RENEWED CITIES,

RENEWED APPRECIATION?

Investigating the appreciation of the urban renewal building style in Dutch cities

Rienje Veenhof
July, 2022

Renewed cities, renewed appreciation?

Investigating the appreciation of the urban renewal building style in Dutch cities

Author

Rienje Veenhof

July 2022

Student number: 5815169

Supervisor

Dr. Martijn Smit

Utrecht University

Faculty of Geosciences

MSc Human Geography

Abstract

This thesis investigates the effect of the Dutch urban renewal building style (1975 – 1985) on housing prices in Amsterdam, Utrecht and Leiden. Although urban renewal is generally seen as a relatively 'unattractive' building style, it is not yet known to what extent this influences transaction prices. Furthermore, the unique spatial lay-out of urban renewal provides the opportunity to gain insight into the price effect of the neighbors' building style on houses as well. Because it is challenging to separate the effects of a building style from other structural and locational characteristics of a house, this study uses a rich data set of housing transactions supplemented with locational variables. The employed methods, hedonic price modelling, cluster analysis and photo documentation, make it possible to untwine the effects of the building style from the other characteristics. The results show that urban renewal creates a small but significant price discount (-3.9%) in comparison to the reference period (1900 – 1951). Furthermore, significant price premiums (+4.9% to +6.1%) are found for urban renewal houses that are surrounded by pre-war buildings, compared to houses located in clusters of urban renewal. However, the explanatory power of the building style is limited compared to other locational and structural factors. Photo documentation of case studies uncovered unconventional and subjective aspects of housing appreciation that could influence prices, namely a desirable streetscape and neighborhood image. This study contributes to the broader field of housing studies by providing empirical support for price effects attributable to a specific and 'undesirable' building style. Additionally, it demonstrates that the spatial configuration of housing can have an effect on prices as well. Furthermore, it submits the use of mixed methods in housing price studies to achieve a deeper and more holistic understanding of 'appreciation' of housing, for instance through the use of a broader range of variables and through the inclusion of subjective and 'soft' housing factors.

Abbreviations

BAG	Dutch Addresses and Buildings key register (Basisregistratie Adressen en Gebouwen)
CBS	Central Bureau of Statistics
DBSCAN	Density-Based Spatial Clustering of Applications with Noise (algorithm)
HPM	Hedonic Price Model
ISR	Interim Saldoregeling
NVM	Dutch Association of Real Estate Brokers and Experts (Nederlandse Coöperatieve Vereniging van Makelaars en Taxateurs)
VIF	Variance Inflation Factor

Acknowledgements

Before you lies the final thesis for my master's degree in Human Geography. I can happily say that I am proud and quite relieved at the sight of the final product. I hope you enjoy reading it as much as I enjoyed working on it!

First and foremost, I would like to thank Martijn Smit, whose expertise and constructive feedback throughout the process were crucial for this thesis. His contagious enthusiasm for the subject and broad range of interests was a great motivation and made the writing of this thesis a lot more fun. I hope you enjoy reading the final product.

I would like to thank the people at the Amsterdam School of Real Estate, especially Douglas Konadu, for helping me gain access to the data. Without their help, the thesis as it is now would not have been possible.

Finally, I would like to thank my friends and family. In particular, I would like to thank my mom, Marian Klamer, who is the sharpest and kindest proof-reader anyone could wish for. I also would like to thank Jan Haak for his great support. Thank you for listening to my brainstorm monologues and for providing me with advice and insights, especially when the process was challenging.

The thesis was written between February and July 2022 in Utrecht and Leiden. All photos, figures and maps were taken or made by me, unless otherwise stated.

Rienje Veenhof

Utrecht, July 2022

Contents

Abstract ... 3
Abbreviations ... 3
Acknowledgements ... 4
1. Introduction ... 7
2. Theoretical framework ... 10
2.1. Characteristics of Dutch Urban Renewal ... 11
2.2. Quantifiable factors influencing housing prices ... 12
2.3. Non-quantifiable factors influencing housing prices ... 16
2.4. Conceptual model ... 20
3. Methodology ... 22
3.1. Research area and period ... 22
3.2. Data ... 23
3.3. Hedonic price modelling ... 27
3.4. Cluster analysis ... 29
3.5. Photo documentation ... 30
4. Results ... 33
4.1. Descriptive statistics ... 33
4.2. Correlations ... 35
4.3. Hedonic price model ... 36
4.4. Cluster analysis ... 41
4.5. Photo documentation ... 46
5. Conclusion ... 51
5.1. Main findings and relevance ... 51
5.2. Answer to research questions and scientific relevance ... 51
6. Discussion ... 56
6.1. Limitations ... 56
6.2. Policy implications ... 57
6.3. Recommendations for future research ... 57
7. Literature ... 58
Appendices ... 64
1. Shooting script ... 64
2. Maps of urban renewal locations and spatial variables ... 65
3. Complete descriptive statistics ... 73
4. Variance inflation factors ... 76
5. Hedonic price model of all building periods ... 78

6. Hedonic price model of all building periods: diagnostic plots 81
7. Urban renewal clusters 83
8. Hedonic price model with clustering variable 84
9. Hedonic price model with clustering variable: diagnostic plots 87
10. Photo documentation 89

1. Introduction

Dutch urban renewal, or 'stadsvernieuwing,' was a period of urban planning policy in Dutch cities during the 1970s and 80s (De Liagre Böhl, 2012; Van Es & Voerman, 2018; Vermeijden, 2001). During this time, inner-city neighborhoods were poorly maintained, marked by high vacancy rates and an outflow of its most affluent households, especially households with children (Atzema, 1991; Van Es & Voerman, 2018). Policymakers tried to address these problems through large-scale demolition, modernist building styles and 'cityvorming,' the development of offices and commercial buildings at the expense of residential areas (Van Es & Voerman, 2018). In the 1960s and 70s, new social movements of inner-city inhabitants emerged, actively opposing these policies (De Liagre Böhl, 2012). This coincided with other societal changes, such as the increase in one-person households and the growth of the younger adult population especially in student cities (Atzema, 1991). These developments marked the starting point of a new orientation for urban policy and planning: 'stadsvernieuwing.' The Dutch urban renewal period peaked between 1975-1985 (Van Es & Voerman, 2018) and is characterized by affordable, small-scale redevelopment and renovation, a focus on residential (rather than economic) purposes and the aim to retain as much of the existing social and urban structure as possible. Opinions are divided on whether urban renewal policy succeeded in their objective to preserve the existing social networks of the neighborhoods (De Liagre Böhl, 2012, p. 343). Nowadays, urban renewal neighborhoods have developed over diverse pathways. De Liagre Böhl (2012) distinguishes three types of neighborhoods today that have been renovated under urban renewal policy: working class neighborhoods (e.g., Leiden-Noord), gentrifying neighborhoods (the Jordaan in Amsterdam) and so-called 'problem neighborhoods' (the Schilderswijk in The Hague), demonstrating the different development routes urban renewal areas have taken since the 1980s. Currently, post-war architectural styles, such as urban renewal, are generally seen as aesthetically undesirable (Rolheiser, Van Dijk & Van de Minne, 2020), and by some even as downright ugly (e.g., Beek, 2019; De Jong, 2018; Van Walsum, 2019). Van Es and Voerman (2018) report that the negative image of urban renewal architecture is largely based on the appearance of the relatively large and uniform complexes in neighborhoods adjacent to city centers, while the isolated and smaller-scale buildings inside the center are often overlooked. Nevertheless, urban renewal housing, because of the policy's focus on inner-city or adjacent areas, is often located in desirable locations close to city centers.

Rolheiser et al. (2020) argue that vintage effects, the price effect of older architectural styles, only create a price premium in the Netherlands if it concerns older (pre-war) housing in a 'desirable' style. Thus, they argue that the simple style of post-war housing era does not enjoy price premiums because it is typically regarded as 'undesirable.' However, Blom, Jansen and Van der Heiden (2004) note that Dutch early post-war neighborhoods (1945-1965), for a long time only appreciated by architectural historians, are slowly being re-appreciated by other groups such as architects, urban designers and residents. As the early post-war building style is generally seen as the precursor to urban renewal, this could suggest that urban renewal might see similar re-appreciation, enhanced by the desirability of the location of these houses. In the context of Chicago, Coulson and McMillen (2008) established a U-shaped temporal pattern for price premiums on building styles: "prices decline for many years, after which they begin to rise." (p.148), showing that price appreciation can be reversed. Rolheiser et al. (2020) suggest that future research should investigate the price dynamics of more specific vintage styles and characteristics. The potential re-valuation of urban renewal in the future in combination with its desirable location near city-centers and the current pressure on the inner-city housing market in the Netherlands (Buitelaar & Schilder, 2017) makes the current valuation of Dutch urban renewal a relevant topic of research.

Only a limited number of studies have investigated the relationship between house prices and building styles (Buitelaar & Schilder, 2017). Therefore, this study aims to respond to this research gap by investigating the appreciation of a specific, unresearched building style. Furthermore, to the author's knowledge, so far there have only been studies into the positive price effects of 'desirable' Dutch styles, but none into the possible negative price effects of 'undesirable' styles, such as urban renewal. Urban renewal style is a suitable option for study because of its heterogenous locations in and around city centers. Additionally, it has a specific spatial layout that is of interest to researchers. Urban renewal was constructed in two ways (see Figure 1.1): first, it was constructed in inner-city areas on locations where it replaced older, pre-war housing that was too deteriorated for renovation. These houses are (semi-)isolated houses surrounded by pre-war building styles and were usually built with the intention to seamlessly integrate with the surrounding architecture, albeit in a more sober style. Secondly, urban renewal has been constructed in blocks of homogenous housing without mixing with other building styles, sometimes as large as entire neighborhoods (Van Es & Voerman, 2018). These spatial configurations provide an interesting opportunity to not only investigate the price effect of the building style itself, but also in relation to the building styles that surround it.

A: Urban renewal (left, 1981) next to historic housing (1450) in the city center (Zwaansteeg).

B: Urban renewal (1983) surrounding a pre-war estate (1901) (Minstraat).

C: Demolition and reconstruction in the urban renewal style on neighborhood scale in Sterrenwijk (1982).

D: Urban renewal (left, 1985) facing pre-war housing (right, 1875) (Notenbomenlaan).

Figure 1.1: Examples of different spatial configurations of urban renewal in Utrecht

Furthermore, in the context of housing price analysis, a research gap can be identified regarding the investigation of more intangible or subjective housing variables that are often omitted from quantitative research, even though recent findings suggest that these are influential (Law, Paige & Russell, 2019; Rong, Yang, Kang & Chegut, 2020). These variables include aspects like unobstructed views or neighborhood image. Glaeser, Kominers, Luca & Naik (2018) note that housing price analysis only rarely takes the external factor of the appearance of the neighborhood into account. This research aims to address this gap by examining outliers of previous quantitative analyses through qualitative, explorative methods to identify possibly influential variables.

This study can inform policymakers and urban planners about the economic effects of specific building styles and urban forms. By giving insight into influential aspects of specific building styles and by focusing on the appreciation of consumers through price premiums or discounts, it can help local governments guide future development that is more closely aligned with the preferences of residents (Buitelaar & Schilder, 2017). Furthermore, research into the urban renewal period can give especially useful insight into strategies to address contemporary spatial planning issues. Blom and Timmer (2022) mention parallels between the urban challenges during the 1970s and 80s and today. Although the macroeconomic and social context has changed, Dutch cities face a housing shortage that, once again, is to be solved mainly by newly built housing within the existing city borders. Similar to the urban renewal period, residents, especially households with children, find themselves squeezed out of the city or in suboptimal housing situations due to rising rents and housing prices (Blom & Timmer, 2022). Tailoring (re)development to the area and the human scale through community participation were crucial policy topics then as well as now (Blom & Timmer, 2022). By evaluating the effects of the urban renewal period, useful lessons could be learned on how to address contemporary challenges.

By making use of hedonic price modeling and data provided by the Dutch Association of Real Estate Brokers and Experts, this research aims to provide insights into the price effect of the Dutch urban renewal style. Three Dutch cities were chosen to apply this analysis: the two larger cities of Amsterdam and Utrecht, and the smaller city of Leiden. Although each of these cities has its own unique characteristics, they are all university cities located in the Randstad with a historic center. Specific attention is given to the spatial configuration of this style by looking at the differences in price effect between clustered and isolated urban renewal. Furthermore, this research expands to explore other possibly influential factors that are not typically included in price analysis through the investigation of outliers using photo documentation.

Research questions

Looking at the problem statement and literature, this research aims to answer the following questions:

- *To what extent does building style influence the price of houses built in Dutch urban renewal style?*
- *To what extent are clustered urban renewal houses priced differently than isolated urban renewal houses?*
- *What further factors can visually be identified that are relevant to the price of urban renewal housing?*

2. Theoretical framework

To estimate the price effect of the urban renewal building style, in comparison to other styles and in different spatial configurations, an overview is needed of the varied factors that influence housing price. This theoretical framework will survey the literature on these factors and theorize how these apply to the context of Dutch urban renewal. Agreed transaction prices reflect the buyer's appreciation of these factors related to the house and its surroundings in a monetary value (Visser, Van Dam & Hooimeijer, 2008). Factors relating to housing prices can be subdivided into three geographical scales: the house, the nearby neighbors or street and the neighborhood. Furthermore, more conceptual distinctions can be made between the factors that can be used to structure this theoretical framework. This distinction is visualized in Figure 2.1.

Conceptually, the factors that determine the value of a house (or any real estate) can be divided into object-related factors and market-related factors (Ronteltrap, Konadu & Marquard, 2016). Market-related factors consist of macroeconomic influences on price, such as inflation, the interest rate, the gross national product and consumer confidence. In the Netherlands, influence of inflation, the interest rate, mortgage tax deductions and overall financialization of the housing market are especially salient (Arundel & Hochstenbach, 2020). Object-related factors refer to characteristics of the house itself, such as floor size, location and the quality of the surrounding neighborhood (Ronteltrap et al., 2016). Since this research investigates the price effect of building style, an object-related factor, this literature review will focus on object-related factors, leaving market-related factors outside its scope. These object-related factors can be further subdivided into quantifiable and non-quantifiable factors, depending on whether it is possible to measure them numerically. Quantifiable factors include variables such as distance to the nearest park or floor size, while non-quantifiable factors include influences such as neighborhood image or the aesthetic quality of the street. Furthermore, quantifiable factors can be further subdivided into a set of 'efficient' and 'inefficient' factors. Efficient factors refer to factors that are not only measurable, but are also methodologically 'efficient' to measure or calculate. Many of these 'efficient' factors are essential for reliable housing price estimation, such as the number of rooms, its location or its size. As a result, these efficient factors are commonly present in most research on housing prices and in transaction datasets, while other 'inefficient' factors, such as traffic noise or sunlight incidence, are less commonly included.

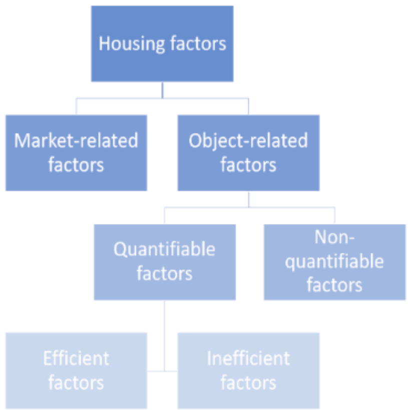


Figure 2.1: Conceptual hierarchy of influential factors on housing price

This conceptual distinction is made because this research aims to analyze the price effects of urban renewal not only through a relatively 'simple' hedonic price model [HPM] including all efficient, 'common' factors, but aims to provide a more holistic analysis of price factors by also identifying non-quantifiable factors. Therefore, this theoretical framework will first discuss the literature on quantifiable factors that influence housing prices, especially in connection to building styles. Subsequently, a literature review is provided that summarizes studies that investigate non-quantifiable actors. The factors identified in this review will be summarized in a conceptual model and provide the theoretical basis for this research. However, before embarking on this, literature describing the characteristics of Dutch urban renewal will be briefly discussed to provide context for the building style and its distinguishing features.

2.1. Characteristics of Dutch Urban Renewal

To meaningfully interpret the applicability and relevancy of the factors summarized in the following theoretical framework for urban renewal, some insight is required into its architectural and structural characteristics. On the city-level, urban renewal architecture has a distinct spatial configuration. During the urban renewal period, new housing was constructed after demolition of pre-war housing that was too decayed for renovation, as well as on former industrial sites in the inner city (Van Es & Voerman, 2018). This 'sloop-nieuwbouw' ('demolition-redevelopment') sometimes included only one or a few houses, but could also comprise entire neighborhoods. Additionally, during the same period, new neighborhoods were constructed on the edge of the city in a similar building style. These new neighborhoods are technically not counted as urban 'renewal,' since their development was not preceded by the demolition of old housing. These neighborhoods constructed without prior demolition are often less appreciated than the 'true' renewal housing, as the architecture is regarded as having a relatively poor and unimaginative design compared to the more ambitious and carefully thought-out design of 'sloop-nieuwbouw' inner-city renewal (Blom & Timmer, 2019).

On the neighborhood level, urban renewal is distinguished by characteristics that originate from building policies of that period. One of the most prominent policies was the cooperation between residents, architects and policy makers in the renewal process (Albers, 2021; Van Es & Voerman, 2018). Characterizing of this policy is the aim to support a diversity of functions in the neighborhood. Residential functions were mixed with shops, small businesses and social-cultural amenities to preserve the daily way of life of the original residents (Albers, 2021; Barzilay, Ferwerda & Blom, 2018; Van Es & Voerman, 2018). Additionally, urban renewal brought more public green facilities and playgrounds to the neighborhood (Figure 2.2C), often through the creation of courtyards (Albers, 2021; Barzilay et al., 2018). Furthermore, the lay-out of urban renewal usually reflected the historic morphology and street patterns (Figure 2.2D). New buildings were designed to reflect the surrounding historic city by carefully fitting and integrating the new construction into the existing scale and context (Albers, 2021; Van Es & Voerman, 2018).

On the level of individual houses, the incorporation of the historic context led to multiple recognizable design characteristics. For example, the fenestration of new buildings could be adapted to the fenestration pattern of surrounding houses (Albers, 2021). Façades were designed to conform to the shape and scale of the historical façades in the neighborhood and had historizing elements (Figure 2.2A, B), but without the ornate decorative elements often present in pre-war housing (Barzilay et al., 2018). While the shape and scale of urban renewal was meant to integrate seamlessly with the historic surroundings, the buildings themselves were often quite sober (Van Es & Voerman, 2018). The simplicity of the design was partly mandated by the fact that building costs had to remain low to keep rents affordable so the old residents could re-inhabit their neighborhood (Albers, 2021). Additionally, the building budget was limited nation-wide by the economic crisis of 1978-1980 (Vermeijden, 2001). Albers (2021) notes how variation in style within urban renewal in inner-city areas is relatively limited, as the building restrictions were quite strict during this era, leaving little room for creativity. Furthermore, the houses are characterized by brick facades, relatively complex parcellation patterns and by staggered facades and building lines (Figure 2.2A, D) (Albers, 2021; Barzilay et al., 2018; Waaldijk, 2020).

A: Staggered building lines and hoisting beams (as historizing elements) in the Wagenaarsstraat, Amsterdam (1976)

B: Urban renewal designed to fit into the existing historic context in the Vrouwjuttenhof, Utrecht (1984) on a previously industrial site

C: Demolition not only created space for new housing, but also for public amenities, like the playground in this picture on the Pontanusstraat, Amsterdam (1981 and 1984)

D: Staggered building lines and integration within the existing neighborhood lay-out on the Keizerstraat, Utrecht (1981)

Figure 2.2: Examples of characterizing features of urban renewal in Amsterdam and Utrecht.

2.2. Quantifiable factors influencing housing prices

Housing markets are characterized by inelastic supply, most commonly attributed to the decision-making and construction lag in the supply and the high durability of real estate (Wheaton, 1999). Therefore, the market is unable to react quickly to user demand, which leads to price premiums or discounts reflecting the willingness to pay of consumers (Buitelaar & Schilder, 2017). Price premiums (or discounts) can be analyzed to discern the influence of factors that constitute these differences in price and the willingness to pay. To investigate the price effect of building style, controlling for both efficient and inefficient variables in an HPM is crucial to isolate the effect of the building style. As mentioned, quantifiable factors influencing housing prices can be subdivided into efficient and inefficient factors. The importance of efficient factors, in particular structural characteristics directly connected to the residence, is already well-established in literature (Sirmans, MacDonald, Macpherson & Zietz, 2006). For this reason, the following section will mainly explore the influence of 'inefficient' factors: factors that are not typically included in HPMs and of which the effects are less well-established. These factors are discussed following the structure of the three geographical levels of the house, the neighbors and the neighborhood.

The influence of house-level structural characteristics and building style on price

'Inefficient' structural house characteristics are typically not considered in most models, as their influence on price is less well-established and limited. For example, Buitelaar and Schilder (2017) initially included garden orientation and the presence of parking space in their model, but exclude these from further analysis because of their limited explanatory power. However, there are studies that focus especially on these less efficient structural house factors. Examples include Helbich, Jochem, Mücke & Höfle (2013), who find a price premium for houses in Vienna with higher incidences of sunlight, or Bourassa, Hoesli and Sun (2004) who find price premiums for the presence of a view in New Zealand.

When surveying the literature on the effect of building styles on price, multiple papers can be found that investigate the price effects of historic or monumental buildings (in the Netherlands: Lazrak, Nijkamp, Rietveld & Rouwendal, 2014; in the US: Ahlfeldt & Mastro, 2012; Been et al. 2014). Lazrak et al. (2014) find a price effect of +26.9% for listed buildings in comparison to non-listed buildings in Zaanstad. Besides Buitelaar and Schilder's (2017) research into Dutch neo-traditional architecture, there is limited research into the effects of specific architectural styles in the Netherlands. However, multiple authors have researched the 'vintage' price effects from distinct building periods, which roughly correspond to building styles that were popular at that time. In their study into housing depreciation in 's-Hertogenbosch, Francke and Van de Minne (2017) find, as a side-result, that housing built between 1960-1970 are significantly lower-priced than other periods, while there are also discounts for 1971-1980 and (to a lesser degree) 1981-1990. They find a significant premium for housing built between 1931-1944, which they associate with consumer valuation of the Amsterdam School (a popular architectural style in the Netherlands), hypothesizing that building style is of influence here. Similarly, Rolheiser et al. (2018) find that the constant-quality price of housing built between 1960-1980 in the historic center of Amsterdam is priced lower than other periods. Van Dijk and Francke (2018) also find significant pricing discounts for both housing built between 1960-1970 and 1971-1980 in the COROP region of Amsterdam. Rolheiser et al. (2020) discuss the relative differences in price dynamics between different building periods, comparing 'desirable' vintages with 'undesirable' vintages. They find that desirable vintages (pre-1900 and 1900-1945) in the Netherlands have higher statistical and economical return premiums than 'undesirable' vintages (1946-1979 and 1980-1999).

In the US, Coulson and McMillen (2008) and Rolheiser (2021) find a negative effect of post-war characteristics on price and neighborhood status, respectively. In the UK, Lindenthal and Johnson (2021) find that, out of a wide variety of building styles, post-war homes are least preferred, with effects strengthening as typical style features are more pronounced. However, the generalizability to other geographical contexts is questionable due to aesthetic and quality differences in post-war styles, as well as local socioeconomic and cultural differences.

Although these results give an indication of the desirability and price effects of post-war styles in the Netherlands, the temporal classification used in these studies does not necessarily coincide with the specific style of urban renewal as it is defined in this study (1975-1985, see section 3.1). The periodization used in the discussed studies actually encompass a variety of building eras and styles from the 1960s to the 2000s, each with their own specific housing and spatial policy including: urban reconstruction ('stadsreconstructie' and 'cityvorming'), urban renewal ('stadsvernieuwing') and urban revitalization ('stedelijke vernieuwing') (Vermeijden, 2001). Overall, although there is no research into the price effect of urban renewal or other specific post-war styles, studies suggest that specific building periods (which roughly coincide with building style) do have price effects, and that post-war periods are associated with a negative price effect.

Price effect of neighboring houses

The price effects of certain characteristics of neighboring real estate are usually not included in HPM's, even though there are studies indicating that factors in the direct vicinity of a house can have price externalities. In the Netherlands, Lazrak et al. (2014) find that historic buildings in Zaanstad create a price premium for non-historic buildings within 50 meters proximity. Van Duijn, Rouwendal & Boersema (2016) find price premiums for housing in the vicinity of redeveloped industrial heritage, although this effect is only found in the G4 cities (Amsterdam, Rotterdam, Utrecht and The Hague). Price externalities of redeveloped industrial heritage could be of relevance for urban renewal housing, as these houses were often constructed in old industrial areas, and thus are frequently located close to old industrial (heritage) sites (Van Es & Voerman, 2018). Additionally, Koster and Rouwendal (2017) find that public investments in the renovation of cultural heritage leads to a price premium (+1.5 to +5.5%) for neighboring houses, especially in larger Dutch historic city centers, where renovated heritage is concentrated. This price effect could be relevant for urban renewal as well, as urban renewal housing was built in locations surrounded by renovated historical buildings (Van Es & Voerman, 2018). In other geographic contexts, real estate values can equally be influenced by surrounding property, be they historic or monumental buildings (Been et al., 2014) or designed by iconic architects (Ahlfeldt & Mastro, 2012). In the UK, Lindenthal and Johnson (2021) find that neighboring homes in a post-war style have a small, but significant, negative effect on prices. Overall, literature finds that specific characteristics of buildings can create price premiums for their neighbors. However, Dutch studies are limited to investigating the externalities of listed monumental and historical property.

Besides price externalities of specific housing characteristics, the clustering of houses in a similar style can also have price effects. The 'ensemble'-value of a built environment refers to the degree in which built properties are in harmony with their neighbors or surroundings (Ruijgrok, 2006). This is a relevant concept for the case of urban renewal, as the 'fill-in' architecture sought to integrate as seamlessly as possible with the existing historic context, thereby aiming to preserve this historic ensemble value. Ruijgrok (2006) presented the first study that investigated the price effect of these ensemble values quantitatively in Tiel (The Netherlands), but did not find a significant price effect, presumably due to shortcomings in the data. Ruijgrok only attributed high ensemble values when neighbors were of the exact same architectural style, but it could be argued that different architectural styles can still be in harmony with each other, especially when the building style tries to mimic the existing context. Lazrak et al. (2014) revisited ensemble effects in Zaanstad, and were able to demonstrate a significant and substantial historic ensemble-effect in historical conservation areas (+27.9%). This demonstrates that housing prices in cities with historical centers also reflect the 'ensemble' of historic neighborhoods and monumental buildings in the vicinity. However, the real monetary value of ensemble values can be difficult to express, as discussed in depth by Nijkamp (2012).

Dutch studies investigating price externalities from clustering of more contemporary styles find contradictory effects. Contrary to their expectations, Buitelaar and Schilder (2017) find that clusters of neo-traditional housing, a generally popular building style, actually have a lower price (-2%) than isolated buildings in that style. They hypothesize that this might be due to a decrease in apparent 'uniqueness' of the building style within clusters. Another explanation could be that a greater supply of a building style in a specific locale leads to reduced prices. Conversely, Lindenthal (2020) finds that clusters of uniform buildings in Rotterdam actually have a price premium (+3.5%) over similar buildings with heterogeneous neighbors. In conclusion, although some research has been done into the price externalities of (historical) buildings in the vicinity and ensemble effects, the topic is still relatively under-researched, especially in a data-driven manner (Lindenthal, 2020), and some results are contradictory.

Price effect of neighborhood characteristics

Housing prices are also influenced by factors on the neighborhood scale. In their nationwide study in the Netherlands, Visser et al. (2008) assess the relationship between a broad range of neighborhood characteristics and prices. They divide relevant environmental characteristics into three categories: physical characteristics, functional characteristics and socio-economic characteristics. Studies concerning the price effect of the physical characteristics of the neighborhood in the Netherlands mainly focus on the presence of nature and water bodies. Luttik (2000), Daams, Sijtsma & Van der Vilst (2016) and Bervaes and Vreke (2004), all find positive price effects for these amenities of 28%, 16% and 15%, respectively. Although these attributes seemingly have a considerable influence, Visser et al. (2008) note that their influence might be overestimated as most studies only investigate a single, or a few, variables, ignoring the influence of omitted variables. They find that physical characteristics of the neighborhood only have limited explanatory power, especially compared to the structural characteristics of the house and (to a lesser extent) the functional characteristics of the neighborhood.

The functional characteristics are, according to Visser et al. (2008), the category of neighborhood characteristics with the most explanatory power. They find that variables related to job accessibility are especially important, such as the distance to a public transport station and motorways. The positive price effect of a proximate railway station is confirmed by Debrezion, Pels & Rietveld (2011) in the case of Amsterdam and Eindhoven, while no significant effect was found for Rotterdam. Debrezion et al. (2011) also analyzed the price effect of the distance to job markets and found proximity to this had significant positive effects in Amsterdam and Rotterdam. However, accessibility can also become a disamenity through additional negative externalities, such as noise or pollution (Visser et al., 2008). This is also reflected in the study of Debrezion et al. (2011): once houses are too close to a railway (within 100 meters), a significant discount is found in Enschede, while comparable results are found for Amsterdam in the case of motorways. Interestingly, a significant premium was found for nearby motorways in Enschede, demonstrating that regional differences play a role in the pricing of real estate. Luttik (2000) also found a price discount (-5%) for houses with traffic noise in the vicinity, although the precise distance and volume of the noise were not described. However, generally speaking, Visser et al. (2008) find that functional characteristics, especially good transport connectivity to work, positively influence housing prices. More recent research by Garretsen and Marlet (2017) in 50 Dutch cities confirms this price premium for work accessibility.

Finally, the effect of socio-economic characteristics of the neighborhood on housing price is a neighborhood characteristic that is relatively less researched because of methodological difficulties and insufficient available data (Visser et al., 2008). Sequeira and Filippova (2021) find that the presence of social housing in New Zealand can create price discounts of -1.7% to -3.3%. This effect is exacerbated in neighborhoods with a low socio-economic status, as they are less able to 'absorb' negative social externalities than wealthier neighborhoods. Both Debrezion et al. (2011) and Visser et al. (2008) include a variable on the percentage of foreigners in a neighborhood as a proxy for the socio-economic status. This is under the hypothesis that a larger share of foreigners would result in a poor neighborhood reputation. Debrezion et al. (2011) find significant negative effects of this on price in Amsterdam and Enschede, and a significant positive effect in Rotterdam. Similarly, average income is also regularly used as a proxy for socio-economic status. However, it remains debatable whether these two proxies are appropriate for socio-economic status, and whether such characteristics are truly quantifiable at all. In general, Visser et al. (2008) and Archer, Gatzlaff & Ling (in the US, 1996) find that the socio-economic characteristics have limited explanatory power.

In summary, several notable influential factors on housing price can be identified in the context of the Netherlands. On the house level, the monumental status and building period seem to influence the price. On the level of the neighboring houses, nearby monumental buildings or (industrial) heritage can have a significant price effect. Clustering of specific styles can have an effect as well, as demonstrated in the case of historical cultural ensemble values (Lazrak et al., 2014) and more contemporary styles (Buitelaar & Schilder, 2017; Lindenthal, 2020). Lastly, on the neighborhood level, influential characteristics include the presence of nature and water and transport accessibility.

2.3. Non-quantifiable factors influencing housing prices

The previous section described the main quantifiable factors of influence on housing prices. The following section will focus on the price effect of non-quantifiable factors on housing, which will supplement the conceptual model at the end of this theoretical framework. Conventional hedonic price analysis usually relies on numeric variables of the kinds described above. However, multiple authors (Law et al., 2019; Rong et al, 2020) identify a research gap into more intangible, qualitative and subjective variables that can affect housing prices, such as the prestige of a neighborhood, materiality and geometry of the building, the quality of views or the desirability of the street. This research gap is due to both the limited availability of data and appropriate methods (Law et al., 2019). Recently, multiple scholars have approached this research gap by developing quantitative methods to capture these factors through various qualitative measures (Daams et al., 2016; Kauko, 2006a;b; Luttik, 2000; Millhouse, 2005), 3D modeling (Rong et al, 2020), visual deep learning (Law et al., 2019) or GIS (Bourassa, Hoesli & Sun, 2005), often in combination with HPM's. These and more studies have been summarized in a literature review, focusing on the influence of non-quantifiable factors on housing price. The results are presented in chronological order of publication in the overview in Table 2.1.

Table 2.1: Overview of studies into the impact of intangible factors on housing prices

Authors	Time and location	Factors	Method	Results	Conceptual scale
Luttik (2000)	Randstad, Leiden, Apeldoorn and Emmen (The Netherlands) 1982 – 1992	Proximity to green or blue landscapes, quality of views on green or blue landscapes and disturbance of traffic noise.	HPM Visual methods	Price premiums were found for properties connected to lakes (+28%), views overlooking the water (+8 to +10%) and views overlooking open space (+6 to +12%).	House and neighborhood characteristics
Bourassa, Hoesli & Sun (2004)	Auckland (New Zealand) N.D.	Type and scope of water view	Literature review Mass appraisal models HPM	The majority of literature finds a premium for a view. However, most studies only measure whether a property has a view or not, while the quality of the view is often disregarded. Wide views have a price premium (+59%), this premium diminishes as the distance to coast increases.	House and neighborhood characteristics
Millhouse (2005)	Boston (USA) 2005	Architectural design	Literature study Interviews with industry leaders and policy makers	One of the identified pathways suggests that desirable design drives prices as it is used as a marketing device by stakeholders.	House characteristics
Bourassa, Hoesli & Sun (2005)	Auckland, Christchurch and Wellington (New Zealand) 1986 – 1996	Quality of structures in the vicinity, water view of a property and landscaping quality of the neighborhood	HPM GIS	Price premiums were found for landscaping quality (+37%), quality of nearby structures (+27%) and the presence of a view (+6.6% to +10.9%). Water view price premiums are higher when houses with such views are scarce.	House, neighbor and neighborhood characteristics
Kauko (2006a)	Helsinki (Finland) 1998 Randstad (The Netherlands) 2003	Housing consumer preferences for accessibility, proximity, neighborhood image, amenity infrastructure, physical environment and municipality.	Semi-structured interviews Analytic hierarchy processing	The housing market contexts of the Randstad and Helsinki are fundamentally different. In the Randstad, the majority of consumers value functionality and spaciousness over location. Tangible environmental characteristics (building density) are more important for them than intangible characteristics (pleasantness, visual factors, image and lifestyle).	House and neighborhood characteristics
Kauko (2006b)	Randstad (The Netherlands) 2003	Housing consumer preferences (see Kauko, 2006a)	Open interviews with real estate and planning professionals	In urban areas, neighborhood image and housing type are the most important determinants for choice. Accessibility is of lesser importance, as this is deemed sufficient 'everywhere.' Similarly, the service infrastructure is of moderate importance, as most amenities are close-by. In urban centers, 'soft' environmental factors, such as street desirability, image and aesthetics, matter	House and neighborhood characteristics

				more than ‘hard’ factors, such as building density. Neighborhood image, defined as a process of “assigning symbolic and sentimental values onto one’s home” (p. 97), is especially influential in Amsterdam and Rotterdam, where respondents attached value to remaining on ‘their’ side of the river IJ and Maas, respectively.	
Plaut & Uzulena (2006)	Riga (Latvia) 1999 – 2004	Interior and exterior architectural design	HPM	Price premiums are associated with brick materials, high ceilings, the presence of balconies, and a separated bathroom and toilet. Wooden materials are associated with a price discount (-28%).	House characteristics
Daams, Sijtsma & Van der Vlist (2016)	The Netherlands 2009 – 2012	Presence of ‘attractive’ natural space	HPM Resident surveys near attractive natural areas	A price premium was found for ‘attractive’ natural space of +16% within 0.5 km, declining to +1.6% within 7 km.	Neighborhood characteristics
Nase, Berry & Adair (2016)	Belfast (Ireland) 2000 – 2008	Appropriateness (compared to surroundings) of material quality, fenestration, mass of buildings, material finishing, building identity, height, overall condition.	HPM Quantified expert opinions	On the building level, premiums were found for material quality (+18%), fenestration (+10.4%) and building mass (+8.6%). On the urban level, only building density influenced prices, a +10% higher density created a price premium of +8.2%.	House characteristics
Law, Paige & Russell (2019)	London (UK) N.D.	Visual desirability at neighborhood and street level	Neural network modelling using Street View images	Traditional housing attributes still explain most of the price variance. However, the model predicts prices better with the images than without. A price premium is found for houses with a high ‘desirability’ score, based on photos containing narrow streets, varying building facades and greenery. Photos of houses along wide motorways, with little greenery and ‘empty’ streets and overpasses were ranked as undesirable.	Neighbor and neighborhood characteristics
Rong et al. (2020)	New York City (USA) 2001 – 2017	Architectural forms	HPM 3D modelling	Price premiums and discounts were found for designs incorporating diagonality (+12.4%), podiums (+9.7%) and setbacks (-10.0%).	House characteristics

Table 2.2 summarizes the influential factors that come forward from the reviewed literature. Only Luttik (2000) makes use of visual methods, who uses this to complement the existing dataset by determining the subjective ‘attractiveness’ of houses, looking at traffic noise, quality of the view and attractive landscape features. With some factors, the distinction between quantifiability and non-quantifiability becomes blurred. For example, Bourassa et al. (2004) research the effect of both the scope and the quality of a view. The scope is measured quantitatively in ordinal measurements, but it remains unclear how exactly this is measured: when is a view considered to be ‘wide’? The quality of the view (and similarly, for green areas and water bodies) remains subjective. Law et al. (2019) use advanced deep learning models to establish the influence of ‘visual desirability’ quantitatively through visual learning, but it remains unclear in what the model exactly defines as ‘visual desirability’. The quantification of these ‘intangible,’ subjective variables and their application within an HPM imply a certain objectivity, which could be misplaced due to their subjective nature. This research tries to avoid the quantification of non-quantifiable factors by taking the results of the HPM as a starting point for qualitive analysis, rather than incorporating them directly in the HPM.

Table 2.2: Overview of non-quantifiable factors influencing housing prices

General factors	Specific factors
Desirable design features	General quality of design
	Architectural forms (diagonality, podiums)
	Architectural features (balconies, high ceilings)
	Desirable materials (bricks)
	Appropriateness of structure compared to surroundings
Views	Presence of a view
	Scope of a view
	Quality of a view
	Views on water bodies or green areas
Landscaping quality	Quality of nearby structures
	Appropriateness of nearby structure
	Attractiveness of nearby natural areas
Pleasantness or desirability of street	Width of street
	Varied building facades
	Visual ‘emptiness’ of a street
	Presence of greenery in the streetscape
Neighborhood image	

An important concluding note is the limited generalizability of studies undertaken in different geographical contexts. Only four of the reviewed studies took place in the Netherlands. In his comparison between Helsinki and the Randstad, Kauko (2006a) stresses how preferences in varying market contexts can differ significantly. Furthermore, he finds differences in preferences between inner-city regions and suburban regions. Therefore, the list of factors above, and especially the magnitude of the variable effects, cannot be directly extrapolated to other areas of study because of variation in local housing markets and cultural differences (Kauko, 2006a). Rather, they function solely as a theoretical foundation. The newly found variables are implemented in the conceptual model below.

2.4. Conceptual model

Figure 2.3 displays the conceptual model for this study. Overall, the three discussed geographical scales are discerned on which the factors influence housing prices (the house, the neighbors and the neighborhood). The discussed quantifiable factors are displayed in yellow, while the non-quantifiable factors are shown purple. Furthermore, the influences of the three scales on price are displayed with solid arrows, while (hypothetical) cross-relations are shown with dotted arrows.

Two influential fields have been added: macroeconomic factors and the regional housing market. The macroeconomic factors were briefly discussed in the introduction of this chapter and are further left outside the scope of this study. The regional housing market encompasses and influences the three geographical levels of factors. Regional submarkets may have differing price developments and housing market conditions. For example, over the last decade, property value increases have been more dramatic in Amsterdam, and to a lesser extent in other large cities, than in other Dutch regions (Arundel & Hochstenbach, 2020), which naturally also influences local housing prices. Other varied submarket-related factors include the selective gentrification of certain cities and neighborhoods, the local household composition and the average income of the population (Hochstenbach & Arundel, 2020). Although the regional submarkets of large cities will differ less between themselves than between large cities and suburban or rural areas, differences in housing market dynamics are still to be expected. For a more in-depth discussion of Dutch regional submarkets and their implications for housing prices, see Arundel and Hochstenbach (2020) and Hochstenbach and Arundel (2020). Although it is important to be aware of the existence of differing regional submarkets, the specific implications of these submarkets for housing prices are outside the scope of this literary review.

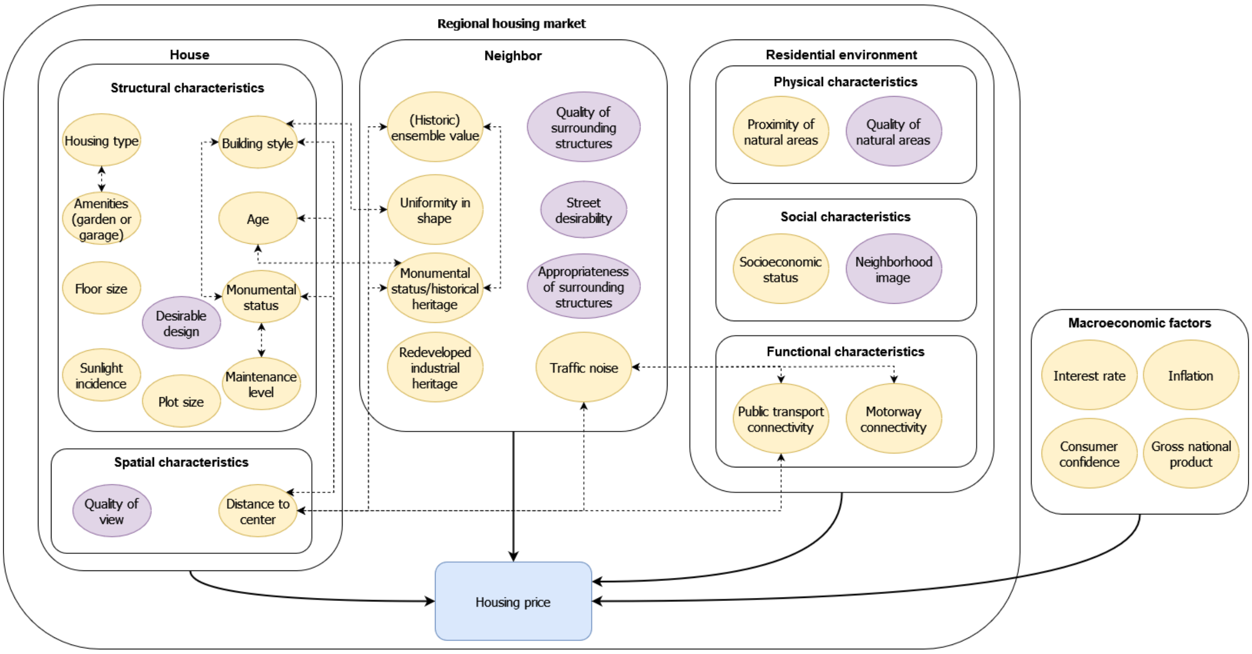


Figure 2.3: Conceptual model of the drivers of housing prices as described in the literature

Additionally, several cross-links between factors were identified in the literature or can be hypothesized. Visser et al. (2008) find that housing type correlates highly with the presence of a garden. Koster and Rouwendal (2017) argue that historic heritage is often clustered in city centers, which points to correlations between the distance to center, monumental status of a house, monumental status of houses in the vicinity and ensemble values. Similarly, Rolheiser et al. (2020) argue that European cities show dense patterns of clustered vintage building styles, suggesting a correlation between distance to center, building style and age. A correlation could also be found between maintenance level and monumental status, as owners of listed monumental houses must follow strict rules regarding their liability to maintain their residence ('erfgoedverordening'). The legislation surrounding heritage also suggests a correlation between age (and thus with building style) and monumental status, as real estate needs to have a significant historical value to become a monument. Hypothetically, a correlation between building style and uniformity is possible, since some building styles are characterized by more homogenous architecture, such as the modernist urban reconstruction in the Netherlands. Lastly, a correlation can be expected between traffic noise and motorway or public transport connectivity, as proximity to either a highway or railway is where noise nuisance is likely to take place (Debrezion et al., 2011). Similarly, there could be a correlation between distance to the city center and traffic noise, as centers are busier with both cars and public transport. Another correlation is possible between public transport connectivity and distance to the center, as city centers also tend to be the points of convergence for the public transport system (Le Clercq & De Vries, 2000). Overall, a certain degree of multicollinearity is to be expected, as the factors are theoretically quite inter-related.

3. Methodology

This research employed mixed methods in two phases. In the first phase, the first two research questions have been researched quantitatively. The outcomes of the first phase were used as starting point for the second phase, where explorative, qualitative research further investigated the outliers of the quantitative analysis. This methodology section first discusses the study's research area, period and data sources. Subsequently, the used analyses are discussed per research question.

3.1. Research area and period

The research area consists of three Dutch cities: Amsterdam, Utrecht and Leiden. The reasoning behind this choice was twofold: firstly, Dutch urban renewal policy has only been implemented in 14 selected Dutch cities (De Liagre Böhl, 2012). Within this selection, six cities (Amsterdam, Utrecht, Rotterdam, The Hague, Leiden and Groningen) received a higher priority from the state in the distribution of financial support (through the Interim Saldoregeling [ISR]). As a result, these cities were able to develop the urban renewal policy to a larger extent than other cities, resulting in larger-scale developments, a more spread-out distribution and more variety in spatial configurations of urban renewal (De Liagre Böhl, 2008). Amsterdam, Utrecht and Leiden were selected from these six cities because they are relatively comparable amongst each other. All have a historic city center and university, and all are located in the Randstad, the Dutch urban 'core' with the highest population, the highest mean housing prices and with most pressure on the housing market (Visser et al., 2008).

The periodization of urban renewal was harder to define, since not all municipalities started development at the same time and with the same intensity (Van Es & Voerman, 2018). The core of urban renewal development lies in the late '70s and early '80s. Policy-wise, a logical starting year would be 1977. In this year, the ISR was introduced and urban renewal development had more financial means at its disposal. However, urban renewal design was already incorporated in new housing in 1975 and 1976 (for examples, see Figure 3.1 and 3.2). Since this research focuses on building style, rather than the policy behind it, 1975 was found to be a more fitting start of the periodization. Both policy-wise and design-wise, 1985 marks the end of the urban renewal period. That year, the ISR was replaced by more decentralized policy ('Wet op de Stadsvernieuwing'), resulting in a more varied implementation of building plans and designs (Van Es & Voerman, 2018). Post-1985 buildings show design features that are more characteristic for building styles in the 90s, rather than for urban renewal. Therefore, the final periodization of urban renewal was set as 1975-1985.

Figure 3.1: Derde Oosterparkstraat (center-left building), Amsterdam (1975).

Figure 3.2: Keerkringplein 6, Utrecht (1976).

3.2. Data

Transaction data was provided by the Dutch Association of Real Estate Brokers and Real Estate Experts [NVM]. The data is at the scale of six-digit ZIP codes (PC6), corresponding to (a part of) one side of a street. NVM facilitates roughly 70% of all sales on the Dutch housing market, forming a representative sample (Buitelaar & Schilder, 2008; Lazrak et al., 2013). The dataset contains transaction data for the period 1985 – 2021. Housing built between 1975 and 1985 was marked by a dummy variable to identify urban renewal housing. Studies researching building styles often make use of expert assessment to classify building styles (e.g., Ahlfeldt & Mastro, 2012; Buitelaar & Schilder, 2017). Alternatively, Lindenthal and Johnson (2021) researched the reliability of machine learning models to identify architectural styles, with promising results. Nevertheless, neither of these methods were deemed necessary in this research to classify urban renewal, as Dutch housing built between 1975 – 1985 is practically completely in this style. This assumption is justified by the fact that this period represents the urban renewal peak period, where national housing policy was overwhelmingly focused on urban renewal, especially in the cities that received ISR (De Liagre Böhl, 2012; Van Es & Voerman, 2018). This assumption was evaluated before analysis by taking a random sample of the dataset (10 for each city) and comparing these with Google Street View images, to confirm the urban renewal style.

Transactions taking place in the same year as the construction year were excluded, as urban renewal policy dictated that new housing had to be sold to the original inhabitants of the neighborhood (Van Es & Voerman, 2018), often resulting in lowered transaction prices that do not reflect the true willingness-to-pay. Similarly, social or rented housing was excluded from analysis, as rent-controlled dwellings hinder accurate hedonic analysis (Lazrak et al., 2013). Service apartments were also excluded from the dataset as there is a large shortage of these special residences designed for impaired residents in the Netherlands, which leads to unrepresentative prices. To control for the price effect other building styles, additional dummies for other building periods were included. The final number of transactions is shown in Table 3.1.

Table 3.1: Total number of transactions per building period

City	Before 1900	1900-1950	1951-1960	1961-1974	1975-1985 *Urban renewal*	1986-1990	1991-2000	2001-2010	2011-2021	Total	%
Amsterdam	10452	50445	8167	13484	10949	7466	15769	9488	991	127211	*55.3%*
Utrecht	3029	38129	7259	6822	4548	2038	6762	6014	506	75107	*32.6%*
Leiden	1799	8812	1667	5299	4739	2190	2505	648	107	27766	*12.1%*
Total	15280	97386	17093	25605	20236	11694	25036	16154	1604	**230084**	*100%*
%	*6.6%*	*42.3%*	*7.4%*	*11.1%*	*8.8%*	*5.1%*	*10.9%*	*7.0%*	*0.7%*	*100%*	

As explained in section 2.1, two types of urban renewal can be discerned: new construction following demolition of existing deteriorated housing on the one hand, and completely newly built housing on the other hand, often located at the borders of the city (see Figure 3.3, for Amsterdam and Leiden, see Appendix 2.1). In order to separate these two types, urban renewal is selected as 'true' urban renewal if there are pre-war buildings within a 50-meter radius. The Dutch Addresses and Buildings key register [BAG] is used for this, as it contains data on the building years of all buildings in the Netherlands (Kadaster, 2022). As 'true' urban renewal involves the demolition of selected pre-war buildings, other pre-war housing still remains in the vicinity, while this is not the case for the newly constructed neighborhoods that are located on the outskirts of the city. Demolished and rebuilt neighborhoods were included when they are surrounded or directly bordering pre-war housing, even if some rebuilt neighborhoods are quite sizable (e.g., Sterrenwijk in Utrecht, Figure 3.2). This choice was made because these neighborhoods, although they lack the spatial variation of more isolated urban renewal, still possess other important qualities of urban renewal; a central location and 'attractive' styles in the vicinity. This is generally not the case for the newly constructed neighborhoods. Although this method is not infallible, visual inspection of the included and excluded data points ensured a sufficiently reliable subset. The filtered dataset with 'real' urban renewal is shown in Figure 3.3 and photographic examples are provided in Figure 3.4. The filtered urban renewal data consists of 5884 'true' urban renewal properties and 14368 other properties from 1975-1985.

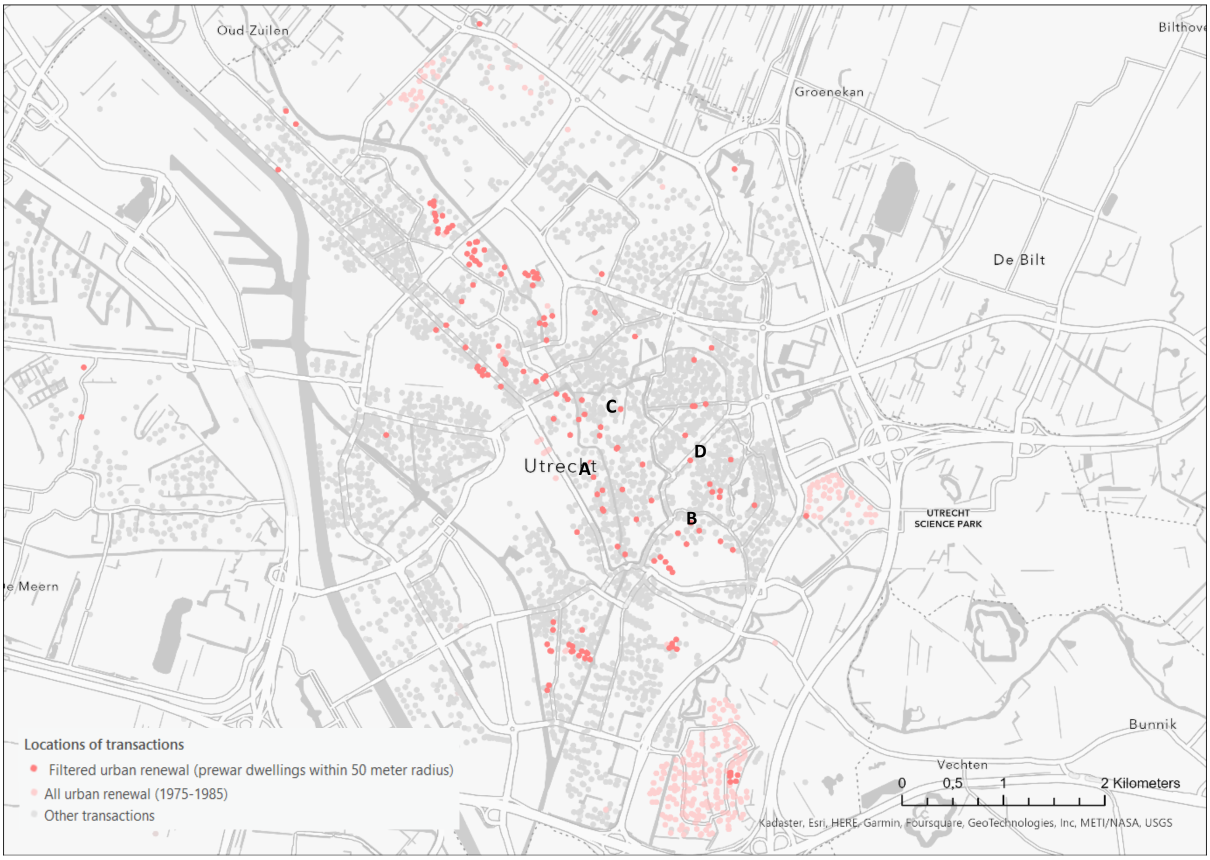


Figure 3.3: Transactions of urban renewal houses before and after filtering 'true' urban renewal, Utrecht. Photos of urban renewal examples are indicated with corresponding letters.

A: Springweg, 1985

B: Minstraat, 1983

C: Keizerstraat, 1981

D: Maliebaan, 1984

Figure 3.4: Examples of urban renewal in Utrecht, corresponding to the letters in Figure 3.3.

Variables

The NVM dataset contains variables on the structural characteristics of the house as well as the location and transaction characteristics. These structural variables include housing type, number of rooms, size, presence of garden, parking space, maintenance level, et cetera. The transaction characteristics include the price and the year of sale. It should be noted that three of the used NVM variables, maintenance state, location on 'busy' road and 'monument-like' appearance, are determined individually by the realtor and can therefore be rather subjective. Francke and Van de Minne (2017) and Rolheiser et al. (2020) researched whether the subjectivity in the NVM maintenance variable is cause for concern. They conclude that there is enough assurance that the evaluations are reliable and not severely biased, since the brokers are obliged to do yearly trainings to keep uniform assessment guidelines. To improve the predictive power of the model and address the issue of spatial dependence (discussed further in 3.3), additional spatial variables are calculated and summarized in Table 3.2. Some examples of the spatial variables are provided in Figure 3.5 and Appendix 2.

Table 3.1: Overview of calculated spatial variables

Variable	**Data source**	**Date**
Distance to city center *Appendix 2.2*	Kadaster and CBS	2021
Distance to nearest train station *Appendix 2.7*	ProRail	2022
Distance to nearest railroad	Kadaster and CBS	2015
Distance to nearest highway entry *Appendix 2.3*	NWB	2022
Distance to nearest highway	Kadaster and CBS	2015
Distance to nearest bus station	OpenStreetMap	Continuously updated

Distance to nearest supermarket	Province of South Holland	2022
Distance to nearest elementary school *Appendix 2.5*	Province of South Holland	2022
Distance to water (rivers, lakes, canals, sea) *Appendix 2.8*	Kadaster and CBS	2015
Distance to natural area (forests, wet and dry natural areas, agricultural areas)	Kadaster and CBS	2015
Distance to recreational green areas (parks, allotment gardens)	Kadaster and CBS	2015
Distance to facilities (retail and hospitality)	Kadaster and CBS	2015
Distance to socio-cultural facilities *Appendix 2.6*	Kadaster and CBS	2015
Distance to monumental buildings *Appendix 2.4*	National Heritage Registry	2020
Livability score	Leefbaarometer	2020

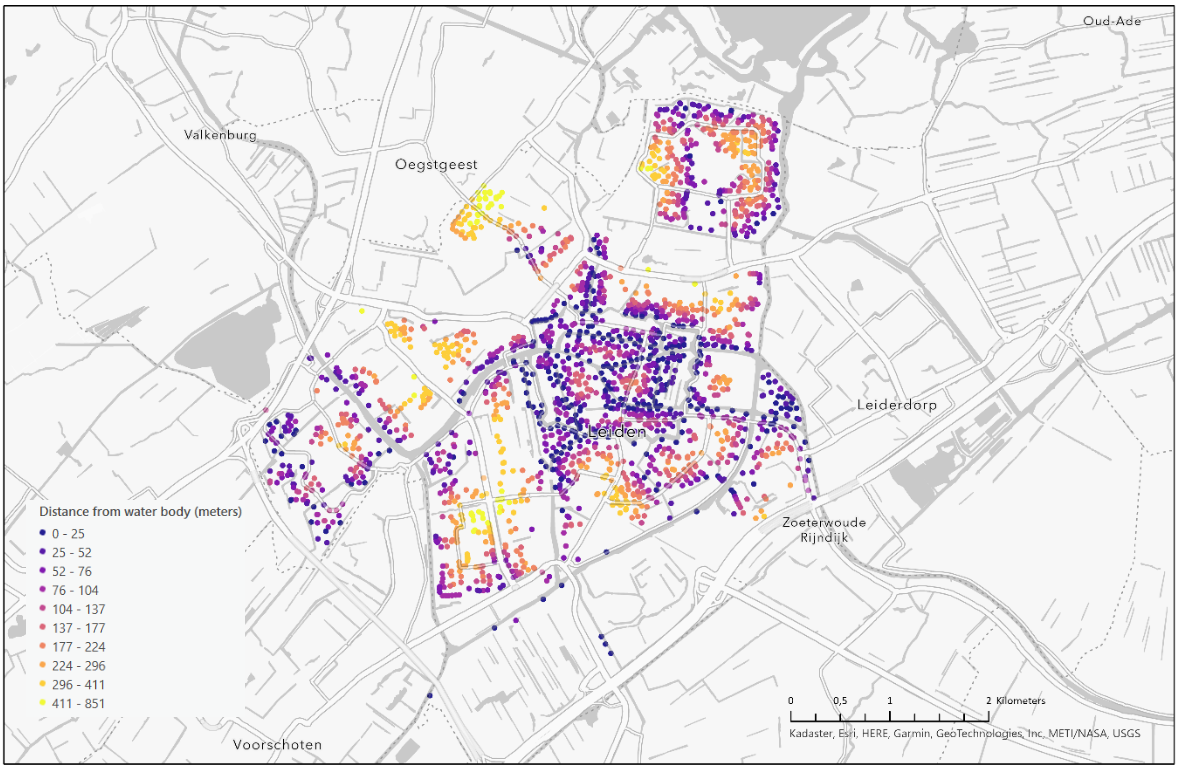


Figure 3.5: Housing transactions in Leiden, coloured by the distance from the nearest water body

In short, the data sources can be summarized as follows: geometries of Dutch municipalities and neighborhoods were extracted from CBS, the Dutch Statistics institute (Kadaster and CBS, 2021). From these geometries, the city centers were selected and the distances between each transaction location and the polygons were calculated. If a transaction was located within the city center polygon, the distance naturally was zero. Additionally, data from Kadaster and CBS (2015) on land use was consulted to calculate the distances to varying land uses and facilities. The locations of train stations were retrieved from a ProRail database, the national railway network agency (ProRail, 2022). Distances to highway entry points were calculated using data from the National Roads Database (Nationaal Wegenbestand, 2022). The distances to public transport locations (except train stations) were calculated with extracted OpenStreetMap data (OpenStreetMap contributors, 2022). The locations of supermarkets and elementary schools were retrieved from the 'Societal Atlas' (Samenlevingsatlas) (Province of South Holland, 2022). The distances to monuments were based on the National Heritage Registry of the Cultural Heritage Agency of the Netherlands (2020). Lastly, the livability scores were retrieved from the Livability index ('Leefbaarometer') in a 100mx100m grid resolution (Leefbaarometer, 2020). The Livability index is a composite index that consists of a large variety of indicators that relate to the socio-economic status of an area. The Livability score was chosen to evaluate the influence of socio-economic characteristics, as it was seen as a more appropriate and less stigmatizing proxy than the conventionally used indicators, such as the average income or the percentage of people with a migration background (Debrezion et al., 2011; Visser et al., 2008). In newer versions of the Livability index, these indicators were removed because of their stigmatizing effects (De Jonge, 2022; Leefbaarometer, 2020). However, the Livability score remains an imperfect substitute and is in its own right often critiqued as a measurement of socio-economic status. For an extended discussion on this, see Uitermark, Hochstenbach & Van Gent (2017).

Data limitations

Despite the richness of the NVM dataset, three limitations in regard to data quality deserve mention. Firstly, the most detailed scale available was on the PC6 zip code level. This means that on a small geographical scale some uncertainty is introduced, as the exact addresses are unknown. This uncertainty is relevant for the calculation of the spatial variables and the cluster analysis. This uncertainty only affects the analysis on a small level and does not influence the general results in a meaningful way. Therefore, the data accuracy still suffices for this study. On the upside, the small aggregation makes the data less prone to infringement of the privacy of individual households.

Secondly, because of human errors, the dataset also contains a small number of incorrect values. Some of these values were far outside the usual bandwidth of values and could therefore be easily detected and removed. After inspecting the data, some highly improbable values for floor surface were found (e.g., apartments larger than 1000m^2). To avoid a high leverage of erroneous values, a cut-off point of 500 m^2 surface floor was determined after inspection of the data, beyond which all cases were removed (242 cases). However, it is likely that some faulty cases without high leverage remained undetected and still persist in the dataset.

Lastly, the BAG dataset, which is used for the filtering of 'real' urban renewal and the clustering analysis, was found to have similar errors: cases with 'incorrect' years of construction. These mainly concerned houses with a pre-war (monumental) exterior building style, which have likely been renovated on the inside to such a degree that a 'new' construction year was entered. When these cases were encountered, they were corrected through cross-examination with Google Street View data. Due to the size of the dataset, it was impossible to check every case, making it possible that some erroneous cases still remain. However, since the number of faulty cases is small, it can be assumed that their effect on the final analysis is negligible.

3.3. Hedonic price modelling

To answer the first research question, *To what extent does building style influence the price of houses built in Dutch urban renewal style?,* a hedonic price model is applied in R. The HPM uses the transaction price to estimate the willingness-to-pay of varying characteristics of a property using regression analysis (Rosen, 1974). Put briefly, HPMs estimate the 'price' or influence of distinct housing attributes, by taking the value of the house into account and controlling for other influential variables. HPMs have established themselves as the 'go-to' method for housing price studies (Visser et al., 2008) into many aspects of housing, such as vintage effects (e.g., Coulson & McMillen, 2008;

Rolheiser et al., 2020; Rolheiser, 2021) and architectural design (Buitelaar & Schilder, 2017; Lazrak et al., 2014; Lindenthal, 2020; Nase, Berry & Adair, 2016; Rong et al., 2020).

One of the limitations of HPMs is that they require both a large number of cases and variables for accurate prediction (Visser et al., 2008). Additionally, HPMs are unable to accommodate to nonlinear effects. Law et al. (2019) find that artificial neural networks are better able to capture nonlinear variables in an HPM than through linear OLS models. They argue that this becomes especially salient in the case of 'intangible' variables, such as neighborhood image, as these variables can amplify the value assigned to structural variables in a non-linear way. Although machine learning provides an opportunity to address the non-linearity problem, this research rather chooses to approach non-linear effects of intangible variables through qualitative methods due to the limited time available.

A last limitation is the threat of the omitted-variable bias, which can undermine the predictive power of HPMs (Kuminoff, Parmeter & Pope, 2010). For an in-depth discussion of HPMs and the omitted-variable bias, see Abbott and Klaiber (2011). Although the NVM dataset is a rich database and additional variables are calculated, it still does not include *all* influential variables, as the complete set of influences on housing prices is simply too large. In a Monte Carlo evaluation of the accuracy of HPMs, Kuminoff et al., (2010) find that the omitted-variable bias can be significantly reduced when spatial and temporal fixed effects are added to the price function. The (dis)advantages of this approach will be discussed in the following section.

Spatial and temporal dependence

Several housing price studies employing HPM identify biases due to spatial dependence (Koster & Rouwendal, 2017; Lazrak et al., 2013; Lindenthal, 2020; Van Duijn et al., 2016), demonstrating that spatial correlation can be an important source of bias and should therefore not be ignored. Spatial dependence, if detected, can be corrected through several methods. Nase et al. (2016) note that studies investigating price effects of real estate design generally rely on two methods to address spatial dependence: first, spatial dependence is treated through adding spatial variables to the regression, such as a variable indicating the distance to the center or job opportunities. Secondly, spatial dependencies can be addressed through the use of spatial fixed effects, where a dummy variable is introduced denoting a larger spatial unit to which individual houses are aggregated (Buitelaar & Schilder, 2017). Additionally, Von Graevenitz and Panduro (2015) state that spatial econometrics models are often applied, either using a spatial error term or a spatial lag term to address spatial correlation.

This study makes use of a combination of spatial variables in the regression and spatial and temporal fixed effects. The advantage of spatial variables is their interpretability and straightforward implementation, as they provide direct insight into influence of distinct spatial effects (Nase et al., 2016). The main downside of this method is that it only controls for the proximity of known variables, and not for spatial dependence *within* these variables or bias from spatially dependent omitted variables (Nase et al., 2016). The main downside to the spatial fixed effects method is that it often is unable to remove all spatial autocorrelation (Anselin & Arribas-Bel, 2013; Nase et al., 2016) and that it oversimplifies the nature of the local omitted variables (Anselin & Lozano-Gracia, 2009). Similarly, the application of spatial econometric models assumes that the omitted spatial dependencies are known a priori, even though this is often not the case (Nase et al., 2016; Von Graevenitz & Panduro, 2015). Both the spatial fixed effect model and the econometric model are 'black boxes'. They are able to compensate for spatial autocorrelation, but provide little understanding of how the spatial variables influence the dependent variable. For geographers, the application of these spatial econometric models or spatial fixed effects is somewhat less interesting because, even though it might improve the model estimation, it does not contribute to a deeper understanding of geographical variation (Visser et al., 2008).

For these reasons, the model applied in this study aimed to account for spatial dependence as much as possible through spatial variables that have been derived from literature. A strong theoretical basis is needed to understand the relevance and workings of the spatial variables (Nase et al., 2016; Von Graevenitz & Panduro, 2015). However, since this research focuses on understanding local housing price influences *within* cities rather than *between* cities, a spatial fixed effect was applied to enable comparison between the three cities. This controlled for the inter-city differences (such as municipal regulations and regional job markets), and allowed focusing on the intra-city local variables. Similarly, a yearly fixed effect was applied to the differing years in the dataset, since this research is not focused on price dynamics, but inter-year differences still had to be accounted for.

Once these two methods had been incorporated into the model, a check for spatial autocorrelation was conducted using k-nearest neighbor weights. The Moran's I was calculated for the locations of urban renewal housing and for the spatial distribution of transaction prices. Afterwards, the Moran's I was calculated for the residuals of the HPM. The latter estimates the degree to which there is spatial autocorrelation between the differences between actual and fitted values. Spatially autocorrelated residuals would indicate that the quality of the model predictions is better or worse depending on the location. The value for K was determined based on a realistic reflection of the 'neighbors' of a point, and therefore depended on the point density of the variables. If some spatial autocorrelation persisted, but not to a problematic degree, this was preferably not corrected using econometric models, since these do not provide more insight in the local variables and workings of housing appreciation.

Model specification

The HPM estimated the influence of the urban renewal style by running the regression with an urban renewal dummy variable alongside other structural characteristics, spatial variables and dummies for other building styles. The dependent variable was the transaction price. The NVM dataset used to answer the first research question contains transactions of all properties in varying building styles. The HPM regression can be generalized as follows:

$$\ln (P_i) = c + bX_i + gY_i + jM_i + \varepsilon$$

Where P_i is the (log-transformed) price of property i. X_i is a vector of housing attributes of i, containing the structural and spatial variables, including the building style dummy for urban renewal. Y_i and M_i are dummy variables for the year of transaction and the municipality of i for the yearly and spatial fixed effects. b, g and j are regression coefficients. The quality of the model was assessed through validation with a test dataset that had been split from the original dataset prior to training the model. The validation set consisted of 30% of the original dataset and was sampled randomly.

3.4. Cluster analysis

To answer the second research question, *To what extent are clustered urban renewal houses priced differently than isolated urban renewal houses?,* a spatially constrained cluster analysis is employed. First, clustered and isolated urban renewal is identified with a Density-Based Spatial Clustering of Applications with Noise [DBSCAN] algorithm. The DBSCAN algorithm is an unsupervised algorithm that clusters spatial points based on spatial density. It was introduced by Ester, Kriegel, Sander & Xu (1996) and is a well-established method in the domains of data mining and biomedicine (Daams, Sijtsma & Veneri, 2019). The algorithm is not regularly used in hedonic pricing studies, with the exception of Daams et al. (2019) in Amsterdam. This is surprising, as DBSCAN offers key advantages over other clustering algorithms, such as K-means or kernel density. First, DBSCAN is a suitable method for (spatial) hedonic studies, since it does not require a predefined number of clusters. Furthermore, the clusters can assume any spatial shape and, most importantly, the algorithm allows the identification of isolated outliers, labelling these as 'noise'. This last feature is key to answering the research question, as a distinction is needed between isolated and clustered urban renewal. For DBSCAN clustering, two parameters are needed: the distance radius and the minimum number of points required to form a cluster.

For this analysis, varying distance thresholds were taken from a range of values from 5 meters to 50 meters, as 50 meters is the maximum distance threshold where Lazrak et al. (2013) found spatial dependence. The clusters of the different thresholds were inspected visually to see if they realistically reflected local clusters. The minimum cluster size was set to 5, as a threshold between 'isolated' urban renewal and a cluster of urban renewal. The DBSCAN algorithm was implemented in GeoDa (version 1.20.0.8, Anselin, Syabri & Kho, 2006), to enable quick, in-between visualization of the different parameter settings. BAG data (Kadaster, 2022) was used, as this also contains urban renewal houses that are not included in the NVM dataset, such as social housing. Although these properties are not reflected in the transaction dataset, they can still be part of a cluster and should therefore be included in the cluster analysis. After analysis, all urban renewal buildings are either attributed to a cluster or classified as isolated 'noise'. Subsequently, three categories are created with dummy variables: 'not clustered' (5 or less properties), 'small clusters' (between 6 and 20 properties) and 'large clusters' (more than 20 properties). Lastly, these dummies can be included in a separate HPM as a variable to analyze the effect of clustering on house prices. The dependent and independent variables of this HPM are the same as in the HPM described in section 3.3, except for the addition of the clustering variables. However, the clustering HPM uses *only* urban renewal transactions as data, since the questions aims to find the difference in prices between clustered and isolated urban renewal.

3.5. Photo documentation

To answer the final research question, *What further factors can visually be identified that are relevant to the valuation of urban renewal housing?*, a photo documentation was conducted on case studies that were the resulting outliers of the previous two analyses. Although the NVM dataset allows controlling for many variables, the omitted variable bias cannot be completely mitigated, as 'subjective', non-measurable variables still play an influential role in pricing. As outliers are likely due to omitted, but influential variables, they provide an opportunity to explore these non-measurable factors. Although visual factors can also be researched quantitatively through machine and deep learning or 3D modelling (see Law et al., 2019; Lindenthal & Johnson, 2021; Rong et al., 2020), this is not possible within the time frame of this research.

Moreover, quantitative methods still approach intangible, non-measurable factors in an objective way, thereby foregoing the potentially subjective nature of the factors. Besides the identification (and quantification) of non-measurable factors, it overlooks how the same factor could manifest itself differently in varying environmental settings, and can by interpretated differently by different people. A focus on the variety and individuality of interpretation of the environment is found in the tradition of behavioral geography. Behavioral geography focuses on how behavioral outcomes (such as willingness to pay) result from an interplay between an individual and the environment, while including the social and physical context (Lynch, 1960). This approach provides a more complete insight into subjective appreciation of houses and how these are related to housing prices, especially since the connection between human perception, the physical environment and the economic consequences of this has often been suggested (Glaeser et al., 2018; Kang et al., 2021; Qiu et al., 2022). Usually, such subjective factors are researched through surveys and interviews (Qiu et al., 2022), which focus more on the perceptions of people. However, the focus can also lie on other objects, such as houses, to compare different environmental settings and object-environment interactions across space (Hall, 2009). Suchar (2004) and Hall (2009) argue that realist photography methods are appropriate for studying non-human subjects, as it conveniently captures local, visual manifestations, such as the details of buildings, which can later be analyzed. Therefore, to explore visual factors on housing price, photo documentation was deemed the most appropriate method.

Photo documentation, and the use of photographs in scientific research in general, are frequently used in the fields of anthropology, environmental psychology and cultural geography to investigate and understand the relationship between place and people (Markwell, 2000). These studies usually take a constructivist approach, where the construction of reality is the focal point. Often, these studies are less concerned with what is *in* the photograph, but rather with *who* took the photo, *why* they photographed something and the meaning it holds for them (Markwell, 2000; Rose, 2012). Another often-employed photographic method is photo-elicitation (Brorsson et al., 2020; Rose, 2012), where respondents are interviewed while discussing a photograph taken by them or by the researcher (Rose, 2012). Although both a constructivist approach and photo-elicitation method could provide interesting insights into the appreciation of building styles from the perspective of people, this study focuses on houses rather than their inhabitants. This realist approach is chosen, partly due to the limited time available, and partly because this makes the quantitative and qualitative parts of this research more compatible, as both focus on the house itself. Photo documentation assumes that photos capture a precise representation, or 'evidence', of what was present at the time the photograph was taken (Rose, 2012).

Photographs in photo documentation are taken in a systematic way, where the photos taken are conceptually linked to the research topic (Rose, 2012). Inspiration is drawn from Suchar's (1997; 2004) photo documentation methods in his research into gentrification in Amsterdam. Suchar systematically structured his photography by using a shooting script: a script listing relevant questions that relate to the study object, ensuring that the photos remain closely connected to the research question. The methodology of photo documentation is shown schematically in Figure 3.6 and will be discussed in the following sections.

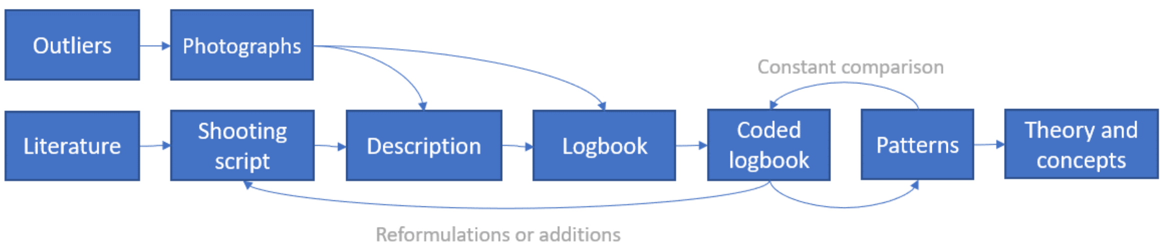


Figure 3.6: Schematic visualization of the photo documentation workflow

Shooting script

Shooting scripts contain questions that can be answered with photographic evidence (Suchar, 1997). Usually, the initial shooting script is based on insights from theory or fieldwork. These initial questions are applied to generate conceptual categories on which to categorize the photographs, which guides the discovery of patterns. Therefore, photo documentation with shooting scripts takes a grounded theory approach (Brorsson, 2020). Grounded theory 'builds up' from observations in the field towards over-arching and more abstract levels of pattern recognition and, eventually, theory formation (Rose, 2012). Grounded theory enables the researcher to discern and formulate the 'bigger picture', while still remaining 'grounded' in observations and theory (Suchar, 2004). The method is an iterative process, as the shooting script can be adapted as new patterns are found. This adaption can in turn make the shooting script more focused and improve the pattern recognition (see Figure 3.6). An initial shooting script, included in Appendix 1, is formulated on the basis of the non-measurable variables that come forward from the literature review (see Table 2.2).

Data collection

Once the outliers were known, a selection was made that of the cases that were included in the photo documentation. Samples were chosen in such a way that all three cities were represented. Because the exact addresses were unknown, the outlying houses were identified on the basis of the transaction price, construction year and floor size. If this was not feasible, pictures were taken of the general streetscape. Furthermore, more recent transactions were preferred over older ones, as for these cases it was less likely that significant changes had been made to the house or to the environment. In case there were non-outlying urban renewal transactions in the vicinity of a case and a direct comparison between the two was appropriate, additional photographs were taken of the compared, 'normal' case to gain more insight into why the case study is an outlier. Photographs were taken at the site following the questions in the shooting script and were shot with a handheld camera in June 2022.

Coding and analysis

Afterwards, the photographs were annotated with short descriptions. The descriptions were saved alongside the photographs in a logbook and consist of short texts in which the visible elements are mentioned and the questions in the shooting script are answered. At this point, initial patterns could be interpreted and new patterns or questions emerged, forcing the researcher to go back to the shooting script and add or adept the questions. Although interviews were not considered a central part to this method, informal interviews with residents were still conducted when the opportunity arose to inform the coding process and to identify relevant qualitative factors that might otherwise be overlooked. In the end, one street interview was conducted and included in the logbook. By comparing the patterns in the descriptions and images of the houses, overarching concepts could be discerned and further synthesized, which gave additional insight into relevant housing characteristics.

4. Results

The following chapter presents the results gathered during this study. These results provide insight into the main purposes of this study: to understand the effect of the urban renewal building style on transaction prices, to investigate the influence of the spatial configuration of urban renewal on those prices and, finally, to explore additional, non-quantifiable housing price factors through the inspection of photographs. However, before discussing these three research aims, attention is paid to the descriptive statistics of urban renewal first.

4.1. Descriptive statistics

In this section, the descriptive statistics of the dataset are briefly discussed to gain a better understanding on how urban renewal key variable statistics compare to other building styles. The complete descriptive statistics of the dataset, split between urban renewal and other transactions, are shown in Appendix 3. In Figure 4.1 the distribution of three variables is shown per city for urban renewal and the other periods. Tests for significance show that urban renewal is sold for lower prices than the average transaction price[1] and has a relatively smaller surface area[2]. In addition, urban renewal is located closer to the city center than the average house[3]. Furthermore, Figure 4.1 shows that there are regional differences between the three cities, which are likely due to variations in local housing market, job market and municipal regulations. Generally speaking, Figure 4.1 show that urban renewal is sold for the highest transaction price in Amsterdam, while the transactions in Leiden concern urban renewal houses that are relatively larger and located closer to the center.

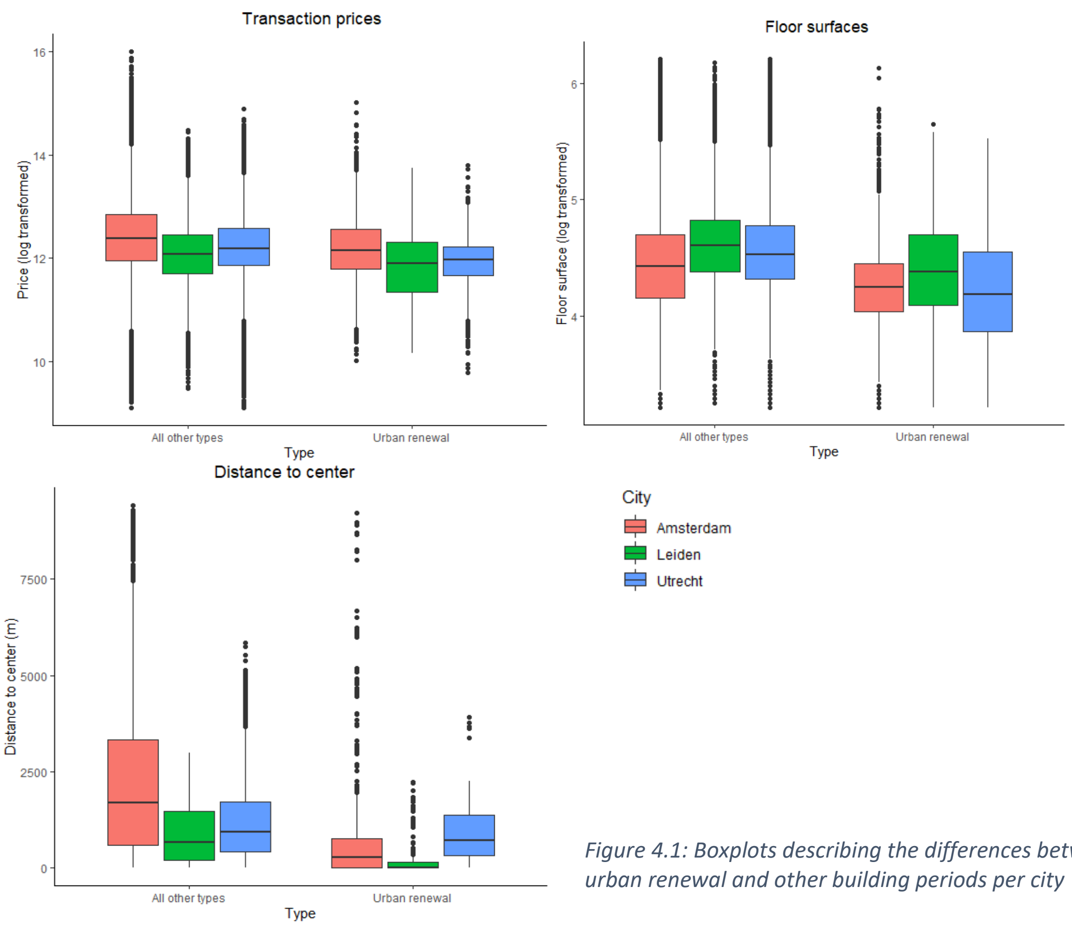


Figure 4.1: Boxplots describing the differences between urban renewal and other building periods per city

[1] The average urban renewal transaction price (M = 213,596, SD = 155,05) and the price of other building periods (M = 279,491, SD = 256,655) differ significantly (t(6317.6) = 23.765, p < 0.001).

[2] The average floor size of an urban renewal house (M = 77 , SD = 33) differs significantly in size (t(6217.2) = 45.305, p < 0.001) from the other building periods (M = 98, SD = 45).

[3] Urban renewal (M = 804, SD = 1,555) is located significantly closer to the city center (t(6281.3) = 44.358, p < 0.001) than other building periods (M = 1,719, SD = 1,769).

Figure 4.2 shows the development of the transaction prices in the dataset from 1985 to 2021. All building periods saw a steep increase in housing prices. Before 2005, urban renewal transaction prices were, on average, slightly higher than the average housing prices. This could be because newly built housing often experiences a price premium because of the good state of the maintenance. Furthermore, newly built housing often has a price premium as it incorporates the newest technologies that are available at the time. After 2005, the average housing price and the average urban renewal price are roughly equal, indicating a relative depreciation of urban renewal. The price dynamics per city show roughly the same trend, with a few differences between the cities. In Leiden, the mean urban renewal price per square meter was never less than the average price of other building periods. In Amsterdam and Utrecht, urban renewal became less appreciated roughly around 2005. Both Amsterdam and Utrecht saw a period of over-appreciation of urban renewal during the 1990s and the early 2000s.

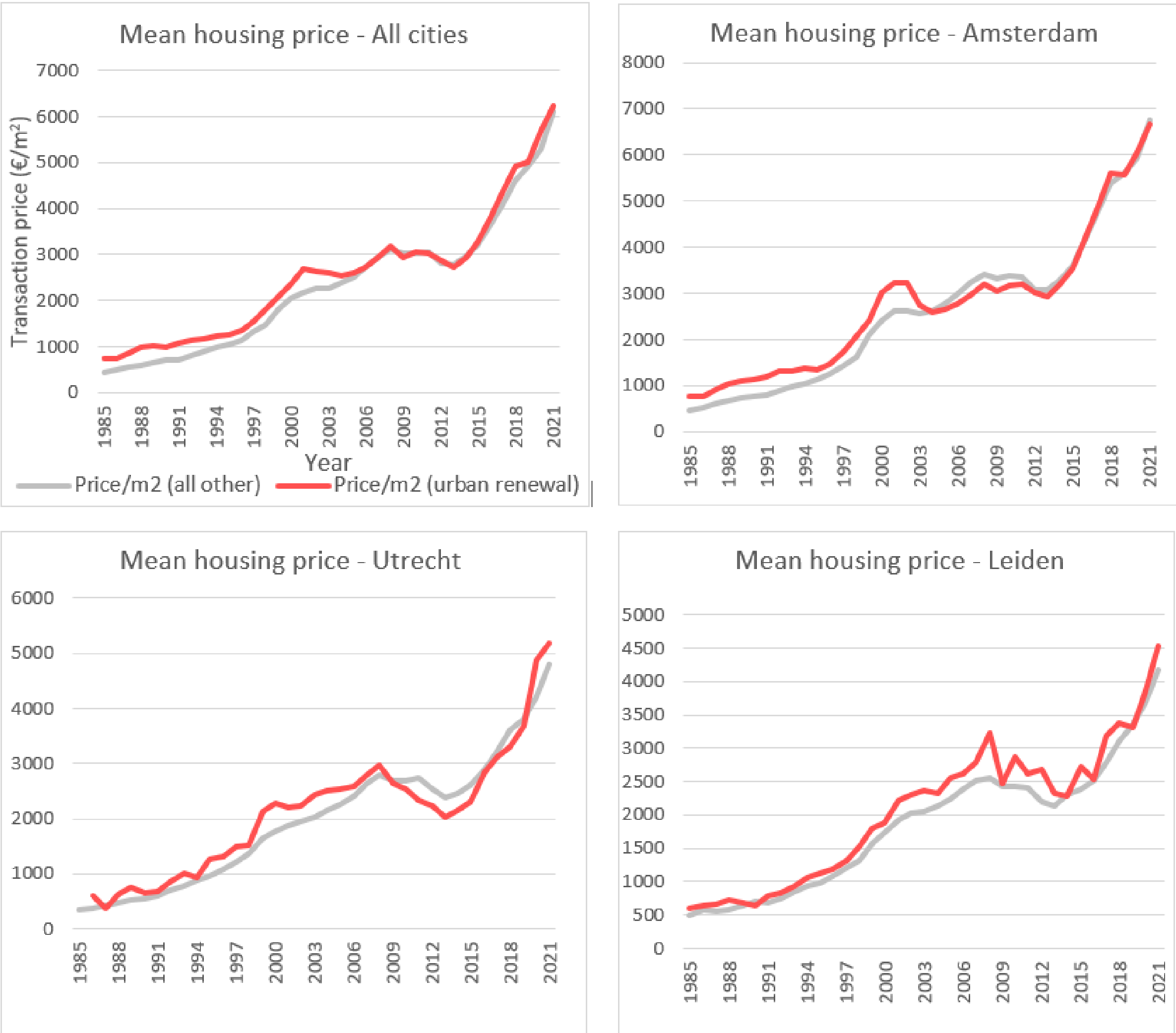


Figure 4.2: Trend in mean transaction prices per square meter for all cities and per city

These descriptive characteristics show that, on average, there are differences in prices and house characteristics between urban renewal and the other periods, as well as between the three cities. These differences emphasize the importance of controlling for such characteristics to isolate the effect of the urban renewal style from the influence of other structural and spatial factors. The differences between cities, due to regional housing market and job conditions, support the use of fixed effects for municipalities that remove these intercity differences.

4.2. Correlations

Figure 4.3 shows the significant correlations ($p < 0.01$) between the variables in the dataset and their strength. Although there are many significantly correlating variables, most of the correlations are weak and therefore not problematic for the analysis. As hypothesized in the conceptual model (see paragraph 2.4), there are correlations between the housing type and the amenities of the house. Unsurprisingly, the presence of an elevator is positively correlated with walkway flats, and the presence of a garage is correlated with parking facilities. Similarly, detached housing is correlated with the villa-housing type. Good interior maintenance is correlated with good exterior maintenance, and vice versa for poor interior and exterior maintenance.

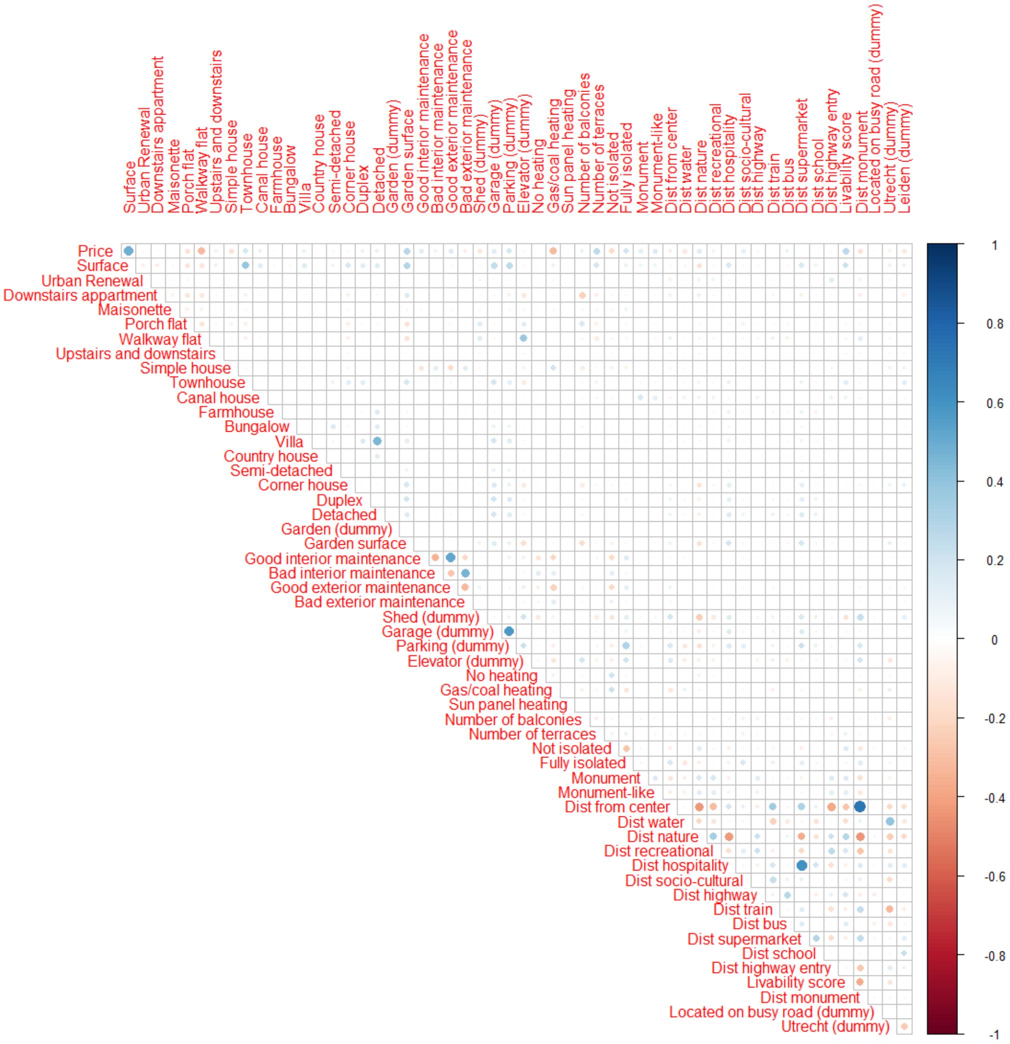


Figure 4.3: Correlation plot of the housing characteristics (reference categories, building periods and transaction years are omitted for brevity)

The spatial variables show significant correlations as well. As expected, the distance to the city center is correlated with the presence of monuments and facilities such as transport connectivity and retail. Similarly, distance to supermarkets is positively correlated with the distance to hospitality and other retail. The distance to the center is weakly negatively correlated with the presence of nature, recreational green, and with the Livability score. The latter indicates that inner-city neighborhoods tend to receive higher Livability scores than neighborhoods on the edges of the city. An explanation for this could be the higher number of services and facilities in city centers (one dimension of the Livability score) and the fact that neighborhoods with lower scores for dimensions such as social cohesion or safety and nuisance are often located on the outer edges of the city.

Because of the presence of many significant correlations, the Variance Inflation Factor [VIF] for each variable was calculated to investigate whether multicollinearity would pose a problem for the quality of the regression results. An overview of the VIF scores can be found in Appendix 4. As a result, two variables were removed from the dataset: the distance to nearest railroad and the orientation of the garden. These variables caused problematic multicollinearity with the distance to nearest train station and the garden dummy, respectively. The resulting VIF-values were all under 3, except for distance to city center (3.6). Although opinions are divided, most scholars agree that an acceptable VIF lies between 5 and 10 (James, Witten, Hastie & Tibshirani, 2013), meaning that all the variables are within the acceptable range of collinearity.

4.3. Hedonic price model

Regression results

The results of the hedonic price model ($R^2 = 0.93$), shown in Table 4.1, reveal a significant price discount for the urban renewal building period. The price effects for each building period are also shown in Figure 4.4. As expected, transaction prices for urban renewal (shown in dark red) have a discount of -3.9% compared to the reference category of 1900 – 1950. The building periods of 1951 – 1960 and 1961 – 1974 indicate even larger discounts than urban renewal: -6.9% and -10% respectively. Other building styles show a price premium relative to the reference period. The price premiums for the four periods between 1986 and 2021 show an upward trend of with housing built between 2011 – 2021 having the highest premium (+11.4%).

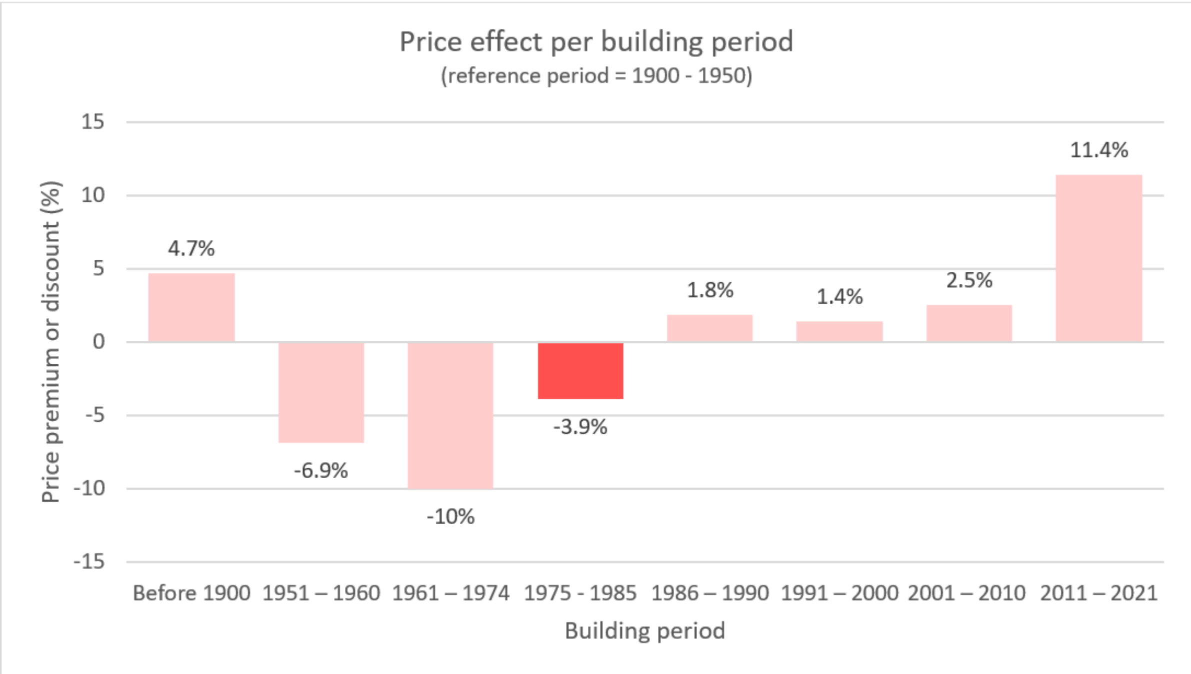


Figure 4.4: Price effect per building period. The urban renewal period is displayed in a darker shade.

Furthermore, structural characteristics related to the housing type were all found to be significant variables in the prediction of housing prices and have a relatively large effect on transaction prices. The signs of the variables are as expected, with price premiums found for detached houses and more luxurious housing types, such as villas, bungalows or country houses. In the case of apartments, downstairs apartments or apartments with both an upstairs and downstairs floor enjoy a slight premium over the other types. Structural characteristics regarding the amenities of the house are all significant but have a limited effect on price compared to the housing type. The 'solar panel heating' dummy is not significant, possibly due to the limited cases with this characteristic that were present in the dataset (n = 48). Surprisingly, fully insulated houses appear to have a slight discount compared to partly insulated dwellings. Similarly, the 'shed' variable indicates a price discount. When running the model separately for each building period, this effect is reflected especially for the post-war building periods (1951 – 1985). Therefore, the unexpected effect could be a mask for an omitted variable associated with the style of fully insulated houses that is not completely removed by the introduction of the building period dummies.

The price effects of the spatial variables are shown in Figure 4.5 and Table 4.1 and describe the discount or premium for each additional kilometer that a house is located further from a spatial feature. Most variables have a significant effect on housing prices; the largest discount was found for houses located further away from monuments (i.e., houses close to monuments were more expensive), while the highest premium was found for houses located farther from bus stations (i.e., houses close to bus stations are cheaper). Especially the distance to monuments could be an interesting variable for future research. This variable might portray the preferences of homebuyers better than variables such as 'distance to center' that do not capture the monumental, cultural and historic ensemble values of historic city centers, while the distance to a monument does. The effects of the distance to nearest water body and nearest recreational green were unsignificant (shown in dashed grey in Figure 4.5). This could be due to what Luttik (2000) and Daams et al. (2016) also find in their studies: basing the hedonic price effect of natural areas on land use data alone is not accurate enough, because this does not incorporate the distinct types of water or natural areas nor does it incorporate the perception of the natural spaces by property buyers. For example, an inner-city canal could be perceived differently as an attractive living location than alongside an industrial canal with heavy inland shipping flows, even though both are 'water bodies'.

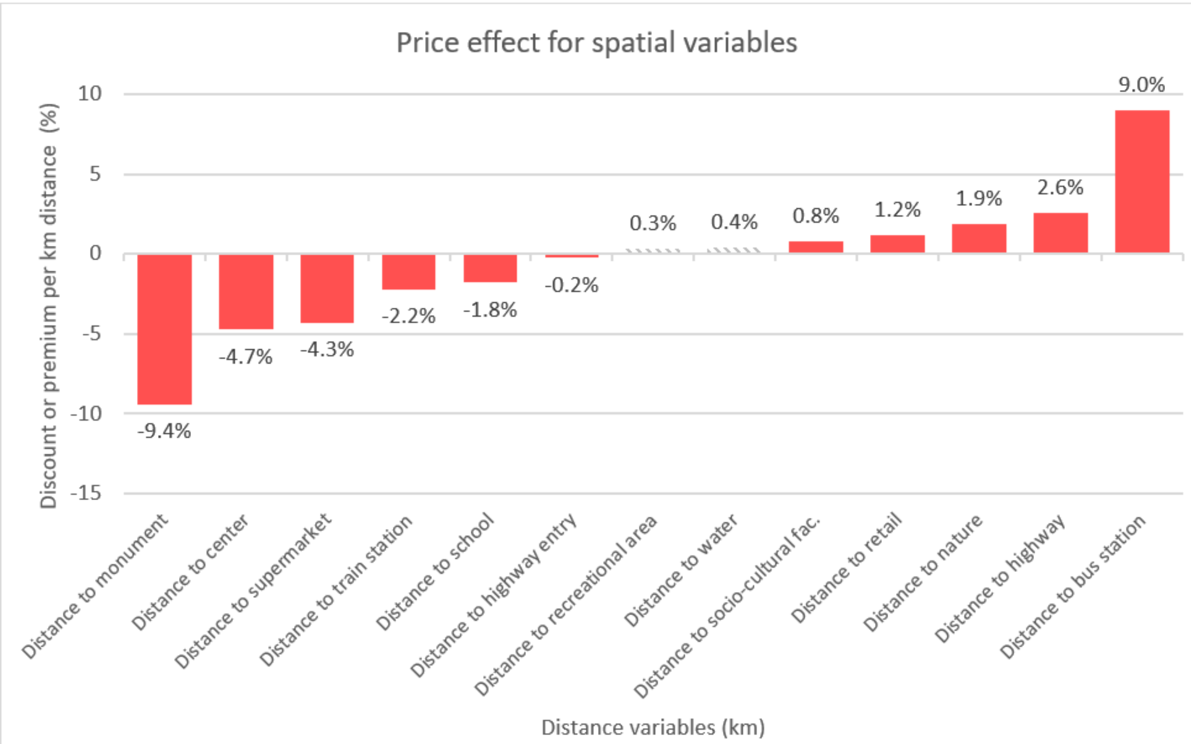


Figure 4.5: Price effect for each spatial variable. Insignificant variables are displayed dashed and grey.

Although most of the spatial variables are significant, their effects on transaction prices are modest. Several possible explanations for this can be put forward. First, although many people claim that housing prices are due to 'location, location and location,' it is likely that the price effects of the structural characteristics of a house trump the effects of the spatial variables. This is in line with findings from many previous studies employing HPM (e.g., Buitelaar & Schilder, 2017; Visser et al., 2008), where the importance of structural characteristics for housing prices is repeatedly shown. In this research, this is exacerbated by the fact that the research area consists of only three cities with a high facility density. This means that most houses have the needed facilities within an acceptable distance, regardless of whether they are living 'close' to the city center or not. This is also reflected in qualitative research in the Randstad by Kauko (2006b), who finds that accessibility and service infrastructure are deemed less important determinants for choice by homebuyers in urban centers, as these are sufficient anywhere.

Within these cities, market shortages therefore mainly occur in the provision of space and suitable housing types rather than in the provision of nearby facilities. This leads to more pronounced price effects of structural characteristics rather than from spatial characteristics, as unfavorable structural characteristics are more likely to be 'deal breakers' for property buyers than an unfavorable location. Interestingly, a longer distance from retail, hospitality and socio-cultural facilities is associated with a price *premium* rather than the expected discount. A possible explanation for this, related to the high facility density of the research area, could be that proximity to certain hospitality (such as bars and nightclubs) and socio-cultural facilities (such as hospitals or psychiatric institutions) might also be perceived as unattractive or cause nuisance that result in a price discount. Similar to the distance to water and recreational green variables, more finely specified land use data that incorporates the perception of homebuyers on certain facilities could increase the accuracy of these factors.

Table 4.1: Regression results of the hedonic price model

Hedonic Price Model

	Dependent variable: Transaction price (ln)	
Independent variables	*Coefficient*	*Std. Error*
Surface (ln)	0.787***	(0.002)
Building period dummies (ref = 1900 – 1950)		
Before 1900	0.047***	(0.002)
1951 – 1960	-0.069***	(0.002)
1961 – 1974	-0.100***	(0.002)
Urban renewal (1975 - 1985)	-0.039***	(0.003)
1986 – 1990	0.018***	(0.002)
1991 – 2000	0.014***	(0.002)
2001 – 2010	0.025***	(0.003)
2011 – 2021	0.114***	(0.006)
Apartment type (ref = Upstairs apartment)		
Downstairs apartment	0.007***	(0.002)
Maisonette	-0.068***	(0.003)
Porch flat	-0.065***	(0.002)
Walkway flat	-0.092***	(0.002)
Up- and downstairs apartment	0.069***	(0.005)
Housing type (ref = single-family dwelling)		
Simple	-0.013***	(0.003)
Townhouse	0.131***	(0.003)
Canal house	0.125***	(0.007)
Farmhouse	0.215***	(0.025)
Bungalow	0.239***	(0.010)
Villa	0.266***	(0.008)

Country house	0.349***	(0.030)
Dwelling type (ref = terraced)		
Semi-detached	0.026***	(0.008)
Corner	0.034***	(0.002)
Duplex	0.099***	(0.005)
Detached	0.225***	(0.007)
House characteristics		
Maintenance level (ref = average maintenance)		
Good interior maintenance	0.091***	(0.002)
Bad interior maintenance	-0.024***	(0.005)
Good exterior maintenance	0.059***	(0.002)
Bad exterior maintenance	-0.131***	(0.007)
Home heating (ref = central heating)		
No heating	-0.035***	(0.003)
Gas or coal heating	-0.119***	(0.002)
Solar panel heating	0.043	(0.028)
Insulation (ref = partly insulated)		
Not insulated	-0.020***	(0.001)
Fully insulated	-0.006*	(0.002)
Garden surface (in square meters)	0.001***	(0.00002)
Shed (dummy)	-0.009***	(0.001)
Garage (dummy)	0.041***	(0.003)
Parking (dummy)	0.036***	(0.002)
Elevator (dummy)	0.025***	(0.002)
Number of balconies	0.024***	(0.001)
Number of roof terraces	0.047***	(0.002)
Monument (dummy)	0.050***	(0.003)
Monumental (dummy)	0.059***	(0.004)
Spatial variables (in kilometers)		
Distance from center	-0.047***	(0.0005)
Distance from water	0.004	(0.004)
Distance from nature	0.019***	(0.0008)
Distance from recreational area	0.003	(0.003)
Distance from retail and hospitality	0.012***	(0.003)
Distance from socio-cultural facilities	0.008***	(0.002)
Distance from highway	0.026***	(0.004)
Distance from train station	-0.022***	(0.0008)
Distance from bus station	0.090***	(0.005)
Distance from supermarket	-0.043***	(0.003)
Distance from school	-0.018***	(0.003)
Distance from highway entry	-0.002**	(0.0007)
Distance from monument	-0.094***	(0.002)
On busy road (dummy)	-0.026***	(0.003)
Livability score	0.412***	(0.002)
Transaction year dummies (ref = 2021)	Not presented here. See Appendix 5.	
Municipality dummies (ref = Amsterdam)		
Utrecht	-0.241***	(0.002)
Leiden	-0.280***	(0.002)

Constant	8.009***	(0.019)
N	161,058	
R^2	0.925	
Adjusted R^2	0.925	
Residual Std. Error	0.198 (df = 160960)	
F Statistic	20,450.810*** (df = 97; 160960)	
Notes:	***Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.	

Lastly, the Livability index has a has a significant price premium for areas with a higher Livability score. Since the effect of the Livability score appears quite large, it is important to note that increasing the Livability coefficient with one unit (one score-point), indicates a shift from a very negative to a very positive neighborhood score (Mandemakers et al., 2021). Lastly, there are price discounts for Utrecht (-24%) and Leiden (-28%) in comparison to Amsterdam. This is expected, as property values have experienced a much steeper growth in Amsterdam over the last two decades than other Dutch cities (Arundel & Hochstenbach, 2020). In addition, Amsterdam also has faced a growing foreign demand for housing which drives up property prices (Savini, Boterman, Van Gent & Majoor, 2016).

Model quality

The prediction of housing prices of the test data with the HPM results in the actual vs. predicted plot shown in Figure 4.6. The mean square error of the model is 0.039, with a mean square error of 0.0 indicating a perfect model.

Figure 4.6: Scatterplot of predicted values vs. the actual values of the validation dataset.

In Figure 4.6, predictions of urban renewal houses are shown in pink, while the other building periods are shown in blue. The predicted and actual prices follow the diagonal, although some outliers can be discerned. The urban renewal transactions are concentrated on the middle and lower end of the transaction prices, confirming that, in general, urban renewal has a lower transaction price than other building periods, although some higher transaction prices do occur. For more figures reflecting the quality of the model (such as checks for homoscedasticity and normality), see Appendix 6.

Spatial autocorrelation

To check for spatial autocorrelation in the data, Moran's I was calculated for the locations of urban renewal housing, the spatial distribution of transaction prices, and for the residuals of the HPM. To determine the value of *k* for the weight matrices, a theoretical threshold was chosen of what can realistically be termed 'neighbors', depending on the density of the data points. To evaluate the spatial dependence of the locations of urban renewal, a *k* of 10 was taken. Since only a portion of the complete dataset consists of urban renewal, the point density is lower. A higher *k* would falsely attribute the nearest data points as being a 'neighbor,' while, in reality, they are too far away to be counted as one. For urban renewal, a weak but significant spatial autocorrelation was found (Moran's I = 0.20, $p < .000$), meaning that urban renewal is slightly more clustered than a completely random distribution. To assess the spatial dependence of both the price and the residuals, a *k* of 30 was taken. As these tests take all data points into account, the density is much higher. This allows a higher *k*-value to realistically reflect the nearest neighbors of a point. Housing price, as expected, is significantly more clustered than a random distribution (Moran's I = 0.37, $p < .000$). This confirms the findings of previous studies (e.g., Bourassa, Cantoni & Hoesli, 2007) that housing prices are spatially dependent. The regression residuals were found to be weakly but significantly autocorrelated (Moran's I = 0.23, $p < .000$). This means that the residuals of the model are slightly more clustered than a random distribution would be. However, since Moran's I is quite low, these values were not considered as problematic and further correction using econometric models was deemed unnecessary.

To conclude, the most important finding from this model is the specific price discount for the urban renewal building style relative to the reference category, while controlling for many other characteristics. The urban renewal price discount indicates that it is relatively unappreciated by homebuyers in comparison to other styles. However, this discount is modest compared to other post-war building periods: both 1951-60 and 1961-74 show larger discounts relative to the 1900-1950 period. This indicates that, of all post-war periods, urban renewal is perhaps the most appreciated one, while other periods show more severe depreciation trends. The unique features of urban renewal, its spatial configuration and its design characteristics, will be explored further in the subsequent analyses and could pinpoint a reason why urban renewal is the 'least underappreciated' of the post-war styles.

4.4. Cluster analysis

The cluster analysis focuses on the spatial configuration of urban renewal: are isolated dwellings appreciated more than clustered ones? These results could give insight into the mechanisms behind the appreciation and depreciation of urban renewal by homebuyers. To analyze this, a separate HPM was trained with a dataset containing only urban renewal transactions. One HPM was done without taking the clustering of urban renewal into account, and one HPM was conducted that did take this property into account. The cluster analysis, using the DBSCAN algorithm, resulted in 5479 clusters and 398 isolated cases (see Table 4.2).

Table 4.2: Overview of the categories of clusters

Category	Range	N
Not clustered	0 – 5 houses	398
Small cluster	6 – 20 houses	1023
Large cluster	20+ houses	4456

The results of the DBSCAN algorithm in Utrecht are shown in Figure 4.7. The map shows clustered urban renewal in qualitative color scheme, while all isolated urban renewal is shown dark blue. For Amsterdam and Leiden, see Appendix 7.

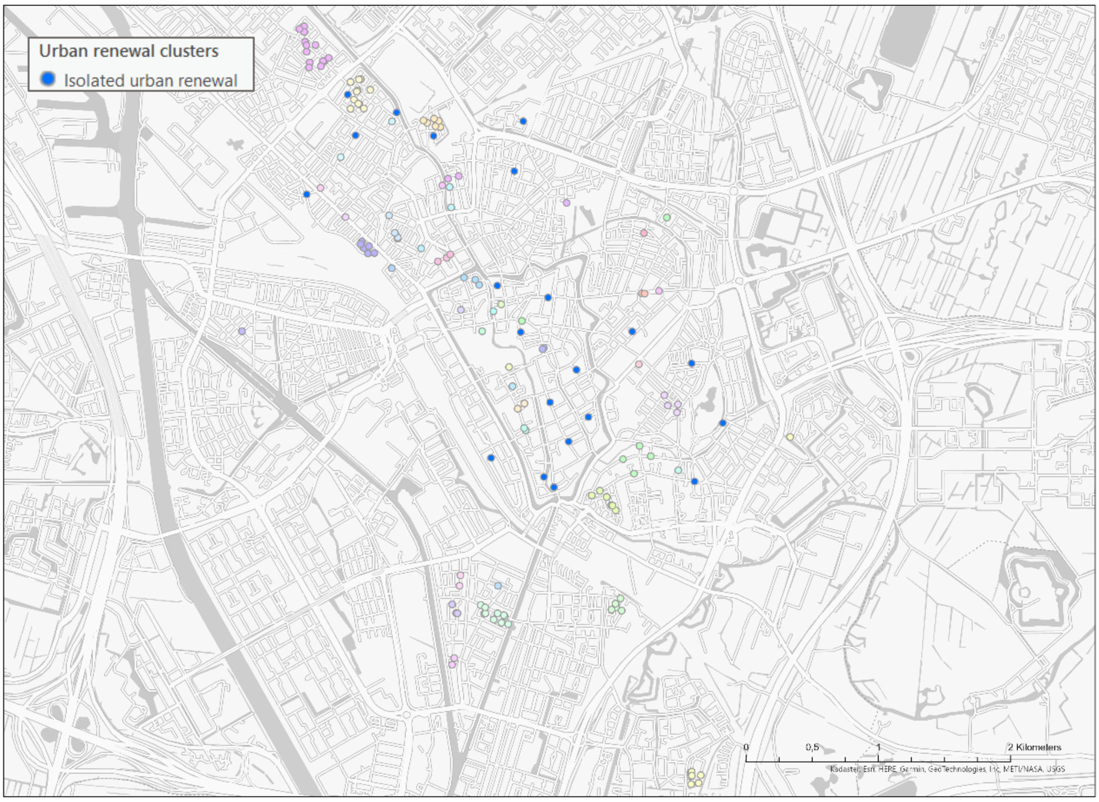


Figure 4.7: Clustered and isolated urban renewal transaction in Utrecht

Regression results

The results of the two HPM's on urban renewal transactions are shown in Table 4.3. The left column contains the results of the HPM without the clustering degree and the right columns shows the results with the clustering degree included. Overall, both models perform slightly better than the HPM on all building style transactions in the previous section (excluding clustering: R^2 = 0.935. Including clustering: R^2 = 0.936). The HPM that includes degrees of clustering shows significant discounts for urban renewal located in small clusters (-4.9%) and in large clusters (-6.1%) when compared to 'isolated', non-clustered urban renewal. This is in line with the hypothesis that isolated urban renewal is preferred over clustered urban renewal, possibly caused by the fact that isolated urban renewal is often directly surrounded by older and more popular building styles. Furthermore, it is in line with the hypothesis that larger clusters (more than 20 houses) are deemed less attractive than small clusters (between 5 and 20 houses).

However, since the introduction of the clustering variables does not add any considerable explanatory power to the model, it is possible that the degree of clustering is correlated to other variables already present in the model, such as the distance to the city center. Since isolated urban renewal occurs more frequently in city centers (for illustration, see Figure 4.7), correlation with the distance to center could be a plausible explanation for its limited explanatory power. When the clustering reference category is replaced with the 'large cluster' dummy, the 'small cluster' dummy loses its significance and vice versa. Upon closer inspection, a VIF-value of 6.6 was found for the distance to the city center variable. Although this is still within the acceptable range (James et al., 2013), it is a relatively high value for this model. After removal of this variable, the 'small cluster' and 'large cluster' dummy become significant. This suggests some collinearity between the size of the clusters and the distance to the center which could influence these results. However, this only seems to affect the small and large cluster dummies.

Therefore, it can still be argued that *isolated* urban renewal has a distinct price premium in comparison to clustered urban renewal.

Table 4.3: Regression results of HPM on urban renewal transactions without (left) and with (right) a clustering variable

Hedonic Price Model with clustering variable – only urban renewal transactions

Dependent variable: Transaction price				
	Model 1: Urban renewal without clustering		*Model 2: Urban renewal with clustering*	
Independent variables	*Coefficient*	*Std. Error*	*Coefficient*	*Std. Error*
Surface (ln)	0.706***	(0.007)	0.704***	(0.007)
Clustering (ref = No cluster/isolated)				
Small cluster	-	-	-0.049***	(0.010)
Large cluster	-	-	-0.061***	(0.009)
Apartment type (ref = Upstairs apartment)				
Downstairs apartment	0.001	(0.008)	0.002	(0.008)
Maisonette	-0.008	(0.009)	-0.006	(0.009)
Porch flat	-0.0003	(0.006)	-0.002	(0.006)
Walkway flat	-0.055***	(0.009)	-0.054***	(0.009)
Up- and downstairs apartment	0.119***	(0.036)	0.105***	(0.036)
Housing type (ref = single-family dwelling)				
Simple	0.026	(0.022)	0.024	(0.022)
Townhouse	0.212***	(0.021)	0.214***	(0.021)
Canal house	0.164***	(0.037)	0.153***	(0.037)
Farmhouse	0.397***	(0.088)	0.351***	(0.088)
Bungalow	0.621***	(0.081)	0.585***	(0.081)
Villa	0.485***	(0.034)	0.461***	(0.034)
Country house	0.476***	(0.063)	0.432***	(0.063)
Dwelling type (ref = terraced)				
Detached	0.082***	(0.011)	0.082***	(0.011)
House characteristics				
Maintenance level (ref = average maintenance)				
Good interior maintenance	0.077***	(0.007)	0.077***	(0.007)
Bad interior maintenance	-0.024	(0.030)	-0.019	(0.030)
Good exterior maintenance	0.006	(0.013)	0.007	(0.013)
Bad exterior maintenance	-0.118	(0.117)	-0.116	(0.116)
Home heating (ref = central heating)				
No heating	-0.022**	(0.011)	-0.020*	(0.011)
Gas or coal heating	-0.085***	(0.022)	-0.086***	(0.022)
Insulation (ref = partly insulated)				
Not insulated	-0.003	(0.005)	-0.002	(0.005)
Fully insulated	0.012	(0.007)	0.011	(0.007)
Garden (dummy)	0.015	(0.034)	0.013	(0.034)
Garden surface	0.0003***	(0.0001)	0.0003***	(0.0001)

Shed (dummy)	-0.015**	(0.006)	-0.013**	(0.006)
Garage (dummy)	0.097***	(0.021)	0.092***	(0.021)
Parking (dummy)	0.069***	(0.013)	0.068***	(0.013)
Elevator (dummy)	0.031***	(0.006)	0.033***	(0.006)
Number of balconies	0.017***	(0.005)	0.018***	(0.005)
Number of roof terraces	0.048***	(0.009)	0.046***	(0.009)
Monument (dummy)	0.070***	(0.011)	0.058***	(0.011)
Monumental (dummy)	0.071***	(0.022)	0.068***	(0.022)
Spatial variables (in kilometers)				
Distance from center	-0.043***	(0.003)	-0.043***	(0.003)
Distance from water	-0.075***	(0.019)	-0.073***	(0.019)
Distance from nature	0.022***	(0.004)	0.024***	(0.004)
Distance from recreational area	0.034***	(0.012)	0.031***	(0.012)
Distance from retail and hospitality	-0.049***	(0.014)	-0.048***	(0.014)
Distance from socio-cultural facilities	0.072***	(0.009)	0.071***	(0.009)
Distance from highway	0.028	(0.020)	0.021	(0.020)
Distance from train station	0.010*	(0.005)	0.008	(0.005)
Distance from bus station	0.154***	(0.027)	0.146***	(0.027)
Distance from supermarket	-0.035**	(0.016)	-0.031*	(0.016)
Distance from school	-0.004	(0.014)	-0.008	(0.014)
Distance from highway entry	-0.024***	(0.004)	-0.024***	(0.004)
Livability score	0.385***	(0.014)	0.377***	(0.014)
Distance from monument	-0.099***	(0.013)	-0.095***	(0.013)
On busy road (dummy)	-0.004	(0.011)	-0.005	(0.011)
Transaction years (ref = 2021)	Not presented here. See Appendix 8.			
Municipality dummies (ref = Amsterdam)				
Utrecht	-0.218***	(0.008)	-0.218***	(0.008)
Leiden	-0.250***	(0.009)	-0.247***	(0.009)
Constant	8.410***	(0.076)	8.510***	(0.077)
N	5877		5877	
R^2	0.935		0.936	
Adjusted R^2	0.934		0.935	
Residual Std. Error	0.157 (df = 5791)		0.157 (df = 5789)	
F Statistic	981.115*** (df = 85; 5791)		966.113*** (df = 87; 5789)	

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Furthermore, some variables in relation to the dwelling type had to be removed from the HPM (semi-detached, corner and duplex houses), as these types only had a handful of cases in the urban renewal subset of the data. Other variables regarding apartment and housing types have become insignificant in comparison to the HPM on all building styles in the previous section. A possible explanation could be that the variation in appearance between apartment types decreases within the same building style. For example, an upstairs apartment from the 1930's building period and a maisonette in urban renewal style visually differ more from each other than when both apartments would be built in urban renewal style. This, in combination with the smaller sample size, could result in smaller price variations between apartment types, so that a significant contribution to transaction price can no longer be detected.

Additionally, some variables relating to the state of maintenance of the house have lost their significance. A likely explanation for this is the limited number of houses in poor maintenance state in the urban renewal subset. Only two cases were found with poor exterior maintenance, and only 15 cases were found with poor interior maintenance. Furthermore, the dummy variables related to the degree of insulation of the house are insignificant, suggesting that this does not influence the transaction price of urban renewal housing.

Lastly, some spatial variables have become insignificant in comparison to the previous HPM on all building styles. As mentioned, some signs of collinearity are present for the distance to center variable which could influence the spatial variables as well. After removal of the distance to center variable, both the distance to nearest school and distance to nearest supermarket became significant, indicating that these variables might be correlated. However, the distance to nearest train station and to the nearest highway entry remain insignificant, as well as the 'on busy road' dummy. Interestingly, the direction of the sign of the 'distance to socio-cultural facilities' variable has become negative, while this was positive in the HPM on all building styles, indicating that a longer distance from socio-cultural facilities is associated with a price discount in the case of urban renewal.

Model quality

The quality of the urban renewal HPM was evaluated in the same way as the HPM of all building styles. The results of the predicted housing prices of the test data are plotted against the actual housing prices in Figure 4.8. The mean square error of the urban renewal model is 0.024, slightly better than the model of all building styles. For a more in-depth quality assessment of the model, see Appendix 9.

Figure 4.8: Scatterplot of predicted values vs. the actual values of the validation dataset

In conclusion, these findings show that isolated urban renewal has a significant premium over other spatial configurations, although this effect is modest. This indicates that, although this is not a priority for homebuyers, they are willing to pay a certain premium for isolated urban renewal housing. Furthermore, these HPM's tell a similar story as the HPM on all building styles; structural characteristics of a household the most explanatory power. Homebuyers are willing to pay (a lot) more for certain housing types and for a larger living surface. Spatial variables do add some explanatory power, but their effect on the transaction price is limited, probably due to similar reasons as discussed for the HPM on all building styles (see paragraph 4.3.1). The following section will dive deeper into other characteristics of urban renewal, mainly its design features and the neighborhoods in which it is located, by taking a different approach through the use of photo documentation.

4.5. Photo documentation

Not all housing characteristics that influence housing prices can be measured quantitatively. The literature review (see section 2.3) showed that subjective and non-quantifiable factors can influence preferences of homebuyers and housing prices. Qualitative research through photo documentation can offer valuable insights into these 'omitted' factors. Especially investigation of outliers is interesting, as these divergent cases are somehow deviating from the pre-determined quantitative variables in the HPM. An example could be urban renewal of which the design almost perfectly mimics the historic context can be perceived very differently than urban renewal that does not integrate as well into its surroundings (for example, see Figure 4.9 and 4.10).

Figure 4.9: Urban renewal (1981, on the right side) almost perfectly mimicking its historic neighbor (left side, 17th century monument) on the Realengracht, Amsterdam.

Figure 4.10: Less ambitious integration of urban renewal in the existing historical context on the Kerkstraat, Amsterdam

Selection of case studies

To select suitable case studies for the photo documentation, a list of outliers was compiled by making a subset of transactions with a studentized residual higher than 3 or lower than -3. This threshold resulted in a total number of 51 urban renewal outliers. From these 51 cases, 20 cases were selected where the transaction had taken place relatively recently (between 2014 – 2021). Of these 20 cases, 8 were in Amsterdam, 4 in Leiden and 3 in Utrecht. All 'shortlisted' outliers were visited in Utrecht and Leiden, three and four sites, respectively. One case in Leiden was excluded from further analysis, because the urban renewal did not fit the definition of 'true' urban renewal as implemented in this study. For reasons of efficiency, 5 sites were visited in Amsterdam, of which 3 were selected for further analysis. Of the 6 discussed cases, 1 was sold for a higher transaction price than the price fitted by the HPM, and 5 were sold for a lower price than expected. When relevant, a comparison was made with nearby non-outlier housing transactions to evaluate in what way the outlying case differed. Houses that are in the same street are simultaneously discussed, which is the case for the Nieuwlichtstraat in Utrecht (case study 6) and the Realengracht in Amsterdam (case study 3). The locations of the discussed case studies are shown in Figure 4.11.

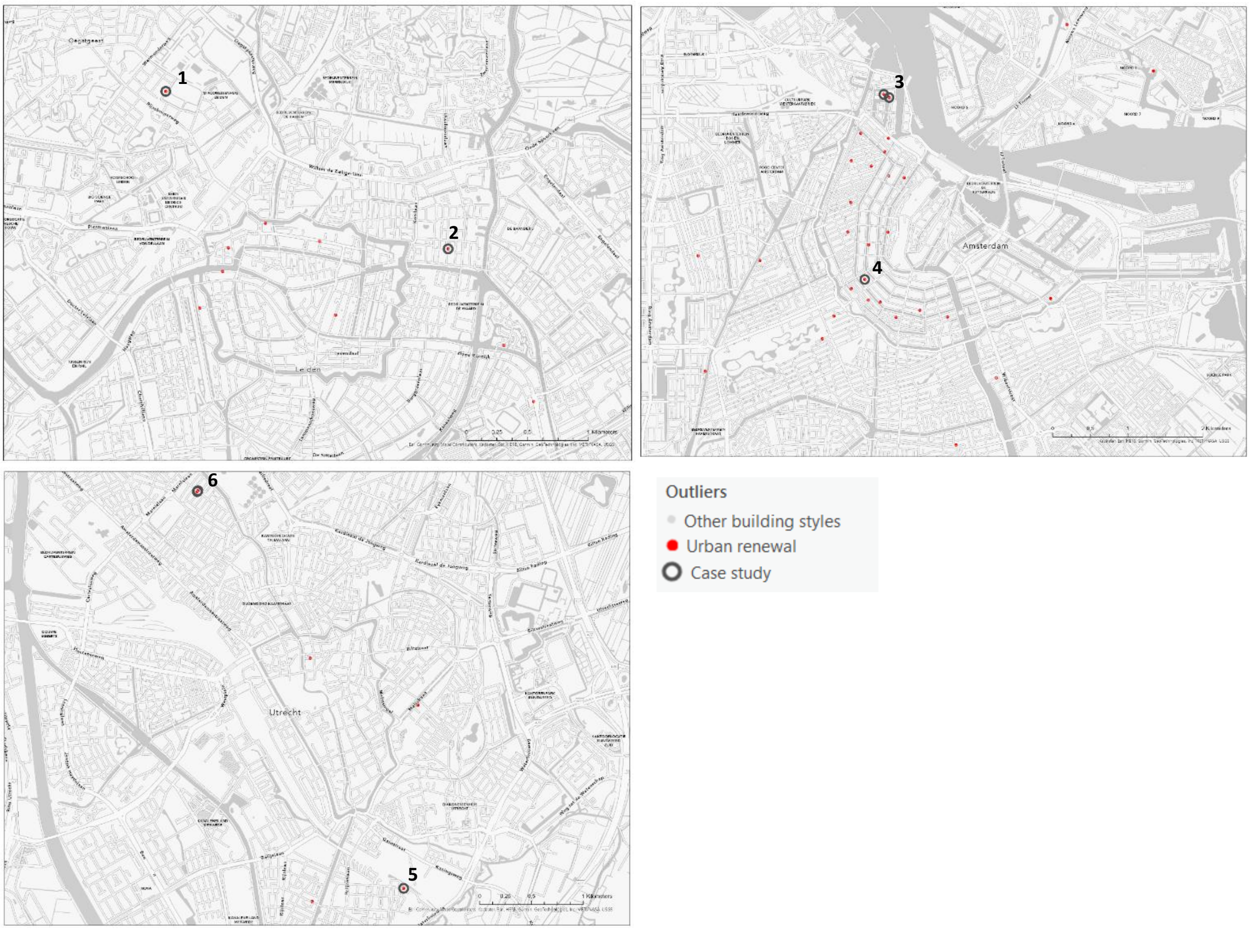


Figure 4.11: Locations and numbers of the selected case studies

Findings

The goal of the photo documentation analysis on the regression outliers was to identify influential factors on housing prices that have not been included in the hedonic model. Despite the findings derived from the photo documentation, it is still likely that a part of the difference in prices cannot be explained through the visual factors alone. Some outliers deviated such a large amount from the predicted value, up to €300,000, that it is unlikely that this is only due to visual factors, such as the streetscape or exterior design. Possible explanations for these large price differences could have to do with the interior structural characteristics or with market factors, for example: a parent selling the house to their children for a reduced tariff. Notwithstanding, several insights can still be gained from the visits to the case studies and the analysis and coding of the photographs. The photographs and descriptions on which these findings are based can be found in Appendix 10.

Findings on the house level: variety and quality of exterior design

First, on the level of the individual houses and the street, the case studies showed that there is a large variety in the types of urban renewal, their spatial configurations, designs and the way that they are integrated into the existing context. Although urban renewal is characterized by a relatively sober and simple style, different case studies showed various levels of detailing within the design, with some being better executed than others. For example, some case studies displayed more features that are characterizing for urban renewal, such as staggered building lines or sunken balconies, while other case studies had a much simpler design without said features (see Figure 4.13, 4.14 and 4.15). A better executed, presumably more expensive, design results in a more attractive house front that also integrates better within the existing context. One case study (see Figure 4.9 and Figure 4.12) was rebuilt in a manner that reflected the existing historical buildings around it so well, that most people (including the researcher) would not recognize it as urban renewal on first sight. Therefore, this house can hardly be attributed to the urban renewal building style, but rather as the style it is mimicking, and this is also reflected in the price.

Figure 4.12: Urban renewal on Realengracht (left building), Amsterdam (case study 3).

Figure 4.13: Staggered building lines and sunken balconies on the Van Beuningenlaan, Leiden (case study 1)

Furthermore, more detailed design and staggered building lines also prevents a certain 'homogenous' and uniform look that is present in some other case studies (see Figure 4.14). Uniform housing, especially in combination with limited greenery, arguably results in a less attractive streetscape which is found in case studies where transaction prices were significantly lower than the expected price. Besides the design of the house itself, a uniform streetscape can also be prevented if the house is in a street with a variety of building styles. According to the opinion of a resident, variation of building styles is already perceived as attractive if multiple styles are present in the same neighborhood. This suggests that the geographical scale on which *other* building styles influence the price of urban renewal might be larger than initially thought. Additionally, not only the variety of building styles is important, but also the type of building style with housing from the 1910's, 1920's and 1930's being explicitly mentioned as attractive. Nevertheless, one case (Figure 4.15) actually had a lower price than expected while being surrounded by 'attractive' pre-war housing. An explanation for this could be the limited integration with the surrounding context and the use of dark brown bricks, black and concrete detailing and the somewhat rigid and somber design. This, in combination with the fact that this urban renewal is the only post-war building in this location, could make it stand out in a negative light compared to its direct neighbors.

Figure 4.14: Simple and homogenous urban renewal design and streetscape on the Lamstraat, Utrecht (case study 5).

Figure 4.15: Integration of urban renewal into the existing context? Kerkstraat, Amsterdam (case study 4).

All this indicates that an attractive, varied streetscape can be quite influential on the appreciation of an individual house. 'Soft' environmental aesthetics such as desirable streets have previously been found to be influential in housing choice in the Randstad (Kauko, 2006b). Aspects of the streetscape that came forward from the case studies included the quantity of greenery. However, it can be argued that the type of greenery also plays a role. Streets where tall greenery (such as trees) is combined in the same spot with medium-height and shorter greenery (bushes and grass) have a more 'abundant' green sight than when a certain type and height of greenery is isolated in a specific part of the street (see Figure 4.14). More homogenous streetscapes with less green, in combination with little integration within the existing context and simpler designs can generally be seen in the case studies that concern houses that are valued less than predicted.

Findings on the neighborhood level: neighborhood image

On the level of the neighborhood, a remarkable finding was that three of the case studies are found in (former) working-class neighborhoods ('volksbuurten'), and that all these cases had lower transaction prices than expected. The overrepresentation of working-class neighborhoods is in itself no surprise, as these neighborhoods were generally high on the agenda for renewal during the urban renewal period due to the poor state of the houses (De Liagre Böhl, 2012; Van Es & Voerman, 2018). However, it *is* remarkable that these cases all have lower prices than expected and that the 'quality' of the design is quite low and simple with relatively bare streetscapes. The urban renewal observed in these neighborhoods is often of a more homogenous type and there is less greenery and mixing with other building styles.

A possible explanation for the low prices, besides the less attractive streetscape, could be a general stigmatizing image that surround working-class neighborhoods in the Netherlands. Working-class neighborhoods are often associated with a low income, less education, unemployment, nuisance and a high percentage of social housing. In recent years, many of these neighborhoods have experienced gentrification, mainly because of their location close to city centers and the presence of single-family homes. All three neighborhoods in these case studies have to some degree faced demolition and renewal and an inflow of students and higher-income families. Especially in Amsterdam (Van Es & Voerman, 2018), redevelopment of these neighborhoods is often protested by the local residents, and the same is reported in popular media for Utrecht (Huisman, 2012; Utrechts Nieuwsblad, 2004) and Leiden (De With, 2021). Although a significant part of these neighborhoods remains social housing, gentrification has brought recent redevelopments of the neighborhood with the placement of higher quality greenery and more attractive streets constructed from red brick (in De Kooi, Figure 4.16) or with demolition and redevelopment of newly built housing (in the Fruitbuurt, Figure 4.17). Despite the rising housing prices associated with gentrification, a certain image or stigma still surrounds these neighborhoods and they are still regarded as a 'volksbuurt' (De Kruijff, 2020; Gemeente Utrecht, 2015; Van der Zande & Manders, 2015).

These results indicate that the model still does not sufficiently account for the 'image' of the neighborhood, currently only measured using the Livability index. This is in line with research by Kauko (2006b), who finds that neighborhood image is one of the most important determinants for housing choice in urban centers. Indicators used by other researchers that relate to neighborhood image include the percentage of non-western migrants, income and the percentage of social housing. In the case of these working-class neighborhoods, non-western migrants would not suffice as an indicator, as most of the original inhabitants are native Dutch. Similarly, average income does not seem to be a suitable indicator as the stigma surrounding these neighborhoods pertains to much more than 'just' a low income. Additionally, gentrification through studentification often does not coincide with a higher average income. Using these indicators as a proxy for a 'poor social image' of a neighborhood has a stigmatizing effect in and of itself, nor is it an accurate determinant for a 'volksbuurt', as not all poor, diverse neighborhoods are 'volksbuurten' and vice versa. A percentage of social housing could be a more suitable indicator to predict the influence on housing price by factors related to the social image of an area, as also shown in research by Sequeira and Filippova (2021).

Figure 4.16: Urban renewal alongside redeveloped street and greenery at Driftstraat, Leiden (case study 2).

Figure 4.17: A mixture of newly-built housing (in the background) mimicking the demolished 1920's workers' houses and urban renewal, Nieuwlichtstraat, Utrecht (case study 6).

Nevertheless, the 'quantification' of these 'soft' indicators will always generalize their complexity and subjectivity. The image and culture surrounding working-class neighborhoods might deter some groups from moving there, but could also attract others towards the neighborhood or might be te reason residents would like to stay. For example, younger generations of working-class residents might prefer to stay in the neighborhood where they grew up and where their friends and family live, reflecting a different perspective on appreciation for a certain neighborhood than an outsider might have. Kauko (2006b) finds that a strong neighborhood image can also lead to residents attaching value to 'their' neighborhood and can form an extra incentive to live there. However, since market housing prices only reflect the 'objective' appreciation of homebuyers, these various facets of appreciation are rarely explored in hedonic price analyses.

This subjectivity does not only apply to neighborhood image, but could also be related to many other housing factors. For example, facilities such as the vicinity of recreational green or water are often simply seen as having a positive price effect. However, some of these facilities were also encountered in a more negative light during the case studies. An example of this is the Kooipark, a park around the corner from the Driftstraat (Figure 4.16) that has been regularly featured negatively in the news due to issues with loitering youth, social unrest and nuisances (e.g.: Janson, 2017; Waard, 2021). Proximity to this type of parks might by some be regarded as a negative factor rather than a positive one. This further underlines a need for the incorporation of differing opinions and perspectives on what constitutes an 'attractive' house, street or neighborhood.

5. Conclusion

5.1. Main findings and relevance

This thesis investigates the price effects of the Dutch urban renewal building style. Although urban renewal is generally seen as a relatively 'unattractive' building style, it is difficult to cleanly separate the effects of the building style from other structural and locational characteristics of the house. Using a rich data set of housing transactions supplemented with locational variables within several methods (i.e., hedonic price modelling, cluster analysis and photo documentation), it was possible to disentangle the effects of the building style from the other housing characteristics. This study has shown that a small but significant price discount (-3.9%) can be attributed to the urban renewal building style relative to the reference building period of 1900 – 1951. Within the complete set of transactions of all building periods, urban renewal has the smallest discount of all post-war periods relative to reference category, while both pre-war and more contemporary building periods had a premium compared to the reference group. Furthermore, within the subset of urban renewal transactions, significant price premiums (+4.9% to +6.1%) were found for isolated urban renewal houses that are surrounded by houses from other building periods, relative to clustered urban renewal. Although the characteristics pertaining to style have significant effects on price, their explanatory power is limited compared to the larger effects of the physical attributes of the house. The most important factors influencing housing prices that came forward from the photo documentation were the desirability of the streetscape and the image and status of the neighborhood.

Overall, the main relevance of this research is the empirical evidence it provides for the price effect that can be attributed to a specific, yet unresearched and 'undesirable' building style, namely urban renewal. Furthermore, it provides empirical support for the notion that the spatial configuration of urban renewal has a significant effect on the price-making of urban renewal houses due to the price effect of surrounding building styles. Lastly, it contributes to filling a research gap regarding more subjective and 'soft' housing factors that influence prices. These results do not necessarily apply only to the research area. Comparable results can probably be found for the other 14 Dutch cities that experienced similar development during the urban renewal period (De Liagre Böhl, 2012), such as Rotterdam or The Hague. Although there are always small local differences in the policy and geographical context, the general findings likely still apply. Similarly, these results could give insight into the appreciation of other post-war buildings styles, but more thorough research is needed before this can be assumed with certainty. In the following section, the answer to each research question will be discussed further and will be compared to previous studies and the wider theoretical discussion.

5.2. Answer to research questions and scientific relevance

To what extent does building style influence the price of houses built in Dutch urban renewal style?

As mentioned, the urban renewal style has a small negative price effect (-3.9%) on the transaction price, relative to the reference category (1900 – 1950). This is in line with the prior expectation that a relative price discount could be attributed to the less-attractive urban renewal building style. However, of all post-war periods, urban renewal has the smallest relative discount. These results suggest that homebuyers appreciate urban renewal homes, and post-war houses in general, less than homes with similar structural characteristics but in a non-post-war building style. This resonates with findings by Buitelaar and Schilder (2017), who, reversely, found a price premium for building styles that are appreciated more than others. The interesting insight provided by the current study is that *unappreciated* building styles also create a price *discount.* Almost all studies as of now into these price effects only investigate premiums caused by attractive styles (e.g., Buitelaar & Schilder, 2017) or only investigate broad, general building periods and styles (e.g., Lindenthal & Johnson, 2021 and Coulson

& McMillen, 2008, Francke & Van de Minne, 2017). The latter studies both find discounts for post-war housing, which is in line with the results from this study. However, none of these studies focusses explicitly on the effect of one explicit post-war style; rather, they provide an overview of the price effects of all building periods. The only study that specifically concerned unappreciated, post-war building styles was by Rolheiser (2021) in the USA, who found a negative vintage effect on socio-economic status of a neighborhood, although this effect displayed a high spatial heterogeneity. Although these studies all hint at a negative price premium for specific post-war building styles, no definite results were available as of yet.

Other post-war building periods (namely 1951 – 1960 and 1961 – 1974) have even larger price discounts relative to the reference period (-6.9% and -10.0% respectively). Other building styles show a relative price premium, with housing built between 2011 – 2021 having the highest premium: +11.4%. The price premiums found for the periods 1986 – 1990 (+1.8%) and 1991 – 2000 (+1.4%) in relation to the post-war periods (1950 – 1985) are somewhat surprising. They are in contrast with findings of Rolheiser et al. (2020), who find no consistent differences in returns between the post-war period 1946 – 1979 and 1980 – 1999. Additionally, they find that pre-war housing (divided into pre-1900 and 1900-1945) both have a higher cumulative return than housing built between 1980 – 1999, while the results of the present study show that pre-war housing actually has a *discount* compared to 1986 – 1990 and 1991 – 2000. An explanation for these contrasting results could be the different methods applied in both studies. Rolheiser et al. investigate the influence of building period on the price *dynamics,* thereby including an explicit time dimension which results in relative premiums or discounts of cumulative returns, rather than the 'simple', non-temporal discounts and premiums from this study. Nevertheless, the different results could still be indicative of varying appreciation for different sub-periods of post-war building styles. If that is the case, the difference could be due to the different periodization used in both studies. A finer specification of building periods might then provide a more nuanced result of the appreciation of specific building styles.

A sidenote should be made in regard to the overall effect of building styles on housing prices. The results show that this effect is rather limited compared to coefficients of other house characteristics. In line with similar findings by Buitelaar and Schilder (2017), Lindenthal (2020) and Visser et al. (2008), the results show that physical housing attributes are by far the most influential indicators for price, and that especially the housing type (e.g., detached or semi-detached) is important in this regard. To put the building style discount into perspective: according to the results of this HPM, a house of 100 m^2 would have a transaction price that is 55% higher than a house of 50 m^2. Similarly, detached housing has a +23% premium relative to terraced housing, while urban renewal only causes a -5% discount.

Regarding the spatial variables, most results of this study are in line with findings from Visser et al. (2008). An interesting contradiction between the two studies concerns the distance to both water and recreational green. In Visser et al. (2008), these attributes appear to be the most important amenities. However, the current results show no significant relationship between housing price and the distance to the nearest water body or recreational green. A few explanations can be put forward for this discrepancy. First, the two studies use slightly different parameters for the presence of water and recreational green. Furthermore, Visser et al. (2008) investigate housing prices on neighborhood level and over the entire Netherlands, a different level of scale than applied in this research. Overall, future research could yield more definite results by combining both levels of scale and through applying a more nuanced definition of 'attractive' green and water facilities by taking different uses and perceptions into account, as also suggested by Luttik (2000) and Daams et al. (2016).

Furthermore, the distance of a house to the nearest monument came forward as one of the most important spatial variables. Although this variable naturally is similar to the distance to the city center in cities with historic centers, it gives an interesting insight into the added value of historical properties in the vicinity of a house. This result is in line with research by Lazrak et al. (2014), who also find premiums for listed monumental buildings in the vicinity in Zaanstad, the Netherlands. This parameter, which is not conventionally used in housing studies employing HPMs, could be useful for future research and give valuable and more in-depth insight into the formation of housing prices in historic centers.

A final contribution of this study to the literature was the use of the Livability index as a parameter for the local social environment. Although the Livability index has its own methodological shortcomings, the results of the HPM shows that it is a suitable parameter for the social environment of a neighborhood. The Livability index might be preferred to other commonly used indicators, such as average income or percentage of non-western migrants, because it is less stigmatizing. However, social status and neighborhood image remain difficult indicators to capture quantitatively, even though this and other studies (e.g., Visser et al., 2008) do suggest that it is an important attribute that significantly influences housing price.

To what extent are clustered urban renewal houses priced differently than isolated urban renewal houses?

This study showed that isolated urban renewal has a significant price premium over clustered urban renewal (+4.9% to +6.1%, depending on the size of the cluster). This suggests that homebuyers appreciate an isolated urban renewal house more than a similar clustered urban renewal house, and are willing to pay a price premium for this. This is in correspondence with the prior expectations, as Van Es and Voerman (2018) report that the large, uniform urban renewal complexes are generally seen as unattractive, while the isolated houses are often better integrated in the surrounding context and have a more attractive direct environment.

These results correspond with several other studies. Lazrak (2014) finds that historic buildings have a price increasing effect on nearby non-historic buildings. The presence of other historic buildings could be a convincing explanation for the price premium for isolated urban renewal, as especially the isolated cases are mainly located in historic centers. Furthermore, Ruijgrok (2006) argues that historic ‘ensemble’-values, meaning the degree in which the houses are in harmony with their (historic) surroundings, can increase prices. Because the design of isolated renewal was especially aimed at integration in the existing historical context, the theory of ensemble-values is applicable here as well. Therefore, the results of this study could support this hypothesis further with statistically significant results. Lastly, Buitelaar and Schilder (2017) find a discount for clustered neo-traditional houses, a relatively popular building style, even though they expected a premium for clustered houses. As an explanation, they propose that this might be due to the fact that people appreciate clustered houses less, because these are less ‘unique’ or ‘authentic’. Additionally, they propose, a larger supply in a specific style would lead to price reductions following the law of supply and demand. Although the latter explanation does not necessarily apply to an ‘unattractive’ style such as urban renewal, it is interesting that both studies find price discounts for clusters, be they in attractive or in unattractive styles. This suggests that ‘uniqueness’ might be an additional factor as to why isolated urban renewal has a price premium, besides integration with the surroundings and positive externalities from historic neighbors. Further research could provide better insight into the precise mechanisms that are beneath the price premium for isolated houses of a particular building style.

Conversely, the results of this study suggest the opposite of results found in a study by Lindenthal (2020). Lindenthal found that uniform clusters in Rotterdam actually have a price premium over heterogenous building styles. However, these different results could also be due to the different methodology applied in this study. Lindenthal determines clusters of homogenous houses by looking at shape similarity determined by an algorithm, instead of at distinctive building periods. In general, the current study contributes to this discussion by presenting empirical support for the notion that price premiums and discounts can be found for isolated and clustered houses, respectively, and that this also holds for a relatively 'unattractive' style, such as urban renewal.

What further factors can visually be identified that are relevant to the price of urban renewal housing?

The photo documentation provides visual cues and anecdotal evidence that support some of the findings that are discussed above. The case studies show that under-appreciated cases can by typified by a monotonous urban renewal building style, in contrast with cases in a more heterogenous urban context. Monotonous urban renewal manifests itself visually through a lack of staggered facades and historizing elements, stony streets with little and isolated greenery, and little detailing. On the contrary, urban renewal is appreciated more when it is seamlessly fitted into the historical context, through mimicking the design of historic structures and through historizing elements, and with plenty of variation in building styles on the street *or* neighborhood level. A street with urban renewal (thus a small cluster) with a pleasant streetscape, plenty of greenery and varied building styles in the semi-direct vicinity does not necessarily have to be less appreciated than other building styles.

An influential factor that comes forward from these findings is the influence of street 'desirability'. As mentioned, the streets of relatively underappreciated houses had 'barren' streetscapes with monotonous housing and street design. This resonates with findings from Kauko (2006b), who finds that home buyers in urban centers deem 'soft' environmental factors, such as street desirability, more important than 'hard' factors such as building density and accessibility. Law et al. (2019) found that 'undesirable' streetscapes cause housing price discounts. In their study, undesirable streetscapes feature wide motorways, little greenery and 'empty'-looking streets, while desirable streetscapes feature narrow streets, abundant greenery and varying building facades. The current study therefore supports the notion of Law et al. (2019) that houses (in urban renewal style) featuring those 'undesirable' streetscapes have lower prices than similar houses in desirable streetscapes. Both studies suggest a promising insight into the potential influence of streetscapes on housing prices. In the field of housing price analysis, it would be interesting for future research to investigate this effect further. The machine learning methods applied by Law et al. (2019) allow an efficient analysis of streetscape desirability of a large number of streets and houses, while qualitative research could provide an insight into the details of the streetscape that make it desirable and investigate the differing perceptions of residents on the desirability of 'their' street.

Another finding from the photo documentation and on-site visits was that nearly all underappreciated cases were located in specific working-class neighborhoods ('volksbuurten'). This fact is likely related to the findings above, as these neighborhoods saw relatively large-scale demolition and homogenous redevelopment because of the general poor state of the houses of the working-class population (Liagre Böhl, 2012; Van Es & Voerman, 2018). The overrepresentation of these neighborhoods in the photo documentation suggests that the image of working-class neighborhoods might influence housing prices, a factor that is not included in the model. Although socio-economic status is included in the model through the Livability score, the 'image' of a neighborhood is a different concept than socio-economic status. Socio-economic status can be measured (more or less) objectively through average income and other statistics. Image, on the other hand, is much more subjective. 'Volksbuurten' are often associated with low education, nuisance, unemployment and a high degree of social housing, but they can also be characterized by a high degree of social cohesion. Similarly, the image of a 'volksbuurt' can be attractive to some homebuyers and unattractive to others. A notable study that corresponds with these findings is Kauko (2006b), who finds that, in urban centers in the Randstad, neighborhood image is one of the most important determinants for housing choice. This study provides anecdotal insight into how neighborhood images (and by extension their effect on housing prices) are much more nuanced and complex than normally captured in a handful of socio-economic parameters. It provides an example of a specific type of neighborhood with a particular image which apparently leads to a noticeable price anomaly. This suggests that, at least in some cases, neighborhood image might have a more far-reaching effect on price than commonly assumed in housing price studies, but also that this effect is complex and subjective and therefore difficult to capture quantitatively.

6. Discussion

6.1. Limitations

Several limitations can be identified for this study. One limitation was the fact that the NVM data was only available at PC6 level. This has several implications for the quality of the results. First, although PC6 is still a relatively detailed resolution, some error is bound to be introduced in the spatial variables as these consist of distances calculated from each house to a certain facility. Because of the PC6 resolution, houses in the same street section receive the same coordinates. Secondly, the PC6 resolution makes the clustering algorithm somewhat less reliable, as the spatial threshold is quite low for attributing a certain house to a cluster or not. Therefore, the error introduced by the PC6 resolution can make the difference between an isolated and a clustered case. Thirdly, the PC6 resolution makes it more difficult to connect the outliers to the correct house for photo documentation. Therefore, it is not completely certain that the houses photographed are identical to the house in the transaction. However, when there was doubt as to what house the transaction concerned, the consideration was made whether this could have a distorting effect on the result. For example, if the exact address is unknown but all houses in a street look almost identical, the uncertainty does not necessarily affect the quality of the photo documentation.

Another practical limitation was the presence of errors in the dataset. After several transactions were encountered with highly unlikely values for floor surface (e.g., apartments of 1000 m^2), it appeared that there were non-systematic errors in the dataset, perhaps introduced through typos during data entry by the realtors. This indicates that as of yet no quality control is in place to check this dataset for such errors. As a resolution, all floor surfaces that are larger than 500 m^2 have been removed from the dataset, with the risk of removing some (very spacious) houses that were not faulty. Furthermore, despite the findings derived from the photo documentation, it is still likely that a part of the difference in prices cannot be explained through the visual factors alone. Some outliers deviated to such a substantial extent from the predicted value, up to €300,000, that it is unlikely that this is only due to factors that can be visually identified, such as the streetscape or exterior design. Possible explanations for this could have to do with the financial context, such as home-owners selling their house to loved ones for a reduced price, or it could have to do with the unobserved interior design, for example a very inconvenient lay-out or outdated design. Unfortunately, it was not possible to retrieve an explanation for these specific price differences.

Lastly, an important limitation pertaining to the investigation into the urban renewal style is the fact that a substantial portion of the existing urban renewal stock is still being used as social housing. Naturally, social housing is not represented in the NVM dataset, and the transaction prices are unknown. This limitation has been corrected in the DBSCAN cluster analysis by adding BAG data within the correct building period to the dataset, but urban renewal social housing is still 'missing' from both HPMs. This means that the sample of urban renewal does not represent all urban renewal housing. Social urban renewal housing is predominantly located in the city center or in neighborhoods directly adjacent to the city center. Therefore, it is likely that there is a bias in the HPM towards the characteristics of owner-occupied urban renewal which are generally located further away from the center. Additionally, this means that the HPMs represent the preferences and appreciation of homebuyers of urban renewal, and does not represent the tastes of residents who rent urban renewal. Although this is quite a severe limitation, it is simply impossible to conduct an HPM without transaction prices, and the current method provides the most reliable insight into the appreciation of urban renewal.

6.2. Policy implications

The outcomes of this research have practical implications for government institutions that are involved with housing market dynamics and those who formulate policy to face the current housing crisis in the Netherlands. Firstly, insights into the price effect and appreciation of building styles can be used by policy makers to either themselves develop dwellings that are more closely aligned with the preferences of homebuyers, or to give priority to external developers who wish to do so. Secondly, a deeper understanding of the urban renewal period in particular can be valuable to policy makers because of the many parallels between the current housing problems and the challenges of the 1970s and 80s, as also pointed out by Blom and Timmer (2022). Since inner-city development is once again one of the main solutions to the current housing shortage, lessons learned from the urban renewal inner-city development can prove helpful to avoid mistakes and support effective housing development that will be appreciated by future residents. For example, the results of this study show that, in general, homebuyers appreciate integrative architecture that blends into the existing context, and depreciate clusters of homogenous design.

6.3. Recommendations for future research

Besides the several recommendations for research that have already been made in the discussion of the individual research questions, two additional recommendations are mentioned here. First, although no sign of re-appreciation could be identified in this study, future research could keep a close eye on the dynamics of specific building styles. This remains an under researched topic, while re-appreciation dynamics have been identified in other geographical contexts and for other post-war styles (Blom et al., 2004; Coulson & McMillen, 2008; Rolheiser et al., 2020). Future researchers should consider that these re-appreciation trends are perhaps more dependent on the specific building style than the age of the building and the related vintage effects, especially since certain building styles age more 'elegantly' because of their functionality and structural soundness, while others could remain 'unappreciated'. Especially research into the style premiums or discounts of a variety of post-war building styles could provide interesting insight into this.

Secondly, future research should focus on understanding the price effects of 'soft' environmental factors, such as the different perspectives on the neighborhood image or a desirable streetscape. Machine learning techniques provide a promising methodology for research into the latter, while mixed methods and qualitative research could be appropriate methods for the former. The challenges for investigating the effect of neighborhood image and streetscape on the appreciation of residents lie mainly in the complexity and subjectivity inherent in both of the aspects. Future research could look for new ways in which these aspects can be incorporated and translated into a general measurement of 'appreciation', perhaps through new methodologies that put less emphasis on transaction prices. Additionally, methods that integrate the preferences of people who rent (especially social housing), which are now often excluded from analysis, would reduce the bias towards the preferences of home-owners and could provide a better reflection of the preferences of the complete population. The extensive question of the interplay between building design and the varying appreciation of residents still requires new insights, especially insights that are data-driven and look into the less-measurable and more holistic part of 'appreciation'.

7. Literature

Abbott, J. K., & Klaiber, H. A. (2011). An embarrassment of riches: Confronting omitted variable bias and multi-scale capitalization in hedonic price models. *Review of Economics and Statistics, 93*(4), 1331-1342.

Ahlfeldt, G. & Mastro, A. 2012. Valuing Iconic Design: Frank Lloyd Wright Architecture in Oak Park, Illinois. *Housing Studies, 27*(8), 1079–1099.

Albers, A. (2021). Designing with ‘direct democracy’: Local residents, architects and the design of urban renewal in Amsterdam, 1970–1990. *Bulletin KNOB,* 1-19.

Anselin, L., & Arribas-Bel, D. (2013). Spatial fixed effects and spatial dependence in a single cross-section. *Papers in Regional Science, 92*(1), 3-17.

Anselin, L., & Lozano-Gracia, N. (2009). Spatial hedonic models. In T. C. Mills (Ed.) *Palgrave handbook of econometrics* (pp. 1213-1250). London: Palgrave Macmillan.

Anselin, L., Syabri, I., & Kho, Y. (2006). GeoDa: An introduction to spatial data analysis. *Geographical Analysis*, 38(1), 5-22.

Archer, W. R., Gatzlaff, D. H., & Ling, D. C. (1996). Measuring the importance of location in house price appreciation. *Journal of Urban Economics, 40*(3), 334-353.

Arundel, R., & Hochstenbach, C. (2020). Divided access and the spatial polarization of housing wealth. *Urban Geography*, *41*(4), 497-523.

Atzema, O. A. (1991). *Stad uit, stad in: residentiële suburbanisatie in Nederland in de jaren zeventig en tachtig.* Utrecht: Geografisch Instituut, Rijksuniversiteit Utrecht.

Barzilay, M., Ferwerda, R., & Blom, A. M. (2018). *Predicaat experimentele woningbouw 1968-1980: verkenning Post 65.* Cultural Heritage Agency of the Netherlands.

Beek, M. (2019, July 9). VVD: Rotterdam is te lelijk, sloop de woningen uit de jaren zeventig en tachtig. *AD/AlgemeenDagblad.nl*

Been, V., Ellen, I. G., Gedal, M., Glaeser, E., & McCabe, B. J. (2014). *Preserving history or hindering growth? The heterogeneous effects of historic districts on local housing markets in New York City* (No. w20446). Cambridge, MA: National Bureau of Economic Research.

Bervaes, J. C. A. M., & Vreke, J. (2004). *De invloed van groen en water op de transactieprijzen van woningen* (No. 959). Wageningen: Alterra.

Blom, A., Jansen, B. & Van der Heiden, M. (2004). *De typologie van de vroeg-naoorlogse woonwijken.* Amersfoort: Cultural Heritage Agency of the Netherlands.

Blom, A. & Timmer, P. (2019). *Hersteld verleden van dorpen en steden: Stads- en dorpsgezichten tijdens de stadsvernieuwing (1961-1985).* Amersfoort: Cultural Heritage Agency of the Netherlands.

Blom, A., & Timmer, P. (2022). Stadsvernieuwing en stads-en dorpsgezichten in de periode 1961-1985: Een geslaagde maar vergeten vectorbenadering. *Tijdschrift voor Historische Geografie, 7*(1), 65-85.

Bourassa, S., Cantoni, E., & Hoesli, M. (2007). Spatial dependence, housing submarkets, and house price prediction. *The Journal of Real Estate Finance and Economics, 35*(2), 143-160.

Bourassa, S., Hoesli, M. and Sun, J. (2004) What’s in a view? *Environment and Planning A, 36*(8), 1427–1450.

Bourassa, S., Hoesli, M., & Sun, J. (2005). The price of aesthetic externalities. *Journal of Real Estate Literature, 13*(2), 167-187.

Brorsson, A., Öhman, A., Lundberg, S., Cutchin, M. P., & Nygård, L. (2020). How accessible are grocery shops for people with dementia? A qualitative study using photo documentation and focus group interviews. *Dementia, 19*(6), 1872-1888.

Buitelaar, E., & Schilder, F. (2017). The economics of style: measuring the price effect of neo-Traditional architecture in housing. *Real Estate Economics, 45*(1), 7-27.

Coulson, N. E., & McMillen, D. P. (2008). Estimating time, age and vintage effects in housing prices. *Journal of Housing Economics, 17*(2), 138-151.

Cultural Heritage Agency of the Netherlands (2020). *Rijksmonumentenregister* [dataset]. Retrieved from https://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/53b60b71-2611-4fda-9aa8-5bfd33afd470?tab=contact

Daams, M. N., Sijtsma, F. J., & van der Vlist, A. J. (2016). The effect of natural space on nearby property prices: accounting for perceived attractiveness. *Land Economics, 92*(3), 389-410.

Daams, M. N., Sijtsma, F. J., & Veneri, P. (2019). Mixed monetary and non-monetary valuation of attractive urban green space: A case study using Amsterdam house prices. *Ecological Economics*, *166*, 106430.

De Jong, T. (2018, May 19). Mooi van lelijkheid. *AD/Utrechts Nieuwsblad.*

De Jonge, H. (2022, April 14). Leefbaarheid in Nederland 2020 [letter of government]. Retrieved from https://www.leefbaarometer.nl/resources/kamerbrief-bij-rapporten-leefbaarometer-30-instrumentenontwikkeling-en-leefbaarheid-in-nederland-2020.pdf

De Kruijff, N. (2020, August 19). Utrechtse volksbuurt Ondiep houdt adem in voor nieuwe rellen. *Algemeen Dagblad.* Retrieved from https://www.ad.nl/utrecht/utrechtse-volksbuurt-ondiep-houdt-adem-in-voor-nieuwe-rellen-die-gastjes-voelen-zich-onaantastbaar~aeb1b7a0/

De Liagre Böhl, H. (2012). *Steden in de steigers: Stadsvernieuwing in Nederland 1970-1990.* Amsterdam: Uitgeverij Bert Bakker.

De With, T. (2021, September 3). Open Monumentendagen: Rondleidingen langs bijzonder renovatieproject in de Oude Kooi. *Leidsch Dagblad.* Retrieved from https://www.leidschdagblad.nl/cnt/dmf20210903_81539731?utm_source=google&utm_medium=organic

Debrezion, G., Pels, E., & Rietveld, P. (2011). The impact of rail transport on real estate prices: an empirical analysis of the Dutch housing market. *Urban studies, 48*(5), 997-1015.

Ester, M., Kriegel, H. P., Sander, J., & Xu, X. (1996, August). A density-based algorithm for discovering clusters in large spatial databases with noise. In *Proceedings of the Second International Conference on Knowledge Discovery and Data Mining* (pp. 226-231). Munich: Institute for Computer Science.

Francke, M. K., & van de Minne, A. M. (2017). Land, structure and depreciation. *Real Estate Economics, 45*(2), 415-451.

Garretsen, H. & Marlet, G. (2017). Amenities and the attraction of Dutch cities. *Regional Studies (51)*5, 724-736.

Gemeente Utrecht (2015). *Buurtenverkenning: Acht Utrechtse buurten onder de loep*. Utrecht: Volksgezondheidsmonitor Utrecht. Retrieved from https://www.volksgezondheidsmonitor.nl/overige-publicaties/page3.html

Glaeser, E. L., Kominers, S. D., Luca, M., & Naik, N. (2018). Big data and big cities: The promises and limitations of improved measures of urban life. *Economic Inquiry, 56*(1), 114-137.

Hall, T. (2009). The camera never lies? Photographic research methods in human geography. *Journal of Geography in Higher Education, 33*(3), 453-462.

Helbich, M., Jochem, A., Mücke, W., & Höfle, B. (2013). Boosting the predictive accuracy of urban hedonic house price models through airborne laser scanning. *Computers, environment and urban systems, 39*, 81-92.

Hochstenbach, C., & Arundel, R. (2020). Spatial housing market polarisation: National and urban dynamics of diverging house values. *Transactions of the Institute of British Geographers, 45*(2), 464-482.

Huisman, C. (2012, February 20). Volksbuurt leeft op na renovatie. *De Volkskrant.* Retrieved from https://zeinstraveerbeek.nl/wp-content/uploads/2013/03/ondiep-volkskrant-022012.pdf

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). *An introduction to statistical learning: with applications in R*. New York City: Springer.

Janson, L. (2017, May 2). Leidse hangjeugd terroriseert De Kooi. *Leidsch Dagblad*. Retrieved from https://m.leidschdagblad.nl/cnt/dmf20180926_21024164?utm_source=google&utm_medium=organic

Kadaster & Centraal Bureau voor de Statistiek (2015). *Bestand Bodemgebruik 2015* [dataset]. Retrieved from https://www.nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/6318009c-7b11-4ab9-9929-735584dfb692?tab=general

Kadaster & Centraal Bureau voor de Statistiek (2021). *Wijk- en buurtkaart 2021* [dataset]. Retrieved from https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/wijk-en-buurtkaart-2021

Kadaster (2022). *BAG* [dataset]. Downloaded on April 11, 2022 from https://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/aa3b5e6e-7baa-40c0-8972-3353e927ec2f?tab=general

Kang, Y., Zhang, F., Gao, S., Peng, W., & Ratti, C. (2021). Human settlement value assessment from a place perspective: Considering human dynamics and perceptions in house price modeling. *Cities*, *118*, 1-14.

Kauko, T. (2006a). What makes a location attractive for the housing consumer? Preliminary findings from metropolitan Helsinki and Randstad Holland using the analytical hierarchy process. *Journal of Housing and the Built Environment, 21*(2), 159-176.

Kauko, T. (2006b). Expressions of housing consumer preferences: Proposition for a research agenda. *Housing, Theory and Society, 23*(2), 92-108.

Koster, H. R., & Rouwendal, J. (2017). Historic Amenities and Housing Externalities: Evidence from the Netherlands. *Economic Journal, 127*(605), 396-420.

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.

Law, S., Paige, B., & Russell, C. (2019). Take a look around: using street view and satellite images to estimate house prices. *ACM Transactions on Intelligent Systems and Technology (TIST), 10*(5), 1-19.

Lazrak, F., Nijkamp, P., Rietveld, P., & Rouwendal, J. (2014). The market value of cultural heritage in urban areas: an application of spatial hedonic pricing. *Journal of Geographical Systems, 16*(1), 89-114.

Le Clercq, F., & de Vries, J. S. (2000). Public transport and the compact city. *Transportation research record, 1735*(1), 3-9.

Leefbaarometer (2020). *Leefbaarometer 3.0 Meting 2020* [database]. Retrieved from https://www.leefbaarometer.nl/page/Open%20data

Lindenthal, T. (2020). Beauty in the Eye of the Home-Owner: Aesthetic Zoning and Residential Property Values. *Real Estate Economics, 48*(2), 530-555.

Lindenthal, T., & Johnson, E. B. (2021). Machine learning, architectural styles and property values. *The Journal of Real Estate Finance and Economics*, online publication, 1-32. doi.org/10.1007/s11146-021-09845-1

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.

Lynch, K. (1960). The image of the environment. In *The Image of the City* (pp. 1-13). Cambridge: MIT Press.

Mandemakers, J., Leidelmeijer, K., Burema, F., Halbersma, M. & Veldkamp, J. (2021). *Instrumentontwikkeling Leefbaarometer 3.0.* Atlas Research. Retrieved from https://www.leefbaarometer.nl/resources/LBM3Instrumentontwikkeling.pdf

Markwell, K. W. (2000). Photo-documentation and analyses as research strategies in human geography. *Australian Geographical Studies, 38*(1), 91-98.

Millhouse, J. A. (2005). *Assessing the effect of architectural design on real estate values: A qualitative approach* [Doctoral dissertation, Massachusetts Institute of Technology].

Nase, I., Berry, J., & Adair, A. (2016). Impact of quality-led design on real estate value: a spatiotemporal analysis of city centre apartments. *Journal of Property research, 33*(4), 309-331.

Nationaal Wegenbestand (2022). *NWB – wegen* [database]. Retrieved from https://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/59c35abe-1749-44da-afe9-548ed5028f9e

Nijkamp, P. (2012). Economic valuation of cultural heritage. In: G. Licciardi, & R. Amirtahmasebi. (Eds.), *The economics of uniqueness: investing in historic city cores and cultural heritage assets for sustainable development* (75-103). Washington D.C.: World Bank Publications.

OpenStreetMap Contributors (2017). *Planet dump* [database]. Retrieved from https://planet.openstreetmap.org

Plaut, S., & Uzulena, E. (2006). Architectural Design and the Value of Housing in Riga, Latvia. *International Real Estate Review, 9*(1), 112-131.

ProRail (2022). *Spoorwegen* [dataset]. Retrieved from https://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/061d5632-41f0-430a-a69d-7564960eb077?tab=general

Province of South Holland (2022). *Voorzieningen voor de Samenlevingsatlas* [dataset]. Retrieved from https://nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/E421FF3C-A264-477F-9863-225C63071FEE?tab=general

Qiu, W., Zhang, Z., Liu, X., Li, W., Li, X., Xu, X., & Huang, X. (2022). Subjective or objective measures of street environment, which are more effective in explaining housing prices? *Landscape and Urban Planning*, *221*, 104358.

Rolheiser, L. (2021). Old, small and unwanted: Post-war housing and neighbourhood socioeconomic status. *Urban Studies, 58*(14), 2952-2970.

Rolheiser, L., Van Dijk, D. & Van de Minne, A. (2018). *Does housing vintage matter? Exploring the historic city center of Amsterdam* (Paper No. 617). Amsterdam: De Nederlandsche Bank.

Rolheiser, L., van Dijk, D., & van de Minne, A. (2020). Housing vintage and price dynamics. *Regional Science and Urban Economics*, *84*, 1-12.

Rong, H., Yang, J., Kang, M., & Chegut, A. (2020). The value of design in real estate asset pricing. *Buildings, 10*(10), 178.

Ronteltrap, C., Konadu, D. & Marquard, A. (2016). *Basissyllabus Inleiding Waarderen* [syllabus]. Amsterdam: Amsterdam School of Real Estate.

Rose, G. (2012). *Visual methodologies: An introduction to researching with visual materials.* Thousand Oaks: Sage.

Rosen, S. (1974). Hedonic prices and implicit markets: product differentiation in pure competition. *Journal of political economy, 82*(1), 34-55.

Ruijgrok, E. C. (2006). The three economic values of cultural heritage: a case study in the Netherlands. *Journal of cultural heritage, 7*(3), 206-213.

Savini, F., Boterman, W. R., Van Gent, W. P., & Majoor, S. (2016). Amsterdam in the 21st century: Geography, housing, spatial development and politics. *Cities*, *52*, 103-113.

Sequeira, V., & Filippova, O. (2021). Does concentration of social housing influence house prices? Evidence from New Zealand. *International Journal of Housing Markets and Analysis, 14*(4), 720-744.

Sirmans, G. S., MacDonald, L., Macpherson, D. A., & Zietz, E. N. (2006). The value of housing characteristics: a meta-analysis. *The Journal of Real Estate Finance and Economics, 33*(3), 215-240.

Suchar, C. (1997). Grounding visual sociology research in shooting scripts. *Qualitative sociology, 20*(1), 33-55.

Suchar, C. (2004). Amsterdam and Chicago: Seeing the macro-characteristics of gentrification. In C. Knowles and J. Sweetman (Ed.) *Picturing the social landscape: Visual methods and the sociological imagination,* (pp. 147-165). Milton Park: Routledge.

Uitermark, J., Hochstenbach, C., & van Gent, W. (2017). The statistical politics of exceptional territories. *Political Geography*, *57*, 60-70.

Utrechts Nieuwsblad (2004, April 28). Utrecht houdt vast aan sloop deel Ondiep. Retrieved from https://advance-lexiscom.proxy.library.uu.nl/api/document?collection=news&id=urn:contentItem:4C86-VCF0-01HD-R0N3-00000-00&context=1516831.

Van der Zande, I. & Manders, R. (2015). *Sociografisch Buurtprofiel Leiden Noord.* Leiden: Libertas Leiden. Retrieved from https://www.libertasleiden.nl/wp-content/uploads/2019/05/Sociografisch-Buurtprofiel-Leiden-Noord.pdf

Van Dijk, D. W., & Francke, M. K. (2018). Internet search behavior, liquidity and prices in the housing market. *Real Estate Economics, 46*(2), 368-403.

Van Duijn, M., Rouwendal, J., & Boersema, R. (2016). Redevelopment of industrial heritage: Insights into external effects on house prices. *Regional Science and Urban Economics, 57*, 91-107.

Van Es, E. & Voerman, L. (2018). *Stadsvernieuwing in Stroomversnelling: Inventarisatie stadsvernieuwingsplannen Interim Saldo Regeling 1977 – 1985.* Amersfoort: Cultural Heritage Agency of the Netherlands.

Van Walsum, S. (2019, April 19). Baudet heeft gelijk: Nederland lijdt onder sterarchitecten. *De Volkskrant.nl.*

Vermeijden, B. (2001). Dutch urban renewal, transformation of the policy discourse 1960–2000. *Journal of Housing and the Built Environment*, *16*(2), 203-232.

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.

Von Graevenitz, K., & Panduro, T. E. (2015). An alternative to the standard spatial econometric approaches in hedonic house price models. *Land Economics, 91*(2), 386-409.

Waaldijk, M. (2020). *Een 'nieuwe' architectonische opgave: Onderzoek naar de contextuele benadering in de architectuur van Aldo van Eyck en Theo Bosch* [Master's thesis, Utrecht University].

Waard, C. (2021, January 26). Gebied rondom Kooipark verboden voor relschoppers. *Sleutelstad.* Retrieved from https://sleutelstad.nl/2021/01/26/burgemeester-stelt-noodverordening-in-voor-gebied-rond-kooipark/

Wheaton, W. C. (1999). Real estate "cycles": some fundamentals. *Real estate economics, 27*(2), 209-230.

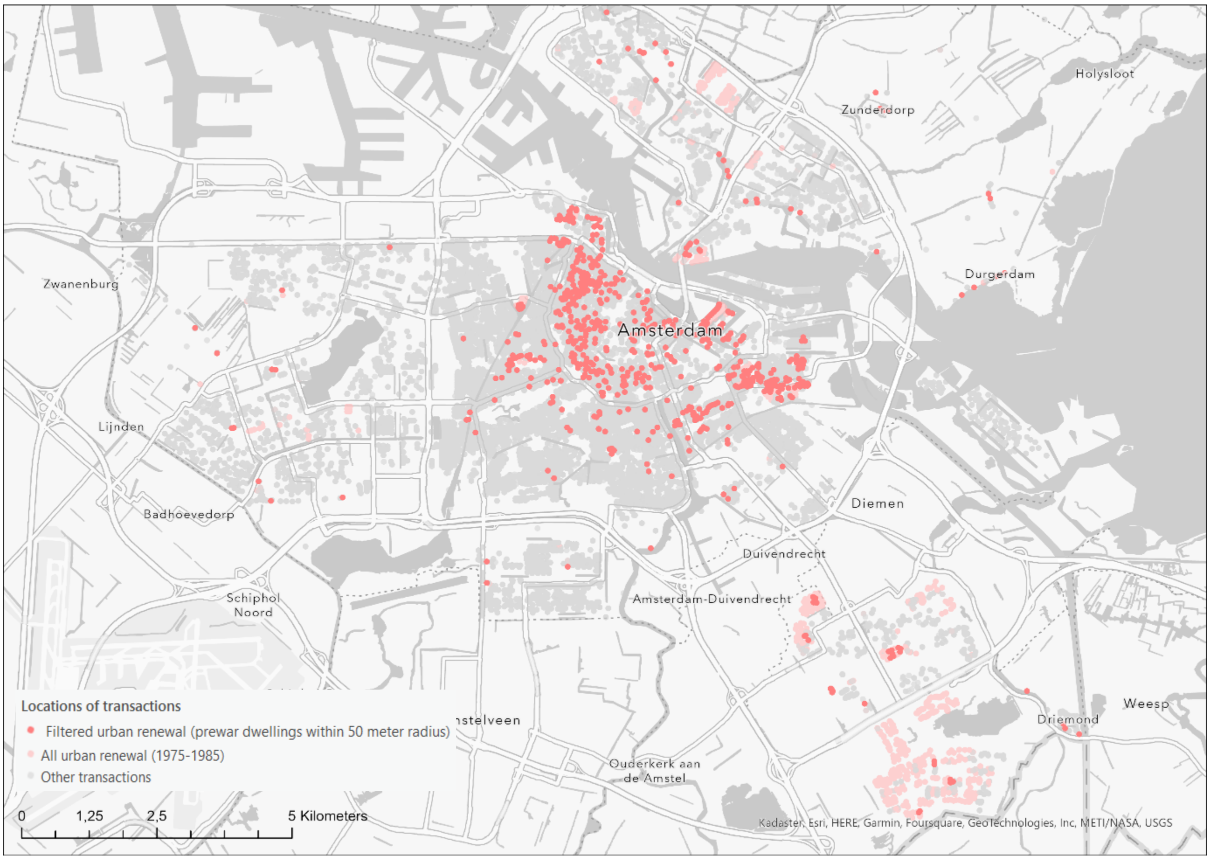
Appendices

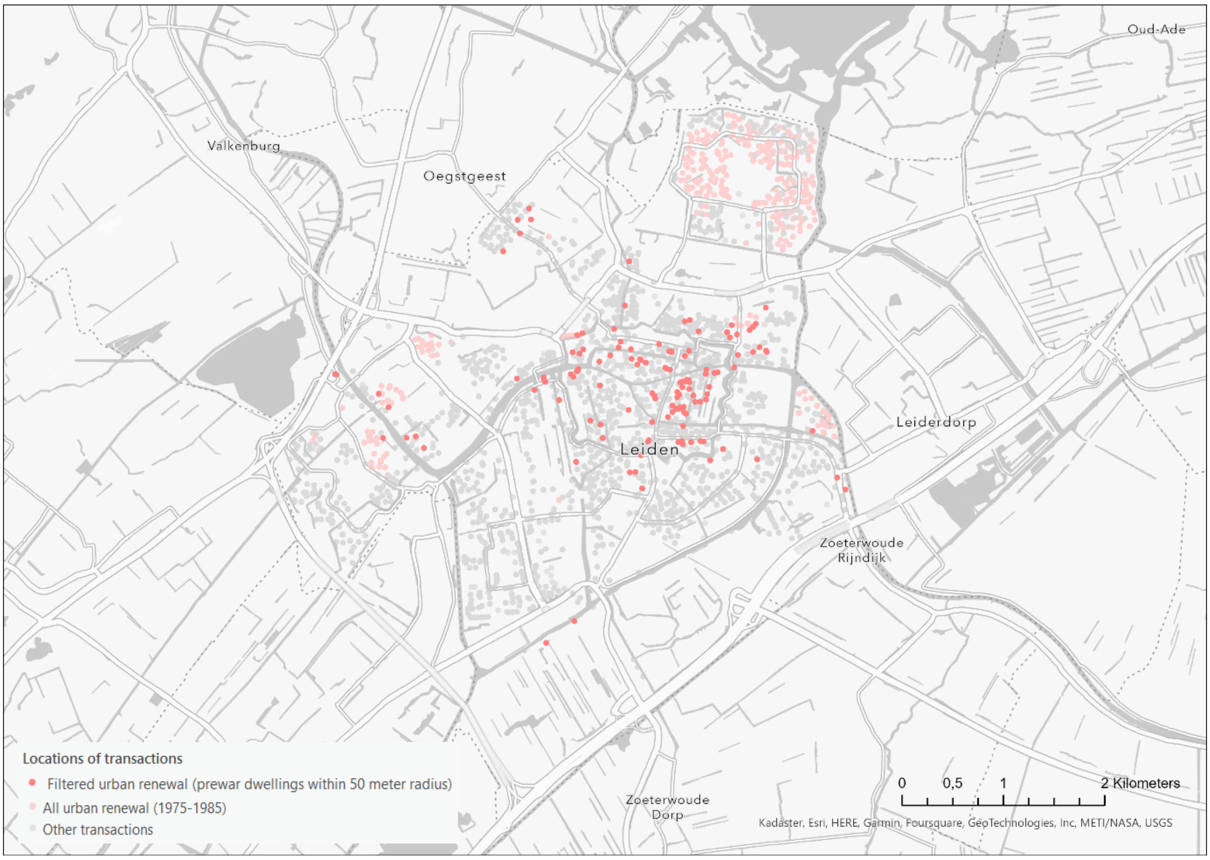
1. Shooting script

- How is the exterior of the house designed?
    - What are the architectural forms and features?
    - What materials are used?
    - How does the house fit in with the surrounding structures?
- What is the quality of the view from the house?
    - What can be seen from the house?
    - What is the scope of the view?
- What is the quality of the landscape around the house?
    - What is the quality of the surrounding structures? Is there variation in building structures?
    - If any, what kind of natural areas are nearby?
    - How pleasant is the street? How wide, empty or busy is it?
- What is the pleasantness of the neighborhood?
    - What kind of people walk by?
    - If any, what kind of services does the neighborhood have?
    - If known, what is the image of the neighborhood and how does this manifest itself visually?

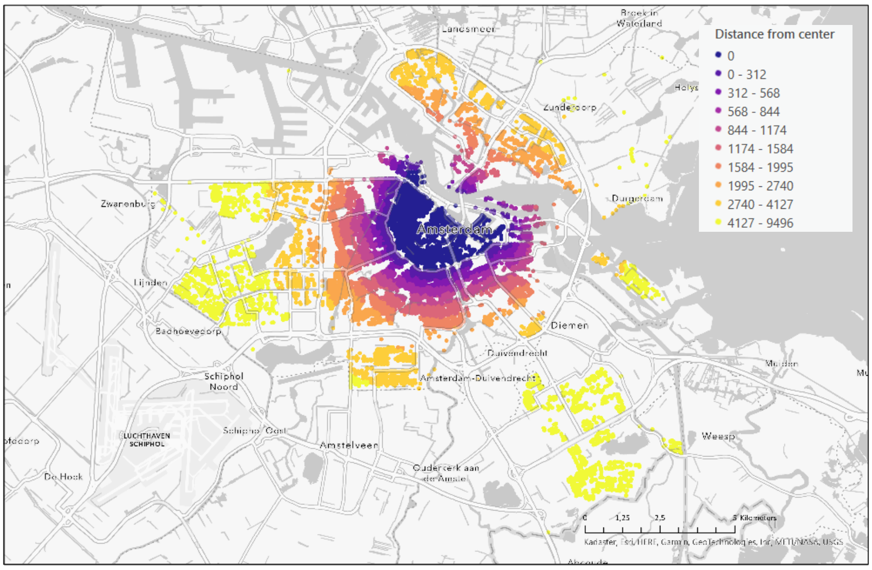
2. Maps of urban renewal locations and spatial variables

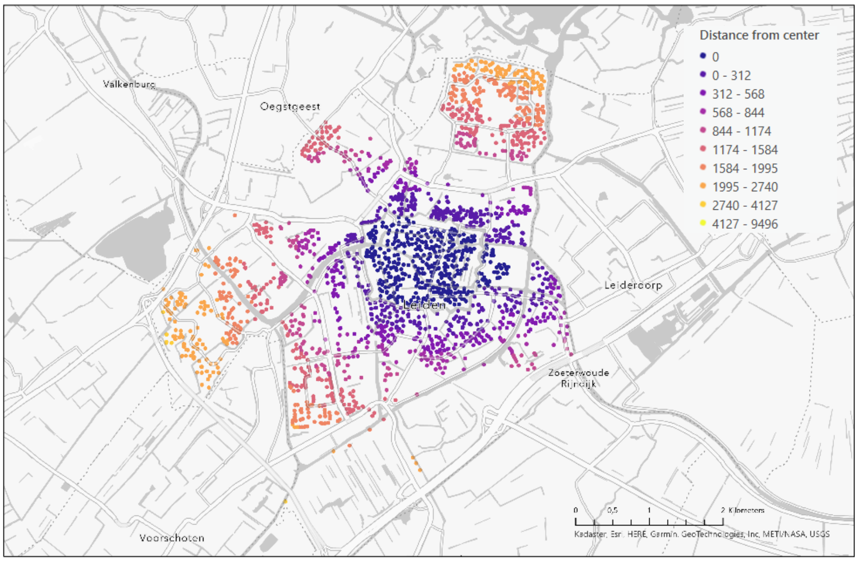
2.1 Locations of urban renewal transactions before and after filtering

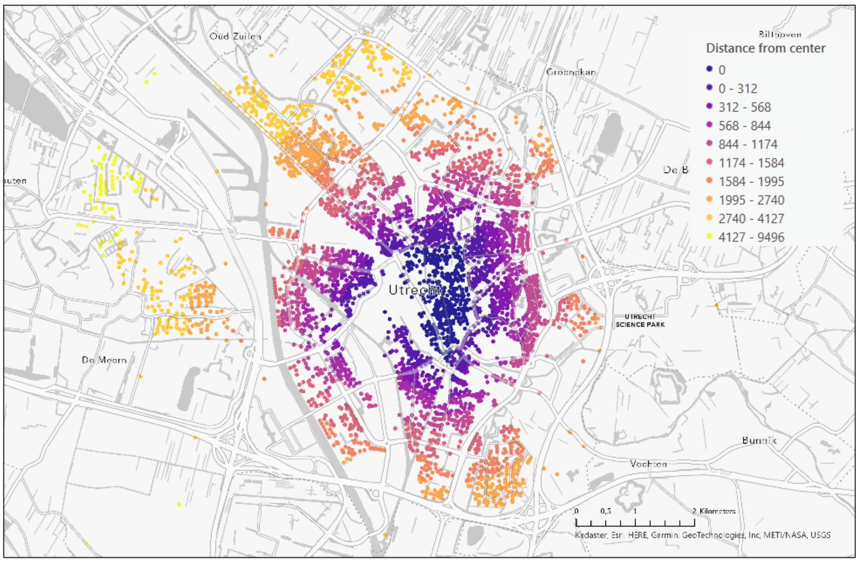




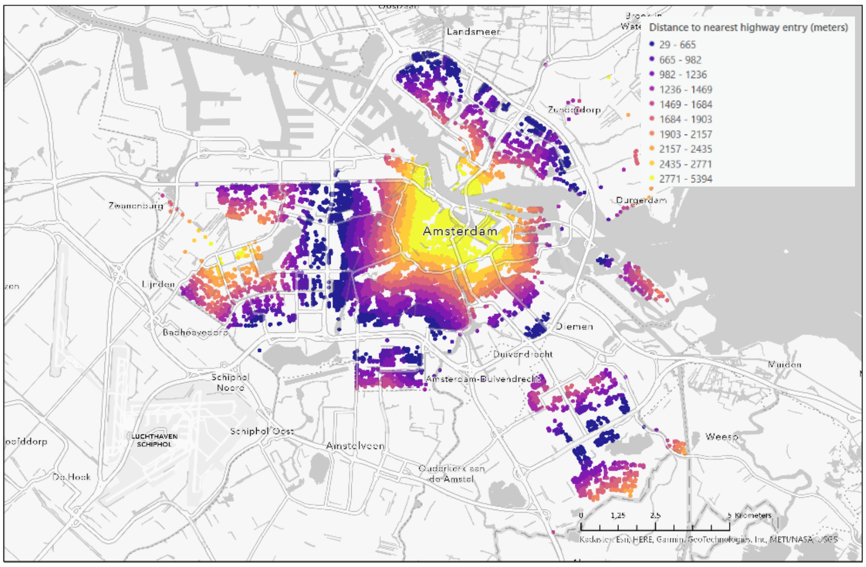
2.2 Distance to city center

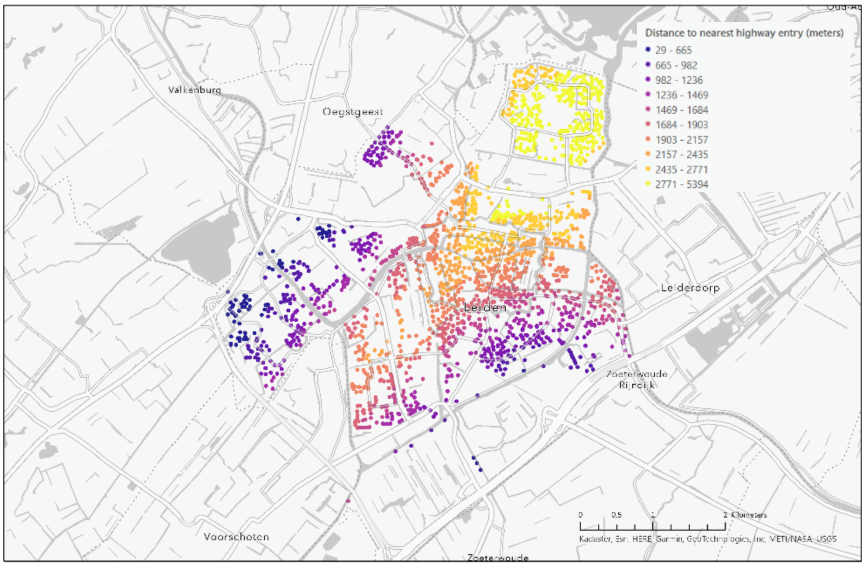


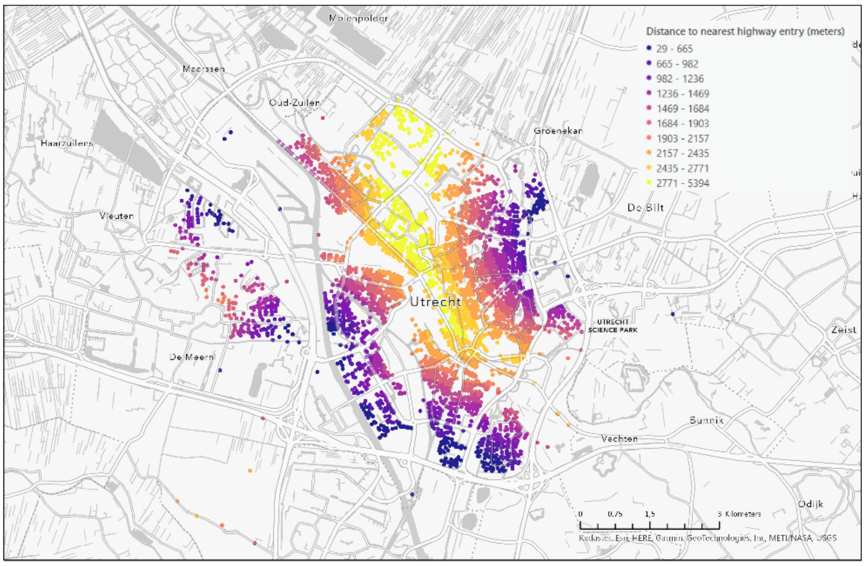




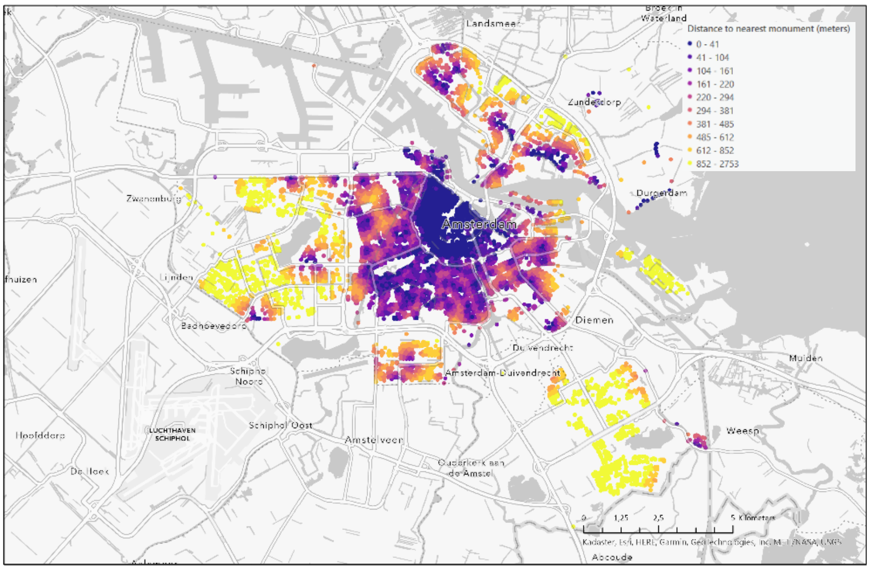
2.3 Distance to nearest highway entry

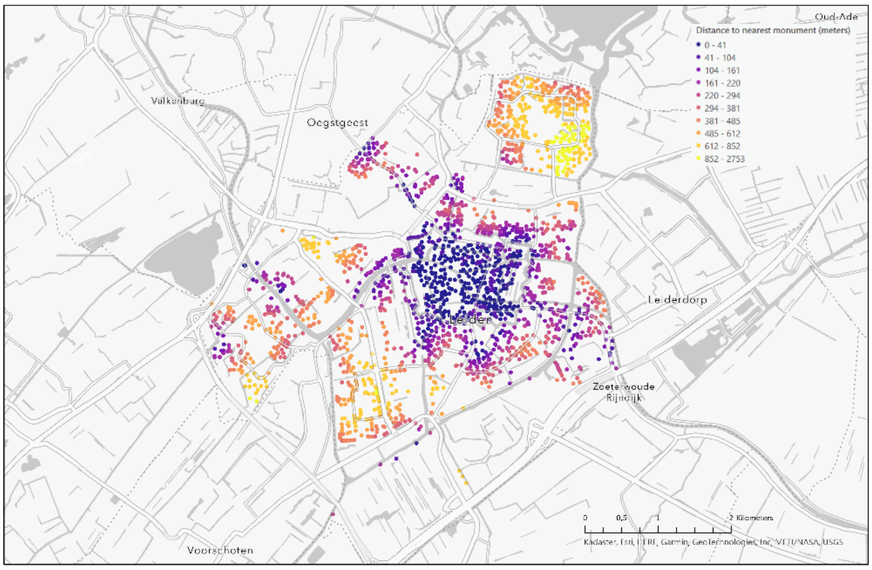


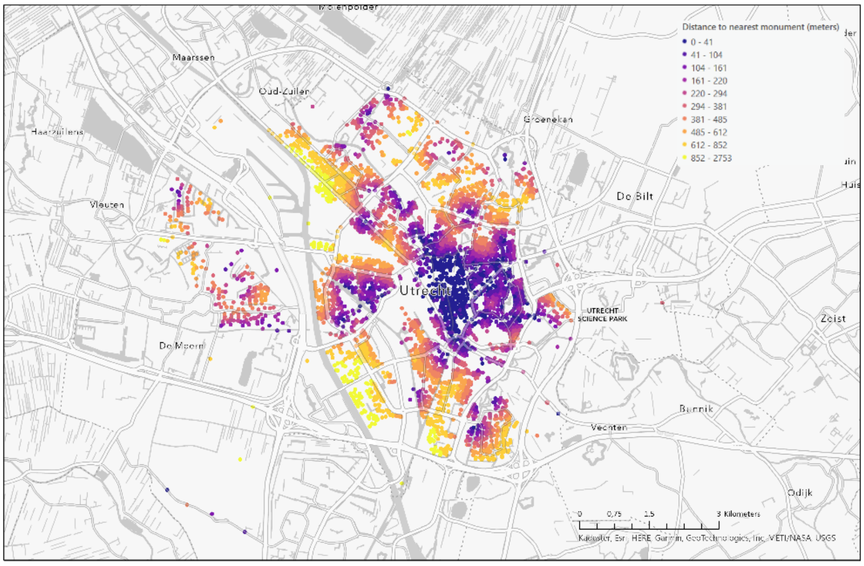




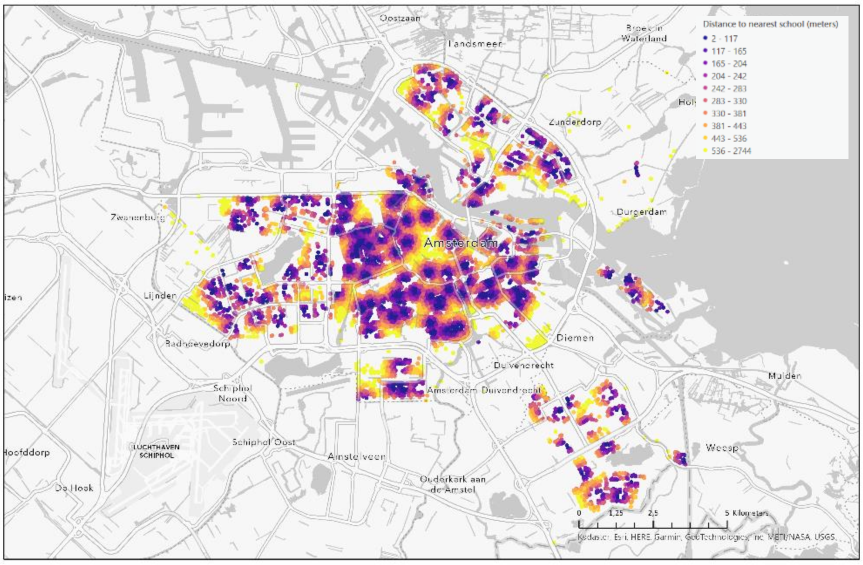
2.4 Distance to nearest monument

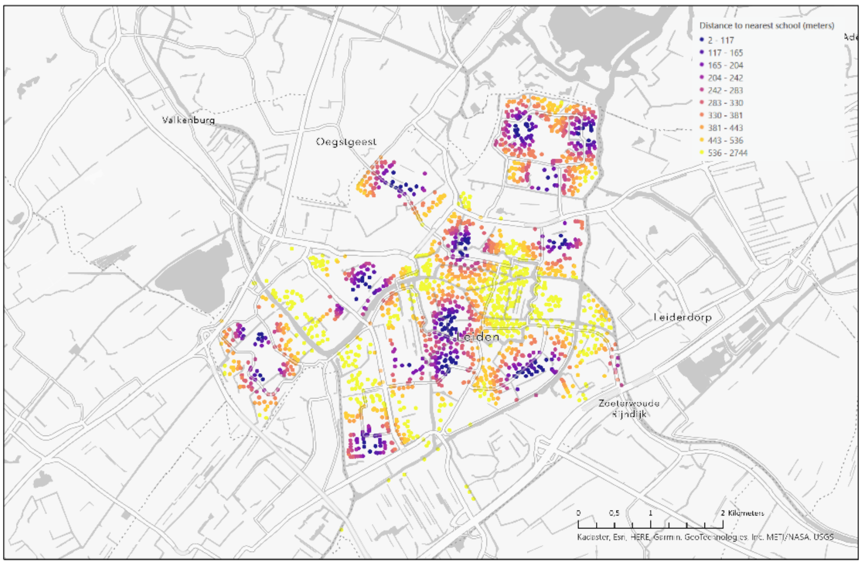


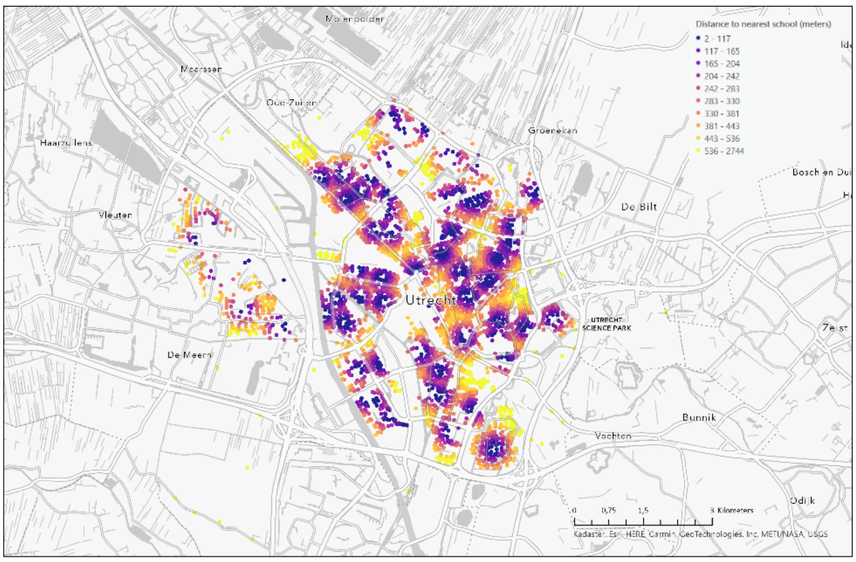




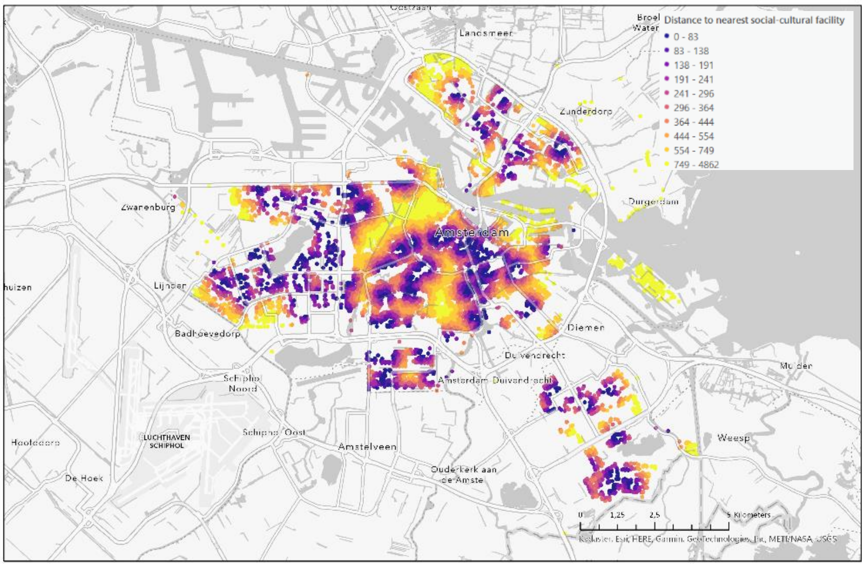
2.5 Distance to nearest elementary school

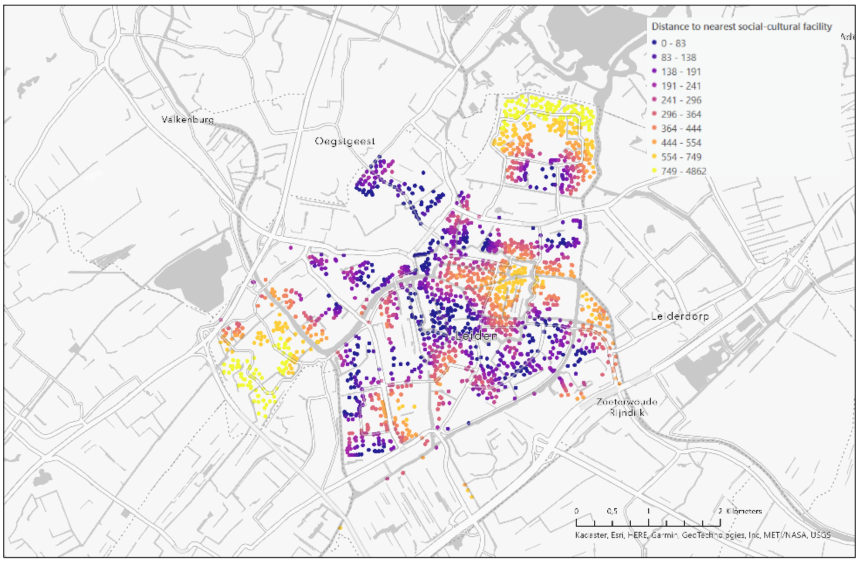


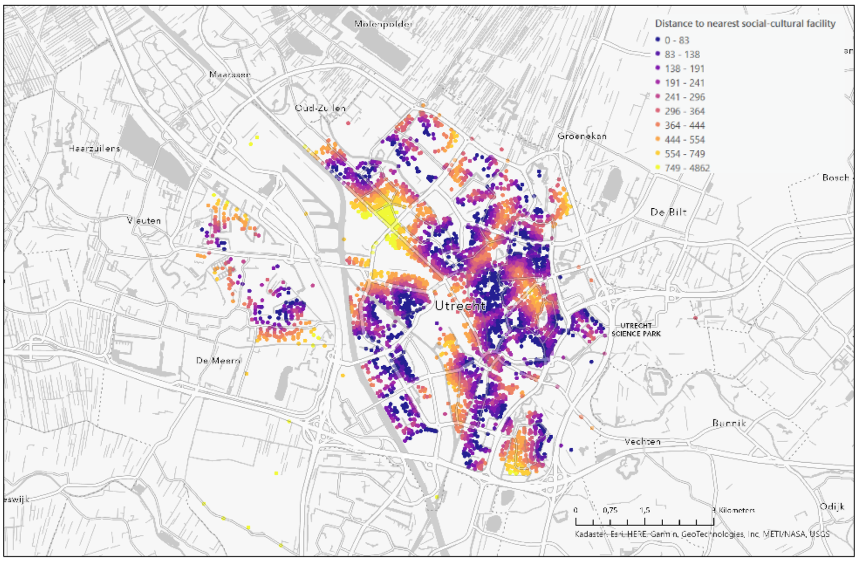




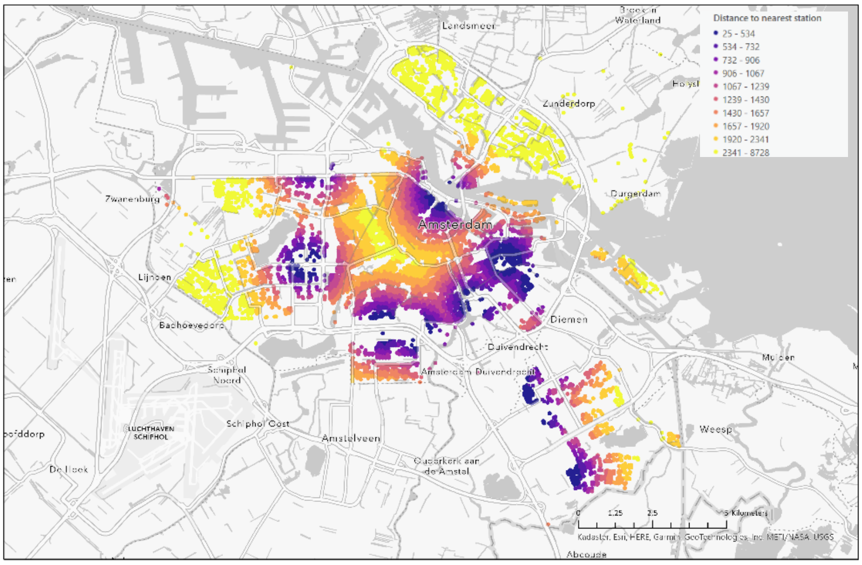
2.6 Distance to nearest socio-cultural facility

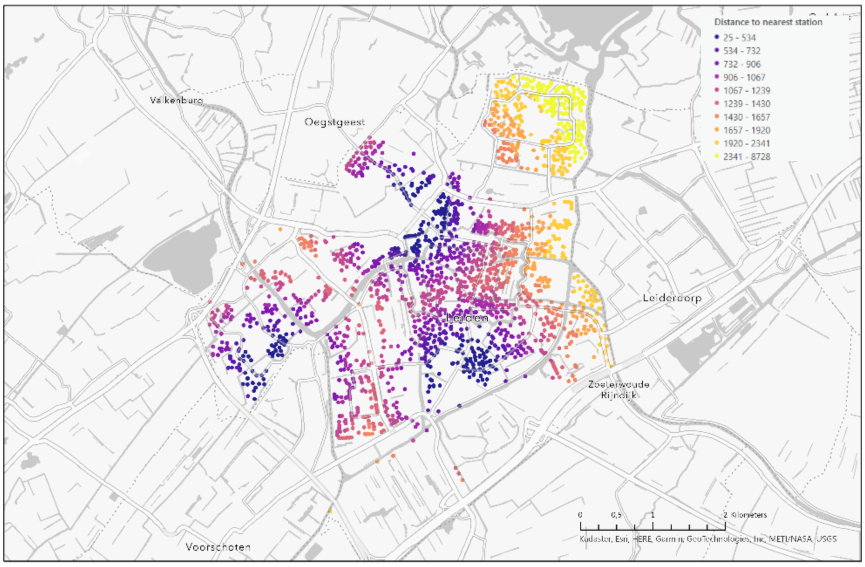


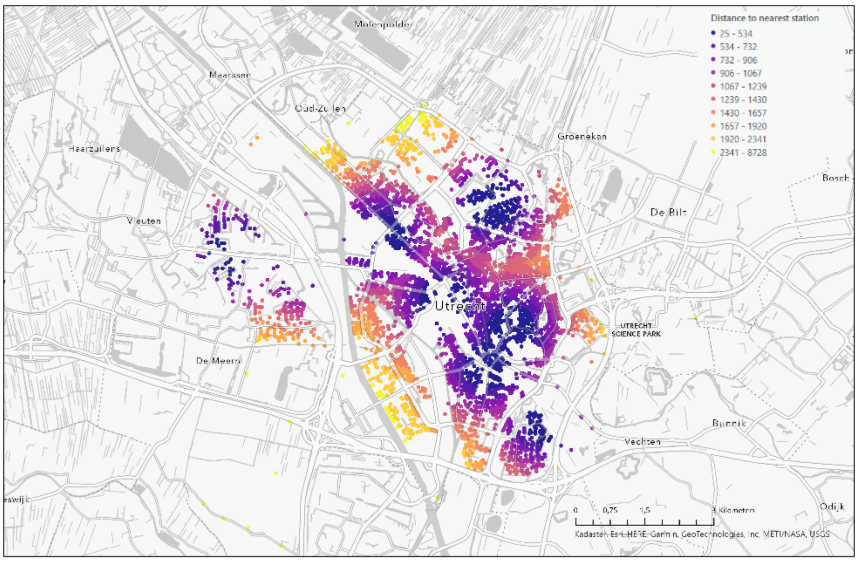




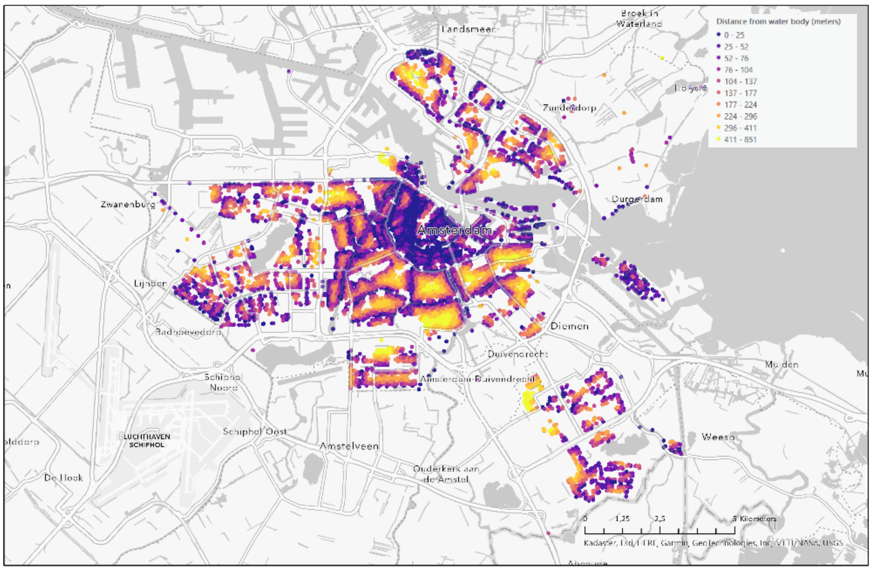
2.7 Distance to nearest train station

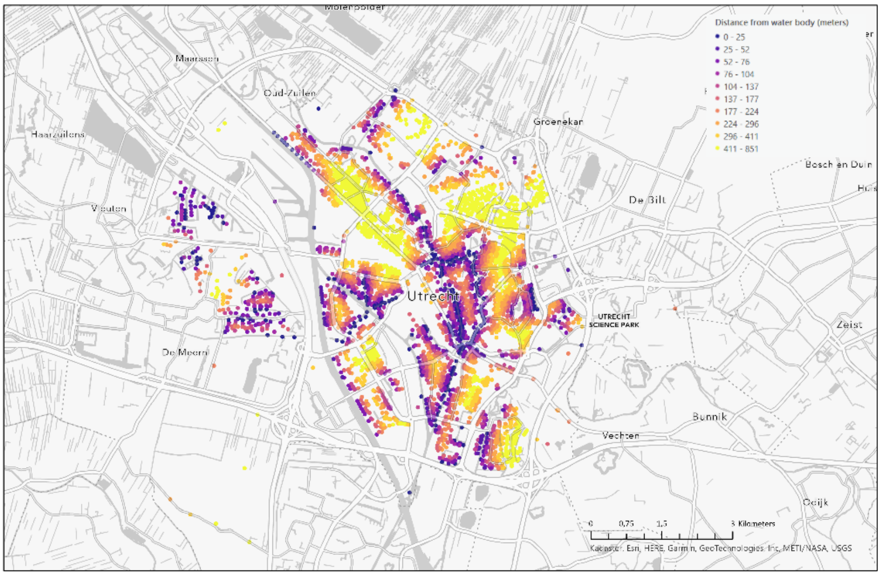






2.8 Distance to nearest water body





3. Complete descriptive statistics

	All other cases (n = 224,207)				Urban renewal (n = 5,877)			
Statistic	**Mean**	**St. Dev.**	**Min**	**Max**	**Mean**	**St. Dev.**	**Min**	**Max**
Transaction price	279,491	256,655	9,076	8,800,000	213,596	155,048	17,697	3,300,000
Surface	98	45	25	495	77.098	33.030	25	460
Apartment types								
Downstairs apartment	0.103	0.304	0	1	0.333	0.471	0	1
Upstairs apartment	0.288	0.453	0	1	0.099	0.299	0	1
Maisonette	0.039	0.193	0	1	0.095	0.294	0	1
Porch flat	0.138	0.345	0	1	0.228	0.420	0	1
Walkway flat	0.112	0.316	0	1	0.126	0.332	0	1
Up- and downstairs apartment	0.010	0.099	0	1	0.003	0.058	0	1
Housing types								
Simple	0.027	0.161	0	1	0.080	0.271	0	1
Single family dwelling	0.217	0.412	0	1	0.011	0.104	0	1
Townhouse	0.053	0.223	0	1	0.013	0.114	0	1
Canal house	0.005	0.073	0	1	0.003	0.057	0	1
Farmhouse	0.0004	0.020	0	1	0.001	0.026	0	1
Bungalow	0.003	0.052	0	1	0.001	0.026	0	1
Villa	0.005	0.069	0	1	0.005	0.072	0	1
Country house	0.0002	0.015	0	1	0.001	0.034	0	1
Dwelling type								
Terraced	0.230	0.421	0	1	0.885	0.319	0	1
Semi-detached	0.004	0.066	0	1	0.011	0.104	0	1
Corner	0.055	0.228	0	1	-	-	-	-
Duplex	0.011	0.106	0	1	-	-	-	-
Detached	0.008	0.090	0	1	0.080	0.271	0	1
House characteristics								
Level of maintenance								
Good interior maintenance	0.873	0.333	0	1	0.883	0.321	0	1
Average interior maintenance	0.110	0.313	0	1	0.111	0.314	0	1
Bad interior maintenance	0.017	0.130	0	1	0.005	0.072	0	1
Good exterior maintenance	0.931	0.253	0	1	0.965	0.183	0	1
Average exterior maintenance	0.061	0.240	0	1	0.034	0.182	0	1
Bad exterior maintenance	0.008	0.088	0	1	0.0003	0.018	0	1
Heating system								
No heating	0.044	0.204	0	1	0.041	0.199	0	1
Gas or coal heating	0.090	0.286	0	1	0.010	0.097	0	1

Central heating	0.866	0.341	0	1	0.949	0.220	0	1
Solar panel heating	0.0003	0.019	0	1	-	-	-	-
Insulation								
Not insulated	0.290	0.454	0	1	0.267	0.442	0	1
Partly insulated	0.549	0.498	0	1	0.630	0.483	0	1
Fully insulated	0.161	0.368	0	1	0.103	0.304	0	1
Garden (dummy)	0.999	0.035	0	1	0.996	0.061	0	1
Garden surface	16.98	37.14	0	995	10	38	0	900
Shed (dummy)	0.690	0.462	0	1	0.851	0.357	0	1
Garage (dummy)	0.047	0.212	0	1	0.019	0.136	0	1
Parking (dummy)	0.128	0.334	0	1	0.048	0.214	0	1
Elevator (dummy)	0.182	0.386	0	1	0.183	0.387	0	1
Number of balconies	0.479	0.535	0	5	0.521	0.540	0	4
Number of roof terraces	0.112	0.326	0	3	0.064	0.249	0	2
Monument (dummy)	0.031	0.173	0	1	0.046	0.209	0	1
Monumental (dummy)	0.020	0.141	0	1	0.010	0.097	0	1
Spatial variables								
Distance from center	1,719	1,769	0	9,413	804	1,555	0	9,233
Distance from water	185	163	0	851	148	162	0	780
Distance from nature	1,415	939	0	4,168	1,874	1,024	0	3,994
Distance from recreational area	241	193	0	4,665	337	218	0	1,465
Distance from retail and hospitality	312	270	0	4,818	244	240	0	2,127
Distance from socio-cultural facilities	370	314	0	4,862	365	264	0	2,760
Distance from highway	171	143	0	892	175	139	0	892
Distance from train station	1,399	822	25	8,728	1,221	646	57	5,474
Distance from bus station	172	100	1	2,116	179	92	1	976
Distance from supermarket	328	216	0.7	4,185	282	210	3	2,237
Distance from school	311	170	2.3	2,744	319	184	25	1,556
Distance from highway entry	1,692	781	30	5,394	2,342	657	201	3,954
Livability score	4.05	0.22	0.0	4.628	4.05	0.25	0	4.63
Distance from monument	398	359	0.0	2,753	215	345	1	2,441
On busy road	0.029	0.168	0	1	0.043	0.202	0	1
Transaction years								
1985	0.003	0.057	0	1	0.005	0.074	0	1
1986	0.006	0.076	0	1	0.012	0.111	0	1
1987	0.006	0.079	0	1	0.015	0.123	0	1
1988	0.007	0.083	0	1	0.012	0.111	0	1

1989	0.009	0.097	0	1	0.015	0.123	0	1
1990	0.009	0.097	0	1	0.016	0.124	0	1
1991	0.011	0.102	0	1	0.019	0.136	0	1
1992	0.012	0.108	0	1	0.015	0.123	0	1
1993	0.013	0.115	0	1	0.018	0.134	0	1
1994	0.015	0.124	0	1	0.017	0.129	0	1
1995	0.019	0.137	0	1	0.022	0.147	0	1
1996	0.022	0.148	0	1	0.020	0.139	0	1
1997	0.024	0.154	0	1	0.021	0.142	0	1
1998	0.025	0.155	0	1	0.016	0.126	0	1
1999	0.024	0.152	0	1	0.017	0.128	0	1
2000	0.026	0.161	0	1	0.018	0.131	0	1
2001	0.029	0.169	0	1	0.015	0.121	0	1
2002	0.032	0.176	0	1	0.022	0.147	0	1
2003	0.034	0.180	0	1	0.024	0.153	0	1
2004	0.037	0.188	0	1	0.033	0.179	0	1
2005	0.041	0.198	0	1	0.036	0.186	0	1
2006	0.043	0.203	0	1	0.046	0.209	0	1
2007	0.042	0.200	0	1	0.037	0.190	0	1
2008	0.039	0.193	0	1	0.040	0.196	0	1
2009	0.031	0.174	0	1	0.036	0.185	0	1
2010	0.033	0.178	0	1	0.034	0.181	0	1
2011	0.028	0.166	0	1	0.032	0.176	0	1
2012	0.027	0.162	0	1	0.033	0.180	0	1
2013	0.027	0.161	0	1	0.043	0.204	0	1
2014	0.041	0.199	0	1	0.056	0.231	0	1
2015	0.048	0.214	0	1	0.050	0.218	0	1
2016	0.048	0.213	0	1	0.044	0.205	0	1
2017	0.041	0.198	0	1	0.032	0.176	0	1
2018	0.037	0.188	0	1	0.029	0.168	0	1
2019	0.041	0.197	0	1	0.036	0.186	0	1
2020	0.043	0.202	0	1	0.036	0.186	0	1
2021	0.026	0.160			0.027	0.163	0	1
Building period								
Before 1900	0.068	0.252	0	1	-	-	-	-
1900 – 1950	0.434	0.496	0	1	-	-	-	-
1951 – 1960	0.076	0.265	0	1	-	-	-	-
1961 – 1974	0.114	0.318	0	1	-	-	-	-
1986 – 1990	0.052	0.222	0	1	-	-	-	-
1991 – 2000	0.112	0.315	0	1	-	-	-	-
2001 – 2010	0.072	0.259	0	1	-	-	-	-
2011 – 2021	0.007	0.084	0	1	-	-	-	-
Municipality								
Amsterdam	0.549	0.498	0	1	0.682	0.465	0	1
Utrecht	0.331	0.471	0	1	0.152	0.359	0	1
Leiden	0.120	0.324	0	1	0.165	0.371	0	1

Total N = 230,084

4. Variance inflation factors

Variables	VIF	Variables	VIF
Surface	1.715965	Distance from highway entry	1.377525
Urban renewal (dummy)	1.102223	Livability score	1.468999
Apartment types		Distance from monument	2.561671
Downstairs apartment	1.232919	On busy road	1.031276
Maisonette	1.089519	**Transaction years**	
Porch flat	1.373215	1985	1.1456
Walkway flat	1.663407	1986	1.254763
Up- and downstairs apartment	1.034928	1987	1.28477
Housing types		1988	1.303403
Simple	1.142458	1989	1.40672
Townhouse	1.312754	1990	1.406916
Canal house	1.098377	1991	1.452208
Farmhouse	1.057341	1992	1.49416
Bungalow	1.080592	1993	1.562303
Villa	1.383127	1994	1.648071
Country house	1.03667	1995	1.791344
Dwelling type		1996	1.900588
Semi-detached	1.063544	1997	1.971249
Corner house	1.167281	1998	1.939473
Duplex	1.169164	1999	1.879533
Detached	1.52235	2000	1.982673
House characteristics		2001	2.084678
Level of maintenance		2002	2.175372
Good interior maintenance	1.532421	2003	2.234487
Bad interior maintenance	1.40433	2004	2.342075
Good exterior maintenance	1.54271	2005	2.490239
Bad exterior maintenance	1.365376	2006	2.550534
Heating system		2007	2.505686
No heating	1.102506	2008	2.403285
Gas or coal heating	1.294044	2009	2.142568
Solar panel heating	1.002057	2010	2.189113
Insulation		2011	2.037994
Not insulated	1.338386	2012	1.983234
Fully insulated	1.822853	2013	1.983936
		2014	2.494902
Garden (dummy)	1.00411	2015	2.702136
Garden surface	1.421506	2016	2.682931
Shed (dummy)	1.292504	2017	2.443236
Garage (dummy)	1.732407	2018	2.29376
Parking (dummy)	2.025566	2019	2.43443
Elevator (dummy)	1.609108	2020	2.504909
Number of balconies	1.304479	**Building period**	
Number of roof terraces	1.149489	Before 1900	1.450789
Monument (dummy)	1.216702	1951 – 1960	1.233728
Monumental (dummy)	1.111046	1961 – 1974	1.627833

Spatial variables		1986 – 1990	1.20402
Distance from center	3.567974	1991 – 2000	1.737385
Distance from water	1.409845	2001 – 2010	1.904129
Distance from Nature	2.430234	2011 – 2021	1.10893
Distance from recreational area	1.349791	**Municipality**	
Distance from retail and hospitality	1.921563	Utrecht	2.307831
Distance from socio-cultural facilities	1.280778	Leiden	1.859819
Distance from highway	1.239682		
Distance from train station	1.550075		
Distance from bus station	1.2093		
Distance from supermarket	1.956049		
Distance from school	1.199741		

N = 5,877

5. Hedonic price model of all building periods

Hedonic Price Model

	Dependent variable: Transaction price	
Independent variables	*Coefficient*	*Std. Error*
Surface (ln)	0.787***	(0.002)
Urban renewal (dummy)	-0.039***	(0.003)
Apartment type (ref = Upstairs apartment)		
Downstairs apartment	0.007***	(0.002)
Maisonette	-0.068***	(0.003)
Porch flat	-0.065***	(0.002)
Walkway flat	-0.092***	(0.002)
Up- and downstairs apartment	0.069***	(0.005)
Housing type (ref = single-family dwelling)		
Simple	-0.013***	(0.003)
Townhouse	0.131***	(0.003)
Canal house	0.125***	(0.007)
Farmhouse	0.215***	(0.025)
Bungalow	0.239***	(0.010)
Villa	0.266***	(0.008)
Country house	0.349***	(0.030)
Dwelling type (ref = terraced)		
Semi-detached	0.026***	(0.008)
Corner	0.034***	(0.002)
Duplex	0.099***	(0.005)
Detached	0.225***	(0.007)
House characteristics		
Maintenance level (ref = average maintenance)		
Good interior maintenance	0.091***	(0.002)
Bad interior maintenance	-0.024***	(0.005)
Good exterior maintenance	0.059***	(0.002)
Bad exterior maintenance	-0.131***	(0.007)
Home heating (ref = central heating)		
No heating	-0.035***	(0.003)
Gas or coal heating	-0.119***	(0.002)
Solar panel heating	0.043	(0.028)
Insulation (ref = partly insulated)		
Not insulated	-0.020***	(0.001)
Fully insulated	-0.006***	(0.002)
Garden (dummy)	-0.039***	(0.014)
Garden surface	0.001***	(0.00002)
Shed (dummy)	-0.009***	(0.001)
Garage (dummy)	0.041***	(0.003)
Parking (dummy)	0.036***	(0.002)
Elevator (dummy)	0.025***	(0.002)
Number of balconies	0.024***	(0.001)
Number of roof terraces	0.047***	(0.002)
Monument (dummy)	0.050***	(0.003)
Monumental (dummy)	0.059***	(0.004)

Spatial variables		
Distance from center	-0.00005***	(0.00000)
Distance from water	-0.00000	(0.00000)
Distance from nature	0.00002***	(0.00000)
Distance from recreational area	0.00000	(0.00000)
Distance from retail and hospitality	0.00001***	(0.00000)
Distance from socio-cultural facilities	0.00001***	(0.00000)
Distance from highway	0.00003***	(0.00000)
Distance from train station	-0.00002***	(0.00000)
Distance from bus station	0.0001***	(0.00001)
Distance from supermarket	-0.00004***	(0.00000)
Distance from school	-0.00002***	(0.00000)
Distance from highway entry	-0.00000***	(0.00000)
Livability score	0.417***	(0.003)
Distance from monument	-0.0001***	(0.00000)
On busy road	-0.027***	(0.003)
Transaction year dummies (ref = 2021)		
1985	-2.570***	(0.009)
1986	-2.464***	(0.007)
1987	-2.331***	(0.007)
1988	-2.220***	(0.007)
1989	-2.122***	(0.006)
1990	-2.071***	(0.006)
1991	-1.986***	(0.006)
1992	-1.887***	(0.006)
1993	-1.783***	(0.005)
1994	-1.704***	(0.005)
1995	-1.634***	(0.005)
1996	-1.508***	(0.005)
1997	-1.381***	(0.005)
1998	-1.280***	(0.004)
1999	-1.097***	(0.004)
2000	-0.982***	(0.004)
2001	-0.917***	(0.004)
2002	-0.883***	(0.004)
2003	-0.884***	(0.004)
2004	-0.857***	(0.004)
2005	-0.809***	(0.004)
2006	-0.749***	(0.004)
2007	-0.663***	(0.004)
2008	-0.615***	(0.004)
2009	-0.664***	(0.004)
2010	-0.659***	(0.004)
2011	-0.668***	(0.004)
2012	-0.743***	(0.004)
2013	-0.774***	(0.004)
2014	-0.716***	(0.004)
2015	-0.633***	(0.004)
2016	-0.503***	(0.004)
2017	-0.376***	(0.004)
2018	-0.257***	(0.004)
2019	-0.199***	(0.004)
2020	-0.127***	(0.004)
Building period dummies (ref = 1900 – 1950)		
Before 1900	0.047***	(0.002)
1951 – 1960	-0.069***	(0.002)
1961 – 1974	-0.100***	(0.002)
1986 – 1990	0.018***	(0.002)

1991 – 2000	0.014***	(0.002)
2001 – 2010	0.025***	(0.003)
2011 – 2021	0.114***	(0.006)
Municipality dummies (ref = Amsterdam)		
Utrecht	-0.241***	(0.002)
Leiden	-0.280***	(0.002)
Constant	8.009***	(0.019)
N	161,058	*N*
R^2	0.925	
Adjusted R^2	0.925	
Residual Std. Error	0.198 (df = 160960)	
F Statistic	20,450.810*** (df = 97; 160960)	
Notes:	***Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.	

6. Hedonic price model of all building periods: diagnostic plots

The diagnostic plots below display the residuals of the hedonic price models. These plots can be used to evaluate the assumptions and quality of the model. The residual vs. fitted plot examines the linearity assumption, the normal Q-Q plot is used to evaluate the normal distribution of the data and the scale-location plot assesses the homoscedasticity of the model.

Residuals vs. fitted

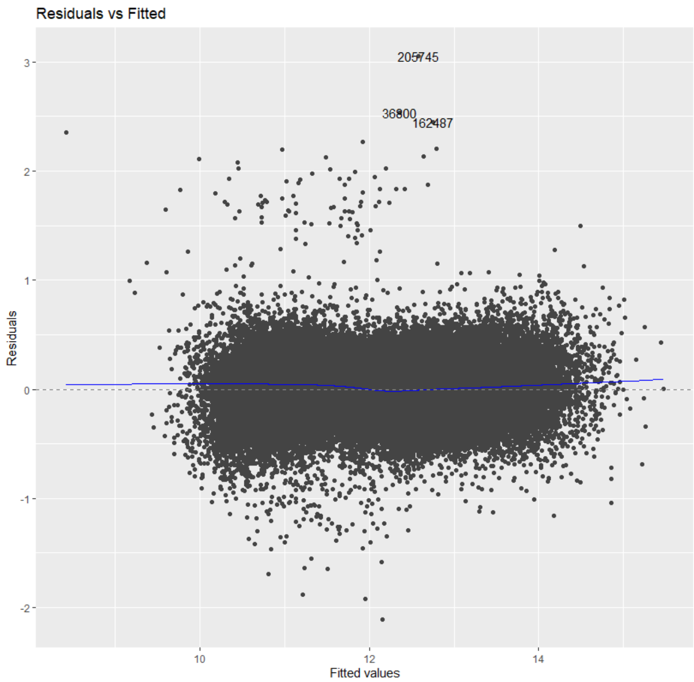


Figure 6.1: Residuals vs. fitted plot

The plot in Figure 6.1 supports the assumption that the data has good linearity. The residuals are distributed around the dashed zero line. Furthermore, the residuals form an equal band without being skewed towards one side, which indicates that the variances are equal.

Normal Q-Q

The plot in Figure 6.2 shows that the residuals of the HPM are mostly normally distributed as most points follow the diagonal line. However, the distribution is skewed in the upper and lower quantiles of the data, indicating that the highest housing prices were higher than would be expected with a normal distribution, and vice versa for the lowest housing prices.

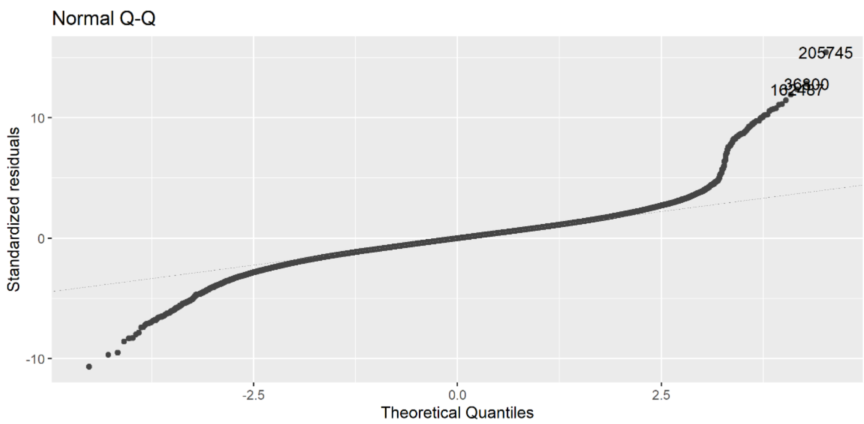


Figure 6.2: Normal Q-Q plot

Scale-location

Finally, the scale-location plot (Figure 6.3) allows examination of the homoscedasticity of the model. Overall, it suggests that the data residuals have equal variances, because the data points are spread in an equal band and follow the blue line. However, a small 'cloud' of points deviates from this band, suggesting a set of outliers.

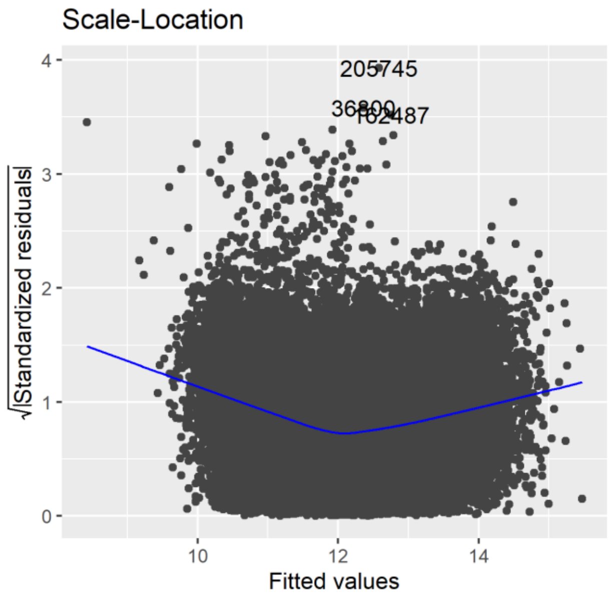
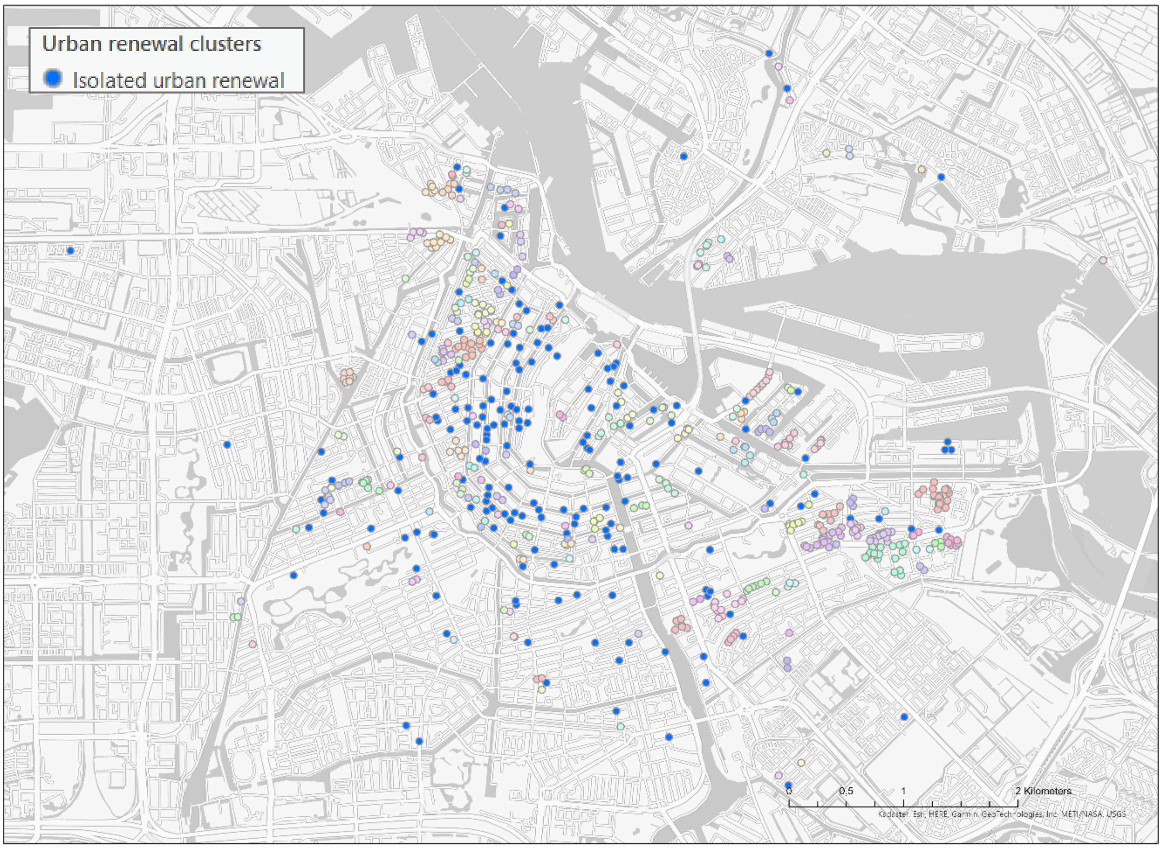
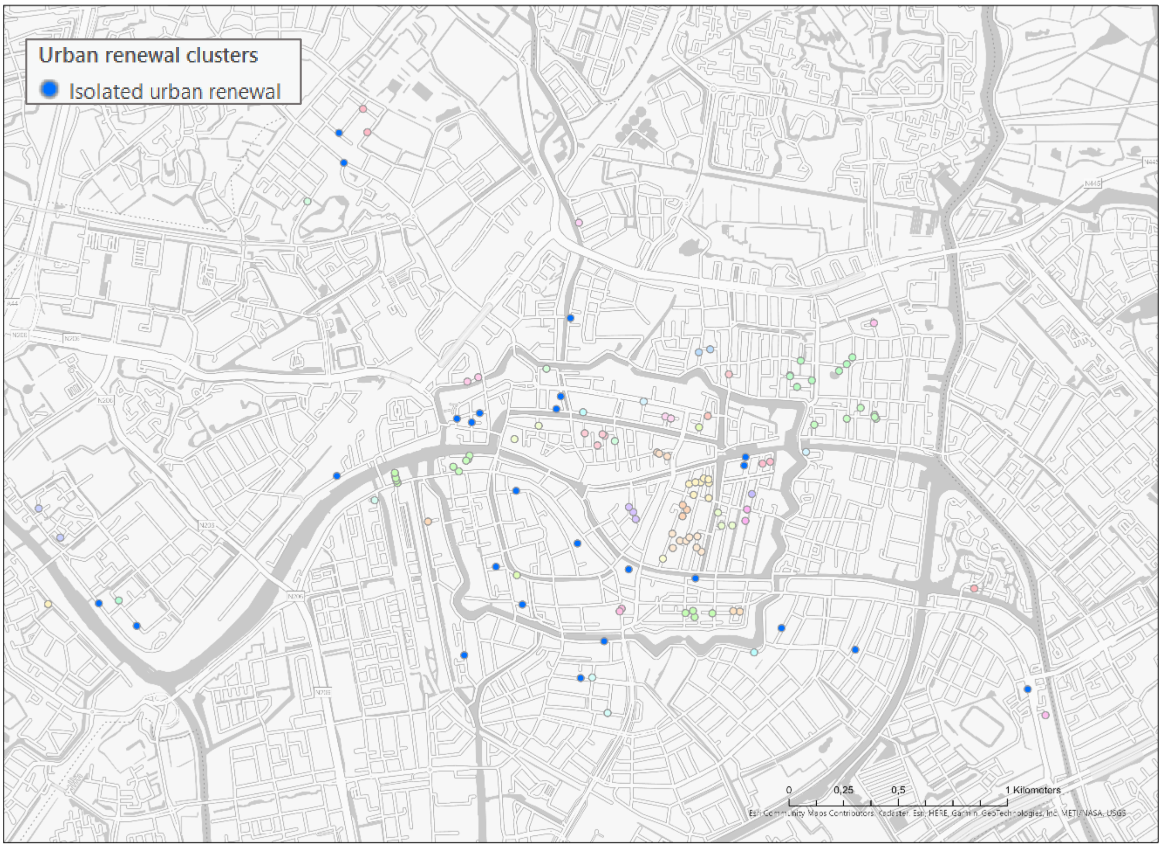


Figure 6.3: Scale-location plot

7. Urban renewal clusters





8. Hedonic price model with clustering variable

Hedonic Price Model with clustering variable – only urban renewal transactions

Dependent variable: Transaction price				
	Model 1: Urban renewal without clustering		*Model 2: Urban renewal with clustering*	
Independent variables	*Coefficient*	*Std. Error*	*Coefficient*	*Std. Error*
Surface (ln)	0.706***	(0.007)	0.704***	(0.007)
Clustering (ref = No cluster/isolated)				
Small cluster	-	-	-0.049***	(0.010)
Large cluster	-	-	-0.061***	(0.009)
Apartment type (ref = Upstairs apartment)				
Downstairs apartment	0.001	(0.008)	0.002	(0.008)
Maisonette	-0.008	(0.009)	-0.006	(0.009)
Porch flat	-0.0003	(0.006)	-0.002	(0.006)
Walkway flat	-0.055***	(0.009)	-0.054***	(0.009)
Up- and downstairs apartment	0.119***	(0.036)	0.105***	(0.036)
Housing type (ref = single-family dwelling)				
Simple	0.026	(0.022)	0.024	(0.022)
Townhouse	0.212***	(0.021)	0.214***	(0.021)
Canal house	0.164***	(0.037)	0.153***	(0.037)
Farmhouse	0.397***	(0.088)	0.351***	(0.088)
Bungalow	0.621***	(0.081)	0.585***	(0.081)
Villa	0.485***	(0.034)	0.461***	(0.034)
Country house	0.476***	(0.063)	0.432***	(0.063)
Dwelling type (ref = terraced)				
Detached	0.082***	(0.011)	0.082***	(0.011)
House characteristics				
Maintenance level (ref = average maintenance)				
Good interior maintenance	0.077***	(0.007)	0.077***	(0.007)
Bad interior maintenance	-0.024	(0.030)	-0.019	(0.030)
Good exterior maintenance	0.006	(0.013)	0.007	(0.013)
Bad exterior maintenance	-0.118	(0.117)	-0.116	(0.116)
Home heating (ref = central heating)				
No heating	-0.022**	(0.011)	-0.020*	(0.011)
Gas or coal heating	-0.085***	(0.022)	-0.086***	(0.022)
Insulation (ref = partly insulated)				
Not insulated	-0.003	(0.005)	-0.002	(0.005)
Fully insulated	0.012	(0.007)	0.011	(0.007)
Garden (dummy)	0.015	(0.034)	0.013	(0.034)
Garden surface	0.0003***	(0.0001)	0.0003***	(0.0001)
Shed (dummy)	-0.015**	(0.006)	-0.013**	(0.006)
Garage (dummy)	0.097***	(0.021)	0.092***	(0.021)
Parking (dummy)	0.069***	(0.013)	0.068***	(0.013)
Elevator (dummy)	0.031***	(0.006)	0.033***	(0.006)
Number of balconies	0.017***	(0.005)	0.018***	(0.005)
Number of roof terraces	0.048***	(0.009)	0.046***	(0.009)

Monument (dummy)	0.070***	(0.011)	0.058***	(0.011)
Monumental (dummy)	0.071***	(0.022)	0.068***	(0.022)
Spatial variables				
Distance from center	-0.043***	(0.003)	-0.043***	(0.003)
Distance from water	-0.075***	(0.019)	-0.073***	(0.019)
Distance from nature	0.022***	(0.004)	0.024***	(0.004)
Distance from recreational area	0.034***	(0.012)	0.031***	(0.012)
Distance from retail and hospitality	-0.049***	(0.014)	-0.048***	(0.014)
Distance from socio-cultural facilities	0.072***	(0.009)	0.071***	(0.009)
Distance from highway	0.028	(0.020)	0.021	(0.020)
Distance from train station	0.010*	(0.005)	0.008	(0.005)
Distance from bus station	0.154***	(0.027)	0.146***	(0.027)
Distance from supermarket	-0.035**	(0.016)	-0.031*	(0.016)
Distance from school	-0.004	(0.014)	-0.008	(0.014)
Distance from highway entry	-0.024***	(0.004)	-0.024***	(0.004)
Livability score	0.385***	(0.014)	0.377***	(0.014)
Distance from monument	-0.099***	(0.013)	-0.095***	(0.013)
On busy road (dummy)	-0.004	(0.011)	-0.005	(0.011)
Transaction years (ref = 2021)				
1985	-2.369***	(0.031)	-2.379***	(0.031)
1986	-2.333***	(0.023)	-2.337***	(0.023)
1987	-2.198***	(0.022)	-2.208***	(0.022)
1988	-2.055***	(0.023)	-2.062***	(0.023)
1989	-1.991***	(0.022)	-1.996***	(0.022)
1990	-1.958***	(0.022)	-1.961***	(0.021)
1991	-1.903***	(0.020)	-1.910***	(0.020)
1992	-1.825***	(0.022)	-1.826***	(0.022)
1993	-1.771***	(0.021)	-1.774***	(0.021)
1994	-1.683***	(0.021)	-1.684***	(0.021)
1995	-1.633***	(0.020)	-1.634***	(0.019)
1996	-1.544***	(0.020)	-1.548***	(0.020)
1997	-1.397***	(0.020)	-1.399***	(0.020)
1998	-1.285***	(0.021)	-1.288***	(0.021)
1999	-1.083***	(0.021)	-1.086***	(0.020)
2000	-0.991***	(0.020)	-0.993***	(0.020)
2001	-0.887***	(0.021)	-0.889***	(0.021)
2002	-0.892***	(0.019)	-0.891***	(0.019)
2003	-0.919***	(0.018)	-0.919***	(0.018)
2004	-0.926***	(0.017)	-0.925***	(0.017)
2005	-0.877***	(0.017)	-0.878***	(0.017)
2006	-0.819***	(0.016)	-0.821***	(0.016)
2007	-0.737***	(0.016)	-0.737***	(0.016)
2008	-0.659***	(0.016)	-0.661***	(0.016)
2009	-0.726***	(0.017)	-0.728***	(0.017)
2010	-0.709***	(0.017)	-0.709***	(0.017)
2011	-0.735***	(0.017)	-0.737***	(0.017)
2012	-0.814***	(0.017)	-0.815***	(0.017)
2013	-0.849***	(0.016)	-0.851***	(0.016)
2014	-0.773***	(0.015)	-0.773***	(0.015)
2015	-0.672***	(0.016)	-0.673***	(0.016)
2016	-0.521***	(0.016)	-0.521***	(0.016)
2017	-0.366***	(0.017)	-0.367***	(0.017)
2018	-0.264***	(0.017)	-0.266***	(0.017)
2019	-0.202***	(0.017)	-0.204***	(0.016)
2020	-0.125***	(0.017)	-0.125***	(0.016)
Municipality dummies (ref = Amsterdam)				
Utrecht	-0.218***	(0.008)	-0.218***	(0.008)

Leiden	-0.250***	(0.009)	-0.247***	(0.009)
Constant	8.410***	(0.076)	8.510***	(0.077)
N	5877		5877	
R^2	0.935		0.936	
Adjusted R^2	0.934		0.935	
Residual Std. Error	0.157 (df = 5791)		0.157 (df = 5789)	
F Statistic	981.115*** (df = 85; 5791)		966.113*** (df = 87; 5789)	

Notes:
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

9. Hedonic price model with clustering variable: diagnostic plots

The plots below display the same diagnostic plots for the HPM on urban renewal housing as the HPM on all building styles: the residual vs. fitted plot examines the linearity assumption, the normal Q-Q plot evaluates the normality of the distribution and the scale-location plot assesses the homoscedasticity of the model.

Residuals vs. fitted

The residuals vs. fitted plot (Figure 9.1) shows that the urban renewal model satisfies the linearity assumption, as the residuals are fitted around the horizontal zero residual line. Apart from some outliers, the data points form a horizontal bond without skewness, suggesting similar variances.

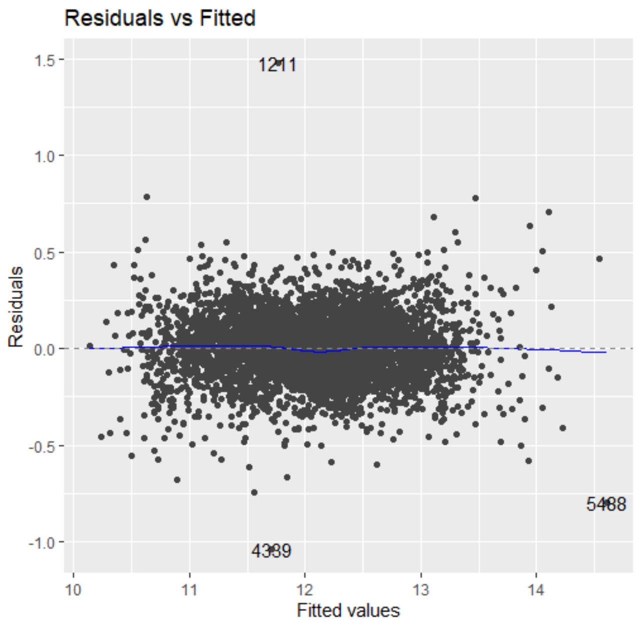


Figure 9.1: Residuals vs. fitted plot

Normal Q-Q

Figure 9.2 shows that the data is reasonably normally distributed, as most points follow the diagonal line. Like the HPM on all building styles, the Q-Q plot on urban renewal transactions shows a skewedness in the highest and lowest quantiles, suggesting that the distribution has longer tails on both side than expected from a normal distribution.

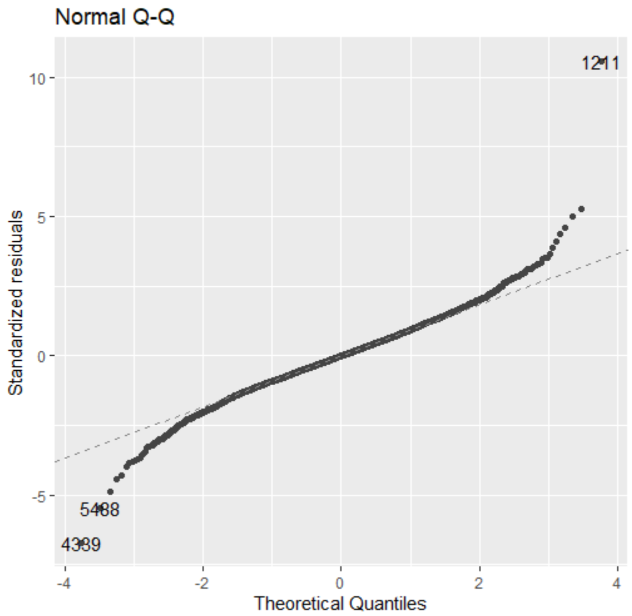


Figure 9.2: Normal Q-Q plot

Scale-location

Finally, the scale-location plot (Figure 9.3) shows that, apart from a few outliers, the residuals have equal variances. The residuals are equally spread in a horizontal band and are not skewed to either side. Therefore, it can be concluded that the model satisfies the assumption of equal variances.

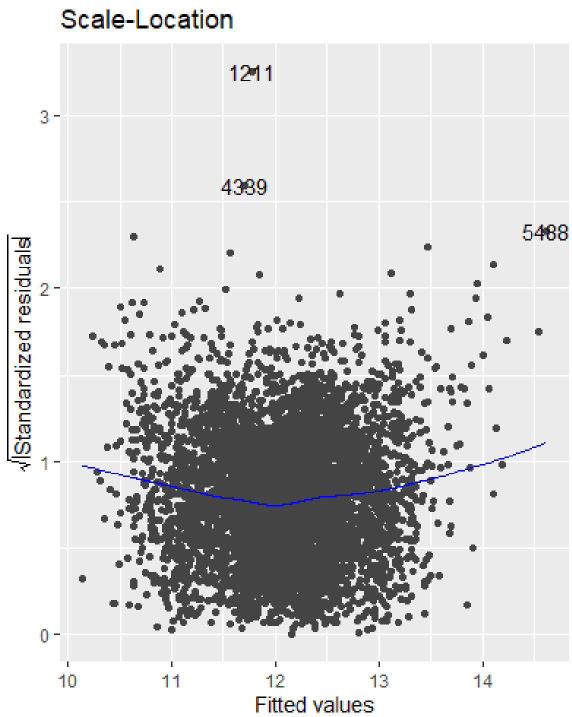


Figure 9.3: Scale-location plot

10. Photo documentation

Case 1: Driftstraat, Leiden	Construction year: 1980 Transaction year: 2015	Expected price: 137,081 Actual price: 85,000	Surface: 48 m^2

Front side of the house

How is the exterior of the house designed?

The houses on the Driftstraat are recognizable as urban renewal because of the light reddish bricks and the small windows. However, it does not display either the characterizing staggered building lines of urban renewal or any historizing elements. It has dark-blue wood paneling as decoration and a gable roof. The most striking feature is the row of apartments along a walkway on top of the houses on the ground floor, making this building a mixture of a walkway flat and a terraced house. Since the surface of the house is only 48 m^2, the transaction likely concerns one of the top apartments.

The height of the building is well-fitted with the surrounding buildings. However, the design (especially the walkway), the colors of the paneling and the shape of the roofs do not reflect the surrounding buildings.

What is the quality of the view from the house?

The house has a view over a small strip of greenery that separates the two lanes of the street. Although the greenery is well-kept, there is some littering, and the patch of green is too small for most recreational purposes. The view of several windows is obstructed by the walkway and parked cars.

What is the quality of the landscape around the house?

The street is quiet, wide, and green. This street section has only urban renewal, but at the beginning, end and on the other side of the street, there is mainly pre-war housing from the 1920’s and 30’s. Of all buildings in the street, this urban renewal block is the newest and the most homogenous. The small Kooipark is only one block away.

What is the pleasantness and image of the neighborhood?

De Kooi is an old working-class neighborhood on the north side of the city center that has seen a steady wave of gentrification since 2016, reflected in the redevelopment of houses and public spaces in the neighborhood and rising housing prices. Newspaper articles mention that many original inhabitants protested the

Further view from the house on the other side of the street

Direct environment of the house towards Lage Rijndijk

recent demolition and redevelopment of certain streets in the neighborhood. On the street, a mix of original inhabitants, students and young urban professionals are seen. The neighborhood mostly consists of pre-war housing, although some streets have been renewed during the urban renewal period. De Kooi has many services, including a shopping center, a park, several schools and a lot of smaller retail stores. The image of De Kooi is still very much that of a working-class neighborhood. This manifests itself visually through the street pattern, the small shops still present in the neighborhood and the many benches and mopeds in front of houses. De Kooi is regularly featured in local newspapers due to social problems with loitering youths, especially in the nearby Kooipark.

What differences are noticeable between this house and other, nearby urban renewal?

In a parallel street, urban renewal was sold recently without a remarkable discount. Upon inspection, these houses (shown in the last picture) turned out to be similar to the 'outlying' urban renewal, with the exception that it did not have a walkway and was less tall. Additionally, the street it was on was much smaller, and did not feature the small strip of greenery.

Direct environment of the house

Comparable housing in parallel street

Case 2: Van Beuningenlaan, Leiden	Construction year: 1979 Transaction year: 2014	Predicted price: 570,000 Actual price: 349,283	Surface: 170 m^2

Front view of the house

How is the exterior of the house designed?
The house is built from typical lighter shaded bricks. It has a gable roof and some staggered geometries, such as the sunken balcony and the ridge above the front door. The front door is slightly higher than the pavement, meaning that the garden is also slightly staggered. The window frames are constructed of dark wood which looks more expensive than typically seen in urban renewal. This urban renewal was built upon old allotment gardens of the surrounding 1920's and 30's neighborhood and older villas. Although the urban renewal directly borders the older neighborhood, it faces outward and is surrounded by greenery. Therefore, integration with the surrounding structures is less relevant in this case. An example of older housing directly bordering the street is shown in the last picture.

One resident of the street walked by and agreed to answer some questions about the house and the neighborhood. For a transcript, see page 34-35. She stated that she found the houses very beautiful because they were elevated above the street level. Additionally, she said she liked them because they were so large, but not in a 'flashy' or gaudy way, but rather in a more modest way. She did think they were slightly 'boring,' especially in comparison to the other, more varied houses of the neighborhood. However, she felt that this boringness belongs to the period in which the houses were built, and that this comes together with functionality and good building quality.

What is the quality of the view from the house?
The houses face a small ditch with abundant greenery. Behind the greenery is an athletics track. The scope of the view is a little obstructed by the greenery because the street is quite narrow. The respondent stated that, for her, the fact that there were no opposite neighbors was a large advantage.

What is the quality of the landscape around the house?
The street is quiet, narrow and lined with trees. On one side of the street, the urban renewal is surrounded by pre-war villas. On the other side of the street, there is a daycare center and a school built in Amsterdam School-style. On the other side of the houses, there are terraced, 1930's houses. In the street itself, there is little variation in the structures. However, on the level of the neighborhood, there is a large variety in building periods as well as housing types. At the end of the street, a large park is located (Leidse Hout).

One side of the street towards Van Slingelandtlaan and view on greenery

Other side of the street towards Antonie Duycklaan and view on greenery

The respondent stated that she enjoys living here because of the building variety on a neighborhood level. She stated that she would not want to live in similar building styles in other neighborhoods (De Waard, De Merenwijk), because those neighborhoods only consist of this particular building style, without any variety.

What is the pleasantness and image of the neighborhood?
The Raadsherenbuurt is a 1930's neighborhood, located on the west-side of the Leiden central station (15 minutes walking distance). It is a popular neighborhood for families and for elderly people, which is also reflected in the people that walk by the street. The respondent remarked that most residents in the street were elderly couples who bought the house when it was newly built. Because of that, some houses have overdue maintenance or outdated interior designs.
The neighborhood has a school, a park (as mentioned) and a day-care. The respondent stated that one of the main benefits of these houses was the neighborhoods in which they were located. A new and sizable house with a garden in this neighborhood really is a 'gem,' because the residents receive the benefits of the variety and the facilities of the neighborhood, without the hassle of maintaining older housing. She also remarked that she prefers this neighborhood over other nearby neighborhoods as it is less posh and there are mainly middle-class people, instead of more upper-class people.

Transcript of interview
- *What do you think about the exterior design of this house?*

I find it quite beautiful. What I find nice about it is the fact that is sort-of half above the ground and there is a basement beneath it. And I like the fact that it is large. Large, but not gaudy or exuberant. Instead, it is quite simple but very spacious, especially those houses with a garage beside it and a room above it.
- *Is there anything you dislike about it?*

From the outside it is a bit boring. Or maybe not… I don't really find them boring. No, I just like them as they are, especially the fact that the front door is sort of hidden and the sunken balconies. For a house from that period… How to say? That period… I guess that all housing from that period is kind of boring, so in that sense it is not the 'perfect' house. Other houses in the neighborhood are more varied. So, in that sense it's not ideal. But because it's so spacious and well-built… They are just structurally really well-built. And the location is good, this is a really pleasant neighborhood. If you are able to get a large house that is new *and* in this neighborhood, with a large garden, without the hassle of those old houses,

Example of one of the villas at the crossing of Van Beuningenlaan and Van Slingelandtlaan, at the edge of the park

maintenance and such, and without opposite neighbors and a view on a sort of park… That is just really nice. And it's still in a classical neighborhood with a lot of peace and quiet and other beautiful houses, a neighborhood with a pleasant atmosphere. If you would have a whole neighborhood of this [these houses], then I wouldn't want to live there, like in the Merenwijk or the Waard. I wouldn't want to live there. Then there is too much dullness.

- *What kind of people live here?*

The people that live here… They are all very old people. People who came to live here as the first residents, they are in their 80s or 90s now. But now they are slowly leaving because they are too old, so you see that some of these houses have already been sold. And you can also see it when looking at the houses, that sort of gravel-tiles and the types of plants in the garden. And the fact that inside there is this sunken sitting area with a fireplace in a weird place, that was in fashion then.

- *What about the street itself, what do you think about it?*

I like living in the Van Beuningenlaan because it's quiet without opposite neighbors and a pleasant view, a lot of space, next to the park. It is a beautiful street. The neighborhood is of course a 20's and 30's neighborhood with diverse types of houses, and there are a lot of trees in the neighborhood which is also beautiful. There is no thoroughfare, so it's quiet. Before, only people from the middle-class lived here. But if you want to live here *now*, then you really need an academic or highly skilled job, but this wasn't the case previously. But now you really need two incomes. So therefore, there are no, or only very little, single people or unskilled jobs. However, it is not yet like in Oegstgeest, very snobby. There are also normal people who just work at a high school or are retired. Except alongside the park, those are very rich people, but that really are only villas. I think that people here don't really care about displaying their wealth.

Case 3: Realengracht, Amsterdam (two outliers: one on the canal-side and one at the side of the alley behind the complex)	Construction year: 1981 (both) Transaction year: 2016 (both)	Predicted price: 606,498 (canal) 434,916 (alley) Actual price: 1,050,000 (canal) 705,000 (alley)	Surface: 179 m^2 (canal) 103 m^2 (alley)

Front view of the apartment complex (Source: W. Schoonenberg/Amsterdam Monumentenstad).

Side view of the complex and original neighboring warehouse

When researching these two outliers, one on the side of the canal and the other on the back of the warehouse, I first suspected that there was a mistake in the dataset, because on first sight this house looks like 17th century warehouses. However, after some research I found out that these warehouses on the Realengracht have been demolished and rebuilt in the same style during the urban renewal period as an apartment complex.

How is the exterior of the house designed?
As mentioned, it is difficult to distinguish the urban renewal apartments from the pre-war warehouses. The windows, balconies, roof shape and hoisting beams mimic the original warehouses. The original warehouses had wooden window panels and anchor plate, like the neighboring warehouse still does. Besides red bricks and wood, the architects also used larger white stones in the wall to imitate the previous warehouses. The building fits seamlessly in the surrounding historic context.

What is the quality of the view from the house?
The house on the canal-side looks out over the intersection of the Realengracht and the Bickersgracht, where many houseboats are docked. It is a wide view, as the boats are quite low and the river is quite broad here. On the other side of the canal is a park (a 'Zen-garden').

What is the quality of the landscape around the house?
The Realengracht is located on an island, Realeneiland, connected to the mainland and other island via three bridges. The street alongside the canal is a dead end. Because of this, there is no throughfare. The street is narrow and lined with trees. There are many benches and flowerbeds, likely placed by the residents. The streets are well maintained and there is a children's playground in the alley alongside the apartment complex. There is quite a lot of other urban renewal complexes on the island, but these are not replicas of previous structures as this case study is. Therefore, the direct neighborhood of the apartment complex consists of a mixture of pre-war (ware)houses, urban renewal and more modern buildings (after 2000).

One side of the street towards Zandhoek

What is the pleasantness and image of the neighborhood?

When I visited, the weather was pleasant and many residents were sitting and chatting on benches on the street. Children were playing on the streets unaccompanied, which is quite rare at a location so close to the central station. However, because of the absence of traffic, there was a peaceful and quiet atmosphere. Looking at the housing prices, the houses on the free market can only be bought by the upper (middle) class. However, Realeneiland also still has around 1000 units of social housing, creating a somewhat more mixed population. There are two small parks nearby and many monumental buildings on the island, as well as on the other islands around.

Other side of the street towards Drieharingenbrug


Taandwarsstraat alley alongside the house, the missing anchor plates can be noticed


A playground and other urban renewal complexes alongside the alley


Back of the apartment complex, where the second outlier is located. This apartment faces more typical urban renewal houses, is smaller and was sold for a lower price.

Case 4: Kerkstraat, Amsterdam	Construction year: 1976 Transaction year: 2021	Predicted price: 546,003 Actual price: 337,500	Surface: 55 m^2

Urban renewal on the Kerkstraat

The view from the house

How is the exterior of the house designed?

The apartment complex has hoisting beams, sunken balconies and ‘hidden’ entrance doors typical for urban renewal. Besides simple bricks, some lighter concrete was used around the windows. The bricks are quite dark for urban renewal, and the dark exterior is exacerbated by the dark windowsills and detailing. The height of the ground floor is similar to the neighboring buildings, but the rest of the proportions do not necessarily match the neighbors very closely. Some greenery has been planted in front of the building. It does not feature staggered building lines. Geometry-wise, the building integrates fairly well into the eclectic mix of houses and building styles present in the street. However, in terms of color, detailing, window-size and window placement, it does not necessarily integrate well. The sunken front door is a break in style.

What is the quality of the view from the house?

The house looks out on houses on the opposite side of the street. Since the street is quite narrow, the opposite neighbors are quite close and the scope is narrow. The opposite houses are mostly pre-war buildings from the 17th, 18th and 19th century.

What is the quality of the landscape around the house?

The landscape around the house can be described as a typical street in the historic center of Amsterdam. It features a variety of historical building styles. The buildings are all in decent shape and seem to have been renovated recently (one is being renovated right now). There is virtually no greenery in the street, although houses around the canals often have private backyards that are not visible from the street. The nearest park is the Vondelpark. The street is quite narrow and features a coffeeshop, 3 hotels, 2 restaurants and a bar. Besides the canals themselves, there are no green or other natural areas in the vicinity of the street. Traffic-wise, the street itself is relatively quiet. However, the street crosses the Leidsestraat, which is a busy and touristy shopping street with many pedestrians, cars and trams.

What is the pleasantness and image of the neighborhood?

The street is located between the Keizersgracht, Prinsengracht, Leidsegracht and Leidsestraat, one of the busiest tourist areas of Amsterdam. When I visited, the people in the street consisted mostly of groups of (young) tourists, people working in the hotels

View of the street towards the Leidsegracht

View of the street towards the Leidsestraat

and restaurants and some residents. The neighborhood in general is busy with tourists as it is the main walking route between the central station and the red light distract on the one side and the Rijksmuseum, Leidseplein and Vondelpark on the other side. This flow of tourists could cause nuisance to residents. The canal area in general has an image of being upper class and features some of the most valuable real estate of the city. The neighborhood features a large variety of services, such as museums, shops, restaurants and hotels.

Busy shopping street at the corner of the Kerkstraat

Case 5: Lamstraat, Utrecht	Construction year: 1979 Transaction year: 2016	Predicted price: 136,847 Actual price: 83,000	Surface: 43 m^2

Front view of the apartment complex

View on opposite side of the street with social student housing

How is the exterior of the house designed?

The transaction concerns one of the apartments in the corner house shown in the picture. The house is designed as a typical urban renewal house found more often in locations with larger-scale demolition and redevelopment during the 1970s. It features simple, light-red bricks, small windows and a white paneled bay window or walkway. An entrance is elevated and connected to the street with a small set of stairs, which is also seen more often in this type of urban renewal. It features some staggered building lines, especially in the roof, the bay window and the staircase. Since the scale of urban renewal at this site is quite large, the whole street has been rebuilt in a similar style. Therefore, integration with older surrounding buildings is less relevant. The nearest buildings from before the urban renewal period are one street away and consists of 1920s houses and 1950s apartment buildings. The NVM dataset marked the state of maintenance as 'mediocre,' which is remarkably low since almost all the maintenance scores given to urban renewal are 'good' or above.

What is the quality of the view from the house?

The house looks out over a small courtyard with some trees, and three connected streets with opposite neighbors in the same architectural style. On the direct opposite side, there is an apartment complex for social student housing. The street is quite narrow and since most houses are the same height, the scope of the view is limited.

What is the quality of the landscape around the house?

Although there are some trees in front of the house and in the streets, the overall streetscape is quite bare and stone-y. There are many parking spaces and a small pavement. The houses, pavement and street are all built from similarly colored stones, which contributes to the homogenous and 'bare' look. Although the surrounding structures are varied in geometric shapes, they are all constructed from the same types of bricks, windowsills and roofs. The street is quiet and has a sort of 'empty' look. At the end of the street,

View of the street towards the house from Kariboestraat


View on the other side of the street towards Opaalweg

along the cycling road, there is more greenery and a small walking path alongside a small river.

What is the pleasantness and image of the neighborhood?

The house is in the Bokkenbuurt neighborhood. De Bokkenbuurt used to be a working-class neighborhood where several streets were demolished and rebuilt during the urban renewal period, despite many protests from residents. The new housing was built following the motto of 'building for the neighborhood,' where new housing was developed in cooperation with residents and with the aim to keep the existing neighborhood morphology and social atmosphere. The Bokkenbuurt consists of social housing, student housing and free market housing. Many of the free market housing previously were social housing units that have been sold. When visiting the neighborhood, diverse types of residents can be seen. The current population is a mix of original working-class residents, 'new' higher-income families, students and families with a migration background.

The neighborhood has limited services apart from a small community center. There is a shopping center nearby in the next neighborhood. There is little recreational green, although there is some greenery for non-recreation purposes, most importantly a graveyard bordering the neighborhood. Most pre-war, owner-occupied houses in the neighborhood are separated by the graveyard. A municipality-led report on the Bokkenbuurt termed it a 'forgotten neighborhood.' The survey also reported that the social cohesion between residents has steadily declined over the last decade, as working-class families moved away.

Cycling street and railway at the end of the street

1920s housing along the cycling street

Parallel street with similar architecture

1950s apartment buildings on parallel street

Case 6: Nieuwlichtstraat, Utrecht (two outliers: one sold in 2018 (a) and one in 2019 (b))	Construction year: 1980 (both) Transaction year: 2018 and 2019	Predicted price: 347,031 (b) and 302,322 (a) Actual price: 217,500 (b) and 166,000 (a)	Surface: 105 m^2 (b) and 109 m^2 (a)

Front view of the house

How is the exterior of the house designed?
The apartment complex is similar to the houses in the Lamstraat and Bokkenbuurt. One of the apartment buildings in the Nieuwlichtstraat (7th picture) even is identical to the building in the Lamstraat case study. They are designed in a similar simple style with light-brown bricks, small windows and staggered building lines. Similar to the Lamstraat, the NVM data shows that the interior state of maintenance of these houses was 'mediocre.' One remarkable feature of this house is that the typical urban renewal staircases have been closed off with a glass and metal fence, likely placed there a while after the construction was finished. Contrary to the Lamstraat, there is some mixing of other building styles in the Nieuwlichtstraat, especially with more contemporary styles (see 4th picture) and with houses from the 1920s (5th picture). Remarkably, the newly built housing (2016) seems to mimic the existing urban renewal housing in terms of (roof)shape and height, although it uses a different type of brick and roofing tiles. Therefore, although the urban renewal itself does not fit in with the older housing in the street, the newly built housing does fit in with the urban renewal.

What is the quality of the view from the house?
The houses look out over a daycare and playground. Although the daycare was built during the same period, its exterior design is quite different from the houses. Because of the playground, the view is relatively wide. However, because there is not a lot of greenery in the street, the view is quite bare and mainly consists of concrete.

What is the quality of the landscape around the house?
Similar to the Bokkenbuurt, there is little greenery in the street, apart from the trees that line the street. The street sections show no variation, although in general there is some variation over the whole street because of the different building periods. There are two grass fields and playgrounds in the direct neighborhood where sports were being played when I visited.


Side view of the house

View from the house

The street is quite wide, with broad pavements and double-parking lanes. Because of the little greenery, the general look of the street is quite stone-like. The street is quiet, with few pedestrians and some cars.

What is the pleasantness and image of the neighborhood?
The Fruitbuurt, where the Nieuwlichtstraat is located, forms together with the Bomenbuurt the larger district of Ondiep. Similar to the Bokkenbuurt, Ondiep was originally a working-class neighborhood built in the 1910's and 1920's where often multiple generations of a family lived in the same neighborhood. Recently, the composition of the neighborhood has changed as families with a higher income, students and families with a migration background have moved in. Over the last decade, several parts of Ondiep have been demolished and rebuilt, despite protests by residents. The original residents had priority for a house in the neighborhood, but these were often too expensive and many of them moved somewhere else. The social composition of the neighborhood is reflected in the people that are present in the street, and by the garden chairs and mopeds in front of the houses. Although the composition of the neighborhood has changed, Ondiep still has the image of a working-class neighborhood. However, at the time of writing, an urban renewal single-family house is for sale for 450,000 and an apartment for 260,000, amounts which most working-class home seekers are unable to afford. The neighborhood offers a few services, such as a school, daycare, sporting facilities and some small shops.

Newly built housing (2016) in a side street


Other side of the street towards Ondiep (street), with some 1920s housing


One side of the street towards Marnixlaan


Identical house as Lamstraat