ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Bachelor Thesis [Urban Port & Transport Economics]

The Green City: How parks and public gardens influence the value of housing in Dutch neighborhoods.

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Abstract

The often unmonetized value of parks (and greenery in general) is argued to result in a sensitivity to urban pressures (More, Stevens & Allen, 1988) related to urbanization, presenting a trade-off between preservation of environmental amenities (such as parks) and urban densification (Osland, Östh & Nordvik, 2020). Considering the believed relevant setting of the Netherlands, this study therefore aims to quantify the value of parks and assesses their considerations through the, based on the hedonic pricing method, hypothesized positive relationship with housing value. Therefore, the effect of relative land use intended for parks and public gardens is estimated with a fixed effects regression on neighborhood level. The results however indicate a negative *decreasing returns* relationship and illustrates that the overall average marginal effect is negative as a one percent point (0.01) increase of relative land use intended for parks and public gardens in a neighborhood is associated with 0.004% decrease in average housing value for that neighborhood. Expressing these marginal effects in monetarized measures, this corresponds to a 1,131 euro decrease per house and a 891,546 euro decrease per neighborhood on average. However, the results also indicate that marginal effects for non-densely populated neighborhoods can be positive, ranging to 15,755 euro per house and 4,6 million euros per neighborhood on average. Moreover, high-value neighborhoods are found to have less negative marginal effects compared to low-value neighborhoods. Altogether, considering the locational distribution, positive effects appear to be mainly present for relatively large neighborhoods, while the strongest negative effects appears to apply mainly to small (city) neighborhoods.

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1. Introduction

Traditionally, (urban) parks, which mainly arose to increase the quality of life in cities around the industrial revolution following the associated massive urbanization and related decline of nature in the 20th century (Loures, Santos & Panagopoulos, 2007), have (among others) functioned as a place for recreation and environmental improvements (Solecki & Welch, 1995). Today, the notion on the potential importance of environmental amenities (such as parks) for the wellbeing of urban residents in terms of leisure, health and aesthetics is becoming increasingly well-known (Osland, Östh & Norvik, 2020). However, at the same time, these environmental amenities are under increasing pressure from current trends of urbanization (Osland, et. al.) as open spaces are paved to make way for buildings and roads necessary for a growing urban population (Poudyal, Hodges & Merrett, 2009). Together, this is argued to result in a trade-off between the preservation of environmental amenities and urban densification (Osland et. al.).

In the Netherlands, this trade-off seems to be gaining importance. On the one hand, environmental concerns and the ability of greenery to reduce the vulnerability of cities for climate change through, for example, better water management (Kennisportaal Klimaatadaptie), might result in a desired preservation of greenery. On the other hand, the Netherlands is struggling with a vast housing shortage, currently estimated by ABF Research at 300,000 houses (Kraniotis, 2021) and resulting in the planned building of 900,000 houses up to and including 2030 (NOS, 2022). This, in turn, leads to an increased pressure on greenery, as building such a large number of homes is accompanied by the idea that building in green areas is inevitable (Jansma & Roemer, 2021).

The sensitivity of parks (and green areas in general) to these pressures is argued to be primarily due to their non-monetized value (More, Stevens & Allen, 1988). Since most environmental amenities are public or quasi-public local goods, an observable market price is often lacking, which complicates their valuation (Osland et. al.). However, it is believed that parks can influence the attractiveness of locations and thus the surrounding real estate prices (More et. al.), which is, in turn, alleged to establish a link between ecology and economy (Luttik, 2000).

Assessing the value of parks through housing values can contribute to public awareness of the (potential) loss of value associated with the disappearance of parks (as illustrated by Tyrväinen & Miettinen, 2000). More ambitiously, assessing their value can additionally accommodate cost-benefit analyses relating to the preservation of environmental amenities (Osland et. al.) and can thus influence related decisions (Tyrväinen & Miettinen). This, in turn, might strengthen the position of existent greenery (Luttik) or encourage the introduction of new ones. Together, it might serve as a counterweight to urban expansion plans (Luttik) by ensuring long-run and sustainable protection (Osland et. al.).

Due to the Dutch standard in which parks and public gardens are combined into one measurement, the following research question is established:

How do parks and public gardens influence the value of housing in the Netherlands?

In order to make conclusions regrading this main question, the relationship between housing value and the relative land use intended for parks and public gardens is estimated with a fixed effects regression. In addition, several considerations regarding the value of parks are explored, referring to the inclusion of a quadratic term and both population and housing value interaction effects. By doing so, the research additionally hopes to contribute to the existing literature as such a research has, as far as the researcher knows, not been conducted for the Netherlands. The several considerations included may furthermore contribute to spatial design by indicating where parks are considered most valuable.

The remainder of this paper will first define both environmental amenities in general and parks in specific, followed by a discussion of their associated advantages, disadvantages and their expected relationship with housing value. This will ultimately result in hypotheses for both the main relationship and the considerations. Thereafter, the methodology will be discussed and individual choices will be elaborated on, subsequently further explained by a description of the data used and associated measures for every variable in the regression equation. Following, the results will be presented and conclusions regarding the established hypotheses and the main question will be made. Finally, the implications of these conclusions will be explored and recommendations regarding further research will be presented.

2. Theoretical framework

In order to establish hypotheses based on existing literature, first environmental amenities in general and their relationship with housing value will be explored. Thereafter, the choice for parks and public gardens will be elaborated on, followed by an identification of the associated advantages and disadvantages. Finally, measures will be identified and hypotheses related to the main relationship and considerations on this relationship will be established.

2.1 Environmental amenities and housing value

To explore the effect of environmental amenities (such as parks) on housing values, these attributes must first be defined. In their research into the concepts of environmental and natural amenities, Schaeffer & Dissart (2018) argue that although (environmental) amenities have been a topic of interest for several decades to economists, geographers and spatial planners, a generally accepted definition is still lacking. They however conclude that most scholars consider both environmental and natural amenities as '*place-based natural/environmental attributes that provide local benefits to people or firms'*.

Accordingly, they identify two converges in the literature regarding their characteristics as they appear to be characterized by the (i) impossibility to be moved to other locations and the (ii) local and often subjective impact on predominantly people (such as an improved quality of life). Referring to the latter, living in the proximity of environmental amenities is argued to provide a range of welfare benefits, including but not limited to improved physical and mental health, creative inspiration and enjoyable views (Gibbons, Mourato & Resende, 2014). However, their unpriced and intangible character makes their contributions often difficult to quantify (Jim & Chen, 2006).

To overcome this quantification challenge, house prices can be used through a so-called *hedonic pricing method*. The basic idea is that houses are valued for their attributes, consisting of their structural characteristics (such as house type and size) and locality (Luttik, 2000). Therefore, housing prices for locations with more enjoyable environmental amenities are, all else equal, expected to be higher (Osland, Östh & Nordvik, 2020). This premium is then argued to establish a link between ecology and economy, which, in turn, can demonstrate the value of these environmental amenities (Luttik). Accordingly, Luttik explores the effect of various environmental amenities on house prices in eight Dutch regions or towns and finds that attractive landscapes, compared to less attractive environmental surroundings, can yield a premium of 5-12%.

However, Panduro & Veie (2013) argue that the heterogeneity in types of greenery is associated with a great diversity of benefits (and costs) that these different types of greenery (such as parks or green buffers) provide. They therefore argue that green space is not 'one' (environmental) amenity, but consists of a collection of different amenities, each with its own effect on house prices. This ultimately leads them to the identification of 8 greenery classes based on accessibility, maintenance and the land use of adjacent areas. They accordingly find different estimated coefficients for different types of greenery, leading to the suggestion that the effect of environmental amenities on house prices should be specified into a focused group of environmental amenities rather than an aggregation.

2.2 Parks (and public gardens)

2.2.1 The effect of parks on housing values

In order to account for the heterogeneity in greenery described above, the research will focus on parks (and public gardens). Loures, Santos & Panagopoulos (2007) argue that the development of (urban) parks dates back to England where they were introduced to improve the quality of urban life during the industrial revolution era, following the associated massive urbanization and related decline of nature in the 20^{th} century. Currently, in the classification of greenery by Panduro & Veie (2013), parks are described as high maintenance areas which can provide multiple recreational opportunities and various features such as small lakes, flowers, trees, sport opportunities, and lawns.

Moreover, they are considered relatively accessible to the public through the identified footpaths that allow walking into the area. In combination with the relatively short average travel distance associated with parks of 0,9 kilometers (compared to e.g. forests of 1,7 kilometers) (CBS, 2015), the focus on parks in this research is expected to accommodate the earlier mentioned argued local character of impacts associated with environmental amenities (Schaeffer & Dissart, 2018). In their characteristics, parks differ from, for example, nature and agricultural areas, which are respectively considered less well maintained and relatively inaccessible.

Besides being accessible and consisting of different features, parks are associated with various advantages, possibly able to generate house price premiums. For example, Loures, Santos & Panagopoulos (2007) argue that (urban) parks can provide various environmental, recreational, psychological, aesthetical and economic benefits to communities. These benefits, in turn, can be further subdivided into two classes: (i) *on-site* benefits associated with people using the park directly, and (ii) *off-site* (*external*) benefits associated with people outside of the park (More, Stevens & Allen, 1988). As it is considered that these benefits can be provided simultaneously (Solecki & Welch, 1995), people living in proximity of urban parks are argued potentially able to benefit from both (More et. al.).

On-site benefits

More, Stevens & Allen (1988) argue, in accordance with the classification of parks as generating various recreational opportunities by Panduro & Veie (2013) above, that the main on-site park-related benefit refers to *recreational* possibilities, which are in turn often associated with its facilities and equipment (such as playgrounds and soccer fields). More et. al. however argue that on-site benefits can also refer to more passive activities, such as sitting on a bench or people watching.

Accordingly, Chiesura (2004) explores on-site benefits through perceptions and attitudes of people visiting urban parks in the Netherlands, France and Spain. Urban nature (in proximity of where people live and work) is argued to generate *emotional, psychological and social benefits*, which in turn improve the quality of life. Parks seem to create an ‘oasis’ in the city that people visit to escape from everyday life routines, the stressful city and the associated physical contours of cars and buildings, to a relaxed and safe environment where they can socialize. In addition, it is claimed that the experience of nature can generate a collection of positive feelings, ranging from freedom to happiness and luck.

Since parks are considered environmental amenities (e.g. Schaeffer & Dissart, 2018), the previously argued benefits of general environmental amenities related to their direct use, such as the potentially improved health*,* pleasing views (*aesthetic*) and creative inspiration (Gibbons, Mourato & Resende, 2014), are additionally expected to apply here.

External benefits

Parks can furthermore provide various (often *environmental*) external benefits, such as reduced air pollution provided from trees, provision of habitat for wildlife ranging beyond the border of the park (More, Stevens & Allen, 1988) and flood protection (Solecki & Welch, 1995). Referring to the latter, it is in general believed that greenery in cities can reduce the vulnerability of these cities to climate change related problems, as it can, for example, improve water management and limit warming, thereby mitigating effects from high temperatures and heavy rainfall (Kennisportaal Klimaatadaptie). In dense urban environments, greenery can additionally reduce housing density and thus improve light and reduce noise (Panduro & Veie, 2013).

Besides all abovementioned benefits associated with parks, Lin, Wu & De Sousa (2013) also describe some possible *negative* externalities, such as congestion and noise resulting from the activities parks offer and their users.

Altogether, the argued local character of their impacts (Schaeffer & Dissart, 2018) and their classification as accessible and capable of providing a wide range of features and associated benefits described above (e.g. Panduro & Veie, 2013; More, Stevens & Allen, 1988), lead to the expectation that parks can still make substantial contributions to the attractiveness and thereby the housing value of locations. More generally, More et. al. argue that parks provide benefits that are reflected in the real estate prices of the surrounding areas (according to Loures et. al. referring to the *economic* benefit provided by parks), as they can make locations (neighborhoods) pleasant places to live.

In order to estimate the (net)effect of these advantages (and disadvantages) related to parks on housing values, parks must be measured. In their previously cited research into the concept of environmental amenities, Schaeffer & Dissart (2018) find that the percentage of *land use intended for* (area share) or *distance to* are the predominantly used indicators to measure *green area, open space & park* (one of the most commonly used measures for environmental amenities) in empirical studies. However, Osland, Östh & Nordvik (2020) argue that parks should be measured by their area share, as the value of larger parks is capitalized into house prices rather than living in closer proximity. (The choice for this measure is further explained in the Methodology section.) Accordingly, Osland et. al find (in their Oslo based study) a positive relation between the relative land use for parks and house prices, as a house located in an area where the relative land use for parks is highest can attract a premium of 7.3% over houses located in areas with the lowest relative land use for parks.

Since the land use intended for both parks and public gardens has been combined into one measurement in the Netherlands, and this study uses house values rather than house prices (explained further in the Data section), this results in the hypothesis below.

The relative land use intended for parks and public gardens in a neighborhood is expected to positively influence the value of housing in this neighborhood.

2.2.2 Considerations on the value of parks

However, various factors can influence the value of parks and therefore also the above established hypothesis. Fernandez & Bucarem (2019) for example consider the complexities of the housing market, which may cloud valuation. They argue that locational and geographic specifics can influence the capitalization of amenities into prices. Likewise, the state of the economy and it's cycles are hypothesized to influence the buyer's perception of amenities, which, in turn, might influence their contribution to price formation.

Population density

Osland, Östh & Nordvik (2020) furthermore review the importance of population density and argue that the value of open spaces (such as parks) is higher in more densely populated areas. For parks, this could be the result of the earlier argued (Chiesura, 2004) 'oasis' that parks can create, which in densely populated areas might differ more strongly from the general landscape. In addition, the described benefits related to reduced housing density might be more relevant here. Together, it results in the following hypothesis:

The population density in a neighborhood is expected to increase the value of parks.

Housing value

Likewise, the value of parks in neighborhoods might be influenced by the average housing value in these neighborhoods, due to associated different appreciations and perceptions of residents in these areas (related to parks), which in turn can influence capitalization. Moreover, high-value areas might already be relatively more attractive locations, which might lead to a lower added value associated with more land use intended for parks and/or public gardens, resulting in the following hypothesis:

The average housing value of a neighborhood is expected to decrease the value of parks.

3. Methodology

To estimate the effect of relative land use intended for parks and public gardens in a neighborhood on the housing value of houses located in this neighborhood, a semi-log regression with both individual and municipal specific time fixed effects is supplemented with multiple control variables. In the following paragraphs, the choices made with regard to the methodology will be elaborated on by discussing the individual elements and their considerations. Furthermore, a regression equation and related interpretation of the estimated coefficient for relative land use will be described.

3.1 General regression set-up

Relative land use

The main variable of interest for all regressions refers to the relative land use intended for parks and public gardens. The use of a relative rather than an absolute measure allows the size of neighborhoods to be taken into account, since a park of a given size is expected to have a different value for its surroundings when this area refers to a large or small neighborhood. Moreover, the use of an absolute measure would suggest that the amount of park in a neighborhood could increase indefinitely, while the total size of a neighborhood is often (if not always) fixed and an increase in land use intended for parks and public gardens therefore necessarily leads to a decrease in land use for other uses. The relative measure, as roughly suggested by Gibbons, Mourato & Resende (2014), therefore ultimately illustrates the effect of an increased share of land for parks while shares for other uses, for example urban or other (environmental) amenities decrease. Finally, the use of a land use measure in general is in line with the intended contribution to the discussion regarding the trade-off between urban expansion (associated with a decrease in land use intended for greenery) and preservation of greenery.

Semi-log

To estimate the effect of relative land use for parks (and public gardens) the study will use a log-linear regression model specification, for which the effect of the explanatory variables is proportional to the level of the dependent variable, based on several considerations. Jim & Chen (2006) first conclude that semi-log hedonic pricing models provide, compare to linear ones, more accurate house price estimates (for their Guangzhou based study). Moreover, Gibbons, Mourato & Resende (2014) and Bolitzer & Netusil (2000) both prefer a semi-log specification, arguing that this is the standard in recent studies and allows for a non-constant relationship between the explanatory and dependent variable, respectively. While log transformations results in missing values for observations with original housing values of zero, this problem seems insignificant for this research as the minimum value if greater than zero (further elaborated on in Table 4.1 of the Data section).

Fixed effects

Furthermore, fixed effects will be used as this allows for the control of variables that cannot or are not measured (Allison, 2009). Using both individual and municipality-specific time fixed effects allows controlling for bias resulting from excluded variables that are constant over time but are different across entities (neighborhoods) *and* bias from excluded variables that are constant over entities (neighborhoods) but change over time, respectively (Hanck, Arnold, Gerber & Schmelzer, 2019).

For the neighborhood fixed effects, each *individual* (in this research; neighborhood) is used as its own control, thereby controlling for all stable characteristics of *individuals* (neighborhoods) (Allison, 2009). These fixed effects are for example expected to capture the heterogeneity of locational and geographic specifics that can influence amenity capitalization into prices mentioned before (Fernandez & Bucarem, 2019). Moreover, Gibbons, Mourato & Resende (2014) argue that including time fixed effects can deflate the house value (price) data, which in turn allows the estimation to capture the '*pure change in housing prices*' over the observation periods (Osland, Östh & Nordvik, 2020). In order to recognize the potential difference in time effects between locations, the time fixed effects are added per municipality, thereby expected able to capture both municipal-specific and general (nation-specific) time effects such as the state of the general and local economy which, as aforementioned, can influence the perceptions of buyers regarding amenities and thus their contribution to price formation (Fernandez & Bucarem).

However, Allison argues that using a fixed effects regression comes with two data requirements: (i) the dependent variable (in this research; WOZ) must be measured at least twice for every *individual* (neighborhood) and these observations must be directly comparable and (ii) the explanatory variables of interest (in this research; land use) must be different in value for a substantial part of the sample. As this research uses panel data, which refers to the analysis of multiple neighborhoods in multiple observation periods, the first requirement is expected to be fulfilled. Based on the (*between* and *within)* standard deviation of land use intended for parks and public gardens illustrated in Table 3.1 below, there appears to be sufficient *within* variation, and the change in value for the explanatory variable of interest is therefore considered sufficiently, satisfying the second requirement.

Table 3.1 Standard deviation land use intended for parks and public gardens

	Mean	Std. dev	Min	Max
Overall	2.451	6.612	0	199
Between		6.622	0	195.75
Within		1.407	-72.299	57.951

Notes: Where between refers to the variation between different neighborhoods and within refers to the variation within the same neighborhood.

Control variables

While the usage of fixed effects can control for some of the potential bias, it is unable to control for time-varying characteristics of the neighborhood (Allison, 2009). Therefore, first *sociodemographic* neighborhood characteristics (population composition and income) are considered, which are believed to fluctuate over time. In addition, as indicated earlier, besides land use for parks and public gardens, various attributes of the house and its surrounding can influence the value of the house (which might also correlate with the land use for parks and can thus impose bias). To justify the requirement of the *hedonic pricing method* to include all these attributes (Luttik, 2000), the model includes two additional types of explanatory variables: *housing characteristics*, consisting of a range of variables indicating the housing composition of neighborhoods and *features of the location* consisting of the accessibility to various amenities (as locality does not only corresponds to environmental amenities such as parks (Luttik)).

However, when choosing appropriate control variables, the implications for the estimated park effect should be taken into account. For example, Osland, Östh & Nordvik (2020) argue the situation in which only people with higher incomes can afford to live in areas with enjoyable parks and/or public gardens, so that the estimated relationship does not reflect the average willingness to pay, but rather preferences that are only realizable for people with a high income. This results in the idea of adding income as a control variable. However, it could also be argued that the attraction of people with a high income and the associated expected increase in the house price is part of the park effect (by increasing the attractiveness of the location) and controlling for income thus results in an incomplete park estimate.

Such a trade-off must be made for all potential control variables, in this study resulting in the exclusion of income but preservation of all other control variables as their inclusion and possibly related incomplete estimated parks effect is believed not to be a result of the increased attractiveness of locations, which this research ultimately seeks to quantify. For example, increased land use for parks necessarily leads to a decrease in land use for other uses (because the total area of a neighborhood is often fixed), such as housing, and can thus be associated with a lower number of houses. Although this in turn might be associated (from simple supply and demand theory) with a higher house price, this reduced number of houses is not due to the possible increased attractiveness of the location, but rather the scarcity of land.

3.2 Model specification and interpretation

In this research, all discussed elements ultimately result in the following regression equation:

$$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \beta_2(relative\ land\ use_{i,t}^2) + \beta_3(interaction\ effect(s)) + \beta_4(housing\ characteristics_{i,t}) + \beta_5(sociodemographic_{i,t}) + \beta_6(location\ features_{i,t}) + FE_i + FE_{j,t} + \varepsilon_{i,t}$$

The dependent variable refers to a natural logarithmic transformation of the average *WOZ value* per neighborhood, which is used as a proxy for housing prices (further elaborated on in the Data section). The variable of interest then corresponds to the *relative land use* intended for parks and public gardens, measured in shares. In order to test for a non-linear relationship a *quadratic term* is added. Referring back to the considerations on the value of parks, *two interaction effects* are included, referring to (i) population density and (ii) a dummy indicating a high or low WOZ value location based on the median housing value of 239 thousand euros (further elaborated on later). Finally, several control variables groups (*housing characteristics, sociodemographic, location features*) and both individual (FE_i) and municipality specific time fixed effects ($FE_{j,t}$) are added. The neighborhood and municipality of each observation is indicated by subscript i and j respectively.

Estimated coefficients of the main variable of interest should be interpreted as followed: *A one percent point increase (0.01) in the relative land use intended for parks is associated with a* β_1 *percent increase in average WOZ value.*

4. Data

In order to specify the regression equation prepared above, the following section elaborates on the characteristics of the related data used. First, general elaboration on the data source and level will be made, followed by a discussion of the dependent and independent main variables. Detailed information and descriptive statistics on individual variables within the additional control variable groups can be found in Appendix A.

General data specifics

All data corresponds to open data from *Centraal Bureau voor de Statistiek* (from now on CBS), which argues to gain insight into social issues in the Netherlands by providing reliable information and data (CBS, n.d.-a). As previously argued, only data at *neighborhood* level is used, as this is the most disaggregate measure available (measures at district or municipal level are therefore excluded). Accordingly, CBS defines a neighborhood as a homogenously demarcated area from a constructive or socio-economic point of view, which is part of a municipality and often also part of a district (CBS, 2021). To match the data availability of all variables, the data used only corresponds to the years 2010, 2012, 2015 and 2017 (CBS, n.d.-b/ CBS, n.d.-h).

4.1 Dependent and explanatory variables

WOZ value

The dependent variable in this study corresponds to the average value of real estate based on the *Wet Waardering Onroerende Zaken (WOZ)* per neighborhood (for neighborhoods with a housing stock greater than 20/ number of WOZ objects greater than 50) (CBS, n.d.-b). This valuation is determined by means of an appraisal of comparable properties sold around the valuation date and measured as the amount that the real estate should yield on January 1st of the previous year (Rijksoverheid, n.d.).

The WOZ value is used as a proxy for house prices as the average transaction house price measures average purchase prices of the homes sold within the observation period, and thus depends on the characteristics of these houses sold. To illustrate: if in a certain period mainly large detached houses with vast gardens are sold, the average purchase price will probably be higher compared to a period when mainly small terraced houses are sold, although this does not necessarily means that the value of the houses within the neighborhood is higher in the first period (CBS, n.d.-i). Although the possible retrospective nature of the WOZ value might also distort the estimates, the limitations of transaction house prices described above are considered to be more problematic. However, for completeness, in the establishment of the final model lags are considered.

Table 4.1 below illustrates the descriptive statistics of the average (logarithmic) WOZ values. Because the WOZ value distribution appears to show some high outliers (which do not necessarily correspond to errors) as illustrated by Figure C.1 in the Appendix, the WOZ value for high and low value areas is divided based on the median value of 239 thousand euros.

Table 4.1 Descriptive statistics average (logarithmic) WOZ value for Dutch neighborhoods.

Variable	Number of observations	Mean	Standard deviation	Min	Max
WOZ value	37,463	262,174	119543.3	38,000	1,941,000
Log WOZ value	37,463	12.394	0.398	10.545	14.479

Relative land use for parks and public gardens

The main variable of interest in this study corresponds to the relative land use intended for parks (and public gardens). This variable is determined for each neighborhood based on the formula below:

$$\frac{area\ intended\ for\ parks\ and\ public\ gardens\ (ha)}{total\ area\ (ha)}$$

The area intended for parks and public gardens is by CBS indicated as land with landscaping in use for relaxation and consists of the following: (i) areas open to the public consisting of lawns, playing and sunbathing areas, paths, flower beds, shrub plants, water features and groves (ii) greenbelts and forest-like sections of the park (CBS, n.d.-e). The total area per neighborhood is also measured by CBS as the sum of inland water and land areas in whole hectares (CBS, n.d.-b).

In order to align the total area of the neighborhood with the park measure (which can also consist of water features), water areas have also been included here. Table 4.2 below illustrates the descriptive statistics and hints towards the presence of a few outliers, the largest of which corresponds to 100% in the *Postwegflat* neighborhood and a park which is additionally classified as neighborhood. After research into the relevant neighborhoods (via Google Maps, Kadastrale Kaart and Funda), these neighborhoods indeed appear to have a lot of greenery, and it can therefore not be concluded with certainty that these are erroneous outliers, causing their retention.

Table 4.2 Descriptive statistics average total and relative land use for parks and public gardens for Dutch neighborhoods.

Variable	Number of observations	Mean	Standard deviation	Min	Max
Land use	49,448	2.451039	6.612322	0	199
Relative land use	49,447	0.0339503	0.0755148	0	1

Population density

For the interaction effect, population density is measured as the number of residents per square kilometer, measured on the 1st of January of each year by CBS. The measure is calculated based on the number of residents divided by the total land area, and is only calculated for neighborhoods with 10 or more residents (CBS, n.d.-b). To allow for the interpretation of estimates, the measure is rescaled and used in hundreds of people. Table 4.3 below illustrates descriptive statistics.

Table 4.3 Descriptive statistics population density for Dutch neighborhoods.

Variable	Number of observations	Mean	Standard deviation	Min	Max
Population density	47,141	27.17827	34.80663	0	359.21

5. Results

In the following section, the establishment of the preferred semi-log fixed effects model supplemented with several control variables and a possible quadratic relationship is discussed in detail. Thereafter, the results regarding the main hypothesis of a positive relationship between relative land use intended for parks (and public gardens) and the value of housing will be assessed and supplemented with the assessment of the established hypotheses regarding the considerations on the value of parks related to population density and WOZ levels. The various considerations and comparisons (e.g. with absolute measures) will first be individually assessed to allow for interpretation. Appendix B provides a full description of the regression equations and results for the different models by number.

5.1 Establishing the model

Table 5.1 below illustrates the results for the variable of interest *relative land use* while the full models are documented in Table B.1 of the Appendix. Model 1 refers to the estimate with only relative land use as an explanatory variable. Model 2, 3, 4 and 5 respectively introduce *income* and the three control variable groups; *housing characteristics* of the neighborhood, *sociodemo*graphic neighborhood measures and *location features*. Model 5 and 6 subsequently introduce *individual neighborhood* and *general time fixed effects* respectively. Finally, Model 7 substitutes the general time fixed effects for *municipal specific time fixed effects*. In order to accommodate comparison, Models 1/5 (without fixed effects and with robust standard errors) and Model 6/8 (with fixed effects) are set to the same sample.

Table 5.1 Regression results of the relationship between relative land use intended for parks & public gardens and WOZ values, adding control variable groups and fixed effects one by one.

	Log WOZ value							
Variable	**(1) OLS**	**(2) + income**	**(3) + housing charact**	**(4) + sociodemo**	**(5) + location features**	**(6) + individual FE**	**(7) + general time FE**	**(8) + municipal time FE**
Relative land use	-1.004***	-1.106***	-0.753***	-0.458***	-0.349***	-0.048	0.006	0.031
	(0.033)	(0.022)	(0.031)	(0.027)	(0.027)	(0.030)	(0.022)	(0.020)
Constant	12.434***	11.557***	1.275***	4.464***	5.412***	10.972	11.226	11.616
	(0.002)	(0.011)	(1.989)	(1.669)	(1.605)	(0.566)	(0.422)	(0.385)
Observations	37,114	36,433	37,114	37,114	37,114	33,346	33,346	33,346
R^2	0.036	0.371	0.114	0.352	0.388	0.970	0.984	0.988
Individual neighborhood fixed effects	No	No	No	No	No	Yes	Yes	Yes
Municipality specific time fixed effects	No	No	No	No	No	No	No	Yes
General time fixed effects	No	No	No	No	No	No	Yes	No

Standard errors in parentheses (for non-fixed effects regressions, robust standard errors are used); * p < 0.1, ** p < 0.05, *** p < 0.01

Considering income

Based on the consideration discussed previously regarding the exclusion of income as a control variable, Model 2 in Table 5.1 (full results in Table B.1 of the Appendix) above gives results including income. While the relative land use effect remains highly significant, the positive correlation between income and relative land use for parks (which could, matching expectations, indicate that people with higher incomes sort in green neighborhoods) and the significant positive income effect on housing value, together result in income lowering the estimated relative land use coefficient. This could indicate, again matching expectations, that a part of the (positive) park effect results from a self-sorting effect and is thus lost when controlling for income. Since it is argued that the self-sorting effects is a result of the increased attractiveness of the neighborhood related to an increases park area, income is not added as a control variable.

Considering the control variable groups

Although the estimate for the relative land use effect in Table 5.1 above appears to be highly significant in simple Model 1, several effects of including control variable groups and fixed effects can be distinguished. While the coefficients of individual variables within the control groups often differ (Table B.1 in the Appendix), adding the three groups of control variables (Model 3/5) overall increases the estimated relative land use effect (associated coefficient less negative), indicating an underestimated relative land use effect related to their exclusion.

Likewise, adding individual and time fixed effects (Model 6/7) is associated with an increased coefficient, again indicating the elimination of an underestimated relative land use effect. Moreover, the addition of time fixed effects (Model 7/8) results in a non-significant relative land use effect, which could indicate that both relative land use for parks and housing value differ over time without a clear relation between the two. Furthermore, substituting general time fixed effects with municipal specific time fixed effects (Model 8) is associated with a stronger increase in the relative land use effect, demonstrating that the two are indeed different from each other, which is expected to justifying the inclusion of the latter as it is believed to be more comprehensive.

Since the coefficient of relative land use differs between all model specifications, bias might be present for the exclusion of all additions. Thus, controlling for all identified groups of control variables and adding (municipal specific) fixed effects in Model 8 is expected to provide the most reliable estimates and therefore refers to the preferred model, which will now be expanded and discussed in more detail.

5.1.2 Basic relative land use effect

Based on Model 8 in Table 5.2 below (and Table 5.1 above), an increase of 1 percent point (0.01) relative land use intended for parks & public gardens is associated with a *non-significant* 0.03% increase in average WOZ value. Allowing for a non-linear (quadratic) relationship, Model 8q of Table 5.2 (full regression results in Appendix B.2) however illustrates a highly significant quadratic relationship, whose addition is furthermore associated with the level relative land use effect becoming highly significant negative. Together they indicate that the relationship between relative land use intended for parks and public gardens and housing WOZ values is characterized by jointly significant *(F(2,22993) = 10.21, corresponding to a p-value of 0.000) decreasing returns*, indicating that the negative effect weakens in the level of relative land use.

Furthermore, Table B.2 in the Appendix illustrates that this negative *decreasing returns* relationship is present for all model specifications, while the specific form changes (without a clear pattern but eventually appearing to become less steep and less negative, as visualized in Figure B2 in the Appendix). As argued before, Model 8 is expected to provide the most reliable estimates, and is therefore also preferred here.

Table 5.2 Regression results of the relationship between relative land use intended for parks & public gardens and WOZ values, allowing for a quadratic relationship.

	Log WOZ	
Variable	**(8)**	**(8.q) + quadratic**
Relative land use	0.031	-0.089***
	(0.020)	(0.035)
Relative land use^2		0.421***
		(0.099)
Constant	11.616	11.608***
	(0.385)	(0.384)
Observations	33,346	33,346
R^2	0.988	0.988
Neighborhood individual fixed effects	Yes	Yes
Municipality time fixed effects	Yes	Yes
Control variables	Yes	Yes

Standard errors in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

Notes: Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features).*

Figure 5.1 below visualizes the marginal effect of a 1 percent point (0.01) increase in relative land use intended for parks and public gardens and indicates that the above described *decreasing returns* can eventually result in a positive marginal effect (from around 0.11 share of land use intended for parks and public gardens). When considering the distribution of relative land use values (Figure C.2 in the Appendix) these observations however appear to be in minority. Therefore, the average marginal effect is negative (-0.06%) for the observations in the regression sample.

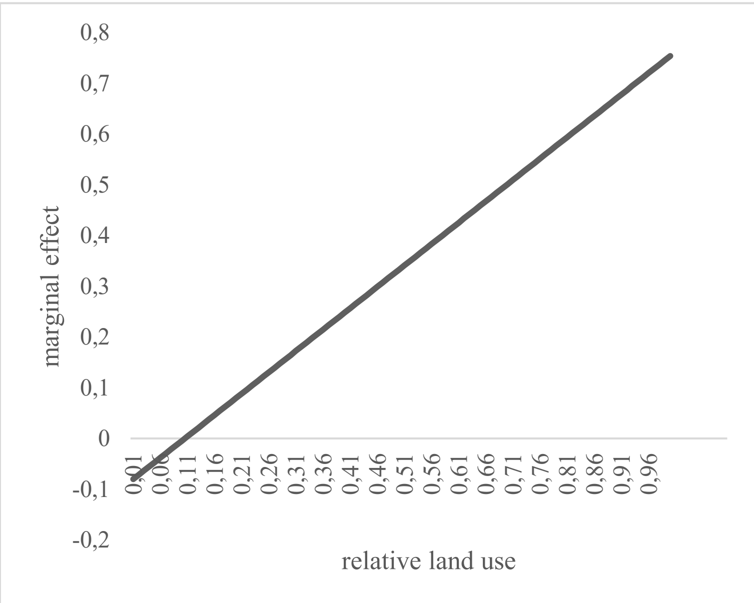

Figure 5.1 Marginal effect of a 1 percent point (0.01) increase in relative land use on WOZ values, in percentages.

Notes: Marginal effect is determined based on the regression results in Model 8.q (allowing for a quadratic relationship) of Table 5.2 and corresponds to the following formula: $-0.089 + (2 \times 0.421 \times relative\ land\ use)$. *Estimations use three control variable groups (housing characteristics* of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects*

Comparison with absolute land use

As argued, the variable of interest in this research relates to *relative* rather than *absolute* land use based on the often limited total area of neighborhoods and the assumed difference in park-effect for large and small surrounding neighborhoods. To consider this choice, Table 5.3 below (full results in Appendix Table B.3) documents the results for Model 8.q and 8 as specified above, but now with an *absolute* rather than a *relative* land use measure. Model 8.q.a first shows that, in contrast to the relative measure, there is no significant quadratic relationship, which is therefore in Model 8.a omitted.

More importantly, it shows that an increase of 1 hectare land use intended for parks and public gardens within a neighborhood is associated with a 0.1% (β*100%) *increase* in the average WOZ housing value within the neighborhood, while a 1 percent point increase in relative land use was associated with an average *decrease* (-0.06%) in housing value. In general, it illustrates that infinitely more park is ultimately best as each additional hectare of land use intended for parks is associated with a constant increase in housing value. However, as argued earlier, it does not take into account the consequences of this increased land use for parks related to the often limited and fixed size of a neighborhood: less land use for other uses. The absolute measure therefore illustrates the effect of more park in the hypothetical situation that this extra park can always be built in an 'extra part of neighborhood'. Based on this practically impossible interpretation, the analysis will continue with the relative measure.

Table 5.3 Regression results of the relationship between absolute land use intended for parks & public gardens and WOZ values.

	Log WOZ	
Variable	**(8.q.a) Absolute land use quadratic**	**(8a) Absolute land use**
Absolute land use	0.001***	0.001***
	(0.000)	(0.000)
Absolute land use^2	-5.82e-06	
	(4.8e-06)	
Constant	11.624***	11.623***
	(0.384)	(0.384)
Observations	33,346	33,346
R^2	0.988	0.988
Individual neighborhood fixed effects	Yes	Yes
Municipality specific time fixed effects	Yes	Yes
Control variables	Yes	Yes

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features).*

Considering lags

As argued, the retrospective nature of WOZ values might distort the estimates. To consider this, Table 5.4 below (full results in appendix B.4) illustrates results when using lags for the explanatory variables (for example, relative land use intended for parks in the period 2012 is combined with WOZ values in the period 2015 as the data does not provide data on individual years).

Despite the use of lags, the negative and significant *decreasing returns* relationship remains, with roughly a similar shape (as illustrated by Figure B.4 in the Appendix). Since fewer observations are available due to the use of lags and lags cannot be added per year due to a lack of data, the further analysis will continue without lags.

Table 5.4 Regression results of the relationship between relative land use intended for parks & public gardens and WOZ values, considering lags.

	Log WOZ	
Variable	**(8.q)**	**(8.q.l) + lags**
Relative land use	-0.089***	-0.139***
	(0.035)	(0.045)
Relative land use^2	0.421***	0.650***
	(0.099)	(0.123)
Constant	11.608***	12.666***
	(0.384)	(0.423
Observations	33,346	23,261
R^2	0.988	0.989
Individual neighborhood fixed effects	Yes	Yes
Municipality specific fixed effects	Yes	Yes
Control variables	Yes	Yes

Standard errors in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01
Notes: Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features).*

5.2 Considerations regarding the value of parks

5.2.1 Population density

Model 9 in Table 5.5 below indicates the presence of a highly significant but relatively small negative interaction effect between relative land use for parks (and public gardens) and population density (full models documented in Appendix Table B.5). Keeping relative land use constant, an increase in population density is associated with a lower relative land use effect, suggesting that, contrary to expectations, parks are overall somewhat more valuable in low-density locations. This might indicate that people living in low-density locations perceive parks and public gardens as more valuable compared to people in high-density locations, and thus have a higher willingness to pay. One could imagine, for example, that nature lovers sort themselves in low population density locations, because it is expected that there is here more room for greenery in general (although the average land use for parks and public gardens in specific appears to be relatively low as discussed below). Their love for nature can then result in a higher perceived value for parks (categorized as greenery) in these areas.

However, the inclusion of the population interaction effect also caused the level relative land use coefficient to become positive (and insignificant), together representing a positive *increased returns* relationship. As the quadratic relative land use remains significant, an F-test is performed to test the joint significance of the included relative land use effects (plain, quadratic and interaction).

Together, these three effects are jointly significant according to the F-test results, *F(3,22991) = 11.92 and the corresponding p-value of 0.000*.

Table 5.5 Regression results of the relationship between relative land use intended for parks & public gardens and WOZ values, adding a population density interaction term.

	Log WOZ value	
Variable	**(8.q)**	**(9) + population interaction**
Relative land use	-0.089***	0.044
	(0.035)	(0.049)
Relative land use^2	0.421***	0.352***
	(0.099)	(0.101)
Relative land use * pop density		-0.002***
		(0.001)
Pop density		-0.001***
		(0.000)
Income		
Constant	11.608***	11.680***
	(0.384)	(0.383)
Observations	33,346	33,346
R^2	0.988	0.988
Individual neighborhood fixed effects	Yes	Yes
Municipality specific time fixed effects	Yes	Yes
Control variables	Yes	Yes

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Notes: Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features).*

Figure 5.2 below illustrates the marginal effect of a 1 percent point (0.01) increase in relative land use for three different population density values (corresponding to the 25%, 50% and 75% percentiles) and, in addition to the above argued quadratic relationship, visualizes that when the population density in neighborhoods is low, increasing the relative land use has a more positive effect on housing value. It also shows that while the marginal effect is always positive for relatively low densely populated neighborhoods, the effect can be negative for densely populated areas (and when considering the distribution of relative land use values in Figure C.2 in the appendix this seems to refer to the majority).

Accordingly, Table 5.6 below describes the calculated average marginal effects per percentile of population density for the observations within the regression sample and illustrates that, while the less densely populated thus have highest average marginal effects, they also have the lowest average relative land use intended for parks and public gardens. This in turn indicates that the more positive average marginal effect is an effect of the population density rather than a high land use share for parks (and the *increasing returns* here related to relative land use).

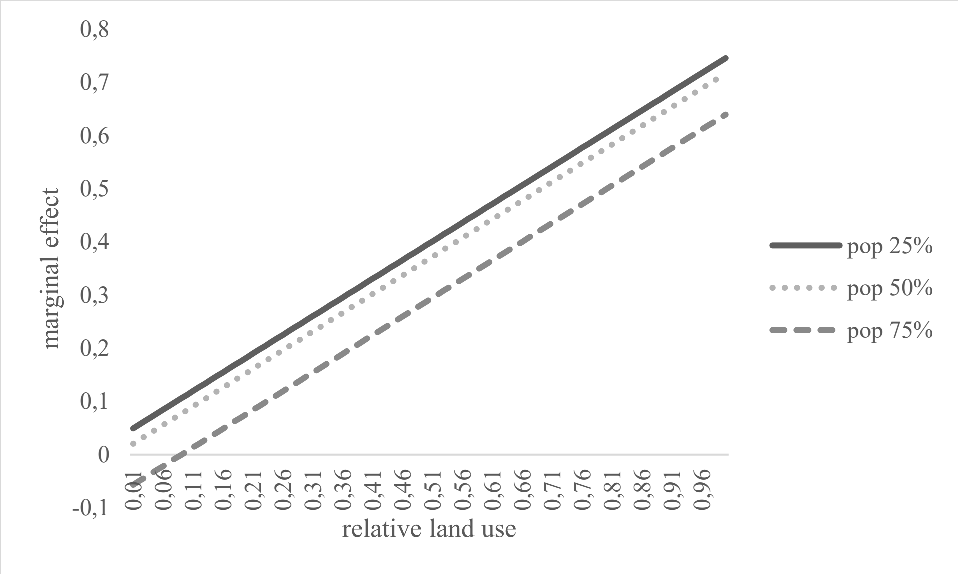

Figure 5.2 Marginal effect of a 1 percent point (0.01) increase in relative land use on WOZ housing values dependent on population density, in percentages.

Notes: Marginal effect is determined based on the regression results of Model 9 in Table 5.5 (adding a population density interaction term) and corresponds to the following formula: $0.044 + (2 \times 0.352 \times relative\ land\ use) - (0.002 \times population\ density)$. *Estimations use three control variable groups (housing characteristics* of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for a quadratic relationship.*
Population percentiles of 25%, 50% and 75% corresponds respectively to 0.83, 12.81 and 44.88 (×100 persons per square kilometer).

Table 5.6 below additionally aims to express the value of parks in monetary terms by translating the average marginal effects into euros by multiplying with average housing values and stock per category. Columns 4 and 5 respectively illustrate the estimated added value per house (ranging from 15,755 to -18,232 euros) and total neighborhood (ranging from 4 to -23 million euros) associated with a 1 percent point (0.01) increase in relative land use for parks. While the average value per house is consistent with the average marginal effects and indicates that parks are most valuable in the least densely populated areas and become less valuable and eventually negative when increasing population density, the hierarchy changes when summing contributions over the number of houses within neighborhoods. The larger number of houses in slightly more densely populated neighborhoods (Table C.1 in Appendix C), make the second population density group the most attractive for increasing relative land use in terms of neighborhood value. Perhaps most striking is the enormous total negative average value for the most densely populated neighborhoods, referring to 23 million euros.

The table additionally illustrates overall negative effects for the total sample, which is less negative (-0.007%) compared to the plain regression above-mentioned (-0.06%).

Average implicit values (which are averaged out *after* calculating values and documented in Table B.7 in the Appendix) give slightly different (compared to Table 5.6) and conflicting estimates due to the difference in housing value and stock within the categories and are therefore, to allow for interpretation, undiscussed in the further analysis. However, they do indicate the complexity involved in estimating the value of parks.

Table 5.6 Average marginal effect and related implicit value per house and total neighborhood associated with a 1 percent point increase of relative land use intended for parks and public gardens on WOZ values of housing, by population density.

Population density	Average marginal effect	Observations in sample	Implicit value per house	Implicit value total neighborhood	Average relative land use
≤ 0.83	0.044%	4,615	€ 15,755	€ 2,317,619	0.001
≥ 0.83 & ≤ 12.81	0.042%	7,960	€ 12,768	€ 4,069,957	0.015
≥ 12.81 & ≤ 44.88	0.015%	10,462	€ 3,582	€ 3,440,377	0.054
≥ 44.88	-0.090%	10,309	€ -18,232	€ - 23,028,573	0.061
Total	-0.007%	33,346	€ -1,840	€ - 1,450,089	0.039

Notes: Marginal effect is determined based on the regression results of Model 9 in Table 5.5 (adding a population density interaction term) and corresponds to the following formula: $0.044 + (2 \times 0.352 \times relative\ land\ use) - (0.002 \times population\ density)$. *Estimations use three control variable groups (housing characteristics* of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for a quadratic relationship. The implicit monetarized value of these parks are calculated by multiplying the marginal effect with the average WOZ value for the value per house, and subsequently multiplied by the average number of houses for the value per total neighborhood (Table C.1 in Appendix). Number of observations refers to the sample used in order to estimate the relationship (Table 5.5)*

5.2.2 Housing value

In addition, Model 10 in Table 5.7 below indicates the presence of a highly significant and relatively large positive interaction effect between relative land use and housing value of a neighborhood (full models in Appendix Table B.5). Keeping relative land use constant, a neighborhood with an above-median average WOZ value is associated with a higher relative land use effect (0.1 percent point), indicating that, contrary to expectations, parks are overall somewhat more valuable in high-value locations. This may again indicate that residents of high-value locations perceive parks as more valuable than residents of low-value locations. Which, in turn, ensures that, despite the hypothesized more attractive neighborhoods, the willingness to pay is higher here.

However, including the value interaction effect caused the relative land use coefficient to become more negative (still showing *decreasing returns*). Again an F-test is performed to test the joint significance of the included relative land use effects (plain, quadratic and interaction). Together, these three effects are jointly significant according to the F-test results corresponding *to F(3,22838) = 14.86 and the related p-value of 0.000.*

Table 5.7 Regression results of the relationship between relative land use intended for parks & public gardens and WOZ values, adding a housing value interaction term.

	Log WOZ value	
Variable	**(8.q)**	**(10) + value interaction**
Relative land use	-0.089***	-0.126***
	(0.035)	(0.035)
Relative land use^2	0.421***	0.395***
	(0.099)	(0.097)
Relative land use * high-value		0.100***
		(0.021)
High-value		0.044***
		(0.002)
Income		
Constant	11.608***	11.548***
	(0.384)	(0.377)
Observations	33,346	33,346
R^2	0.988	0.988
Individual neighborhood fixed effects	Yes	Yes
Municipality specific time fixed effects	Yes	Yes
Control variables	Yes	Yes

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Notes: Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features).*

Moreover, Figure 5.3 below visualizes the marginal effect of a 1 percent point (0.01) increase in relative land use for both high and low value locations and accordingly indicates, in addition to the above argued *decreasing returns* relationship, that when a neighborhood has above median average WOZ values, increasing the relative land use has a more positive effect on housing value for all relative land use values. However, for both scenarios it remains possible to have negative marginal effects and when considering the distribution of relative land use values (Figure C.2 in the Appendix) these observations appear to be the majority.

Accordingly, Table 5.8 below describes the calculated marginal effects per category of average housing value for the observations within the regression sample and illustrates that while for both scenarios the average marginal effect remains negative, high value areas exhibit lower negative values *and* again have the lowest average relative land use shares, which points to the dominance of the value effect rather than a high relative land use share (and the present *decreasing returns)*.

In addition, Table 5.8 aims to monetarize the value of parks by translating the marginal effects into euros by multiplying with average housing values and stock per category (estimates resulting from averaging *after* calculating values in Appendix Table B.8). Columns 4 and 5 illustrate respectively the translated added value per house (ranging from -15,285 to -1,942 euros) and total neighborhood (ranging from -16 and -1 million euros) associated with a 1 percent point (0.01) increase in relative land use. These findings are in line with the average marginal effect, indicating that parks are most valuable (or least dis-valuable) in high-value areas.

The table also illustrates overall negative effects and values for the total sample. The average marginal effect (-0.05%) for the observations in the regression sample is here again less negative compared to the plain regression abovementioned (-0.06%).

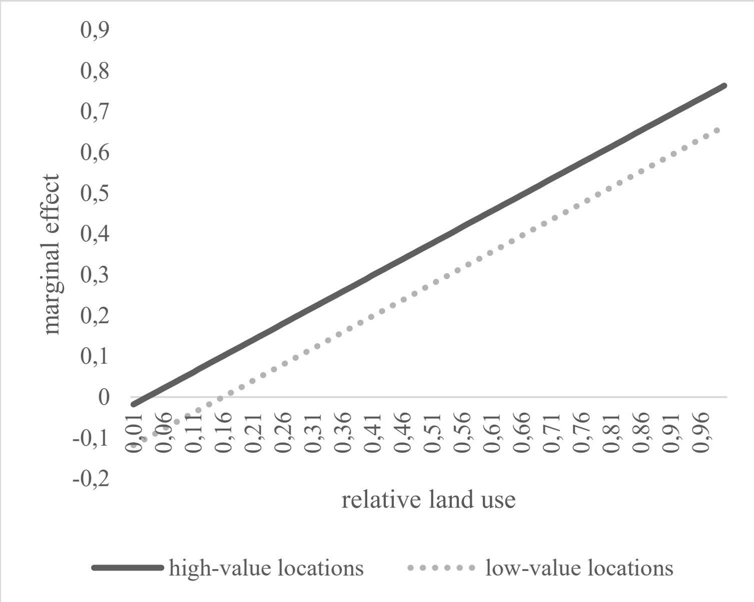

Figure 5.3 Marginal effect per value category of a 1 percent point increase in relative land use WOZ values housing dependent on average housing value, in percentages.

Notes: Marginal effect is determined based on the regression results of Model 10 in Table 5.7 (adding a value interaction) and corresponds to the following formula: $-0.126 + (2 \times 0.395 \times relative\ land\ use) + (0.100 \times high\_value)$. *Estimations use three control variable groups (housing characteristics* of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for a quadratic relationship. High value locations correspond to neighborhoods with an average WOZ value of above 239,000 euros while low-value locations correspond to neighborhoods with an average WOZ value equal to or below 239,000 euros.*

Table 5.8 Average marginal effect and related implicit value per house and total neighborhood associated with a 1 percent point increase of relative land use intended for parks and public gardens on WOZ values of housing, by value category.

Housing value neighborhood	Average marginal effect	Observations in sample	Implicit value per house	Implicit value total neighborhood	Average relative land use
≤ 239,000	-0.085%	17,087	€ -15,285	€ -15,785,644	0.052
> 239,000	-0.006%	16,259	€ -1,942	€ -1,032,078	0.026
Total	-0.046 %	33,346	€ -11,994	€ - 9,454,496	0.039

Notes: Marginal effect is determined based on the regression results of Model 11 in Table 5.7 (adding a value interaction term) and corresponds to the following formula: $-0.126 + (2 \times 0.395 \times relative\ land\ use) + (0.100 \times high\_value)$. *Estimations use three control variable groups (housing characteristics* of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for a quadratic relationship. The implicit monetarized value of these parks are calculated by multiplying the marginal effect with the average WOZ value for the value per house, and subsequently multiplied by the average number of houses for the value per total neighborhood (Table C.1 in Appendix). Number of observations refers to the sample used in order to estimate the relationship (Table 5.7).*

5.2.3 Final relative land use effect

In order to draw conclusions for the main question, the considerations regarding the value of parks are added to the basic relative land use effect in Model 11 described in Table 5.9 below.

Overall, the level, quadratic (together showing a negative *decreasing returns* relationship) and interaction relative land use effects (the values of which are approximately equal to the individual estimates and are thus contrary to expectations) are found to be jointly significant (full regression results in Table B.6 in the Appendix) according to the F-test results corresponding *to F(4,22989) = 15.26 and the related p-value of 0.000.*

Table 5.9 Regression results of the relationship between relative land use intended for parks & public gardens and WOZ values, adding both population and value interaction terms.

	Log WOZ value		
Variable	**(9)** **+ population interaction**	**(10)** **+ value interaction**	**(11)** **Combined**
Relative land use	0.044	-0.126***	-0.010
	(0.049)	(0.035)	(0.050)
Relative land use^2	0.352***	0.395***	0.335***
	(0.101)	(0.097)	(0.099)
Relative land use * population density	-0.002***		-0.002***
	(0.001)		(0.001)
Relative land use * high-value		0.100***	0.098***
		(0.021)	(0.021)
Constant	11.680***	11.548***	11.616***
	(0.383)	(0.377)	(0.375)
Observations	33,346	33,346	33,346
R^2	0.988	0.988	0.988
Individual neighborhood fixed effects	Yes	Yes	Yes
Municipality specific time fixed effects	Yes	Yes	Yes
Control variables	Yes	Yes	Yes

Standard errors in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01
Notes: In Model 9 and 10 population and value interaction terms are added individually, while Model 11 includes both. Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features).*

Based on these results, overall marginal effects are described in Table 5.10 below (estimates resulting from averaging *after* calculating values are documented in Table B.9 in the Appendix), which indicates that the average marginal effect of a one percent point increase of relative land use intended for parks and public gardens is associated with an on average 0.004% decrease in average WOZ housing value, which corresponds to 1,131 euros in value decrease per house and 891,546 euro per neighborhood. This, in turn, leads to a rejection of the hypothesized positive relationship.

As this is against expectations, the author considers two possible (related) explanations: (i) the necessary consequence of more relative land use for parks is less relative land use for other uses, which, compared to parks, are on average considered more valuable, (ii) the necessary decrease in land use for other uses might mean that in neighborhoods where home values are rising, the opportunity cost of more parks is higher, resulting in less propensity to build parks and a negative association between land use for parks and housing values.

Table 5.10 Average marginal effect and related implicit value per house and total neighborhood associated with a 1 percent point increase of relative land sue intended for parks and public gardens, adding both value and population density interaction terms.

	Average marginal effect	**Observations in sample**	**Average implicit value per house**	**Average implicit value total neighborhood**	**Average relative land use**
Total	-0.004%	33,346	€-1,131	€ -891,546	0.039

Notes: Marginal effect is determined based on the regression results of Model 11 Table 5.9 and corresponds to the following formula: $-0.010 + (2 \times 0.335 \times relative\ land\ use) + (-0.002 * population\ density) + \ (0.098 \times high\_value)$. *Estimations use three control variable groups (housing characteristics* of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for a quadratic relationship. The implicit monetarized value of these parks are calculated by multiplying the marginal effect with the average WOZ value for the value per house, and subsequently multiplied by the number of houses for the value per total neighborhood (Table C.1 in Appendix). Number of observations refers to the sample used in order to estimate the relationship (Table 5.9).*

However, when we look at the distribution of these marginal effects (as shown in Figure C.3 in the Appendix), we see that there is potential for positive effects. When exploring the numbers, 49.5% (16,505 of 33,343) of the observations in the regression sample have positive marginal effects. In order to explore the locational distribution of these positive and negative effects, Figure 5.4 below visualizes the average marginal effect, per neighborhood in the Netherlands for the estimated 2010 values.

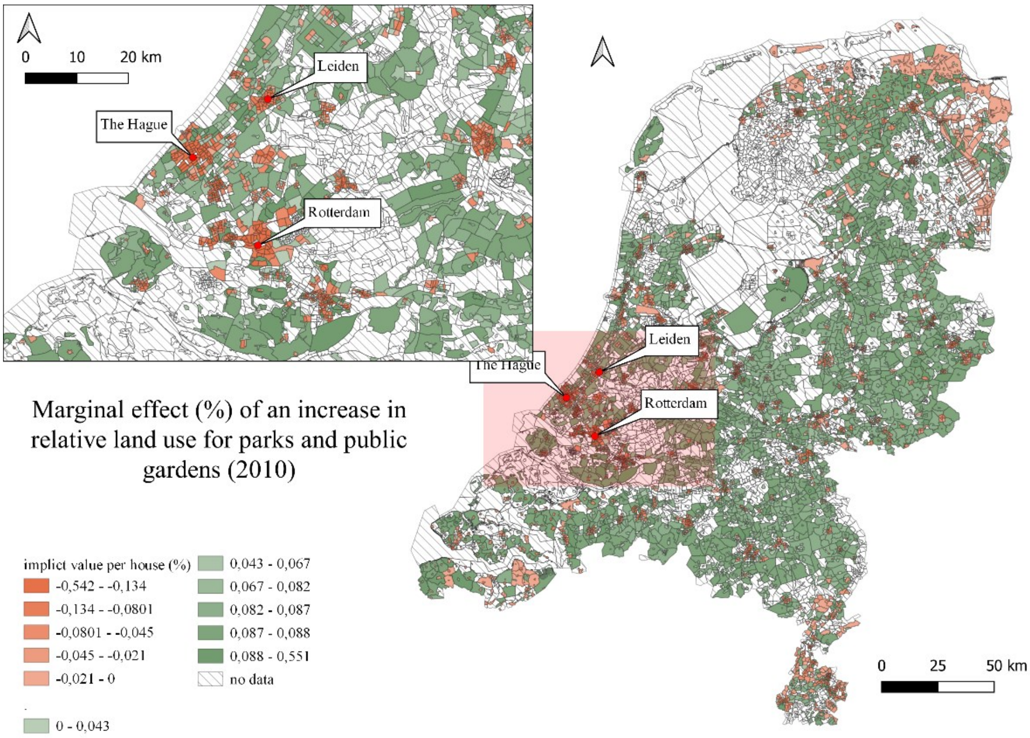

Figure 5.4 Map of the marginal effect for neighborhoods in the Netherlands, 2010
Notes: Calculated average marginal effect is based on the results of Model 11 in Table 5.9 (adding both value and population density interaction terms) and relates to the marginal effect on WOZ values in percentages of a 0.01 increase in relative land use for parks and public gardens for neighborhoods in the regression sample, plain map is provided by CBS. Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for an quadratic relationship.*

Judging by the map above, there seems to be a lack of a clear locational distribution of positive and/or negative marginal effects, and (somewhat surprisingly) positive effects seem to dominate (as the map appears predominantly green). When zooming in, however, the consideration arises that smaller neighborhoods in particular experience negative effects from an increased relative land use for parks, while for larger neighborhoods these effects appear to be predominantly positive. Moreover, the most negative effects seems to relate to (small) city neighborhoods (such as within Rotterdam, Leiden and The Hague).

For completeness, Figure C.5 in the Appendix illustrates the same map for the year 2017 while Figure C.4 in the Appendix plots monetized added values per house, per neighborhood in order to consider a possible different distribution when considering different years and the average WOZ value in neighborhoods respectively. Both however result in the same considerations.

6. Discussion & Conclusion

Based on the argued relevant trade-off between urban densification on the one hand and preservation of environmental amenities on the other (Osland, Östh & Nordvik, 2020), this research has sought to explore the value of parks and public gardens for the Netherlands. Since parks are expected to increase the attractiveness of locations through the argued provision of various benefits, the price of real estate in their surroundings is hypothesized to be higher (More, Stevens & Allen, 1988), which would provide a link to demonstrate the value of parks (Luttik, 2000). The main question of this research is therefore: *How do parks and public gardens influence the value of housing in the Netherlands?*

Based on predominantly used indicators and several considerations, the main variable of interest relates to the relative land use intended for parks and public gardens and an overall positive relationship is hypothesized. The results of the conducted research indicate that while absolute land use measures indicate the presence of a significant positive effect, an overall basic (both individual and jointly significant) *decreasing returns* negative relationship between relative land use and housing value is present. This indicates that the negative relationship decreases in the amount of relative land use intended for parks and can eventually become positive. In addition, several considerations regarding the value of parks are explored by adding two interaction effects. These results in turn indicate the presence of a (i) highly significant but rather small negative interaction effect between relative land use and population density, and a (ii) highly significant and relatively big positive interaction effect between relative land use and housing value. On the one hand, keeping relative land use constant, an increase in population density is, contrary to expectations, associated with a lower relative land use effect (and a lower value of parks). On the other hand, keeping relative land use constant, a neighborhood with an above median average WOZ value is, contrary to expectations, associated with a higher relative land use effect (and a higher value of parks).

To quantify the value of parks, considerations related to the value of parks are combined with the 'basic' relative land use effect. Based on these results, the average marginal effect is -0.004%, which indicates that a one percent point (0.01) increase in relative land use intended for parks and public gardens is associated with a 0.004% decrease in WOZ housing value, which is in contradiction with the hypothesized positive relationship. However, when looking at the distribution of the marginal effects, 49.5% of the estimated marginal effects appear to be positive, and these positive effects appear to be particularly present for relatively large neighborhoods while strongest negative effects are found in small (city) neighborhoods. Expressing the marginal effects in monetized measures, increasing the relative land use intended for parks with one percent point (0.01) is however on average associated with a decrease in the average house value of 1,131 euros. Taking into account the number of houses in neighborhoods, an equal increase in relative land use is associated with a decrease of 892 thousand euros in total WOZ neighborhood value.

6.1 Implications

Although this research aimed to quantify the value of parks and public gardens to contribute to the public awareness of the potential loss of value associated with disappearing greenery (as illustrated by Tyrväinen & Miettinen, 2000) and strengthen the position of greenery (Luttik, 2000), the average marginal effect found and the associated hypothesis contradiction seem to indicate opposite. However, the conducted research also illustrates the complexity regarding the value of parks: Although the average marginal value is thus negative, positive and less-negative marginal effects are found for non-densely populated and higher value areas respectively, indicating that parks certainly can have positive value if placed in the 'right' neighborhood (which appear to be predominantly larger neighborhoods). It is striking that these areas with positive and less-negative marginal effects currently also have relatively low land use shares for parks and public gardens, which might indicate that our parks are incorrectly located from a value perspective. By identifying these 'right' neighborhoods, this research hopes to contribute to spatial design. All in all, the study believes to have contributed to the existing literature by indicating that the relationship between environmental amenities (parks) and housing value is not as straightforward positive as the existing literature often suggests.

6.2 Limitations and further research

Although this study thus attempted to quantify the value of parks and public gardens, several factors may limit the study and ensure that some caution is needed to conclude that parks have a negative effect on housing value (and associated disadvantages are thus dominant over advantages). To illustrate: a negative biasing variable that is not caught by either the fixed effects or the additional control variables can lead to an underestimated park effect. While the regression includes individual and time fixed effects as well as additional control variables, it is almost impossible to control for all potential bias causing variables, referring to both measurable and unmeasurable factors. Further research might therefore extend the control variable set, to examine whether the overall negative park effect remains negative.

Moreover, quantifying the value of parks based on housing value captures the value imposed on local residents only (Panduro & Veie, 2013). However (as argued) parks can also provide advantages and disadvantages for non-residents. Osland, Östh & Nordvik (2020) for example argue that environmental amenities might also be important for tourism-oriented companies. In addition, while reverse causality cannot be considered entirely impossible, Osland et. al. argue that natural amenities are overall not located in particular locations because of house prices. Accordingly, for this research, reverse causality is not expected to be a major issue.

Furthermore, the geographical level *neighborhood* can only provide estimates at this same level and is thus unable to capture effects of individual parks. While this is the most disaggregate measure available for the data and is thus expected to reflect the effect better than e.g. municipalities (a park on one side of the municipality is expected to have no or little effect on housing at the other side of the municipality, while this effect is more credible on neighborhood level), it cannot be ruled out that estimates correspond to a few observations (for exmaple in close proximity to parks or public gardens) that strongly influence the average, rather than illustrate the overall increased/decreased attractiveness of the neighborhood. Follow-up research could therefore conduct an individual based study to overcome the limitations related to this geographical level. This approach is similar to that of Luttik (2000) discussed earlier, but given the possible heterogeneity between locations found, the scope of the study could be extended to the Netherlands as a whole.

The heterogeneity of effects associated with different types of greenery (Panduro & Veie, 2013), may furthermore offer opportunities for a broadening study in which effects related to different types of greenery can be compared. By combining the above with all other classifications for land use and thus including the total land use in the analysis, a reference category can be chosen. This, in turn, could estimate the value of parks compared to, for example, *urban* land use rather than *other* land uses, which was indirectly the approach of this study (as roughly illustrated by Gibbons, Mourato & Resende, 2014).

Moreover, the combination of a relative land use measure with a neighborhood level study cannot capture effects that extend beyond the border of the related neighborhood, while houses located on the edge of a neighborhood might benefit/suffer from the land use in the adjacent neighborhood. Additionally, it is argued that when big changes occur in areas, the estimated hedonic function cannot reasonably be assumed to be stable over time (Freeman, 2003, in Osland, Östh & Nordvik, 2020). Given the considerably long observation period (2010-2017), this could pose additional problems.

Finally, the examined considerations regarding the value of parks might offer follow-up opportunities, as further research could further examine the reasoning behind the found considerations related to population density and housing value. In addition, exploring other considerations, such as the influence of the age composition of neighborhoods, could be the focus of future research.

7. Appendix

A. Information regarding additional variables

A.1 Housing characteristics

- *Housing stock:*

Housing stock is measured as the total number of houses on the 1st of January of every year, and rescaled to hundreds for better interpretation. A house is defined by CBS as a residential object with at least one residential function (CBS, n.d.-b).

- *Share of construction year*

Year of construction refers to the year in which a house (or building in which a house is located) was originally completed. Any subsequent changes to the property will thus not change this variable. CBS distinguished two categories: before and after 2000. The two categories are measured in percentages compared to the total housing stock on January 1st of every year and only measured for neighborhoods with a housing stock greater than 20 (CBS, n.d.-b).

A.2 Sociodemographic characteristics of the neighborhood

- *Income*

Income is measured as the average yearly personal income per resident, measured on the 1st of January of every year. Personal income refers to the following components of gross income: income from work, own company, insurance benefits and social security benefits (excluding child benefit). Measures are in 1000 euros and are only measured for neighborhoods with at least 100 persons in private households (CBS, n.d.-b).

- *Age group share*

Age groups are calculated as the percentage of a neighborhood's total population that belongs to a particular age group (absolute numbers are rounded to five at random and both measures are provided by CBS) on January 1st of every year, consisting of 0-15, 15-25, 25-45, 45-65 and >65 years. Residents whose exact residence is not clear are not included in neighborhood measurements (CBS, n.d.-b). A relative measure is used to account for potential size differences between neighborhoods.

- *Immigrant share*

Immigrant share is calculated based on the percentage of a neighborhood's total population having a *western* (one of the European countries (excluding Turkey), North America, Oceania, Indonesia and Japan) or *non-western* (Afrika, Latin America, Turkey and Asian countries excluding Japan and Indonesia) immigration background on January 1st of every year. People with a migration background include: people born abroad with at least one parent born abroad and people born in the Netherlands with at least one parent born abroad (CBS, n.d.-b). Population measurement considerations mentioned above also apply here.

A.3 Features of the location

To capture other local features, average distances between residential address and various amenities are used. Distance is calculated over paved roads that can be used by cars (no bicycle paths or footpaths, but ferry crossing included), while one-way traffic and entry bans are not taken into account. Distances are only measured for neighborhoods with more than 10 residents where the exact location of the address could be determined in 90 percent or more of the cases.

The selected amenities relate to the following (based on data availability and to keep the number of control variables realistic): education (elementary schools); care (general practice responsible for general medical care) and retail (large supermarket, referring to a shop with multiple types of daily items and a minimum area of 150m2) (CBS, n.d.-b).

Table A.1 Descriptive statistics additional variables for neighborhoods in the Netherlands

Variable	Number of observations	Mean	Standard deviation	Min	Max
Housing stock	49,030	605.979	891.157	0	14328
Share of construction year					
After 2000	44,159	13.214	20.143	0	100
Before 2000	44,159	86.796	20.144	0	100
Age group shares					
0-15	46,179	16.366	6.308	0	100
15-25	46,179	12.249	6.341	0	100
25-45	46,179	25.334	9.385	0	100
45-65	46,179	30.684	8.420	0	100
>65	46,179	17.816	10.076	0	100
Immigrant share					
Western	46,179	8.139	6.720	0	100
Non-western	46,179	6.555	10.401	0	100
Distance to					
Care	46,901	1.685	1.400	0.1	12
Education	46,586	1.126	0.908	0.1	10.4
Retail	46,901	1.594	1.349	0	11.8
Income	39,493	24.159	6.327	-3.8	142

B. Full model results

1	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \varepsilon_{i,t}$
1.q	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \boldsymbol{\beta_2(relative\ land\ use^{\,2}_{i,t})} + \varepsilon_{i,t}$
1.q.l	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,\boldsymbol{t-1}}) + \beta_2(relative\ land\ use^{\,2}_{i,\boldsymbol{t-1}}) + \varepsilon_{i,t}$
2	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \boldsymbol{\beta_2(income_{i,t})} + \varepsilon_{i,t}$
3	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \boldsymbol{\beta_2(housing\ characteristics_{i})} + \varepsilon_{i,t}$
3.q	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \beta_2(housing\ characteristics_{i,t})$ $+ \boldsymbol{\beta_3(relative\ land\ use^{\,2}_{i,t})} + \varepsilon_{i,t}$
3.q.l	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,\boldsymbol{t-1}}) + \beta_2(housing\ characteristics_{i,\boldsymbol{t-1}})$ $+ \beta_3(relative\ land\ use^{\,2}_{i,\boldsymbol{t-1}}) + \varepsilon_{i,t}$
4	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \beta_2(housing\ characteristics_{i,t})$ $+ \boldsymbol{\beta_3(sociodemographic_{i,t})} + \varepsilon_{i,t}$
4.q	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \beta_2(housing\ characteristics_{i,t})$ $+ \beta_3(sociodemographic_{i,t}) + \boldsymbol{\beta_4(relative\ land\ use^{\,2}_{i,t})} + \varepsilon_{i,t}$
4.q.l	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,\boldsymbol{t-1}}) + \beta_2(housing\ characteristics_{i,\boldsymbol{t-1}})$ $+ \beta_3(sociodemographic_{i,\boldsymbol{t-1}}) + \beta_4(relative\ land\ use^{\,2}_{i,\boldsymbol{t-1}}) + \varepsilon_{i,t}$
5	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \beta_2(housing\ characteristics_{i,t})$ $+ \beta_3(sociodemographic_{i,t}) + \boldsymbol{\beta_4(location\ features_{i,t})} + \varepsilon_{i,t}$
5.q	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \beta_2(housing\ characteristics_{i,t})$ $+ \beta_3(sociodemographic_{i,t}) + \beta_4(location\ features_{i.t}) + \boldsymbol{\beta_5(relative\ land\ use^{\,2}_{i,t})}$ $+ \varepsilon_{i,t}$
5.q.l	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,\boldsymbol{t-1}}) + \beta_2(housing\ characteristics_{i,\boldsymbol{t-1}})$ $+ \beta_3(sociodemographic_{i,\boldsymbol{t-1}}) + \beta_4(location\ features_{i.\boldsymbol{t-1}})$ $+ \beta_5(relative\ land\ use^{\,2}_{i,\boldsymbol{t-1}}) + \varepsilon_{i,t}$
6	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \beta_2(housing\ characteristics_{i,t})$ $+ \beta_3(sociodemographic_{i,t}) + \beta_4(location\ features_{i,t}) + \boldsymbol{FE_i} + \varepsilon_{i,t}$
6.q	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \beta_2(housing\ characteristics_{i,t})$ $+ \beta_3(sociodemographic_{i,t}) + \beta_4(location\ features_{i,t}) + \boldsymbol{\beta_5(relative\ land\ use^{\,2}_{i,t})}$ $+ FE_i + \varepsilon_{i,t}$
6.q.l	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,\boldsymbol{t-1}}) + \beta_2(housing\ characteristics_{i,\boldsymbol{t-1}})$ $+ \beta_3(sociodemographic_{i,\boldsymbol{t-1}})$ $+ \beta_4(location\ features_{i,\boldsymbol{t-1}}) + \beta_5(relative\ land\ use^{\,2}_{i,\boldsymbol{t-1}}) + FE_i + \varepsilon_{i,t}$
7	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \beta_2(housing\ characteristics_{i,t})$ $+ \beta_3(sociodemographic_{i,t}) + \beta_4(location\ features_{i,t}) + FE_i + \boldsymbol{FE_t} + \varepsilon_{i,t}$
7.q	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,t}) + \beta_2(housing\ characteristics_{i,t})$ $+ \beta_3(sociodemographic_{i,t}) + \beta_4(location\ features_{i,t}) + \boldsymbol{\beta_5(relative\ land\ use^{\,2}_{i,t})}$ $+ FE_i + FE_t + \varepsilon_{i,t}$
7.q.l	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{\ i,\boldsymbol{t-1}}) + \beta_2(housing\ characteristics_{i,\boldsymbol{t-1}})$ $+ \beta_3(sociodemographic_{i,\boldsymbol{t-1}}) + \beta_4(location\ features_{i,\boldsymbol{t-1}})$ $+ \beta_5(relative\ land\ use^{\,2}_{i,\boldsymbol{t-1}}) + FE_i + FE_t + \varepsilon_{i,t}$

8	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{i,t}) + \beta_2(housing\ characteristics_{i,t}) + \beta_3(sociodemographic_{i,t}) + \beta_4(location\ features_{i,t}) + FE_i + \boldsymbol{FE_{t,j}} + \varepsilon_{i,t}$
8.q	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{i,t}) + \boldsymbol{\beta_2(relative\ land\ use^2_{i,t})} + \beta_3(housing\ characteristics_{i,t}) + \beta_4(sociodemographic_{i,t}) + \beta_5(location\ features_{i,t}) + FE_i + FE_{t,j} + \varepsilon_{i,t}$
8.q.l	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{i,\boldsymbol{t-1}}) + \beta_2(relative\ land\ use^2_{i,\boldsymbol{t-1}}) + \beta_3(housing\ characteristics_{i,\boldsymbol{t-1}}) + \beta_4(sociodemographic_{i,\boldsymbol{t-1}}) + \beta_5(location\ features_{i,\boldsymbol{t-1}}) + FE_i + FE_{t,j} + \varepsilon_{i,t}$
8a	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(\boldsymbol{absolute\ land\ use_{i,t}}) + \beta_2(housing\ characteristics_{i,t}) + \beta_3(sociodemographic_{i,t}) + \beta_4(location\ features_{i,t}) + FE_i + FE_{t,j} + \varepsilon_{i,t}$
8.q.a	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(\boldsymbol{absolute\ land\ use_{i,t}}) + \beta_2(\boldsymbol{absolute\ land\ use^2_{i,t}})\ \beta_3(housing\ characteristics_{i,t}) + \beta_4(sociodemographic_{i,t}) + \beta_5(location\ features_{i,t}) + FE_i + FE_{t,j} + \varepsilon_{i,t}$
9	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{i,t}) + \beta_2(relative\ land\ use^2_{i,t}) + \boldsymbol{\beta_3(relative\ land\ use_{i,t} * population\ density_{i,t})} + \beta_4(housing\ characteristics_{i,t}) + \beta_5(sociodemographic_{i,t}) + \beta_6(location\ features_{i,t}) + \boldsymbol{\beta_6(population\ density_{i,t})} + FE_i + FE_{t,j} + \varepsilon_{i,t}$
10	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{i,t}) + \beta_2(relative\ land\ use^2_{i,t}) + \boldsymbol{\beta_3(relative\ land\ use_{i,t} * high\_value_{i,t})} + \beta_4(housing\ characteristics_{i,t}) + \beta_5(sociodemographic_{i,t}) + \beta_6(location\ features_{i,t}) + \boldsymbol{\beta_6(high\_value_{i,t})} + FE_i + FE_{t,j} + \varepsilon_{i,t}$
11	$\log(WOZ\ value_{i,t}) = \alpha + \beta_1(relative\ land\ use_{i,t}) + \beta_2(relative\ land\ use^2_{i,t}) + \beta_3(relative\ land\ use_{i,t} * population\ density_{i,t}) + \beta_4(relative\ land\ use_{i,t} * high\_value_{i,t}) + \beta_5(housing\ characteristics_{i,t}) + \beta_6(sociodemographic_{i,t}) + \beta_7(location\ features_{i,t}) + \beta_8(population\ density_{i,t}) + \beta_9(high\_value_{i,t}) + FE_i + FE_{t,j} + \varepsilon_{i,t}$

Additions and/or changes in bold

Table B.1 Full regression results of the relationship between relative land use intended for parks & public gardens and WOZ values, adding control variable groups and fixed effects one by one.

	Log WOZ value							
Variable	**(1) OLS**	**(2) + income**	**(3) + housing**	**(4) + sociodemo**	**(5) + location features**	**(6) + individual FE**	**(7) + general time FE**	**(8) + municipal time FE**
Relative land use	-1.004***	-1.106***	-0.753***	-0.458***	-0.349***	-0.048	0.006	0.031
	(0.033)	(0.022)	(0.031)	(0.027)	(0.027)	(0.030)	(0.022)	(0.020)
Income		0.036***						
		(0.000)						
Housing stock			-0.011***	-0.003***	-0.001***	-0.122***	-0.007***	-0.008***
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Share of construction year								
Before 2000			0.112***	0.063***	0.054***	0.020***	0.008*	0.004
			(0.020)	(0.017)	(0.016)	(0.006)	(0.004)	(0.004)
After 2000			0.114***	0.067***	0.057***	0.018***	0.009**	0.006
			(0.020)	(0.017)	(0.016)	(0.006)	(0.004)	(0.004)
Age group shares								
0-15				0.032***	0.032***	0.007***	0.009***	0.008***
				(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
15-25				0.021***	0.019***	-0.003***	0.001***	0.002***
				(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
25-45				-0.003***	-0.003***	-0.002***	-0.002***	-0.000***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
45-65				0.025***	0.021***	-0.002***	0.006***	0.006***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
>65				0.013***	0.012***	-0.014***	0.002***	0.003***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Immigrant share								
Western				0.007***	0.008***	-0.006***	0.002***	-0.000
				(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Non-western				-0.010***	-0.010***	-0.013***	-0.005***	-0.005***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Distance to								
Education					0.123***	0.005**	0.019***	0.014***
					(0.003)	(0.002)	(0.002)	(0.002)
Care					-0.017***	0.000	0.010***	0.007***
					(0.002)	(0.002)	(0.001)	(0.001)
Retail					0.002	0.004**	0.015***	0.011***
					(0.002)	(0.002)	(0.001)	(0.001)
Constant	12.434***	11.557***	1.275	4.464***	5.412***	10.972***	11.226***	11.616***
	(0.002)	(0.011)	(1.989)	(1.669)	(1.605)	(0.566)	(0.422)	(0.385)
Observations	37,114	36,433	37,144	37,144	37,114	33,346	33,346	33,346
R^2	0.036	0.371	0.114	0.352	0.388	0.970	0.984	0.988
Individual neighborhood fixed effects	No	No	No	No	No	Yes	Yes	Yes
Municipality specific time fixed effects	No	No	No	No	No	No	No	Yes
General time fixed effects	No	No	No	No	No	No	Yes	No

Standard errors in parentheses (for non-fixed effects regressions, robust standard errors are used); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table B.2 Full regression results of the relationship between relative land use intended for parks & public gardens and WOZ values, allowing for a quadratic relationship and adding control variable groups and fixed effects one by one.

							Log WOZ
Variable	**(1.q) OLS**	**(3.q) + housing**	**(4.q) + socio**	**(5.q) + location features**	**(6.q) + individ. FE**	**(7.q) + general time FE**	**(8.q) + municipal time FE**
Relative land use	-1.972***	-1.284***	-1.000***	-0.805***	-0.202***	-0.134***	-0.089***
	(0.107)	(0.082)	(0.077)	(0.073)	(0.051)	(0.038)	(0.035)
Relative land use^2	3.197***	1.716***	1.742***	1.449***	0.547***	0.499***	0.421***
	(0.402)	(0.289)	(0.275)	(0.252)	(0.148)	(0.109)	(0.099)
Housing stock		-0.010***	-0.002***	-0.001***	-0.012***	-0.007***	-0.008***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Share of construction year							
Before 2000		0.109***	0.060***	0.052***	0.020***	0.008*	0.004
		(0.020)	(0.017)	(0.016)	(0.006)	(0.004)	(0.004)
After 2000		0.111***	0.064***	0.055***	0.018***	0.009**	0.006
		(0.020)	(0.017)	(0.016)	(0.006)	(0.004)	(0.004)
Age group shares							
0-15			0.032***	0.032***	0.007***	0.009***	0.008***
			(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
15-25			0.021***	0.019***	-0.003***	0.001***	0.002***
			(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
25-45			-0.003***	-0.003***	-0.002***	-0.000***	-0.000***
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
45-65			0.025***	0.021***	-0.002***	0.006***	0.006***
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
>65			0.013***	0.012***	-0.142***	0.002***	0.003***
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Immigrant share							
Western			0.008***	0.008***	-0.006***	0.002***	-0.000
			(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Non-western			-0.010***	-0.010***	-0.013***	-0.005***	-0.005***
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Distance to							
Education				0.122***	0.005**	0.019***	0.014***
				(0.003)	(0.002)	(0.002)	(0.002)
Care				-0.018***	0.000	0.010***	0.007***
				(0.002)	(0.002)	(0.001)	(0.001)
Retail				0.001	0.004**	0.014***	0.011***
				(0.002)	(0.002)	(0.001)	(0.001)
Constant	12.449***	1.555	4.750***	5.614***	10.967***	11.222***	11.608***
	(0.003)	(1.988)	(1.667)	(1.603)	(0.566)	(0.422)	(0.384)
Observations	37,114	37,114	37,114	37,114	33,346	33,346	33,346
R^2	0.048	0.118	0.355	0.390	0.970	0.984	0.988
Individual neighborhood fixed effects	No	No	No	No	No	Yes	Yes
Municipality specific time fixed effects	No	No	No	No	No	No	Yes
General time fixed effects	No	No	No	No	No	Yes	No

Standard errors in parentheses (for non-fixed effects regressions, robust standard errors are used); * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

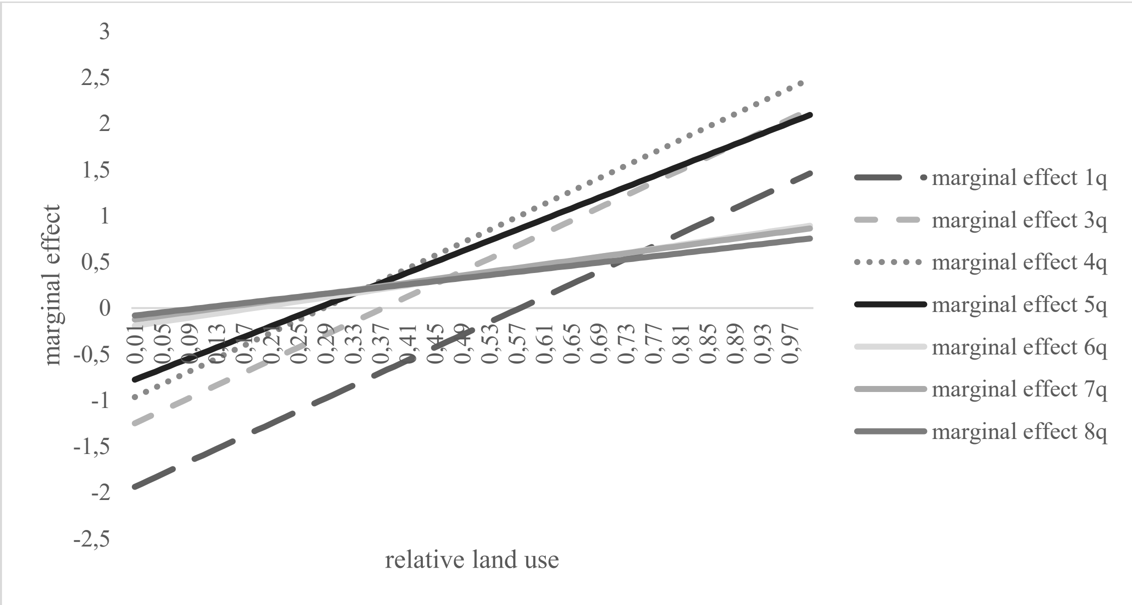

Figure B.2 Marginal effect of a 1 percent point (0.01) increase in relative land use on WOZ housing values, in percentages.

Notes: Marginal effect is determined based on the regression results of Table B.2 (allowing for a quadratic relationship). Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects.*

Table B.3 Full regression results of the relationship between absolute land use intended for parks & public gardens and WOZ values.

Variable	Log WOZ (8.q.a) Absolute land use non-linear	(8a) Absolute land use
Absolute land use	0.001***	0.001***
	(0.000)	(0.000)
Absolute land use^2	-5.82e-06	
	(4.8e-06)	
Housing stock	-0.008***	-0.008***
	(0.000)	(0.000)
Share of construction year		
Before 2000	0.004	0.004
	(0.004)	(0.004)
After 2000	0.006	0.006
	(0.004)	(0.004)
Age group shares		
0-15	0.008***	0.008***
	(0.000)	(0.000)
15-25	0.002***	0.002***
	(0.000)	(0.000)
25-45	-0.000***	-0.000***
	(0.000)	(0.000)
45-65	0.006***	0.006***
	(0.000)	(0.000)
>65	0.003***	0.003***
	(0.000)	(0.000)
Immigrant share		
Western	-0.000	-0.000
	(0.000)	(0.000)
Non-western	-0.005***	-0.005***
	(0.000)	(0.000)
Distance to		
Education	0.014***	0.014***
	(0.002)	(0.002)
Care	0.007***	0.007***
	(0.001)	(0.001)
Retail	0.011***	0.011***
	(0.001)	(0.001)
Constant	11.624***	11.623***
	(0.384)	(0.384)
Observations	33,346	33,346
R^2	0.988	0.988
Individual neighborhood fixed effects	Yes	Yes
Municipality specific time fixed effects	Yes	Yes
Control variables	Yes	Yes

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features).*

Table B.4 Full regression results of the relationship between relative land use intended for parks & public gardens and WOZ values, considering lags and adding control variable groups and fixed effects one by one.

							Log WOZ
Variable	**(1.q.l) OLS + lags**	**(3.q.l) +housing + lags**	**(4.q.l) + socio + lags**	**(5.q.l) +location + lags**	**(6.8.l) + individ. FE + lags**	**(7.q.l) + general time FE + lags**	**(8.q.l) + municipal FE + lags**
Relative land use	-1.992**	-1.227***	-0.846***	-0.628***	-0.187***	-0.162***	-0.139***
	(0.148)	(0.108)	(0.092)	(0.085)	(0.068)	(0.048)	(0.045)
Relative land use^2	3.353***	1.646***	1.453***	1.131***	0.584***	0.675***	0.650***
	(0.569)	(0.390)	(0.330)	(0.300)	(0.191)	(0.135)	(0.123)
Housing stock		-0.011***	-0.002***	-0.007***	-0.003***	-0.002***	-0.002***
		(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Share of construction year							
Before 2000		0.038*	-0.009	-0.015	-0.074***	-0.005	-0.004
		(0.023)	(0.019)	(0.018)	(0.006)	(0.005)	(0.004)
After 2000		0.040*	-0.004	-0.011	-0.075***	-0.005	-0.003
		(0.023)	(0.019)	(0.018)	(0.006)	(0.005)	(0.004)
Age group shares							
0-15			0.035***	0.034***	0.002***	0.002***	0.001***
			(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
15-25			0.026***	0.024***	-0.004***	-0.001***	-0.001***
			(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
25-45			-0.002***	-0.003***	0.001***	-0.007***	-0.000**
			(0.000)	(0.000)	(0.000)	(0.00)	(0.000)
45-65			0.027***	0.023***	-0.003***	0.001***	0.002***
			(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
>65			0.016***	0.015***	-0.010***	-0.000	0.000
			(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Immigrant share							
Western			0.004***	0.004***	-0.002***	0.001***	0.000
			(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Non-western			-0.00***	-0.010***	-0.007***	-0.001***	-0.002***
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Distance to							
Education				0.134***	-0.005*	0.003	0.002
				(0.004)	(0.003)	(0.002)	(0.002)
Care				-0.017***	0.007**	0.002	0.001
				(0.002)	(0.003)	(0.002)	(0.002)
Retail				0.001	-0.004*	0.001	0.000
				(0.003)	(0.002)	(0.002)	(0.002)
Constant	12.414***	8.666***	11.304***	11.994***	20.156***	12.836***	12.666***
	(0.003)	(2.262)	(1.903)	(1.833)	(0.648)	(0.462)	(0.423)
Observations	25,120	25,120	25,120	25,120	23,261	23,261	23,261
R^2	0.048	0.124	0.379	0.421	0.972	0.986	0.989
Individual neighborhood fixed effects	No	No	No	No	No	Yes	Yes
Municipality specific time fixed effects	No	No	No	No	No	No	Yes
General time fixed effects	No	No	No	No	No	Yes	No

Standard errors in parentheses (for non-fixed effects regressions, robust standard errors are used); * p < 0.1, ** p < 0.05, *** p < 0.01

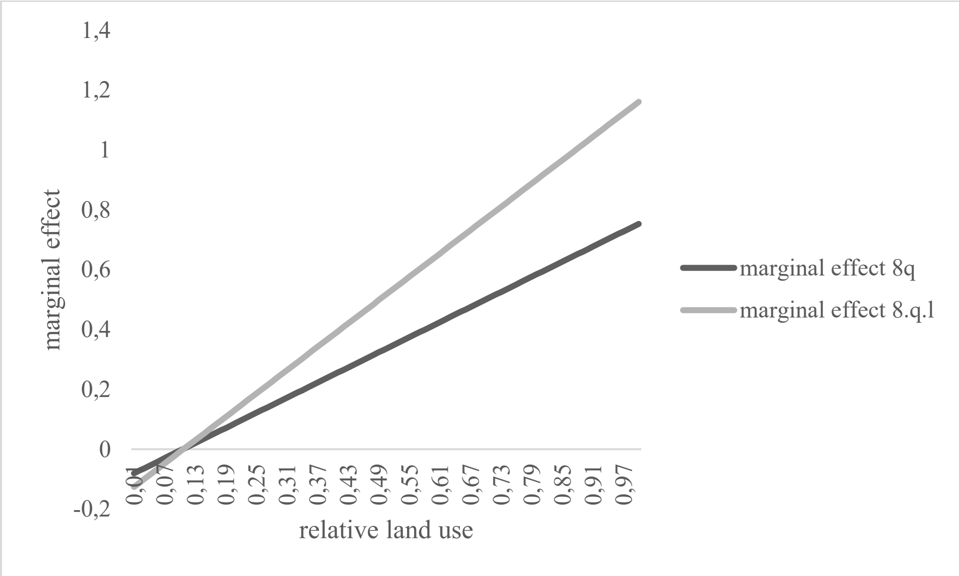

Figure B.4 Marginal effect of a 1 percent point (0.01) increase in relative land use on WOZ housing values, in percentages.

Notes: Marginal effect is determined based on the regression results of Table B.4 (considering lags). Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for a quadratic relationship.*

Table B.5 Full regression results of the relationship between relative land use intended for parks & public gardens and WOZ values, adding considerations regarding the value of parks individually.

	Log WOZ value		
Variable	**(8.q)**	**(9) + population interaction**	**(10) + value interaction**
Relative land use	-0.089***	0.044	-0.126***
	(0.035)	(0.049)	(0.035)
Relative land use^2	0.421***	0.352***	0.395***
	(0.099)	(0.101)	(0.097)
Relative land use * pop density		-0.002***	
		(0.001)	
Pop density		-0.001***	
		(0.000)	
Relative land use * high-value			0.100***
			(0.021)
High-value			0.044***
			(0.002)
Housing stock	-0.008***	-0.007***	-0.007***
	(0.000)	(0.000)	(0.000)
Share of construction year			
Before 2000	0.004	0.004	0.005
	(0.004)	(0.004)	(0.004)
After 2000	0.006	0.005	0.006
	(0.004)	(0.004)	(0.004)
Age group shares			
0-15	0.008***	0.008***	0.008***
	(0.000)	(0.000)	(0.000)
15-25	0.002***	0.002***	0.001***
	(0.000)	(0.00)	(0.000)
25-45	-0.000***	-0.000***	-0.000**
	(0.000)	(0.000)	(0.000)
45-65	0.006***	0.006***	0.006***
	(0.000)	(0.000)	(0.000)*
>65	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)
Immigrant share			
Western	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
Non-western	-0.005***	0.005***	-0.005***
	(0.000)	(0.000)	(0.000)
Distance to			
Education	0.014***	0.013***	0.013***
	(0.002)	(0.002)	(0.001)
Care	0.007***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)
Retail	0.011***	0.011***	0.011***
	(0.001)	(0.001)	(0.001)
Constant	11.608***	11.680***	11.548***
	(0.384)	(0.383)	(0.377)
Observations	33,346	33,346	33,346
R^2	0.988	0.988	0.988
Individual neighborhood fixed effects	Yes	Yes	Yes
Municipality specific time fixed effects	Yes	Yes	Yes
Control variables	Yes	Yes	Yes

Standard errors in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

Notes: Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features).*

Table B.6 Full regression results of the relationship between absolute land use intended for parks & public gardens and WOZ values, adding both population and value interaction terms.

	Log WOZ
	(11) Combined
Variable	
Relative land use	-0.010
	(0.050)
Relative land use^2	0.335***
	(0.099)
Relative land use * population density	-0.002***
	(0.001)
Population density	-0.001***
	(0.000)
Relative land use * high_value	0.098***
	(0.021)
High_value	0.043***
	(0.002)
Housing stock	-0.006***
	(0.000)
Share of construction year	
Before 2000	0.005
	(0.004)
After 2000	0.006
	(0.004)
Age group shares	
0-15	0.008***
	(0.000)
15-25	0.002***
	(0.000)
25-45	-0.000***
	(0.000)
45-65	0.006***
	(0.000)
>65	0.003***
	(0.000)
Immigrant share	
Western	-0.000
	(0.000)
Non-western	-0.005***
	(0.000)
Distance to	
Education	0.012***
	(0.001)
Care	0.005***
	(0.001)
Retail	0.010***
	(0.001)
Constant	11.616***
	(0.375)
Observations	33,346
R^2	0.988
Individual neighborhood fixed effects	Yes
Municipality specific time fixed effects	Yes
Control variables	Yes

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features).*

Table B.7 Average marginal effect and related average implicit value per house and total neighborhood associated with a 1 percent point increase of relative land use intended for parks and public gardens on WOZ values of housing, by population density.

Population density	Average marginal effect	Observations in sample	Average implicit value per house	Average implicit value total neighborhood	Average relative land use	Average number of houses
≤ 0.83	0.044%	4,615	€ 15,766	€ 2,299,149	0.001	147
≥ 0.83 & ≤ 12.81	0.042%	7,960	€ 13,272	€ 3,586,580	0.015	319
≥ 12.81 & ≤ 44.88	0.015%	10,462	€ 3,587	€ 2,425,856	0.054	960
≥ 44.88	-0.090%	10,309	€ -17,797	€ - 25,700,000	0.061	1263
Total	-0.007%	33,346	€ 973	€ - 6,003,194	0.039	788

Notes: Marginal effect is determined based on the regression results of Model 9 in Table 5.5 and corresponds to the following formula: $0.044 + (2 \times 0.352 \times relative\ land\ use) - (0.002 \times population\ density)$. *Estimations use three control variable groups (housing characteristics* of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for a quadratic relationship. The implicit monetarized value of these parks are calculated by multiplying the marginal effect with the average WOZ value in the associated neighborhood for the value per house, and subsequently multiplied by the number of houses of the associated neighborhoods for the value per total neighborhood. Number of observations refers to the sample used in order to estimate the relationship (Table 5.5).*

Table B.8 Average marginal effect and related average implicit value per house and total neighborhood associated with a 1 percent point increase of relative land use intended for parks and public gardens on WOZ values of housing by housing value category.

Housing value neighborhood	Average marginal effect	Observations in sample	Average implicit value per house	Average implicit value total neighborhood	Average relative land use
≤ 239,000	-0.085%	17,087	€ -15,554	€ -14,300,000	0.052
≥ 239,000	-0.006	16,259	€ -2,079	€ 816,568	0.026
Total	-0.046 %	33,346	€ -8,984	€ - 6,923,924	0.039

Notes: Marginal effect is determined based on the regression results of Model 10 in Table 5.7 and corresponds to the following formula: $-0.126 + (2 \times 0.395 \times relative\ land\ use) + (0.100 \times high\_value)$. *Estimations use three control variable groups (housing characteristics* of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for a quadratic relationship. The implicit monetarized value of these parks are calculated by multiplying the marginal effect with the average WOZ value in the associated neighborhood for the value per house, and subsequently multiplied by the number of houses of the associated neighborhoods for the value per total neighborhood. Number of observations refers to the sample used in order to estimate the relationship (Table 5.7).*

Table B.9 Average marginal effect and related implicit value per house and total neighborhood associated with a 1 percent point increase of relative land sue intended for parks and public gardens.

Average marginal effect	Observations in sample	Average implicit value per house	Average implicit value total neighborhood	Average relative land use
-0.004%	33,346	€ 5,230	€ -5,191,494	0.039

Notes: Marginal effect is determined based on the regression results of Model 11 in Table 5.9 and corresponds to the following formula: $-0.010 + (2 \times 0.335 \times relative\ land\ use) + (-0.002 * population\ density) + (0.098 \times high\_value)$. *Estimations use three control variable groups (housing characteristics* of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for a quadratic relationship. The implicit monetarized value of these parks are calculated by multiplying the marginal effect with the average WOZ value in the associated neighborhood for the value per house, and subsequently multiplied by the number of houses of the associated neighborhoods for the value per total neighborhood. Number of observations refers to the sample used in order to estimate the relationship (Table 5.9).*

C. Additional figures and tables

Figures

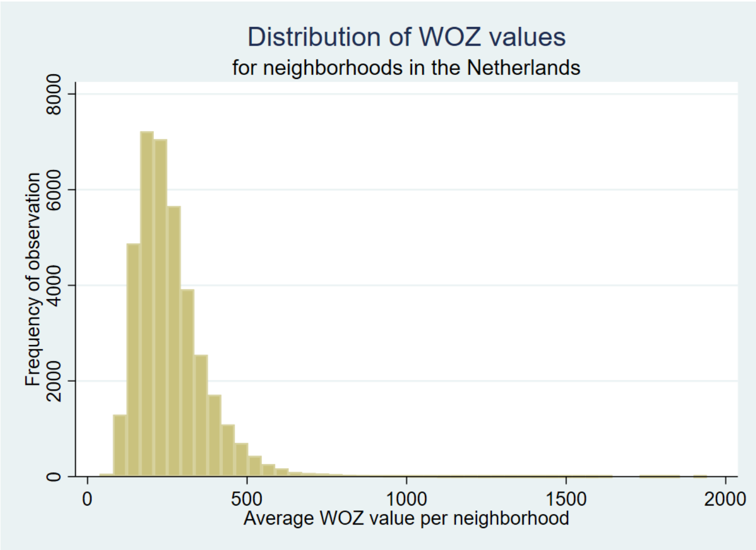

Figure C.1 Distribution of the average WOZ value for neighborhoods in the Netherlands.
Notes: The average WOZ value is displayed in thousands of euros to increase the legibility of the figure.

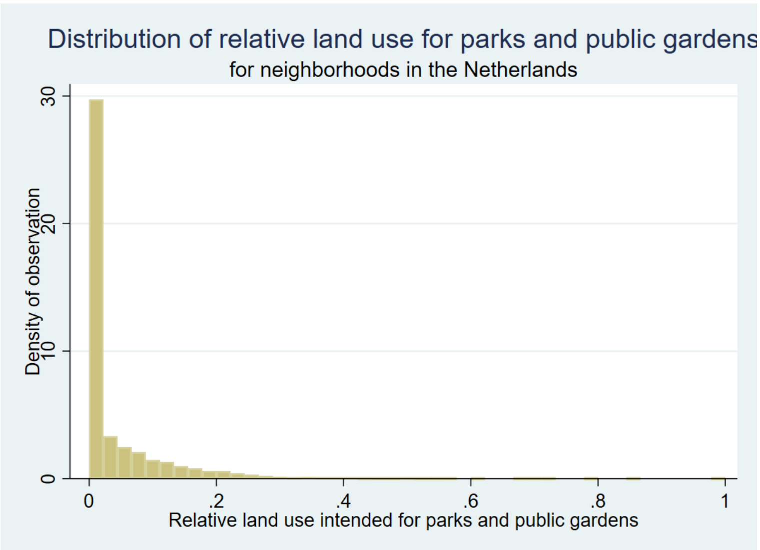

Figure C.2 Distribution of the relative land use intended for parks and public gardens.
Notes: Observations refer to the observation sample used in the fixed effect regressions.

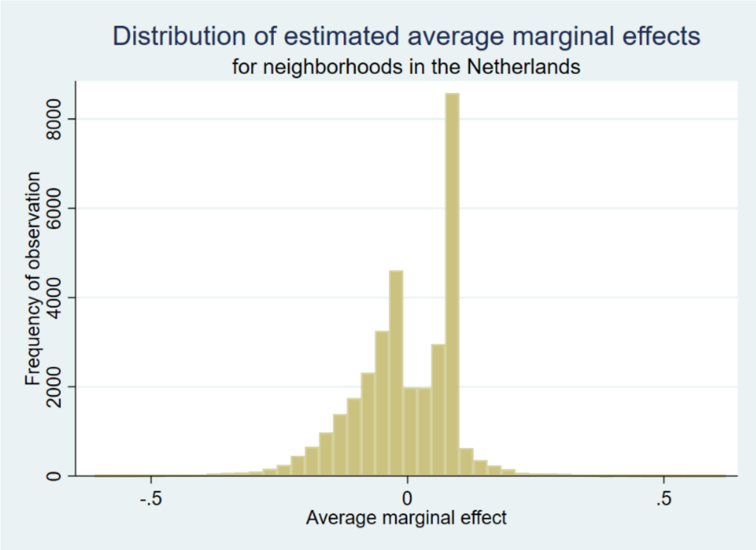

Figure C.3 Distribution of estimated average marginal effects.
Notes: Estimations refer to the results of Model 11 in Table 5.9 & B.6.

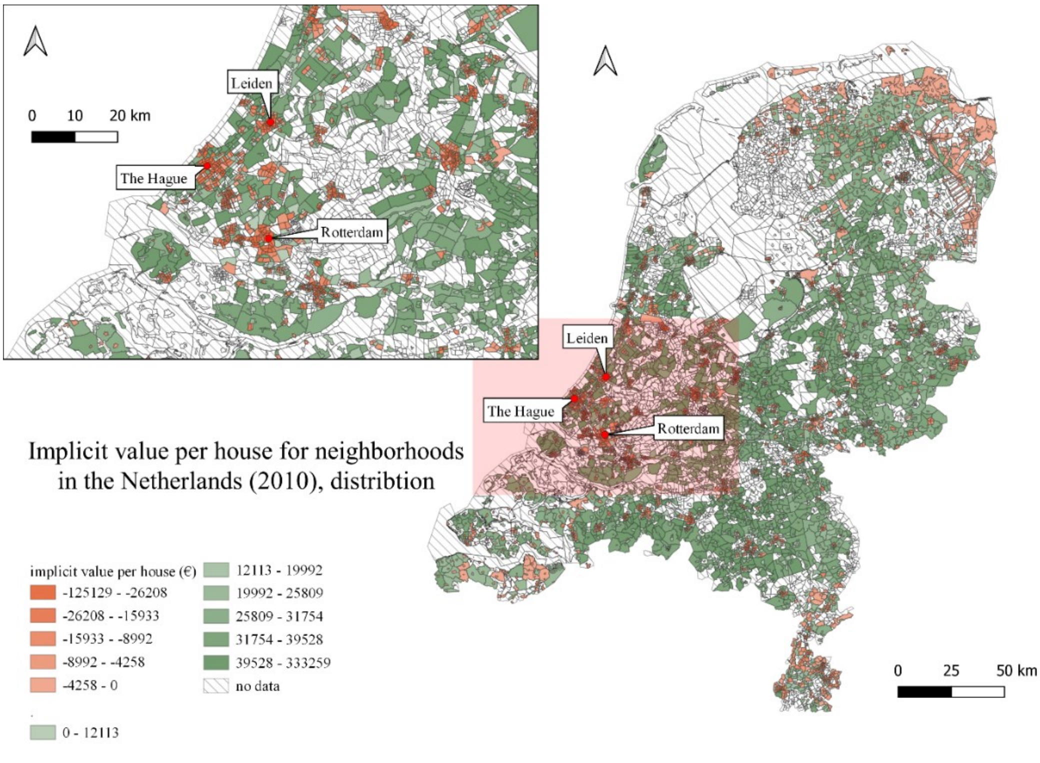

Figure C.4 Map of the implicit value per house for neighborhoods in the Netherlands, 2010.

Notes: Calculated implicit value is based on the results of Model 11 in Table 5.9 (adding both value and population density interaction terms) and relates to the marginal added value per house of a 0.01 increase in relative land use for parks and public gardens for neighborhoods in the regression sample, plain map is provided by CBS. Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodem*ographic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for an quadratic relationship.*

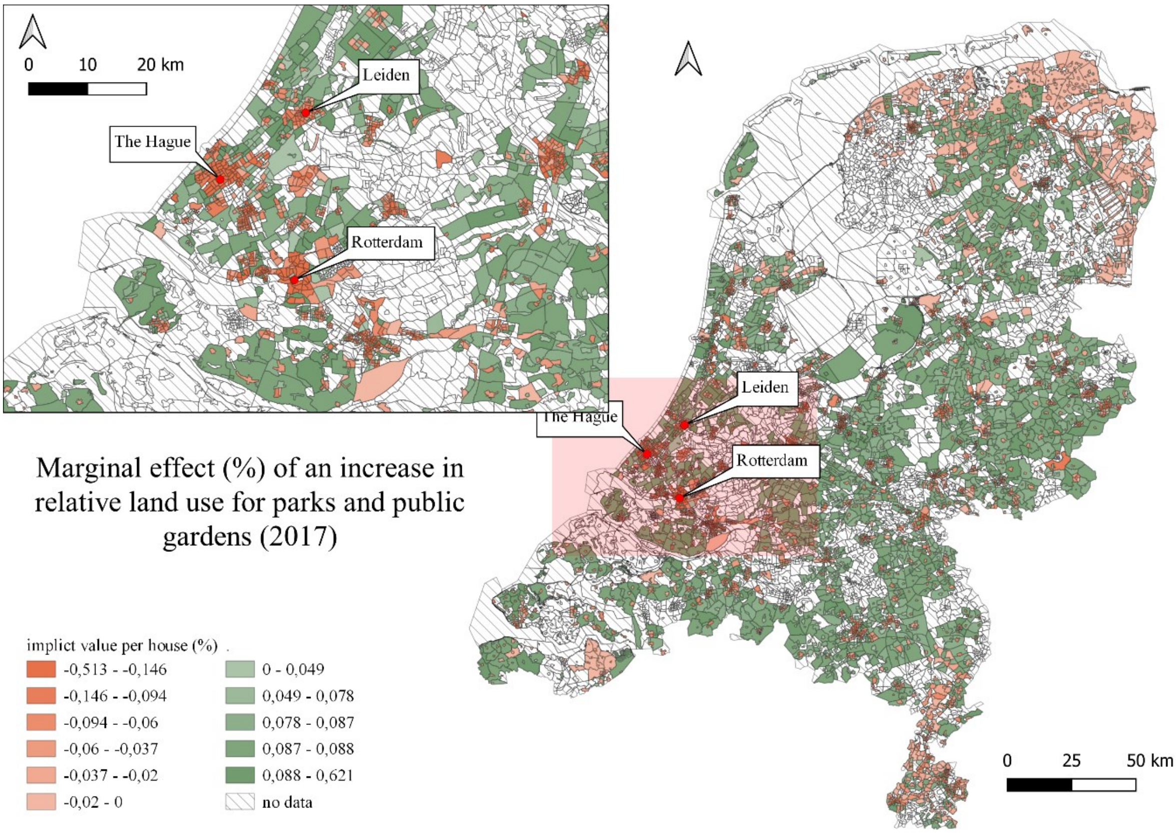

Figure C.5 Map of the marginal effect for neighborhoods in the Netherlands, 2017.

Notes: Calculated marginal effect is based on the results of Model 11 in Table 5.9 (adding both value and population density interaction terms) and relates to the marginal effect on WOZ values in percentages of a 0.01 increase in relative land use for parks and public gardens for neighborhoods in the regression sample, plain map is provided by CBS. Estimations use three control variable groups (housing characteristics of the neighborhood, *sociodemo*graphic neighborhood measures and *location features) and both neighborhood individual and municipality specific time fixed effects, while allowing for an quadratic relationship.*

Tables

Table C.1 Descriptive statistics for categories of population density and housing value

Category	Observations	Mean WOZ	Mean housing stock
≤ 0.83 population density	4,615	358,275	147
≥ 0.83 & ≤ 12.81 population density	7,960	304,212	319
≥ 12.81 & ≤ 44.88 population density	10,462	239,705	960
≥ 44.88 population density	10,309	202,233	1,263
≤ 239,000 average housing value	17,087	180,525	1,033
> 239,000 average housing value	16,259	343,375	531
Total	33,346	259,928	788

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