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HOUSEHOLDS' WILLINGNESS TO PAY FOR ATTRACTIVE GREEN AREAS

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Abstract

This paper discusses households' willingness to pay for a marginal change in the presence of national attractive green areas within their living environments, based on a hedonic approach. Attractive green area presence in the living environment is measured by a distance-weighted size index regarding all attractive green areas within 2.5 kilometers from property. Dutch housing data are used, providing 65,268 observations that describe properties' values, characteristics and the disposable income level of households. Estimates of households' willingness to pay for a marginal increase in attractive green area are compared to estimates for households' willingness to pay for a marginal increase in green area. Results indicate that households value national attractive green areas over regular green areas. On average households in a higher income class are implicitly willing to pay more for a marginal increase in the distance-weighted size of attractive green area in their living environments, compared to households in a lower income class. The findings reported in this study will be useful to spatial planning.

Keywords: property value, attractive green area, hedonic model, distance-weighted size index

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1. Introduction

1.1 Context

The presence of green area within the living environment is recognized as a positive determinant of human well-being (Newton, 2007). Nevertheless, household's potential access to green areas has not received sufficient attention in post-war Dutch housing policy, which has merely been aimed at reducing quantitative housing shortages on the supply side (Aalbers, 2003; Pellenbarg & Van Steen, 2005). Although shortages have been recognized during the 1990's, green areas have not received sufficient attention with housing policy predominantly aimed at reducing qualitative shortages (Ministry of Housing, Spatial Planning and the Environment, 2000; Aalbers, 2003). Large groups of Dutch households may experience recreational nature deficiencies in their living environment, given normative hypothesises on household's demand for nearby green area hectares and supply capacity (De Vries et al., 2004).

An important aspect in the degree to which households can be satisfied in their qualitative housing needs is their financial budget available for spending (Oleson, 2004; Sheppard, 1999). Knowledge of households' willingness to pay for the consumption of green areas within a certain proximity to their residential properties, and the influence of the green areas' attractiveness on the extent of this willingness to pay, is relevant to both policymakers and market actors (Tyrväinen & Miettinen, 2000). Policymakers may want to sustain or increase the wellbeing of households, optimizing the spatial allocation of land use functions including housing and nature – while seeking opportunities to increase property tax benefits. A real-estate developer, on the other hand, may be interested in the estimated value households implicitly attach to non-market phenomena, including the presence of green areas in their living environment, when determining a developments specification, taking into consideration the demand of a specified target group of households. The quantification of benefits that households derive from green areas enhances the weighing of costs and benefits of providing or conserving green area acreage against providing or conserving other, explicitly valued, land use types, e.g. housing.

Implicit marginal prices for non-market environmental amenities related to residential property can be estimated using contingent valuation or hedonic pricing methods (Morancho, 2003). Contingent valuation involves asking people directly what price they would be willing to pay, in a hypothetical market, for a specific change in the amount of a good, for their use or conservation (Venkatachalam, 2004). This method, which measures stated preferences, is criticized for its validity and reliability (Venkatachalam, 2004). Contrary to contingent valuation, hedonic pricing methods are used to analyse actual behaviour, measuring revealed preferences (Tyrväinen & Miettinen, 2000). The hedonic pricing method indirectly obtains the implicit values of property characteristics, deriving these from the estimated influence of these characteristics on the price of a property (Rosen, 1974; Malpezzi, 2002). From here we take a hedonic approach to the subject of this study.

A considerable number of earlier hedonic studies have focused at the capitalization of the spatial proximity of green areas into residential housing values (see the review by Crompton, 2001). From capitalization parameters a marginal willingness to pay for green areas can be derived (Bartik, 1988).

A methodological limitation of many hedonic studies is the use of simplistic distance or access measures to describe spatial relations between objects (Geoghegan et al., 1997). Most studies regarding amenity effects of green areas on property values include only characteristics from the green areas nearest to properties, or a percentage of green areas within a given range from properties, in their analysis. An exception is found in Kong et al. (2007) who use a size-distance index to measure scenery forest, though only measuring the nearest feature from the property. Conway et al. (2010) argue that future hedonic studies on green area amenity effects can be improved by incorporating a measure of green area quality in green area measures.

An examination of empirical hedonic studies indicates that insight into relations between household's income and household's implicit valuation of attractive green areas within their living environment is limitedly available. In this study I try to fill in this research gap. An improved measure of green areas, based on indices used in earlier studies by Hillsdon et al. (2006) and Cotteleer et al. (2008), is used to describe the distance-weighted size of national attractive green areas within 2.5 kilometres from a household's property. The distance-weighted size index for national attractive green areas, yielded by the measure described above, is included in a hedonic price model to estimate Dutch households' willingness to pay for national attractive green areas within their living environments. The income level of these households is taken into account explicitly. How do households, discriminated by income class, value a marginal change in green area presence in their living environment, taking into account the national attractiveness of these green areas?

1.2 Research questions

- *How can relations between household income and the households' willingness to pay for attractive green areas be based on residential property values?*

This question is to be answered by examining literature regarding the relations between household income and level of utility derived from housing consumption and earlier hedonic studies on the capitalization of amenity effects, including those of green areas, on property values. Insights of Rosen (1974), Epple (1987), Sheppard (1999) and Palmquist (2003) who discuss utility and demand functions that determine the hedonic price function, can be used to describe relations between household income, utility and willingness to pay for housing characteristics. Empirical results of earlier studies focusing on the capitalization of green areas into residential property values are reviewed, including findings of Morancho (2003), Tyrväinen (1997), Tyrväinen and Miettinen (2000), Conway et al. (2010), Poudyal (2009) and Kong et al. (2007). Studies by Visser and Van Dam (2006) and Rouwendal & Van der Straaten (2008) can be used to gain insight in the relation between green areas and property values specifically for the Netherlands. An interesting phenomenon is described by Anderson & West (2006), who find that amenity values for proximity of non-urban parks to properties rise with income, reporting higher amenity values in wealthier neighbourhoods.

- *What index can measure green areas in a household's living environment accurately, including a measure of potential recreational utility of green areas to households?*

Learning from earlier studies strengths and limitations, a green area index will be constructed that is able to describe the distance of multiple green areas to a single property, while taking into account the green areas' sizes and including a measure of potential recreational utility of green areas to households. Geoghegan et al. (1997) discuss the shortcomings of several green areas measures. A measure describing the size of objects weighed for the objects' distance to a specific property is discussed by Cotteleer et al. (2008) and Hillsdon et al. (2006). Kong (2007) reports empirical findings for a size-distance interaction variable, measuring relations between residential properties and urban green space, implemented in a hedonic price model. The distance-weighted size indices used by the authors cited above provide a basis for the construction of the green area index used in this study.

- *What values do households implicitly attach to green areas within their living environment?*

A hedonic price model will be used to estimate the capitalization of green area presence into residential property values. Diewert (2003) and Malpezzi (2002) discuss relevant model specification issues, e.g. the selection and form of variables to be used. Relevant data will be obtained from different sources, and then combined in a Geographical Information System (GIS). Residential property values, physical characteristics and locations are obtained from the WoON2009 dataset, as well as each household's annual disposable income. WoON2009 is a product of the Dutch Ministry of Housing, Spatial Planning and the Environment and Statistics Netherlands. Land use maps of Statistics Netherlands provide the geometry of green areas, i.e. parks and forests. A measure of the attractiveness of green areas is derived from the Hotspotmonitor dataset.

Green area capitalization parameters will be estimated using multivariate linear regression. From these parameters marginal values that each single household in the sample implicitly attaches to a specific amount of green areas can be derived, following Tyrvaïnen (1997), Rouwendal & Van der Straaten (2008) and Conway et al. (2010). Then variation in willingness to pay is explored by showing and interpreting willingness to pay values per household income class.

1.3 Overview

In chapter two, an examination of literature and the hypotheses derived from earlier studies' findings are presented. In chapter three the data used is described first; then green area measures used in this study are discussed, followed by an overview of descriptive statistics for the data used and the specification of the empirical model. In chapter four households' willingness to pay for a marginal change in the amount of attractive green area in their living environment is analysed. Findings, and their implications for spatial planning, are discussed in chapter five.

2. Theoretical framework

2.1 Foundations of hedonic pricing

Residential property is a differentiated product, characterized by extreme heterogeneity (Palmquist, 2003). Residential properties are traded on a market, which reveals transaction prices or rents households explicitly pay for owning or renting a property. Prices that households pay for property do not explicitly reveal the price paid for the properties' characteristics, as an amount is paid for owning or renting the property as a whole, the latter referred to by Sheppard (1999) as a bundle of characteristics. Following Rosen (1974), a particular property is described by

$$Z = (z_1, z_2, \ldots, z_n) \tag{1}$$

where $z_1, z_2, \ldots, z_n$ are the characteristics of property *Z*.

Within the explicit property market implicit markets for property characteristics can be distinguished, as an observed property price can be regarded as a function of the specific amounts of characteristics associated with the property in concern (Rosen, 1974; Sheppard, 1999). Hedonic pricing enables the estimation of these characteristics' implicit prices (Rosen, 1974). A general assumption in hedonic studies on implicit prices for property characteristics is that housing supply is fixed in the short-run, as models used focus on the consumer market, assuming market equilibrium (Palmquist, 2003; Malpezzi, 2002). Thus can the hedonic price function, as formulated by Rosen (1974), be given by

$$P(z) = p(z_1, z_2, \ldots, z_n) \tag{2}$$

where *P(z)*, the price of property *z*, is determined by the prices *p* of the property characteristics. Subdivisions of property characteristics can be made. This function describes the equilibrium price of property in a given market, where households are price-takers adjusting the quantities of property characteristics consumed to its exogenous prices (Palmquist, 2003; Malpezzi, 2002; Epple, 1987).

Given the hedonic price function households are assumed to choose a single property that maximizes their utility (Anderson & West, 2006; Palmquist, 2003). Following Rosen (1974) and Bartik (1988) household *j*'s utility can be described as

$$U^j = u^j(Z, x, \alpha) \tag{3}$$

where U^j describes household *j*'s[1] utility as composed of the utility derived from housing characteristics given by vector *Z* and non-housing goods *x,* and *α* denotes a vector of household characteristics (Epple, 1987).

From the utility function in equation (3) a household's willingness to pay for properties - as bundles of characteristics - can, given household characteristics, income and utility level, be derived to the implicit bid rent function

$$U^j \; Z^j, Y^j - \theta^j, \alpha^j \;\; = u^j \tag{4}$$

where $\theta^j = \theta^j(Z^j, Y^j, u^j, \alpha^j)$ describes the bid for household income Y^j (Sheppard, 1999; Palmquist, 2003). The price a household would pay for different properties given certain sets of characteristics, of given amounts, is revealed by this bid rent function, holding utility level constant (Gross, 1988). A household's utility maximizing choice for a property is characterized by the household bid rent function being tangent to the hedonic price function (Gross, 1988; Sheppard, 1999). Household *j*'s decision maximizing utility *U* is subject to the problem given in equation (5), see Bartik (1988) and Sheppard (1999),

$$\underset{Z,\,x}{\text{Maximize}} \; U^j \;\; Z, x \;\; \text{subject to } p \;\; Z \;\; + x \leq Y^j \tag{5}$$

where *p(Z)* and *p(x)* are the prices of housing characteristics *Z* and non-housing goods *x*. Assuming that all income *Y* is spend on a certain combination of quantities of *Z* and *x*, the problem in (5) may be solved using the Lagrange multiplier method (Estrin et al., 2008). A Lagrangian function can be defined by

$$L = U\,(Z, x) + \lambda\,(p(Z) + x - Y) \tag{6}$$

where λ is the Lagrange multiplier. The first-order conditions[2] for (6) to be maximized are

$$\frac{\partial L}{\partial Z} = \frac{\partial U}{\partial Z} - \lambda p_Z = 0 \tag{7}$$

$$\frac{\partial L}{\partial x} = \frac{\partial U}{\partial x} - \lambda p_x = 0 \tag{8}$$

$$\frac{\partial L}{\partial \lambda} = Y - p_Z Z - p_x x = 0 \tag{9}$$

[1] Where *j* reflects a specific single household out of a set of *N* households.

[2] Second-order conditions are satisfied as a diminishing marginal rate of substitution between *Z* and *x* is assumed, as well as a households' preference of consuming more goods over fewer (Estrin et al., 2008).

As reflected by equation (9) a household must choose a bundle of goods on the budget constraint to maximise utility. Dividing equation (7) by (8) yields equation (10) that reveals certain properties of the maximum attained by the household.

$$\frac{\partial p}{\partial Z} = \frac{\partial U}{\partial Z} \;/\; \left(\frac{\partial U}{\partial x}\right) \qquad (10)$$

The left-hand of equation (10) is the ratio of the property price *p*'s and property characteristic *Z*'s deratives, and the right-hand side expresses the marginal rate of substitution between housing characteristics *Z* and non-housing goods *x*[3]. Households may however equate their marginal willingness to pay for property characteristics to the characteristics' marginal prices (Bartik, 1988).

2.2 Measurement of green areas

In this section green area measures used in earlier studies are discussed. Specific types of data and analysis tools enable the analysis of relatively complicated spatial patterns in green area locations (see Geoghegan et al., 1997). As many hedonic studies seem to use more basic measures of green areas I will discuss those measures and the studies which they were applied for.

Several hedonic studies use a proximity measure, describing the distance between a property and a green area. Morancho (2003) shows an inverse relationship between the distance of property to a green area and property price, as property prices drop approximately €1,800 for an added 100 meters of distance to the nearest green area. A similar distance decay effect on property values related to green areas is also reported by Tyrväinen & Miettinen (2000), Crompton (2001), Conway et al. (2010), Visser & Van Dam (2006) and Rouwendal & Van der Straaten (2008)[4]. Diminishing green area amenity effects on property prices shows that distance matters to the measurement of green areas. A proximity measure does however not distinguish small and large green areas (Cotteleer et al., 2008).

Morancho (2003) and Poudyal et al. (2009) report separate coefficients for both the size of and distance to the nearest urban park. The relation between park size and property value is unclear. According to Morancho (2003) the size of the nearest park is not a significant predictor of property price, while Poudyal (2009) contradicts this. The simultaneous inclusion of separate size and distance measures of the nearest green area in a hedonic price equation, as in Morancho (2003) and Poudyal et al. (2009), may however lead to biased estimations according to Kong et al. (2007).

[3] A diminishing marginal rate of substitution between goods *Z* and *x* is assumed here, and that households prefer a higher quantity of goods over a lower quantity of goods. Thus, second-order conditions are satisfied (Estrin et al., 2008).

[4] Studies by Visser & Van Dam (2006) and Rouwendal & Van der Straaten (2008) indicate that diminishing green area amenity effects on property prices may exist in the Netherlands, after distances of respectively 50 and 100 meters from properties.

Therefore, Kong et al. (2007) use an interaction term to measure green area presence, equated by dividing the size of the nearest park by its distance to the property in regard. This method in measuring green area characteristics is reasonable as findings of Poudyal et al. (2009) show that green area proximity and green area size are substitutes. This is vital, as by dividing green area size by its distance to a household's property it is assumed that, in example, a large park located far away from a household's property may be of equal utility to the household compared to a small park nearby the property.

Most of the studies discussed above measure only the characteristics of green areas nearest to property. As such, potential amenity effects of parks located beyond-nearest parks are neglected. In contrast to nearest green area measures, a percentage of green areas within a given radius[5] from a property does cover a larger spatial extent, providing a measure of green area density. However, this measure assumes that every percent of green area surface within this area provides equal utility to a household, which is unlikely, as earlier studies indicate distance decay in households' valuation of green areas (Tyrväinen & Miettinen, 2000; Morancho, 2003; Conway et al., 2010; Crompton, 2001; Visser & Van Dam, 2006; Rouwendal & Van der Straaten, 2008).

A green area measure that can cover a large spatial extent while taking into account the size of separate green areas, which is weighted for the green area's distance to a property is the so-called Reilly-index, that is used in an earlier study by Cotteleer (2008). The Reilly-index measures green area presence in a given area as the sum of the distance-weighted sizes of all green areas in that area.

Table 2.1 – Basic green area measures

Measure	What is measured	Significance	'Shortcoming'
Proximity[a, b, c, d, e, f, h]	The distance between a property and a green area	Distance decay in amenity effects	Does not distinguish green areas by size
Size[c, e, h]	The size of a green area	Amenity affects may change with green area size	Significance is doubtful
Size/distance interaction[f]	The size of a green area and it's distance to property	Yields proper estimation of amenity effects taking both size and distance into account	No straightforward interpretation, as size and distance are assumed substitutes
% surface within a given radius [f, g, h, i, j]	The relative amount of green area within a given radius from a property	Can measure green areas over a large spatial extent	Does not regard the characteristics of separate green areas
Reilly-index [k]	The sum of distance-weighted sizes of all green areas in a given area	Can cover a large spatial extent, while measuring separate green areas' size and distance to property	No straightforward interpretation, as size and distance are assumed substitutes

[a] Tyrväinen (1997) [b] Tyrväinen & Miettinen (2000) [c] Morancho (2003) [d] Visser & Van Dam (2006) [e] Poudyal (2009) [f] Kong et al. (2007) [g] Conway et al. (2010) [h] Anderson & West (2006) [i] Netusil et al. (2010), [j] Rouwendal & Van der Straaten (2008), [k] Cotteleer et al. (2008)

[5] While some other studies measure the percentage of green area within a property's neighbourhood (see Tyrväinen, 1997; Tyrväinen & Miettinen, 2000; Visser & Van Dam, 2006).

2.3 Willingness to pay for green areas

Several studies expanded green area[6] hedonics by equating household's willingness to pay. A study by Tyrväinen (1997) shows a negative marginal willingness to pay for a 100 meter decrease in distance of the nearest forest park to a property in a Finnish city, while an increase in the percentage of green space in the housing district is valued slightly positive. Conway et al. (2010) report a statistically significant willingness to pay $171 for a one percent increase in green area surface in the area between a 200 and 300 meter radius from a property. They show a positive willingness to pay for increases in green areas within hundred meter rings further from the property, although being statistically non-significant and subject to distance decay. A methodological limitation of this study is the use of only 259 observations.

Rouwendal & Van der Straaten (2008) examine the effect of the relative amount of parks and public gardens in a 500 meter radius from property on property prices in three different Dutch cities separately. A one percent increase in this amount was averagely valued €401 in Amsterdam, €1,455 in The Hague and €987 in Rotterdam. Rouwendal & Van der Straaten (2008) report that in Amsterdam the willingness to pay for green areas is mainly explained by households high valuation of one specific park, which they claim is attractive, although no empirical evidence of that claim is presented. Nevertheless their observation indicates that the relative attractiveness of green areas may be an important characteristic that should be taken into account when estimating willingness to pay for green areas.

Earlier studies also show that a household's demand for green areas is related to its income level, which may influence the marginal willingness to pay. Poudyal et al. (2009) report a positive, though inelastic (y=0.43), relation between household income and demand for park acreage, which seems consistent with findings by Brasington & Hite (2005) who show that people with higher incomes demand more environmental quality, and Netusil et al. (2010), who study households demand for tree canopy near property.

2.4 Hypotheses

In this study households are assumed to attain their maximal utility level by consuming a preferred combination and quantity of property characteristics, bundled in a specific property, and non-housing goods. As prices are given, the quantity of goods a household can consume is constrained by the household's disposable budget (Sheppard, 1999). Therefore, the outcome of a household's choice for buying or renting a specific property implicitly reflects its valuation of the

[6] Green areas are subject to different definitions across the examined studies, so findings will only be discussed in a general sense.

properties' characteristics, which in turn reveals the household's marginal willingness to pay for these characteristics (Malpezzi, 2002; Palmquist, 2003).

This study focuses at examining the hypothesises (1) that implicit marginal prices for green area presence in a household's living environment exist, (2) that different groups of households, discriminated by disposable income class, are willing to pay unequal amounts of money for green area presence in their living environment, and (3) that households are willing to pay unequal amounts of money for a marginal increase in national attractive green area in their living environment, compared to an equal increase in green area presence.

3 Data and methodology

3.1 Data description

The Netherlands is my study area. The surface of this country, excluding marine territory, is approximately 4.15 million hectares. The largest population concentrations are found in the western part of the Netherlands, while most green area hectares are found in the central and more peripheral regions.

Housing data were obtained from the Dutch Ministry of Housing, Spatial Planning and the Environment and Statistics Netherlands in the WoON2009 dataset, version 1.2 from April 2010. These data were generated by a survey that is held every three years. The WoON2009 dataset contains 78,071 observations, each describing properties' structural, neighbourhood and locational characteristics, and socio-economic details of the properties' users, in 2009. 74,607 Observations include an officially registered, non-surveyed, assessed property value on January first, 2009. I assume these values to reflect the occupying household's valuation of the properties characteristics. 6,055 Cases containing incomplete or erroneous[7] information were removed from the dataset. Furthermore, 149 of the remaining cases were removed as the respective household's incomes showed to be negative. A single initial regression was then performed to obtain residuals, in order to detect possible outliers. Observations that contained outliers, defined as standardized residuals that exceed the value 3, as suggested by Yan & Su (2009), were removed from the from the dataset. My final dataset contains 65,276 observations with complete information.

Properties' locations are given by a four digit postal area code. All cases containing a property value were selected for further analysis. Their postal area codes were then used to geocode the properties in a Geographical Information System (GIS). Values describing neighbourhood characteristics were added to each property observation, using the Statistics Netherlands' CBS

[7] E.g. one postal code yielded no usable coordinates for GIS analysis, leading to the deletion of 18 cases.

neighbourhood and district map, from the Dutch Land Registry Office (2011). These variables describe per property observation the properties' distance to the nearest large urban municipality, and the average property value and number of commercial businesses in the municipality where the property is located.

Data on green areas is derived from Statistics Netherlands' 2008 land use statistics GIS map. This polygon map describes the coverage of 38 land use functions in the Netherlands, distinguishing parks, public gardens and forests of one hectare in size and larger. These categories are merged, forming a set of 37,815 green areas totalling 372,781 hectares in size.

A measure of green areas' attractiveness is derived from the Hotspotmonitor (2010) dataset from the University of Groningen. The Hotspotmonitor is an online survey tool which allows people to pinpoint, within Dutch national borders, two green or blue natural areas they perceive as being an attractive area on a Google Maps based map. The dataset used contains 6,036 points describing national attractive places, pinpointed by 3018 individuals[8]. These attractive places were imported in a GIS. I use the 6,036 national attractive places to add a measure of national attractivity to the green spaces regarded. Green areas incorporated in the Statistics Netherlands dataset showed to have been pinpointed 1,807 times[9], leading to a set of 892 national attractive green areas in the Netherlands, covering a total surface of 131,264 hectares.

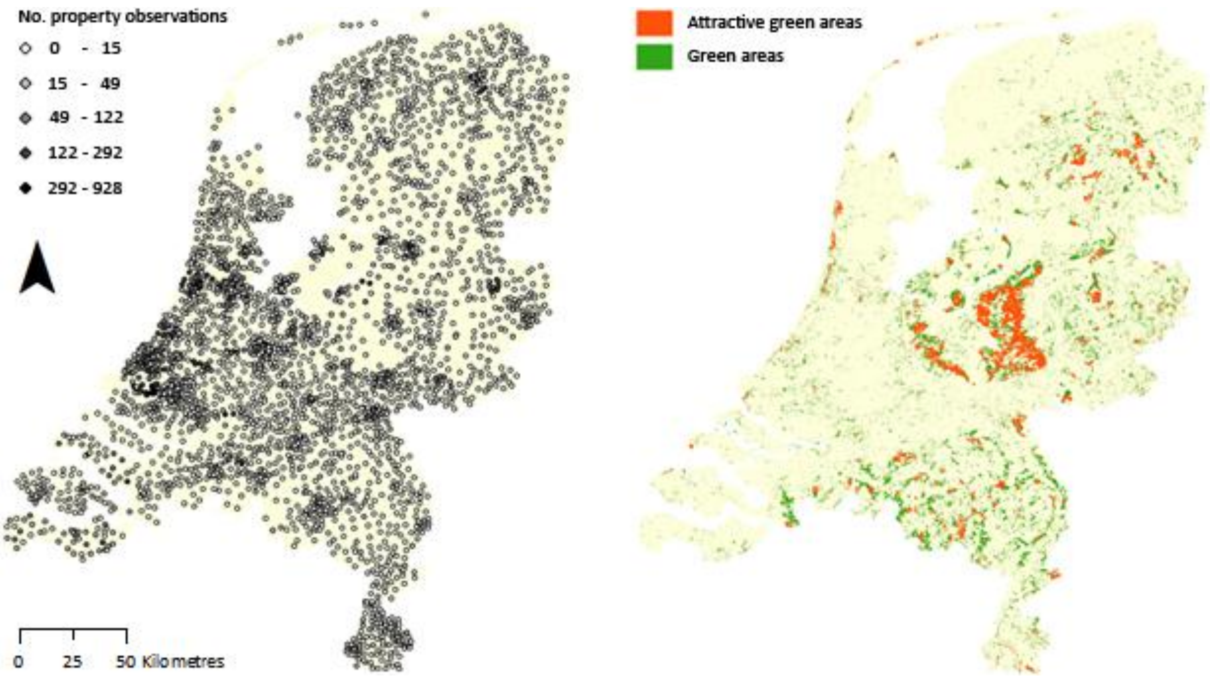


Figure 3.1 – Visualization of data

[8] Who live in different parts of the Netherlands. The sample of Hotspotmonitor respondents reflects the Dutch population's socio-economic distribution.

[9] When determining whether a green area has been pinpointed as being attractive, a spatial deviation in the marker's location of 50 meters around the green area is tolerated.

3.2 Green area indices

To measure the amount of green area within a household's living environment, a household's living environment is defined by the space within a 2.5 kilometre[10] radius from a household's property. Following studies by Hillsdon et al. (2006) and Cotteleer et al. (2008), of which the latter is a hedonic study, I construct a distance-weighted size index that weighs the size of all green areas within the 2.5 kilometre living environment for their distance to a specific property, as visualized in figure 3.2. This green area distance-weighted size measure covers the full spatial extent of the living environment radius specified, whilst incorporating the phenomenon of distance decay[11] in green area utility to households by dividing each green area's size by its distance to the household's property.

Figure 3.2 – Small-scale example of the used green area measure

The per property distance-weighted size index for green areas is specified by

$$G_i = {}_j \frac{S_j}{d_{ij < 2.5\mathrm{km}}} \qquad (11)$$

where G_i denotes the distance-weighted sizes of all green areas in the living environment surrounding property *i* as a sum of the size of each green area S_j, in square meters, divided by the Euclidean distance in meters *d* from the green areas' centroid to property *i*, which is first multiplied with a dummy which value is one when the distance is ≤ 2.5 kilometres and zero if the distance is larger. Figure 3.2 shows a simple example of how the index presented in equation (11) measures green areas A, B, C and D's distance-weighted size for property *i*, assuming that these are the only green areas within a 2.5 kilometre radius from property *i*. The index equations' specification allows for a flexible interpretation of a change in the index value. A marginal change in the distance-weighted size index for property *i* could in example reflect multiple, individually less impacting, changes in for example the surface of green areas A, B, C and D, or an increase in surface size for a

[10] Following a study on green area deficiencies in the Netherlands by De Vries et al. (2004).
[11] This phenomenon is discussed in section 2.2.

single green area at a distance in meters from property *i* equal to the increase in surface size in square meters.

A second distance-weighted size index describing solely relations between properties and attractive green areas is defined, based on the suggestion by Hillsdon et al. (2006) to add attractivity into the equation. In equation (12) the binary variable Att_j is added, that takes the value of 1 when green area *j* is national attractive, and 0 if not.

$$A_i = \sum_{j} \frac{Att_j S_j}{d_{ij < 2.5km}} \quad (12)$$

A_i Now describes a distance-weighted size measure of attractive green areas only, for property *i*.

3.3 Descriptives

The net annual disposable income of each household occupying one of the 65,268 properties observed in this study is known. Based on a household's disposable income level it is assigned to one of eight disposable income classes defined in table 3.1.

Table 3.1 – Disposable income classes

(€) Class[12]	Obs.	Mean	St.dev.
< 10.000	1,335	€6,484.75	€2,533.96
10.000 – 20.000	14,033	€15,850.45	€2,577.57
20.001 – 30.000	16,654	€24,779.19	€2,876.57
30.001 – 40.000	13,472	€34,844.62	€2,868.81
40.001 – 50.000	8,879	€44,530.12	€2,892.97
50.001 – 75.000	8,306	€59,244.28	€6,735.41
75.001 – 100.000	1,613	€84,405.26	€6,821.10
> 100.000	976	€151,256.40	€71,017.94
Pooled data	*65,268*	*€35,000.22*	*€23,674.94*

The dataset further contains continuous variables describing structural property characteristics, such as the number of rooms, the total liveable surface in square meters, and dichotomous variables, i.e. dummies. The dummies included in the model describe whether the property is an apartment, in which time period it was built, with the period of 1991 to 2009 as the reference, and the presence of a garden, garage or carport, balcony or roof terrace, or central heating. Dummies are given a value of 1 when the regarded property characteristic is present or 0 if the characteristic is absent. Properties' locational and neighbourhood characteristics include dummy variables describing whether a given property is located in the Northern, Eastern, Western or Southern part in the Netherlands, where the latter is the reference. Also the mean appraised value of properties, in euros, in the year 2008, in the municipality where an observed property is located is included in this vector, as well as the number of commercial companies in the municipality in 2009, and the observed properties' distance to a large municipality in kilometres.

[12] Statistics Netherlands' definition of disposable income was used to derive these values from the household's registered gross income. The income classes are based on Statistics Netherlands' income classes.

Table 3.2 –Values for green area indices, per household income class

Variable	Mean	*Std. dev.*
WOZ (€)	233,436	134,214
Apartment	.36	.48
Build before 1906	.04	.20
Building period 1906 - 1944	.16	.36
Building period 1945 - 1970	.30	.46
Building period 1971 – 1990	.29	.45
No. rooms	4.24	1.14
Total liveable surface (m²)	114.40	72.63
Garden	.67	.47
Garage or carport	.30	.46
Balcony or roof terrace	.44	.50
Central heating	.81	.40
Northern Netherlands	.06	.24
Eastern Netherlands	.20	.40
Western Netherlands	.62	.49
Regeneration neighbourhood	.08	.27
Mean property value in municipality (€)	239,360	68,911
No. of commercial businesses in municipality (x1000)	5.44	8.32
Distance to large municipality (km)	6.68	12.86
Green area index[13] (dw-m²)	1,406	1,510
Attractive green area index (dw-m²)	255	796

No. of observations = 65.268; Valid N = 65.268

Distance-weighted size indices for both green areas and attractive green areas are described in table 3.3 and figure 3.3. The mean and standard deviation of the distance-weighted size indices are reported for observations of each of the eight separate income classes, and one group of pooled observations.

Table 3.3 –Average values for green area indices, per household income class

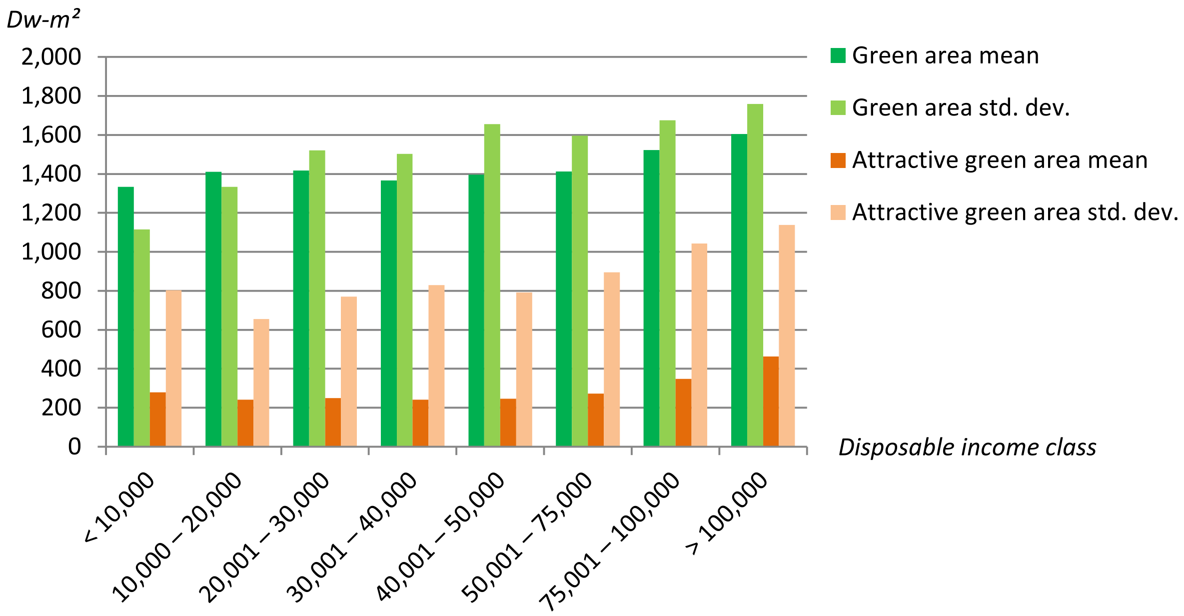
D.i (€) class	Green area index		Attractive green area index	
	Mean	*Std. dev.*	*Mean*	*Std. dev.*
< 10,000	1,333	1,116	279	804
10,000 – 20,000	1,411	1,333	241	655
20,001 – 30,000	1,418	1,521	250	771
30,001 – 40,000	1,366	1,503	242	830
40,001 – 50,000	1,396	1,656	247	792
50,001 – 75,000	1,412	1,597	273	895
75,001 – 100,000	1,522	1,676	348	1,043
> 100,000	1,605	1,760	463	1,139
Total	*1,406*	*1,510*	*255*	*796*

[13] With distance-weighted square meter (dw-m²) as the unit of measurement.

Table 3.3 shows that on average, the household's regarded may potentially derive utility from 1.406 square meters of green area within their living environment, with a standard deviation of 1,510, suggesting that rather large differences exist in the spatial distribution of green areas in the areas assessed. On average, less than a fifth share of this green areas' distance-weighted size is found to be national attractive. 44.4% Of the sample's households may actually enjoy the presence of attractive green area in their living environments, while regular green area is found in 99.3% of the regarded living environments.

For the lowest income households the distance-weighted size index for green areas has the lowest mean value reported, while the highest mean value is found for the highest income class group of households. However, the relation between income class and the mean distance-weighted size index for green area is not linear. As figure 3.3 shows, on average, index values are low for lower income level households, and then decrease somewhat with a further increase in household's income level, and then ultimately they rise for households from the two highest income classes.

The mean and standard deviation values for the distance-weighted size index for attractive green areas, shown per household income class in figure 3.3, reveals that apart from a relatively high value found for the lowest income class, the index seems more positively and linearly related with income level than the green area index. Also, the standard deviations show that larger relative differences between living environments exist in



Figuur 3.3 – Green area per household disposable income class

the amount of distance-weighted attractive green areas measured. Attractive green area index values are explicitly higher for households in the two highest income classes, compared to lower income classes' index values. The amount of green areas within households living environments that can be considered as being national attractive, by relating both indices mean values, is the largest for households from the two highest income classes.

3.4 Empirical model

In this study a hedonic price function is estimated using an ordinary least squares model. Variables have been selected based on the description of a 'full dataset' by Malpezzi (2002). Then correlations between predictors were examined, as well as the linearity of each predictor's relation with the predicted variable. Natural log transformations were applied to some predictors to enforce a linear relationship with the predicted variable.

The model, defined by a semi-logarithmic functional form[14], follows the equation

$$\ln P_i = \beta_0 + \beta_i S_{ij} + \beta_i N_{ij} + \beta_i G_{ij} + \epsilon_i \qquad (13)$$

where $\ln P_i$ is the price of property *i*, β_0 is the constant, vector *S* denotes *j* structural characteristics, vector *N* denotes *j* neighbourhood characteristics and vector *G* denotes *j* green area characteristics for the *i*th property observation, while epsilon ε denotes the error term[15].

The residuals are assumed to follow

$$\varepsilon \sim \text{i.i.d.N}\ (\mu, \sigma_\varepsilon^2) \qquad (14)$$

where μ describes the mean and $\sigma_\varepsilon{}^2$ the variance. Assumptions for the error term $\sigma_\varepsilon{}^2$ are homoscedasticity, e.g. constant variance, independence, denoted as *i.i.d.*, and a normal distribution (Yan & Su, 2009). Also, a linear relationship between all predictors and the dependent variable is assumed (Yan & Su, 2009).

When the hedonic price equation has successfully been estimated using regression analysis, marginal implicit prices for property characteristics can be derived from the corresponding capitalization parameters, as

$$WTP_{ij} = \beta_j / Q_{ij} * P_i \qquad (15)$$

where WTP_{ij} denotes the willingness to pay of household *i* for a marginal increase in the quantity of property characteristic *j* consumed, β_j is the capitalization parameter estimated for property characteristic *j*, Q_{ij} is the quantity of property characteristic *j* consumed by household *i*, and P_i is the assessed value of household *i*'s property.

[14] Literature does not provide a best practice to the specification of the functional form of the model estimated (Morancho, 2003; Anderson & West, 2006; Malpezzi, 2002). Malpezzi (2002) and Diewert (2003) do however recommend the use of a semi-log functional form.

[15] In studies on environmental amenity effects property characteristics are commonly subdivided by structural, neighbourhood and environmental amenity characteristics (see Geoghegan et al., 1997; Mahan et al., 2000; Anderson & West, 2006; Kong et al., 2007; Poudyal et al., 2009).

Some earlier studies apply a second-stage analysis to uncover structural demand parameters, by regressing implicit prices of a property characteristics upon the quantities consumed and household's socio-economic characteristics as suggested by Rosen (1974). This process may yield biased estimates due to endogeneity, and therefore not applied in this study (Epple, 1987; Sheppard, 1999; Malpezzi, 2002; Palmquist, 2003).

4. Empirical results

4.1 Green area capitalization

In this section three different models estimated for the pooled set of observations are presented. However, as green area capitalization may vary for groups of observations, discriminated by household income class, separate regression analyses are performed for these groups of observations. Neither of the estimations from either the pooled or income class specific hedonic models violates the assumptions for ordinary least squares regression. Each regression's set of studentized residuals satisfy the assumptions of normality and constant variance, and examination of the predictors' VIF values shows that no collinearity among these independent variables is present in neither model. Independence of predictors is assumed following Yan & Su (2009), as the data used consists of independent survey entries that have not been gathered in a time sequence.

I first present the pooled model's estimates, followed by the income class specific models' estimates. The estimates for the three pooled model variations are shown in table 4.1. Most parameters estimated are statistically highly significant. Model 1's adjusted R^2 value tells us that most variance in property values is explained by properties' structural characteristics. The apartment coefficient tells us that non-apartments are valued higher than apartments, while coefficients for dummies per time period in which a property was built indicate that properties constructed between 1991 and 2009, and properties build before 1905, are valued relatively higher than properties build in other periods. Positive capitalization into property values is separately found for the number of rooms, liveable surface and the presence of a garden, garage or carport, balcony or roof terrace, and central heating. The coefficients of logged independent variables are easy to interpret, as they reflect elasticities (Malpezzi, 2002). In example, a 10% increase in a property's total liveable surface leads to a 2.1% increase in the property's value.

Model 2 is more comprehensive than model 1, including variables describing properties' neighbourhood and locational characteristics. Model 3 is the 'complete' model, where variables for green area indices are added into the equation. The adjusted R^2 of 0.69 indicates that a large proportion of the variance in property values is explained by the predictors included in this model.

Table 4.1 – OLS estimations for a semi-log model

Variable[16]	Model 1		Model 2		Model 3	
	β	*t*	*β*	*t*	*β*	*t*
(Constant)		770.166		257.659		250.645
Apartment[a]	-.164***	-33.010	-.163***	-38.763	-.166***	-39.283
Build before 1905[b]	-.007**	-2.284	-.003	-1.318	-.005*	-1.900
Building period 1906 – 1944 [b]	-.075***	-22.868	-.087***	-31.974	-.091***	-33.022
Building period 1945 – 1970 [b]	-.246***	-69.534	-.237***	-79.912	-.239***	-80.450
Building period 1971 – 1990 [b]	-.167***	-48.270	-.168***	-58.124	-.169***	-58.444
No. rooms	.237***	67.059	.230***	78.270	.230***	78.314
Ln. total liveable surface (m²)	.212***	62.161	.202***	70.987	.201***	70.943
Garden[c]	.101***	20.617	.072***	17.674	.071***	17.473
Garage or carport[d]	.227***	76.959	.252***	99.000	.252***	98.955
Balcony or roof terrace[e]	.130***	37.583	.088***	30.420	.088***	30.247
Central heating[f]	.043***	15.191	.042***	17.450	.042***	17.447
Northern Netherlands[g]			-.024***	-8.826	-.026***	-9.631
Eastern Netherlands[g]			.018***	5.337	.016***	4.949
Western Netherlands[g]			.097***	27.204	.096***	26.833
Regeneration neighbourhood[h]			-.092***	-37.432	-.096***	-38.570
Ln mean municipal property value (€)			.318***	131.040	.312***	125.664
Ln no. of com. businesses (x1000)			.036***	11.692	.030***	9.544
Ln distance to large municipality (km)			-.090***	-32.641	-.092***	-33.345
Ln green area index (m²)			.014***	5.686	,004	1.637
Ln attractive green area index (m²)					.026***	9.938
R² adj.		0.54		0.69		0.69
F		7,081.443		7,463.885		7.106.254
Df		65,276		65,276		65,276

*Significance levels: * P<0.1 ** p<0.05 *** P < 0.01*

The coefficient for the index describing the distance-weighted size of green areas in a household's living environment, presented in model 2, indicates that the presence of green areas within 2.5 kilometre of a property capitalizes into the properties' value positively at a significance level of p<0.01. The inclusion of a variable which weighs the index in regard for green areas' attractivity, in model 3, shows that the distance-weighted size of attractive green areas within 2.5 kilometres is valued even more. Adding this variable into the equation in model 3 reduces both the, still positive, amenity effect and the significance level of the 'regular' green area distance-weighted size index, compared to the estimate for model 2. Presumably, the attractive green area distance-weighted size index reduces the regular green area distance-weighted size index' explanatory power, as the R² adjusted values for model 2 and 3 are nearly the same, when rounded off.

[16] References for dummy variables are [a] non-apartment, [b] building period 1991-2009 [c] no garden [d] no garage or carport [e] no balcony or roof terrace [f] other heating systems [g] Southern Netherlands [h] Non-regeneration neighbourhood.

Using the reported parameter for the attractive green area index, which gives the variables elasticity with property value, monetary benefits from an increase in attractive green area in a household's living area can be equated. A 10% increase in attractive green areas' distance-weighted size, within 2,500 meters from a property, increases the properties' value by 0.26%. When equated on this studies' sample's mean values, this means that either the realization of 25.5m² of attractive green area directly neighbouring a property valued at €233,435, or the realization of approximately 6.4 hectare[17] at a distance of 2.5 kilometre of the property, would increase the properties' value by €607. The size and distance values showed here are exemplary, as for each distance to the property a different size of attractive green area would hold the property values increase of €607 constant.

It should be noted that the equation discussed above is based on a parameter that is equal for all observations. Green area amenity effects may, however, not be constant for households from different income classes. As this study focusses at potential differences in willingness to pay for green area between households from different income classes, income class distinctive information on capitalization parameters is needed. Therefore, I perform separate regression analyses[18] to estimate green area distance-weighted size indices' capitalization parameters for observations grouped by disposable income class.

Table 4.2 – Parameters for distance-weighted m² of (attractive) green area, per income class

Model per	Obs.	Green area		Attractive green area		Model statistics		
income class (€)		*β*	*t*	*β*	*t*	*R² adj.*	*F*	*Df*
< 10,000	1,335	-.046**	-2.326	.005	.253	.60	101.353	1,334
10,000 – 20,000	14,033	-.006	-.934	.010	1.591	.58	967.055	14,032
20,001 – 30,000	16,654	.001	.102	.015***	2.630	.59	1218.290	16,654
30,001 – 40,000	13,472	.011*	1.660	.031***	4.720	.59	956.796	13,472
40,001 – 50,000	8,879	-.004	-.441	.039***	4.649	.57	579.978	8,876
50,001 – 75,000	8,306	.006	.677	.055***	6.273	.58	560.657	8,305
75,001 – 100,000	1,613	.003	.150	.074***	3.554	.60	121.859	1,612
> 100,000	976	.055**	2.176	.071***	2.607	.62	78.918	975
Pooled model	*65,268*	.004	1.637	.026***	9.938	*.69*	7.106.254	*65,276*

*Significance levels: * P<0.1 ** p<0.05 *** P < 0.01*

Table 4.2 shows these separately estimated parameters per group of observations distinguished. The hedonic models estimated follow specifications equal to the model 3 reported in table 4.1. A Chow test confirms that structural differences exist between these groups' parameters[19]. For practical matters, I present only green area indices' parameters for each model estimated, and some statistics on overall model performance (see table 4.2).

[17] 25,5m² * 2.500 = 63.750m² = ~ 64 hectare.

[18] For each regression the 'complete' model specification as used in model 3, presented in table 4.1, is used.

[19] The Chow test returns a F value of 38.26, which is larger than the critical F value of 2.54 for p < 0.001.

Households' valuation of green area in the living environment does, as suggested by the outcome of the Chow test, fluctuate across samples of different income groups. Households with a disposable income under €10,000 are found, statistically significant at the conventional $p<0.05$ level, to value the presence of green area in their living environment negatively. Insignificant valuation for green area is found for household disposable income classes ranging from €10,000 to €100,000, with an exception for households with a disposable income of €30,001 to €40,000 who value green area in their living environment positively, though only significant at $p<0.1$. Households in the highest income class value regular green areas' distance weighted size rather high compared to households with less income.

In contrast to green area distance-weighted size within the living environment, attractive green area distance-weighted square size is valued positively among all distinguished household income classes, mostly at a statistically highly significant level. The rate of capitalization of attractive green area distance-weighted size within the living environment into property values is found to be positively related with income level, as shown in table 4.2. Would households' willingness to pay for a marginal distance weighted square meter of attractive green area within the living environment show a similar relation with income?

4.2 Willingness to pay

Following earlier studies by Tyrväinen (1997), Rouwendal and Van der Straaten (2008) and Conway et al. (2010), I derive marginal prices households implicitly attach to attractive green areas. The derived implicit marginal prices reflect household's willingness to pay for a marginal distance-weighted square meter of attractive green area in their living environment, and can be used directly to evaluate changes in green area stock (Tyrväinen, 1997).

Willingness to pay is equated per observation, using the specific parameter shown in table 4.2 that corresponds with the disposable income class the observation belongs to. In table 4.3 and figure 4.1 households mean willingness to pay for a marginal increase in either the distance-weighted size of green area or attractive green area in their living environment are both presented per income class. When parameters used to equate willingness to pay are statistically significant they are marked explicitly in table 4.3, to indicate the willingness to pay values' statistical meaningfulness.

Households' willingness to pay for a marginal increase in distance-weighted size of attractive green area in their living environment shows a consistent positive relationship with income level. This holds for both the absolute values for mean marginal willingness to pay as for the ratio of mean willingness to pay to the mean disposable income per income class. On average households from each income class are willing to pay more for a marginal increase in attractive green area, than for a marginal increase in green area within their living environment. In absolute values, the difference between the mean willingness to pay for green area and attractive green area roughly increases for each relatively higher income class. The values for the groups of households in classes of the lowest and highest disposable incomes are the exceptions to this phenomenon.

Table 4.3 –Marginal willingness to pay for distance-weighted m² of (attractive) green area

Disposable	Green area MWTP				Attractive green area MWTP			
income (€) class	*Mean*	*Std. dev.*	*Sig.*	*% d.i.*[20]	*Mean*	*Std. dev.*	*Sig.*	*% d.i.*[21]
< 10,000	-€21.89	€123.76	**	-.338%	€3.79	€9.90		.058%
10,000 – 20,000	-€2.43	€11.91		-.015%	€8.18	€24.46		.052%
20,001 – 30,000	€0.59	€3.47		.002%	€14.10	€47.66	***	.057%
30,001 – 40,000	€7.89	€37.81	*	.023%	€33.67	€125.18	***	.097%
40,001 – 50,000	-€3.39	€22.24		-.008%	€42.52	€160.55	***	.096%
50,001 – 75,000	€6.33	€26.13		.011%	€70.57	€277.51	***	.119%
75,001 – 100,000	€3.05	€9.99		.004%	€113.19	€393.11	***	.134%
> 100,000	€91.91	€334.58	**	.061%	€138.44	€553.96	***	.092%
Pooled model	*€2.78*	*€14.97*		*.008%*	*€26.89*	*€99.01*	***	*.077%*

*The significance level (sig) of the beta used in the willingness to pay equation is given by: * P<0.1 ** p<0.05 *** P<0.01*

Households from the lowest income class are even willing to pay €21.89 for a marginal decrease in green area presence within their living environment, while they value a marginal distance-weighted square meter of attractive green area at €3.79[22]. In contrast, households having a disposable income of €100,000 or higher value both green area and attractive green area presence in their living environment most of all households. This group of households is also the sole group that attaches a relatively high value to regular green area distance-weighted size within 2.5 kilometres from their property.

The marginal willingness to pay values presented in table 4.3 are plotted as lines in figure 4.1, for an easier interpretation of their relation to the household income classes distinguished. Figure 4.1 shows that willingness to pay for attractive green areas' distance weighted size rises to a particularly high level for the two highest income classes. This is remarkable, as table 3.3, in section 3.4, showed us earlier that, on average, households from these income classes implicitly consume more distance-weighted square meters of attractive green areas than households from lower income classes. A higher consumption should, as shown in equation 15, lower marginal willingness to pay. Yet, households from the two highest income classes are willing to pay more for a marginal increase in attractive green area distance-weighted size within 2.5 kilometres from their property than

[20] This column contains values showing the mean MWTP for green area value as a percentage of the mean disposable income (d.i.) per disposable income class.

[21] This column contains values showing the mean MWTP for attractive green area value as a percentage of the mean disposable income (d.i.) per disposable income class.

[22] The values found for the <€10,000 income class are relatively high, as in this class the mean property value is rather high compared to other classes mean property values, due to the presence of a group of households who have a low income but own relatively expensive property. Further examination of data available shows that this group of households comprises of elderly and people with high savings.

households from income classes with lower amounts of attractive green area distance-weighted square meters present in their living environments. This is explained through relatively higher property values that are found among observations from the two highest income classes, as these outweigh the higher quantities of attractive green area consumed by these households in the equation of willingness to pay.

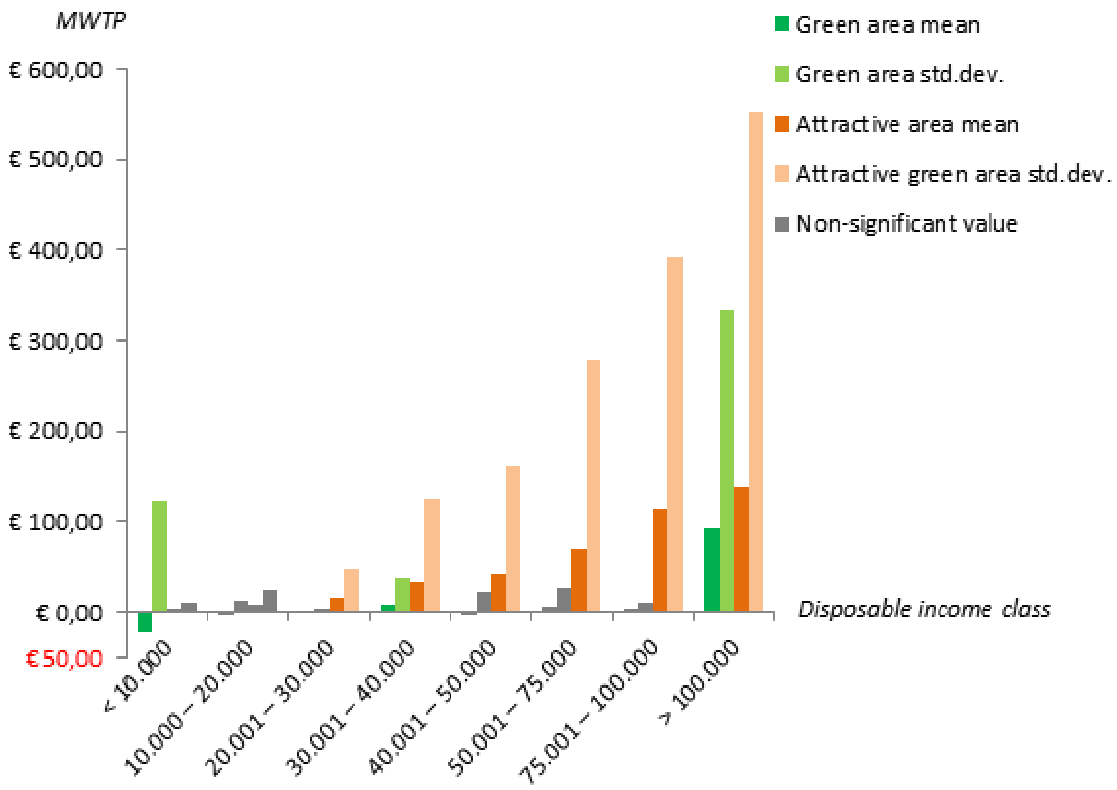


Figure 1.1 – Households' marginal willingness to pay for a distance weighted m² of (attractive) green area[23]

High property values also explain part of the volatility in standard deviations shown in table 4.3 and figure 4.1, indicating large differences in households' willingness to pay for (attractive) green area between, and within, the income classes distinguished. The green area distance-weighted size index' relatively high standard deviations, found for highest and lowest disposable income classes respectively, can be explained by upward deviations in property values that are relatively larger than the green area distance-weighted size deviations found for observations from these income classes, compared to deviations found among other income classes' observations. When equating willingness to pay for attractive green area distance-weighted size, a higher property value, ceteris paribus, leads to a higher value of willingness to pay for this property characteristic. The opposite holds for the value reflecting the measured quantity of attractive green area that is implicitly consumed by a household. Explaining the per each higher income class steepening increase in both the mean and

[23] The figure visualizes the values presented in table 4.3.

standard deviation values for households’ marginal willingness to pay for a distance-weighted square meter of attractive green area follows the same reasoning. Both the mean and standard deviation values describing quantities of distance-weighted square meters present in the living environment of households rise with each higher income class, but not as strong as property values increase. The overall bandwidth of willingness to pay is higher for a marginal distance-weighted square meter of attractive green area than for green area. However, standard deviation values for households’ willingness to pay for a marginal distance-weighted square meter of attractive green area show a relatively smaller distance from the mean than the values describing willingness to pay for a marginal distance-weighted square meter of green area. This indicates smaller relative differences in the valuation of a marginal distance-weighted square meter of attractive green area between the household classes distinguished.

5. Conclusions and discussion

This study explored the relation between Dutch households’ income level and their willingness to pay for attractive green area in their living environments. In this study the unit of green area measurement is the distance-weighted square meter. This measure was chosen as it allows for more detailed measurement of green areas than the common basic measures used in earlier studies. The distance-weighted size index takes into account the distance decay effects in household’s valuation of green area found by earlier studies, while a second version of this index has been used that also added green areas’ national attractiveness to the index’ equation. Hedonic price functions have been estimated for eight groups of observations, discriminated by the households’ disposable income level, and a pooled set of observations. By the estimation of these, equally specified, hedonic price functions, structurally different capitalization rates of both regular green areas and attractive green areas were revealed for the eight sets of household observations. From the capitalization parameters yielded by estimating the hedonic price function each single households’ marginal willingness to pay value was derived.

My findings show that the households regarded are implicitly willing to pay for a marginal increase in the amount of distance-weighted square meters of green area within their living environment. Households implicitly value national attractive green areas over green areas. Households from a relatively higher income class are willing to pay more for a marginal increase in the distance-weighted size of attractive green area in their living environments than households from a lower income class. The mean implicit value that households from different income classes implicitly attach to a marginal distance-weighted square meter of national attractive green area in their living environments ranges from €14.10 to €138.44. These values represent respectively 0.057% and 0.134% of the specific income class group of observations' mean annual disposable income. These values are difficult to compare to values reported in earlier studies, given the rather unique green area measurement technique applied in this study.

The positive relation found between households' disposable income class and households' valuation of attractive green areas within its living environment suggests that an household's financial budget may not only affect the quantity of green area 'consumed', as suggested by budget constraint theory, but may also influence the household's preferences for the quality of the green area. The latter suggestion arises from the observation that the presence of attractive green areas in the living environment capitalizes at a relatively larger magnitude into higher income households properties' values than into relatively lower income class households properties' values. A similar observation, be it for regular green areas, was reported earlier by Anderson & West (2006).

This study has multiple implications for spatial policy. My estimates show that the attractiveness of green areas is an important factor to take into account when designing greening strategies. Estimates presented in this study indicate that households from all income classes distinguished are on average implicitly willing to pay a premium for a marginal change in attractive green area presence in their living environments over a similar change in green area presence, with amounts roughly increasing with income level. Contrastingly, households' implicit valuation of green areas is found to be volatile, and more important, negative for households belonging to several mainly lower income classes. Therefore greening policy should be carefully tailored to the context of its target area's population characteristics to achieve the effects desired.

Another implication of this study is that conserving national attractive green areas benefits local residential property owners, as their properties' values partly depend on these areas' existence. These property owners, and potential property buyers as well, may be willing to pay for conserving, or realising, national attractive green area in their living environment, either implicitly or explicitly, where the latter would require further research.

The technique of green area measurement used in this study offers an opportunity for a future study to explore whether realising new attractive green areas is economically self-sustainable. As attractive green area amenity effects are assumed to extend to all properties within 2.5 kilometres of the green area's range, with an impact that varies by the distance between the green area and a specific property, the total value of the properties in this 'catchment area' may rise by a significant amount. Would property tax benefits to local governments, yielded by providing attractive green area, outweigh the costs of realising attractive green area? Such a study would be even more interesting when taking account of economic benefits, related to attractive green areas, households, which are not capitalized into property values, as suggested earlier by Conway et al. (2010).

This study has, however, some methodological limitations which may be addressed in future studies. Possible spatial autocorrelation in the model's residuals is not addressed, while the estimation of a spatial lag or spatial error model may prevent possible biases in estimation. The relation between household income level and the consumption of attractive green area may be explored further by estimating structural demand parameters as suggested by Rosen (1974). Although the measurement of green areas in this study was more comprehensive than in several earlier studies, it could be improved by adding a distance decay parameter to the index used, as suggested by Hillsdon et al. (2006). Also, as the green area measure used in this study was based on a dataset containing green areas with a lower boundary of one hectare in size, estimations could be improved by measuring green from a dataset also containing smaller green areas. Measures of green area attractiveness on a regional or even local spatial scale may yield deeper insight into households' implicit valuation of green areas.

Taking households' preferences regarding their physical surroundings into account is undoubtedly of value added when trying to understand the complex spatial relations at which spatial planning focuses, enabling better informed spatial policy (non)interventions that may contribute positively to households' wellbeing.

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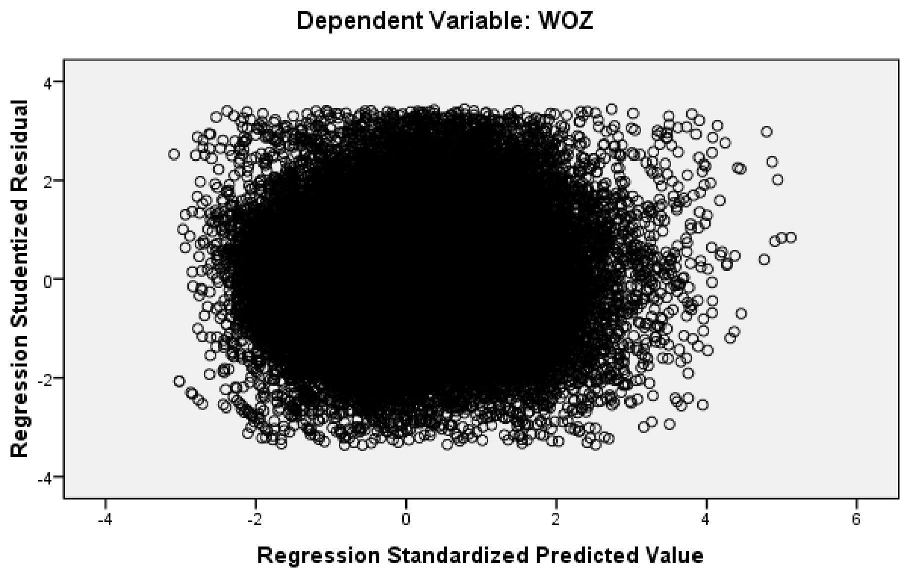
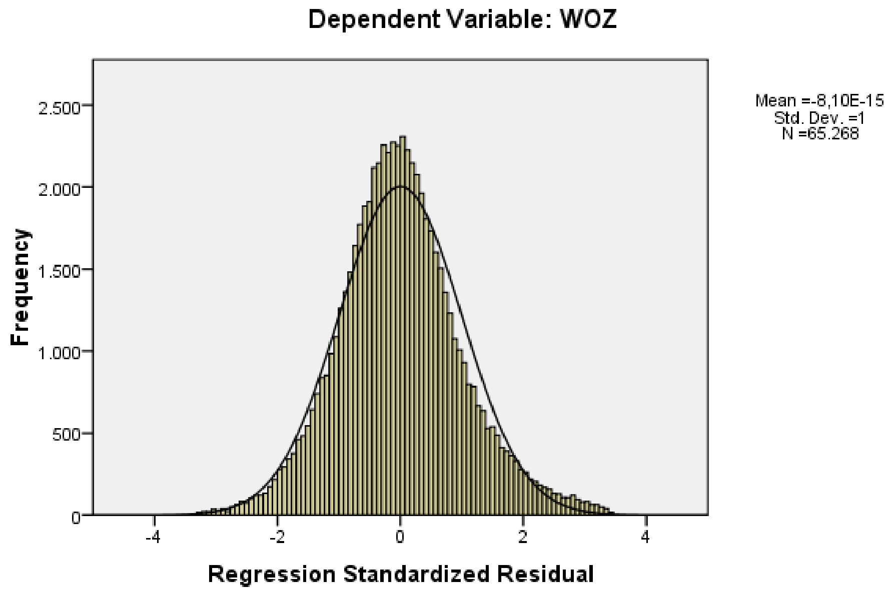
Appendix A – Model diagnostics

Model	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	7,695	,031		250,645	,000		
Apartment	-,162	,004	-,166	-39,283	,000	,271	3,684
Build before 1905	-,011	,006	-,005	-1,900	,057	,856	1,168
Building period 1906 – 1944	-,118	,004	-,091	-33,022	,000	,636	1,573
Building period 1945 – 1970	-,245	,003	-,239	-80,450	,000	,547	1,830
Building period 1971 – 1990	-,176	,003	-,169	-58,444	,000	,574	1,741
No. rooms	,077	,001	,230	78,341	,000	,558	1,793
Ln. total liveable surface	,180	,003	,201	70,943	,000	,599	1,671
Garden	,071	,004	,071	17,473	,000	,291	3,440
Garage or carport	,259	,003	,252	98,955	,000	,745	1,342
Balcony or roof terrace	,083	,003	,088	30,247	,000	,572	1,748
Central heating	,049	,003	,042	17,447	,000	,850	1,176
Northern Netherlands	-,051	,005	-,026	-9,631	,000	,652	1,533
Eastern Netherlands	,019	,004	,016	4,949	,000	,446	2,243
Western Netherlands	,093	,003	,096	26,833	,000	,375	2,663
Regeneration neighbourhood	-,165	,004	-,096	-38,570	,000	,781	1,280
Ln mean municipal property value	,614	,005	,312	125,664	,000	,781	1,281
Ln no. of com. businesses	,012	,001	,030	9,544	,000	,486	2,058
Ln distance to large municipality	-,033	,001	-,092	-33,345	,000	,628	1,592
Ln green area index	,002	,001	,004	1,637	,102	,738	1,354
Ln attractive green area index	,004	,000	,026	9,938	,000	,692	1,444

a. Dependent Variable: Ln WOZ


Dependent Variable: WOZ
Regression Studentized Residual
Regression Standardized Predicted Value
4
2
0
-2
-4
-4
-2
0
2
4
6


Dependent Variable: WOZ
Mean =-8,10E-15
Std. Dev. =1
N =65.268
Frequency
Regression Standardized Residual
2.500
2.000
1.500
1.000
500
0
-4
-2
0
2
4

Collinearity diagnostics[a]: variance proportions (1)

			(Constant)	Apartment	Build before 1905	Building period 1906 – 1944	Building period 1945 – 1970	Building period 1971 – 1990	No. rooms	Ln. total liveable surface	Garden	Garage or carport	Balcony or roof terrace
1	10.703	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	2.029	2.297	.00	.01	.00	.00	.00	.01	.00	.00	.00	.03	.01
3	1.064	3.172	.00	.01	.04	.26	.08	.01	.00	.00	.00	.00	.01
4	1.031	3.222	.00	.00	.13	.01	.04	.04	.00	.00	.00	.00	.00
5	.994	3.282	.00	.00	.59	.05	.01	.00	.00	.00	.00	.00	.00
6	.957	3.345	.00	.00	.01	.02	.06	.16	.00	.00	.00	.00	.00
7	.880	3.487	.00	.00	.00	.01	.03	.04	.00	.00	.00	.00	.00
8	.771	3.725	.00	.03	.01	.05	.02	.00	.00	.00	.01	.00	.06
9	.595	4.240	.00	.00	.00	.00	.03	.01	.00	.00	.01	.51	.05
10	.515	4.560	.00	.01	.00	.03	.00	.00	.00	.00	.00	.19	.00
11	.435	4.961	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01
12	.273	6.266	.00	.14	.00	.00	.00	.01	.00	.00	.00	.09	.56
13	.205	7.222	.00	.03	.14	.39	.40	.40	.00	.00	.00	.06	.06
14	.178	7.744	.00	.09	.03	.09	.12	.15	.00	.00	.00	.01	.06
15	.140	8.744	.00	.01	.02	.05	.11	.08	.01	.00	.02	.00	.01
16	.096	10.575	.00	.11	.00	.01	.05	.04	.04	.00	.09	.04	.00
17	.069	12.450	.00	.12	.01	.00	.00	.00	.32	.00	.66	.02	.16
18	.043	15.773	.00	.35	.00	.00	.01	.02	.45	.01	.16	.00	.00
19	.016	26.254	.01	.02	.00	.00	.00	.00	.10	.10	.02	.01	.00
20	.005	44.428	.03	.04	.00	.01	.04	.02	.08	.84	.00	.01	.00
21	.001	125.360	.96	.02	.00	.00	.01	.00	.00	.04	.00	.01	.00

a. Dependent Variable: Ln WOZ

Collinearity diagnostics[a]: variance proportions (2)

	Central heating	Northern Netherlands	Eastern Netherlands	Western Netherlands	Regeneration neighbourhood	Ln mean municipal property value	Ln no. of com. businesses	Ln distance to large municipality	Ln green area index	Ln attractive green area index
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.01	.01	.00	.04	.00	.01	.02	.00	.01
3	.00	.01	.01	.00	.01	.00	.00	.01	.00	.00
4	.00	.25	.05	.00	.00	.00	.00	.00	.00	.00
5	.00	.08	.01	.00	.00	.00	.00	.00	.00	.00
6	.00	.01	.10	.01	.02	.00	.00	.00	.00	.01
7	.00	.17	.05	.02	.20	.00	.00	.00	.00	.01
8	.00	.01	.05	.01	.31	.00	.00	.00	.00	.00
9	.00	.03	.01	.00	.09	.00	.00	.03	.00	.01
10	.00	.00	.00	.00	.14	.00	.01	.37	.00	.10
11	.00	.01	.02	.00	.02	.00	.02	.16	.00	.64
12	.01	.00	.00	.00	.06	.00	.12	.02	.00	.01
13	.01	.01	.00	.00	.03	.00	.20	.11	.00	.00
14	.34	.00	.00	.01	.03	.00	.31	.11	.00	.01
15	.52	.07	.13	.18	.02	.00	.16	.03	.00	.00
16	.08	.24	.49	.66	.01	.00	.02	.00	.01	.00
17	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
18	.02	.01	.03	.02	.00	.00	.02	.00	.14	.02
19	.02	.02	.01	.05	.00	.01	.00	.04	.78	.09
20	.00	.00	.01	.02	.00	.07	.00	.00	.05	.00
21	.00	.05	.01	.01	.00	.91	.12	.09	.02	.07

Correlations: definition of variables

Variable	Label	Variable	Label	Variable	Label
Ln WOZ	1	Ln. total liveable surface	8	Western Netherlands	15
Apartment	2	Garden	9	Regeneration neighbourhood	16
Build before 1905	3	Garage or carport	10	Ln mean municipal property value	17
Building period 1906 - 1944	4	Balcony or roof terrace	11	Ln no. of com. businesses	18
Building period 1945 - 1970	5	Central heating	12	Ln distance to large municipality	19
Building period 1971 - 1990	6	Northern Netherlands	13	Ln green area index	20
No. rooms	7	Eastern Netherlands	14	Ln attractive green area index	21

Correlations (1)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.000												
	65268												
2	-,497**	1.000											
	.000												
	65268	65268											
3	,076**	-,039**	1.000										
	.000	.000											
	65268	65268	65268										
4	,051**	-,032**	-,089**	1.000									
	.000	.000	.000										
	65268	65268	65268	65268									
5	-,249**	,120**	-,135**	-,284**	1.000								
	.000	.000	.000	.000									
	65268	65268	65268	65268	65268								
6	-,018**	-,078**	-,131**	-,275**	-,420**	1.000							
	.000	.000	.000	.000	.000								
	65268	65268	65268	65268	65268	65268							
7	,567**	-,534**	,052**	,049**	-,072**	.006	1.000						
	.000	.000	.000	.000	.000	.122							
	65268	65268	65268	65268	65268	65268	65268						
8	,571**	-,447**	,042**	.001	-,163**	,027**	,563**	1.000					
	.000	.000	.000	.782	.000	.000	.000						
	65268	65268	65268	65268	65268	65268	65268	65268					
9	,428**	-,814**	-,008*	,056**	-,111**	,085**	,457**	,380**	1.000				
	.000	.000	.037	.000	.000	.000	.000	.000					
	65268	65268	65268	65268	65268	65268	65268	65268	65268				
10	,482**	-,315**	-,009*	-,075**	-,096**	,032**	,335**	,379**	,264**	1.000			
	.000	.000	.020	.000	.000	.000	.000	.000	.000				
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268			
11	-,131**	,546**	-,039**	,011**	,115**	-,110**	-,164**	-,131**	-,604**	-,105**	1.000		
	.000	.000	.000	.006	.000	.000	.000	.000	.000	.000			
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268		
12	,259**	-,350**	,012**	,051**	-,128**	,057**	,223**	,213**	,334**	,156**	-,208**	1.000	
	.000	.000	.001	.000	.000	.000	.000	.000	.000	.000	.000		
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	
13	-,054**	-,083**	,020**	,011**	-.003	.001	,052**	,050**	,067**	,111**	-,076**	,060**	1.000
	.000	.000	.000	.005	.454	.723	.000	.000	.000	.000	.000	.000	
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268

Correlations (2)

	1	2	3	4	5	6	7	8	9	10	11	12	13
14	,024**	-,141**	-,014**	-,052**	-,035**	,038**	,072**	,063**	,127**	,109**	-,111**	,055**	-,131**
	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268
15	-,030**	,239**	,019**	,071**	,017**	-,058**	-,130**	-,145**	-,206**	-,237**	,200**	-,120**	-,329**
	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268
16	-,232**	,236**	-.001	,044**	,060**	-,083**	-,151**	-,152**	-,196**	-,134**	,126**	-,085**	-,053**
	.000	.000	.741	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268
17	,449**	-,153**	-,012**	,016**	-,028**	,026**	,118**	,114**	,142**	,103**	-,053**	,098**	-,144**
	.000	.000	.003	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268
18	-,248**	,394**	.005	,115**	.001	-,118**	-,253**	-,231**	-,329**	-,283**	,228**	-,204**	-,169**
	.000	.000	.214	.000	.839	.000	.000	.000	.000	.000	.000	.000	.000
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268
19	,045**	-,294**	,011**	-,093**	-,015**	,077**	,173**	,154**	,246**	,269**	-,231**	,147**	,122**
	.000	.000	.003	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268
20	-,052**	,162**	-,062**	,028**	,058**	-,016**	-,094**	-,075**	-,131**	-,108**	,148**	-,093**	-,098**
	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268
21	-,032**	,196**	.002	,141**	,042**	-,083**	-,100**	-,093**	-,149**	-,103**	,147**	-,080**	-,042**
	.000	.000	.691	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268	65268

Correlations (3)

	14	15	16	17	18	19	20	21
14	1.000							
	65268							
15	-,645**	1.000						
	.000							
	65268	65268						
16	-,063**	,125**	1.000					
	.000	.000						
	65268	65268	65268					
17	-,036**	,055**	-,128**	1.000				
	.000	.000	.000					
	65268	65268	65268	65268				
18	-,098**	,237**	,432**	-,243**	1.000			
	.000	.000	.000	.000				
	65268	65268	65268	65268	65268			
19	,150**	-,249**	-,214**	-,085**	-,516**	1.000		
	.000	.000	.000	.000	.000			
	65268	65268	65268	65268	65268	65268		
20	,089**	-,055**	,101**	,048**	,249**	-,277**	1.000	
	.000	.000	.000	.000	.000	.000		
	65268	65268	65268	65268	65268	65268	65268	
21	-,010*	,062**	,264**	,124**	,323**	-,211**	,425**	1.000
	.013	.000	.000	.000	.000	.000	.000	
	65268	65268	65268	65268	65268	65268	65268	65268