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Abstract
Using a hedonic property value 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 a wide range 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 house 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
JEL Classifications: R11, R29

1. Introduction

The UK is home to a wide range of ecosystems, natural habitats and other green areas that play an important role in biodiversity conservation. In terms of broad habitats, farmland occupies the largest area, almost 50% of the country, followed by semi-natural grasslands and mountains, which together cover approximately a third of the UK, and woodland covering just over 12% (Fuller et al., 2002). Some 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). Another commonly used designation is the Green Belt, used in planning policy in the UK 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).

Some natural areas have especial heritage interest or historical importance. In the UK, many of these areas belong to the National Trust (NT), the UK'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 NT 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 (NT, 2010)

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). 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 (GLUD, 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).

Living within or in close proximity to desirable natural areas and environmental resources such as coastal or woodland habitats, designated areas, managed properties, and parks, water resources and domestic gardens, provide a large number of positive welfare benefits to residents, including numerous opportunities for recreation and leisure. There are over 5 billion day visits to the English countryside each year (TNS, 2004) and about one third of all leisure visits in England were to the countryside, coast or woodlands (Natural England, 2005). Popular National Parks such as the Peak District, the Yorkshire Dales and the Lake District, attract in the order of 8 to 10 million visits each year (National Parks, 2010). There are some 14 million yearly visits to the National Trust's 'pay for entry' properties, and an estimated 50 million visits to its open air properties (NT, 2010a). In England, just under 50% of the population use 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). Furthermore, gardening is thought to be one of the most commonly practiced type of physical activity in the UK (Crespo et al., 1996; Yusuf et al.,1996; Magnus et al., 1979) with UK households spending on average 71 hours a year gardening (Mintel, 1997). Many people actively try to attract wild species to their gardens with an increasing interest in wildlife gardening, keeping ponds, provision of bird nesting sites, and wild bird feeding, the most popular activity (Gaston et al., 2007).

Apart from leisure and recreation visits, many other amenity benefits can be derived from natural areas and resources which include opportunities for green exercise, visual amenity, mental or psychological well-being, source of inspiration, wildlife viewing, ecological education opportunities, etc. The Millenium Ecosystem Assessment (2005) refers to all these types of benefits as the 'cultural services' provided by ecosystems.

Economic valuation methods such as stated and revealed preference techniques have been widely applied to estimate the cultural ecosystem services associated with green areas and environmental resources (e.g. Garrod and Willis, 1999; Tyrvainen and Miettinen, 2000; Earnhart, 2001; Poor et al., 2007). There is a long tradition of studies using the hedonic price method (HPM) to estimate the effect of environmental amenities and disamenities on property prices, and the application to the valuation of air quality is well-known (e.g. Ridker and Henning 1967; Chay and Greenstone 2005). Of particular relevance to this paper are applications to road noise (Day at al., 2006; Wilhelmsson 2000), agricultural acitivities (Le Goffe 2000), water quality (Leggett and Bockstael, 2000; Boyle, Poor and Taylor, 1999), preserved natural areas (Correll, Lillydahl, and Singell, 1978; Lee and Linneman, 1998), wetlands (Doss and Taff, 1996; Mahan, Polasky, and Adams, 2000), forests (Garrod and Willis, 1992; Thorsnes, 2002), nature views (Benson et al., 1998; Patterson & Boyle, 2002; Luttik, 2000; Morancho, 2003), urban trees (Anderson and Cordell, 1985; Morales, 1980; Morales, Micha, and Weber, 1983) and open space (Cheshire and Sheppard, 1995, 1998; McConnell and Walls, 2005). Some of these papers are based on fairly small geographical study zones. Of note, in the UK, a very recent study of the London housing market by Smith (2010) found that each hectare of green park space within 1km of housing increases house prices by 0.08%. Cheshire and Sheppard (2002) using data from Reading showed 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). An earlier study for England by Garrod and Willis (1992) is similar to ours in its approach, and 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 or many other potential confounding geographical factors.

The most common methodological approach in these studies has been to include distance from the property to the environmental amenity as an explanatory variable in the model. More recently the use of GIS has improved the ability of hedonic regressions to explain variation in house prices by considering not just proximity but also amount and topography of the environmental amenities, for example by using as an explanatory variable the proportion of an amenity existing within a certain radius of a house. All these studies support the assumption that that the choice of a house reflects an implicit choice over the nearby environmental amenities so that the value of marginal changes in proximity to these amenities is reflected in house prices.

In this paper we estimate the amenity value associated with UK habitats, designated areas, heritage sites, domestic gardens and other natural amenities using a hedonic price approach (Sheppard, 1999; Champ et al., 2003). The contribution of our work relative to previous studies is that we have an extremely large and representative data set of housing transactions over a 13 year period for the whole of Britain, and we construct a wide range of land cover variables and variable capturing access to environmental amenities. Most importantly, we control carefully for 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. To our knowledge, this is the first nationwide study of the value of proximity to such a wide range of natural amenities in England. The remainder of the paper is organized as follows. In Section 2 we provide more details about our methodological approach, Section 3 presents and discusses our main findings and Section 4 offers some summary conclusions.

2. Methodology

2.1. Hedonic Price Method

As noted above, we use the hedonic price method (HPM) to estimate the amenity value of a range of habitats, designated areas, heritage sites, private gardens and several other environmental goods (Sheppard, 1999; Champ et al., 2003). The HPM – also known as hedonic regression – assumes that we can look at house transactions to infer the implicit value of the house's underlying characteristics (structural, locational/ accessibility, neighbourhood and environmental). From a policy perspective this method is desirable as it is based on clear theoretical foundations and on observable market behaviour rather than on stated preference surveys. Rosen (1974) presents the theoretical rationale for the hedonic price analysis of composite goods like housing, showing that the utility benefit of marginal changes in one component of the bundle of housing attributes can be monetised by measuring the additional expenditure incurred in equilibrium.

Essentially, applied hedonic analysis of property values recovers these marginal valuations or 'implicit prices' of the separate housing attributes from a regression of housing sales prices on the component attributes of the house sold - its structural characteristics, environmental quality, neighbourhood amenities, labour market opportunities and so on. The appropriate functional form for this 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:

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

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}. Equation (1) models house prices as a function of these variables, an unobserved labour market effect f_j and other unobserved components ε_{it}. In our regressions, s_{it} includes house attributes such as property type, floor area, floor area-squared, central heating type, garage, tenure, new build, age, age-squared, number of bathrooms, number of bedrooms, year and month dummies. The following neighbourhood or geographic characteristics are included in n_{it}: distances to various types of transport infrastructure (stations, motorways, primary roads, A-roads), distance to the centre of the local labour market, land area of the ward, population density, local school quality, distance to the nearest school. Unmeasured labour market characteristics (f_j) and other broader regional differences are controlled for by including Travel To Work Areas (TTWA) dummies, that is our estimates of the effects of environmental amenities will be based on within-TTWA variation in environmental quality. The environmental characteristics (x_{it}) are the focus of our analysis and 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 (see Section 2.2 for more detail regarding all these variables). Regression estimates of the coefficient vector β_1 provide the implicit prices of the environmental attributes in which we are interested..

Note that, although we have multiple years of transactions in our 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 for the period under study.

2.2. Data description

Our units of analysis are individual houses located across England, Wales and Scotland. Our sample has around 1 million housing transactions (with information on location at full postcode level, from the Nationwide building society) in the UK, over 1996-2008, along with the sales prices and 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, single, double, none), tenure, new build, age, age-squared, number of bathrooms (dummies), number of bedrooms (dummies), year and month dummies. We also have Travel To Work Areas (TTWA) dummies to control for labour market variables such as wages and unemployment rates and more general geographic factors that we do not observe. The specifications that include TTWA dummies, utilise only the variation in environmental amenities and housing prices occurring within each TTWA (i.e. within each labour market) and so take account of more general differences between TTWAs in their labour and housing market characteristics. In this paper, we only 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 (England, Scotland and Wales) for those environmental amenities for which this is feasible.

With regards to local environmental characteristics, we use 9 broad habitat categories, which we constructed from the Land Cover Map 2000, in our hedonic regressions describing the physical land cover in terms of the share of 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 habitat variables are defined as the proportional share (0 to 1) of a particular habitat within the 1 km square in which a house is located. 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.

We also use 6 land use share variables taken from the Generalised Land Use Database (CLG, 2007). These variables depict the land use share (0 to 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) to (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).

Two additional variables depicting designation status were created: 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 show the association between ward Green Belt designation, National Park designation and house prices.

We constructed five 'distance to' variables describing distance 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,

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[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 NT' variable reflects also some elements of built heritage that are impossible to disentangle from surrounding natural features.

between each resource and each house identified by its postcode. Distance is measured as the straight line distance to the nearest of these features.

We also constructed a number of other geographic variables, included primarily as control variables. 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, and Gibbons, Machin and Silva, 2009), 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.

The last variable for which a coefficient is reported is the '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.

There are a number of limitations to this analysis. Firstly, although we have several years of house price data, we do not have good information on changes in land cover and other environmental amenities over time (and if we did, we suspect that the changes would be too small to be useful). We therefore estimate the cross-sectional relationship between environmental amenities and prices, using control variables in our regressions to account for omitted characteristics that affect prices and are correlated with environmental amenities, and which would otherwise bias our estimates. It is, however, impossible to control for all salient characteristics at the local neighbourhood level because 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 strategy is therefore to rely on a more restricted set of control variables (described above), plus the TTWA dummy variables, 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 fairly simplistic 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 environmental amenities, which would be infeasible to construct given the national coverage of our dataset. 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 using TTWA dummies. This provides some reassurance that our regression results provide a useful representation of the values attached to proximity to environmental amenities in England.

Table 1 presents summary statistics for the housing transactions data in relation to the key environmental variables considered. The table contains mean land area shares (i.e. the proportion of land in a particular use) and other statistics given that there is a house sale there at some point during the sample period. 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).

3. Results and discussion: Hedonic estimates of amenity value

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. Data are taken from the Nationwide transactions database, as described in section 2.2. The environmental variables are also described in section 2.2. The table reports coefficients and standard errors.[2]

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 dummies to take account of differences in wages and other opportunities in different labour markets. In this specification, the coefficients are estimated from variation in the variables within labour market boundaries, so broader level inter-labour market and inter-regional differences are ignored. Taking account of labour market differences in this way is important, because theory indicates (Roback, 1982) that the value of environmental and other amenities will be reflected in both housing costs and wages. 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. 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.

[2] Standard errors are clustered at the Travel to Work Area (TTWA) level to allow for heteroscedasticity and spatial and temporal correlation in the error structure within TTWAs.

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. The statistical significance relates to the precision of the estimate, and the degree of confidence that the association is not a feature of this particular sample rather than an underlying relationship in the population. Three stars indicates that the chance of observing this estimate if there is no underlying relationship is less than 1%, 2 stars indicates 5%, and one star indicates a weak level of statistical significance at 10%. No stars indicates that there is a high chance of observing this coefficient even if there is no underlying relationship, i.e. the coefficient is statistically insignificantly different from zero at the 10% level. 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 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 one percentage point (0.01) increase in the share of gardens is associated with a 2% increase in the sales price. This figure can be calculated exactly 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 and 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 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 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.

Including TTWA dummies to control more effectively for wage and other inter-labour market differences in Model 3, 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%).

Domestic gardens, green space and areas of water within the census ward all attract a similar positive price premium, with a 1 percentage 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 £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. Despite this, the magnitudes indicate potentially sizeable willingness to pay for homes in these locations. National Park designation appears to add about 5% to prices, which at the mean transaction price of £194,040 in 2008 was worth around £9,400 (note that the coefficient in Model 3, Table 2, and respective implicit price in Table 3 is for an increase of only one percentage point in the share of the ward designated as National Park).

The results on physical land cover shares (within 1km squares) 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).[3] A one percentage point increase in the share of this land cover attracts a premium of 0.4% (Model 3, Table 2), or £768 (All England model, Table 3). There is also a strong and large positive effect from increases in broadleaved woodland (0.19% or £377), a weaker but still sizeable relationship with coniferous woodland (0.12% or £227, but only marginally significant). Enclosed farmland attracts a small positive premium (0.06% or £113). Mountain terrain attracts quite a high premium (0.09% or £166), but the coefficient is not precisely measured. Proximate marine and semi-natural grassland land cover does not appear to have much of an effect on prices, whereas inland bare ground has a strong negative impact, with prices falling by 0.38% (£738) with each 1 percentage 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

[3] 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.

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 1km increase in distance to rivers lowering prices by 0.9% or £1,750 although this coefficient is only marginally statistically significant (see Tables 2 and 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 £460. 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 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 is in line with estimates using more sophisticated 'regression discontinuity' designs that exploit differences across school admissions district boundaries. 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, Machin and Silva (2008). 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 metres from a school and turning negative beyond that distance.[4]

[4] From the coefficients, the derivative of prices with respect to school quality is obtained as 0.022 - 0.20 x distance (in km)

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 £5,800 for houses in Green Belt locations, which offer access to cities, coupled with tight restrictions on housing supply.

Distance to churches (those classified as having steeples or towers on Ordnance Survey maps) also comes out as important, with 1km 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.

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 km2 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 Figure 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 darker green 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 £2,000 per year at a 3% 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 some £2,000 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 £2,000 per year to avoid the relatively poor accessibility of environmental amenities that characterises these locations relative to the average in England.

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 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.

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. Overall, we conclude that the house market in England reveals substantial amenity value attached to a number of habitats, protected and managed areas, private gardens and local environmental amenities. 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. A summary of our key findings for England is presented in Table 4.

Our analysis also highlighted a number of gaps in data availability for this type of hedonic analysis. First, we do not have good information on changes in land cover and other environmental amenities over time. Second, we do not have local neighbourhood data on potentially relevant factors such as crime rates, retail accessibility, localised air quality access, etc. Third, we do not have information on diversity of land cover outside the immediate vicinity of a property or on the benefits of accessibility to multiple instances of a particular amenity. Fourth, data from Scotland, Wales and Northern Ireland for the environmental (and other) variables that were used was limited. Ward land use shares were not available outside of England, and we did not have access to data on

National Parks in Scotland, Nature Reserves in Wales, National Trust properties in Scotland, nor any school quality data outside of England. Fifth, the analysis focuses mostly on environmental amenities due to lack of data on disamenities such as proximity to landfill sites or to flood risk areas. Finally, the data also lacks detail on view-sheds and visibility of environmental amenities, which would be infeasible to construct given the national coverage of our dataset. Although these caveats, the hedonic analysis conducted in this paper provides original nationwide estimates of the value of proximity to several natural amenities in England that are robust to changes in specification and sample. Furthermore, we present comparison estimates for Great Britain (England, Scotland and Wales) for those environmental amenities for which data are available.

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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	0.068	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
National Park	0.003	0.049	1
Ward area (km2)	10385	19884	462470
Land in 1km square:			
Marine and coastal margins	0.005	0.036	1
Freshwater, wetlands, floodplains	0.006	0.025	0.851
Mountains, moors and heathland	0.029	0.017	0.782
Semi-natural grassland	0.076	0.087	1
Enclosed farmland	0.246	0.236	1
Coniferous woodland	0.056	0.025	0.94
Broadleaved woodland	0.060	0.077	0.90
Inland bare ground	0.007	0.026	0.90
Distance (100kms) to:			
Coastline	0.275	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
Accessibility and other variables:			
Distance to station	0.028	0.032	0.599
Distance to motorways	0.137	0.199	2.161
Distance to primary road	0.020	0.024	0.581
Distance to A-road	0.013	0.019	0.330
Distance to TTWA centre	0.099	0.066	0.625
Population (1000s/km2)	3.205	2.404	17.92
Age7-11 Value Added (standardised)	0.000	1.000	4.949
Distance to School (km)	0.084	0.278	0.854
Distance x value-added	0.000	0.025	0.696
Distance to nearest church (100kms)[1]	0.008	0.005	0.019
Mean purchase price (£, 1996-2008)	135,750	(96,230)	1,625,000
Ln price	11.608	(0.656)	16.62

Notes: (1) Table reports unweighted means and standard deviations
(2) Sample is Nationwide housing transactions in England, 1996-2008.
(3) Sample size is 1,013,125, except [1] 448,936.

Table 2: Property prices and environmental amenities (OLS regression estimates)

	Model 1: OLS	Model 2: + housing characteristics	Model 3: + TTWA dummies	Model 4: Metropolitan areas TTWAs	Model 5: All Great Britain
Ward share of:					
Domestic gardens	***2.03	***1.35	***1.01	***1.20	-
	(0.32)	(0.23)	(0.119)	(0.22)	
Green space	***1.50	***1.00	***1.04	***1.20	-
	(0.16)	(0.13)	(0.08)	(0.13)	
Water	***1.24	***0.75	***0.97	***1.09	-
	(0.19)	(0.14)	(0.08)	(0.15)	
Domestic buildings	**2.31	***1.21	***2.16	***2.30	-
	(0.92)	(0.45)	(0.30)	(0.16)	
Other buildings	***3.60	***2.89	***2.67	***3.02	-
	(0.44)	(0.35)	(0.23)	(0.29)	
Green Belt	-0.01	-0.03	0.02	**0.03	-
	(0.03)	(0.04)	(0.02)	(0.02)	
National Park	**-0.14	-0.02	0.05	0.01	-
	(-0.06)	(0.05)	(0.04)	(0.04)	
Ward area (km2)	***0.000002	*0.0000007	***0.0000009	**0.000001	-
	(0.0000005)	(0.0000004)	(0.0000002)	(0.0000005)	
Distance (100kms) to:					
Coastline	-0.15	**-0.15	-0.14	***-0.53	*-0.20
	(0.11)	(0.08)	(0.13)	(0.24)	(0.12)
Rivers	1.35	0.92	*-0.91	***-2.16	*-1.05
	(0.97)	(1.01)	(0.69)	(0.48)	(0.62)
National Parks	**0.22	**0.17	***-0.24	***-0.40	-
	(0.09)	(0.06)	(0.09)	(0.14)	
Nature Reserves	***-0.54	***-0.42	-0.07	-0.28	-
	(0.20)	(0.19)	(0.23)	(0.51)	
National Trust properties	***-1.85	***-1.67	***-0.70	-0.38	-
	(0.33)	(0.25)	(0.17)	(0.33)	
Land in 1km x 1km square:					
Marine and coastal margins	-0.36	**-0.26	0.04	-0.15	0.04
	(0.23)	(0.12)	(0.04)	(0.12)	(0.04)
Freshwater, wetlands, floodplains	***1.05	***1.09	***0.40	***0.47	**0.32
	(0.27)	(0.21)	(0.15)	(0.02)	(0.14)
Mountains, moors and heathland	0.09	0.19	0.09	0.08	-0.07
	(0.22)	(0.21)	(0.10)	(0.21)	(0.08)
Semi-natural grassland	***-0.18	***-0.25	-0.01	-0.02	-0.02
	(0.06)	(0.06)	(0.02)	(0.04)	(0.03)
Enclosed farmland	0.16	0.08	***0.06	***0.07	***0.09
	(0.07)	(0.03)	(0.01)	(0.02)	(0.02)
Coniferous woodland	**0.53	*0.33	*0.12	0.09	**0.15
	(0.22)	(0.15)	(0.06)	(0.12)	(0.07)
Broadleaved woodland	***0.82	***0.60	***0.19	***0.17	***0.25
	(0.08)	(0.07)	(0.04)	(0.08)	(0.04)
Inland bare ground	**-0.87	**-0.73	***-0.38	***-0.42	***-0.45
	(0.31)	(0.27)	(0.10)	(0.12)	(0.12)

	Model 1: OLS	Model 2: + housing characteristics	Model 3: + TTWA dummies	Model 4: Metropolitan areas TTWAs	Model 5: All Great Britain
Accessibility/other:					
Distance to station	-	***-1.15	-0.14	-0.15	0.06
		(0.25)	(0.21)	(0.58)	(0.20)
Distance to motorways	-	***-0.27	-0.17	-0.38	-0.06
		(0.07)	(0.11)	(0.41)	(0.10)
Distance to primary road	-	0.69	-0.17	0.06	0.10
		(0.38)	(0.17)	(0.46)	(0.18)
Distance to A-road	-	***-0.64	0.16	0.33	**0.51
		(0.24)	(0.20)	(0.58)	(0.26)
Population (1000s/km2)	-	***0.03	0.002	0.004	0.002
		(0.008)	(0.005)	(0.003)	(0.007)
Age7-11 Value Added (standard deviation)	-	***0.035	***0.022	***0.032	-
		(0.006)	(0.004)	(0.004)	
Distance to School	-	-0.17	***0.85	***4.49	-
		(0.27)	(0.33)	(1.34)	
Distance x value-added	-	*-0.27	**-0.20	-1.10	-
		(0.15)	(0.08)	(0.26)	
Distance to TTWA centre	-	***0.98	**-0.61	**-1.09	**-0.60
		(0.14)	(0.27)	(0.49)	(0.26)
Distance to nearest church	-	-	-	***-4.21	-
				(0.95)	
House characteristics	No	Yes	Yes	Yes	Yes
TTWA fixed effects	No	No	Yes	Yes	Yes
R-squared	0.516	0.766	0.865	0.854	0.854
Sample size	1,013,125	1,013,125	1,013,125	448,936	1,135,234

Notes: (1) 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).

(2) Ward share coefficients show approximate % change in price for 1 percentage point increase in share of Census Ward in land use. Omitted category is other land uses not listed.

(3) $1km^2$ landcover share coefficients show approximate % change in price for 1 percentage point increase in share of the 1km square containing the property (≈ 10000 m^2 within nearest 1 million m^2). Omitted category is urban.

(4) Distance coefficients show approximate % change in price for 1km increase in distance.

(5) Sample is Nationwide housing transactions in England, 1996-2008, except for Model 5, where the sample refers to Great Britain.

(6) Unreported housing characteristics in Models 2 to 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.

(7) Metropolitan areas in Model 4 includes North West, West Midlands and London and is restricted to sales within 2km of nearest church.

(8) ***p<0.01, **p<0.05, *p<0.10.

Table 3: Implicit prices by region (£ capitalised values)

	ALL ENGLAND	LONDON, SOUTH EAST AND WEST	MIDLANDS, EAST MIDLANDS AND EAST	NORTH, NORTH WEST AND YORKSHIRE
Ward share of:				
Domestic gardens	***1,970	***1,769	***1,955	***2,487
Green space	***2,020	***2,068	***1,200	***1,773
Water	***1,886	***1,794	***1,179	***1,911
Domestic buildings	***4,242	***4,796	610	**2,292
Other buildings	***5,244	***5,955	***2,858	4,593
Green Belt	41	19	81	17
National Park	94	*-184	***256	131
Ward area (+10 km2)	***0.017	***0.034	**0.013	***0.009
Distance to:				
Coastline	-275	-56	-94	-348
Rivers	*-1,751	-2,446	***-2,711	-884
National Parks	***-461	**-348	-188	***-782
Nature Reserves	-143	-1,322	632	-402
National Trust properties	***-1,347	***-3,596	-212	***-1,117
Land in 1km square:				
Marine and coastal margins	70	138	53	58
Freshwater, wetlands, floodplains	***768	***1,332	36	233
Mountains, moors and heathland	166	-155	-258	***832
Semi-natural grassland	-27	6	-32	**-191
Enclosed farmland	***113	***123	32	**71
Coniferous woodland	*227	***305	307	-131
Broadleaved woodland	***377	***495	***412	*240
Inland bare ground	***-738	***-1,055	-111	**-479
Accessibility/other:				
Distance to station	-260	123	*-687	-294
Distance to motorways	-339	-459	-416	-30
Distance to primary road	-324	-344	227	99.4
Distance to A-road	318	997	-230	-508
Population (+100/km2)	***0.30	*0.12	***0.33	***0.20
Age7-11 Value Added (+ 1 standard deviation)	***4,300	***5,600	***3,800	***2,700
Distance to School	***1,661	***3,092	90	**1,534
Distance x value-added	**-393	-558	***-379	73
Distance to TTWA centre	**-1,173	*-1,741	*-518	**-851
Sample size	1,013,125	476,846	341,527	194,752
Mean house price 2008	£194,040	£243,850	£181,058	£158,095

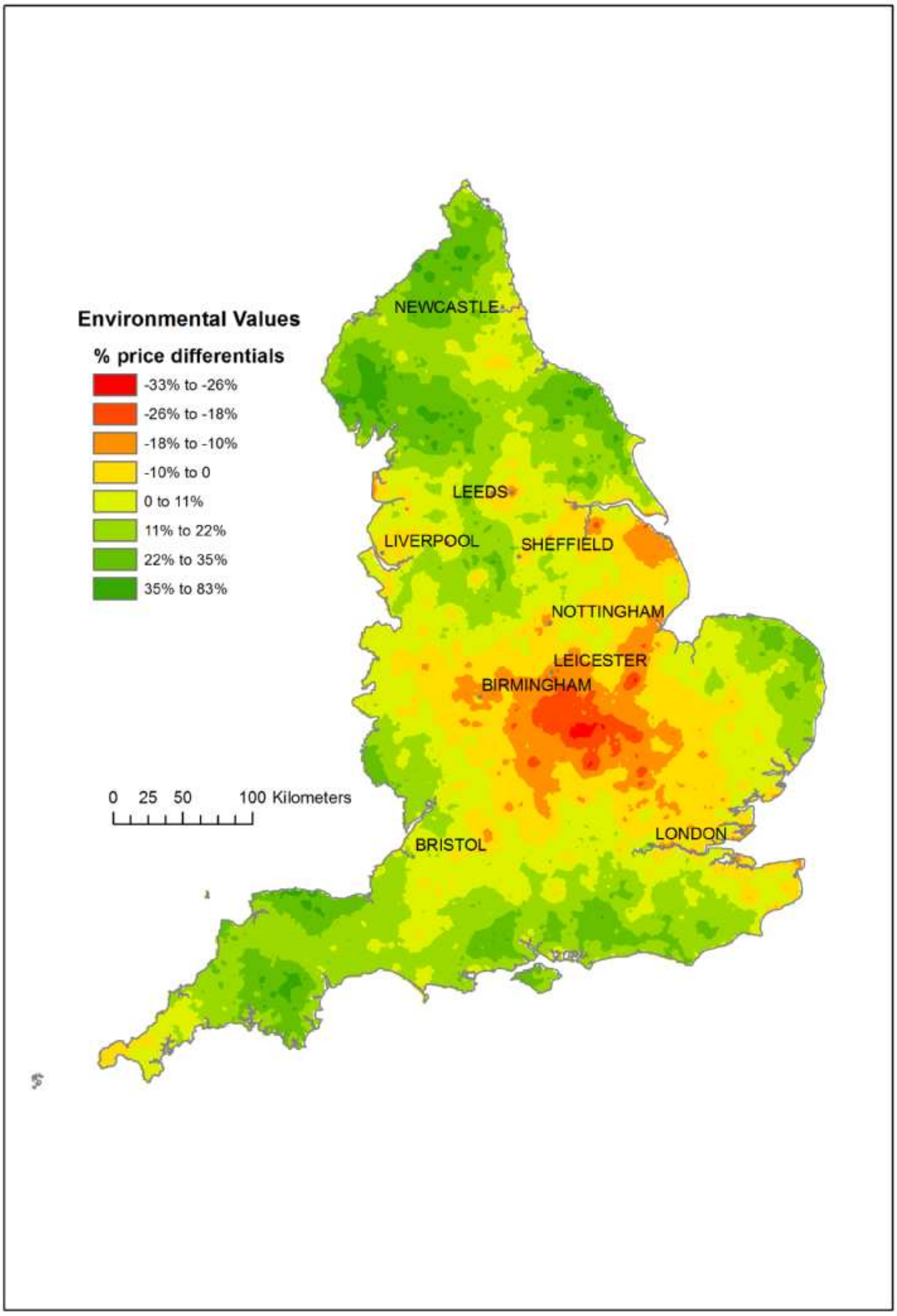
(1)Table reports marginal willingness to pay, evaluated at regional mean prices. The All England estimates correspond to the coefficients in Model 3, Table 3.
(2) Distance variables evaluated for 1km change.
(3) Land shares evaluated for 1 percentage point change.
(4) School value added evaluated for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

Table 4: Implicit prices for 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	£70	
Freshwater, wetlands, floodplains	0.40% increase in house prices	£768	***
Mountains, moors and heathland	0.09% increase in house prices	£166	
Semi-natural grassland	0.01% decrease in house prices	-£27	
Enclosed farmland	0.06% increase in house prices	£113	***
Broadleaved woodland	0.19% increase in house prices	£377	***
Coniferous woodland	0.12% increase in house prices	£227	*
Inland bare ground	0.38% decrease in house prices	-£738	***
	1 percentage point increase in land use share:		
Domestic gardens	1.01% increase in house prices	£1,970	***
Green space	1.04% increase in house prices	£2,020	***
Water	0.97% increase in house prices	£1,886	***
	Designation:		
Being in the Green Belt *(in major metropolitan areas)*	3.00% increase in house prices	£5,800	**
Being in a National Park	5.00% increase in house prices	£9,400	
	1 km increase in distance:		
Distance to coastline	0.14% fall in house prices	-£275	
Distance to rivers	0.91% fall in house prices	-£1,751	*
Distance to National Parks	0.24% fall in house prices	-£461	***
Distance to Nature Reserves	0.07% fall in house prices	-£143	
Distance to National Trust land	0.70 % fall in house prices	-£1,347	***

Note: The stars indicate statistical significance levels ***p<0.01, **p<0.05, *p<0.10.

Figure 1: Geographical distribution of environmental value (predicted price differentials from property value regressions)



Note: % price differentials are based on log price differentials, and correspond to maximum % differentials relative to the national mean price level.

BIS Department for Business Innovation & Skills

Communities and Local Government

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