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Cathrine Ulla Jensen
Toke Emil Panduro
Thomas Hedemark Lundhede
Kathrine von Graevenitz
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Department of Food and Resource Economics (IFRO)
University of Copenhagen
Rolighedsvej 25
DK 1958 Frederiksberg DENMARK
www.ifro.ku.dk/english/

Robin Hood in reverse? Assessing the distributional effects of urban nature using a second-stage hedonic house price model

Corresponding author
Cathrine Ulla Jensen

Contact details
Email: cuj@ifro.ku.dk
Phone +45 3533 3677

Affiliation
Department of Food and Resource Economics
Faculty of Science, University of Copenhagen
Rolighedsvej 23
1958 Frederiksberg Copenhagen, Denmark

Authors:
Cathrine Ulla Jensen[1], Toke Emil Panduro[1,] Thomas Hedemark Lundhede[1,2], Kathrine von Graevenitz[3], Bo Jellesmark Thorsen[1,2]

Affiliation:
[1] Department of Food and Resource Economics, Faculty of Science, University of Copenhagen, Rolighedsvej 23, 1958 Frederiksberg Copenhagen, Denmark
[2] Centre for Macroecology, Evolution and Climate, University of Copenhagen, Rolighedsvej 23, 1958 Frederiksberg Copenhagen, Denmark
[3] Department of Environmental and Resource Economics, Centre for European Economic Research (ZEW), P.O. Box 103443, 68034 Mannheim, Germany.

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ABSTRACT

We analyse the housing markets in a suburb north of the Danish capital Copenhagen. We find that households sort themselves in relation to nature area. The concentration of affluent households decreases rapidly with distance to nature. This indicates that a welfare change generated by a change in the supply of urban nature could be skewed due to a systematic difference in preference that is highly correlated with demographics. In this paper we assess if and to what extent this is the case.

We conduct a second-stage hedonic house price study and recover household-specific preferences for availability of nature. Preference parameters are identified locally through restrictions on household utility-functions. First, we assess the relation between demographic factors and household WTP for nature. Households with higher incomes and wealth have a 0.9% higher WTP per 1.000 EUR and this figure is slightly higher at the low end of the distribution. Interestingly, education mainly impacts the centre of the distribution and impacts the tails less.

We conduct a policy simulation to illustrate how heterogeneity in preferences and local supply of nature areas can drive the outcome of a welfare economic assessment of a policy change.

Our study contributes to the discussion of the distributional aspects of environmental benefits. This is a discussion mainly fuelled by stated-preference methods, and we contribute with results based on a revealed-preference method. Our results show that socio-economic distribution is a relevant factor to consider when evaluating nature area policies.

Keywords: public policy, green space, 2nd stage hedonic regression, quantile regression

1 INTRODUCTION

The role of urban and peri-urban nature areas, such as parks and nature areas, has received considerable attention from urban planning debates and research. These nature areas provide a range of services, including recreational opportunities and amenity values; they also, potentially, have various effects on health, community building, and other social values. These values are mainly, but not exclusively, enjoyed by the households living in close proximity to urban parks and peri-urban nature areas. Research has taken several different approaches to investigating the values of green space for humans. Studies have investigated the role of seeing and visiting nature areas on aspects of human health (van den Berg, Koole, & van der Wulp, 2003; Willis & Crabtree, 2011), and others have developed tools to assess the broader sets of social values associated with urban green areas (Tyrväinen, Mäkinen, & Schipperijn, 2007). Hedonic house price studies have attempted to capture the economic value of proximity to various forms of urban green areas and peri-urban nature using hedonic house price approaches (e.g., (Lake, Lovett, Bateman, & Day, 2000; Panduro & Veie, 2013; Sander, Polasky, & Haight, 2010; Tyrväinen & Miettinen, 2000). While, in general, all of these approaches find that the availability of urban and peri-urban green areas has significant positive benefits for surrounding households, they provide little insight into how these benefits are distributed in the population. This study contributes to the literature by identifying the preferences of households and modelling preference heterogeneity and, on that basis; it goes further by addressing the question of who benefits most from policies that affect access to nature area.

In this study we assess the distributional profile of changes in the provision of public nature area in the northern suburbs of the Danish capital. We recover local household-specific preferences for nature area through a two-stage hedonic house price model. The main obstacle in a second stage analysis of the hedonic method is the endogeneity of the implicit prices obtained from the first stage hedonic price model. We address this by imposing functional restrictions on the utility function. This approach originates from Bajari & Benkard, (2005) and was applied that same year by Bajari & Kahn (2005), who assessed preferences for racial compositions of neighbourhoods. Another more recent application is that of von Graevenitz (2013) on road-noise and Panduro, Jensen, Lundhede, & Thorsen (2016). Chattopadhyay (1999) uses a related approach and identifies preferences through functional form assumptions in the context of air pollution. Our application of this approach to nature areas is novel. Interestingly, assumptions regarding the functional form of utility functions are frequently found in, e.g., stated preference studies on environmental values (Train, 2009). We consider the transparency of the method of Bajari & Benkard (2005) an advantage in contrast to the instrumental variable approaches applied in some second-stage studies in the literature, where instrument validity is often hard to assess. On the other hand, using functional form specification as an identifying restriction must be considered a local approximation only, implying that our preference elicitation has lower external validity compared to well-founded multi-market IV approaches. Based on our estimates of preferences, we find a large degree of preference heterogeneity in our study area.

We use the preference parameter to analyse preference heterogeneity by regressing logged willingness to pay (WTP) against observed demographics. The relation between demographics and WTP may not be the same across the WTP-distribution. We estimate a model that can recover such differences. Our purpose is to achieve a more comprehensive evaluation of the distributional effects of policies targeting the availability of nature areas. This approach contrasts with previous hedonic studies that have only evaluated effects at the mean of the distribution. However, several stated preference studies have applied quantile regression to analyse distributional aspects of environmental policies. Belluzzo (2004) used contingent valuation to analyse the WTP for the management and improvement of an important Brazilian river basin near Rio de Janeiro. He included age, income and education as explanatory variables and noted significant differences between the size and significance levels of coefficients at the tails of the distribution, suggesting that the respondents who would benefit from the project differ significantly in terms of socio-demographic characteristics from those who would experience a welfare-loss. In their study of WTP for air and noise pollution reductions via the introduction of hydrogen buses in London, O'Garra & Mourato (2007) also find that determinants of WTP vary across the WTP-distribution. Quantile regressions have also been used to analyse the distributional aspects of changes in urban nature by Notaro & De Salvo (2010), who assessed tourists' WTP – using contingent valuation – to save an urban forest near Garda Lake in Italy, where a tree species is threatened by disease. They found that the lower median of WTP was unaffected by income, whereas the level of education was only a factor at the low end of the distribution. In our analysis we find a higher level of income to be associated with a higher WTP for nature area amenities across the distribution.

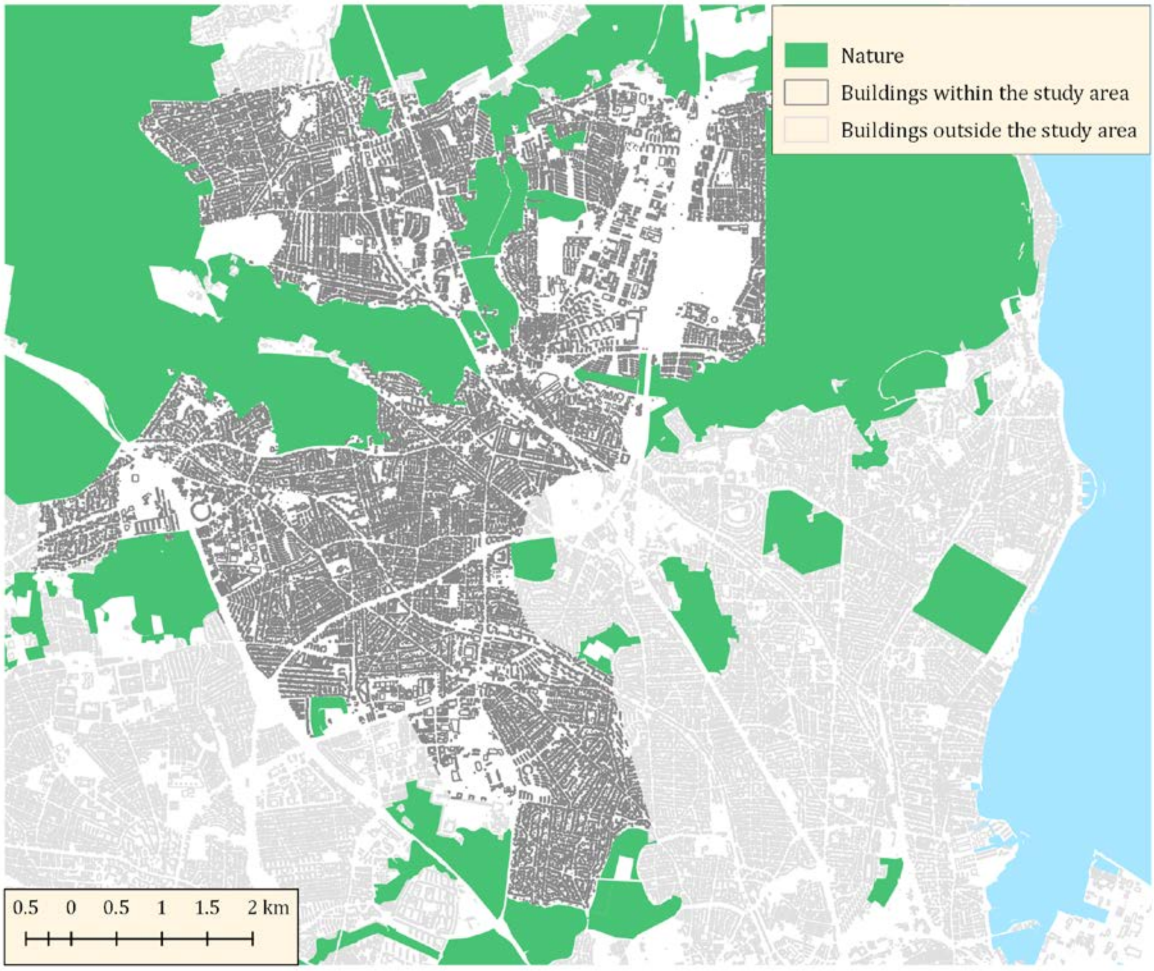
Through a policy simulation, we demonstrate the usefulness of the detailed preference elicitation approach for policy evaluation across income groups and preference variations. We analyse the welfare impacts of removing 21 Ha of nature areas in two different neighbourhoods. The two central differences between the neighbourhoods are the existing supply of nature areas and household income levels. The first neighbourhood has an abundant supply of nature areas and a high income level, and the second neighbourhood has a low supply of nature areas and a lower income level relative to the other neighbourhood. The two cases reveal that the welfare economic effect is much larger in the second neighbourhood even though the households in the first neighbourhood have a higher willingness to accept (WTA) a loss of nature in general. This is due to the relative loss of nature being much larger in the second neighbourhood compared to the first neighbourhood.

2 STUDY AREA AND HOW TO MEASURE NATURE AREA

2.1 DATA

The study area covers 3,900 Ha of urban and peri-urban lands in Northern Zealand just north of the Danish capital Copenhagen. The area is characterized by large nature areas, with old forests, lakes and open fields interspersed and around the urban areas. The study area was selected by analysing and plotting the residuals from a naïve hedonic house price model for the greater Copenhagen area. The residuals showed clear patterns of areas where property prices were over- and under-predicted, which followed distinct barriers in the urban landscape such as large roads, railway tracks and large nature areas. These patterns suggested that the pricing within this area was homogenous and distinctly different from the rest of the city of Copenhagen. Therefore, we regard the area as a single property market for single-family houses.

FIGURE 1: THE STUDY AREA



The dataset consists of 2,376 single-family detached properties traded at arms-length between 2007 and 2010. A total of 72 properties, traded for more than 900.000 EUR or fewer than 100.000 EUR, were removed as outliers (>3% of the sample). In addition to sales price, the date of the transaction and the exact geocode of the property, the dataset also includes the structural characteristics of the property, e.g., number of rooms. This information was extracted from the Danish Registry of Buildings and Housing (SKAT, 2012)

Spatial variables, which capture various qualities of the surroundings of the property, were calculated for each property using R (R Core Team, 2015) and ArcGIS 10.2.1 (ESRI 2011, 2015). The spatial data were supplied by the Danish Geodata Agency (The Danish Geodata Agency, 2011) and by the Danish Business Authority (Danish Business Authority, 2011). Please see appendices for summary statistics and variable-descriptions.

2.2 Defining nature area availability

In the hedonic literature, proximity and density measures have often been used to capture how people perceive green space as a part of the housing bundle, see, e.g., Tyrväinen & Miettinen (2000), Kong, Yin, & Nakagoshi (2007), or Orford (2002). In this paper we distinguish between proximity to peri-urban nature areas and other types of urban green spaces. Green space is not a uniform good but rather several distinct goods that enable different recreational services and amenities (Panduro & Veie, 2013). Within the survey area, green spaces were classified into different categories. Nature areas were identified as being large continuous green spaces containing open fields of grass, tree cover, and lakes, and containing small gravel roads and walking paths but otherwise a low level of recreational facilities. These features of the nature area enable people to move through the landscape along the gravel roads or walking paths and make them less likely to stray away from roads and walking paths. This is perhaps the feature that distinguishes nature areas the most from other types of green spaces. People experience nature areas as more natural landscapes that are not maintained by society (Vining, Merrick, & Price, 2008). This distinguishes them from green spaces such as urban parks, common areas between buildings, churchyards, sports fields and agriculture fields as defined by Panduro & Veie (2013).

We measure nature as the density in the area surrounding each house. This measure captures the number of hectares of peri-urban nature areas available within 800 meters of each house. The 800-meter truncation was selected on the basis of model fit and parameter efficiency after systematically evaluating several variants of the first stage hedonic model. Different variants of density measures have been applied in several hedonic house price studies. Density and patchiness measures of urban green space were used by Kong et al. (2007) in combination with distance measures. Studying the value of peri-urban forest land areas in North Carolina, USA, Cho, Jung, & Kim (2009) applied patch size, patch density and edge density measures for both deciduous and evergreen forests. Studies such as those of Mansfield, Pattanayak, McDow, McDonald, & Halpin (2005) and Jiao & Liu (2010) also applied forms of density measures, whereas absolute size measures of the nearest green areas are applied by, e.g., Morancho (2003).

2.3 Sociodemographic data

We used socio-demographic variables to decompose household-specific preferences for access to nature areas. Each property was linked to individual socio-demographic data from Statistics Denmark. The socio-demographic data describe the household occupying the property in 2011 using a number of relevant variables, such as income, education, car-ownership, etc. Due to the sensitive nature of individual level socio-demographic data, they were spatially blurred using a raster mosaic of 100*100 meters, which was subsequently refined and matched to individual properties by Geomatic A/S. In Table 1, we see that the mean income, wealth and share of households with more than 1 adult decreases with distance to the nearest nature area.

TABLE 1 DEMOGRAPHICS (MEAN) GIVEN SHORTEST DISTANCE TO A NATURE AREA

	0-200 m	200-400 m	400-600 m	600-800 m	> 800 m	Full sample
Income (1000EUR)	101.36	89.19	81.21	78.16	70.28	84.69
Wealth (1000EUR)	507.88	402.12	349.31	333.72	280.31	379.49
Higher education	0.90	0.82	0.70	0.72	0.55	0.74
Self employed	0.17	0.15	0.26	0.22	0.27	0.21
Top manager	0.75	0.72	0.53	0.56	0.39	0.60
Employee	0.08	0.11	0.19	0.21	0.31	0.18
Age min 61	0.39	0.25	0.19	0.14	0.12	0.23
Single	0.06	0.11	0.15	0.12	0.11	0.11
Single parent	0.05	0.09	0.13	0.10	0.11	0.09
Nature availability 800 m (ha)	68.07	46.49	18.30	3.26	0	29.48
Properties	541	506	467	350	512	2,376

Note: 2,376 observations

3 THEORETICAL FRAMEWORK

3.1 THE HEDONIC METHOD

A property can be regarded as a bundle of three types of attributes. The first two are structural attributes, which describe the private good characteristics, and neighbourhood attributes, which describe local public goods. Peri-urban nature areas constitute the third category. Structural attributes describe the quality of the property itself, e.g., number of rooms or build year. Neighbourhood characteristics describe various qualities of the surroundings, such as access to greenspace (including nature areas), the level of road noise or distance to public transport. Neighbourhood characteristics are public goods, and the level of such a good is something properties close to each other will have in common. Not all aspects of a property are as easily observed by the analyst as by the consumer, and the third type of attributes refers to those qualities that are not explicitly accounted for by the observed structural and neighbourhood attributes.

The hedonic price function h maps the relation between the price p_j of property j and K observed characteristics X_j and the unobserved characteristics ξ_j:

$$p_j = p(X_j, \xi_j) \tag{1}$$

The utility a household i derives from occupying property j is a function f of housing (X_j, ξ_j) and all other goods c:

$$u_{ij} = u(X_j, \xi_j, c) \tag{2}$$

Following Bajari & Kahn (2005), we model the choice of housing as a static problem. This assumption is quite strong, though quite standard in the hedonic literature. Bishop & Murphy (2011) show that the assumption of myopic consumers can lead to biased estimates, especially for attributes which are expected to change over time. Given the Danish urban planning regulation, we find that the supply of nature areas is rather stable over time, and thus we believe any resulting bias to be limited.The function *f* maps the relation between utility and the flow of housing services and all other goods. The traded price is converted to an implicit rental value by converting the observed trade price p_j into a perpetual annuity by assuming perpetual life for the house asset and multiplying the observed price with a discount rate π.

Households are assumed to be rational utility maximizers who choose their preferred bundle *j*(i)* based on their income and thus face the following maximization problem:

$$\max_{x,c} u(X_j, \xi_j, c_i)\; s.t.\, y_i = \pi p(X_j, \xi_j) + \mathrm{c}_i \tag{3}$$

For a housing bundle *j** to be the utility maximizing choice for household *i*, the following first order condition must hold for each continuous good $x_{j*,k}$:

$$\frac{\delta u(X_{j*}, \xi_{j*}, c_i)/\delta x_{jk}}{\delta u(X_j, \xi_j, c_i)/\delta c_i} = \pi \frac{\delta p(X_{j*}, \xi_{j*})}{\delta x_{j,k}} \tag{4}$$

The right hand side of the equation is the marginal cost or annual implicit price recovered from the hedonic price function, and the left hand side is the household's marginal rate of substitution. We are using cross-section data and therefore only observe one choice for each household and from that obtain one point on the indifference curve for each household. Bajari & Benkard (2005) assume weak separability in the housing goods and impose a functional form for the utility function *f*, where the functional form of the utility is logarithmic in housing goods and quasilinear in income:

$$u_{ij} = u(X_j, c_i) = \sum_k \gamma_{ik} \log(x_{jk}) + c_i \tag{5}$$

A household's preference or taste for a housing good k is described by γ_{ik}. By assuming separability, an assumption common in consumer theory, the marginal rate of substitution of a good k is independent of the level of all other goods including the unobserved quality, ξ_j. The first order condition (4) with respect to $x_{j*,k}$ collapses to (6) and rearranges into (7):

$$\frac{\gamma_{ik}}{x_{j*k}} = \pi \frac{\delta p(X_{j*}, \xi_{j*})}{\delta x_{j,k}} \tag{6}$$

$$\gamma_{ik} = x_{j*k}\pi \frac{\delta p(X_{j*},\xi_{j*})}{\delta x_{j,k}} \quad (7)$$

An estimate of a household's specific taste for housing good k is now readily estimated, as x_{j*k} is the observed level of k chosen by household i, and $\pi \frac{\delta p(X_{j*},\xi_{j*})}{\delta x_{j,k}}$ is the marginal implicit price of k obtained from the first stage hedonic regression. Using the recovered preference parameter WTP for a change in k from x_k^0 to x_k^{1}:

$$WTP_{ik} = \gamma_{ik}\log(x_k^1 - x_k^0) \quad (8)$$

It is useful to think of the identifying assumption on utility as a local approximation for a given level of income. As a result, it is also most likely to provide accurate insights into changes that do not depart too far from the observed choices made. The bigger the change under analysis, the larger is the role played by the functional form assumption in determining WTP for that change.

4 EMPIRICAL APPLICATION

4.1 RECOVERING HOUSEHOLD-SPECIFIC TASTES FOR NATURE

The price function in (1) was estimated as a general additive model (GAM), with a gamma distribution assumption using a logarithmic link function:

$$\ln(p_{lj}) = \sum_k \beta_k\, x_{jk} + f_1(t_j; S_1) + f_2(x_j, y_j; S_2) + \delta_l + \xi_{lj} \quad (9)$$

We calculated and tested a number of spatial control variables using different spatial ranges and functional forms in the pricing function as suggested by (von Graevenitz & Panduro, 2015). The choice of covariates and their spatial scales were based on model fit and parameter efficiency over a range of selected proximity cut-off values. Access to nature is described by the density of nature areas within a radius of 800 m, after testing other measures as described above.

General development in prices over time was controlled for by the smoothing function $f_1(t_j; S_1)$, which allows for continuous and data driven controls. Please see Wood (2006) for an elaboration.
In the empirical application of the housing model, unobserved quality ξ_{lj} is treated as an i.i.d. error-term. This implies imposing the standard hedonic assumption, namely that unobserved quality is independent of the observed quality (Bajari & Kahn, 2005). We controlled for spatial autocorrelation both through a smoothing term $f_1(x_j, y_j; S_2)$ and through spatial "neighbourhood" fixed effects δ_l. Based on model fit we used school district fixed effects and a spatial smoothing term.

In the second step the estimated household specific taste γ_{ik} was recovered using (7):

$$\hat{\gamma}_{\mathrm{ik}} = x_{j*k} \times \hat{P}_{\mathrm{j*,2011}} \times \pi \times \widehat{\beta_k} \quad (10)$$

We discounted the observed transaction price $\hat{P}_{j*,2011}$ to primo 2011 using the price trend estimated by the model and transformed the estimated capitalized value into a perpetual annuity by multiplying with an asset return rate, π. This implicit yearly rental value was then multiplied with the estimated coefficient for good k, the parameter estimate $\hat{\beta}_k$ from the hedonic price function and the level of k in the housing bundle that household i chose, x_{j*k}.

We excluded households who chose a corner-solution because the marginal rate of substitution only is smaller or equal to the marginal cost. In other words, eq. 6) does not hold for corner solutions and we cannot recover the exact preference parameter for those households.

4.2 Analysing the variation in WTP

We analysed preference heterogeneity by regressing estimates of WTP on demographic variables, allowing for different effects across the WTP-distribution. A conditional mean model implicitly assumes that the effect of covariates moves the entire distribution with a fixed factor. We relax that assumption by, in addition to standard OLS, also estimating quantile regressions (QR)

We estimated:

$$Q_\tau(\ln(WTP)|D_i) = \alpha_\tau + \sum_d^D \alpha_{d\tau} D_{di} \tag{11}$$

where D_i are covariates, α_τ is an intercept that captures the intercept for the τ^{th} decile, D_{di} are D observed demographic characteristics, and $\alpha_{d\,\tau}$ is a vector of parameters describing the variation that can be explained by each observable characteristic in the τ^{th} decile. The coefficients in α_d represent the marginal effect of the explanatory variable d on the τ^{th} conditional quantile in the estimated preference distribution. We estimated QRs in R using the Quantreg package (Koenker, 2013). Note that when fitting a regression conditional on τ, all observations contribute to the fitting of the regression even though only a sample of points determines the parameters. There are as many determining points as there are parameters, but which points depends on all observations in the sample (Koenker & Hallock, 2001).

5 Results

5.1 Recovering tastes and estimating WTP

We present one hedonic price model with three different spatial controls. The results are shown in Table 2, where we only list estimates of the nature availability variable, the intercept and model statistics. The model includes more than 25 explanatory variables and full results are found in Appendix 2. The coefficients for the structural and neighbourhood control variables conform to expectations, e.g., increasing the number of rooms or number of bathrooms is associated with a higher price, whereas decreasing the distance to a larger road is associated with a lower price.

TABLE 2 ESTIMATED IMPLICIT PRICES

	Fixed effect	Fixed effect spatial smoothing	Fixed effect Clustered residual
	(1)	(2)	(3)
Nature availability (ha within 800 m)	0.00187***	0.00171***	0.00187***
	(0.00019)	(0.00019)	(0.00023)
Constant	3.86384***	3.76999***	3.86384***
	(0.09273)	(0.09199)	(0.14599)
Adjusted R^2	0.544	0.582	0.544
Log Likelihood	-14,124	-14,102	-14,124
AIC	28,312	28,204	28,2312

Note: N=2,376 $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

The parameter for availability of peri-urban nature areas reflects a marginal implicit price of an increase in density of one Ha within an 800 m radius of the property. It corresponds to a price premium of 0.17-0.19% per house per ha, which again corresponds to a marginal WTP of approximately 800 EUR per Ha and household for an average-priced property in the sample (the mean in the sample is 452,474 EUR (2011)).

We control for spatial autocorrelation by imposing a spatial fixed effect on school districts (model 1) by including both a fixed effect and a smoothing term across space (model 2) and by using a spatial fixed effect where the residuals are clustered (model 3), thereby taking into account that observations within a school district are more correlated than those between school districts. We find our parameter estimates related to nature availability to be robust to a range of spatial controls using fixed effects on different spatial scales (municipality, postal code, road code and school district) and flexibility of the spatial smoothing term. This lends support to our assumption that unobserved neighbourhood quality is uncorrelated with the observed quality we control for.

Using model (2) of Table 2, the resulting distribution of household specific preference parameters were calculated and summarized in Table 3. We find a median preference parameter for the 1,864 households who bought nature as a part of their housing bundle of 674 EUR/per year. We used an interest rate of 3%. The distribution is right-skewed with a few households showing a very high preference for nature access.

TABLE 3 PREFERENCE-PARAMETER

	Min	1st quantile	Median	Mean	3rd quantile	Max
Preference parameter	0.0001	189	674	968	1,491	7,128

Note: N= 1,864. Values are EUR/year

Using the assumed utility function and the recovered preference parameter, the WTP for a change in nature density from z^0 to z^1 can be calculated as $\hat{\gamma}_{ik}(\log(z^1) - \log(z^0))$. Table 4 summarizes the household specific WTP for a selected set of discrete changes in nature density. The median density for the households who bought nature density is approximately 30 ha, the lower quantile is approximately 20 ha, and the upper quantile is approximately 60 ha.

TABLE 4 ANNUAL WTP FOR A CHANGE IN NATURE DENSITY (EUR/YEAR)

	Min	1st quantile	Median	Mean	3rd quantile	Max	St. Dev.
10 to 30 ha	0	207	741	1,063	1,638	7,831	1,036
20 to 30 ha	0	77	273	392	604	2,890	382
30 to 60 ha	0	131	467	671	1,033	4,941	654
40 to 60 ha	0	77	273	392	604	2,890	382
50 to 60 ha	0	34	123	176	272	1,300	172
Implicit price		24 EUR/ per ha/per year/per household					

Note: N=1,864, the implicit price is based on an average priced property in the sample at a 3% interest rate.

The restriction on the functional form of the utility function implies that the WTP for a percentage change in nature density is constant, exemplified in the table with a change from 20 to 30 Ha and a change from 40 to 60 ha, which both correspond to a 50% increase.

5.2 Variation in WTP across demographics

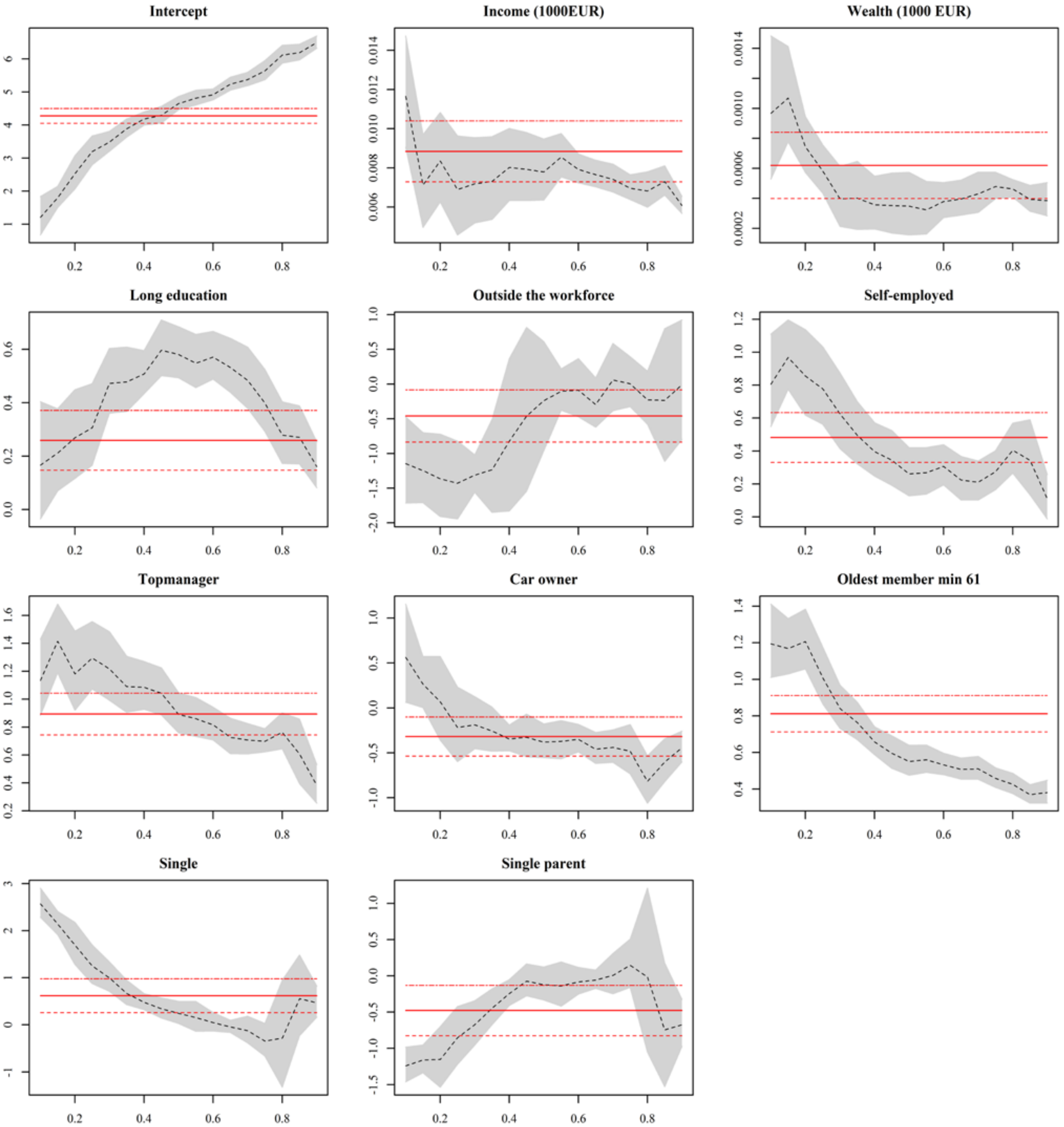
The log of WTP is regressed on socio-demographic variables using OLS and quantile regression (see Figure 2). The quantile regression approach offers an insight into the heterogeneity across the price distribution, but it comes at the cost of increased complexity. The quantile regressions were run on each 5-percentile from the 10th to the 90th percentile, resulting in 17 estimated coefficients for each parameter for each model-run. Therefore, results are presented using figures. The full results for each 20th percentile are reported in the appendix. The signs of the estimated parameters conform to expectations, and when significant, they show the same sign, but their magnitude differs across the distribution.

The baseline is a household with a yearly income of 81,129 EUR and wealth of 376,846 EUR, corresponding to the medians in the sample. The household consists of a minimum of two adults, and a minimum of one member is an employee; no one is over age 60 and no member holds a university degree. The dependent variable is logged WTP, and the estimated parameters are thus the percentage effect on WTP for a one unit increase in the variable of interest holding all else constant. The OLS estimates show the impact of the covariate on the conditional mean WTP. In Figure 2 the conditional mean estimate is presented in red using a full line and standard errors are shown by two dotted lines. The quantile regression coefficient estimates for each 5th percentile are connected by a black dotted line, and the standard errors are outlined by the grey areas in the figure.

At the conditional mean, an increase in “Income” of 1,000 EUR increases WTP by 0.9%. Turning to the quantile results, the increase ranges from 0.6% to 1.2%, with the largest impact in the lowest part of the WTP distribution. However, as the confidence intervals for the OLS and the quantile regressions overlap there is no significant difference in the relationship between income and WTP across the distribution of WTP. Wealth exhibits the same profile as income, with the highest relative effect in the low part of the distribution and a relative constant effect across the middle-to-high end of the distribution. Note that our data and model identify preferences locally for a given level of income. Thus, we cannot say anything about what the individual household would do should their income increase; but, through the quantile regression we can see the degree to which the relationship between income and WTP varies for households with high vs. low WTP for availability of peri-urban nature.

The effect on the conditional mean WTP from increasing the education for one member of the household is 25% regardless of the initial level of WTP. The quantile regressions are conditional on the quantile so that the estimated parameter gives the change in WTP associated with increasing the education level, assuming that the position of the household in the WTP distribution among all other households with the same characteristics does not change. In a regression conditional on the 40th percentile, if the household has the 40th percentile WTP and one member changes education levels, the WTP will increase by 53%, corresponding to the 40th percentile for households where a minimum of one member has higher education. In absolute terms this increase corresponds to 36 EUR/year.

FIGURE 2
RESULTS OF EXPLAINING WTP BY OBSERVED DEMOGRAPHICS



Higher education increases WTP across the whole distribution but matters the most around the median WTP and less so in the tails. So, it seems that education mainly moves the median households and to a lesser degree moves the extremes. Employment matters the most for households with a WTP below the median. For households with a WTP above the median, a change from employment to a situation where all members are either unemployed, retired or students does not affect their WTP. In contrast, if the WTP is already under the median it will result in a decrease in the range of 25-100%.

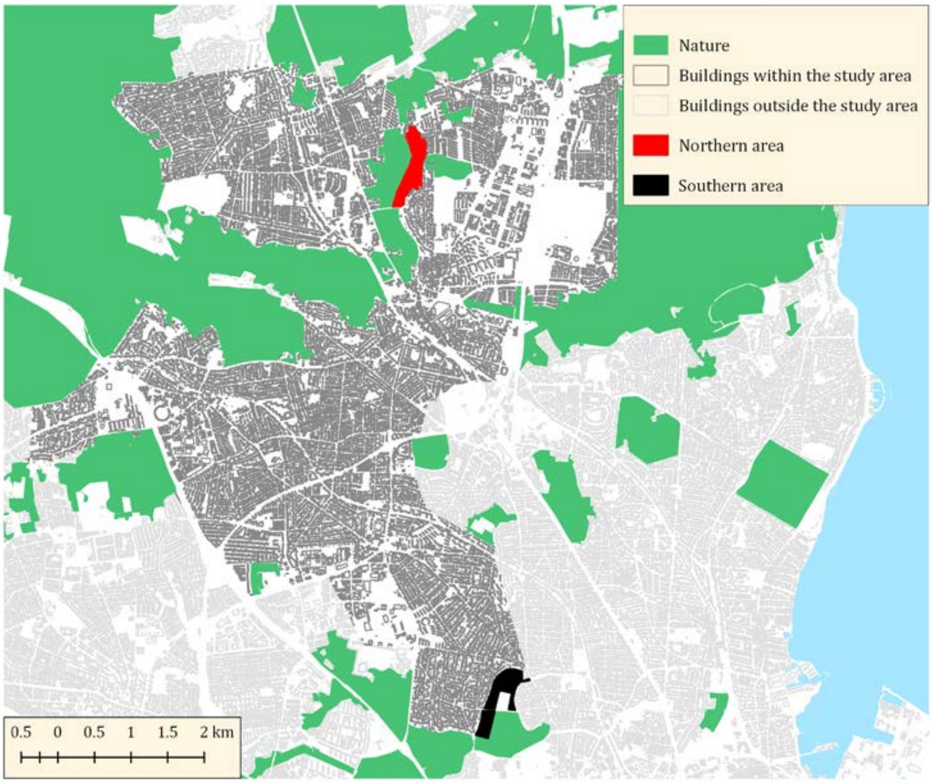
Older households (defined by the oldest household member) show a higher WTP compared to households with no member above the age of 60. The impact ranges from 120-40%, with the highest impact on low WTP. This means that as the household ages, the tails are pulled towards the mean, with the highest increase in relative terms happening on the left side of the WTP-distribution.

There are very few single households and even fewer single households with children. Up to the median WTP, we observe that single households exhibit a higher WTP compared to households with two adults and a minimum of one child. For single parents, the “single” and “single parent” coefficients should be interpreted together. In our sample, 10% of the households are single parents, which are households we would expect to have a lower disposable income compared to a household consisting of two adults only, as the income measure is the yearly income of the adult with the highest income. Even so, we find that in the lower parts of the WTP-distribution single parents have a WTP which is approximately 50% larger (-1.154+1.693=0.539) than a similar household with two adults. Car ownership could affect WTP negatively because a car reduces the time cost of transport (which makes it easier to reach substitutes for nearby nature areas) and reduces disposable income. This is the case on average and particularly for households with a high WTP. However, it is not so for the households with a low WTP, where instead we see that car-ownership affects WTP positively, suggesting that at this end, households tend to buy more nature when they own a car, possibly increasing distance to work, for example, instead.

5.3 Policy Simulation: Removing 21 Ha of Nature Area

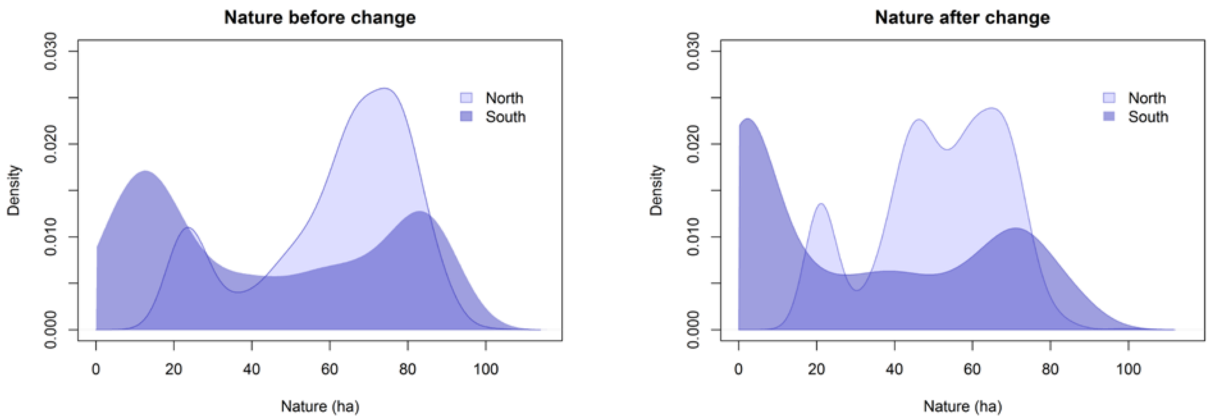
Above we estimated the WTP for a change in nature availability from 20 to 30 ha, and it was evident that high-income households would be willing to pay more while maintaining their initial utility level with an increase in nature availability. Here, we turn the scenario upside down. We estimate the WTP as the amount of money a household would pay to avoid a reduction in nature availability of 21 Ha of nature areas in two specific case areas. The case areas differ in terms of location: one is located in the northern part of the survey area, and the other is located in the southern part of the survey area (see figure 3). Apart from location, the case areas differ in two central aspects: the northern case area has a high availability of nature areas and its households have a higher income relative to the southern case area, which has a much lower level of income and nature area availability.

FIGURE 3: TWO POLICY AREAS



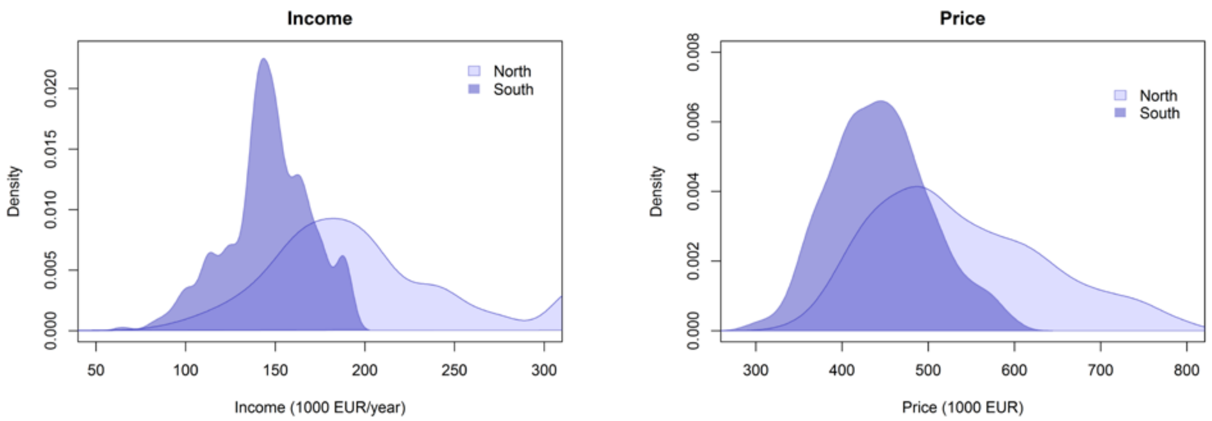
Removing 21 Ha of the nature area will have different impacts on the relative availability of nature areas in the two case areas. Figure 4 shows the distribution of nature availability across households before and after the removal of 21 Ha of the nature area. In the northern case, the removal of 21 Ha of the nature area pushes the higher end of the distribution to the left, as households with an abundant amount of nature availability experience a reduction in availability. In the southern case, the lower end of the distribution, in particular, is pushed to the left. In this case, the households with low availability obtain an even smaller nature area or none at all.

FIGURE 4
DISTRIBUTION OF NATURE AVAILABILITY BEFORE AND AFTER THE CHANGE



Not all homes near the affected nature areas are traded in the period from which we have data, but we know their characteristics. We predict house prices based on the first stage hedonic model estimated above and calculate preferences for nature availability using the same procedure as that used for recovering preferences for households in transacted properties. The income levels and sales prices of the houses are more dispersed in the northern case area compared to the southern case. In Figure 5, the distribution of income and sales prices is shown for both cases. In the southern case, area household and sales prices are more homogeneous, having a tighter distribution than the northern case. In contrast, the right tail, especially, of the distribution for both income and sales prices for the northern case is much thicker, which reveals that a large number of households have a high income and that a large proportion of the houses in the area are expensive.

FIGURE 5
DISTRIBUTION OF INCOME AND PRICE



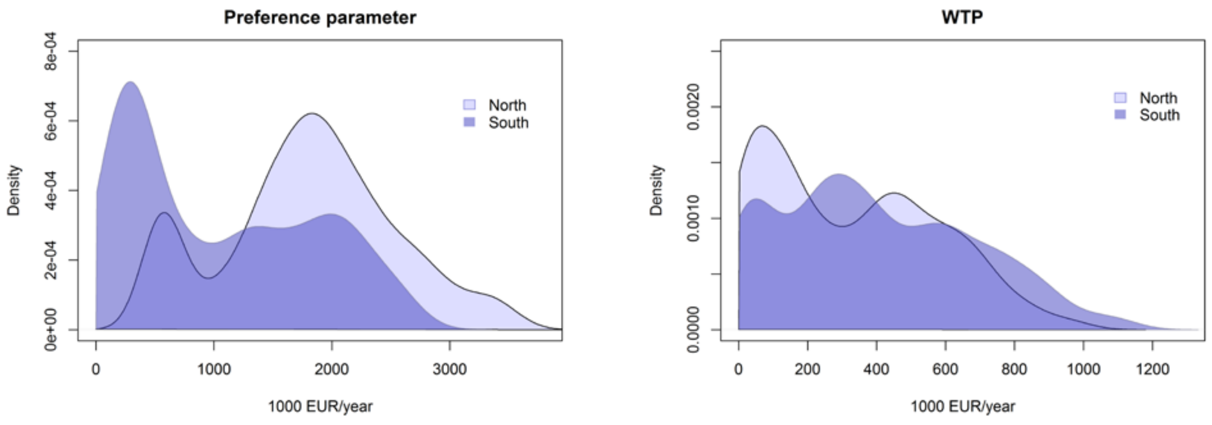
Our model result shows that high-income households have stronger preferences for nature and tend to occupy homes with high levels of nature. Poorer households choose less nature because their marginal WTP for more nature is smaller than the price set by the market. Even so, there is a significant impact on lower income families due to their numbers, which dominates the outcome of our welfare economic assessment. In table 6 and Figure 6, the welfare economic effect of the removal of 21 Ha of nature area is summarized. In the Southern case area, 991 households would be affected, and in the North 831 households would be affected. The total loss of welfare in the Northern case area is 278.000 EUR/year, and in the Southern area it is 404.000 EUR/year.

Based on preferences alone, Northern households have far stronger preferences for nature, as is also reflected in their choice of homes with far more nature. Even so, we find higher WTP for avoiding the loss of 21 Ha of nature area in the Southern case. This scenario result is driven by the fact that the households in the northern case area would experience a relatively small impact on their nature access compared to their southern counterparts. The relative impact of going from an abundant availability of nature to a less abundant availability is less severe than going from a lower availability to a very low availability. The calculated welfare economic impact of the scenario reflects that households in our model have a decreasing marginal WTP for nature area availability.

TABLE 6
WTP IN EUR/YEAR

	Total WTP	WTP/household	WTP/Ha	Affected households
Northern	277,790	334	34	831
Southern	404,362	408	37	991

FIGURE 6
DISTRIBUTION OF PREFERENCES AND WTP FOR AVOIDING LOSS



6 Discussion

6.1 Who demands nature area?

We find that variation in WTP can, to some degree, be explained by demographics. Across the whole WTP distribution, we find that WTP increases with wealth and income, weakly supporting the hypothesis that nature availability is a good with a progressive benefit distribution. For households with a low WTP for nature areas, the main determining factors for their WTP are employment status, whether they are reaching retirement age and whether they are single parents. In contrast, households with a high WTP do not change their WTP if they are single parents but react more on car-ownership compared to the rest of the population. The few single parents who have a high WTP may be different on other unobservable demographics compared to those with a low WTP. Households with a high WTP for nature areas may also have a preference for the good, which overshadows the effect on disposable income from being a single parent.

In the environmental literature applying second stage hedonics, distributional aspects have been given little attention and treated only superficially. Brasington & Hite (2005) estimated a second-stage model for the distance to pollution hazard sites. In their first-stage hedonic regression they included neighbourhood-level measures of income, poverty and education in the house price regression as explanatory variables. The same variables also appeared in their second stage demand regressions. They found a small but significant positive income elasticity of demand but also found positive effects of education and number of children on the demand for distance to hazard sites. Another study focusing on urban nature area is that of Poudyal, Hodges, & Merrett (2009), who analysed the demand for urban green space in Roanoke, Virginia. They analysed distributional aspects of urban green space preferences and found a significant but fairly small positive income elasticity of demand; they also found that other socio-demographic demand shifters did matter. Netusil, Chattopadhyay, & Kovacs (2010) estimated second-stage models of the demand for tree canopy cover and found weak effects of demographic demand shifters, including income. Using a related approach, namely a horizontal sorting model, Klaiber & Phaneuf (2010) examine preference heterogeneity for open space. They find evidence of substantial heterogeneity both across types of green space and types of households. In their study, wealthier households were more likely to locate near natural areas, and less wealthy households were more likely to locate near agricultural land. None of these studies examined the welfare impacts of policy changes across the income distribution.

6.2 Lessons from a policy simulation

We explore the implications of our model results by investigating a scenario where 21 Ha of nature areas are removed in two case areas. We find that WTP is highest for the area surrounded by households with the lowest average income. This result may at first seem surprising, as we know from the analysis of preferences that high-income households have a stronger preference for nature area availability. However, the effect of preferences is outweighed by the declining marginal utility as captured by the log-linear utility function. As households in the lower income case area have considerably lower availability of nature areas at the outset, losing 21 Ha almost eliminates the entire availability of nature for a significant proportion of the households living in the case area. In contrast, the residents of the high-income case area would still enjoy a high level of nature availability even after the change. The model results and the scenario in the paper emphasize that the welfare economic impact of landscape policy changes related to nature areas is driven by both the preference of the affected households and the local supply of nature. Although preferences are stronger among high-income groups, the relative change in local supply can just as well drive the outcome of a welfare economic assessment.

6.3 CAVEATS AND KEY ASSUMPTIONS

We are able to explain 10-16% of the preference variation in our quantile regression model of WTP. In the context of microdata and given that in the estimation of the preference parameter we include all unexplained variation; this is a fairly high explanatory power. Even so, a large percentage of the variation in the preference variation is left unexplained, which could also imply that classical demographic variables – or at least those used in this paper – do not fully capture the preference variation. Our dataset describing demographics is related to the residents in 2011. Thus, we essentially assume that the new residents moving to the area during the period 2007-2010 have the same observed demographics as those who lived there in 2011 – or at least that the demographic mean parameters of the 100×100 m fitted mean estimates were constant over the period. Our sample covers only four years and, given the short period, we have no reason to believe that the composition of households in terms of demographics has changed substantially.

We have shown that the density of high-income households decreases with decreasing nature availability across our case area. This of course reflects that they have – on average – higher WTP for nature availability and hence sort themselves disproportionally into these areas – as opposed to lower income households, who, on average, have lower WTP for nature availability. Such a sorting is further exacerbated by the sorting itself, driving prices of properties up in areas where nature availability is high and vice versa. These dynamics are not accounted for in policy simulations based on second-stage hedonic studies, which rest on the assumption that the market is in equilibrium. This should be kept in mind particularly when investigating larger policy changes. Small policy changes, like the one evaluated in this paper, is less likely to be affected by these indirect sorting process. Klaiber & Phaneuf (2010) simulate policy scenarios similar to ours using their sorting model to predict the response of prices. They find that the general equilibrium effects can extend well beyond the area directly affected by the policy through such price adjustments. We further note that our simulation cannot account for adjustments that households and landowners make to open space supply following a policy change. Walsh (2007) studies green space policies in a general equilibrium setting, allowing households to adjust private open space in response to changes in public open space supplied. He finds that such general equilibrium effects may be large and that increases in public open space can result in a reduction of overall open space available as households reduce the amount of land privately allocated to open space.

A number of important assumptions are made in our analyses, which merit further mention. This study is one the few in the environmental economics literature that moves beyond implicit prices in a hedonic study. Here, we suggest a transparent identification strategy based on functional form restrictions, suggested and applied by Bajari & Benkard (2005) and later applied by Bajari & Kahn (2005) and von Graevenitz (2013). The empirical procedure consists of two steps, where we first estimate a hedonic price function. The model produces one implicit price for each attribute. Importantly, we assumed, supported by an analysis of the residuals using a naive OLS-regression, that the study area only covers one market described by one price function.

In the second step, we impose an assumption about the functional form of utility, which can of course be criticized for being a strong restriction. However, the chosen form can be seen as a (good specific) local approximation for the unknown true form. Given the interpretation as a local approximation, one should note that as the size of a policy change increases, so does the impact of the assumed form of the utility function on any evaluation outcome. The method is well suited for recovering and evaluating household specific WTP/WTA for smaller changes. Other approaches for obtaining identification, such as using an IV approach on multiple market models (e.g., Day, Bateman, & Lake (2007), are sometimes less transparent and give rise to other theoretical and empirical obstacles that must be resolved.

The exact identification of a preference parameter relies on the household not choosing a corner solution, and thus we need the household to buy into the market to obtain more than just a lower bound for taste. In the WTP-analysis, we subset the sample to households who bought nature availability, thereby making our estimates on variation in WTP a lower bound, relative to the variation across the whole population.

7 CONCLUSION

Within the hedonic literature, very few studies move beyond implicit prices and onto estimating full demand schedules. This serves as a very thin basis for discussing the distributional impacts of public policy and might be the reason for the small contribution from the hedonic literature to the discussion of distributional impacts from planning policies, such as urban greening policies, which we mainly find in the stated preference literature. The identification in the 2^{nd} stage comes at the cost of a key assumption, which is a restriction on the functional form of the utility function. When evaluating smaller changes, the restriction has little bearing on the results compared to using the implicit price, but in the case of large changes the impact of such an identification strategy should be evaluated carefully.

We use quantile regressions to analyse whether the relation between demographics and WTP is constant across the WTP-distribution. We find factors such as wealth and income to be relatively stable, whereas higher education affects the centre of the distribution but affects the tails to a lesser degree. In our exploration of the model results, we find that policy changes in the supply of nature areas may impact less well-off household just as much or even more from a welfare economic point of view. Less well-off households have, in general, bought less nature availability and are more commonly based in areas with lower supply. An absolute change in availability would therefore impact them relatively more. Given that we assume a decreasing marginal WTP for nature areas, a policy scenario where little nature availability from the outset is reduced even more would translate into a large welfare economic impact compared to a situation where the opposite was true. This finding highlights that the outcome of a welfare economic assessment of a policy scenario related to nature areas can be driven by both different preferences among socio-economic groups as well as the local supply of nature areas.

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APPENDICES

TABEL 1 FIRST STAGE RESULTS

	School	**School+smoothing**	**School with clustered residuals**
Log (area)	0.44020***	0.43878***	0.44208***
	(0.02028)	(0.02028)	(0.03323)
Toilets	0.05011***	0.05094***	0.04796***
	(0.00905)	(0.00903)	(0.01074)
Garden	0.00013***	0.00014***	0.00013***
	(0.00001)	(0.00001)	(0.00002)
Roof: tile	0.05264***	0.05031***	0.05216***
	(0.00853)	(0.00859)	(0.00918)
Roof: Cement	0.04392**	0.04128**	0.04298**
	(0.01976)	(0.01975)	(0.02041)
Bathrooms	0.02663***	0.02628**	0.03013***
	(0.01028)	(0.01025)	(0.01129)
Rebuild in 70-ies	-0.02329*	-0.02163	-0.02579*
	(0.01387)	(0.01384)	(0.01420)
Rebuild in 00-s	0.07060***	0.07061***	0.07032***
	(0.02002)	(0.01998)	(0.02028)
Big roads within 400 m	-0.00016***	-0.00016***	-0.00015***
	(0.00004)	(0.00004)	(0.00005)
Nature within 800 m	0.00182***	0.00171***	0.00187***
	(0.00018)	(0.00019)	(0.00023)
Constant	3.70593***	3.76999***	3.86384***
	(0.08915)	(0.09199)	(0.14599)
AIC	28,209	28,204	28,313
Observations	2,376	2,376	2,376
Adjusted R^2	0.579	0.582	0.579
Log Likelihood	-14,105	-14,102	-14,124

TABLE 2: VARIATION IN WTP EXPLAINED BY DEMOGRAPHICS

	OLS	**Quantile regression**			
		20%	40%	60%	80%

Intercept	4.274***	2.529***	4.183***	4.915***	6.116***
	(0.223)	(0.415)	(0.165)	(0.137)	(0.224)
Income (1000 EUR)	0.009***	0.008***	0.008***	0.008***	0.007***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
Wealth (1000 EUR)	0.001***	0.001***	0.0004**	0.0004***	0.0005***
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.00005)
Long education	0.259**	0.269*	0.508***	0.571***	0.278***
	(0.112)	(0.138)	(0.067)	(0.074)	(0.096)
Outside the workforce	-0.461	-1.365***	-0.824	-0.087	-0.228
	(0.377)	(0.494)	(0.913)	(0.348)	(0.317)
Self-employed	0.482***	0.855***	0.396***	0.306***	0.405***
	(0.151)	(0.216)	(0.135)	(0.101)	(0.126)
Topmanager	0.893***	1.181***	1.085***	0.816***	0.762***
	(0.149)	(0.235)	(0.143)	(0.098)	(0.107)
Car owner	-0.319	0.068	-0.346***	-0.349***	-0.818***
	(0.217)	(0.387)	(0.119)	(0.127)	(0.219)
Oldest member min 61	0.812***	1.207***	0.658***	0.532***	0.426***
	(0.099)	(0.136)	(0.063)	(0.049)	(0.046)
Single	0.617*	1.693***	0.478***	0.048	-0.284
	(0.359)	(0.370)	(0.141)	(0.162)	(0.946)
Single parent	-0.479	-1.154***	-0.245*	-0.083	-0.016
	(0.347)	(0.347)	(0.148)	(0.153)	(0.941)
R^2/Pseudo R	0.15	0.10	0.15	0.16	0.14

Note: N= 1,864 *p<0.1; **p<0.05; ***p<0.01