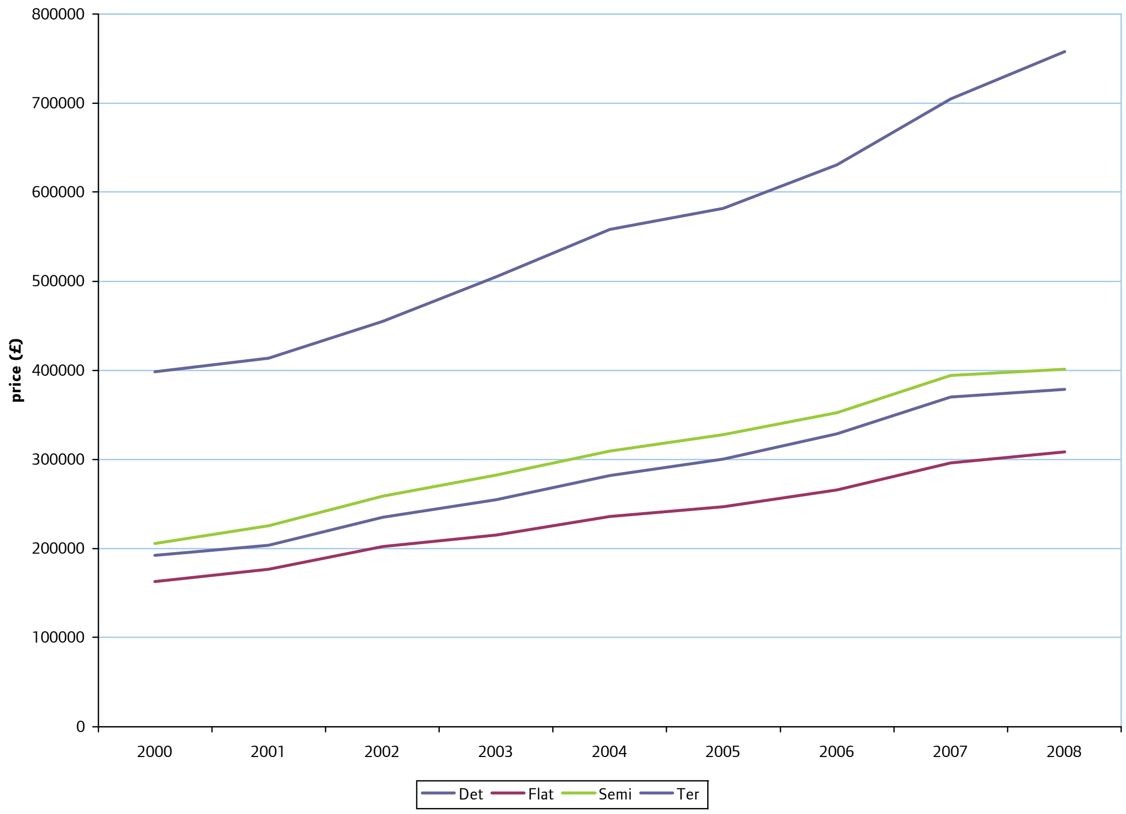
By mapping the residuals of the models it is possible to estimate where the mostly highly valued green spaces are according to the property market. Further information on green space quality is needed to validate this issue, but this is not at present possible to measure without manual surveying techniques.

Appendix A- Calculating Average House Prices

Property markets are clearly dynamic, as can be seen in significant price rises over the last two decades followed by declines in the recent financial crises. Calculating a static average house prices geography therefore requires analysing temporal change and normalising prices to a particular time period.

This analysis uses a simple method of calculating the percentage change in average house price sales in Greater London disaggregated by housing type. As can be seen in Figure A1 average house prices have risen by around 90-100% for all housing types in Greater London. This confirms that a proportional change approach is a better approximation of prices rises than absolute price changes. Furthermore there are some differences between housing types, particularly in relation to detached housing, which supports disaggregating the data by housing type.

Figure A1: Average House Sale Prices in Greater London 2000-2008 by Housing Type



Source: Land Registry

The Land Registry transaction sales data can then be adjusted to 2000 prices using the housing type and time of sale. These sale prices are then geo-coded at postcode unit scale, and averaged over the spatial unit of output areas in GIS.
There are some shortcomings with this approach that could be addressed in further work. The main error is a selection error, where those houses that change hands more frequently

(e.g. new build flats) will produce more transactions and be disproportionately emphasised in the average figures. A statistical weighting procedure could be used to minimise this error. Another issue not catered for in this model is seasonal variation.

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Vietnamese

Nếu bạn muốn có văn bản tài liệu này bằng ngôn ngữ của mình, hãy liên hệ theo số điện thoại hoặc địa chỉ dưới đây.

Greek

Αν θέλετε να αποκτήσετε αντίγραφο του παρόντος εγγράφου στη δική σας γλώσσα, παρακαλείστε να επικοινωνήσετε τηλεφωνικά στον αριθμό αυτό ή ταχυδρομικά στην παρακάτω διεύθυνση.

Turkish

Bu belgenin kendi dilinizde hazırlanmış bir nüshasını edinmek için, lütfen aşağıdaki telefon numarasını arayınız veya adrese başvurunuz.

Punjabi

ਜੇ ਤੁਹਾਨੂੰ ਇਸ ਦਸਤਾਵੇਜ਼ ਦੀ ਕਾਪੀ ਤੁਹਾਡੀ ਆਪਣੀ ਭਾਸ਼ਾ ਵਿਚ ਚਾਹੀਦੀ ਹੈ, ਤਾਂ ਹੇਠ ਲਿਖੇ ਨੰਬਰ 'ਤੇ ਫ਼ੋਨ ਕਰੋ ਜਾਂ ਹੇਠ ਲਿਖੇ ਪਤੇ 'ਤੇ ਰਾਬਤਾ ਕਰੋ:

Hindi

यदि आप इस दस्तावेज की प्रति अपनी भाषा में चाहते हैं, तो कृपया निम्नलिखित नंबर पर फोन करें अथवा नीचे दिये गये पते पर संपर्क करें

Bengali

আপনি যদি আপনার ভাষায় এই দলিলের প্রতিলিপি (কপি) চান, তা হলে নীচের ফোন্ নম্বরে বা ঠিকানায় অনুগ্রহ করে যোগাযোগ করুন।

Urdu

اگر آپ اِس دستاویز کی نقل اپنی زبان میں چاھتے ھیں، تو براہ کرم نیچے دئے گئے نمبر پر فون کریں یا دیئے گئے پتے پر رابطہ کریں

Arabic

إذا أردت نسخة من هذه الوثيقة بلغتك، يرجى الاتصال برقم الهاتف أو مراسلة العنوان أدناه

Gujarati

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