ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Master Thesis [programme Urban, Port and Transport Economics]

The effect of natural amenities on house prices in the urban settings of Nijmegen and Rotterdam: a hedonic perspective

Name student: Tenzin Rinchen Dorjee

Student ID number: 446379

Supervisor: prof.dr. Frank G. van Oort

Second assessor: prof. Jeroen van Haaren

Date final version: 16-08-2021

Abstract

This thesis discusses the way natural amenities in urban settings are captured in house prices, in the cities of Nijmegen and Rotterdam for the period of 2011-2019. Using pseudo-panel data, hedonic price regressions in combination with neighbourhood-fixed and year-fixed effects have been employed. In addition to the main effects of the natural amenities, interaction effects have been added to expose any interaction mechanisms between different types of natural amenities. Proximity to the natural amenities has been calculated using two distance bands (400m and 800m), both of which have been evaluated. Ultimately, increased access to proximate water bodies has been found to be significantly positive for both distance bands in Rotterdam and in Nijmegen. A difference in valuation can be observed between the cities, but general trends applicable to both are also found. Furthermore, a multitude of interaction effects have been found significant, indicating that the composition of the amenities mix does matter for house prices.

Acknowledgements

It is no exaggeration when I tell you that this has been the single most demanding academic piece of writing and research I have undertaken. It is therefore more important than ever, to thank and acknowledge everyone who supported me in the process of writing this thesis. Furthermore, I would like to acknowledge my supervisor, prof.dr. Frank G. van Oort, for the continuous feedback and for keeping my thesis on track. In addition, I would like to acknowledge my previous supervisor, dr. Zhiling Wang for providing me with honest feedback in the beginnings of the project. Lastly, I would like to thank prof. Jeroen van Haaren for his constructive feedback regarding the data selection process.

Table of Contents

Introduction

Problem setting and relevance

In the last decades the call for a more sustainable society has also ingrained itself in governmental policies, with urban planning being no exception (NÆss, 2001). These sustainable policies often strive towards a more 'ecologically liveable' city, stressing the importance of natural elements in the urban setting (Kenworthy, 2006). The value of these natural amenities cannot be directly measured, yet can have a considerable price impact as non-market amenities (Stromberg, Öhrner, Brockwell, & Liu, 2021). In the past years, hedonic price regressions have often been utilised to valuate such amenities, in particular with regard to urban green parks or urban open spaces (Brander & Koetse, 2011).

Meta-analysis of hedonic price regressions on the value of urban open spaces has resulted in a positive, yet insignificant effect of said spaces on house prices in the United States (Brander & Koetse, 2011). Multiple other research papers have also focused on urban parks, such as estimating area size and distance interaction effects in New Zealand (Fernandez & Bucaram, 2019) and measuring the effect of a direct view on said parks in South Korea (Jung, Baek, Sohn, & Yoo, 2016). The influence of other natural amenities has also been studied in similar fashion. A global meta-analysis showed that a view on a river significantly increases house prices regardless of macro-geographical locations (W. Y. Chen, Li, & Hua, 2019). Views on parks and open space have a similar effect on house prices, but the same meta-analysis paper also indicates that views on forest areas are more likely to lower house prices (Crompton & Nicholls, 2019). The number of proximate street trees has also been found to positively influence house prices in Portland, a city in North-West of the United States (Donovan & Butry, 2010). Additionally, multiple studies have found that impact of natural amenities on house prices is dependent on the degree of proximity (Melichar & Kaprová, 2013; Nilsson, 2014).

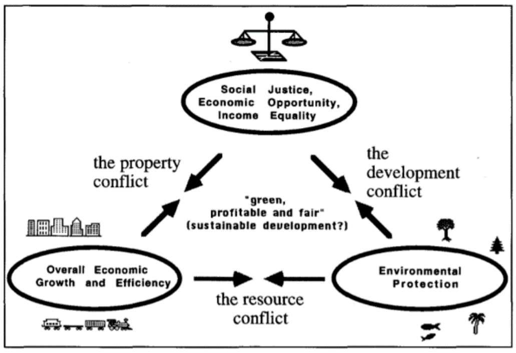
A small number of comparable studies have also been conducted in The Netherlands. Daniel, Florax, & Rietveld (2009) found that even though historic flood risk significantly decreases house value, a smaller, simulataneous positive effect for proximity to water bodies still exist. Another hedonic price regression found this same positive effect for proximity to water bodies, but also saw that this effect quickly drops off on greater distances (Rouwendal, Levkovich, & Van Marwijk, 2017). A positive effect can also be observed for the presence of parks (Fennema, Veeneklaas, & Vreke, 1996), with Bout asserting that in The Netherlands, park size does matter (Bout, 2017). When it comes to studies that take multiple natural amenities into consideration, Visser, Van Dam, & Hooimeijer (2008) found that woodland and water have an effect on house pricing, as opposed to the presence of parks. This is in contrast with earlier findings of Luttik (2000), which state that whilst water bodies appear to be the dominant price-deciding natural amenity, parks also positively effect house value. There seems to be no congruent approach in definition of proximity, with the above-mentioned studies using continuously measured variables or a variation of different distance bands ranging from direct view to 800 metres.

This paper aims to consider the role of multiple proximate natural amenities in house valuation, enriching the literature with a more current and detailed perspective on house pricing in Nijmegen and Rotterdam. As mentioned, previous studies on the Netherlands are either focused on one amenity or use relatively old datasets, while Nijmegen and Rotterdam have not been researched before – it is this gap in the scientific domain that this paper aims to address. Both cities have typical waterfront planning situations and aim for a more sustainable development exploiting this. Nijmegen additionally has a more natural green-areas layout, while Rotterdam invests relatively more in parks. Next to the benefit of drawing twice the inferences, studying two cities allows for a better idea of generalisation by comparing which findings are consistent over the two cities.

With sustainability as an important pillar in urban planning, cities are faced with the difficult task of implementing the sustainable measures within their pre-existing goals of economic development, social equity and environmental protection (Campbell, 1996). These goals are visualised in figure 1, showing the potential clashes between stakeholders.

Figure 1

Triangle of conflicting planning goals and associated conflicts



Note. The ideal implementation of all three leads to the centre goal. From “Green Cities, Growing Cities, Just Cities?: Urban planning and the contradictions of sustainable development,” by S. Campbell, 1996, *Journal of the American Planning Association*, 62(3), p.298.

NÆs (2001) argues that the key to successful sustainable city development is for the city to find enough allies to push through change rather than to build consensus among all stakeholders. Both viewpoints foresee the city planners to convince stakeholders of the fruitfulness of the sustainable development. A correct valuation of urban natural amenities can aid stakeholders (such as project developers and house owners) and policy makers in decision-making. This also holds true for the cities Nijmegen and Rotterdam, both of which emphasise green spaces and sustainability in their city visions (Gemeente Nijmegen, 2020b; Gemeente Rotterdam, 2018).

Research question

In trying to address the above, the following research question arises:

- *How are proximate urban natural amenities valued in house prices?*

This question can be divided into multiple sub-questions:

- Are there identifiable effects for proximate green and blue amenities?
- Does proximity of green and blue amenities matter?
- Does size or composition of green and blue amenities matter?
- Do interaction or reinforcing effects exist between these natural amenities?
- Is there a difference in valuation between cities?

Thesis outline

This introduction will first be followed by the Theoretical Framework, in which the relevant literature will be summarised and used to form hypotheses. The next chapter will be Data & Methodology, in which the data will be described and the research methodology explained. The chapter will be followed by the Results, which will describe the outcomes of modelling exercises. The Conclusion chapter then interprets these results whilst the final chapter Discussion and Limitations will discuss relevant caveats.

Theoretical Framework

Firstly, the history and origin of natural amenities in the city-context is explained. Secondly, the documented benefits of natural urban amenities are summarised. Then, the general relationship between cities and their amenities is explained. This is followed by a short summary of possible valuation methods, after which the results of earlier valuations of natural urban amenities are discussed. The theoretical framework is then concluded by formulating hypotheses to the sub-questions, based on earlier research.

The history of natural urban amenities in Western-Europe and the United States

The current phenomenon of urban public parks did not start to take shape before halfway the 1800s (Gothein & Archer-Hind, 2014). In the Middle Ages there was no demand for such amenities, with open meadows available outside of the walls so close by. The Renaissance did see wealthy citizens take up their own private gardens. These gardens were open to the public, but the actual access was limited – certain areas could be off-limit or benches were only for nobility. It is only in the mid-1800s that most of existing parks were fully opened to the public and that new public parks were constructed (Clark, 1973). The process of industrialisation began to pick up pace and cities started to expand rapidly: the new factory jobs attracted people and vice versa. With the increasing stress on industrial cities making for a dirty, polluted living environment, governments and philanthropic entrepreneurs started to reserve and make space for public gardens. A priest of the Bishop of London wrote the following about these parks in the 1840s (Clark, 1973):

“they, who might otherwise have been absolutely pent up and stifled in the smoke and din of their enormous prison may take breath in our parks…. To satisfy that inextinguishable love for nature and fresh air and the bright face of the sun….”

The strong belief in societal health benefits of the public parks (like the idea that parks could ‘cure’ drunkenness) caused the institutionalisation of public parks into legislation (such as the Public Health Act of 1848 in England), in order to mandate local governments to establish these amenities (Clark, 1973).

As mentioned, the introduction of public parks went hand in hand with the industrialisation and urbanisation of European countries and the United States. However, Europe and the United States did not develop the same attitude towards urban park planning (Duempelmann, 2009). In the United States, parks were seen as systems by the beginning of the 20th century, and were often approached from a city-wide level. They were to flow throughout the city like a river, with natural features like creeks as anchor points. The common thought was that a system of parks could serve as a backbone to the city and as a means to regulate the development of its built environment. A well-organised system of parks was a way of conveying a city's prowess, whilst also serving a functional purpose (Duempelmann, 2009). In European countries parks were seen as belts and girdles, more like singular entities in a city rather than an all-encompassing system (Duempelmann, 2009). A shift was also seen to the inclusion of more recreational sports fields within parks, in response to concerns over unhealthy diets and insufficient facilities for urban working classes (Tate, 2018).

Post-war suburbanisation led to a decline in urban park investment in the 1950s (Tate, 2018). Especially in the United States institutionalised neglect continued till deep in the 1970s, with parks increasingly perceived as dangerous. However, the 1980s saw interest in urban parks revitalised again – old industrial sites were repurposed and constructed into new parks (Tate, 2018).

The history of urban trees and forests in Western-Europe and the United States

The first forests emerged around 380 million years ago in the Late Devonian, long before any humans were around (Berry & Marshall, 2015). In early medieval times, forests were seen as volatile places, both for good and for bad (Paletto, Sereno, & Furuido, 2008). It was a place outside of the city where people could escape to and hide out, a place where lovers could secretly meet, but also a place where wolves roamed and bandits ambushed. During the medieval times this attitude changed, with cities starting to take ownership of neighbouring forests (Forrest & Konijnendijk, 2005). These city forests were initially used as places of recreation and as hunting places for nobility, while also providing a source of timber. The steady growth of cities caused these forests to be cut for agricultural purposes, which saw forest usage by commoners conflict with the nobility's hunting activities. This resulted into more restricted access for commonfolk (Gerhold, 2007). In the 17th and 18th century existing forests were changed and new forests were planted to accommodate the nobility and the new rich bourgeoisie. Additionally, some new forests were also constructed for the general public. In the following centuries, industrialisation saw forestry felled and new forests planted for their timber production (Paletto et al., 2008). The related increase in urbanisation also led to an increased recreational usage of urban forests by the city population (Forrest & Konijnendijk, 2005). Designated green belts and zones where no housing or industry was allowed to develop, included forestry. Urban forestry was seen as relief places for the good of 'spiritual and bodily hygiene'(Forrest & Konijnendijk, 2005). At the end of the twentieth century, construction of parks was still mainly focused around recreational usage. However, other functions such as 'biodiversity, water protection, enhancing the landscape and the creation of attractive environments for housing and economic development' started to play a role in decision-making (Forrest & Konijnendijk, 2005).

Urban trees were already common in ancient times, when trees were planted next to public buildings such as temples, civic buildings and amphitheatres (Gerhold, 2007). In medieval times, the extent was mainly limited to trees in private gardens, such as those of monasteries. It is not until the 16th, 17th and

18th century that urban trees are reintroduced in a public setting, when trees are used for beautification and shade purposes alongside streets and promenades. The rapid city population expansion in the 19th century driven by the industrial revolution caused difficulties in managing the urban trees (Ricard, 2005). An example of such difficulties is the destruction or damaging of street trees in the process of 'expanding the number and widening of existing roads, stringing aerial electric lines, and digging below-ground gas lines' (Ricard, 2005). Management of urban green became a profession of its own (think of tree wardens), which saw urban trees part of an integrated city vision which included parks. Trees were planned and planted on mass-scale, with local citizens forming associations lobbying for new greenery in their own neighbourhood: any profitable timber could increase the value of their land, while also providing health benefits, refreshing shade and making the area more visually appealing (Forrest & Konijnendijk, 2005).

History of urban water in Western Europe and The Netherlands

The presence of water resources has greatly affected the location of human settlements, especially when mankind had limited ability to transform and utilise natural landscapes (Wang & Gao, 2020). It is therefore no surprise that people concentrated around water bodies such as rivers, seas and lakes. They offered a source of clean drinking water, facilitated fertile ground and eventually enabled water transportation. With the expansions of cities settled next to rivers, the increasing stress on the water resources called for water management (Wang & Gao, 2020). Especially during the industrialisation did cities take a toll on local water sources, as water bodies became more polluted (both with chemical and organic pollution) whilst simultaneously being used more (Deligne, 2016; Euzen & Haghe, 2007). This put more emphasis on sanitation-related water management, as water management traditionally focused water safety and transport (Lintsen, 2002). When it became clear that the polluted water indeed infected people, sewerage systems started to arise in cities, which would later incorporate full-fledge drainage systems (Brown, Keath, & Wong, 2009).

The Netherlands in particular has a long and distinct history of water management, which Hooimeijer (2020) categorised into five distinct phases:

- natural water management (until 1000)
- defensive water management (1000–1500)
- anticipative water management (1500–1800)
- offensive water management (1800–1890)
- manipulative water management (1890–1990)
- adaptive manipulative water management (1990 until today).

Natural water management (until 1000) was constrained to digging ditches for agricultural purposes and to settling high up along rivers to avoid any flooding. It was not until 1000 that mankind had enough ability for more a more ambitious, defensive water management. This consisted of the heavy implementation of dykes and dams to protect themselves against the water. Dams also proved to be sources of economic income and traffic with the need for ship transfers – something which Rotterdam at the time also benefited from. From 1500 onwards, better understanding of water systems and increased political collaboration led to a more comprehensive control over bigger water areas: the scope of (anticipative) water management increased to whole polders and rivers being controlled with windmills, dams, dykes and sluices (Hooimeijer, 2020). An even more offensive water management started to arise in 1800-1890 (Hooimeijer, 2020). The invention of steam engines led to a more mass-scale planning approach with canal constructions, whilst the increased urbanisation and industrialisation leads to the earlier-mentioned sanitation-focused approach. From 1890 to 1990 a more manipulative water management was employed: the introduction of electricity and the engine enabled drastic changes (Hooimeijer, 2020). Drinking water and waste water systems became separated, while largely being moved underground. With car infrastructure demanding space and open water bodies smelling bad due to high density industry cities, most existing urban water bodies were filled in. This brings us to the current situation, where no consensus prevails regarding approach. However, a new attitude did emerge in which the call for natural, sustainable water systems is embedded in the realisation of the impacts of climate change, the vulnerability of natural and human environments and the necessity of adaptation (Hooimeijer, 2020).

Benefits of urban greenery and water bodies as urban amenities

As mentioned earlier, urban greenery (green zones) and water bodies (blue zones) have historically been valued as recreational areas and regarded as a means to help cure societal diseases. Current literature shows that a similarly positive contemporary view is held on the value of these natural urban amenities. Urban trees remove air pollution, reduce stress and depression levels, encourage physical activity, foster community ties and can help manage storm water (Turner-Skoff & Cavender, 2019). Similar effects are also found for urban parks and forests: they offer cooler environments and help cool surrounding area (Y. Chen & Wong, 2006), are associated with decreased depression rates and encourage physical exercise (Coombes, Jones, & Melvyn, 2010) and support a more healthy modal shift (Frank, Schmid, Sallis, Chapman, & Saelens, 2005). The presence of urban water (bodies) also provide comparable mental health, social and recreational benefits (Nutsford, Pearson, Kingham, & Reitsma, 2016; Völker & Kistemann, 2011).

In the last decades, these benefits of natural amenities have become of particular interest with the increased focus on sustainability in city planning (NÆss, 2001). Natural amenities play a key role in most ecological city visions. For example, Kenworthy (2006) argues that it takes a comprehensive planning policy to become more sustainable, and stresses the importance of green urban spaces and of a societal modal shift towards walking and cycling. It is clear that these go hand in hand, with natural zones and street trees improving walkability of a city (Frank et al., 2005). Another important aspect according to Kenworthy (2006) is a compact, mixed-use urban form. High-density planning allows allow for more efficient use of public amenities, cuts down on transport usage and allows for walkability. However, the nature of high-density building stock makes for heat islands in cities (Y. Chen & Wong, 2006). Natural amenities like urban parks can help cool down the immediate and surrounding area. NÆss (2001) recognised the importance of high-density cities too and saw natural amenities as essential in order for dense cities to remain liveable and for them to actually reap the benefits of their high density.

Cities and urban amenities

Initially, most of the of academic discourse regarding cities were from a producer perspective, without regard for cities as centres of consumption amenities (Glaeser, Kolko, & Saiz, 2001). From a producer perspective, cities exist because of the inherent agglomeration economies (Brueckner, 2011). Technological (increasing the productivity without lowering costs), pecuniary (decreasing costs whilst productivity of inputs are unaffected) and retail agglomeration economies (co-location of individual retail shops generates gains through in-store externalities) beneficial for producers. Potential causes are knowledge spillovers, decrease in transport costs and the propensity to visit another store, respectively. The traditional flipside has been that cities were bad for non-work consumption; higher rents, longer commutes and higher crime rates made the city less desirable (Glaeser et al., 2001).

Glaeser, Kolko and Saiz (2001) were one of the first to view cities from a consumer perspective, as a centre of consumption. They argue that a higher share of income being spent on housing and transportation is a sign of increased importance of a desirable living location. Extrapolating this trend, the hypothesis is posited that cities will either grow or decline according to the level of amenities available. Correspondingly, they identify four ‘critical urban amenities’ in cities:

- the presence of a rich variety of services and consumer goods
- aesthetics and physical setting
- good public services
- speed (ease of which services and jobs can be accessed, measured in transport costs)

Subsequent research has indeed shown that urban amenities are good predictors for city growth (Carlino & Saiz, 2019; Garretsen & Marlet, 2016). Critics have also remarked that this might not be particularly true for cities of smaller sizes (Kalsø Hansen & Winther, 2010). The smaller the city, the more its endogenous resources are dependent on geographical and cultural context to be the supposed growth drivers.

Urban parks, trees, forests and water bodies can be classified as both the first type of critical urban amenity and the second type. Park usage such as enjoying a walk or going jogging can be seen as the consumption of a public good (Stewart, Gil-Egui, & Pileggi, 2010), whilst the inclusion of green and blue spaces in the city are also part of the city aesthetics and physical setting (Nutsford et al., 2016; Völker & Kistemann, 2011).

Valuation of urban amenities

Typical valuation methods of public good type usage of non-market natural amenities can be divided into 'revealed preference' and 'stated preference' approaches (Young, 1996). Revealed preference methods use data to infer any possible pricing, whereas stated preference methods ask consumers their willingness-to-pay. Two popular valuation methods in open space literature are the stated-preference contingent valuation method (CVM) and the revealed-preference hedonic pricing method (HPM). CVM estimates are generally annual willingness-to-pay values, whereas HPM estimates are changes in house prices (Brander & Koetse, 2011). Moreover, HPM is likely to deal with proximity to natural amenities, whilst CVM is mostly concerned with the area of the natural amenities. Hedonic pricing is applied to markets for goods where all participants know the bundle of characteristics that the good consist of, with no option of unbundling the characteristics (Young, 1996). In the case of house prices, this can include general attributes such as plot size, but also attributes pertaining proximity to or presence of the natural amenities (e.g. close access to a lake).

Previous findings regarding hedonic price regressions on house prices and natural amenities

In isolation, proximity to urban trees (Donovan & Butry, 2010), urban forests (Tyrväinen & Miettinen, 2000), urban water bodies (Lansford & Jones, 1995) and urban parks (Wu & Dong, 2014) all have documented positive effects on house prices. However, the size of impact is dependent on the degree of proximity and on location-specific characteristics (Melichar & Kaprová, 2013; Nilsson, 2014). Moreover, a view of the amenity can already be enough to warrant a premium (W. Y. Chen et al., 2019; Jung et al., 2016). However, some studies suggest that extreme proximity can lead to initial lower premiums, as negative externalities of others' park usage such as noise might be experienced more directly (Stromberg et al., 2021).

In the Netherlands, similarly mostly positive results have been found. Fennema, Veeneklaas and Vreke (1996) found that the presence of local urban parks significantly increases house prices by 7.2% on average. Rouwendal, Levkovich and Van Marwijk (2017) found that immediate proximity to urban water bodies like lakes and waterways leads to a significant 4-6% increase in house prices, but this effect declines to 1% at a distance of 60m and becomes insignificant any distance beyond 60m. Another paper found an increase of 2.7% in price if a dwelling is within 500m of a river, yet any past floodings cause prices to drop by 7.4% (Daniel et al., 2009). Moreover, Bout (2017) found that park size can also be a factor in revealed amenity value, with park size positively affecting house prices in Utrecht whilst no significant effect is observed in The Hague. Visser, Van Dam and Hooimeijer (2008) studied the effect of all the natural urban amenities and found that the most important physical environment characteristic positively influencing the price per m^2 is the percentage of wooded area in the neighbourhood (0.09 per m^2) and the presence of wooded area within 50m (0.04 per m^2). The presence of water bodies also adds a premium (0.04 per m^2), while parks do not have any significant effect. This is not completely in line with the earlier findings of Luttik (2000), who found major house prices increases for dwellings with gardens facing water connected to sizeable lakes (up to 28%), with other large increase being views on water (8–10%) and open spaces like parks (6–12%). In contrast to the later research of Visser, Van Dam and Hooijmeijer, proximity to woods never turned out to be significant.

Hypotheses

As introduced in the introduction, the main research question formulated as follows:

How are proximate urban natural amenities valued in house prices?

From this research question four hypotheses arise, which are founded in the theoretical framework laid out above. Several avenues are explored to estimate the manner in which urban natural amenities are valued in house prices. The first avenue is the general, main effect of natural amenities: does an increased presence of natural amenities increase or decrease house prices? Previous research has linked urban natural amenities to health and recreational benefits. An increase of these amenities might allow for benefits reaped, with more amenities perhaps allowing for a wider range of recreational usage. The first hypothesis is therefore formulated as follows:

A bigger presence of green and blue amenities has a positive effect on house prices.

A bigger presence of the natural amenities is operationalised in different manners for the amenities. Detailed specification is discussed in the data chapter, but different measures have been applied to different amenities. In general, the accessible amenities within a specified distance band are taken into consideration, of which the total area is then summed. A bigger presence can thus be achieved by the presence of either more or bigger parks, water bodies and forests. In case of trees, an increase in presence is equated to an increase in number of present trees within the distance band (which can also be seen as a measure of tree coverage).

The second avenue is the spatial nature of the research question: amenities closer to home might be valued more positively than amenities further away. Considering the hypothesised positive effects of natural amenities, it is not beyond reason to assume a preference for these amenities to be in closer proximity. Whilst previous research has indeed found empirical evidence of more closely-located green and blue amenities having higher positive effects on house prices, it has also found evidence for negative externalities such as excessive noise. The following hypothesis has been devised:

More proximate green and blue amenities have a higher positive effect on house prices.

'More proximate green and blue amenities' has been operationalised by measuring the presence of natural amenities using a smaller (400 metres) and bigger (800 metres) distance band. This allows for an impact comparison between the level of amenities close to a house and the level of amenities including amenities a lot further away.

The third avenue is the possibility of different natural amenities interacting with each other, making for a more complex and nuanced effect of natural amenities on house prices. A lot of research has focused on a natural amenity in isolation, whilst different types of natural amenities are often interspersed throughout the city. A lot less research has focused on the interaction effects between these amenities, but research focusing on multiple amenities did not always find all amenities to be significantly affecting house prices. However, if one considers that natural amenities provide similar health and recreational benefits, then interaction effects seem likely to occur. This is also true if part of the value lies in an attractive landscape, which is affected by the composition of the natural amenities mix. Therefore, it is hypothesised that interaction and reinforcing effects do exist between natural amenities.

Interaction effects and reinforcing effects exist between natural amenities.

'Interaction effects and reinforcing effects' has been operationalised as the two-way, three-way and four-way interaction effects between natural amenities.

The last and fourth avenue is the likelihood that the effects of natural amenities are context-specific and thus differ per city. Meta-analyses have found general positive effects for different types of greenery and blue amenities, but other research have also found these benefits to be dependent on location-specific characteristics. In other words, different locations have different valuations for different types of natural amenities. The following hypothesis has therefore been hypothesised:

Valuation of natural amenities is different in Nijmegen and Rotterdam

Nijmegen and Rotterdam are two Dutch cities which share similarities, but also have their own characteristics making for two different contexts in which the effects of natural amenities on house prices can be gauged. Both Nijmegen and Rotterdam are situated next to a big river, with Nijmegen also located next to traditionally present forestry. Rotterdam is a bigger city, with urban parks forming the more typical city greenery. Considering the difference in context (the difference in city size and natural type of greenery), a different valuation for natural amenities in Nijmegen and Rotterdam is hypothesised.

Data

In the following chapter, the data used in this research will be examined. Firstly, the data collection and any transformations will be discussed. Secondly, the key variables will be studied and described.

Data collection and transformations

The dataset used comprises of open-source, private and manually-collected data. Firstly, a private dataset was made available by NVM, the Dutch association of real estate agents and appraisers (NVM, 2020). This pseudo panel-dataset contained transaction details of house purchases in Rotterdam and Nijmegen over 2011-2019, a period of nine years. These extensive details consisted of house prices, transaction dates, spatial attributes and structural property attributes. NVM is the largest association of its kind in The Netherlands and covers around 70% of the market (NVM, 2021), so it is reasonable to assume that dataset covers around 70% of the transactions as well. All observations within 400 metres of the municipality border were dropped, this is due to the used methodology, which will be explained in a further chapter. Any observations belonging to postal codes with less than 100 observations were dropped too, which will be explained in the methodology section as well. Furthermore, certain attributes were dropped due to either a lack of completeness or a high correlation (.8 or higher) with other attributes (see Appendix, Table 1). Additionally, the dataset has been carefully sanitised from any measurement errors in the variables. Some observations had clearly faulty house prices, with values as '999' for missing values. Such observations were dropped, whilst other incorrect observations (such as a value of '125' where a value of 125,000 was more likely) have been corrected where possible by searching publicly available data. The same manual inspection has been applied to the number of square metres. Moreover, all observations with a price less than €50,000 or higher than €5,000,000 were dropped as well to reduce the effect of possibly spurious outliers. Ultimately, not all attributes in the dataset have been incorporated in the models. Instead, only the number of square metres, the construction period, the house class, the availability of parking, the condition of the interior and the number of rooms have been used. The use of these attributes yielded a compact, yet sufficiently explanatory base model that stayed robust over different city-distance band specifications (these specifications will be discussed later on in this chapter). Secondly, forestry data was sourced using 'Bestand Bodemgebruik', a public dataset maintained by the Dutch Central Bureau for Statistics (Centraal Bureau voor de Statistiek, 2015). The dataset is updated every 3 years and the 2015 edition used is the most recent freely publicly available edition. It contains the digital geometry of land use in the Netherlands based on a map with a scale of 1:10.000, with categories such as forestry, residential and recreation. Geometries denoting forestry have been incorporated as whole, whilst the recreational geometries were manually assessed to see if they can be categorised as forestry. Thirdly, another public dataset 'Basisregistratie Topografie (BRT) TOP10NL' by Kadaster (2020), which is the Dutch national public cadastre, has been used. The yearly-updated dataset contains several topographic elements such as buildings, height, roads but also water, all mapped on a scale of 1:5.000 to 1:25.000. Only the water elements were incorporated. Fourthly, urban tree data has been sourced from two public datasets, one for the trees in Nijmegen (Gemeente Nijmegen, 2020a) and the other for trees in Rotterdam (Gemeente Rotterdam, 2020). They are authored by their respective municipalities and cover single urban trees maintained by the municipality, but do not cover any private trees or trees in parks or forest patches. Finally, a dataset was constructed manually containing all the parks in Rotterdam and Nijmegen, since no such dataset was available. Non-extensive lists given by the municipalities and Google Earth's natural amenity label were used as guides, but were both incomplete and in the case of Google Earth, contained noise. Since no hard criteria exist for what is defined as a park, criteria were set manually. The area should be green, should inhibit some recreational value due to the greenery and should be of significant size – a minimum size of around two acres (8100 m^2) has been set. This meant in practice that edge cases such as areas without any green (or just a small grass patch) but containing concrete football or basketball fields were rejected. However, Park Leeuwenstein, a grass field with some monumental trees, a pedestrian pathway cutting through and some benches did get recognised as a park (see figure 2). The presence of benches and monumental indicated the recreational value of the greenery was significant enough. If needed, additional online research was conducted to gauge whether the area was used as a park (potential indicators could have been social media posts or street photography). Any parks built within the time period of 2011-2019 have been excluded. This is to prevent parks that have been built afterwards to count for previously observed house prices, something which otherwise could not be avoided due to technical limitations. Tables of identified parks and their corresponding sizes has been made available (Table 2 and 3, Appendix).

Table 1. Descriptive statistics for key variables in Nijmegen and Rotterdam

Nijmegen	**obs**	**mean**	**standard deviation**	**min**	**max**
House price	5,054	259,042	131150.2	80000	1250000
Park area	24	76.252	245.734	8.280	783.385
Forestry area	40	43.852	974.766	6.104	6055.216
Water area	526	974.3296	286.912	0.25	5859.783
Trees	62475				
Rotterdam	**obs**	**mean**	**standard deviation**	**min**	**max**
House price	5,069	350641.6	241068.9	56700	3800000
Park area	65	60.755	395.209	9.142	3029.110
Forestry area	58	33.108	132.446	1.497	585.375
Water area	3737	6.836	78.977	0.001	3722.762
Trees	157303				

Figure 2

Park Leeuwenstein in Nijmegen

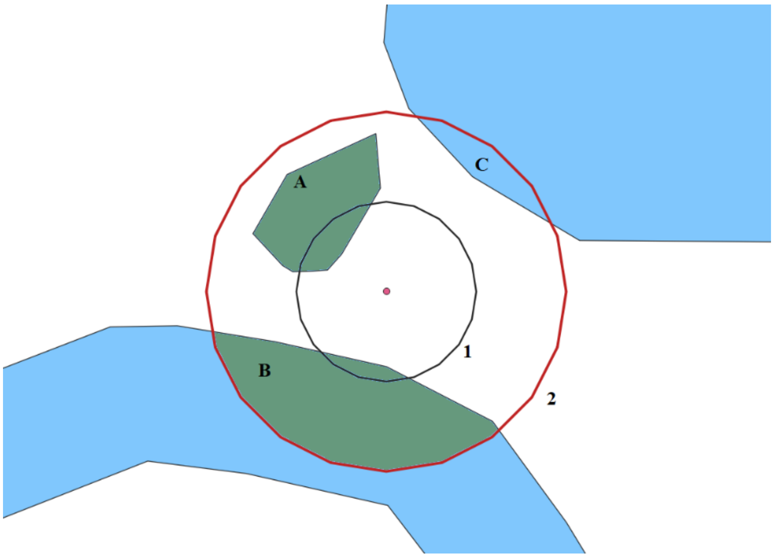
Note. A monumental tree in the foreground, with visible resting benches and a meandering pathway through the grass fields. From "Komkommermagnolia in het park Leeuwenstein, Nijmegen, Gelderland, Nederland," by L. Goudzwaard, 2013 (from https://www.monumentaltrees.com/nl/fotos/25941/). Copyright 2013 by Goudzwaard. Reprinted with permission

Key variables description

The dependent variable, house prices will be corrected for house price inflation using the relevant house price indices (see table 4, Appendix) (Centraal Bureau voor de Statistiek, 2021) and will undergo a log transformation. Building upon previous literature, a log-linear model will be applied (Riera, Mhawej, Mavsar, & Brey, 2006). The advantages are that it solves the non-linearity in the price function (Kuminoff, Parmeter, & Pope, 2010), allows for an easier interpretation and solves skewedness in distribution. Table 1 contains the descriptive statistics for the house transactions (before the log transformation), natural amenities and area of access to natural amenities. These statistics can also be found split by city and distance band in the Appendix, (see Tables 5-8), whilst full tables including the statistics for the structural characteristics can be found in Tables 9-12, Appendix. An explanation of the house characteristics names and categorical values can be found in Table 13, Appendix. Park access has been defined as the cumulative area size of parks within the distance band (measured in 100,000 m^2). In general, two distance bands have been set for this research: 400 meters and 800 metres. The 400 metres distance band represents a commonly used definition of walkability catchment (O'Hare, 2006), whilst the 800 metres distance band is used as a check for the effect for proximity. So if two parks are within the specified distance (400 metres or 800 metres), then the area of the parks are summed – not just the area that falls within the distance band. Forestry access has been defined in an analogous manner. Water access has been defined in different manner, as it is not the total area size that is summed. Similarly, the distance band has used to select the accessible water bodies. However, summing the total water body area does not make for salient data, whilst water bodies are often connected in a complex water system. An example is a proximate small pond connected to a more distant river, which if summed would falsely indicate a lot of proximate water. Instead, another distance band is applied to define the size (in 100,000 m^2) of the proximate water bodies. This extra distance band is 400 metres. Figure 3 visualises the described proximate water access methodology. Water bodies A and B are (partly) positioned within distance band 1 and the respective shade parts within both distance bands (1 and 2) will be summed accordingly. Since no part of water body C is located within the first distance band, no area will be taken into consideration (even though part of C is located within the second distance band).

Figure 3

Proximate water access calculation method



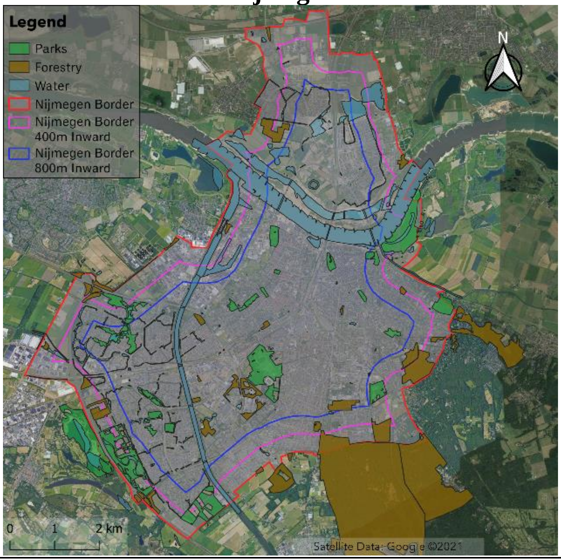
Tree access is established as the number of trees within the relevant distance band (400 metres or 800 metres) and is measured per 100 trees. Tree access, along with the other natural amenity variables (park, forestry and water access) have been mean-centred to help with the interpretation of the interaction effects. Moreover, additional minimum-centred and maximum-centred variables have been created to further assist in the analysis of interaction effects (the used centering-values can be found in Table 5-8, Appendix).

To visualise the geographical distribution of the key variables, three figures depicting house distribution, tree distribution and park, forestry and water distribution have been devised for each city, see Table 2.

Table 2. Geographical spreads of key variables in Nijmegen and Rotterdam

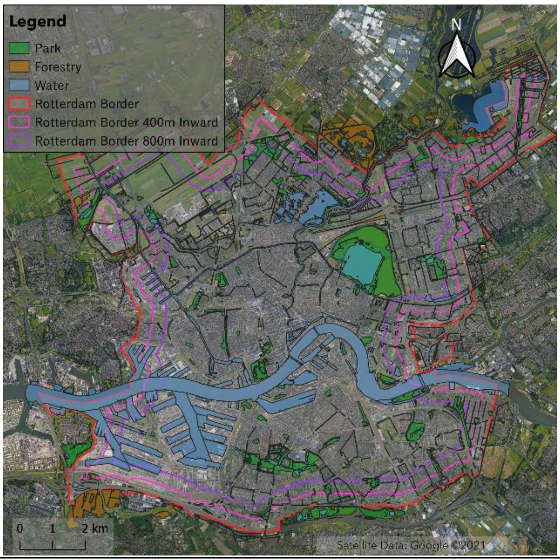
<table>
<tr>
<td>

Geographical spread of parks, forestry and water in Nijmegen



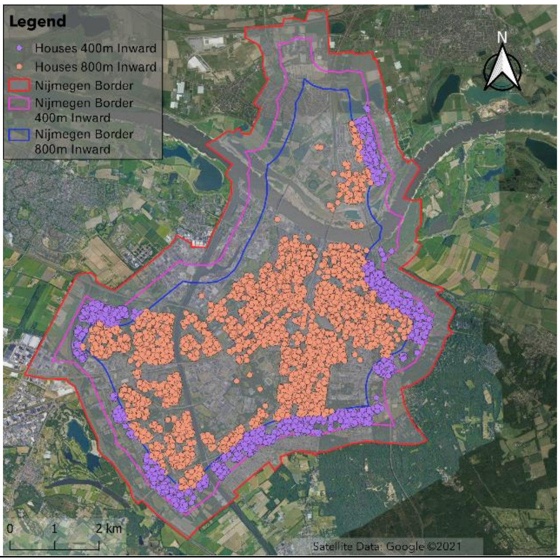
</td>
<td>

Geographical spread of parks, forestry and water in Rotterdam



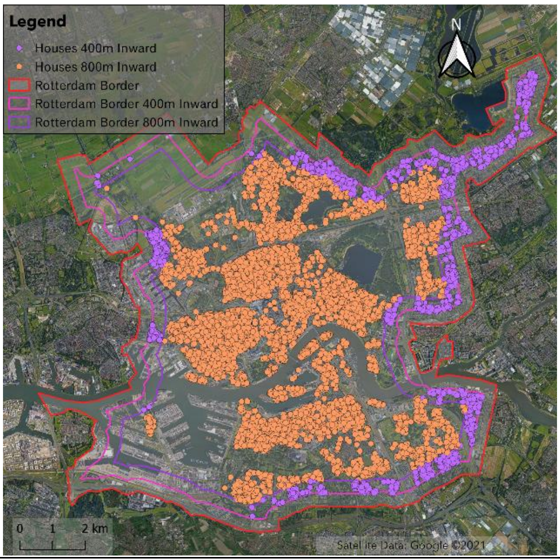
</td>
</tr>
<tr>
<td>

Geographical spread of houses in Nijmegen



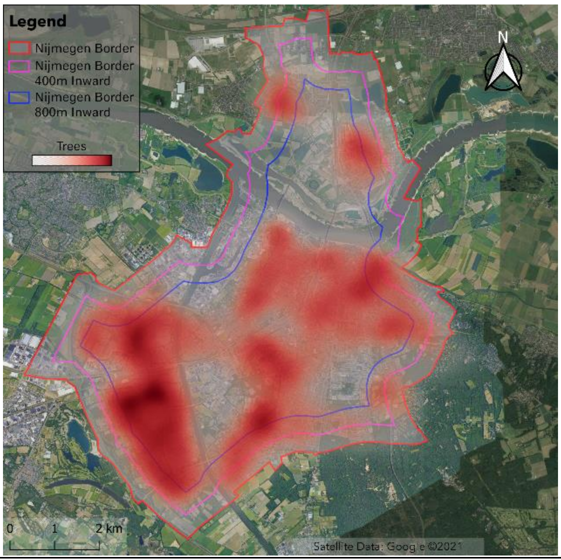
</td>
<td>

Geographical spread of houses in Rotterdam



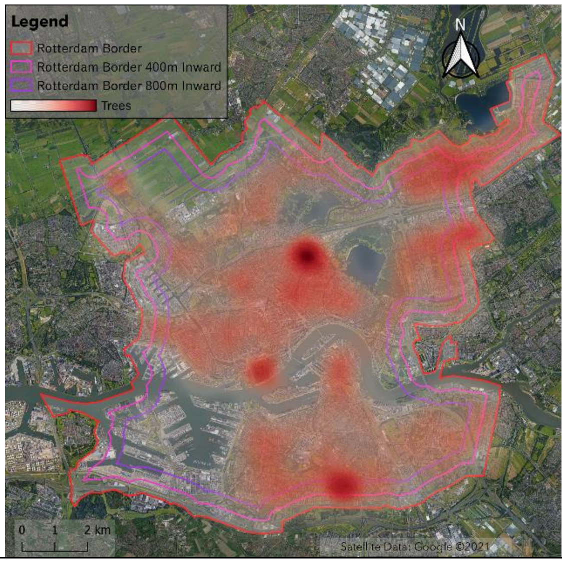
</td>
</tr>
<tr>
<td>

Geographical spread of trees in Nijmegen



</td>
<td>

Geographical spread of trees in Rotterdam



</td>
</tr>
</table>

It is important to note that in Nijmegen the border is manually changed to exclude Kwakkenberg, a rich villa neighbourhood. This neighbourhood is relatively green, with house properties having big, private gardens. Even though public forestry, non-private trees and greenery are all present, they are not or incompletely identified in the dataset, whilst manual correction was not feasible. This in conjunction with the propensity of the house observations to be outliers (due to the villa-nature of the neighbourhood), prompted removal of the neighbourhood.

The figures in Table 2 reveal a heterogenous spatial distribution of the natural amenities, for both Nijmegen and Rotterdam. Noticeable is the area in the middle towards the south of Nijmegen, which is distinctively lacking any house transactions and public street trees. This area consists of a business park Winkelsteeg and the adjacent Goffert park and forestry, of which the latter are represented in the respective natural amenities categories. Another area lacking noticeably in house transactions and natural amenities is the area located in the south-west of Rotterdam. This area is the port area of the Waalhaven and the adjacent port business.

Methodology

The hedonic pricing method

The hedonic pricing method is a revealed valuation method, in which data is used to infer pricing (Young, 1996). In hedonic pricing goods can be seen as bundles of characteristics, with all the participants knowing these characteristics. It is assumed that the price of the good is a function of its attributes, with an implicit price existing for each attribute. A statistical analysis such as a regression can then determine and reveal the pricing for these implicit attributes. The method has been adapted to several markets, but has been particularly often applied to the residential housing market, mostly in an effort to measure the effect of environmental variables (Young, 1996). The above assumptions fit the housing market well: the buyer and seller are often well-informed of the house properties, whilst the assumption that house prices are determined by the combination of housing characteristics does not seem far-fetched. These housing characteristics include structural properties such as plot size and number of rooms, neighbourhood characteristics such as crime rate, accessibility to jobs, but also locational characteristics such as distance to amenities such as the nearest supermarket and parks (Young, 1996).

An important advantage of hedonic pricing methods is that it allows for observational data and analyses actual choices. This is in contrast to stated preference methods, where respondents are asked to state their willingness-to-pay (WTP). Stated preference methods can be susceptible to accidentally biased questions, influencing the WTP (Bateman, 1994). This ranges from accidentally anchoring respondents to price points, to selecting payment vehicles that are associated with higher pay-outs (the opposite might also occur, using tax as a payment vehicle results in al lower WTP (Brander & Koetse, 2011)). Even the quantity of unbiased information influences the WTP, with higher quantities possibly resulting into higher WTP (Bateman, 1994). While careful research and survey design might avoid these problems, hedonic pricing methods do not have to deal with these problems at all. Another advantage of hedonic pricing methods with respect to residential housing, is that they typically rely on data sources that are well-curated and reliable (Bateman, 1994), while the use of market prices make for a good value indicators since the property market is relatively efficient in coordinating information.

There are also disadvantages to the use of hedonic price regressions. One of the drawbacks is that the hedonic pricing method, like many other demand models, assume observed prices to be equilibrium prices. However, this might not hold true in the real estate market where adjustment costs can be large (Sopranzetti, 2015). More so, the equilibrium assumption also does not hold if buyers are not fully knowledgeable about all the characteristics of the housing bundle (Young, 1996). The most likely and important problem is that omitted variable bias (OVB) can easily occur, as it can be hard to include every characteristic important to the consumer (Kuminoff et al., 2010). Other pitfalls can be the existence of measurement errors and multicollinearity, with measurement errors relating to the errors in observed variables and multicollinearity concerning the difficulty in interpretating multiple closely related variables. Lastly, hedonic price regression is useful for measuring the change in house prices due to certain characteristics, but its value measurement is limited to that – value of amenities might extend to other avenues than ownership and stays thus unmeasured (Young, 1996).

For this paper, the disadvantages signal potential pitfalls in the hedonic pricing method research design. However, whilst it might be true that property markets are not perfect markets, in general they do perform well (Young, 1996). Furthermore, omitted variable bias in structural house characteristics will be limited by the usage of an extensive dataset, while any OVB in the neighbourhood characteristics will be addressed using neighbourhood fixed effects. The addition of multiple natural amenity variables make any OVB within that regard unlikely, yet OVB might still persist in other forms of locational characteristics.

Fixed neighbourhood and time effects

The research design will also include neighbourhood fixed effects and time-specific effects. Fixed effects is a method of pooling data consisting of multiple observations per fixed unit. In our case this means multiple house price and characteristics per neighbourhood and year. It is important to notice that the nature of our dataset is not actually panel data but repeated cross-sections. Instead of multiple observations on an individual level (observations tracking the same house over time), individuals are not followed over time, with the cross-section at every time interval likely containing different individual houses. This type of data allows for pseudo-panel models such as said fixed effects (Guillerm, 2017). As there are no multiple observations per individual entity (the house-level) to take a mean of, it is impossible to demean any individual-fixed effects. However, the observations maybe divided into higher-level cohorts (neighbourhoods), which enables demeaning using the within-neighbourhood mean for the time-fixed effects of each variable over all houses (Bellemare, 2016). The unit-level of observations stays the house-level, but instead of individual fixed effects the higher-level neighbourhood fixed-effects are employed. This manner of conducting fixed effects is only valid under two assumptions. Firstly, the sample needs to be random, as the samples over different time periods are matched on their observable and unobservable characteristics. This can be ensured by using cohorts of a big enough size, such as 100 observations per cohort (Guillerm, 2017). This is why earlier in the data collection process, postal codes with less than 100 observations were dropped. Secondly, the samples must be unlikely to change with the time intervals, something which the inclusion of year fixed effects can greatly help achieve.

A general advantage of (standard) fixed effects pooling is that it helps in cases of limited number of spatial units and number of observations, which can lead to an imbalance of too many explanatory variables and too few cases (Riera et al., 2006). This is often a problem for time series and cross-sectional analysis, but with pooling the impact can be assessed through a large number of predictors in a multivariate framework. A second advantage is that it allows for the simultaneous exploitation of the space and time dimension: a pooled model tests for all geographical entities through time as opposed to a cross-sectional model (all entities at once) or a time-series model (one entity through several time periods) (Riera et al., 2006). A disadvantage is that effects are not as generalisable, unlike random effects which comes with extra explanatory power at a cost of the assumption uncorrelated errors. Hausman tests have been conducted, which all reject the main hypothesis of errors uncorrelated with the predictor (see table 14 and 15, Appendix). This indicates that fixed effects are more suitable than random effects. The modified Wald statistics were computed for the relevant models to test for groupwise heteroskedasticity. In all models the null hypothesis of homoscedastic errors was rejected (see table 16 and 17, Appendix) after which Huber/White estimators were incorporated to obtain heteroskedasticity-robust standard errors.

Spatial- and time fixed effects can help alleviate endogeneity problems. As recounted in the literature framework, early users of natural amenities such as parks and public gardens have mainly been the rich nobility. This could pose an endogeneity problem, as that indicates that the independent variable parks is affected by the dependent variable house prices. The use of neighbourhood fixed effects allows to control for neighbourhood-specific effects that do not vary over time – considering that wealth tends to cluster spatially and a neighbourhoods wealth composition is unlikely to change over a time period of nine years (Meen, Nygaard, & Meen, 2013), this could alleviate part of the endogeneity problem. Spatial fixed effects also reduce omitted variable bias in comparison to normal pooling (Kuminoff et al., 2010), as it accounts for omitted neighbourhood-dependent characteristics. Fixed time effects in the form of year dummies absorb exogenous shocks and account for other time-variant effects.

Specified model

The above-mentioned ultimately leads to the following specified models:

$$lnY_{gt} = \alpha_0 + \beta X_{gt} + \tau_t + \delta_g + \epsilon_{gt}$$

$$\log house\ price_{gt} = constant + structural\ house\ characteristics + fixed\ year\ effects$$
$$+ fixed\ neighbourhood\ effects + error\ term$$

This first model does not include any variables relating to natural amenities. lnY_{gt} is the natural logarithm of the inflation-adjusted house price in neighbourhood g in year t. βX_{it} denote the coefficients of the structural house characteristics, whilst τ_t denotes the year-fixed effects and δ_g denotes the vector of neighbourhood-fixed effects. α_0 is the constant and ϵ_{gt} represents the clustered standard errors (with a mean of zero).

$$\log house\ price_{gt} = constant + structural\ house\ characteristics + fixed\ year\ effects + fixed\ neighbourhood\ effects + natural\ amenities + error\ term$$

The second model is the same as the first model, yet this time the main variables of interest are added – the access to proximate natural amenities. As mentioned in the literature framework, these main variables are expected to have a positive sign.

$$\log house\ price_{gt} = constant + structural\ house\ characteristics + fixed\ year\ effects + fixed\ neighbourhood\ effects + natural\ amenities + natural\ amenities\ interaction\ effects + error\ term$$

The third model is the same as the second model, yet this interaction effects between the main variables of interest are added. As mentioned in the literature framework, it is unclear whether the interaction effects are going to have a positive or negative sign, but they are expected to be significant. The interaction effects will also be assessed on minimum-centred and maximum-centred variables.

These models will be evaluated for the two cities (Nijmegen and Rotterdam) and two distance bands (400 metres and 800 metres).

Results

The base model consisting of only the structural characteristics seems to stay relatively consistent throughout the different city-distance band combinations (see Table 3 and 4, they present the estimated results for the effect of natural amenities on house price transactions, containing the results of the three specified models for each city-distance band combination). For Nijmegen and the 400m distance band, all the structural characteristics are found significant, except for certain time periods. Houses from the time periods of 1945-1959, 1981-1990, 1991-2000 and 2000-now are all insignificantly different from houses built before 1900. Houses in time periods between 1900 and 1945 are significantly more positively valued, which seems to be consistent with market findings (generally, these houses are built with high quality construction materials (Broekhoven, 2021). Conversely, houses built decades later post-war are generally less popular, which is reflected in the significantly negative coefficient for the periods of 1960-1970 and 1971-1981. When changing distance bands to 800 metres (and thus further restricting the sample), another coefficient becomes significantly positive for newer houses from the period of 1991-2000. Different house classes also each have their significant coefficients, with the size of positive house price impact being the biggest for villas and farmhouses. A smaller positive coefficient is found for mansions and canal houses, whilst the smallest coefficient belongs to single family dwellings. The difference in coefficient all seem natural, with only estates not significantly differing from the category of remaining houses. It must be noticed that when further restricting the sample to houses used for 800 metres distance band, no coefficient for estates can be estimated at all, revealing the small number of estimates in Nijmegen. Furthermore, an above average interior state positively affects house prices, whilst a below average interior state decreases house prices. The total square metres of the houses is positively impacting the valuation of houses, as is the number of rooms – both of which were to be expected. The availability of some form of car parking also positively affects house prices. Year-specific fixed effects also capture a significant amount of variation, with the sign and size of coefficient clearly depicting the impact of the 2013 housing crisis and the subsequent boom in the Dutch housing market. In Rotterdam, very similar results for the base regression can be found, with only the effect of particular time periods differing. All other coefficients have a similar size and keep the same sign. Whilst older homes in the period of 1906-1944 are still significantly positive, houses built in 1960-1980 are not anymore negatively affecting the house price. Perhaps this difference in price attitude towards post-war houses can be attributed to the much greater scale of destruction in the bombing of Rotterdam during the Second World War. Whereas changing the distance band to 800m and thus further restricting the sample in Nijmegen makes houses from 1991-2000 turn significant, in Rotterdam that time period remains insignificant. Instead, the periods of 1980-1990 and 2000-now turn out to impact house prices significantly positive. Lastly, a change in the valuation of estates is also observed, as in Rotterdam estates are positively impacting the valuation by far the most (an effect which persists when changing distance bands). Furthermore, the size of the coefficients for farmhouses, villas and estates are by far bigger in Rotterdam. Concludingly, the base regressions is quite consistent throughout all the city-model specifications. This is further supported by the adjusted R-squared values, which are similar across cities and stay relatively the same when changing distance bands (see Tables 18-30 in the Appendix for the R-squared values for each model). Restricting the sample to the houses used for the 800 metres distance band leads to a small reduction of 2.5% in Nijmegen and an even smaller increase of 0.1% in Rotterdam, while staying around the 70% and 75% explained variance respectively. Of course, the outskirts of a city are not of the exact same nature as the inner centre, but the robustness of the neighbourhood-fixed and year-fixed base models take any grave concerns away.

Table 3. Pseudo-panel regression of natural amenities on the log of real house transaction prices in Nijmegen, 2011-2019

	Nijmegen Base 400 m	**Nijmegen Main 400 m**	**Nijmegen Interaction 400 m**	**Nijmegen Base 800 m**	**Nijmegen Main 800 m**	**Nijmegen Interaction 800 m**
m²	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)
Construction Period						
1906-1930	0.07*** (0.006)	0.068*** (0.005)	0.067*** (0.006)	0.054** (0.032)	0.06** (0.015)	0.057** (0.019)
1931-1944	0.077*** (0.005)	0.076*** (0.003)	0.077*** (0.002)	0.058** (0.026)	0.062** (0.019)	0.059** (0.019)
1945-1959	-0.018 (0.5)	-0.016 (0.563)	-0.014 (0.615)	-0.021 (0.424)	-0.021 (0.427)	-0.025 (0.33)
1960-1970	-0.097*** (0.004)	-0.089*** (0.005)	-0.078** (0.015)	-0.073** (0.031)	-0.063* (0.063)	-0.063* (0.066)
1971-1980	-0.085*** (0.01)	-0.075** (0.011)	-0.07** (0.016)	-0.069** (0.043)	-0.052 (0.105)	-0.053* (0.095)
1981-1990	-0.01 (0.839)	0.001 (0.984)	0.011 (0.811)	0.019 (0.69)	0.027 (0.564)	0.024 (0.585)
1991-2000	0.087 (0.127)	0.086* (0.099)	0.083* (0.095)	0.122** (0.017)	0.109** (0.036)	0.115** (0.022)
≥ 2001	0.045 (0.248)	0.044 (0.262)	0.049 (0.101)	0.065 (0.2)	0.058 (0.153)	0.061* (0.094)
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.042** (0.026)	0.043** (0.018)	0.043** (0.013)	0.061*** (0.005)	0.056*** (0.009)	0.055** (0.011)
Mansion or Canal House	0.096*** (0.007)	0.096*** (0.006)	0.104*** (0.004)	0.116*** (0.004)	0.111*** (0.003)	0.11*** (0.004)
Farmhouse or Bungalow	0.15*** (0.000)	0.148*** (0.000)	0.144*** (0.000)	0.155*** (0.000)	0.148*** (0.000)	0.152*** (0.000)
Villa	0.157*** (0.006)	0.167*** (0.001)	0.156*** (0.006)	0.202*** (0.002)	0.185*** (0.003)	0.185*** (0.003)
Estate	0.029 (0.515)	0.017 (0.724)	0.048 (0.336)	n/a (n/a)	n/a (n/a)	n/a (n/a)
Parking **Available**	0.151*** (0.000)	0.147*** (0.000)	0.143*** (0.000)	0.133*** (0.000)	0.129*** (0.000)	0.13*** (0.000)
Interior State						

Above Average	0.134*** (0.000)	0.133*** (0.000)	0.132*** (0.000)	0.125*** (0.000)	0.127*** (0.000)	0.127*** (0.000)
Below Average	-0.052** (0.011)	-0.054*** (0.004)	-0.065*** (0.000)	-0.036 (0.176)	-0.042* (0.063)	-0.054*** (0.002)
Rooms	0.023*** (0.001)	0.024*** (0.000)	0.026*** (0.000)	0.028*** (0.000)	0.028*** (0.000)	0.028*** (0.000)
Park	- -	-0.002 (0.695)	-0.026*** (0.001)	- -	-0.001 (0.84)	0.02 (0.359)
Water	- -	0.048* (0.093)	-0.295*** (0.01)	- -	0.043*** (0.000)	0.065 (0.141)
Forest	- -	-0.002 (0.209)	-0.009 (0.284)	- -	0 (0.483)	0.001 (0.964)
Trees	- -	-0.005 (0.394)	-0.002 (0.77)	- -	-0.004** (0.019)	-0.003 (0.56)
Park*Water	- -	- -	-0.361*** (0.000)	- -	- -	0.025 (0.345)
Park*Forest	- -	- -	-0.019** (0.021)	- -	- -	0.01 (0.411)
Park*Trees	- -	- -	0.006** (0.018)	- -	- -	-0.001 (0.621)
Water*Forest	- -	- -	-0.257*** (0.005)	- -	- -	0.012 (0.604)
Water*Trees	- -	- -	-0.257*** (0.005)	- -	- -	0.012 (0.604)
Forest*Trees	- -	- -	0.006** (0.018)	- -	- -	0 (0.927)
Park*Water*Forest	- -	- -	-0.319*** (0.000)	- -	- -	0.01 (0.527)
Park*Water*Trees	- -	- -	-0.002 (0.77)	- -	- -	-0.003 (0.288)
Park*Forest*Trees	- -	- -	-0.015 (0.433)	- -	- -	-0.001 (0.439)
Water*Forest*Trees	- -	- -	0.006 (0.552)	- -	- -	0.001 (0.696)
Park*Water*Forest*Trees	- -	- -	0.004 (0.152)	- -	- -	-0.001*** (0.000)
Year						
2012	-0.121*** (0.000)	-0.12*** (0.000)	-0.118*** (0.000)	-0.117*** (0.000)	-0.115*** (0.000)	-0.115*** (0.000)
2013	-0.236*** (0.000)	-0.234*** (0.000)	-0.233*** (0.000)	-0.24*** (0.000)	-0.236*** (0.000)	-0.237*** (0.000)
2014	-0.184*** (0.000)	-0.183*** (0.000)	-0.181*** (0.000)	-0.18*** (0.000)	-0.18*** (0.000)	-0.181*** (0.000)
2015	-0.12*** (0.000)	-0.119*** (0.000)	-0.116*** (0.000)	-0.115*** (0.000)	-0.114*** (0.000)	-0.115*** (0.000)
2016	-0.007 (0.723)	-0.007 (0.728)	-0.005 (0.77)	-0.008 (0.742)	-0.007 (0.793)	-0.005 (0.841)
2017	0.151*** (0.000)	0.151*** (0.000)	0.152*** (0.000)	0.149*** (0.000)	0.15*** (0.000)	0.15*** (0.000)
2018	0.314*** (0.000)	0.314*** (0.000)	0.315*** (0.000)	0.306*** (0.000)	0.307*** (0.000)	0.305*** (0.000)
2019	0.433*** (0.000)	0.433*** (0.000)	0.438*** (0.000)	0.428*** (0.000)	0.431*** (0.000)	0.428*** (0.000)
Constant	11.456*** (0.000)	11.452*** (0.000)	11.448*** (0.000)	11.448*** (0.000)	11.453*** (0.000)	11.462*** (0.000)

Table 4. Pseudo-panel regression of natural amenities on the log of real house transaction prices in Rotterdam, 2011-2019

	Rotterdam Base 400 m	Rotterdam Main 400 m	Rotterdam Interaction 400 m	Rotterdam Base 800 m	Rotterdam Main 800 m	Rotterdam Interaction 800 m
m²	0.005*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)
Construction Period						
1906-1930	0.064** (0.029)	0.069* (0.088)	0.078* (0.066)	0.064*** (0.001)	0.073*** (0.004)	0.069*** (0.003)
1931-1944	0.06 (0.103)	0.085* (0.058)	0.099** (0.028)	0.069** (0.014)	0.091** (0.011)	0.096*** (0.007)
1945-1959	0.026 (0.546)	0.042 (0.205)	0.055* (0.097)	0.038 (0.109)	0.055* (0.067)	0.061* (0.058)
1960-1970	-0.004 (0.892)	0.021 (0.537)	0.032 (0.366)	-0.007 (0.776)	0.02 (0.499)	0.017 (0.575)
1971-1980	0.016 (0.595)	0.045 (0.225)	0.057 (0.116)	-0.013 (0.686)	0.008 (0.82)	0.008 (0.816)
1981-1990	0.002 (0.95)	0.033 (0.413)	0.045 (0.252)	0.059* (0.088)	0.083** (0.027)	0.082** (0.031)
1991-2000	0.05 (0.353)	0.076 (0.143)	0.098* (0.057)	0.054 (0.31)	0.077 (0.177)	0.071 (0.216)
≥ 2001	0.062 (0.281)	0.089** (0.031)	0.103** (0.015)	0.072* (0.07)	0.1*** (0.006)	0.112*** (0.001)
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.052*** (0.001)	0.055*** (0.000)	0.054*** (0.001)	0.064*** (0.001)	0.063*** (0.001)	0.063*** (0.000)
Mansion or Canal House	0.174*** (0.000)	0.167*** (0.000)	0.167*** (0.000)	0.185*** (0.000)	0.175*** (0.000)	0.173*** (0.000)
Farmhouse or Bungalow	0.34*** (0.000)	0.343*** (0.000)	0.353*** (0.000)	0.354*** (0.000)	0.354*** (0.000)	0.361*** (0.000)
Villa	0.431*** (0.000)	0.407*** (0.000)	0.401*** (0.000)	0.491*** (0.000)	0.48*** (0.000)	0.482*** (0.000)
Estate	0.45*** (0.005)	0.471*** (0.005)	0.472*** (0.004)	0.565*** (0.000)	0.604*** (0.000)	0.616*** (0.000)
Parking						
Available	0.098*** (0.000)	0.095*** (0.000)	0.095*** (0.000)	0.099*** (0.000)	0.098*** (0.000)	0.098*** (0.000)
Interior State						
Above Average	0.161*** (0.000)	0.158*** (0.000)	0.157*** (0.000)	0.159*** (0.000)	0.161*** (0.000)	0.16*** (0.000)
Below Average	-0.085** (0.021)	-0.081** (0.03)	-0.081** (0.033)	-0.097** (0.014)	-0.091** (0.022)	-0.09** (0.012)
Rooms	0.01* (0.066)	0.012** (0.034)	0.012** (0.033)	0.009** (0.037)	0.011*** (0.004)	0.01*** (0.006)
Park	- -	-0.001 (0.589)	-0.001 (0.694)	- -	0.002 (0.21)	0.003 (0.324)
Water	- -	0.137*** (0.002)	0.06 (0.377)	- -	0.028** (0.025)	-0.003 (0.897)
Forest	- -	- -	0.002 (0.152)	- -	- -	0.001 (0.509)
Trees	-	-0.002	-0.003	-	-0.001	0.004

	-	(0.702)	(0.381)	-	(0.589)	(0.573)
Park*Water	- -	- -	-0.003 (0.762)	- -	- -	0.002 (0.113)
Park*Forest	- -	- -	0.002 (0.152)	- -	- -	0.001 (0.509)
Park*Trees	- -	- -	0.002 (0.178)	- -	- -	0 (0.729)
Water*Forest	- -	- -	-0.133 (0.207)	- -	- -	-0.027 (0.581)
Water*Trees	- -	- -	-0.022** (0.042)	- -	- -	-0.003** (0.047)
Forest*Trees	- -	- -	0.003 (0.635)	- -	- -	0.005 (0.403)
Park*Water*Forest	- -	- -	0.014 (0.118)	- -	- -	0.001 (0.567)
Park*Water*Trees	- -	- -	-0.001 (0.824)	- -	- -	0 (0.135)
Park*Forest*Trees	- -	- -	0 (0.99)	- -	- -	0 (0.558)
Water*Forest*Trees	- -	- -	-0.052 (0.11)	- -	- -	-0.003 (0.213)
Park*Water*Forest*Trees	- -	- -	0.005* (0.098)	- -	- -	0 (0.234)
Year						
2012	-0.11*** (0.000)	-0.11*** (0.000)	-0.108*** (0.000)	-0.126*** (0.000)	-0.121*** (0.000)	-0.12*** (0.000)
2013	-0.219*** (0.000)	-0.217*** (0.000)	-0.216*** (0.000)	-0.226*** (0.000)	-0.221*** (0.000)	-0.218*** (0.000)
2014	-0.197*** (0.000)	-0.196*** (0.000)	-0.194*** (0.000)	-0.182*** (0.000)	-0.181*** (0.000)	-0.18*** (0.000)
2015	-0.096*** (0.000)	-0.095*** (0.000)	-0.093*** (0.000)	-0.082*** (0.001)	-0.082*** (0.001)	-0.082*** (0.001)
2016	0.053*** (0.009)	0.054*** (0.009)	0.056*** (0.006)	0.063** (0.012)	0.064*** (0.009)	0.064** (0.012)
2017	0.234*** (0.000)	0.234*** (0.000)	0.235*** (0.000)	0.242*** (0.000)	0.243*** (0.000)	0.244*** (0.000)
2018	0.421*** (0.000)	0.418*** (0.000)	0.419*** (0.000)	0.446*** (0.000)	0.448*** (0.000)	0.449*** (0.000)
2019	0.523*** (0.000)	0.522*** (0.000)	0.525*** (0.000)	0.532*** (0.000)	0.537*** (0.000)	0.538*** (0.000)
Constant	11.551*** (0.000)	11.546*** (0.000)	11.525*** (0.000)	11.626*** (0.000)	11.619*** (0.000)	11.603*** (0.000)

Results for Nijmegen

Adding the variables denoting the area of proximate natural amenities for a distance band of 400 metres in the city of Nijmegen barely seems to affect the model fit. The adjusted R-squared goes down from 0.712 to 0.703, indicating that the model with proximate natural amenities fits the data 0.9% worse than the model without. Whilst the addition of variables cannot lead to less explained variance, the decrease in the adjusted R-squared can be attributed to the penalty it applies for including extra variables. From the added natural amenities only water turned out to be significant, with an increase of $(e^{0.048 \cdot 1} - 1) =$ 4.92% in house price per additional 100,000 square metres of proximate water bodies. Considering that the mean proximate water body size is 17,148 square metres, a more natural scale would be the increase of $(e^{0.048 \cdot 0.1} - 1) = 0.48\%$ in house price per additional 10,000 square metres of proximate water bodies (further percentage increases are calculated using the same exponential formula, but the notation will be omitted as it will be considered trivial). More access to proximate water bodies within a 400 metres range is therefore positively valued in Nijmegen. Meanwhile, the lack of increase in captured variance suggests that this effect must come from the pre-included base estimators. Looking at the results, the sizeable change is the construction period of 2001 and later becoming significantly positive. This entails that whilst the individual changes in the other variables did not alter their sign or turn the coefficients significant, collectively they did explain less.

Adding the same variables but for a distance band of 800 metres also results in a worse model fit, with the adjusted R-squared going down from 0.687 to 0.647. Similarly to the results for the 400 metres distance band, water becomes significant accounting for a comparable, but slightly smaller 0.43% increase in house price per additional 10,000 square metres. However, the number of trees also turned significant for the increased distance band. One hundred additional street trees within 800 metres decreases the house price by 0.4%. As it helps to implement relevant scales when comparing impact sizes of different effects, the standard deviation of a number of trees in a distance band of 800 metres is employed, which is 692 trees. Such a deviation accounts for a total decrease of 2.73%, compared to a standard deviation of 93,000 square metres of urban water bodies amounting to an increase of 4,08%. Unlike the positive sign of water, the negative sign for trees comes rather unexpectedly. Tree benefits have been well-documented, with trees offering shade and health-related benefits. Perhaps the direct costs are outweighing any advantages trees have, with trees seen as particularly ugly in a city environment or annoyingly maintenance-heavy with leaves, berries and nuts falling on top of the pavement. It could be possible that whilst these costs are taken into account, a house buyer might not realise the potential benefits of tree density. In such cases house prices will not reflect the city-wide benefits of trees. Another possibility could be that the number of trees in the vicinity acts as a proxy for other, omitted variables. As the number of urban trees is primarily driven by the number of street trees, it might capture any variance related to increased road density. Increased road density in the city might indicate a more urbanised area where greenery, except for trees, is rather scarce. As such, street trees might actually capture the variance opposite of an increase in natural amenities. The significance of water and trees is not actually newfound, as the R-squared did not increase. Two coefficients of the base regression did see their significance change, houses constructed in the period of 1971-1980 no longer significantly positively impact house prices, whilst a below average interior maintenance state now negatively impact house prices in a significant manner. The first might indicate that houses built within that period are built around more natural amenities in the not-so-direct proximity. The latter variable, interior state, saw a similar pattern of increase in significance across the 400 metres distance band specifications. This could indicate that interior state captured part of the variance explained by natural amenities and only now that the starting point of interior state is insignificant. Whilst the other variables did not change in sign or deviated too far off, the newfound significant estimators nuance the already-existent explanation of the variance.

Adding the interaction effects on top of the main effects of natural amenities for a distance band of 400 metres leads to a better model fit, with the adjusted R-squared rising to 0.733. At the mean level of amenities, six of the eleven interaction effects are found to be significant. Subsequently, the conditional effects for park and water also turned significant. The conditional effect of parks negatively affects house prices, whilst interestingly, the conditional effect for water does so too. Of the significant interaction effects, four have a negative sign (park*water, park*forest, park*water*forest and water*forest) and two have positive signs (park*trees, park*forest*trees). Due to the interlinking nature of these interaction effects, it is hard to make any interpretations of the isolated terms. However, the impact of a change in natural amenity levels (at the mean level) can be estimated by summing relevant interaction terms and conditional effects. For a standard deviation change in accessible park area (182729 m^2), the total change in house price equals $positive\ interaction\ effects + negative\ interaction\ effects + conditional\ effect = 0.1953 - 0.2375 - 0.0464 = -0.0886 \rightarrow$ a 8.86% decrease. Similarly, single standard deviation changes in water, forestry and trees cause a 35.32% decrease, 25.22% decrease and 3.27% increase respectively. More accessible park area, water bodies and forestry are thus negatively valued, whilst an increase in street trees is positively valued. Using Tables 31-38 in the Appendix, the mean-level numbers can be put in context using coefficients for interaction and conditional effects at the minimum- and maximum-level of natural amenities. These show that (the signs of) the mean-level coefficients are actually very similar to the maximum-level of coefficients, whilst the signs of the minimum-level coefficients are more different. This hints at a possible explanation why extra accessible forestry, water bodies and parks are valued negatively at the mean amenity-level: once a sufficient level of amenities is reached, further increases do not provide any value and are actually negatively impacting house prices. At the minimum-level of natural amenities, increases in any natural amenity are valued positively. At the maximum-level, only additional street trees are still valued positively whilst extra parks, water bodies and forestry is valued negatively. Again a distinct difference is found between street trees and other amenities, which indicates that street trees are viewed to have distinctively different benefits and costs. This different nature makes that they are less affected by the amenity level of other natural amenities. It could also be an indication that street trees are indeed functioning as a proxy for a higher street density, which is not a natural amenity (almost the opposite of it).

Adding interaction effects for the 800 distance band in Nijmegen paints a different picture and reduces the model fit from 0.647 to 0.642 (adjusted R-squared). Only the four-way interaction effect of the eleven added interaction effects is significant at the mean-level. The four-way interaction effect has a negative coefficient, which entails that an additional unit of any natural amenity will lead to a decrease in house prices, whilst a diverse amenity mix is especially costly. This holds true since no conditional effect and no other interaction effect is also significant. A familiar situation emerges when comparing these interaction effects to those of the minimum-level and maximum-level: the mean-level coefficients are much more similar to the maximum-level coefficients. At the maximum-level, adding extra amenities will not significantly change house prices at all. Things become more unclear at the minimum-level, where some interaction interlinking interaction effects are significant. Manually estimating the effects shows that parks and especially forestry is positively valued, whilst extra water only minimally decreases house prices. Additional street trees however, are negatively valued. Overall, it seems like that once a certain level of amenities is reached, the effects of extra amenities dwindle. The difference in distance bands reveals an interesting finding: the excess of natural amenities is much more negatively valued when it is more proximate. Moreover, a distinction can again be made between street trees and other types of amenities. Whereas last time street trees were a lot less affected by the other natural amenities reaching a certain sufficiency level, this time street trees are negatively affecting house prices in a scenario where all natural amenities are at their minimum level. The continuous difference seems to hint that street trees are indeed (also) capturing the variance of increased street density.

Results for Rotterdam

Adding the variables denoting the area of proximate natural amenities for a distance band of 400 metres in Rotterdam only slightly improves the model fit, with the R-squared shifting from 0.757 to 0.766. Water turns out to be a highly significant, increasing house prices by 14.7% for per 100,000 square metres of proximate water body. To put this into perspective, one standard deviation equalling 40,905 square metres increases house prices by 6.01%. Looking at the base estimators, no real changes in coefficients and significance can be observed, except for the construction periods of 1931-1944 and 2001 and later, both of which become significantly positive. Considering that the inclusion of water is the only significant addition to the base model, it is likely these variables are a positive confounder for the effect of water on house prices. This entails that within these time periods, relatively more houses were built in near proximity of water.

Adding the same main effects but for a distance band of 800 metres yields a better fitting model as well, with the R-squared increasing from 0.758 to 0.793. Water is significantly positive again, whilst forestry turns out to be significantly negative. The effect of water seems a lot less pronounced this time, but there is also more water to be found within a 800 metres distance band. Ultimately, one standard deviation in total accessible proximate water bodies increases house prices by 5.24%, which is only slightly smaller than for the distance band of 400 metres. The effect of water on house prices is thus relatively stable and not heavily subject to a distance effect where further (but still relatively proximate) water bodies are valued lower. Moreover, forestry has a significantly negative effect on house prices, lowering them by 2.43% for an additional 220,670 square metres of forestry (equalling one standard deviation of forestry). The increase in R-squared shows that the newly-found significance does not have to come from other variables, but is in fact newly-explained variance. Furthermore, no difference in the base estimators have been observed except for the construction period of 1945-1959 becoming significant after adding the now-significant variables forestry and water.

Including interaction effects for a distance band of 400 metres in Rotterdam barely changes the model fit, with the adjusted R-squared going down from 0.766 to 0.764. The decrease entails that the model does not explain enough new variance to make up for the penalty for adding new variables. Still, two significant interaction effects can be discerned. These interaction effects can thus nuance the way the natural amenities influence, but do not explain much (if any) additional variance. The interaction effect between water and urban trees is significantly negative at the mean-level of amenities. Additionally, the four-way interaction effect is found to be significantly positive. This entails that in general, a more diverse mix will be more positively valued. The inclusion of the above interaction effects also turned the construction periods 1945-1959 and 1991-2000 significant. Considering that this is wasn't the case when only main effects were added, it is likely that they are positive confounders in the effect of the interaction between water and trees on house prices. Houses built in these periods are likely to be surrounded by both water and trees, which is why it the periods did not turn significant when the main effects were only considered in isolation. Whilst the effects for forestry and parks are undoubtedly positive, at first glance it is not clear that the effect of water and trees ultimately is positive too: an additional 100 street trees in proximity leads to an decrease of $-0.0091 + 0.0004 \rightarrow 0.87\%$. An additional 100,000 square metres of accessible water bodies leads to a decrease of $-0.1607 + 0.0077 \rightarrow 15.30\%$. Alternatively, an increase of a standard deviation leads to a house price decrease of 2.28% and 6.60% for street trees and water bodies respectively. Perhaps water bodies are more likely to be unappealing or offer less recreational value near locations with more street trees. Or the reverse could be possible, that a high density of water bodies diminish the benefits of street trees and whilst making street trees stand out as particularly unattractive. If street trees actually act like a proxy for street density (as suggested earlier), then it means that water bodies are more unattractive in areas of high street density. This could point to the smaller canal types that offer less recreational value instead of the bigger urban water bodies which are surrounded relatively less by streets. Comparing these interaction effects to the minimum-level and the maximum-level natural amenity situation shows some differences. Both in the minimum-level and in the maximum-level do all amenities positively affect house prices, except for a very small negative effect for trees in the minimum-level. Apparently, the negative valuation of water is rather mean-specific.

Including interaction effects for a distance band of 800 metres in Rotterdam also changes the model fit very little, with the adjusted R-squared shifting from 0.793 to 0.779. This indicates that the interaction effects once again only nuance the way amenities influence house prices, rather than explain uncaptured variation. Only the interaction effect between trees and water is significant (as it was in the 400 metres distance band). One standard deviation change in trees leads to a 4.87% reduction in house prices, whilst one standard deviation change in water lowers the house prices by 14.98% at the mean level of amenities. The interpretation of this finding remains that either more proximate trees decrease the value of a proximate environment full of water, or that an increased presence of proximate water bodies devalue street trees. Or, which might be more likely, that a higher number of street trees actually function as a proxy for increased street density. After all, a beautiful, peaceful water body is likely to offer more recreational value if it is actually quiet and not surrounded by noisy streets. Also worth considering is the lack of a distance effect when it comes to the negative interaction effect of trees and water. Instead of diminishing in size, the negative effects actually increased in impact when switching to a bigger distance band, whilst accounting for the associated increase in amenities within a bigger distance band. Water and street trees further away (whilst still being proximate) are thus as impactful (if not bigger) than water and street trees close by. Comparing the interaction effect to minimum-level and maximum-level of amenities allows for a salient pattern to emerge. No interaction-effects or conditional effects are significant in the maximum amenity-level (so no additional amenities will increase or decrease the house prices). Only two interaction effects are significant in the minimum level, ultimately resulting in no significant effect for trees, a negative effect of parks on house prices, and a positive effect of water and forestry. The negative interaction effect between street trees and water is thus rather mean-specific, similar to the negative effect for water in the 400 metres distance band. At least for the 800 metres band, a sufficiency level for water bodies exist after which water bodies negatively interact with street trees. This is until a certain threshold again, after which the additional proximate water body area stops negatively affecting and stops being negatively affected by trees.

Small comparison between Nijmegen and Rotterdam

As mentioned before, the base models performed relatively well and stayed robust throughout distance bands for both cities, with Rotterdam slightly outperforming Nijmegen. The coefficients in the base model itself also did not show much difference for both cities, with Nijmegen putting slightly more emphasis in which time period a building has been constructed. When it comes to the main effects, the effect of water clearly stayed significant throughout all specifications. The coefficient is a little bigger in Rotterdam, whilst the prevalence of water bodies is also higher in Rotterdam. Rotterdam seems to be truly water-oriented, also when it comes to housing. Furthermore, a negative impact of street trees was found for trees in the 800 metres distance band in Nijmegen, whilst also being prevalent as a negative factor in interaction effects (even when all natural amenities are at their minimum-level). The same holds true in Rotterdam, where especially the interaction effect between water and trees is a consistent element. The negative impact of street trees on house prices raises questions in both cities whether the street trees are viewed that unfavourably, or whether they are capturing variance from a missing variable (perhaps street density). Another general trend found in both cities is that at the minimum-level, all amenities except for trees are likely to positively impact house prices, indicating that a sort of threshold exists, after which an increase in natural amenities becomes less attractive.

Conclusion

The role of multiple proximate natural amenities in house valuation has been considered, taking the form of urban parks, water bodies, forestry and street trees. Pseudo-panel methods have been employed to estimate the effect of the natural amenities on the house prices in the cities of Nijmegen and Rotterdam. Variables were constructed to capture the size of proximate parks, water bodies and forestry while the number of proximate street trees was also take into account. Proximity was defined using distance bands of 400 metres and 800 metres. For every city and distance band combination three neighbourhood-fixed and year-fixed effects have been estimated, resulting in a total of twelve models. These models were used to confirm or reject the four hypotheses devised to answer the following main research question:

'How are proximate urban natural amenities valued in house prices?'

The first hypothesis states '*A bigger presence of green and blue amenities has a positive effect on house prices'*. In Nijmegen and Rotterdam natural amenities were found to both positively and negatively affect house prices. When considering the main effects only, it becomes clear that the blue amenity water is a consistently positive factor. However, in Nijmegen an increase in street tree density has been found to negatively impact house prices, whilst in Rotterdam a similar effect was found for forestry. Taking interaction effects into consideration, it becomes clear that all the amenities except for street trees positively impact house prices until a certain extent, after which impacts diminish or turn negative. The peculiar position of street trees might be due to street trees being seen as a proxy for increased street presence, which in turn negatively affects the use value of other natural amenities. The hypothesis is partly rejected, as a bigger presence of green and blue amenities has indeed a positive effect on house prices until a certain extent, whilst acknowledging the possibility of street trees actually negatively impacting house prices and the found negative main effect of forestry in Rotterdam.

The second hypothesis states that '*More proximate green and blue amenities have a higher positive effect on house prices'*.

When observing the interaction effects at the minimum-level, mean-level and maximum-level in Nijmegen, it is revealed that an excess of natural amenities is valued more negatively in closer proximity (using the smaller distance band). In Rotterdam, the main effect of water stays relatively the same strength when comparing the bigger distance band to the smaller distance band. Moreover, the negative interaction effect between water and trees becomes bigger when considering a bigger distance band. However, in both Rotterdam and Nijmegen positive interaction effects exist in closer proximity, and disappear when taking into account a bigger distance band. This shows that positive effects that do not exist on a bigger scale do exist on a more proximate scale. Overall, the hypothesis is again only partly rejected.

The third hypothesis states that '*Interaction effects and reinforcing effects exist between natural amenities.'* In all the four models (one for each city and distance band) where any possible interaction effects were specified, multiple significant interaction effects can be found. These interaction effects to not limit themselves to amenities that were previously significant (water, forestry) and also include all amenities at least once. Main effects that were previously insignificant also become significant conditional effects in multiple cases. Remarkably consistent is the negative interaction effect between trees and water bodies, which can be found in Rotterdam for both distance bands. This finding is part of a broader phenomenon that almost every significant interaction effect including street trees has a negative sign. Interaction effects are also likely to lose power after a sufficient level of proximate amenities is gathered. Considering the multitude of significant interaction effects and the presence in every model specified as having interaction effects, the hypothesis is accepted.

Lastly, the fourth hypothesis states that *'Valuation of natural amenities is different in Nijmegen and Rotterdam'*. Multiple results consistent over both cities have been found, such as the positive effect of water and the negative effects of urban trees. However, the size of the positive effect of water is much larger in Rotterdam than in Nijmegen. Other patterns such as the apparent existence of a satisfactory amenities level after which the effects of amenities become smaller or negative also exists in both cities. Nonetheless, not all the interaction effects have been found significant in both cities, nor do the size of the coefficients always match up. As a result, the fourth hypothesis is accepted. Even though basic patterns are similar, the ultimate effects and their sizes are of such difference that valuation does differ over the two cities.

To answer the main research question, it has become clear that in Rotterdam and Nijmegen proximate natural amenities are valued in the house price, but not always and definitely not all of them. Near-proximity seems to impact the effect of natural urban amenities on house prices, yet not always in a positive manner. An increase in size will also likely increase any positive effects, up until a certain extent. Even though the main effects do not always allow for all amenities to affect house prices, all natural amenities are likely to affect house prices when allowing for interaction effects. A difference can be observed between Nijmegen and Rotterdam, but general trends are applicable to both cities.

Discussion and limitations

The used methodology in thesis does not come without its limitations. An important assumption of OLS is the assumption of exogeneity, which forbids any endogenous variables to be included (Hicks, 1994). Endogeneity occurs when the explanatory variable is influenced by the same variable as one of the independent variables (a confounder), or if the independent variable is influenced by the dependent variable directly. The potential for endogeneity poses a big problem for this paper, as mentioned in the methodology. House prices could be influencing the area of access to proximate greenery, with park usage historically been associated with the nobility. Perhaps more affluent neighbourhoods are able to spend more money on green maintenance as poorer neighbourhoods suffer of misallocation of funds or have more pressing issues. Whatever the reason may be, this paper attempted to alleviate these endogeneity problems by incorporating fixed effects. However, this only covers neighbourhood-fixed and year-fixed endogeneity. In other words, if confounders cluster in neighbourhoods or years then the problem is alleviated (which very well could be the case). But even spatially clustered endogeneity might not be removed if the clusters do not align with the grouping variable. Other methods are a lot more equipped to deal with such endogeneity: an instrumental variable set-up or a difference-in-difference model (in an ideal scenario houses are followed over time with access to natural amenities as a treatment variable). Another potentially serious issue is omitted variable bias. Whilst fixed-effects are relatively qualified to handle OVB, hedonic price regression work under the assumption that all the characteristics are bundled. Any failure to do so might misattribute price changes to changes in observed bundle characteristics. An example of OVB could be the lack of variables indicating other, non-natural amenity service levels (which can be problematic if they are not clustered along the fixed effects grouping variables). Perhaps the most-referred to non-existent variable in this thesis is the street density. One of the severe shortcomings of this paper is that it is not clear whether street trees actually only capture the variance related to street trees, as street density is not accounted for. This only became apparent when analysing the results, and is something future research should definitely include as a control variable.

Other limiting factors of this research the cohort size, which averaged well above 100 observations but still faced some cohorts less than that, even though postal codes with less than 100 observations were pruned. A lack of large enough cohorts could introduce bias and measurement errors. Another limiting factor is the use of the four-digit postal code as grouping variable. Even though it is a simple and understandable measure, the actual neighbourhoods might not follow the same clustering. PC4-codes are devised with the postal services in mind, so high-density residential areas might have very small pc4-clusters, even though they are part of the same neighbourhood. Whilst the usage area of area within distance band allowed for interaction effects between amenities whilst preserving a measure of size and distance, a continuous variable for distance could identify proximity related effects in a more precise manner. Also, whilst 400 metres and 800 metres are common measures for walkability, they also face criticism for being too simplistic. Perhaps using a band based on a maximum road distance or other walkability catchments would capture proximity better.

Bibliography

Bateman, I. (1994). Contingent valuation and hedonic pricing: Problems and possibilities. *Landscape Research*, *19*(1), 30–32. https://doi.org/10.1080/01426399408706420

Bellemare, M. F. (2016, March 21). 'Metrics Monday: What to Do with Repeated Cross Sections? – Marc F. Bellemare. Retrieved July 26, 2021, from https://marcfbellemare.com/wordpress/11800

Berry, C. M., & Marshall, J. E. A. (2015). Lycopsid forests in the early Late Devonian paleoequatorial zone of Svalbard. *Geology*, *43*(12), 1043–1046. https://doi.org/10.1130/G37000.1

Bout, F. P. (2017). *Size matters… (Master Thesis)*. Retrieved from hdl.handle.net/2105/41636

Brander, L. M., & Koetse, M. J. (2011). The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of Environmental Management*, *92*(10), 2763–2773. https://doi.org/10.1016/j.jenvman.2011.06.019

Broekhoven, S. (2021). Het geheim van het jarendertighuis. Retrieved August 11, 2021, from Geschiedenis van Zuid-Holland website: https://geschiedenisvanzuidholland.nl/verhalen/verhalen/het-geheim-van-het-jarendertighuis/

Brown, R. R., Keath, N., & Wong, T. H. F. (2009). Urban water management in cities: historical, current and future regimes. *Water Science and Technology*, *59*(5), 847–855. https://doi.org/10.2166/WST.2009.029

Brueckner, J. K. (2011). *Lectures on urban economics*. Cambridge, Massachusetts: MIT Press.

Campbell, S. (1996). Green Cities, Growing Cities, Just Cities?: Urban planning and the contradictions of sustainable development. *Journal of the American Planning Association*, *62*(3), 296–312. https://doi.org/10.1080/01944369608975696

Carlino, G. A., & Saiz, A. (2019). Beautiful city: Leisure amenities and urban growth. *Journal of Regional Science*, *59*(3), 369–408. https://doi.org/10.1111/jors.12438

Centraal Bureau voor de Statistiek. (2015). Basisregistratie Topografie (BRT) TOPNL. *Dataset*. Retrieved from https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/natuur-en-milieu/bestand-bodemgebruik

Centraal Bureau voor de Statistiek. (2021). Bestaande koopwoningen; verkoopprijzen prijsindex. *Dataset*. Retrieved from https://opendata.cbs.nl/#/CBS/nl/dataset/83906NED/table?dl=568B8%0A

Chen, W. Y., Li, X., & Hua, J. (2019, November 25). Environmental amenities of urban rivers and residential property values: A global meta-analysis. *Science of the Total Environment*, Vol. 693, p. 133628. https://doi.org/10.1016/j.scitotenv.2019.133628

Chen, Y., & Wong, N. H. (2006). Thermal benefits of city parks. *Energy and Buildings*, *38*(2), 105–120. https://doi.org/10.1016/J.ENBUILD.2005.04.003

Clark, F. (1973). Nineteenth-Century Public Parks from 1830. *Garden History*, *1*(3), 31. https://doi.org/10.2307/1586332

Coombes, A., Jones, A. P., & Melvyn, H. (2010). The relationship of physical activity and overweight to objectively measured green space accessibility and use. *Social Science & Medicine (1982)*, *70*(6), 816–822. https://doi.org/10.1016/J.SOCSCIMED.2009.11.020

Crompton, J. L., & Nicholls, S. (2019). The Impact of Park Views on Property Values. *Leisure Sciences*. https://doi.org/10.1080/01490400.2019.1703125

Daniel, V. E., Florax, R. J. G. M., & Rietveld, P. (2009). Floods and residential property values: A hedonic price analysis for the netherlands. *Built Environment*, *35*(4), 563–576. https://doi.org/10.2148/benv.35.4.563

Deligne, C. (2016). Industrialisation, manure and water quality in the 19th century. The Senne River in Brussels as a case study. *Water History*, *8*(3), 235–255. https://doi.org/10.1007/S12685-016-0163-0

Donovan, G. H., & Butry, D. T. (2010). Trees in the city: Valuing street trees in Portland, Oregon. *Landscape and Urban Planning*, *94*(2), 77–83. https://doi.org/10.1016/j.landurbplan.2009.07.019

Duempelmann, S. (2009). Creating order with nature: Transatlantic transfer of ideas in park system planning in twentieth-century Washington D.C., Chicago, Berlin and Rome. *Planning Perspectives*, *24*(2), 143–173. https://doi.org/10.1080/02665430902734277

Euzen, A., & Haghe, J.-P. (2007). Drinking water from the Seine in the 18th century, or the emergence of the filtration fountain. *5th IWHA Conference, Past and Futures of Water — Tampere*. Retrieved from https://www.academia.edu/download/53520025/Drinking_water_from_the_Seine_in_the_18t20170615-2967-c2fxmp.pdf

Fennema, A. T., Veeneklaas, F. R., & Vreke, J. (1996). Meerwaarde woningen door nabijheid van groen; relatie in vooronderzoek empirisch aangetoond. *Stedebouw En Ruimtelijke Ordening* , *77*(3), 33–35. Retrieved from https://library.wur.nl/WebQuery/wurpubs/304226

Fernandez, M. A., & Bucaram, S. (2019). The changing face of environmental amenities: Heterogeneity across housing submarkets and time. *Land Use Policy*, *83*, 449–460. https://doi.org/10.1016/j.landusepol.2019.02.024

Forrest, M., & Konijnendijk, C. (2005). Urban Forests and Trees. In C. Konijnendijk, K. Nilsson, T. Randrup, & J. Schipperijn (Eds.), *Urban Forests and Trees: A Reference Book*. https://doi.org/10.1007/3-540-27684-X_3

Frank, L. D., Schmid, T. L., Sallis, J. F., Chapman, J., & Saelens, B. E. (2005). Linking objectively measured physical activity with objectively measured urban form: findings from SMARTRAQ. *American Journal of Preventive Medicine*, *28*(2 Suppl 2), 117–125. https://doi.org/10.1016/J.AMEPRE.2004.11.001

Garretsen, H., & Marlet, G. (2016). *Regional Studies Amenities and the attraction of Dutch cities*. https://doi.org/10.1080/00343404.2015.1135239

Gemeente Nijmegen. (2020a). Bomen Nijmegen Nijmeegse Geoserver. Retrieved July 17, 2021, from https://data.overheid.nl/dataset/11218-bomen-nijmegen

Gemeente Nijmegen. (2020b). *Nijmegen Stad in Beweging: Omgevingsvisie 2020-2040*. Retrieved from https://www.nijmegen.nl/fileadmin/bestanden/bestuur/bestuursdossiers/omgevingsvisie/Nijmegen-stad-in-beweging-omgevingsvisie-2020-2040.pdf

Gemeente Rotterdam. (2018). *Verkenning Omgevingsvisie Rotterdam*. Retrieved from https://rotterdam.notubiz.nl/document/7429255/1/19bb438

Gemeente Rotterdam. (2020). Bomen Beheersysteem Buitenruimte Rotterdam. *Dataset*. Retrieved from https://data.overheid.nl/dataset/6098-bomen-rotterdam

Gerhold, H. D. (2007). Origins of Urban Forestry. In *Urban and Community Forestry in the Northeast* (pp. 1–23). https://doi.org/10.1007/978-1-4020-4289-8_1

Glaeser, E. L., Kolko, J., & Saiz, A. (2001). Consumer city. *Journal of Economic Geography*, *1*(1), 27–50. https://doi.org/10.1093/JEG/1.1.27

Gothein, M. L. S., & Archer-Hind, L. (2014). A History of Garden Art. In *A History of Garden Art*. https://doi.org/10.1017/cbo9781107706781

Goudzwaard, L. (2013). Komkommermagnolia in het park Leeuwenstein, Nijmegen, Gelderland, Nederland. Retrieved August 8, 2021, from https://www.monumentaltrees.com/nl/fotos/25941/

Guillerm, M. (2017). Pseudo-panel methods and an example of application to Household Wealth data. *Economie et Statistique*, *2017*(491–492), 109–130. https://doi.org/10.24187/ECOSTAT.2017.491D.1908

Hicks, A. M. (1994). Introduction to pooling. In *The Comparative Political Economy of the Welfare State* (pp. 169–188). https://doi.org/10.1017/CBO9781139174053.007

Hooimeijer, F. (2020). Rotterdam : A dynamic polder city in the Randstad. In *The Randstad* (pp. 81–99). https://doi.org/10.4324/9780203383346-6

Jung, T. Y., Baek, Y. J., Sohn, J., & Yoo, S. (2016). The Effect of an Urban Park View on the Price of Apartment - A Case of Songdo Central Park -. *Journal of Environmental Impact Assessment*, *25*(6), 457–465. https://doi.org/10.14249/eia.2016.25.6.457

Kadaster. (2020). TOP10NL Basis Registratie Topografie (BRT). *Dataset*. Retrieved from https://www.pdok.nl/introductie/-/article/basisregistratie-topografie-brt-topnl

Kalsø Hansen, H., & Winther, L. (2010). Amenities and Urban and Regional Development: Critique of a New Growth Paradigm. *Regional Studies Association Annual International Conference 2010, Regional Responses and Global Shifts: Actors, Institutions and Organisations*. Retrieved from http://www.regional-studies-assoc.ac.uk/events/2010/may-pecs/papers/Hansen.pdf

Kenworthy, J. R. (2006). The eco-city: Ten key transport and planning dimensions for sustainable city development. *Environment and Urbanization*, *18*(1), 67–85. https://doi.org/10.1177/0956247806063947

Kuminoff, N. V., Parmeter, C. F., & Pope, J. C. (2010). Which hedonic models can we trust to recover the marginal willingness to pay for environmental amenities? *Journal of Environmental Economics and Management*, *60*(3), 145–160. https://doi.org/10.1016/J.JEEM.2010.06.001

Lansford, N. H., & Jones, L. L. (1995). Marginal price of lake recreation and aesthetics: an hedonic approach. *Journal of Agricultural & Applied Economics*, *27*(1), 212–223. https://doi.org/10.1017/S107407080001974X

Lintsen, H. (2002). Two Centuries of Central Water Management in the Netherlands. *Technology and Culture*, *43*(3), 549–568. Retrieved from http://www.jstor.org/stable/25147959

Luttik, J. (2000). The value of trees, water and open space as reflected by house prices in the Netherlands. *Landscape and Urban Planning*, *48*(3–4), 161–167. https://doi.org/10.1016/S0169-2046(00)00039-6

Meen, G., Nygaard, C., & Meen, J. (2013). The Causes of Long-Term Neighbourhood Change. In M. van Ham, D. Manley, N. Bailey, L. Simpson, & D. Maclennan (Eds.), *Understanding Neighbourhood Dynamics: New Insights for Neighbourhood Effects Research* (pp. 43–62). https://doi.org/10.1007/978-94-007-4854-5_3

Melichar, J., & Kaprová, K. (2013). Revealing preferences of Prague's homebuyers toward greenery amenities: The empirical evidence of distance–size effect. *Landscape and Urban Planning*, *109*(1), 56–66. https://doi.org/10.1016/J.LANDURBPLAN.2012.09.003

NÆss, P. (2001). Urban planning and sustainable development. *European Planning Studies*, *9*(4), 503–524. https://doi.org/10.1080/713666490

Nilsson, P. (2014). Natural amenities in urban space – A geographically weighted regression approach. *Landscape and Urban Planning*, *121*, 45–54. https://doi.org/10.1016/J.LANDURBPLAN.2013.08.017

Nutsford, D., Pearson, A. L., Kingham, S., & Reitsma, F. (2016). Residential exposure to visible blue space (but not green space) associated with lower psychological distress in a capital city. *Health & Place*, *39*, 70–78. https://doi.org/10.1016/J.HEALTHPLACE.2016.03.002

NVM. (2020). House Prices. *Dataset*. Retrieved from De Nederlandse Coöperatieve Vereniging van Makelaars en Taxateurs

NVM. (2021). *ANALYSE WONINGMARKT 1e kwartaal 2021*. Retrieved from https://www.nvm.nl/media/zl4dymdo/bijlage-1-nvm-analyse-woningmarkt-1e-kwartaal-2021-15-april-2021.pdf

O'Hare, D. (2006). Urban Walkability in the Subtropical City: Some Intemperate Considerations from SEQ | QUT ePrints. In Queensland University of Technology (Ed.), *Kennedy, R (Ed.) Subtropical Cities 2006*

Conference (pp. 131–136). Retrieved from http://www.subtropicalcities2006.qut.edu.au/Papers.html

Paletto, A., Sereno, C., & Furuido, H. (2008). Historical evolution of forest management in Europe and in Japan. 東京大学農学部演習林報告, *119*, 25–44. https://doi.org/2261/24550

Ricard, R. M. (2005). Shade trees and tree wardens: Revising the history of urban forestry. *Journal of Forestry*, *103*(5), 230–233. https://doi.org/10.1093/jof/103.5.230

Riera, P., Mhawej, A., Mavsar, R., & Brey, R. (2006). Fixed-effects hedonic price model for statistical value of live estimations. *Transport Reviews*, *26*(4), 487–500. https://doi.org/10.1080/01441640600602336

Rouwendal, J., Levkovich, O., & Van Marwijk, R. (2017). Estimating the Value of Proximity to Water, When Ceteris Really Is Paribus. *Real Estate Economics*, *45*(4), 829–860. https://doi.org/10.1111/1540-6229.12143

Sopranzetti, B. J. (2015). Hedonic Regression Models. *Handbook of Financial Econometrics and Statistics*, 2119–2134. https://doi.org/10.1007/978-1-4614-7750-1_78

Stewart, C., Gil-Egui, G., & Pileggi, M. (2010). The City Park as a Public Good Reference for Internet Policy Making. *Http://Dx.Doi.Org/10.1080/1369118042000284597*, *7*(3), 337–363. https://doi.org/10.1080/1369118042000284597

Stromberg, P. M., Öhrner, E., Brockwell, E., & Liu, Z. (2021). Valuing urban green amenities with an inequality lens. *Ecological Economics*, *186*, 107067. https://doi.org/10.1016/j.ecolecon.2021.107067

Tate, A. (2018). Urban parks in the twentieth century. *Environment and History*, *24*(1), 81–101. https://doi.org/10.3197/096734018X15137949591855

Turner-Skoff, J. B., & Cavender, N. (2019). The benefits of trees for livable and sustainable communities. *Plants, People, Planet*, *1*(4), 323–335. https://doi.org/10.1002/PPP3.39

Tyrväinen, L., & Miettinen, A. (2000). Property Prices and Urban Forest Amenities. *Journal of Environmental Economics and Management*, *39*(2), 205–223. https://doi.org/10.1006/JEEM.1999.1097

Visser, P., Van Dam, F., & Hooimeijer, P. (2008). Residential environment and spatial variation in house prices in the Netherlands. *Tijdschrift Voor Economische En Sociale Geografie*, *99*(3), 348–360.

https://doi.org/10.1111/j.1467-9663.2008.00472.x

Völker, S., & Kistemann, T. (2011). The impact of blue space on human health and well-being – Salutogenetic health effects of inland surface waters: A review. *International Journal of Hygiene and Environmental Health*, *214*(6), 449–460. https://doi.org/10.1016/J.IJHEH.2011.05.001

Wang, F., & Gao, C. (2020). Settlement–river relationship and locality of river-related built environment: *Https://Doi.Org/10.1177/1420326X20976500*, *29*(10), 1331–1335. https://doi.org/10.1177/1420326X20976500

Wu, W., & Dong, G. (2014). Valuing the “green” amenities in a spatial context. *Journal of Regional Science*, *54*(4), 569–585. https://doi.org/10.1111/jors.12099

Young, R. A. (1996). Measuring economic benefits for water investments and policies. *World Bank Technical Paper*, *338*. https://doi.org/10.1596/0-8213-3745-9

Appendix

Table 1 | Correlation matrices structural house attributes

	m^3	**UFA**
m^2	0.9604	0.9857

	type	**house_category**	**house_characteristics**
House Classe	0.9042	0.9982	0.8213

Table 2 | List of parks in Nijmegen

Name	Area (m^2)
Goffertpark	498936
Kronenburgerpark	52443
Park Staddijk	577550
Park Brakkenstein	126799
Wijkpark Meijhorst	23815
Hatertse Broek	295221
Kopsehof	135572
Julianapark	22081
Valkhofpark	26454
Hunnerpark	30006
Westerpark	82507
Park Leeuwenstein	9969
Planetenpark	43974
Distelpark	16304
Dorpspark Hees	36027
Douglasbos	61924
Uilenbosje	38792
Geologenstrook	77645
Limospark	37999
Grootstalpark	8280
Park de Omloop	214321
Berendonck	783385
Het Anker	177129
Stadswaard	511008

Table 3 | List of parks in Rotterdam

Name	Area (m^2)
Branco van Dantzigpark	9142
Hefpark	9613
Proefpark de Punt	9929
Park de Heij	11594
Park Schoonoord	13145
Wijkpark Het Oude Westen	15214
Middachtenplantsoen	15494
Amelandseplein	16420
Schuttersveld	16783
Albert Schweitzerplantsoen	17719
Buizenpark	17842
Nachtegaalplein	18051
Park 1943	20660
Park Noorderhavenkade	21166
Kaappark	23937
Park de Nieuwe Plantage	24830
Schinnenbaan	24872
Afrikaanderpark	24875
Nassaupark	26865
Karel de Stouteplein	28371
Het Meertje	28610
Semiramistuin	29057
Molenpark	29875
Heemtuin Reyeroord	38048
Park Rozenburg	40148
Dokhavenpark	43031
Zuidelijk Wijkpark	43988
Park de Meidoornweide	47288
Randpark Oosterflank	50259
Prinses Beatrixplantsoen	52024
Sidelingepark	53056
Essenburgpark	53232
Wijktuin Ommoord	56238
Horstenpad	58130
De Oude Plantage	58590
Argonautenpark	60633
Berg- en Broekpark	62098
Valkeniersweide	63471
Varkenoordse Park	68824
Museumpark	70876
Wollefoppenpark	73316
Drechterweide	75545
Prinsemolenpark	76493
Oeverloos	78436
Roel Langerakpark	79091

Table 4 | Dutch house price index, indexed on 2011 = 100

Year	Dutch House Price Index
2011	100
2012	93.47235
2013	87.39801
2014	88.1233
2015	90.66183
2016	95.19492
2017	102.4479
2018	111.6954
2019	119.4016

Table 5 | Descriptive Statistics, Natural Amenities | Nijmegen Houses 400m Inward

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Water	6,109	17.14888	27.08976	0	304.106
Forest	6,109	101.0637	717.9731	0	6337.837
Park	6,109	118.9492	182.7291	0	663.289
Trees	6,109	845.2786	226.2606	2	1450

Table 6 | Descriptive Statistics, Natural Amenities | Nijmegen Houses 800m Inward

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Water	4,539	78.1042	93.95572	0	921.213
Forest	4,539	207.2588	1004.549	0	6247.297
Park	4,539	256.8593	234.7695	0	911.563
Trees	4,539	3184.164	692.6843	0	5093

Table 7 | Descriptive Statistics, Natural Amenities | Rotterdam Houses 400m Inward

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Water	5,293	41.66578	40.90515	0	298.404
Forest	5,293	12.62359	74.12775	0	629.119
Park	5,293	1.54E+02	363.6538	0	3029.11
Trees	5,293	7.96E+02	264.0911	30	1627

Table 8 | Descriptive Statistics, Natural Amenities | Rotterdam Houses 800m Inward

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Water	3,266	225.0045	187.1061	26.832	997.557
Forest	3,266	95.13572	220.6703	0	1136.86
Park	3,266	793.6971	1127.316	0	3361.755
Trees	3,266	2891.911	739.1809	942	5065

Table 9 | Descriptive Statistics | Nijmegen Houses 400m Inward

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Year	6,109	2015.098	2.409442	2011	2019
Price	6,109	255208	124489.9	80000	1225000
logprice	6,109	12.33111	0.45539	11.15508	14.12906
m²	6,109	125.8101	39.34306	40	523
Construction Period	6,109	4.93174	2.071596	1	9
House Class	6,109	2.068096	0.571317	1	6
Parking	6,109	0.300868	0.458673	0	1
Interior State	6,109	0.834015	0.43873	0	2
Rooms	6,109	5.087903	1.327619	1	18
Park	6,109	1.18949	1.82729	0	6.63289
Water	6,109	0.17149	0.27090	0	3.04106
Forest	6,109	1.01064	7.17973	0	63.37837
Trees	6,109	8.45279	2.26261	0.02	14.50

Table 10 | Descriptive Statistics | Nijmegen Houses 800m Inward

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Year	4,539	2015.124	2.410275	2011	2019
Price	4,539	256394.4	124930.3	80000	1225000
logprice	4,539	12.33796	0.45052	11.15508	14.12906
m²	4,539	126.0205	39.16336	45	523
Construction Period	4,539	4.715356	1.975402	1	9
House Class	4,539	2.064111	0.562988	1	5
Parking	4,539	0.313505	0.463969	0	1
Interior State	4,539	0.836087	0.438367	0	2
Rooms	4,539	5.07755	1.324308	1	18
Park	4,539	2.58668	2.35005	0.00	9.11563
Water	4,539	0.78833	0.94141	0.00	9.21213
Forest	4,539	2.07506	10.06587	0.00	62.47297
Trees	4,539	31.88317	6.91297	0.02	50.93000

Table 11 | Descriptive Statistics | Rotterdam Houses 400m Inward

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Year	5,293	2.02E+03	2.324313	2011	2019
Price	5,293	359663	271668.1	55000	3800000
logprice	5,293	12.5749	0.6205	10.7804	15.1747
m²	5,293	139.6911	53.4468	40	532
Construction Period	5,293	5.029662	2.563345	1	9
House Class	5,293	2.278292	0.762038	1	6
Parking	5,293	0.240129	0.427202	0	1
Interior State	5,293	0.849424	0.449866	0	2
Rooms	5,293	5.32628	1.654463	1	44
Park	5,293	1.5361	3.6365	0.000	30.2911
Water	5,293	0.4167	0.4091	0.000	2.9840
Forest	5,293	0.1262	0.7413	0.000	6.2912
Trees	5,293	7.9619	2.6409	0.300	16.2700

Table 12 | Descriptive Statistics | Rotterdam Houses 800m Inward

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Year	3,266	2015.121	2.361637	2011	2019
Price	3,266	391311.7	304892.8	55000	3800000
logprice	3,266	12.6469	0.6404	10.8922	15.1747
m²	3,266	145.192	59.00127	40	517
Construction Period	3,266	4.53613	2.543119	1	9
House Class	3,266	2.330374	0.776478	1	6
Parking	3,266	0.229639	0.420665	0	1
Interior State	3,266	0.858543	0.455911	0	2
Rooms	3,266	5.494795	1.762152	1	17
Park	3,266	7.9370	11.2732	0.0000	33.6176
Water	3,266	2.2500	1.8711	0.2683	9.9756
Forest	3,266	0.9514	2.2067	0.0000	11.3686
Trees	3,266	28.9191	7.3918	9.4200	50.6500

Table 13 | Description of structural house attributes (from NVM dataset)

Variable	Value	Description
m²	Integers (0 if unknown, -1 if no dwelling).	The usable surface of the dwelling, corrected if the stated usable surface is not reliable, in square meters.
Construction Period	1906-1930	The building period of the dwelling.
	1931-1944	
	1945-1959	
	1960-1970	
	1971-1980	
	1981-1990	
	1991-2000	
	≥ 2001	
House Class	Simple dwelling	The sort of dwelling in case it is a house.
	Single Family Dwelling, Houseboat or Recreation Dwelling	
	Mansion or Canal House	
	Farmhouse or Bungalow	
	Villa	
	Estate	
Parking	Unavailable	Indicates the parking possibility.
	Available	
Interior State	Above Average	
	Below Average	
Rooms	Integer	The number of rooms of the dwelling.

Table 14 | Hausman test results for Nijmegen

Model	1	2	3	4	5	6
Base Regression	Yes	No	No	Yes	No	No
Main Effect Regression	No	Yes	No	No	Yes	No
Interaction Effect Regression	No	No	Yes	No	No	Yes
Distance band	400 m	400 m	400 m	800 m	800 m	800 m
Chi^2(19)	2051.77	1742.81	1612.06	-	-	-
Chi^2(17)	-	-	-	1669.86	1307.66	1174.64
Prob>Chi^2	0	0	0	0	0	0

Table 15 | Hausman test results for Rotterdam

Model	7	8	9	10	11	12
Base Regression	Yes	No	No	Yes	No	No
Main Effect Regression	No	Yes	No	No	Yes	No
Interaction Effect Regression	No	No	Yes	No	No	Yes
Distance band	400 m	400 m	400 m	800 m	800 m	800 m
Chi^2(23)	2526.89	2466.56	2444.61	-	-	-
Chi^2(18)	-	-	-	1567.75	1242.62	1056.92
Prob>Chi^2	0	0	0	0	0	0

Table 16 | Wald test results for Nijmegen

Model	1	2	3	4	5	6
Base Regression	Yes	No	No	Yes	No	No
Main Effect Regression	No	Yes	No	No	Yes	No
Interaction Effect Regression	No	No	Yes	No	No	Yes
Distance band	400 m	400 m	400 m	800 m	800 m	800 m
Chi^2(20)	610.66	594.66	592.45	-	-	-
Chi^2(18)	-	-	-	344.36	306.51	293.82
Prob>Chi^2	0	0	0	0	0	0

Table 17 | Wald test results for Rotterdam

Model	7	8	9	10	11	12
Base Regression	Yes	No	No	Yes	No	No
Main Effect Regression	No	Yes	No	No	Yes	No
Interaction Effect Regression	No	No	Yes	No	No	Yes
Distance band	400 m	400 m	400 m	800 m	800 m	800 m
Chi^2(24)	1871.24	1548.43	1551.94	-	-	-
Chi^2(19)	-	-	-	1431.9	1407.09	1506.57
Prob>Chi^2	0	0	0	0	0	0

Table 18 | Base regression on the log house price in Nijmegen using a distance band of 400m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	0.004405106	0.000282717	15.58	0	0.003813374	0.004996839
Construction Period						
1906-1930	0.069726	0.022343	3.12	0.006	0.022961	0.116491
1931-1944	0.076779	0.023867	3.22	0.005	0.026824	0.126734
1945-1959	-0.01801	0.026166	-0.69	0.5	-0.07278	0.036756
1960-1970	-0.09672	0.029332	-3.3	0.004	-0.15812	-0.03533
1971-1980	-0.08498	0.02968	-2.86	0.01	-0.1471	-0.02285
1981-1990	-0.00995	0.048397	-0.21	0.839	-0.11125	0.091342
1991-2000	0.086586	0.054205	1.6	0.127	-0.02686	0.200038
≥ 2001	0.045343	0.038046	1.19	0.248	-0.03429	0.124974
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.042064	0.017415	2.42	0.026	0.005614	0.078514
Mansion or Canal House	0.096335	0.03204	3.01	0.007	0.029274	0.163396
Farmhouse or Bungalow	0.15027	0.025135	5.98	0	0.097662	0.202878
Villa	0.157345	0.051159	3.08	0.006	0.050268	0.264422
Estate	0.028709	0.04328	0.66	0.515	-0.06188	0.119296
Parking						
Available	0.150636	0.010942	13.77	0	0.127734	0.173538
Interior State						
Above Average	0.13356	0.011269	11.85	0	0.109973	0.157146
Below Average	-0.0521	0.018566	-2.81	0.011	-0.09096	-0.01324
Rooms	0.023053	0.005869	3.93	0.001	0.010769	0.035337
Year						
2012	-0.12077	0.011772	-10.26	0	-0.14541	-0.09613
2013	-0.23601	0.015118	-15.61	0	-0.26765	-0.20436
2014	-0.18404	0.016739	-10.99	0	-0.21907	-0.149
2015	-0.12037	0.016906	-7.12	0	-0.15576	-0.08499
2016	-0.0068	0.018926	-0.36	0.723	-0.04641	0.032814
2017	0.151266	0.019408	7.79	0	0.110645	0.191887
2018	0.314331	0.019576	16.06	0	0.273358	0.355304
2019	0.433173	0.016092	26.92	0	0.399492	0.466854
Constant	11.45594	0.045893	249.63	0	11.35989	11.552
Number of observations	6109					
Number of groups	20					
R-squared:						
within	0.7825					
between	0.8352					
overall	0.7121					
Number of observations per group:						
minimum per group	101					
average per group	305.4					
maximum per group	653					

Table 19 | Regression of park amenities on the log house price in Nijmegen using a distance band of 400m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	0.00437393	0.00028178	15.52	0	0.00378415	0.00496370
Construction Period						
1906-1930	0.06766582	0.02156892	3.14	0.005	0.02252156	0.11281010
1931-1944	0.07643459	0.02275276	3.36	0.003	0.02881251	0.12405670
1945-1959	-0.01616489	0.02748974	-0.59	0.563	-0.07370158	0.04137181
1960-1970	-0.08855877	0.02775314	-3.19	0.005	-0.14664680	-0.03047077
1971-1980	-0.07501545	0.02650820	-2.83	0.011	-0.13049780	-0.01953314
1981-1990	0.00090784	0.04598243	0.02	0.984	-0.09533449	0.09715017
1991-2000	0.08626736	0.04980524	1.73	0.099	-0.01797622	0.19051090
≥ 2001	0.04367851	0.03776010	1.16	0.262	-0.03535429	0.12271130
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.04259764	0.01637373	2.6	0.018	0.00832704	0.07686825
Mansion or Canal House	0.09563082	0.03125779	3.06	0.006	0.03020752	0.1610541
Farmhouse or Bungalow	0.14761010	0.02405440	6.14	0	0.09726364	0.1979565
Villa	0.16727850	0.04361835	3.84	0.001	0.07598424	0.2585728
Estate	0.01731500	0.04836460	0.36	0.724	-0.08391327	0.1185433
Parking						
Available	0.14740080	0.01096856	13.44	0	0.1244433	0.1703582
Interior State						
Above Average	0.13315440	0.01142989	11.65	0	0.1092314	0.1570775
Below Average	-0.05403393	0.01644473	-3.29	0.004	-0.0884531400	-0.01961472
Rooms	0.02371357	0.00556256	4.26	0	0.01207099	0.03535614
Park	-0.0021199	0.005329	-0.4	0.695	-0.0132736	0.0090337
Water	0.0477545	0.0269964	1.77	0.093	-0.0087496	0.1042586
Forest	-0.0017829	0.0013719	-1.3	0.209	-0.0046544	0.0010885
Trees	-0.0053871	0.0061732	-0.87	0.394	-0.0183078	0.0075336
Year						
2012	-0.11964520	0.01163295	4.26	0	-0.14399320	-0.09529712
2013	-0.23372430	0.01487349	4.26	0	-0.26485490	-0.20259380
2014	-0.18270810	0.01650986	4.26	0	-0.21726370	-0.14815260
2015	-0.11942230	0.01669426	4.26	0	-0.15436380	-0.08448083
2016	-0.00659668	0.01870294	4.26	0	-0.04574238	0.03254902
2017	0.15130880	0.01916684	4.26	0	0.11119210	0.19142540
2018	0.31387240	0.01933123	4.26	0	0.27341160	0.35433310
2019	0.43329570	0.01613819	4.26	0	0.39951800	0.46707330
Constant	11.45239	0.04826410	4.26	0	11.35137	11.5534
Number of observations	6109					
Number of groups	20					
R-squared:						
within	0.7853					
between	0.8053					
overall	0.7034					
Number of observations per group:						
minimum per group	101					
average per group	305.4					
maximum per group	653					

Table 20 | Regression of park amenities and their interaction effects on the log house price in Nijmegen using a distance band of 400m. robust

Log Price	**Coefficient**	**Standard Error**	**t-value**	**p-value**	**95% Confidence Interval**	
					Lower bound	**Upper bound**
m²	0.0042259320	0.0002516010	16.8	0	0.0036993240	0.0047525400
Construction Period						
1906-1930	0.0674763800	0.0218348300	3.09	0.006	0.0217755600	0.1131772000
1931-1944	0.0773269400	0.0218701000	3.54	0.002	0.0315523000	0.1231016000
1945-1959	-0.0138433800	0.0271095400	-0.51	0.615	-0.0705843000	0.0428975500
1960-1970	-0.0783082100	0.0291242400	-2.69	0.015	-0.1392659000	-0.0173504900
1971-1980	-0.0697484200	0.0264126000	-2.64	0.016	-0.1250306000	-0.0144662200
1981-1990	0.0114204400	0.0472034300	0.24	0.811	-0.0873774800	0.1102184000
1991-2000	0.0827041900	0.0471432300	1.75	0.095	-0.0159677300	0.1813761000
≥ 2001	0.0489322400	0.0283681900	1.72	0.101	-0.0104430600	0.1083075000
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.0434426000	0.0159015700	2.73	0.013	0.0101602300	0.0767249700
Mansion or Canal House	0.1038901000	0.0314395400	3.3	0.004	0.0380863300	0.1696938000
Farmhouse or Bungalow	0.1443820000	0.0242123600	5.96	0	0.0937049600	0.1950591000
Villa	0.1560980000	0.0509351300	3.06	0.006	0.0494895100	0.2627064000
Estate	0.0477554000	0.0483819500	0.99	0.336	-0.0535091900	0.1490200000
Parking						
Available	0.1426166000	0.0097832520	14.58	0	0.1221400000	0.1630932000
Interior State						
Above Average	0.1317138000	0.0099837640	13.19	0	0.1108175000	0.1526100000
Below Average	-0.0648593500	0.0124388800	-5.21	0	-0.0908942200	-0.0388244900
Rooms	0.0257475400	0.0053694540	4.8	0	0.0145091500	0.0369859400
Park	-0.0256371000	0.0062795	-4.08	0.001	-0.0387802	-0.0124941
Water	-0.2952215000	0.1035485	-2.85	0.01	-0.511951	-0.078492
Forest	-0.0088329000	0.0080101	-1.1	0.284	-0.0255983	0.0079326
Trees	-0.0015932000	0.0053695	-0.3	0.77	-0.0128318	0.0096454
Park*Water	-0.0000360760	0.0000069080	-5.22	0	-0.0000505340	-0.0000216170
Park*Forest	-0.0000018750	0.0000007430	-2.53	0.021	-0.0000034290	-0.0000003210
Park*Trees	0.0000005870	0.0000002260	2.6	0.018	0.0000001140	0.0000010610
Water*Forest	-0.0000256900	0.0000082020	-3.13	0.005	-0.0000428580	-0.0000085220
Water*Trees	-0.0000014870	0.0000018560	-0.8	0.433	-0.0000053720	0.0000023980
Forest*Trees	0.0000442000	1.0000442000	1.49	0.152	0.0000442000	1.0000442000
Park*Water*Forest	-0.0000000032	0.0000000006	-5.1	0	-0.0000000045	-0.0000000019
Park*Water*Trees	0.0000000001	0.0000000001	0.61	0.552	-0.0000000001	0.0000000003
Park*Forest*Trees	0.0000000001	0.0000000000	3.19	0.005	0.0000000000	0.0000000001
Water*Forest*Trees	0.0000000001	0.0000000002	0.43	0.67	-0.0000000003	0.0000000005
Park*Water*Forest*Trees	0.0000000000	0.0000000000	1	0.331	0.0000000000	0.0000000000
Year						
2012	-0.1179933000	0.0104862700	-11.25	0	-0.1399413000	-0.0960453100
2013	-0.2332691000	0.0137732200	-16.94	0	-0.2620968000	-0.2044414000
2014	-0.1813235000	0.0165821400	-10.93	0	-0.2160303000	-0.1466166000
2015	-0.1164416000	0.0162932000	-7.15	0	-0.1505437000	-0.0823395900
2016	-0.0054801210	0.0184882300	-0.3	0.77	-0.0441764300	0.0332161900
2017	0.1520799000	0.0184692600	8.23	0	0.1134233000	0.1907365000
2018	0.3147654000	0.0184582200	17.05	0	0.2761319000	0.3533989000
2019	0.4384866000	0.0162806000	26.93	0	0.4044109000	0.4725623000

Constant	11.4480200000	0.0478221200	239.39	0	11.3479200000	11.5481100000
Number of observations	6109					
Number of groups	20					
R-squared:						
within	0.7926					
between	0.8676					
overall	0.7325					
Number of observations per group:						
minimum per group	101					
average per group	305.4					
maximum per group	653					

Table 21 | Base regression on the log house price in Nijmegen using a distance band of 800m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	0.004211	0.000286	14.7	0	0.003606	0.004815
Construction Period						
1906-1930	0.053584	0.023004	2.33	0.032	0.00505	0.102117
1931-1944	0.057523	0.023664	2.43	0.026	0.007597	0.10745
1945-1959	-0.02126	0.025927	-0.82	0.424	-0.07596	0.033443
1960-1970	-0.07329	0.031057	-2.36	0.031	-0.13881	-0.00776
1971-1980	-0.06893	0.03154	-2.19	0.043	-0.13548	-0.00239
1981-1990	0.01895	0.04675	0.41	0.69	-0.07968	0.117583
1991-2000	0.122075	0.046212	2.64	0.017	0.024576	0.219575
≥ 2001	0.065199	0.048927	1.33	0.2	-0.03803	0.168425
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.061493	0.018898	3.25	0.005	0.021622	0.101364
Mansion or Canal House	0.116378	0.035314	3.3	0.004	0.041873	0.190884
Farmhouse or Bungalow	0.154799	0.029242	5.29	0	0.093104	0.216493
Villa	0.202178	0.055658	3.63	0.002	0.08475	0.319606
Parking						
Available	0.132868	0.010001	13.28	0	0.111767	0.153968
Interior State						
Above Average	0.125399	0.010842	11.57	0	0.102524	0.148273
Below Average	-0.03596	0.025446	-1.41	0.176	-0.08964	0.017729
Rooms	0.027785	0.005693	4.88	0	0.015773	0.039796
Year						
2012	-0.11663	0.013403	-8.7	0	-0.14491	-0.08836
2013	-0.24021	0.013962	-17.2	0	-0.26967	-0.21075
2014	-0.1802	0.020453	-8.81	0	-0.22335	-0.13705
2015	-0.11544	0.022282	-5.18	0	-0.16245	-0.06843
2016	-0.00821	0.024509	-0.34	0.742	-0.05992	0.043499
2017	0.149323	0.023969	6.23	0	0.098753	0.199894
2018	0.306374	0.023183	13.22	0	0.257462	0.355287
2019	0.42836	0.020948	20.45	0	0.384164	0.472556
Constant	11.44843	0.061006	187.66	0	11.31972	11.57714
Number of observations	4539					
Number of groups	18					
R-squared:						
within	0.767					
between	0.7636					
overall	0.6869					
Number of observations per group:						
minimum per group	100					
average per group	252.2					
maximum per group	484					

Table 22 | Regression of park amenities on the log house price in Nijmegen using a distance band of 800m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	0.00413645	0.00029335	14.1	0	0.00351753	0.00475537
Construction Period						
1906-1930	0.06034004	0.02233866	2.7	0.015	0.01320960	0.10747050
1931-1944	0.06206955	0.02383805	2.6	0.019	0.01177566	0.11236340
1945-1959	-0.02117737	0.02600037	-0.81	0.427	-0.07603336	0.03367863
1960-1970	-0.06310858	0.03170269	-1.99	0.063	-0.12999540	0.00377825
1971-1980	-0.05159697	0.03015416	-1.71	0.105	-0.11521670	0.01202274
1981-1990	0.02742975	0.04657963	0.59	0.564	-0.07084468	0.12570420
1991-2000	0.10889230	0.04791316	2.27	0.036	0.00780442	0.20998030
≥ 2001	0.05846771	0.03913442	1.49	0.153	-0.02409870	0.14103410
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.05560237	0.01890158	2.94	0.009	0.01572352	0.09548123
Mansion or Canal House	0.11097440	0.03255343	3.41	0.003	0.04229262	0.17965610
Farmhouse or Bungalow	0.14763700	0.02795934	5.28	0	0.08864797	0.20662610
Villa	0.18466630	0.05361079	3.44	0.003	0.07155738	0.29777510
Parking						
Available	0.12890770	0.00909081	14.18	0	0.10972770	0.14808760
Interior State						
Above Average	0.12679540	0.01088899	11.64	0	0.10382160	0.14976920
Below Average	-0.04170048	0.02096999	-1.99	0.063	-0.08594329	0.00254233
Rooms	0.02826131	0.00554529	5.1	0	0.01656177	0.03996084
Park	-8.96E-04	0.0043671	-0.21	0.84	-0.0101098	0.0083179
Water	0.0427546	0.0097924	4.37	0	0.0220945	0.0634147
Forest	-4.25E-04	5.92E-04	-0.72	0.483	-0.0016745	8.25E-04
Trees	-3.55E-03	0.0013722	-2.59	0.019	-0.0064473	-0.000657
Year						
2012	-0.11506120	0.01373978	-8.37	0	-0.14404960	-0.08607283
2013	-0.23629840	0.01288425	-18.34	0	-0.26348180	-0.20911500
2014	-0.17983090	0.02086137	-8.62	0	-0.22384450	-0.13581720
2015	-0.11404690	0.02243497	-5.08	0	-0.16138050	-0.06671325
2016	-0.00667495	0.02500622	-0.27	0.793	-0.05943346	0.04608356
2017	0.15039750	0.02408109	6.25	0	0.09959085	0.20120420
2018	0.30674280	0.02328865	13.17	0	0.25760800	0.35587760
2019	0.43051190	0.02209754	19.48	0	0.38389010	0.47713360
Constant	11.45292000	0.06702524	170.87	0	11.3115	11.59433
Number of observations	4539					
Number of groups	18					
R-squared:						
within	0.7738					
between	0.6297					
overall	0.6472					
Number of observations per group:						
minimum per group	100					
average per group	252.2					
maximum per group	484					

Table 23 | Regression of park amenities and their interaction effects on the log house price in Nijmegen using a distance band of 800m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	0.00411862	0.00029	14.19	0	0.003506	0.004731
Construction Period						
1906-1930	0.05675888	0.021834	2.6	0.019	0.010694	0.102824
1931-1944	0.05923726	0.02284	2.59	0.019	0.01105	0.107424
1945-1959	-0.02473933	0.024683	-1	0.33	-0.07682	0.027338
1960-1970	-0.06289958	0.031996	-1.97	0.066	-0.1304	0.004606
1971-1980	-0.05251585	0.029716	-1.77	0.095	-0.11521	0.01018
1981-1990	0.02427134	0.043643	0.56	0.585	-0.06781	0.11635
1991-2000	0.115085	0.045696	2.52	0.022	0.018675	0.211495
≥ 2001	0.06106152	0.034404	1.77	0.094	-0.01152	0.133647
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.05471405	0.019245	2.84	0.011	0.014112	0.095317
Mansion or Canal House	0.1102325	0.032852	3.36	0.004	0.04092	0.179545
Farmhouse or Bungalow	0.1524411	0.027581	5.53	0	0.09425	0.210632
Villa	0.1853531	0.054389	3.41	0.003	0.070603	0.300104
Parking						
Available	0.1295358	0.009061	14.3	0	0.110419	0.148653
Interior State						
Above Average	0.1274885	0.010593	12.04	0	0.10514	0.149837
Below Average	-0.05381777	0.015103	-3.56	0.002	-0.08568	-0.02195
Rooms	0.02770563	0.005503	5.03	0	0.016096	0.039315
Park	0.0197161	0.020914	0.94	0.359	-0.02441	0.063841
Water	0.0649787	0.042105	1.54	0.141	-0.02385	0.153812
Forest	0.0007539	0.016606	0.05	0.964	-0.03428	0.03579
Trees	-0.0026486	4.45E-03	-0.6	0.56	-0.01204	0.006741
Park*Water	0.000002466	2.54E-06	0.97	0.345	-2.9E-06	7.82E-06
Park*Forest	0.000000959	1.14E-06	0.84	0.411	-1.4E-06	3.36E-06
Park*Trees	-5.89E-08	1.17E-07	-5.00E-01	6.21E-01	-3.1E-07	1.88E-07
Water*Forest	0.000001174	2.22E-06	0.53	0.604	-3.5E-06	5.86E-06
Water*Trees	-2.62E-11	2.39E-11	-1.10E+00	2.88E-01	-7.67E-11	2.42E-11
Forest*Trees	2.11E-08	2.26E-07	0.09	0.927	-4.6E-07	4.97E-07
Park*Water*Forest	9.53E-11	1.47E-10	0.65	0.527	-2.16E-10	4.07E-10
Park*Water*Trees	-2.62E-11	2.39E-11	-1.10E+00	2.88E-01	-7.67E-11	2.42E-11
Park*Forest*Trees	-5.55E-12	7.00E-12	-7.90E-01	4.39E-01	-2.03E-11	9.22E-12
Water*Forest*Trees	1.24E-11	3.13E-11	4.00E-01	6.96E-01	-5.36E-11	7.84E-11
Park*Water*Forest*Trees	-1.06E-15	1.04E-15	-1.03E+00	3.20E-01	-3.25E-15	1.12E-15
Year						
2012	-0.1148254	0.014142	-8.12E+00	0.00E+00	-0.14466	-0.08499

2013	-0.2367804	0.01273	-18.6	0	-0.26364	-0.20992
2014	-0.1805058	0.021015	-8.59	0	-0.22484	-0.13617
2015	-0.11472	0.022633	-5.07	0	-0.16247	-0.06697
2016	-0.005111051	0.025121	-0.2	0.841	-0.05811	0.047889
2017	0.1500861	0.024733	6.07	0	0.097905	0.202267
2018	0.3052378	0.023316	13.09	0	0.256046	0.35443
2019	0.4278042	0.022417	19.08	0	0.380508	0.475101
Constant	11.4623	0.065841	174.09	0	11.32339	11.60122
Number of observations	4539					
Number of groups	18					
R-squared:						
within	0.778					
between	0.5909					
overall	0.6421					
Number of observations per group:						
minimum per group	100					
average per group	252.2					
maximum per group	484					

Table 24 | Base regression on the log house price in Rotterdam using a distance band of 400m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	0.004579	0.000305	15.01	0	0.003948	0.00521
Construction Period						
1906-1930	0.063643	0.027267	2.33	0.029	0.007236	0.12005
1931-1944	0.060118	0.035362	1.7	0.103	-0.01303	0.133269
1945-1959	0.026077	0.042536	0.61	0.546	-0.06191	0.11407
1960-1970	-0.00406	0.029462	-0.14	0.892	-0.065	0.056891
1971-1980	0.015573	0.028866	0.54	0.595	-0.04414	0.075287
1981-1990	0.001975	0.031293	0.06	0.95	-0.06276	0.066709
1991-2000	0.050245	0.05305	0.95	0.353	-0.0595	0.159987
≥ 2001	0.061934	0.056039	1.11	0.281	-0.05399	0.17786
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.051572	0.0137	3.76	0.001	0.023231	0.079912
Mansion or Canal House	0.173588	0.027608	6.29	0	0.116477	0.2307
Farmhouse or Bungalow	0.33957	0.043964	7.72	0	0.248624	0.430516
Villa	0.431011	0.067686	6.37	0	0.290991	0.571031
Estate	0.450197	0.146429	3.07	0.005	0.147286	0.753109
Parking						
Available	0.097612	0.012822	7.61	0	0.071088	0.124137
Interior State						
Above Average	0.160841	0.017565	9.16	0	0.124505	0.197176
Below Average	-0.08494	0.034345	-2.47	0.021	-0.15599	-0.01389
Rooms	0.010118	0.005248	1.93	0.066	-0.00074	0.020975
Year						
2012	-0.10999	0.016686	-6.59	0	-0.14451	-0.07548
2013	-0.21916	0.010858	-20.18	0	-0.24162	-0.1967
2014	-0.19653	0.011305	-17.38	0	-0.21991	-0.17314
2015	-0.09557	0.019832	-4.82	0	-0.1366	-0.05454
2016	0.052893	0.018691	2.83	0.009	0.014229	0.091558
2017	0.233578	0.02178	10.72	0	0.188523	0.278633
2018	0.420511	0.019253	21.84	0	0.380684	0.460338
2019	0.522932	0.015958	32.77	0	0.48992	0.555944
Constant	11.5513	0.054077	213.61	0	11.43944	11.66317
Number of observations	5,293					
Number of groups	24					
R-squared:						
within	0.7636					
between	0.8915					
overall	0.7567					
Number of observations per group:						
minimum per group	101					
average per group	220.5					
maximum per group	522					

Table 25 | Regression of park amenities on the log house price in Rotterdam using a distance band of 400m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	4.40E-03	3.06E-04	14.4	0	3.77E-03	5.04E-03
Construction Period						
1906-1930	6.87E-02	3.85E-02	1.78	0.088	-1.10E-02	1.48E-01
1931-1944	8.55E-02	4.28E-02	2	0.058	-3.15E-03	1.74E-01
1945-1959	4.18E-02	3.20E-02	1.3	0.205	-2.45E-02	1.08E-01
1960-1970	2.15E-02	3.42E-02	0.63	0.537	-4.93E-02	9.22E-02
1971-1980	4.51E-02	3.61E-02	1.25	0.225	-2.97E-02	1.20E-01
1981-1990	3.29E-02	3.95E-02	0.83	0.413	-4.88E-02	1.15E-01
1991-2000	7.62E-02	5.02E-02	1.52	0.143	-2.77E-02	1.80E-01
≥ 2001	8.94E-02	3.89E-02	2.3	0.031	8.91E-03	1.70E-01
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	5.48E-02	1.34E-02	4.1	0	2.72E-02	8.24E-02
Mansion or Canal House	1.67E-01	2.48E-02	6.73	0	1.16E-01	2.18E-01
Farmhouse or Bungalow	3.43E-01	4.28E-02	8.03	0	2.55E-01	4.32E-01
Villa	4.07E-01	5.21E-02	7.82	0	3.00E-01	5.15E-01
Estate	4.71E-01	1.50E-01	3.14	0.005	1.61E-01	7.82E-01
Parking						
Available	9.46E-02	1.30E-02	7.3	0	6.78E-02	1.21E-01
Interior State						
Above Average	1.58E-01	1.62E-02	9.75E+00	0.00E+00	1.24E-01	1.91E-01
Below Average	-8.06E-02	3.48E-02	########	3.00E-02	-1.52E-01	-8.61E-03
Rooms	1.23E-02	5.46E-03	2.25	0.034	9.82E-04	2.36E-02
Park	-0.0007872	0.0014348	-0.55	0.589	-0.0037553	0.002181
Water	0.1365708	0.0382238	3.57	0.002	0.0574989	0.2156427
Forest	-0.0027986	0.006538	-0.43	0.673	-0.0163235	0.0107263
Trees	-0.0017908	0.0046238	-0.39	0.702	-0.0113559	0.0077742
Year						
2012	-1.10E-01	1.72E-02	-6.36	0	-1.45E-01	-7.39E-02
2013	-2.17E-01	1.08E-02	-20.07	0	-2.40E-01	-1.95E-01
2014	-1.96E-01	1.10E-02	-17.84	0	-2.18E-01	-1.73E-01
2015	-9.48E-02	1.96E-02	-4.84	0	-1.35E-01	-5.43E-02
2016	5.36E-02	1.88E-02	2.85	0.009	1.47E-02	9.25E-02
2017	2.34E-01	2.11E-02	11.05	0	1.90E-01	2.77E-01
2018	4.18E-01	1.85E-02	22.65	0	3.80E-01	4.56E-01
2019	5.22E-01	1.54E-02	33.82	0	4.90E-01	5.54E-01
Constant	1.15E+01	6.46E-02	178.83	0	1.14E+01	1.17E+01
Number of observations	5293					
Number of groups	24					
R-squared:						
within	0.7733					
between	0.9032					
overall	0.7656					
Number of observations per group:						
minimum per group	101					
average per group	220.5					
maximum per group	522					

Table 26 | Regression of park amenities and their interaction effects on the log house price in Rotterdam using a distance band of 400m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	0.004372	0.000318	13.77	0	0.003715	0.005028
Construction Period						
1906-1930	0.078432	0.040666	1.93	0.066	-0.00569	0.162556
1931-1944	0.099389	0.042446	2.34	0.028	0.011582	0.187195
1945-1959	0.055147	0.031837	1.73	0.097	-0.01071	0.121007
1960-1970	0.031896	0.034603	0.92	0.366	-0.03968	0.103478
1971-1980	0.057235	0.035017	1.63	0.116	-0.0152	0.129674
1981-1990	0.045385	0.038646	1.17	0.252	-0.03456	0.12533
1991-2000	0.098446	0.049217	2	0.057	-0.00337	0.20026
≥ 2001	0.103362	0.039223	2.64	0.015	0.022223	0.184501
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.0538	0.013407	4.01	0.001	0.026065	0.081535
Mansion or Canal House	0.167244	0.024172	6.92	0	0.117241	0.217247
Farmhouse or Bungalow	0.353409	0.052797	6.69	0	0.244189	0.462628
Villa	0.400993	0.051183	7.83	0	0.295113	0.506873
Estate	0.471542	0.147646	3.19	0.004	0.166113	0.776972
Parking						
Available	0.094677	0.012573	7.53	0	0.068667	0.120687
Interior State						
Above Average	0.157317	0.016157	9.74	0	0.123894	0.19074
Below Average	-0.08065	0.035585	-2.27	0.033	-0.15426	-0.00703
Rooms	0.012429	0.005466	2.27	0.033	0.001122	0.023735
Park	-0.0012849	0.0032218	-0.4	0.694	-0.0079497	0.00538
Water	0.0595451	0.0660315	0.9	0.377	-0.0770514	0.1961416
Forest	-0.0335541	0.0251921	-1.33	0.196	-0.0856679	0.0185597
Trees	-0.0033656	0.0037657	-0.89	0.381	-0.0111555	0.0044243
Park*Water	-2.7E-07	8.7E-07	-0.31	0.762	-2.1E-06	1.53E-06
Park*Forest	2.22E-07	1.5E-07	1.48	0.152	-8.8E-08	5.31E-07
Park*Trees	1.58E-07	1.14E-07	1.39	0.178	-7.7E-08	3.94E-07
Water*Forest	-1.3E-05	1.02E-05	-1.3	0.207	-3.4E-05	7.86E-06
Water*Trees	-2.2E-06	9.99E-07	-2.15	0.042	-4.2E-06	-8.3E-08
Forest*Trees	2.51E-07	5.21E-07	0.48	0.635	-8.3E-07	1.33E-06
Park*Water*Forest	1.35E-10	8.29E-11	1.62	0.118	-3.69E-11	3.06E-10
Park*Water*Trees	-6.58E-12	2.93E-11	-0.22	0.824	-6.71E-11	5.40E-11
Park*Forest*Trees	-2.48E-14	1.90E-12	-0.01	0.99	-3.96E-12	3.91E-12
Water*Forest*Trees	-5.24E-10	3.15E-10	-1.66	0.11	-1.18E-09	1.28E-10
Park*Water*Forest*Trees	4.89E-09	2.83E-09	1.73	0.098	-9.70E-10	1.08E-08
Year						
2012	-0.1081	0.018854	-5.73	0	-0.1471	-0.0691
2013	-0.21558	0.010414	-20.7	0	-0.23712	-0.19404
2014	-0.19361	0.011218	-17.26	0	-0.21681	-0.1704
2015	-0.09336	0.01947	-4.8	0	-0.13364	-0.05309
2016	0.056408	0.018627	3.03	0.006	0.017875	0.094941
2017	0.235024	0.020839	11.28	0	0.191914	0.278133
2018	0.419422	0.018729	22.39	0	0.380678	0.458165

2019	0.524875	0.015246	34.43	0	0.493336	0.556415
Constant	11.52473	0.067879	169.78	0	11.38431	11.66514
Number of observations	5293					
Number of groups	24					
R-squared:						
within	0.7755					
between	0.9045					
overall	0.7641					
Number of observations per group:						
minimum per group	101					
average per group	220.5					
maximum per group	522					

Table 27 | Base regression on the log house price in Rotterdam using a distance band of 800m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	0.004153	0.000306	13.56	0	0.003509	0.004796
Construction Period						
1906-1930	0.064191	0.015765	4.07	0.001	0.031069	0.097313
1931-1944	0.069238	0.025484	2.72	0.014	0.015698	0.122778
1945-1959	0.038087	0.022611	1.68	0.109	-0.00942	0.085591
1960-1970	-0.00693	0.023982	-0.29	0.776	-0.05732	0.043454
1971-1980	-0.01272	0.031006	-0.41	0.686	-0.07786	0.052422
1981-1990	0.059358	0.032936	1.8	0.088	-0.00984	0.128554
1991-2000	0.053657	0.051347	1.04	0.31	-0.05422	0.161532
≥ 2001	0.071993	0.037368	1.93	0.07	-0.00651	0.150501
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.064343	0.01532	4.2	0.001	0.032156	0.09653
Mansion or Canal House	0.184655	0.028806	6.41	0	0.124136	0.245174
Farmhouse or Bungalow	0.354456	0.066932	5.3	0	0.213838	0.495075
Villa	0.491279	0.066198	7.42	0	0.352201	0.630356
Estate	0.564675	0.08313	6.79	0	0.390026	0.739324
Parking						
Available	0.099314	0.013824	7.18	0	0.070271	0.128358
Interior State						
Above Average	0.159155	0.017027	9.35	0	0.123383	0.194928
Below Average	-0.09729	0.035768	-2.72	0.014	-0.17244	-0.02215
Rooms	0.009491	0.004206	2.26	0.037	0.000655	0.018327
Year						
2012	-0.12618	0.020384	-6.19	0	-0.169	-0.08335
2013	-0.22622	0.016936	-13.36	0	-0.26181	-0.19064
2014	-0.18153	0.013214	-13.74	0	-0.20929	-0.15377
2015	-0.08189	0.021793	-3.76	0.001	-0.12767	-0.0361
2016	0.062664	0.022453	2.79	0.012	0.015492	0.109837
2017	0.242241	0.026558	9.12	0	0.186445	0.298037
2018	0.446162	0.020042	22.26	0	0.404054	0.488269
2019	0.532344	0.019608	27.15	0	0.491148	0.57354
Constant	11.62612	0.051581	225.4	0	11.51775	11.73448
Number of observations	3266					
Number of groups	19					
R-squared:						
within	0.7532					
between	0.8883					
overall	0.7581					
Number of observations per group:						
minimum per group	101					
average per group	171.9					
maximum per group	319					

Table 29 | Regression of park amenities on the log house price in Rotterdam using a distance band of 800m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	0.004003	0.030883	12.96	0	0.003354	0.030883
Construction Period						
1906-1930	0.072738	0.030883	3.28	0.004	0.02612	0.119356
1931-1944	0.091224	0.030883	2.81	0.011	0.023139	0.159309
1945-1959	0.05518	0.030883	1.95	0.067	-0.00439	0.114753
1960-1970	0.019722	0.030883	0.69	0.499	-0.04038	0.079825
1971-1980	0.008127	0.030883	0.23	0.82	-0.06598	0.082238
1981-1990	0.082523	0.030883	2.41	0.027	0.010571	0.154475
1991-2000	0.077451	0.030883	1.41	0.177	-0.03828	0.193179
≥ 2001	0.100216	0.030883	3.13	0.006	0.03288	0.167551
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.063103	0.030883	4.16	0.001	0.031227	0.094979
Mansion or Canal House	0.17502	0.030883	6.81	0	0.121025	0.229014
Farmhouse or Bungalow	0.354288	0.030883	5.41	0	0.216618	0.491958
Villa	0.480192	0.030883	9.93	0	0.378645	0.581739
Estate	0.60444	0.030883	6.43	0	0.406929	0.80195
Parking						
Available	0.097622	0.030883	7.55	0	0.070473	0.124771
Interior State						
Above Average	0.161222	0.030883	9.04	0	0.123742	0.198702
Below Average	-0.09094	0.030883	-2.5	0.022	-0.16731	-0.01458
Rooms	0.011438	0.030883	3.26	0.004	0.004068	0.018809
	0.002072	0.001595	1.3	0.21	-0.00128	0.005423
Park	0.028344	0.011569	2.45	0.025	0.004038	0.05265
Water	-0.01139	0.006534	-1.74	0.098	-0.02512	0.00234
Forest	-0.00137	0.00249	-0.55	0.589	-0.0066	0.00386
Trees						
Year	-0.12142	0.030883	-5.79	0	-0.16549	-0.07735
2012	-0.22135	0.030883	-13.81	0	-0.25503	-0.18767
2013	-0.18123	0.030883	-14.06	0	-0.20832	-0.15414
2014	-0.0819	0.030883	-3.95	0.001	-0.12549	-0.03831
2015	0.064283	0.030883	2.92	0.009	0.017983	0.110583
2016	0.24346	0.030883	9.46	0	0.189397	0.297522
2017	0.447585	0.030883	22.79	0	0.40632	0.488851
2018	0.536666	0.030883	28.53	0	0.497148	0.576185
2019						
	1161.916	5.848656	198.66	0	11.49629	11.74204
Constant	0.004003	0.030883	12.96	0	0.003354	0.030883
Number of observations	3266					
Number of groups	19					
R-squared:						
within	0.7597					
between	0.9363					
overall	0.7929					
Number of observations per group:						
minimum per group	101					
average per group	171.9					
maximum per group	319					

Table 30 | Regression of park amenities and their interaction effects on the log house price in Rotterdam using a distance band of 800m. robust

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
m²	0.003997	0.000305	13.12	0	0.003357	0.004637
Construction Period						
1906-1930	0.069436	0.020397	3.4	0.003	0.026583	0.112289
1931-1944	0.096013	0.031799	3.02	0.007	0.029206	0.16282
1945-1959	0.061386	0.030294	2.03	0.058	-0.00226	0.12503
1960-1970	0.016651	0.029158	0.57	0.575	-0.04461	0.077909
1971-1980	0.007845	0.033202	0.24	0.816	-0.06191	0.0776
1981-1990	0.082079	0.03512	2.34	0.031	0.008294	0.155863
1991-2000	0.070526	0.054956	1.28	0.216	-0.04493	0.185984
≥ 2001	0.112391	0.029291	3.84	0.001	0.050853	0.173929
House Class						
Single Family Dwelling, Houseboat or Recreation Dwelling	0.063437	0.014524	4.37	0	0.032924	0.09395
Mansion or Canal House	0.172991	0.025569	6.77	0	0.119273	0.226709
Farmhouse or Bungalow	0.360798	0.06776	5.32	0	0.218439	0.503156
Villa	0.481845	0.04782	10.08	0	0.381379	0.582311
Estate	0.616028	0.0934	6.6	0	0.419801	0.812254
Parking						
Available	0.098334	0.013024	7.55E+00	0	0.070972	0.125696
Interior State						
Above Average	0.159739	0.017818	8.97E+00	0	0.122306	0.197173
Below Average	-0.08991	0.032017	########	0.012	-0.15717	-0.02264
Rooms	0.01043	0.003374	3.09E+00	0.006	0.003342	0.017517
Park	0.0033384	0.0032933	1.01	0.324	-0.0035807	0.0102575
Water	-0.0027773	0.021132	-0.13	0.897	-0.047174	0.0416194
Forest	-0.0462728	0.0570641	-0.81	0.428	-0.16616	0.0736145
Trees	0.0035313	0.0061441	0.57	0.573	-0.0093771	0.0164397
Park*Water	1.78E-07	1.07E-07	1.67E+00	0.113	-4.6E-08	4.03E-07
Park*Forest	1.48E-07	2.19E-07	6.70E-01	0.509	-3.1E-07	6.08E-07
Park*Trees	-9.5E-09	2.7E-08	-3.50E-01	0.729	-6.6E-08	4.73E-08
Water*Forest	-2.7E-06	4.87E-06	-5.60E-01	0.581	-1.3E-05	7.5E-06
Water*Trees	-3.1E-07	1.44E-07	########	0.047	-6.1E-07	-4.6E-09
Forest*Trees	5.37E-07	6.26E-07	8.60E-01	0.403	-7.8E-07	1.85E-06
Park*Water*Forest	1.27E-11	2.18E-11	5.80E-01	0.567	-3.31E-11	5.85E-11
Park*Water*Trees	1.97E-12	1.26E-12	1.56E+00	0.135	-6.76E-13	4.61E-12
Park*Forest*Trees	-1.47E-12	2.46E-12	-6.00E-01	0.558	-6.64E-12	3.70E-12
Water*Forest*Trees	-3.49E-11	2.70E-11	-1.29	0.213	-9.17E-11	2.19E-11
Park*Water*Forest*Trees	1.37E-16	1.11E-16	1.23	0.234	-9.66E-17	3.70E-16
Year						
2012	-0.11956	0.021548	-5.55	0	-0.16483	-0.07428
2013	-0.21823	0.016426	-13.29	0	-0.25274	-0.18372
2014	-0.17974	0.01282	-14.02	0	-0.20667	-0.1528
2015	-0.08166	0.021531	-3.79	0.001	-0.12689	-0.03643
2016	0.063843	0.022851	2.79	0.012	0.015835	0.111851
2017	0.243648	0.027359	8.91	0	0.186169	0.301127
2018	0.448669	0.020959	21.41	0	0.404636	0.492702
2019	0.538021	0.02168	24.82	0	0.492473	0.583569

Constant	11.60341	0.08041	144.3	0	11.43447	11.77234
Number of observations	3266					
Number of groups	19					
R-squared:						
within	0.7624					
between	0.9119					
overall	0.7789					
Number of observations per group:						
minimum per group	101					
average per group	171.9					
maximum per group	319					

Table 31 | The interaction effects for Nijmegen, using a distance band of 400m at a minimum level of natural amenities

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Park	-0.01045	0.019861	-0.53	0.605	-0.05201	0.031123
Water	0.153574	0.044137	3.48	0.003	0.061194	0.245954
Forest	0.003926	0.006753	0.58	0.568	-0.01021	0.018059
Trees	-0.00346	0.007589	-0.46	0.653	-0.01935	0.012423
Park*Water	park*water	0.008368	0.06113	0.14	0.893	-0.11958
Park*Forest	park*forest	0.00553	0.013983	0.4	0.697	-0.02374
Park*Trees	park*trees	0.001223	0.002236	0.55	0.591	-0.00346
Water*Forest	water*forest	0.162529	0.101294	1.6	0.125	-0.04948
Water*Trees	water*trees	-0.01704	0.006905	-2.47	0.023	-0.03149
Forest*Trees	forest*trees	-0.00136	0.000848	-1.61	0.124	-0.00314
Park*Water*Forest	-0.41395	0.120151	-3.45	0.003	-0.66543	-0.16247
Park*Water*Trees	-0.00553	0.008435	-0.66	0.52	-0.02318	0.012128
Park*Forest*Trees	0.00361	0.001933	1.87	0.077	-0.00044	0.007656
Water*Forest*Trees	-0.00472	0.013378	-0.35	0.728	-0.03273	0.023277
Park*Water*Forest*Trees	0.011245	0.011272	1	0.331	-0.01235	0.034838

Table 32 | The interaction effects for Nijmegen, using a distance band of 800m at a minimum level of natural amenities

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Park	-0.0324	0.018964	-1.71	0.106	-0.07241	0.007613
Water	0.016933	0.014753	1.15	0.267	-0.01419	0.048059
Forest	0.034077	0.007463	4.57	0	0.018331	0.049822
Trees	-0.00482	0.001585	-3.04	0.007	-0.00816	-0.00147
Park*Water	0.018112	0.004248	4.26	0.001	0.00915	0.027073
Park*Forest	-0.00697	0.004501	-1.55	0.14	-0.01647	0.002526
Park*Trees	0.00089	0.000628	1.42	0.174	-0.00043	0.002215
Water*Forest	-0.14031	0.068263	-2.06	0.056	-0.28433	0.003717
Water*Trees	0.000347	0.000917	0.38	0.709	-0.00159	0.002281
Forest*Trees	-0.0015	0.000329	-4.57	0	-0.0022	-0.00081
Park*Water*Forest	0.043445	0.045748	0.95	0.356	-0.05307	0.139965
Park*Water*Trees	-0.00042	0.000338	-1.23	0.235	-0.00113	0.000297
Park*Forest*Trees	0.000284	0.000159	1.78	0.093	-5.3E-05	0.00062
Water*Forest*Trees	0.003995	0.002324	1.72	0.104	-0.00091	0.008898
Park*Water*Forest*Trees	-0.00106	0.001037	-1.03	0.32	-0.00325	0.001125

Table 33 | The interaction effects for Nijmegen, using a distance band of 400m at a maximum level of natural amenities

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Park	-56.5757	10.8451	-5.22	0	-79.2747	-33.8766
Water	-125.551	25.52173	-4.92	0	-178.968	-72.1332
Forest	-5.58062	1.14191	-4.89	0	-7.97067	-3.19058
Trees	1.227675	2.746708	0.45	0.66	-4.52125	6.976601
Park*Water	-19.9713	3.815296	-5.23	0	-27.9568	-11.9858
Park*Forest	-0.88955	0.171067	-5.2	0	-1.2476	-0.5315
Park*Trees	0.278855	0.095435	2.92	0.009	0.079107	0.478602
Water*Forest	-1.97249	0.402039	-4.91	0	-2.81397	-1.13101
Water*Trees	-0.20476	0.897711	-0.23	0.822	-2.08369	1.674174
Forest*Trees	0.021662	0.04305	0.5	0.621	-0.06844	0.111767
Park*Water*Forest	-0.31405	0.060164	-5.22	0	-0.43998	-0.18813
Park*Water*Trees	-0.00483	0.007991	-0.6	0.553	-0.02155	0.011898
Park*Forest*Trees	0.004614	0.001411	3.27	0.004	0.001661	0.007566
Water*Forest*Trees	-0.00246	0.014075	-0.17	0.863	-0.03191	0.027002
Park*Water*Forest*Trees	Omitted					

Table 34 | The interaction effects for Nijmegen, using a distance band of 800m at a maximum level of natural amenities

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Park	-5.71947	6.67251	-0.86	0.403	-19.7972	8.358293
Water	-2.15282	5.086525	-0.42	0.677	-12.8845	8.57881
Forest	-0.29284	0.721707	-0.41	0.69	-1.81551	1.229828
Trees	-3.24109	5.254478	-0.62	0.546	-14.3271	7.844885
Park*Water	-0.67296	0.741251	-0.91	0.377	-2.23686	0.890945
Park*Forest	-0.09131	0.106943	-0.85	0.405	-0.31694	0.134319
Park*Trees	-0.59732	0.590757	-1.01	0.326	-1.8437	0.649074
Water*Forest	-0.03457	0.080675	-0.43	0.674	-0.20478	0.135638
Water*Trees	-0.35952	0.577586	-0.62	0.542	-1.57812	0.859075
Forest*Trees	-0.05143	0.08389	-0.61	0.548	-0.22842	0.125567
Park*Water*Forest	-0.01072	0.01187	-0.9	0.379	-0.03577	0.014319
Park*Water*Trees	-0.06686	0.065027	-1.03	0.318	-0.20405	0.070334
Park*Forest*Trees	-0.00951	0.009431	-1.01	0.327	-0.02941	0.010384
Water*Forest*Trees	-0.0057	0.009214	-0.62	0.544	-0.02514	0.01374
Park*Water*Forest*Trees	-0.00106	0.001037	-1.03	0.32	-0.00325	0.001125

Table 35 | The interaction effects for Rotterdam, using a distance band of 400m at a minimum level of natural amenities

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Park	-0.01595	0.012967	-1.23	0.231	-0.04277	0.010876
Water	0.182062	0.030328	6	0	0.119323	0.2448
Forest	-0.18356	0.126969	-1.45	0.162	-0.44622	0.079092
Trees	-0.00073	0.006967	-0.1	0.918	-0.01514	0.013685
Park*Water	0.005404	0.018228	0.3	0.77	-0.0323	0.043111
Park*Forest	0.012247	0.006507	1.88	0.073	-0.00121	0.025708
Park*Trees	0.002115	0.001547	1.37	0.185	-0.00109	0.005315
Water*Forest	0.305717	0.167756	1.82	0.081	-0.04131	0.652746
Water*Trees	-0.01293	0.010734	-1.2	0.241	-0.03513	0.009275
Forest*Trees	0.02747	0.018881	1.45	0.159	-0.01159	0.066528
Park*Water*Forest	-0.02403	0.013821	-1.74	0.095	-0.05262	0.004559
Park*Water*Trees	0.002898	-0.44	0.664	-0.00727	0.004718	
Park*Forest*Trees	-0.00204	0.001093	-1.87	0.075	-0.0043	0.000219
Water*Forest*Trees	-0.05991	0.035773	-1.67	0.108	-0.13391	0.014095
Park*Water*Forest*Trees	0.004893	0.002834	1.73	0.098	-0.00097	0.010756

Table 36 | The interaction effects for Rotterdam, using a distance band of 800m at a minimum level of natural amenities

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Park	0.002491	0.010738	0.23	0.819	-0.02007	0.02505
Water	0.024412	0.019215	1.27	0.22	-0.01596	0.064781
Forest	-0.28786	0.180864	-1.59	0.129	-0.66784	0.092124
Trees	-0.00136	0.003076	-0.44	0.664	-0.00782	0.005105
Park*Water	-0.00072	0.002236	-0.32	0.75	-0.00542	0.003975
Park*Forest	0.007116	0.005183	1.37	0.187	-0.00377	0.018004
Park*Trees	-8.7E-05	0.000341	-0.25	0.802	-0.0008	0.00063
Water*Forest	0.051675	0.021579	2.39	0.028	0.00634	0.097011
Water*Trees	-0.00029	0.001553	-0.19	0.854	-0.00355	0.002972
Forest*Trees	0.015599	0.012326	1.27	0.222	-0.0103	0.041495
Park*Water*Forest	-0.0014	0.000634	-2.21	0.041	-0.00273	-6.7E-05
Park*Water*Trees	6.65E-05	6.21E-05	1.07	0.298	-6.4E-05	0.000197
Park*Forest*Trees	-0.00042	0.000359	-1.17	0.259	-0.00117	0.000335
Water*Forest*Trees	-0.00457	0.00358	-1.28	0.218	-0.01209	0.002948
Park*Water*Forest*Trees	0.000137	0.000111	1.23	0.234	-9.7E-05	0.00037

Table 37 | The interaction effects for Rotterdam, using a distance band of 400m at a maximum level of natural amenities

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Park	0.861023	0.525644	1.64	0.115	-0.22635	1.948401
Water	5.739109	3.528052	1.63	0.117	-1.55922	13.03744
Forest	2.587419	1.510333	1.71	0.1	-0.53694	5.711781
Trees	1.351238	0.866634	1.56	0.133	-0.44153	3.144007
Park*Water	0.325478	0.200768	1.62	0.119	-0.08984	0.740797
Park*Forest	0.141127	0.083467	1.69	0.104	-0.03154	0.31379
Park*Trees	0.077329	0.046693	1.66	0.111	-0.01926	0.173921
Water*Forest	0.988187	0.560495	1.76	0.091	-0.17129	2.147659
Water*Trees	0.504043	0.326321	1.54	0.136	-0.171	1.17909
Forest*Trees	0.229174	0.138604	1.65	0.112	-0.05755	0.515898
Park*Water*Forest	0.054114	0.031651	1.71	0.101	-0.01136	0.11959
Park*Water*Trees	0.029509	0.018122	1.63	0.117	-0.00798	0.066997
Park*Forest*Trees	0.01256	0.007378	1.7	0.102	-0.0027	0.027823
Water*Forest*Trees	0.088316	0.051388	1.72	0.099	-0.01799	0.194621
Park*Water*Forest*Trees	0.004893	0.002834	1.73	0.098	-0.00097	0.010756

Table 38 | The interaction effects for Rotterdam, using a distance band of 800m at a maximum level of natural amenities

Log Price	Coefficient	Standard Error	t-value	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Park	0.371858	0.398633	0.93	0.363	-0.46564	1.209355
Water	0.146888	0.176726	0.83	0.417	-0.2244	0.518176
Forest	0.071539	0.126143	0.57	0.578	-0.19348	0.336557
Trees	0.035329	0.040386	0.87	0.393	-0.04952	0.120177
Park*Water	0.050285	0.050464	1	0.332	-0.05574	0.156306
Park*Forest	0.031081	0.036105	0.86	0.401	-0.04477	0.106935
Park*Trees	0.010912	0.009564	1.14	0.269	-0.00918	0.031005
Water*Forest	0.005855	0.014181	0.41	0.685	-0.02394	0.035649
Water*Trees	0.002281	0.004244	0.54	0.598	-0.00663	0.011196
Forest*Trees	0.001823	0.003114	0.59	0.566	-0.00472	0.008366
Park*Water*Forest	0.004246	0.004547	0.93	0.363	-0.00531	0.013799
Park*Water*Trees	0.001623	0.001269	1.28	0.217	-0.00104	0.004289
Park*Forest*Trees	0.000911	0.00085	1.07	0.298	-0.00088	0.002697
Water*Forest*Trees	2.95E-05	0.000394	0.07	0.941	-0.0008	0.000857
Park*Water*Forest*Trees	0.000137	0.000111	1.23	0.234	-9.7E-05	0.00037