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The Amenity Value of English Nature: A Hedonic Price Approach

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Abstract Using a hedonic property price approach, we estimate the amenity value associated with proximity to habitats, designated areas, domestic gardens and other natural amenities in England. There is a long tradition of studies looking at the effect of environmental amenities and disamenities on property prices. But, to our knowledge, this is the first nationwide study of the value of proximity to a large number of natural amenities in England. We analysed 1 million housing transactions over 1996–2008 and considered a large number of environmental characteristics. Results reveal that the effects of many of these environmental variables are highly statistically significant, and are quite large in economic magnitude. Gardens, green space and areas of water within the census ward all attract a considerable positive price premium. There is also a strong positive effect from freshwater and flood plain locations, broadleaved woodland, coniferous woodland and enclosed farmland. Increasing distance to natural amenities such as rivers, National Parks and National Trust sites is unambiguously associated with a fall in house prices. Our preferred regression specifications control for unobserved labour market and other geographical factors using Travel to Work Area fixed effects, and the estimates are fairly insensitive to changes in specification and sample. This provides some reassurance that the hedonic price results provide a useful representation of the values attached to proximity to environmental amenities in England. Overall, we conclude that the housing market in England reveals substantial amenity value attached to a number of habitats, designations, private gardens and local environmental amenities.

Keywords Amenity value · Hedonic price method (HPM) · Environmental amenities

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1 Introduction

Living within or in close proximity to desirable natural areas and environmental resources such as coastal, river or woodland habitats, managed and protected areas, and urban parks and gardens is thought to provide a large number of positive welfare benefits to the public. These include not only numerous opportunities for recreation, leisure and wildlife viewing, but also the possibility of improved physical health through green exercise, visual amenity, improved mental or psychological well-being, artistic inspiration, and ecological education. The Millennium Ecosystem Assessment (2005) refers to these types of amenity benefits as the 'cultural services' provided by ecosystems, while the UK National Ecosystem Assessment (2011) classifies them as the 'cultural goods or benefits' provided by environmental settings and wild species diversity.

Economic valuation methods such as stated and revealed preference techniques have been widely applied to estimate the cultural ecosystem benefits associated with green areas and environmental resources (e.g. Garrod and Willis 1999; Tyrvainen and Miettinen 2000; Earnhart 2001; Poor et al. 2007). In particular, there is a long tradition of hedonic price studies measuring environmental values by investigating the effect of environmental amenities on property prices. The first environmental study, Ridker and Henning's analysis of the effects of air pollution on house prices, dates back to 1967.

In the 40 years that elapsed since this pioneering contribution, there have been dozens of studies estimating the price impacts of a wide range of other environmental amenities such as water quality (Walsh et al. 2011; Leggett and Bockstael 2000; Boyle et al. 1999), preserved natural areas (Correll et al. 1978; Lee and Linneman 1998), wetlands (Doss and Taff 1996; Mahan et al. 2000), forests (Garrod and Willis 1992; Tyrvainen and Miettinen 2000; Thorsnes 2002), beaches (Landry and Hindsley 2011), agricultural activities (Le Goffe 2000), nature views (Benson et al. 1998; Paterson and Boyle 2002; Luttik 2000; Morancho 2003), urban trees (Anderson and Cordell 1985; Morales 1980; Morales et al. 1983) and open spaces (Cheshire and Sheppard 1995, 1998; Bolitzer and Netusil 2000; Netusil 2005; McConnell and Walls 2005). Disamenities such as road noise (Day et al. 2006; Wilhelmsson 2000) have also been investigated. For the most part, this large body of literature has consistently shown an observable effect of environmental factors on property prices.

A broad inspection of these previous works shows that environmental hedonic studies typically focus on a single or a very limited number of environmental attributes, thereby possibly failing to account for the interplay between multiple environmental amenities and housing preferences. Examples include recent large studies such as Walsh et al. (2011) valuing water quality changes in Orange County, Florida, USA and Landry and Hindsley (2011) valuing beach quality in Tybee Island, Georgia, USA. Garrod and Willis (1992) found that proximity to hardwood forests had a positive influence on house prices whilst mature conifers had a negative effect. However, their study does not take account of the influence of other land cover types. We only found a handful of studies that looked at more than one environmental amenity. For example, Geoghegan (2002) looked at amenity effects related to proximity to several types of open space in Howard County, Maryland, and found that only permanently protected open spaces (preserves, parks, and easements) have a statistically significant relationship with land prices. Omitting potentially important variables from the hedonic price model can lead to serious specification bias. By and large, because of lack of data or small sample sizes, existing studies also fail to control for a wide enough range of potentially confounding geographical factors and are particularly lacking in location and neighbourhood characteristics (e.g. school quality, crime rates, job market characteristics, etc).

Furthermore, past hedonic analysis are often applied to narrow geographical locations (counties, cities or parts of cities) and based on small sample sizes. For example, Cheshire and Sheppard (2002) used data from a UK city (Reading) to show that the benefits associated with accessible open space (e.g. parks) considerably exceeded those from more inaccessible open space (e.g. green belt and farmland). Some of the largest areas and sample sizes we could find in recent environmental valuation studies were that of Walsh et al. (2011)—who employ a dataset of 54,000 property sales to investigate the value of surface water quality in Orange County (covering 2,600 km^2), Florida—and Netusil et al. (2010)—who use just over 30,000 property sales in a comprehensive second stage hedonic price analysis of the benefits of tree canopy cover in Portland, USA. Most other recent studies are based on substantially smaller sample sizes. Pearson et al. (2002) study on the impact of an Australian National Park on surrounding land values was based on 641 prices for a single year 1999. In 2007, a study of urban green space in Jinan City in China used a sample 124 property prices for the year of 2004 (Kong et al. 2007). More recently, Yusuf and Resosudarmo (2009) studied the impact of air pollution on property prices in Jakarta, Indonesia, based on a sample of 470 observations for 1998, while Landry and Hindsley (2011) valued beach quality in Tybee Island (57 km^2), Georgia, USA, using 372 real estate transactions. The representativeness of these small area studies is open to question, so it is important to know if the link between environmental characteristics and house prices remains discernible when conducting the analysis over a much wider geographical area with a greater environmental diversity. Moreover, an analysis at a wider geographical scale potentially permits the investigation of the value of larger scale environmental variables, such as different habitats or ecosystems and different types of protected areas.

In this paper we estimate the amenity value associated with habitats, designated areas, heritage sites, domestic gardens and other natural amenities in England (and Great Britain to a lesser extent) using a hedonic price approach (Sheppard 1999; Champ et al. 2003). Our study adds to the body of evidence on environmental values using this method, by estimating the value of a wide range of environmental amenities, using a very large and representative data set of housing transactions over a 13 year period, and a large and diverse geographical study area (the whole of England and Great Britain). We assemble data on a large number of control variables (important neighbourhood attributes, transport accessibility and differences in local labour market opportunities between locations) all of which are potentially highly correlated with the availability of natural amenities. Our regression specifications control for Travel to Work Area (labour market) fixed effects, so estimation of the effects of environmental amenities comes from within-labour market variation. This method controls for earnings and other labour market differences across space without the need for direct measure of wages and employment opportunities. To our knowledge, this is the first nationwide study of the value of such a wide range of natural amenities in England (and Great Britain). The remainder of the paper is organized as follows. In Sect. 2 we provide further details about our methodological approach, Sect. 3 presents and discusses our main findings and Sect. 4 offers some summary conclusions.

2 Methodology

The hedonic price method uses housing market transactions to infer the implicit value of the house's underlying characteristics (structural, locational/ accessibility, neighbourhood and environmental). Rosen (1974) presents the theoretical rationale for this analysis, showing that the utility benefit of marginal changes in one component of the bundle of attributes in a composite good like housing can be monetised by measuring the additional expenditure incurred in equilibrium. These firm foundations in economic theory and observable market behaviour, rather than on stated preference surveys, make the method desirable from a policy perspective.

Applied hedonic analysis recovers the marginal valuations or ‘implicit prices’ of the separate housing attributes from a regression of housing transaction sales prices on the component attributes of the house sold—its structural characteristics, environmental quality, neighbourhood amenities, labour market opportunities and so on. Hedonic price studies of environmental quality must therefore link data on housing transaction locations to measures of environmental quality. In recent years, the use of geographical information systems (GIS) and the availability of GIS data on environmental quality have increased the detail and flexibility with which these attributes can be linked to house locations, allowing for improved accuracy in the consideration of proximity to natural features, designated natural areas, and the amount and topography of the local environmental amenities.

2.1 Data Description

2.1.1 Geographical Area

Whilst most previous analysis using property values for environmental valuation were applied to relatively restricted geographical areas such as cities or parts of cities, our analysis spans the whole of England, with some comparisons made with Great Britain (England, Scotland and Wales). Specifically, our units of analysis are individual houses located across England (130,395 km^2), Scotland (78,772 km^2) and Wales (20,779 km^2).

2.1.2 House Price Data

We use a very large sample of about 1 million housing transactions in Great Britain, over 1996–2008, with information on location at full postcode level (about 17 houses on average). The house sales price data is from the Nationwide building society. In this paper, we mainly make use of house transactions for England as we do not have complete environmental data for the other regions. However, we present comparison estimates for Great Britain for those environmental amenities for which this is feasible. Our sample size is the largest we have found in the environmental hedonic literature.

2.1.3 Environmental Variables

Great Britain is home to a wide range of ecosystems, natural habitats and other green areas that play an important role in biodiversity conservation. Our analysis considers a large number of these natural amenities related to land cover, terrain and designated natural areas.

First, we use nine broad habitat categories, which we constructed from the Land Cover Map 2000 (remote sensed data from the Centre for Ecology and Hydrology) describing the physical land cover in terms of the proportional share (0–1) of a particular habitat within the 1km x 1km square in which the property is located: (1) Marine and coastal margins; (2) Freshwater, wetlands and flood plains; (3) Mountains, moors and heathland; (4) Semi-natural grasslands; (5) Enclosed farmland; (6) Coniferous woodland; (7) Broad-leaved/mixed woodland; (8) Urban; and (9) Inland Bare Ground. The omitted class in this group is ‘Urban’, so the model coefficients reported in the results section should be interpreted as describing the effect on prices as the share in a given land cover is increased, whilst decreasing the share of urban land cover. Currently, in Great Britain, farmland occupies the largest area, almost 50 % of the country, followed by semi-natural grasslands and mountains, which together cover approximately a third of Great Britain, with woodland covering just over 12 % (Fuller et al. 2002). There are over 5 billion day visits to the English countryside each year (TNS Travel and Tourism 2004) and about one third of all leisure visits in England were to the countryside, coast or woodlands (Natural England 2005).

Natural amenities are also provided at a much more localised scale, through urban parks and other formal and informal urban green spaces such as people's own domestic gardens. Mean per capita provision of accessible public green spaces in urban areas of England was recently calculated at 1.79 ha per 1,000 people (CABE 2010) with just under 50 % of the population using public urban green spaces at least once a week (Defra 2009) while just under 90 % said they used their local parks or open spaces regularly (DCLG 2008). Moreover, approximately 23 million households (87 % of all homes) have access to a private garden. Domestic gardens in England constitute just over 4 % (564,500 ha) of total land cover with the majority being located in urban areas and covering an average 13 % of the urban landscape (Generalised Land Use Database 2005). Despite modern trends, such as the paving over front gardens, it is increasingly recognized that domestic gardens provide crucial habitats for plant and animal species (Gaston et al. 2007). Indeed, gardening is thought to be one of the most commonly practiced type of physical activity in Great Britain (Crespo et al. 1996; Yusuf et al. 1996; Magnus et al. 1979) with British households spending on average 71 h a year gardening (MINTEL 1997). To try and capture some of these amenities, we also use six land use share variables taken from the Generalised Land Use Database (CLG 2007). These variables depict the land use share (0–1), in the Census ward in which a house is located, of the following land types: (1) Domestic gardens; (2) Green space; (3) Water; (4) Domestic buildings; (5) Non-domestic buildings and (6) 'Other'. The hedonic model coefficients indicate the association between increases in the land use share in categories (1)–(5), whilst decreasing the share in the omitted 'other' group. This omitted category incorporates transport infrastructure, paths and other land uses (Roads; Paths; Rail; Other land uses, (largely hard-standing); and Unclassified in the source land use classification).

Especially important, rare or threatened natural areas are formally designated under various pieces of national and international legislation to ensure their protection. One of the best known designations are National Parks, aiming to conserve the natural beauty and cultural heritage of areas of outstanding landscape value and to provide opportunities for the public to understand and enjoy these special qualities. There are 10 National Parks in England, 3 in Wales and 2 in Scotland (National Parks 2010). Popular National Parks such as the Peak District, the Yorkshire Dales and the Lake District, attract in the order of 8–10 million visits each year (National Parks 2010). Another commonly used designation is the Green Belt, used in planning policy in Great Britain to avoid excessive urban sprawl by retaining areas of largely undeveloped, wild, or agricultural land surrounding urban areas. There are around 14 Green Belts throughout England, covering 13 % of land area (CLG 2010), with the largest being the London Green Belt covering about 486,000 hectares. To capture the value of such designated areas we created two additional variables depicting designation status: respectively, the proportion (0–1) of Green Belt land and of National Park land in the Census ward in which a house is located. The model coefficients in the results section show the association between ward Green Belt designation, National Park designation and house prices.

We also constructed five 'distance to' variables describing proximity to various natural and environmental amenities, namely (1) distance to coastline, (2) distance to rivers, (3) distance to National Parks (England and Wales), (4) distance to National Nature Reserves

(England and Scotland), and (5) distance to land owned by the National Trust.[1] The effects of these variables are scaled in terms of the distance, in 100s of kilometres, between each resource and each house identified by its postcode. Distance is measured in a straight line to the nearest of these features. The inclusion of a variable depicting proximity to National Trust properties was motivated by the desire to capture the heritage interest or historical importance sometimes associated with certain natural areas. In Great Britain many of these areas belong to the National Trust, the country's leading independent conservation and environmental organisation, acting as a guardian for the nation in the acquisition and permanent preservation of places of historic interest and natural beauty. The Trust manages around 254,000 hectares (627,000 acres) of countryside moorland, beaches and coastline in England, Wales and Northern Ireland, 709 miles of coastline (1,141 km), as well as a large number of historic gardens and nature reserves (National Trust 2010). There are some 14 million yearly visits to its 'pay for entry' properties, and an estimated 50 million visits to its open air properties. We also included distance to the nearest of the twenty four National Nature Reserves in England that were established to protect the finest wildlife and geological sites in the country, and are a selection of the best existing Sites of Special Scientific Interest (Natural England 2011).

Some of our regression specifications include the effect of 'distance to the nearest church'. This variable is intended to capture potential amenities associated with the places where churches are located—i.e. historic locations in town centres, with historical buildings, and focal points for business and retail—but may arguably also capture to some extent the amenity value of churches, via their architecture, churchyards, church gardens and cemeteries. This is only reported for a subset of metropolitan areas in England (spanning London, the North West, Birmingham and West Midlands) for which the variable was constructed by the researchers from Ordnance Survey digital map data. The sample is restricted to properties within 2km of one of the churches in this church dataset.

Table 1 presents summary statistics for the housing transactions data in relation to the key environmental variables considered. The table contains mean, standard deviation and maximum of the land area shares (i.e. the proportion of land in a particular use) and distances, for the housing transactions sample. The figures are thus representative of residential sites in England, rather than the land area as a whole. Inspection of the table shows that housing transactions are more prevalent in certain types of land cover. For example, the average house sale is in a ward in which 20 % of the land use is gardens. The table also indicates that, as expected, most of the houses are in wards that are urban (i.e. the missing base category among the land cover variables).

2.1.4 Control Variables

Another distinguishing feature of our analysis is the large number of control variables considered. Along with the house sales price data, we have data on several internal and local characteristics of the houses. Internal housing characteristics are property type, floor area, floor area-squared, central heating type (none or full, part, by type of fuel), garage (space,

[1] It should be noted that our dataset includes distance to all (916) National Trust properties. Although the overwhelming majority of these properties contain (or are near) picturesque or important natural environmental amenities, some also contain houses and other built features. For example, NT's most visited property Wakehurst Place, the country estate of the Royal Botanic Gardens (Kew), features not only 188 hectares of ornamental gardens, temperate woodlands and lakes but also an Elizabethan Mansion and Kew's Millennium Seed Bank. Hence, the amenity value captured by the 'distance to land owned by the National Trust' variable reflects also some elements of built heritage that are impossible to disentangle from surrounding natural features.

Table 1 Summary statistics for the housing transactions data

	Mean	Standard deviation	Maximum
Ward share of			
Domestic gardens	0.205	0.134	0.629
Green space	0.511	0.267	0.989
Water	0.024	0.067	0.888
Domestic buildings	0.067	0.049	0.311
Other buildings	0.031	0.034	0.496
Green Belt	0.155	0.321	1.000
National Park	0.003	0.049	1.000
Ward area (km^2)	10.385	19.884	462.471
Distance (100 km) to			
Coastline	0.276	0.275	1.028
Rivers	0.011	0.012	0.467
National Parks	0.467	0.291	1.669
Nature Reserves	0.130	0.078	0.751
National Trust properties	0.072	0.053	0.459
Land in 1 km square			
Marine and coastal margins	0.005	0.036	1.000
Freshwater, wetlands, floodplains	0.006	0.025	0.851
Mountains, moors and heathland	0.029	0.018	0.782
Semi-natural grassland	0.076	0.086	1.000
Enclosed farmland	0.246	0.236	1.000
Coniferous woodland	0.006	0.025	0.943
Broadleaved woodland	0.060	0.077	0.899
Inland bare ground	0.007	0.026	0.895
Topography			
Altitude (100 m)	0.642	0.484	4.812
Slope (10 s degrees)	0.172	0.161	2.980
East facing slope	0.249	0.432	1.000
South facing slope	0.269	0.443	1.000
West facing slope	0.223	0.321	1.000
Accessibility and other variables			
Distance to station (100 km)	0.028	0.032	0.407
Distance to motorways (100 km)	0.137	0.199	1.695
Distance to primary road (100 km)	0.020	0.024	0.283
Distance to A-road (100 km)	0.013	0.019	0.330
Distance to TTWA centre (100 km)	0.099	0.066	0.449
Population (1,000 s/km^2)	3.205	2.404	17.916
Age 7–11 value added (standardised)	0.000	1.000	4.949
Distance to school (km)	0.843	2.059	85.434
Distance $\times$ value-added	0.038	2.456	0.696

Table 1 continued

	Mean	Standard deviation	Maximum
Distance to nearest church (km)	0.796	0.461	2.000
Mean purchase price (£, 1996–2008)	135,750	96,230	1,625,000
Ln price	11.608	0.656	16.619

Table reports unweighted means and standard deviations
Sample is Nationwide housing transactions in England, 1996–2008
Sample size is 1,011,831, except distance to church 448,445

single, double, none), tenure, new build, age, age-squared, number of bathrooms (dummies), number of bedrooms (dummies), year and month dummies.

Hedonic studies that cover multiple labour markets need to take account of variation in earnings and employment, because amenity differences are potentially compensated through expected earnings as well as housing prices (Roback 1982; Albouy 2008; Gibbons et al. 2011). Workers will be willing to pay more for housing costs and/or accept lower wages to live in more desirable places. Consequently, we can only value amenities using housing costs alone by comparing transactions at places within the same labour market, where the expected wage is similar in each place. We use Travel to Work Area (TTWA) fixed effects to control for all labour market variables such as wages and unemployment rates and more general geographic factors (e.g. climate) that we do not observe. There are 243 TTWAs in the 2007 definition that is based on 2001 Census data (Coombes and Bond 2008). These TTWAs are defined as zones where at least 67 % of the resident population work within the same area, and at least 67 % of the employees in the area live in the area (the means are around 80 %). Our preferred regression specifications difference all the regression variables from their TTWA means (the within-groups transformation, equivalent to including TTWA dummies) and therefore estimate the effects of amenities using variation occurring within each TTWA (i.e. within each labour market).[2]

We also constructed a number of other geographic control variables. The first set of these represent the topography of the site of the house location, derived from digital elevation model data. These 90 m raster data come from the UK SRTM digital elevation model available from the ShareGeo service (http://www.sharegeo.ac.uk/handle/10672/5). From these data we derive the altitude, slope angle, and aspect of the house postcode. Aspect is categorised into four directions, North (>315° or ≤45°), East (>45° & ≤135°), South (>135° & ≤225°) and West (>225° & ≤315°), and dummy variables for the East, South and West directions are included in the regressions (North being the baseline).

Five variables capture distances to various types of transport infrastructure (stations, motorways, primary roads, A-roads) and distance to the centre of the local labour market (Travel to Work Area, 2007 definition). The land area of the ward and the population density are also included as control variables. Local school quality is often regarded as an important determinant of housing prices (see for example Gibbons and Machin 2003; Gibbons et al. 2013), so we include variables for the effectiveness of the nearest school in raising pupil achievement (mean age 7–11 gains in test scores or 'value-added'), distance to the nearest school, and interactions between these variables. Summary statistics for housing transactions in relation to topography, schools, accessibility and other control variables are also contained in Table 1.

[2] In principle, consumer prices are a factor too, but local data on prices is unavailable and goods prices are unlikely to vary within TTWAs.

2.2 Functional Form

The appropriate functional form for the hedonic price regression specification is arguable, but in our empirical work we follow the standard in recent studies and estimate semi-logarithmic regression models of the form:[3]

$$LnHP_{ijt} = \alpha + x'_{it}\beta_{1i} + n'_{it}\beta_{2i} + s'_{it}\beta_{3i} + f_j + \tau_t + \varepsilon_{it}, \quad (1)$$

where the dependent variable ($LnHP_{ijt}$) is the natural logarithm of the sale price for each property transaction 'i' in labour market j in period t. The environmental variables of interest are included in vector x_{it}, with control variables for neighbourhood characteristics n_{it} and structural housing characteristics s_{it}. There are potentially unobserved labour market effects (f_j), period specific effects (τ_t) and other residual unobserved components (ε_{it}). All the variables are described in detail in Sect. 2.1. Housing market attributes s_{it} include property type, floor area, floor area-squared, central heating type, garage, tenure, new build, age, age-squared, number of bathrooms, and number of bedrooms. The vector n_{it} includes distances to various types of transport infrastructure (stations, motorways, primary roads, A-roads), distance to the centre of the local labour market, topography, land area of the ward, population density, local school quality, and distance to the nearest school. Labour market fixed effects (f_j) are controlled for by differencing the data from the TTWA mean (i.e. we use a within-groups fixed effects estimator). Time effects (τ_t) are captured by year and month dummy variables, and serve to deflate and deasonalise the price data.

The environmental characteristics (x_{it}) that are the focus of our analysis include nine broad habitat categories, six land use types, proportion of Green Belt land and of National Park land in the Census ward in which a house is located, nearest distance to coastline, to rivers, to National Parks, to National Nature Reserves, to land owned by the National Trust and to the nearest church. Regression estimates of the coefficient vector β_1 provide the implicit prices of the environmental attributes in which we are interested.

2.3 Limitations

Although we have multiple years of transactions in house price data, this is a fundamentally cross-sectional analysis because the data sources available at the present time offer only limited information on changes over time in natural amenities and land cover (and we suspect that the changes would be too small to be useful). There are obvious limitations to this type of analysis since it is impossible to control for all salient characteristics at the local neighbourhood level. We do not have data on all potentially relevant factors (e.g. crime rates, retail accessibility, localised air quality) and if we had the data it would be infeasible to include everything in the regressions. Our research design must therefore rely on a more restricted set of control variables (described above), plus TTWA fixed effects, to try to ensure that the estimated effects of the environmental amenities reflect willingness to pay for these amenities rather than willingness to pay for omitted characteristics with which they are correlated. Our representation of the accessibility of amenities is also restricted in that we look only at the land cover in the vicinity of a property and the distance to the nearest amenity of each type. We do not, therefore, consider the diversity of land cover or the benefits of accessibility to multiple instances of a particular amenity (e.g. if households are willing to pay more to have many National Trust properties close by). Our data also lacks detail on view-sheds and visibility of

[3] There is a large body of work investigating different functional forms for the hedonic price equation. Of note, more recently, several authors have also explored semiparametric and nonparametric specifications (e.g. Bontemps et al. 2008; Parmeter and Henderson 2007).

environmental amenities, which would be infeasible to construct given the national coverage of our dataset, although we do include measures of altitude, slope and aspect as discussed in Sect. 2.1.4. Finally, the main part of our analysis only refers to England for the full set of environmental variables, as we do not have complete environmental data for the other regions. Even given these limitations, it turns out that the estimates are fairly insensitive to changes in specification and sample—once we take proper account of inter-labour market differences. This provides some reassurance that our regression results provide a useful representation of the values attached to proximity to environmental amenities in England.

3 Results and Discussion

Table 2 presents the ordinary least squares regression estimates from five hedonic property value models in which the dependent variable is the natural log of the sales price, and the explanatory variables are a range of environmental attributes characterising the place in which the property is located plus a large number of control variables as described in Sects. 2.1.3 and 2.1.4, respectively. Data are taken from the Nationwide transactions database, as explained in Sect. 2.1.2. The table reports coefficients and standard errors.[4]

Model 1 (Table 2) is a simple model in which only the environmental attributes (plus year and month dummies) are included as explanatory variables. Model 2 introduces a set of structural property characteristics listed in the table notes. Model 3 adds in Travel to Work Area fixed effects. Finally, Model 4 repeats the analysis of Model 3 for the sub-sample of metropolitan sales for which we have computed distance to the nearest church and Model 5 provides estimates for England, Scotland and Wales using only those attributes for which we have complete data for all these countries.

The coefficients report the change in log prices corresponding to a unit change in the explanatory variables (scaled as indicated in Table 2). The standard errors indicate the precision of the estimates. The asterisks indicate the level of statistical significance, from 1 % (3 stars) to 10 % (1 star). Note that interpretation of the results requires that we take into account both the magnitude of the coefficient, and the precision with which it is measured. A coefficient can be large in magnitude implying potentially large price effects, but be imprecisely measured, and hence statistically insignificantly different from zero. In such cases, there must remain some uncertainty about whether or not the corresponding characteristic is economically important.

Looking at the coefficients and standard errors in OLS Model 1 (Table 2) reveals that many of the land use and land cover variables are highly statistically significant, and represent quite large implied economic effects. For example, in the first row of Model 1, a 1 % point (0.01) increase in the share of gardens is associated with a 2 % increase in the sales price. This figure can be calculated by applying the transformation exp(0.01*beta)-1, or, to a good approximation, by reading off the coefficient beta as the % change in prices in response to a 0.01 change in the share of gardens. There are similarly large coefficients for other ward land use shares in Model 1, but no association of prices with Green Belt designation. The associations with physical land cover types present a mixed picture, with freshwater with woodland strongly associated with higher prices, semi-natural grassland and bare ground associated with lower prices, and other land cover types having small associations or associations that are statistically indistinguishable from zero. Some of the coefficients on the

4 Standard errors are clustered at the Travel to Work Area level to allow for heteroscedasticity and spatial and temporal correlation in the error structure within TTWAs.

Table 2 Property prices and environmental amenities (regression estimates)

	(1) OLS	(2) + housing characteristics	(3) + TTWA fixed effects	(4) Metropolitan areas, with churches	(5) All Great Britain
Ward share of					
Domestic gardens	2.122***	1.415***	1.016***	1.165***	–
	(0.458)	(0.234)	(0.133)	(0.252)	
Green space	1.837***	1.038***	1.041***	1.184***	–
	(0.269)	(0.129)	(0.076)	(0.146)	
Water	1.363***	0.738***	0.973***	1.088***	–
	(0.285)	(0.144)	(0.080)	(0.152)	
Domestic buildings	3.185***	1.200***	2.177***	2.321***	–
	(0.304)	(0.453)	(0.307)	(0.161)	
Other buildings	4.059***	2.952***	2.672***	2.971***	–
	(0.589)	(0.351)	(0.226)	(0.317)	
Green Belt	−0.047	−0.023	0.022	0.032*	–
	(0.041)	(0.036)	(0.019)	(0.017)	
National Park	−0.207**	0.018	0.048	−0.002	–
	(0.096)	(0.051)	(0.039)	(0.043)	
Ward area (km^2)	0.002***	0.001*	0.001***	0.001**	–
	(0.001)	(0.000)	(0.000)	(0.000)	
Distance (100 kms) to					
Coastline	−0.511***	−0.098	−0.141	−0.620***	−0.204*
	(0.074)	(0.091)	(0.124)	(0.227)	(0.117)
Rivers	0.230	1.269	−0.938	−2.569***	−1.105
	(0.910)	(1.055)	(0.819)	(0.718)	(0.718)
National Parks	0.273***	0.158***	−0.240***	−0.407***	–
	(0.090)	(0.058)	(0.088)	(0.137)	
Nature Reserves	−0.473	−0.380*	−0.075	−0.313	–
	(0.306)	(0.193)	(0.241)	(0.538)	
National Trust properties	−2.083***	−1.744***	−0.695***	−0.320	–
	(0.416)	(0.242)	(0.172)	(0.337)	
Land share in 1km-square					
Marine and coastal margins	−0.697***	−0.278**	0.039	−0.112	0.039
	(0.238)	(0.114)	(0.034)	(0.105)	(0.041)
Freshwater, wetlands, floodplains	0.901***	0.966***	0.357**	0.445***	0.296**
	(0.177)	(0.220)	(0.147)	(0.141)	(0.142)
Mountains, moors and heathland	0.113	0.261	0.083	0.012	−0.072
	(0.326)	(0.195)	(0.100)	(0.225)	(0.083)
Semi-natural grassland	−0.222**	−0.234***	−0.014	−0.029	−0.019
	(0.090)	(0.059)	(0.024)	(0.045)	(0.025)

Table 2 continued

	(1) OLS	(2) + housing characteristics	(3) + TTWA fixed effects	(4) Metropolitan areas, with churches	(5) All Great Britain
Enclosed farmland	0.172**	0.081***	0.059***	0.077***	0.088***
	(0.065)	(0.030)	(0.012)	(0.025)	(0.017)
Coniferous woodland	0.544*	0.353**	0.119*	0.105	0.147**
	(0.307)	(0.151)	(0.062)	(0.126)	(0.068)
Broadleaved woodland	0.549***	0.656***	0.193***	0.153***	0.243***
	(0.099)	(0.073)	(0.031)	(0.055)	(0.038)
Inland bare ground	−0.787**	−0.646**	−0.379***	−0.440***	−0.444***
	(0.313)	(0.301)	(0.101)	(0.113)	(0.125)
Topography					
Altitude (100 m)	–	−0.052*	0.000	0.045	0.003
		(0.028)	(0.023)	(0.044)	(0.018)
Slope (10 s degrees)	–	−0.048	0.006	−0.001	0.009
		(0.032)	(0.015)	(0.026)	(0.018)
East facing slope	–	0.002	0.006	0.005	0.001
		(0.006)	(0.004)	(0.006)	(0.004)
South facing slope	–	0.011	0.005	0.004	0.001
		(0.008)	(0.005)	(0.009)	(0.004)
West facing slope	–	−0.004	−0.001	−0.006	−0.001
		(0.006)	(0.003)	(0.004)	(0.004)
Accessibility/other					
Distance to station	–	−1.102***	−0.142	−0.285	0.057
		(0.238)	(0.197)	(0.506)	(0.187)
Distance to motorways	–	−0.271***	−0.179	−0.415	−0.068
		(0.064)	(0.116)	(0.416)	(0.100)
Distance to primary road	–	0.687*	−0.177	0.055	0.099
		(0.360)	(0.168)	(0.452)	(0.177)
Distance to A-road	–	−0.670***	0.159	0.305	0.508**
		(0.239)	(0.196)	(0.561)	(0.255)
Population (1,000 s/km^2)	–	0.032***	0.002	0.004	0.002
		(0.008)	(0.005)	(0.003)	(0.007)
Age 7–11 value added (SD)	–	0.035***	0.022***	0.032***	–
		(0.006)	(0.004)	(0.004)	
Distance to school	–	−0.002	0.009**	0.045***	–
		(0.003)	(0.003)	(0.013)	
Distance × value-added	–	−0.003*	−0.002**	−0.011***	–
		(0.001)	(0.001)	(0.003)	
Distance to TTWA centre	–	0.984***	−0.603**	−1.105**	−0.598**
		(0.138)	(0.270)	(0.499)	(0.266)

Table 2 continued

	(1) OLS	(2) + housing characteristics	(3) + TTWA fixed effects	(4) Metropolitan areas, with churches	(5) All Great Britain
Distance to nearest church	–			−0.042***	–
				(0.009)	
House characteristics	No	Yes	Yes	Yes	Yes
TTWA fixed effects	No	No	Yes	Yes	Yes
Observations	1,011,831	1,011,831	1,011,831	448,445	1,133,433
R-squared	0.518	0.768	0.866	0.855	0.854

Table reports coefficients and standard errors from OLS regressions of ln house sales prices on environmental amenities. Standard errors are clustered at Travel To Work Area level (2007 definition)
Ward share coefficients show approximate % change in price for 1 % point increase in share of Census Ward in land use. Omitted category is ‘other land uses not listed’
1 km^2 landcover share coefficients show approximate % change in price for 1 % point increase in share of the 1 km square containing the property (=10,000 m^2 within nearest 1 million m^2). Omitted category is ‘urban’
Distance coefficients show approximate % change in price for 1km increase in distance
Sample is Nationwide housing transactions in England, 1996–2008, except for Model 5, where the sample refers to Great Britain
Unreported housing characteristics in Models 2–5 are property type, floor area, floor area-squared, central heating type (none or full, part, by type of fuel), garage (space, single, double, none), tenure, new build, age, age-squared, number of bathrooms (dummies), number of bedrooms (dummies), year and month dummies
Metropolitan areas in Model 4 include North West, West Midlands and London and is restricted to sales within 2km of nearest church
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

distance to environmental amenities variables in Model 1 (and indeed in Model 2) have counterintuitive signs, if interpreted as valuations of access to amenities.

The partially counterintuitive pattern in Model 1 is unsurprising, given that there are innumerable price-relevant housing characteristics and geographical attributes that are omitted from this specification. Many of these are likely to be correlated with the environmental and land use variables leading to potential omitted variable biases. However, introducing a set of housing characteristics and measures of transport accessibility as control variables in Model 2 (Table 2) has surprisingly little effect on the general pattern of results in terms of coefficient magnitude and statistical significance. There are some changes in the point estimates, and some coefficients become more or less significant, but the general picture is the same.

Controlling for wage and other inter-labour market differences in Model 3 (Table 2), our preferred model, provides potentially more credible estimates of the influence of the environmental amenities on housing prices, and we now discuss these in more detail. The first column of Table 3 (All England) summarises the estimates of the monetary implicit prices of environmental amenities in England corresponding to Model 3’s regression coefficients. Note that these implicit prices are capitalised values i.e. present values, rather than annual willingness to pay. Long run annualised figures can be obtained by multiplying the present values by an appropriate discount rate (e.g. 3.5 %).

Domestic gardens, green space and areas of water within the census ward all attract a similar positive price premium, with a 1 % point increase in one of these land use shares increasing prices by around 1 % (Model 3, Table 2). Translating these into monetary implicit prices in column 1 (All England model) on Table 3 indicates capitalised values of around

Table 3 Implicit prices by region (£ capitalised values)

	(1) All England	(2) London, South East and West	(3) Midlands, East Midlands and East	(4) North, North West and Yorkshire
Percentage point ward share of				
Domestic gardens	1,982***	1,673***	1,955***	2,515***
Green space	2,031***	2,033***	1,200***	1,804***
Water	1,897***	1,831***	1,180***	1,926***
Domestic buildings	4,271***	4,918***	609	2,329**
Other buildings	5,254***	5,868***	2,858***	4,625***
Green Belt	42	23	81	18
National Park	92	−225**	252***	137
Ward area (km^2)	1.7***	3.2***	1.3**	0.9**
Distance (1 kms) to				
Coastline	−274	−279	−91	−205
Rivers	−1,811	−3,350	−2,684**	−548
National Parks	−465***	−361**	−186	−793***
Nature Reserves	−146	−1,347	632	−397
National Trust properties	−1,344***	−3,545***	−213	−1,118**
Percentage point in 1 km^2				
Marine and coastal margins	76	220	49	38
Freshwater, wetlands, floodplains	694**	1,247***	42	169
Mountains, moors and heathland	161	−196	−273*	889***
Semi-natural grassland	−27	−5	−34	−173***
Enclosed farmland	115***	127**	32	73**
Coniferous woodland	232*	281**	296	−159
Broadleaved woodland	376***	433***	405***	237*
Inland bare ground	−733***	−1,024***	−108	−425*
Topography				
Altitude (100 m)	34	1,1959*	−326	−4,948
Slope (10 s degrees)	1,238	−1,804	3,460	3,697
East	1,231*	3,321***	952	1,133
South	999	3,481***	861	−798
West	−115	374	727	−1,654*
Accessibility/other				
Distance to station (km)	−276	−30	−686*	−236
Distance to motorways (km)	−346	−487	−418	−10
Distance to primary road (km)	−344	−392	221	132
Distance to A-road (km)	309	955	−234	−491
Population (1,000 s/km^2)	320	1,250	−3,317***	−1,907**

Table 3 continued

	(1) All England	(2) London, South East and West	(3) Midlands, East Midlands and East	(4) North, North West and Yorkshire
Age 7–11 value added (SD)	4,280***	5,644***	3,826***	2,657***
Distance to school (km)	1,656**	3,127***	90	1,494**
Distance × value-added	−399**	−607	−380***	64
Distance to TTWA centre (km)	−1,166**	−1,731*	−516*	−822**
Observations	1,011,831	475,780	341,450	194,601
Mean house price	194,040	243,850	181,058	158,095

Table reports marginal willingness to pay, evaluated at regional mean prices. The All England estimates correspond to the coefficients in Model 3, Table 2
Distance variables evaluated for 1km change
Land shares evaluated for 1 % point change
School value added evaluated for 1 standard deviation change
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$

£2,000 for these land use changes. The share of land use allocated to buildings has a large positive association with prices. This may, in part, reflect willingness to pay for dense and non-isolated places where there is other proximate human habitation. However, there is a potential omitted variables issue here because build density will tend to be higher in places where land costs are higher, and where land costs are higher due to other amenities that we do not observe. As such, the coefficients may represent willingness to pay for these omitted amenities rather than willingness to pay for a more built up environment. Therefore, some caution is needed in interpretation.

Neither Green Belt nor National Park designation shows a strong statistical association with prices because the coefficients are not precisely measured. However, the National Park coefficient indicates the effect of being inside the park relative to just outside it, given that we control for distance to the National Park boundary (see further discussion below). Despite this, the magnitudes indicate potentially sizeable willingness to pay simply for National Park status. National Park designation (i.e. 100 % of the ward in National Park status) appears to add about 4.8 % to prices, which at the mean transaction price of £194,040 in 2008 was worth around £9,200 (note that the coefficient in Model 3, Table 2, and respective implicit price in Table 3 is for an increase of only 1 % point in the share of the ward designated as National Park).

The results on physical land cover shares (within 1 km^2) indicate a strong positive effect from freshwater, wetlands and flood plain locations which is smaller than, though consistent with, the result based on ward shares (i.e. the ward share of water).[5] A 1 % point increase in the share of this land cover attracts a premium of 0.36 % (Model 3, Table 2), or £694 (All England model, Table 3). There is also a strong and large positive effect from increases in broadleaved woodland (0.19 % or £376), and a weaker but still sizeable relationship with coniferous woodland (0.12 % or £232, but only marginally significant). Enclosed farmland attracts a small positive premium (0.06 % or £115). Mountain terrain attracts a higher premium (0.08 % or £161), but the coefficient is not precisely measured. Proximate marine and semi-natural grassland land cover does not appear to have much of an effect

[5] The ward-based water shares and 1km square freshwater, wetlands and floodplains shares are weakly correlated with each other which suggests they are measuring different water cover.

on prices, whereas inland bare ground has a strong negative impact, with prices falling by 0.38 % (£733) with each 1 % point increase in the share of bare ground. Given the scaling of these variables, these implicit prices can also be interpreted as the willingness to pay for an extra 10,000 m^2 of that land use within the 1 million m^2 grid in which a house is located.

The coefficients on the distance variables (Model 3, Table 2) show that increasing distance to natural amenities is unambiguously associated with a fall in prices. This finding is consistent with the idea that home buyers are paying for accessibility to these natural features. The biggest effect in terms of magnitude is related to distance to rivers, with a 1 km increase in distance to rivers lowering prices by 0.93 % or £1,811 although this coefficient is only marginally statistically significant (see Tables 2, 3). Smaller but more precisely measured effects relate to distance from National Parks and National Trust sites. Each 1km increase in distance to the nearest National Park lowers prices by 0.24 % or £465. This implies that being inside a National Park (i.e. at zero distance from it), combined with 100 % of the ward as a National Park, implies a huge £33,686 premium relative to the average house in England (which is 46.7 km from a National Park). Each 1km increase in distance to the nearest National Trust owned site is associated with a 0.7 % or £1,350 fall in prices. Distances to coastline and nature reserves also lowers prices (by about £140–£275 per km), although in these cases the estimates are not statistically significant.

The accessibility variables at the bottom of Table 2 (and Table 3) are intended as control variables so we do not discuss these at length. It is worth noting that they generally have the expected signs when interpreted as measures of the value of transport accessibility, but are not individually significant. Distance to the TTWA centre reduces housing prices, which is consistent with the theory in urban economics that lower housing costs compensate for higher commuting costs as workers live further out from the central business district in cities. Note also that this coefficient in Model 2 (Table 2) does not have the sign we would expect from theory, which highlights the importance of controlling effectively for between-labour market differences as we do in Model 3. The estimates of the effect of school quality on house prices in Model 3 (Table 2) is in line with estimates using more sophisticated 'regression discontinuity' designs that exploit differences across school admissions district boundaries (see Black and Machin 2011). The estimate implies that a one standard deviation increase in nearest primary school value-added raises prices by 2.2 % for houses located next to the school, which is similar to the figure reported in Gibbons et al. (2013). The interactions of school quality with distance also work in the directions theory would suggest, although distance from a school attenuates the quality premium more rapidly than we would expect, implicitly falling to zero by 110 m from a school and turning negative beyond that distance.[6] Topography variables are generally insignificant across all model specifications in Table 2.

Restricting the sample to major metropolitan regions in Model 4 (Table 2) leads to a pattern of coefficients that is broadly similar to those discussed above for Model 3. However, some effects become more significant and the implicit prices larger, particularly those related to distance to coastline, rivers and National Parks. As might be expected, Green Belt designation becomes more important when looking at major metropolitan areas. The results indicate a willingness to pay amounting to around £7,000 for houses in Green Belt locations, which offer access to cities, coupled with tight restrictions on housing supply.

[6] From the coefficients, the derivative of prices with respect to school quality is obtained as 0.022–0.20 × distance (in km).

Distance to churches (those classified as having steeples or towers on Ordnance Survey maps) also comes out as important, with 1 km increase in distance associated with a large 4.2 % fall in prices, worth about £8,150 (Model 4, Table 2). This figure may be best interpreted as a valuation of the places with which churches are associated—traditional parts of town centres, focal points for businesses and retail, etc.—rather than a valuation of specifically church-related amenities and spiritual values. However, the environmental amenities provided by church grounds and architectural values of traditional churches could arguably also be relevant factors.

For purposes of comparison, Model 5 in Table 2 extends the analysis to the whole of Great Britain. The ward land use shares are not available outside of England, and we do not have data on National Parks in Scotland, Nature Reserves in Wales or National Trust properties in Scotland, nor any school quality data except in England. These variables are therefore dropped from the analysis. The patterns amongst the remaining coefficients are similar to those in the Model 3 regression for England only, providing some reassurance that the estimates are transferrable to Great Britain as a whole. Indeed, the coefficients on the 1 km^2 land cover variables are generally insensitive to the changes in sample between Models 3, 4 and 5 in Table 2.

Using the coefficients from Table 2, we can predict the (log) house price differentials that can be attributed to variations in the level of environment amenities across the country. We do this using the coefficients from Model 3 (Table 2), and expressing the variation in environmental quality in terms of deviations around their means, and ignoring the contribution of housing attributes and the other control variables and TTWA dummies in the regression. The resulting predictions therefore show the variation in prices around the mean in England, and are mapped in Fig. 1.

Figure 1 shows the house price variation in 10 categories. The mean house price in 2008 was around £194,000, so, for example, the lightest shaded areas represent the places with the highest value of environmental amenities, amounting to valuations of £67,900 and above in present value terms. Annualised over a long time horizon, this is equivalent to a willingness to pay £2,376 per year at a 3.5 % discount rate. These highest values are seen in areas such as the Lake District, Northumberland, North York Moors, Pennines, Dartmoor and Exmoor. The implication is that home buyers are willing to pay this amount per year to gain the environmental amenities and accessibility of these locations, relative to the average place in England. Lowest levels of environmental value occur in central England, somewhere in the vicinity of Northampton. We estimate that people are prepared to pay around £1,765 per year to avoid the relatively poor accessibility of environmental amenities that characterises these locations relative to the average in England. Note that from the data underlying this map, we can estimate that the top 1 % postcode has over 1.7 times as much environmental value as the bottom 1 % postcode, a difference which is worth around £105,000 (capitalised value) or £3,700 per year.

As a final step in the analysis, we report separate results for grouped Government Office Regions in England. Columns 2–4 of Table 3 show the implicit prices (capitalised) for these groups, derived from separate regressions for each regional group sample and based on the mean 2008 house price in each sample (reported in the last row of the table). Looking across these columns, it is evident that there are differences in the capitalised values and significance of the various environmental amenities according to region, although the results are qualitatively similar. The ward land use shares of gardens, green space and water have remarkably similar implicit prices regardless of region. The first notable difference is the greater importance of National Park designation in the Midlands regions (the Peak District and Broads National Parks), but lesser importance of National Trust sites. It is also evident

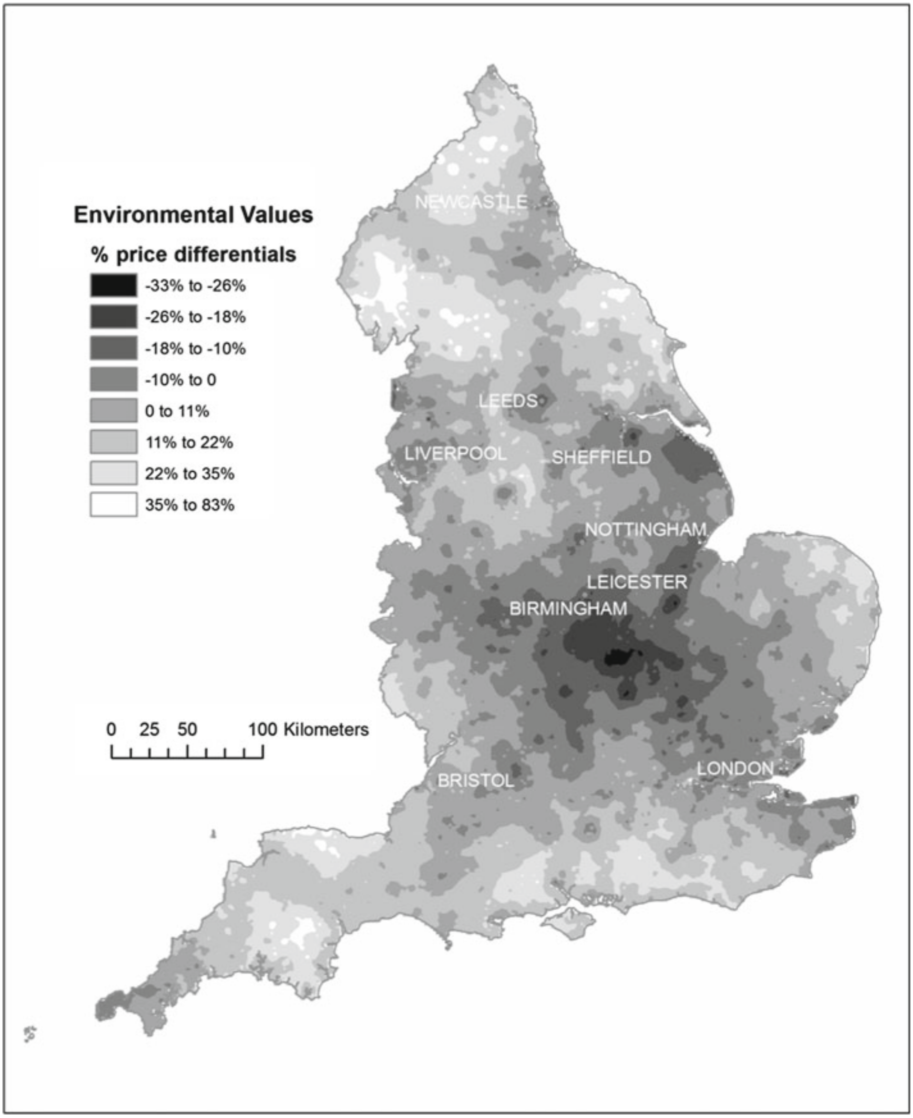

Fig. 1 Geographical distribution of environmental value (predicted price differentials from property value regressions). % Price differentials are based on log price differentials, and correspond to maximum % differentials relative to the national mean price level

that the value of freshwater, wetlands and floodplain locations is driven predominantly by London and the south of England. Coniferous woodland attracts value in the regions other than the north, but broadleaved woodland attracts a positive premium everywhere. Although mountains, moors and heathland cover had no significant effect on prices in England as a whole, we see it attracts a substantial positive premium in those locations where this land cover is predominantly found, i.e. the North, North West and Yorkshire. The topography of the housing transaction site is also more interesting in London, South East and West, where we find substantial premia for high ground facing South and East.

4 Conclusions

The hedonic price approach was used to estimate the amenity value associated with proximity to habitats, designated areas, domestic gardens and other natural amenities in England. To our knowledge, this is the first nationwide study of the value of proximity to such a wide range of natural amenities in England (and Great Britain). Overall, we conclude that the house market in England reveals substantial amenity value attached to a number of diverse natural settings. For convenience, a summary of our key findings for England is presented in Table 4. Although results are generally similar, for some amenities we found evidence of significant differences across regions within England. Many of the key results appear to be broadly transferable to Great Britain.

This article provides new evidence on the benefits of a wide range of environmental amenities within a national setting, using a labour market fixed effects regression design, coupled with a rich dataset on environmental amenities and other geographical control variables. Our results are robust to changes in specification and sample. However, our analysis also highlighted a number of limitations in design and data availability for this type of research. First,

Table 4 Implicit prices for key environmental amenities in England (£ capitalised values)

Environmental amenity	% change in house value with	Implicit price in relation to average 2008 house price	
1 percentage point increase in share of land cover			
Marine and coastal margins	0.04 % increase in house prices	£76	
Freshwater, wetlands, floodplains	0.36 % increase in house prices	£694	***
Mountains, moors and heathland	0.08 % increase in house prices	£161	
Semi-natural grassland	0.01 % decrease in house prices	£-27	
Enclosed farmland	0.06 % increase in house prices	£115	***
Broadleaved woodland	0.19 % increase in house prices	£376	***
Coniferous woodland	0.12 % increase in house prices	£232	*
Inland bare ground	0.38 % decrease in house prices	£-733***	***
1 percentage point increase in land use share			
Domestic gardens	1.02 % increase in house prices	£1,982	***
Green space	1.04 % increase in house prices	£2,031	***
Water	0.97 % increase in house prices	£1,897	***
Designation			
Being in the Green Belt *(major metro. areas)*	3.25 % increase in house prices	£6,967	*
Being in a National Park, relative to mean	17.36 % increase in house prices	£33,686	***
1 km increase in distance			
Distance to coastline	0.14 % fall in house prices	−£274	
Distance to rivers	0.93 % fall in house prices	−£1,811	*
Distance to National Parks	0.24 % fall in house prices	−£465	***
Distance to Nature Reserves	0.08 % fall in house prices	−£146	
Distance to National Trust land	0.70 % fall in house prices	−£1,344	***

Being in a National Park calculation is based on zero distance from National Park and having a ward share of 100 % National Park

The stars indicate statistical significance levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

control-variable based research designs are always open to criticism since it is infeasible to include all relevant factors in regression models (for example, we had no data on local crime rates). Changes in land-cover and environmental amenities (e.g. through erosion, development activities, park designations etc.) offer the potential for more robust quasi-experimental, repeat-sales based designs. However, instances of these kinds of changes are hard to find, and good national data is rare. Data limitations (lack of ward level information on land use) also prevented us from extending the full analysis to the whole of Great Britain. We looked at a limited set of environmental amenities and have not investigated the effect of disamenities (proximity to landfill or flood risk), the role of diversity in land cover, the benefits of accessibility to multiple instances of a particular amenity, nor the role of views. There is an inevitable trade-off between achieving national coverage and representativeness, and providing detail of amenities at this level.

Overall, the key finding from this work is that environmental amenities are highly valued by home-owners and have a substantial impact on housing prices. Moving the bottom 1 % postcode to the best 1 % postcode in England is worth about £105,000 (or £3,700 per year) in terms of the environmental amenities provided.

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