Sustainable Urban Form and Residential Development Viability

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Abstract

Arguments about sustainable urban form have generally been in normative terms without recourse to its practicality. The paper shows that the essential elements are outcomes of real estate markets. The focus of the research is to examine the economic sustainability constraints to the adaptation of the existing urban form via housing market development viability. To address the task a series of econometric models are linked together to estimate spatial patterns of viability in five cities. The results demonstrate a substantial difference between cities that can be attributed not to urban form per se but to socio-economic factors. This demonstrates that in practice it is impossible to divorce the physical structure of cities from their economic and social structure. Viability is also influenced strongly by public policy through the location of social housing. The research suggests that a driving force/constraint for development viability is the level of neighbourhood house prices. Large swathes of negative viability are found even without accounting for the additional costs of brownfield development suggesting that there are major constraints to the reconfiguration of housing markets in some cities in a piecemeal way.

Introduction

The last decade has seen a considerable interest in urban sustainability and a debate has ensued about the impact of urban form. There is a growing literature on the issues, with sustainability seen as depending on three constructs – environmental (including transport), social and economic dimensions. Much of the argument about the sustainability of urban forms has focused simply on increasing the density of development, ensuring a mix of uses, containing urban 'sprawl' and achieving social and economic diversity and vitality – characterised as the concept of a 'compact city' (Jenks *et al*, 1996). UK Government policy has embraced this view of sustainability and its principles have become the dominant planning ethos (Urban Task Force, 1999).

The government has sought to achieve the 'compact city' by following a stringent defence of the green belts surrounding the cities and the reuse of 'brownfield' land. More recently government policies have extended planning advice to include exhorting higher residential densities. National Planning Policy Guidance to local planning authorities has been amended to advise the following:

- avoid developments which make inefficient use of land (those of less than 30 dwellings per hectare net;
- encourage housing development which makes more efficient use of land (between 30 and 50 dwellings per hectare net); and
- seek greater intensity of development at places with good public transport accessibility such as city, town, district and local centres or around major nodes along good quality public transport corridors. (DCLG, 2006}.

At the same time the country faces a housing shortage especially in the South East of England where there is particular pressure brought about my immigration into the region especially in recent times from outside of the UK (Thomas, 2006). Concerned about the impact of the housing market on the economy the Barker Review (2003, 2004) was initiated by the government. It identified housing supply constraints as a major influence on the housing market and as a consequence UK real house prices have risen by 2% per year between 1971 and 2001 creating affordability problems (Barker, 2003). These supply constraints were seen not simply as stemming from the planning system's defence of the green belt as critics such and Evans and Hartwich (2005) argue. Part of the supply problem Barker (2003) suggested was a 'market failure' in the provision of brownfield land for development which also reflected the wider issues of housebuilders' responses to risks. A fundamental problem was the low value of brownfield land resulting from relatively high development costs, coupled with high existing use values which may prevent development.

Following a subsequent Barker (2006) report on the planning system the UK government now seems committed to relaxing land supply constraints although it is yet to emerge how this is to be consistent with its commitment to the compact city. There are therefore a range of uncertainties about the future shape of government policy. Furthermore the literature has tended to be normative so the concept of a sustainable urban form has not been subject to a fundamental review of its theoretical and empirical underpinnings. There are for example arguments that a combination of the compact city and dispersed urban form, known as polycentric urban structure should be preferred (Camagni et al, 2002). Polycentricity is a concept that has been adopted in European policy, which it is claimed to promote economic growth and equality across Europe (Commission of European Union, 1999, Davoudi, 2003). The one point of concensus is that the existing cities need to be adapted to be more sustainable.

This paper begins by briefly reviewing the economic arguments for (different) sustainable urban form(s) and outlining the importance of land use viability. This provides the justification for the subject. The overall objective of the paper is to consider the spatial pattern of residential development viability by examining the relationship between prices and building costs within cities. It applies a fundamental viability equation, house price minus costs, for each location within five cities. To achieve this task it combines house price and construction cost data using a range of data sets to simulate "viability" maps for each city. The five case study cities are Edinburgh, Glasgow, Leicester, Oxford and Sheffield with population's ranging from just over 100,000 to more than 500,000.

The statistical problem has a starting point data on individual house prices and data on construction costs for individual development projects. There are four steps to the analysis:

- Estimate statistical model of house prices
- Estimate statistical model of costs
- Combine the two models of price and cost to estimate development 'viability'
- Assess the spatial pattern of development 'viability'

The model of house prices is a hedonic regression model that breaks down house prices into its constituent attribute prices. The attributes can be differentiated into housing, location and neighbourhood characteristics including density and are based on data from the Land Registry and the Census. The construction costs model is also estimated using regression analysis based on data derived from planning applications.

Economic Sustainability

Much of the economic debate on sustainability has focused on the benefits of compact cities to economic performance. The economic arguments in favour of the compact city include the view that it can improve economic performance (Cevero, 2001); high density mixed-use areas

could contribute towards profitability and economic growth, lower energy consumption, and greater allocative and distributive efficiency (Camagni et al, 1998). Economically, it is argued that a compact urban form can lead to new business formation and innovation, which also attracts new residents. Barton (2000) further argues that mixed land use with high residential densities increases the viability of services and transport provision, while at the same time increasing access and the greater choice of services. High density urban areas are also argued to aid the efficient operation of local labour markets (Prud'homme and Lee, 1999).

Some dispute the sustainability of a compact urban form by arguing that its characteristics may lead to unsustainable outcomes. Knight (1996) contends that diseconomies may occur, such as congestion and externalities, when the central structure becomes too big. This harks back to the optimal city size debate of the 1970s (see Alonso, 1971; Evans, 1972; Richardson, 1973). Breheny (1992) argues that a compact urban form may result in a reduction in environmental quality as development creates the loss of open spaces. The compact city may also be unable to accommodate substantive population growth, where high density development may mean the urban area is already close to capacity and the potential for further expansion is somewhat limited (Anas et al, 2000). Supporters of the alternative population dispersal model emphasise either the benefits of a decentralised 'rural' or 'semi-rural' life style with low development costs, or the unstoppable market forces that will create decentralised communities with low energy consumption and congestion (Richardson and Gordon, 1993; Gordon and Richardson, 1997).

Many of these arguments are principally normative and certainly weak on supporting specific evidence. Many of these conflicting views are unresolved. The role of density is at the heart of this debate about the nature of sustainable urban form but this is determined by the operation of local real estate markets within a framework of transport costs (that determines accessibility relationships) which in turn is dependent on the transport infrastructure (Alonso, 1964). Planning will also shape the market but not alter these fundamental relationships. The housing market as the largest land use and the determinant of population density in particular has therefore a key role in urban form and its sustainability.

This paper does not start with a prescriptive perspective on sustainable urban form. On the other hand the vision of sustainability is as the maximisation of urban output or productivity subject to a series of sustainability constraints as a form of linear (or more precisely non-linear) programming problem. These constraints include the adaptation of the existing urban form. Changes to urban form are mediated through the operation of local property markets within a framework set by the transport system, public policy and the level of household incomes (Jones et al, 2005).   The potential for reshaping urban form and reformulation of the spatial economy is therefore subject to property market and public development viability constraints and ultimately the creation of sustainable markets (Jones and Watkins, 1996). It is also dependent on the supply of housing of the quality, price and type affordable to meet the current needs of households. This paper parks this last issue and focuses on housing market viability.

Research Method and Data

This section sets out the detail of the steps of the research method. As noted above the two primary tasks are the estimation of separate regression models for house prices and development costs for each city. These models explain prices and costs by reference to the characteristics of housing and development projects respectively. The output of these models is used to simulate the development value and costs of standardised new housing projects. These steps are considered in turn.

House Price Model

Individual house prices can be seen as a function of physical attributes and location. The house price model is a hedonic regression model where the dependent variable is derived from transactions data derived from the land registry. There is now an extensive house price literature that has applied this approach, see for example Cheshire and Sheppard (2004). It enables housing to be viewed as a composite good and prices to be ascribed to the individual attributes (Rosen, 2004). Parameter estimates (implicit prices or attribute prices) can then be used to predict the price of a standardised property. There are a number of implicit assumptions that the model presumes not least equilibrium in the housing market but also independence between the variables. The research here is based on housing transactions in a single year, 2002.

The independent variables included in the analysis are set out in Table 1 and encompass house type and neighbourhood characteristics and location. The characteristics of the property are simply the house type expressed as a series of dummy variables. House price and house type are derived from land registry data. Land Registry data include all registered property transactions but the data is limited by the fact that the data contain very few details on property characteristics. In fact the Scottish Land Registry provides no data on housing characteristics and it was necessary to undertake an additional statistical exercise to estimate these attributes for Glasgow and Edinburgh. This is described in the Appendix.

Location is defined by distance to the respective city centre and is calculated from the centre of the Census output area in which the property is located. Neighbourhood characteristics are considered at two levels, Census output and super output areas, broadly equivalent to 140 and 600 households respectively. (These areas are applied in England with equivalents applicable in Scotland). These neighbourhood variables are defined in physical terms and incorporate measures of residential density and characteristics of the built environment. They include the percentage of different house types, sizes and tenures, and the number of households per hectare. Other socio-economic characteristics of the neighbourhood are excluded as the focus of the paper is on urban form.

Table 1   Definition of Variables

Variable	Description	Source
Detached	Dummy variable for individual property type	HMLR 2002 house price data
Terrace	Dummy variable for individual property type	Derived from HMLR 2002 house price data
Flat	Dummy variable for individual property type	Derived from HMLR 2002 house price data
Distance to city centre	Distance to city centre from centroid of output area in km	Calculated using coordinates of central points of output area
Distance^2	(Distance to city centre from centroid of output area in km)^2	Calculated using coordinates of central points of output area
O pp 1 rm	% of 1 room properties in output area	UK Census 2001
O pp 2 rms	% of 2 room properties in output area	UK Census 2001
O pp 5-6 rms	% of 5-6 room properties in output area	UK Census 2001
O pp 7+ rms	% of properties of 7+ rooms in output area	UK Census 2001
O pp detached	% of detached properties in output area	UK Census 2001
O pp terraced	% of terraced properties in output area	UK Census 2001
O pp flats	% of flats in output area	UK Census 2001
O pp not ground floor	% of households with first floor as lowest floor level in output area	UK Census 2001
S pp detached	% of detached properties in super output area	UK Census 2001
S pp terraced	% of terracrd properties in super output area	UK Census 2001
S pp flats	% of flats in super output area	UK Census 2001
S pp 1 rm	% of one roomed properties in super output area	UK Census 2001
S pp 2 rms	% of two roomed properties in super output area	UK Census 2001
S pp 5/6 rms	% of five/six roomed properties in super output area	UK Census 2001
S pp 7+ rms	% of properties of 7+ rooms in super output area	UK Census 2001
S pp social rented	% of social housing in super output area	UK Census 2001
S pp private rented	% of private rented housing in super output area	UK Census 2001
S households per hect	Households per hectare in super output area	UK Census 2001

Development Costs Model

Project-specific costs are influenced by the size of the development project, through potential economies / diseconomies of scale and by altering the length of construction period and hence exposure to economic uncertainties. Regional and local economic factors can also influence

costs via the relative cost and supply of labour and materials. Macro economic variables over time may be significant in affecting supply costs through changing interest rates and inflation. A model of development costs is estimated using a regression model. Such a model requires information on development project size, specification, cost and location.

There are two potential alternative data sources appropriate for the estimation of such a cost model. These are the Building Cost Information Service (BCIS), a database maintained by the Royal Institution of Chartered Surveyors and information derived from planning applications and provided electronically by Emap-Glenigan. Each of the data sources is subject to a number of limitations. The BCIS data include details of the number, and broad type, of housing units constructed, location, number of floors and a detailed breakdown of construction costs into major areas including superstructure, services, infrastructure and so on. However, such complete information is only available for a limited number of construction projects biased toward small schemes with housing association as the client. The Emap-Glenigan data comprise a dataset of 11,058 observations, each having been derived from a planning application. Only applications from private developers, primarily house builders, and for developments of between 20 and 1,000 housing units, are considered. This data cover the period 1995 to 2005 inclusive.

The main advantage of the Emap-Glenigan dataset relative to the BCIS data is its size. Other advantages include some detail regarding the characteristics of projects. For example, the dataset includes details on number of units (split between houses, luxury houses, bungalows / low density housing and flats / apartments). Disadvantages include the fact that no information on construction type, quantity of floorspace constructed or other design details are included. In addition, the construction cost included in planning applications is based on the applicant's estimates rather than cost incurred. On balance the Emap-Glenigan data is preferred and the results presented below use this data source (although a parallel analysis was undertaken with the BCIS data).

The independent variables included in the regression analysis are a series of variables that describe the housing that comprise the development – total number of housing units constructed on site (not distinguishing between small / large or flats / houses); number of flats and number of bungalows. These three variables broadly describe a wide range of development types. In addition, the dataset includes a set of dummy variables signifying that the development represents either: luxury housing, flats or bungalows / low density housing. If all three dummy variables are coded zero then this flags a development comprising "standard" (not luxury) housing. In order to test for, and capture, some of the expected non-linearity between development size and construction costs, we also include a quadratic on total number of units (i.e. units^2). Spatial and temporal variation in construction costs are accounted for by a series of government office region and time dummies as well as a small set of property/ density variables drawn from the 2001 Census and measured at local authority level. These latter three variables are the percentage of detached houses, percentage of flats and the population density of the relevant local authority area. These variables are justified

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on the basis that construction costs are likely to vary spatially, partly in relation to the density and extent of urbanisation of the area in which the constuction site is situated. Given that these hypothesised effects are related to the characteristics of the surrounding area, and not the specification of the development itself, it is appropriate to use aggregate spatial measures such as those available from the Census.

Simulating Development 'Viability'

Development viability/profitability can be considered within a simple 'residual valuation' calculation whereby construction and land costs are subtracted from the revenue from house sales. Alternatively using the same equation development land can be valued by estimating revenue from house sales and subtracting expected costs and an acceptable level of profit. In a competitive market an acceptable level of profit would be 'normal' profits, that just sufficient to undertake the project.

In this research only two of these variables are known or at least can be estimated, revenue and construction costs. Following Henneberry (1999) the analysis estimates the 'residue' after construction costs have been subtracted from the revenue of a series of hypothetical developments.   This residue is an indicator of viability because if it falls below the normal profit level then the project will not be built. While normal profits are an unknown a negative residue implies negative land values (requiring public financial support and zero profit otherwise).

Spatial Patterns of Viability

In the final step of the research a spatial analysis of these 'residue' or residual values is presented. A set of five city development viability maps for a standard development in each output area of each city also provides a visual representation of the results.

Results of House Price and Development Cost Models

House Prices

The hedonic house price model is estimated using ordinary least squares regression. A summary of the results for the five cities are provided by Table 2. The full results of the hedonic estimations are shown separately for each city in tables A – F in the Appendix. The coefficients are broadly in keeping with expectations although some unexpected results are evident. For example, in the three English cities, detached properties have a higher predicted value, all other variables held constant. In the two Scottish cities, detached properties have a lower predicted value than semi-detached properties with identical other characteristics. There is also evidence of some variation in the other property type coefficients. For example, the discount associated with the terraced property type is highest in Sheffield and is relatively

modest in Oxford. The coefficients of the property type proxy variables (Census variables measured at output area level) are comparable between the five cities. Exceptions are Leicester, in which many of these variables are not significant and therefore drop out of the model altogether, and Oxford where a number of the coefficients are different to those found in the other cities. In particular, there is evidence from the Oxford model that higher density property types have higher values, unlike in the other cities.

Table 2   Summary of hedonic regression results

Variable	Pooled	Edinburgh	Glasgow	Sheffield	Leicester	Oxford
Detached (d)		-0.028	-0.082	0.13	0.134	0.056
Terrace (d)	-0.158	-0.135	-0.161	-0.218	-0.167	-0.086
Flat (d)	-0.052	-0.132	-0.141	-0.112	-0.221	-0.326
Distance to city centre	-0.301	-0.387	-0.167	0.439	-0.312	-0.035
Distance^2	0.157	0.138	0.076	-0.381	0.379	
O pp 1 rm	0.012		0.014	0.041	0.037	0.175
O pp 2 rms	-0.081	-0.044	-0.112			-0.145
O pp 5-6 rms	0.096	0.169	0.048	0.058	0.134	0.127
O pp 7+ rms	0.232	0.319	0.126	0.201	0.351	0.208
O pp detached	0.026	0.089	0.084	0.054		0.058
O pp terraced	-0.021	-0.064	-0.049	-0.06		0.052
O pp flats	-0.041	-0.133	-0.102	-0.036		0.119
O pp not ground floor	-0.069	0.022	-0.031		0.141	0.076
S pp detached			-0.09			-0.137
S pp terraced	-0.026		-0.063	-0.043	-0.047	
S pp flats	0.13			0.269	0.175	0.143
S pp 1 rm		0.051	-0.028	0.061		-0.102
S pp 2 rms		-0.023	0.047	-0.042		0.084
S pp 5/6 rms		-0.056		0.18	0.052	-0.091
S pp 7+ rms	0.19	0.151	0.23	0.283	0.044	0.241
S pp social rented	-0.249	-0.229	-0.276	-0.087	-0.247	-0.274
S pp private rented	0.128	0.07	0.141	0.202	0.077	
S households per hect	-0.057	-0.046	-0.071	0.047	-0.077	-0.088

The main accessibility measures, distance and squared distance from the city centre, broadly behave as expected. In order for house prices to decrease at a decreasing rate with distance from the city centre our expectation is for negative and positive coefficients on the variables respectively. This is the case in the pooled model and in Glasgow, Edinburgh and Leicester. In Oxford only the distance variable is significant suggesting a more marked reduction in values with distance from the city centre and in Sheffield the coefficients are reversed. The

literal interpretation of this is that values increase with distance from the city centre, but at a decreasing rate.

With the exception of Sheffield, household density reduces house prices, all other variables held constant. Sheffield is also notable given the rather different coefficient of the social rented and private rented variables. Incidence of social renting reduces house prices markedly in the other four cities but the effect is much smaller in Sheffield. In addition private renting is associated with higher house prices in all five cities but the size of the effect is larger in Sheffield than the other four cities.

Development Costs

Using ordinary least squares, a predictive model of construction costs accounting for locational factors, project size and project specification is estimated. The model includes squared number of housing units as an explanatory variable. This is designed to test for non-linearities in the relationship between construction costs and project size. The results of the OLS estimation are shown in table 3.

The results closely mirror those obtained using the BCIS data (but not presented here) and are generally in keeping with expectations. For example, project cost increases with number of units and decreases with squared units, i.e. costs rise with project size but at a decreasing rate. As noted above, there are four dummy variables describing housing development type as "housing", "luxury housing", "flats" and "bungalows / low density housing". The "housing" development type is implicit in the constant. The coefficients for luxury housing, flats and bungalows are in keeping with expectations. Luxury housing costs are higher, flat development costs substantially lower and bungalow costs marginally lower. As information about the planning status and prior use of sites is not available in the data, differential development costs for greenfield and brownfield sites cannot be estimated directly but only inferred from the coefficients on other variables such as density and house types.

Unit construction costs rise as the flat component rises. However, developments comprising entirely flats have a lower per unit construction cost than those comprising entirely housing. This may be suggestive of economies of scale or it may reveal efficiencies of developers that specialise exclusively in flats. Alternatively, the results may suggest a form of omitted variable bias resulting from failure to measure some important determinant of construction costs such as finish quality or some other indicator of market segmentation.

In terms of the Census variables, construction costs are higher where the proportion of detached properties or the proportion of flats in a local authority area are higher. This suggests, for example, that urbanised local authority areas and very low density authorities have higher construction cost levels. The sign and significance of the population density

variable also suggests that costs are higher in highly urbanised local authority areas. However, the standardised Betas indicate that all of the census variables have only a marginal influence on total project construction cost levels.

Table 3   Construction cost model based on Emap-Glenigan data

Variable	Coefficient	Std. Beta	t statistic	
Constant	13.598		612.391	***
Units	0.015	1.441	148.717	***
Units^2	0.000	-0.758	-82.559	***
Lux_hsg (1,0)	0.055	0.020	4.402	***
Flats (1,0)	-0.261	-0.150	-24.569	***
Bungalows (1,0)	-0.073	-0.009	-1.658	*
Units, flats	0.001	0.057	8.685	***
Units, bungalows	-0.001	-0.014	-2.592	**
Y1997	0.075	0.013	2.714	***
Y1998	0.175	0.048	8.518	***
Y1999	0.196	0.078	11.305	***
Y2000	0.233	0.099	13.785	***
Y2001	0.221	0.100	13.336	***
Y2002	0.237	0.106	14.238	***
Y2003	0.268	0.122	16.147	***
Y2004	0.365	0.146	20.895	***
Y2005	0.597	0.040	9.180	***
GOR_NE	-0.033	-0.008	-1.845	*
GOR_YH	-0.046	-0.017	-3.677	***
GOR_EM	-0.036	-0.013	-2.738	***
GOR_WM	-0.030	-0.010	-2.227	**
GOR_LON	0.093	0.031	5.113	***
GOR_WAL	-0.031	-0.008	-1.697	*
% detached, LA	0.001	0.021	3.115	***
% flats, LA	0.001	0.027	3.904	***
POPDENS, LA	0.002	0.042	4.983	***
R Square	0.802			
Adjusted R Square	0.801			
Std. Error	0.364			
F statistic	1802.565			

*** Significant at 1%; ** significant at 5%; * significant at 10%

Simulating Residential Development Viability

The analysis in this section draws together the construction cost and hedonic housing price models. These are used to predict the construction costs of a set of hypothetical development types in the five cities. To decide on the appropriate development types a descriptive analysis of the data is undertaken. Restricting the analysis to projects between 20 and 500 housing

units this reveals that the median project size is approximately 40. The flatted component of mixed developments ranges between 0 and 50% but the median is approximately 40%. This is noteworthy because it reveals that there are no residential developments with a dominant share of flats – it appears that almost all developments are exclusively flats, or else have a relatively minor proportion of flats (less than 50%). Overall this analysis suggests there are three stereotype developments: flatted, low-density housing and mixed housing flats.

To reflect these three dominant development types the specification of the hypothetical developments is as follows:

- 40 units of low-density housing.
- 20 units of housing, 20 units of flats.
- 40 units of flats.

The simulation follows a relatively simple static approach (i.e. ignoring time). The calculation takes the form of a gross residual valuation in which residual value is equal to the surplus of development value over development costs. Residual value is therefore a composite of land value, developer's profit and unmeasured development costs.

As noted above, the approach requires the prediction of development costs (proxied by predicted construction costs) and development value. Predicting construction costs using the regression model shown in table 3 requires project-specific variable values (housing type, number of units, flat / housing split), a time period (2002) and locational information including region and three measures of city density (proportion of housing that is detached, proportion terraced and local authority level population density). From these variables, the model predicts total construction cost although, as mentioned above, no account is taken of the length of construction period or of macro economic variables such as interest rates or inflation. The value predicted is constant for a given development type in each city.

Predicting development value is more complicated given the additional complexity of the hedonic housing price models. The coefficients of the hedonic models vary between the five cities requiring separate house price predictions for each city. In addition, the variables measured for the purpose of estimating the hedonic models do not map directly onto those used to estimate the construction cost model. The hedonic variables can be summarised in four main sets:

1.   Property specific-variables (property type).
2.   Physical property variable proxies (output area measures of property type and size).
3.   Locational variables (distance to city centre, and its square).
4.   Neighbourhood level measures of density (super output area variables).

To facilitate the predictions, variables belonging to (1) and (2) are given fixed values. The locational variables (distance and squared distance from the city centre) are permitted to vary.

Predictions are undertaken separately for every output area in the five cities. In addition, the neighbourhood level measures of density (4) are assigned their actual values. The predictions should therefore embody a number of assumptions and conditions:

- A predicted total value of 40 units of (housing / flats or housing plus flats) is generated for every output area in the five cities.

- Property type, size and other physical variables should be held fixed (the predictions should be for "constant quality" housing developments).

- The impact of distance from the CBD and neighbourhood density on development value varies both within and between cities, according to actual variable values.

Analysis of Simulated Development Viability

To compare the results of the simulations for the different development types the residual values are 'standardised' by expressing them as a percentage of gross development value. This is a useful device as it provides an easy comparison of revenue and costs (ignoring land costs and development profits). The simulations reveal significant variation in residential development viability both between and within cities. Table 4 summarises the key viability measures distinguishing between the three development types and between the five cities.

Table 4   Summary of simulated viability percentages

	Housing		Housing / flats		Flats	
City	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Edinburgh	50.0	21.1	39.4	25.6	41.7	24.6
Glasgow	6.8	35.8	-26.7	48.6	-48.4	56.9
Leicester	34.6	11.2	18.8	13.9	19.2	13.8
Oxford	69.1	8.1	61.9	10.0	62.5	9.9
Sheffield	23.5	22.3	12.2	25.6	21.7	22.8

Note: Figures are residual value expressed as a % of gross development value

The figures should be interpreted with some caution and bearing in mind that they summarise a range of variables simulated at Census output area level. The city means are considerably different ranging from only 6.8% in Glasgow (for the housing development type) to 69.1% in Oxford for the same development type. However, there is also considerable variation within cities. For example, the standard deviation for Glasgow (the city with the lowest means) is highest suggesting that in Glasgow, development viability is highly contingent on location. Meanwhile, in Oxford, the simulated means are very high and standard deviations are low suggesting that residential development projects are likely to be viable in most locations within the city. This conclusion is tempered by the fact that proportional land costs will be a function of this residual value less development profits. For example text books typically take normal profits as 20% of gross development value. Applying this standard, which is a

simplification (see below), land values would average almost half of gross development value in Oxford, 15% in Leicester and be negative in Glasgow.

Of further interest is the relationship between the different development types. In Edinburgh and Oxford, viability is broadly constant between the three development types while the variation in Leicester and Sheffield is higher and is highest of all in Glasgow. This may be suggestive that the susceptibility of development viability to location within the city is higher in the less compact and less affluent of the study areas.

Spatial Patterns of Viability

An analysis of the viability variables within each city reveals that viability is primarily correlated with tenure and accessibility (distance from the city centre). These analyses are shown in table 5. Correlation with household density is relatively low, except in the case of Oxford (negative correlation). Meanwhile, correlation with super output area (SOA) level proportions of property types are also relatively low although these are notably higher in the three English cities than the two Scottish cities. An analysis of the viability variables within each city reveals that viability is primarily correlated with local tenure patterns and accessibility (distance from the city centre). These analyses are shown in table 5. Correlation with household density is relatively low, except in the case of Oxford (negative correlation). Meanwhile, correlation with SOA level proportions of property types are also relatively low although these are notably higher in the three English cities than the two Scottish cities.

Table 5   Correlations between simulated viability and density / urban form

Variable	Gross Development Value				
	Edinburgh	Glasgow	Leicester	Oxford	Sheffield
Households per hectare	0.101	0.149	-0.192	-0.312	0.037
SOA % detached	0.214	0.198	0.377	0.288	0.355
SOA % terraced	-0.249	-0.261	-0.185	-0.179	-0.203
SOA % flats	0.080	0.075	0.159	0.299	0.201
SOA % social rented	-0.792	-0.884	-0.806	-0.790	-0.677
SOA % private rented	0.429	0.622	0.401	0.689	0.466
Distance from city centre	-0.504	-0.373	-0.005	-0.591	0.117
Distance2 from city centre	-0.418	-0.388	0.021	-0.613	0.046
Observations (COAs)	3,492	3,960	830	397	1,600

Further perspective is provided on the spatial variation of development viability by mapping the simulated values. Figures 1 to 5 summarise simulated viability maps for the mixed housing / flatted development type for each city. Care needs to be taken in the interpretation of these patterns. As noted earlier viability is a residual value that does not account for land values. Negative values certainly imply a lack of viability and a positive value suggests a positive land value but not necessarily viability. These maps implicitly also implicitly assume

cities are built on a uniform physical plain with no variable land conditions and differential rates of site preparation. They also ignore exceptional site specific additional costs. These maps should therefore be seen as spatial indicators of relative profitability. Further it should be remembered that different locations will represent different perceived levels of development risk and so required rates of return will also vary spatially (Jones, 1996). Incorporating this effect exacerbates the gradients in the maps.

In Edinburgh (figure 1) predicted development profitability is high in most output areas. Exceptions are found in and around the peripheral council housing estate of Craigmillar and Wester Hailes. Development viability is noticeably lower in the immediate vicinity of these areas. In Glasgow (figure 2), the position is quite different. Development profitability is at viable levels in the city centre, an extended corridor through the west end and towards Clydeside in the west of the city and a wedge from the city centre through to the suburbs in the southwest quarter of the city. These are the established owner occupied housing market areas within the city. It is worth noting that the analysis, based on 2002, precedes much of the recent strong house price growth witnessed in the city.

Similar patterns emerge in both Leicester (figure 3) and Sheffield (figure 5) with development predicted to be either viable or borderline viable in most locations. In Leicester, non-viability is clustered broadly in a ring midway between the city centre and the outer fringe. In Sheffield, non-viability is predicted to occur broadly on the eastern side of the city with viability peaking in very central locations. The position in Oxford is non-revealing (figure 4) given that development is predicted to be highly profitable in all Census output areas (COAs) without exception.

There are a number of striking points that emerge from this analysis. First, the absolute level of viability in a city is clearly a function of the affluence of the city, an exogenous factor in the original conceptual framework. Second, the intra-urban patterns of viability are primarily determined by the spatial structure of house prices, which is in turn linked to intra-urban accessibility and the tenure distribution within local neighbourhoods. Neighbourhood density is only a minor influence on viability but this is may be partly due to the fact that densities in public sector housing estates are included in the correlation analysis. Densities are also a function of historic development patterns.

Conclusions

Planning in the UK has emphasised the compact urban form but this policy is now under threat as it is now acknowledged that these urban development constraints have created severe affordability problems in the housing market. In a sense the status quo is unsustainable but the alternatives remain clouded. There is much debate about the nature of sustainable urban form although most of the arguments are in normative terms. It is not clear that the framework

of the current sustainable urban form debate is fruitful. The paper has focused on the economic dimension of sustainability but clearly there are environmental and social dimensions. It has therefore not promulgated an ideal urban form. However, the essential elements of urban form are shown to be outcomes of real estate markets and the housing market as the largest land use is perhaps the most important key to creating a more sustainable form. The focus of the paper is therefore to examine the constraints to the adaptation of the existing urban form via housing market development viability.

To address the task a series of econometric models are linked together to estimate spatial patterns of viability in five cities. The results demonstrate a substantial difference between cities that can be attributed not to urban form per se but to socio-economic factors. This demonstrates that in practice it is impossible to divorce the physical structure of cities from their economic and social structure. Viability is also influenced strongly by public policy through the location of social housing. The research suggests that a driving force/constraint for development viability is the level of neighbourhood house prices and this questions the simplicity of the Barker hypothesis that brownfield development is constrained by the associated additional costs and risks. Large swathes of negative viability even without accounting for the additional costs of brownfield development suggest that there are major constraints to the reconfiguration of housing markets in some cities in a piecemeal way. Adapting cities will arguably require grand designs to fundamentally reconstruct intra-urban house price structures.

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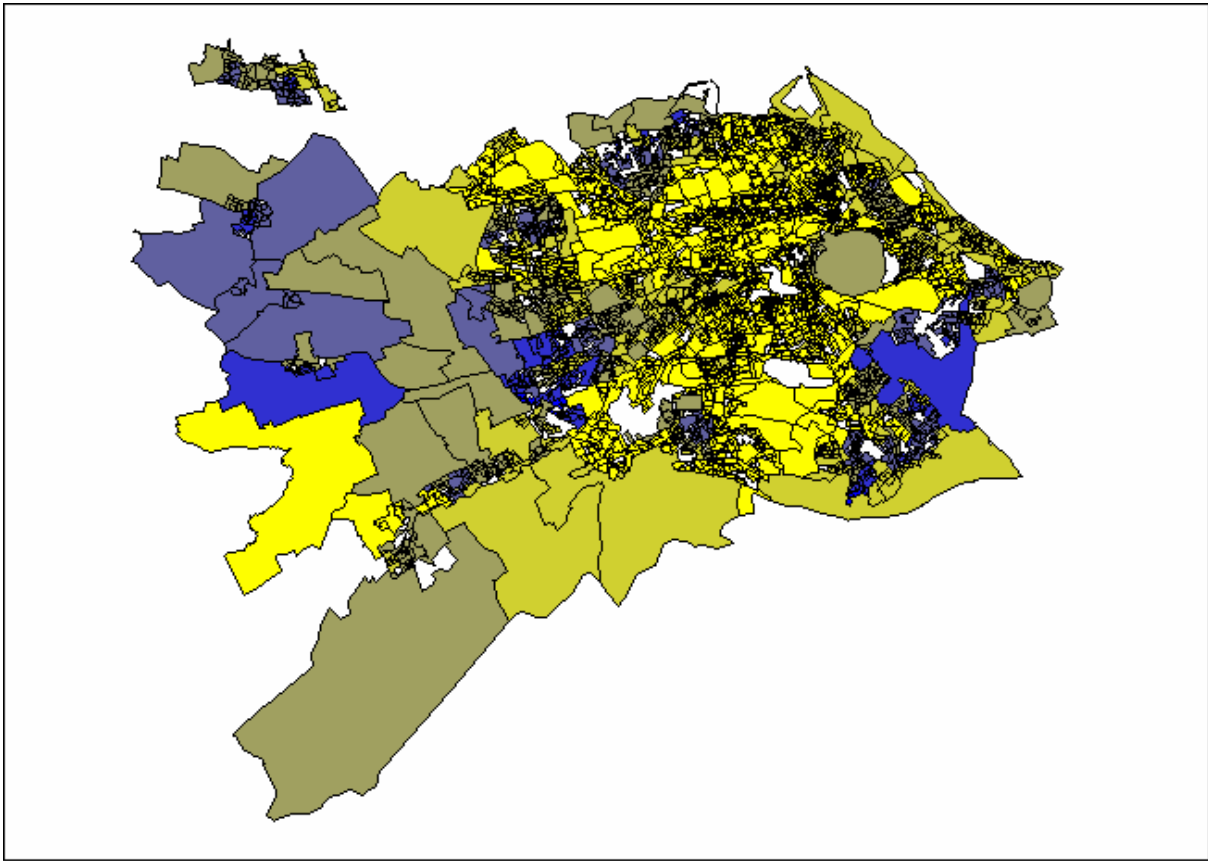
Figure 1
Spatial variation in mixed housing / flatted development viability within Edinburgh

☐	50 to 80 (2019)
☐	31 to 50 (1888)
☐	10 to 31 (2259)
☐	-21 to 10 (1771)
☐	-66 to -21 (1357)
☐	-161 to -66 (985)
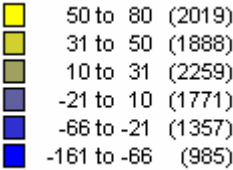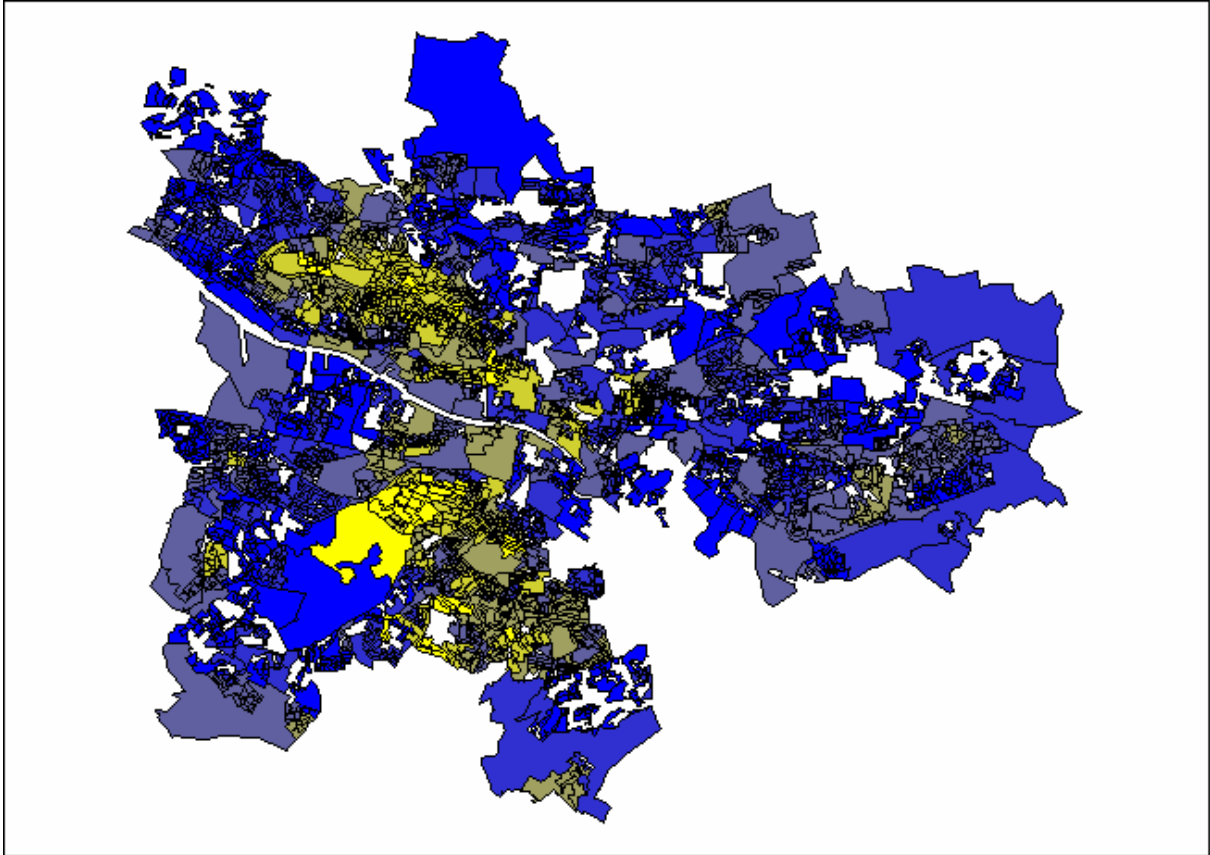
Figure 2
Spatial variation in mixed housing / flatted development viability within Glasgow

Figure 3
Spatial variation in mixed housing / flatted development viability within Leicester
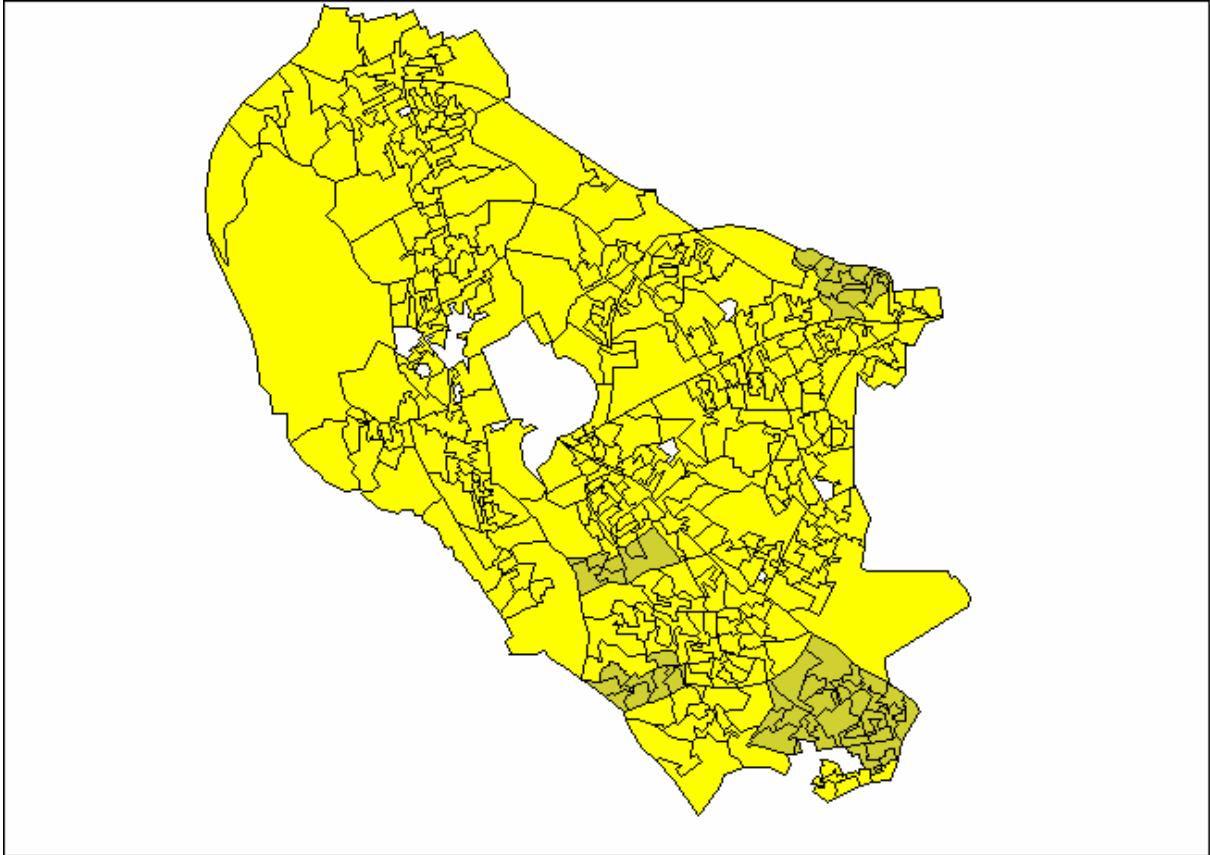
Figure 4
Spatial variation in mixed housing / flatted development viability within Oxford
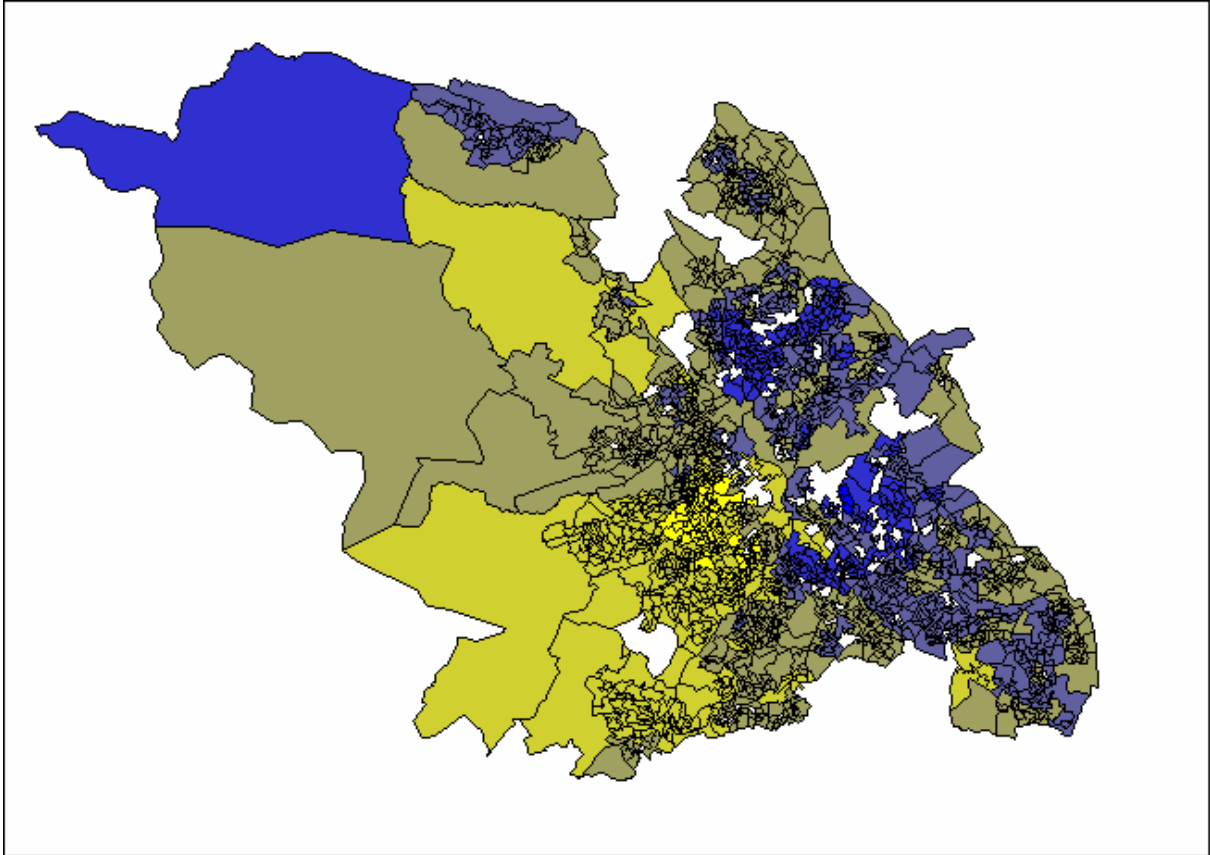
Figure 5
Spatial variation in mixed housing / flatted development viability within Sheffield

APPENDIX

A. Pooled (5 city) hedonic model

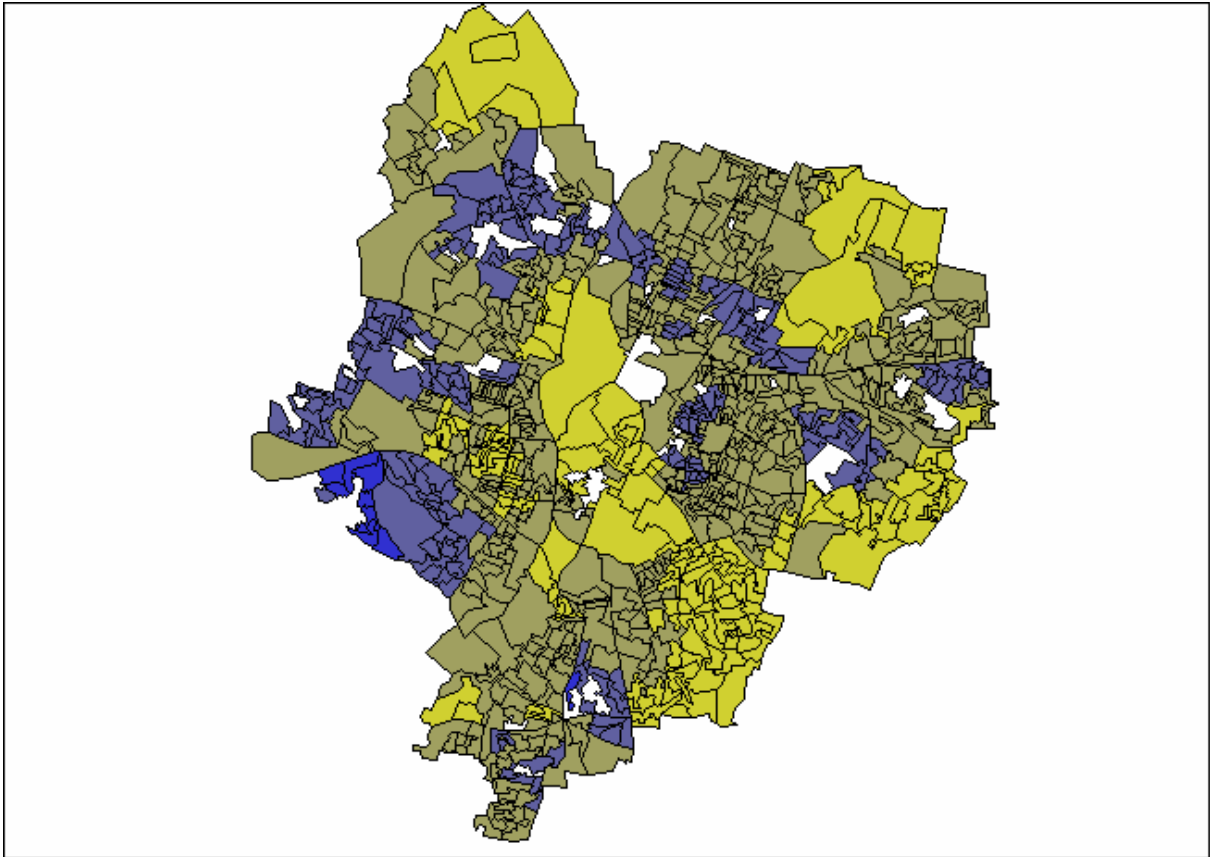| Variable	Coefficient	Std. Beta	t statistic		VIF
Constant	11.377		478.724	***	
Terrace (dummy)	-0.331	-0.158	-36.299	***	1.627
Flat (dummy)	-0.169	-0.052	-13.681	***	1.244
Distance (km) to city centre	-0.099	-0.301	-24.499	***	13.033
Distance^2	0.004	0.157	14.064	***	10.776
OA % props 1 rm	0.003	0.012	3.059	***	1.254
OA % props 2 rms	-0.007	-0.081	-18.469	***	1.643
OA % props 5-6 rms	0.003	0.096	17.313	***	2.627
OA % props 7+ rms	0.013	0.232	35.297	***	3.745
OA % props not ground floor	-0.003	-0.069	-8.654	***	5.454
OA % props detached	0.001	0.026	4.42	***	2.896
OA % props terraced	-0.001	-0.021	-2.731	***	4.913
OA % props flats	-0.001	-0.041	-3.015	***	16.321
SOA % props terraced	-0.001	-0.026	-3.541	***	4.764
SOA % props flats	0.003	0.13	11.615	***	10.847
SOA % props 7+ rms	0.013	0.19	29.009	***	3.693
SOA % props social rented	-0.01	-0.249	-55.049	***	1.761
SOA % props private rented	0.009	0.128	23.405	***	2.571
SOA households per hect	-0.001	-0.057	-13.966	***	1.432
R Square	0.393				
Adjusted R Square	0.393				
Std. Error	0.629				
F statistic	1885.4	***			

*** significant at 1%; ** significant at 5%

B.   Hedonic estimation results - Edinburgh

Variable	Coefficient	Std. Beta	t statistic		VIF
Constant	11.837		243.994	***	
Detached (dummy)	-0.165	-0.028	-4.24	***	1.137
Terrace (dummy)	-0.422	-0.135	-17.425	***	1.579
Flat (dummy)	-0.387	-0.132	-13.628	***	2.459
Distance (km) to city centre	-0.115	-0.387	-15.704	***	15.962
Distance^2	0.003	0.138	6.425	***	12.148
OA % props 2 rms	-0.003	-0.044	-4.931	***	2.129
OA % props 5/6 rms	0.006	0.169	17.044	***	2.573
OA % props 7+ rms	0.015	0.319	30.811	***	2.823
OA % props not ground floor	0.001	0.022	1.665	*	4.611
OA % props detached	0.004	0.089	6.998	***	4.272
OA % props terraced	-0.003	-0.064	-6.444	***	2.572
OA % props flats	-0.003	-0.133	-6.849	***	9.926
SOA % props 1 rm	0.035	0.051	6.374	***	1.684
SOA % props 2 rms	-0.002	-0.023	-1.882	*	3.863
SOA % props 5/6 rms	-0.003	-0.056	-4.649	***	3.774
SOA % props 7+ rms	0.009	0.151	11.194	***	4.794
SOA % props social rented	-0.012	-0.229	-27.237	***	1.856
SOA % props private rented	0.005	0.07	6.672	***	2.859
SOA households per hect	-0.001	-0.046	-6.168	***	1.461
R Square	0.400				
Adjusted R Square	0.399				
Std. Error	0.602				
F statistic	552.288				

C.   Hedonic estimation results - Glasgow

Variable	Coefficient	Std. Beta	t statistic		VIF
Constant	11.495		221.661	***	
Detached (dummy)	-0.548	-0.082	-12.455	***	1.099
Terrace (dummy)	-0.482	-0.161	-19.377	***	1.757
Flat (dummy)	-0.698	-0.141	-17.652	***	1.622
Distance (km) to city centre	-0.066	-0.167	-5.608	***	22.576
Distance^2	0.003	0.076	2.626	***	21.379
OA % props 1 rm	0.003	0.014	1.842	*	1.478
OA % props 2 rms	-0.009	-0.112	-11.591	***	2.369
OA % props 5/6 rms	0.002	0.048	5.520	***	1.904
OA % props 7+ rms	0.011	0.126	11.664	***	2.951
OA % props not ground floor	-0.001	-0.031	-2.213	**	5.089
OA % props detached	0.006	0.084	6.217	***	4.623
OA % props terraced	-0.002	-0.049	-4.180	***	3.563
OA % props flats	-0.002	-0.102	-5.31	***	9.464
SOA % props detached	-0.008	-0.09	-6.219	***	5.319
SOA % props terraced	-0.004	-0.063	-6.071	***	2.716
SOA % props 1 rm	-0.012	-0.028	-3.228	***	1.945
SOA % props 2 rms	0.005	0.047	4.306	***	3.021
SOA % props 7+ rms	0.025	0.230	18.729	***	3.854
SOA % props social rented	-0.010	-0.276	-26.411	***	2.791
SOA % props private rented	0.010	0.141	11.708	***	3.686
SOA households per hect	-0.001	-0.071	-9.489	***	1.412
R Square	0.295				
Adjusted R Square	0.294				
Std. Error	0.705				
F statistic	357.628				

D.   Hedonic estimation results - Sheffield

Variable	Coefficient	Std. Beta	t statistic		VIF
Constant	9.771		169.791	***	
Detached (dummy)	0.197	0.130	13.858	***	1.921
Terrace (dummy)	-0.293	-0.218	-22.878	***	1.984
Flat (dummy)	-0.258	-0.112	-12.396	***	1.770
Distance (km) to city centre	0.100	0.439	13.061	***	24.609
Distance^2	-0.006	-0.381	-12.548	***	20.075
OA % props 1 rm	0.01	0.041	3.545	***	2.881
OA % props 5/6 rms	0.002	0.058	4.206	***	4.107
OA % props 7+ rms	0.008	0.201	12.974	***	5.239
OA % props detached	0.002	0.054	4.274	***	3.420
OA % props terraced	-0.001	-0.060	-4.352	***	4.169
OA % props flats	-0.001	-0.036	-2.290	**	5.252
SOA % props terraced	-0.001	-0.043	-2.796	***	5.140
SOA % props flats	0.011	0.269	16.115	***	6.058
SOA % props 1 rm	0.024	0.061	3.830	***	5.534
SOA % props 2 rms	-0.012	-0.042	-2.996	***	4.295
SOA % props 5/6 rms	0.009	0.18	11.668	***	5.157
SOA % props 7+ rms	0.014	0.283	16.437	***	6.463
SOA % props social rented	-0.003	-0.087	-7.249	***	3.126
SOA % props private rented	0.011	0.202	13.550	***	4.848
SOA households per hect	0.002	0.047	5.270	***	1.730
R Square	0.527				
Adjusted R Square	0.527				
Std. Error	0.437				
F statistic	574.354				

E.   Hedonic estimation results - Leicester

Variable	Coefficient	Std. Beta	t statistic		VIF
Constant	10.91		165.393	***	
Detached (dummy)	0.171	0.134	10.830	***	1.526
Terrace (dummy)	-0.165	-0.167	-11.529	***	2.103
Flat (dummy)	-0.445	-0.221	-16.661	***	1.761
Distance (km) to city centre	-0.116	-0.312	-6.033	***	26.814
Distance^2	0.021	0.379	7.559	***	25.149
OA % props 1 rm	0.009	0.037	2.980	***	1.532
OA % props 5/6 rms	0.004	0.134	6.664	***	4.030
OA % props 7+ rms	0.014	0.351	19.650	***	3.191
OA % props not ground floor	0.007	0.141	7.382	***	3.634
SOA % props terraced	-0.001	-0.047	-2.218	**	4.497
SOA % props flats	0.005	0.175	6.208	***	7.954
SOA % props 5/6 rms	0.002	0.052	2.100	**	6.171
SOA % props 7+ rms	0.002	0.044	2.072	**	4.439
SOA % props social rented	-0.007	-0.247	-15.786	***	2.460
SOA % props private rented	0.003	0.077	3.705	***	4.333
SOA households per hect	-0.002	-0.077	-5.256	***	2.151
R Square	0.426				
Adjusted R Square	0.425				
Std. Error	0.373				
F statistic	267.066				

F.   Hedonic estimation results - Oxford

Variable	Coefficient	Std. Beta	t statistic		VIF
Constant	11.912		98.092	***	
Detached (dummy)	0.079	0.056	3.03	***	1.772
Terrace (dummy)	-0.101	-0.086	-4.782	***	1.677
Flat (dummy)	-0.428	-0.326	-16.846	***	1.932
Distance (km) to city centre	-0.014	-0.035	-1.664	*	2.283
OA % props 1 rm	0.028	0.175	8.407	***	2.230
OA % props 2 rms	-0.017	-0.145	-6.520	***	2.550
OA % props 5/6 rms	0.004	0.127	3.285	***	7.649
OA % props 7+ rms	0.008	0.208	5.770	***	6.663
OA % props detached	0.002	0.058	1.666	*	6.134
OA % props terraced	0.001	0.052	2.365	**	2.497
OA % props flats	0.003	0.119	2.660	***	10.294
OA % props not ground floor	0.003	0.076	2.472	**	4.873
SOA % props detached	-0.006	-0.137	-4.147	***	5.578
SOA % props flats	0.005	0.143	3.887	***	6.922
SOA % props 1 rm	-0.020	-0.102	-3.864	***	3.611
SOA % props 2 rms	0.016	0.084	2.500	**	5.772
SOA % props 5/6 rms	-0.003	-0.091	-2.137	**	9.426
SOA % props 7+ rms	0.011	0.241	6.544	***	6.953
SOA % props social rented	-0.010	-0.274	-14.871	***	1.744
SOA households per hect	-0.004	-0.088	-5.693	***	1.221
R Square	0.503				
Adjusted R Square	0.499				
Std. Error	0.372				
F statistic	129.411				

G.   Flat / terraced logit model

Sub-appendices G through I summarise the results of a series of binary logistic estimations centred around the "property type" variable available in HM Land Registry data (for England and Wales). The Land Register data in Scotland does not include a property type variable. The approach adopted here is to calibrate a predictive model based on the three English cities. Explanatory variables are from the 2001 Census and are chosen on the joint criteria of maximisation of predictive / explanatory power and absence from related models, i.e. only Census variables not used in the hedonic and construction cost estimation models are used in the property type predictive logit models. This practical step eliminates identification problems.

Variables are defined as follows:

pred_mean_Lap	Hedonic regression predicted price of the ith house ÷ local authority mean hedonic regression predicted price
pred_mean_p	As above but divided by SOA level mean hedonic predicted price
Pdetach	Proportion of detached properties in the LA
Psemid	Proportion of semi-detached properties in the LA
Pterr	Proportion of terraced properties in the LA
Pbase	Proportion of properties with a basement in the LA
Pfirstfl	Proportion of properties with a first floor in the LA
Psecndfl	Proportion of properties with a second floor in the LA
pn_SEMID	Proportion of semi-detached properties in the SOA
pn_TERR	Proportion of terraced properties in the SOA
Poneperhh	Proportion of one person households in the LA

Variable	Coefficient	Std. Error	Wald	
Constant	5.576	0.604	85.268	***
Pred_mean_Lap	0.924	0.137	45.62	***
Pred_mean_p	-0.927	0.119	60.372	***
Pdetach	-0.051	0.006	79.015	***
Psemid	-0.062	0.006	118.567	***
Pterr	-0.079	0.005	226.263	***
Pbase	-0.011	0.004	6.83	***
Pfirstfl	-0.036	0.01	13.76	***
Psecndfl	-0.019	0.014	1.795	
pn_SEMID	-0.007	0.003	4.589	**
pn_TERR	-0.023	0.003	58.379	***
Poneperhh	-0.004	0.004	1.042	
-2 Log likelihood	5569.568			
Cox & Snell R Square	0.339			
Nagelkerke R Square	0.531			
Prediction summary				
Terrace - % correct	83.875	(7324)		

Flat - % correct	81.460	(1904)
Overall % correct	83.377	
Cut value	0.20	

*** significant at 1%; ** significant at 5%

H. Flat / detached logit model

Variable	Coefficient	Std. Error	Wald	
Constant	-15.275	1.501	103.505	***
Pred_mean_Lap	7.109	0.298	568.171	***
Pred_mean_p	2.68	0.199	180.805	***
Pdetach	0.052	0.014	14.748	***
Psemid	0.071	0.014	27.384	***
Pterr	0.031	0.013	5.701	**
Pbase	-0.108	0.01	114.307	***
Pfirstfl	0.03	0.026	1.378	
Psecndfl	0.042	0.035	1.429	
pn_SEMID	0.008	0.006	1.713	
pn_TERR	0.081	0.006	158.552	***
Poneperhh	-0.049	0.009	28.786	***
-2 Log likelihood	1500.062			
Cox & Snell R Square	0.643			
Nagelkerke R Square	0.869			
Prediction summary				
Flat	91.334	(1904)		
Detached	94.920	(2815)		
Overall % correct	93.473			
Cut value	0.50			

*** significant at 1%; ** significant at 5%

I. Detached / semi-detached logit model

Variable	Coefficient	Std. Error	Wald	
Constant	-10.684	0.961	123.585	***
Pred_mean_LAp	6.205	0.16	1495.04	***
Pred_mean_p	1.974	0.109	326.203	***
Pdetach	0.025	0.009	8.031	***
Psemid	-0.028	0.009	10.102	***
Pterr	-0.035	0.009	16.124	***
Pbase	-0.051	0.006	80.671	***
Pfirstfl	-0.082	0.016	25.326	***
Psecndfl	-0.002	0.026	0.004	
pn_SEMID	0.016	0.004	18.285	***
pn_TERR	0.066	0.004	277.366	***
Poneperhh	0.006	0.006	1.298	
-2 Log likelihood	4406.180			
Cox & Snell R Square	0.529			

Nagelkerke R Square	0.750	
<u>Prediction summary</u>		
Semi-detached	89.56	(6612)
Detached	87.92	(2815)
Overall % correct	89.07	
Cut value	0.25	

*** significant at 1%; ** significant at 5%