MASTER

Measuring the relation between tall buildings and housing values within Dutch cities

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Measuring the relation between tall buildings and housing values in Dutch cities

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Title:

Measuring the relation between tall buildings and housing values within Dutch cities

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Preface

Dear reader,

In front of you lies my final thesis "Measuring the relation between tall buildings and housing values within Dutch cities" for the track Urban Systems & Real Estate as part of the master Architecture, Building and Planning from the Eindhoven University of Technology. The reason why I chose this subject came as a result of my personal interest in high-rise developments that arose during my visits to the U.S. and Asia combined with the current housing shortage there is in the Netherlands. These fields of interest have made me want to complete my studies with a research on high-rise developments. In total I have worked for over a year on this final piece that wraps up my studies in Eindhoven and also finalizes my time as a student.

First of all, I want to thank Theo Arentze, Ioulia Ossokina and Peter van der Waerden from the TU Eindhoven for the expertise they brought into my research and for the constructive feedback during our meetings and the suggestions on where to look for next.

Secondly, I want to thank my direct coworkers and supervisors at Arcadis who helped me out when I had certain questions or when I was stuck within my research. In particular I want to thank Kees Swinkels, Janneke Roosjen and Tjark Huisman who helped me out during difficulties I encountered during this period.

Finally, I want to thank all my friends and family who supported me during the writing of this study as it was very challenging. As a result of the ongoing pandemic I had to adapt constantly into new workplaces; from my bedroom towards an office and at some point also back to university again. Nevertheless I'm very happy that the world is slightly opening up again and I'm ready to explore it again!

Alain Groeneveld

Zeist, January, 2022

Summary

Motivation

The Netherlands currently experiences a very tight housing market and recent policy documents make it clear that a larger housing supply is essential. This creates opportunities for new real estate developments and also raises the question of where these developments should be realized. Recent policy documents by the Dutch government such as the Nationale Omgevingsvisie (2020), showed that there is a growing emphasis on housing (re-)developments nearby already existing medium-sized urban areas paired with densifications. Meanwhile, the way in which these densifications and redevelopments of urban areas should be realized is the reallocation of brownfield (urban) locations and densification of Dutch urban cores. Besides, the current trends of densification and the development of high-rise buildings seem to occur all over Europe. Densification is also partly the result of the growing demand for urban living and the increasing degree of urbanization worldwide.

The aforementioned trends result in more high-rise buildings in cities. It is known from literature that the appreciation that people have for the qualities of environmental features (e.g. accessibility or greenspaces) can be translated into the housing transaction prices. High-rise buildings appears to be negatively associated by people, as they are linked with larger demands for parking spaces, altered lines of sights and shadowing effects. This raises the question whether there is a negative relationship in place as a result of high-rise buildings on nearby located houses on the transaction price. This resulted in the following research question:

"What effect does the existence of nearby high-rise buildings have on the transaction value of the closely located residential real estate?"

Methodology and data

To answer this research question, a hedonic price model was used. This regression method made it possible to statistically relate the housing transaction prices to the frequencies and heights of high-rise buildings in their surroundings. This method was applied to the following five medium-sized Dutch cities: Amersfoort, Groningen, 's-Hertogenbosch, Nijmegen and Tilburg. These cities were chosen because they are similar in size and have a comparable population structure. To answer the research question, all real estate objects taller than 15 meters were identified in said cities and labeled as high-rise. This was achieved by using a geographic information system (GIS) and 3D (building-)height maps of the Netherlands. Subsequently the angle between the dwelling and nearest high-rise object (referred to as building angle) was computed in GIS using trigonometrical functions. This building angle is larger when the high-rise objects are taller or when the dwelling is located closer to the high-rise object. The building angle was used as a proxy for the degree to which high-rise buildings have aesthetic effects on the houses (e.g. through the obstruction of views). The data that was prepared in this manner was merged with a transaction dataset provided by the Dutch Association of Real Estate Brokers and Real Estate Experts (referred to as NVM) over the years 2016 to 2018. For the resulting dataset of about 16 thousand single-family homes, multiple specifications of the hedonic pricing model were estimated, including one with fixed effects at the four-digit zip code level.

Results

First of all, the presence of a high-rise object in the vicinity of 50 meters from a dwelling goes paired with a decrease in price of 2.9%. This is in line with the existing literature that showed that the presence of high-rise buildings is associated with negative external effects such as a higher parking pressure, altered lines of sight or shadowing effects.

Secondly, this study suggest – unexpectedly – that there is a weak yet positive relationship in place between the building angle and the housing transaction price of dwellings in the near vicinity of high-rise. In other words, the proximity of high-rise seems to become less negative when the high-rise building is taller or nearer. A possible explanation could lay in the fact that the taller high-rise objects in the dataset could possibly also be water towers, church towers and other monumental objects. However, the absolute values of the standardized coefficients are low. Also, a positive relationship with the housing transaction price was found if not the angle but number of high-rise objects is used as a regressor. However, also in this case the standardized coefficient was very low.

Conclusion & recommendations

The results of this study suggest that although presence of high-rise buildings in the vicinity of a house is negatively valued, neither the density of high-rise buildings nor the high-rise building angle have additional negative effects. This suggests that the close proximity of high-rise objects might give certain benefits for neighboring residents, for example, because high-rise buildings often house more than one function and, hence, may be associated with the addition of new functions in an area. These findings could help policymakers to develop spatial policies regarding high-rise buildings in urban areas.

However, there are also a number of limitations that arose throughout this study. First, the contribution of high-rise buildings to the neighboring housing prices is relatively low. This could suggest that the degree of high-rise plays a relatively small role and other factors weigh more heavily in people's housing preferences. Second, this study examined only five medium-sized Dutch cities with relatively few high-rise buildings. It might very well be that the presence of high-rise buildings in larger cities like Rotterdam or Amsterdam has a different relationship with the housing transaction price. Third, the used lower limit of 15-meters to classify buildings as high-rise was relatively low. This lower boundary caused that building objects were sometimes wrongly marked as high-rise because they were overshadowed by trees. Therefore, it is recommended that the contents of the 3D maps may need to be validated in a different way to achieve better measurements. Fourth, this dataset could not differentiate the functions of the high-rise buildings. In particular, the dataset contained a number of water towers, spires or chimneys that were classified as high-rise buildings. For future research it is therefore recommended that buildings are classified according to their zoning plans and, in addition, that the focus is laid on residential or office buildings.

Samenvatting

Motivatie

De woningmarkt in Nederland is momenteel erg verhit en kampt met een enorme schaarste. Daarnaast maken recente beleidsstukken het vrij duidelijk dat er een grotere woningvoorraad nodig is. Dit creëert kansen voor nieuwe vastgoedontwikkelingen en doet ook de vraag rijzen waar deze ontwikkelingen plaats kunnen vinden. De recente Nationale Omgevingsvisie van het Ministerie van Binnenlandse Zaken (2020) laat zien dat er een grotere nadruk komt te liggen op het (her-)ontwikkelen van woningen nabij stedelijke gebieden dan wel het verdichten van deze gebieden. De manier waarop deze verdichtingen en herontwikkelingen van stedelijke gebieden plaats moeten vinden is door het herbestemmen van bestaand vastgoed en het verder verdichten van Nederlandse stadscentra. Deze trends van verdichting en herontwikkelingen lijken vrijwel overal in Europa zichtbaar. Dit is deels te wijten aan de groeiende vraag voor het wonen in stedelijke gebieden en de groeiende wereldwijde urbanisatiegraad.

Genoemde trends leiden tot meer hoogbouw in de steden. Uit de literatuur is bekend dat de waardering die mensen hebben voor de kwaliteit van de omgevingseigenschappen (bijvoorbeeld bereikbaarheid of groenvoorzieningen) zich kan vertalen in de prijs van woningen. Hoogbouw lijkt door de mensen negatief gewaardeerd te worden, want deze wordt geassocieerd met een hoge parkeerdruk, veranderde zichtlijnen of schaduwwerking. Dit wekt dan ook de vraag of er mogelijkerwijs negatieve prijseffecten ondervonden kunnen worden van hoogbouw in de buurt van bestaande woningen. Dit leidt tot de volgende onderzoeksvraag:

“Welk effect heeft de aanwezigheid van hoogbouw op de transactiewaarde van het nabijgelegen woonvastgoed?”

Methode en data

Om deze onderzoeksvraag te beantwoorden is een hedonische prijzenmodel gebruikt. Deze regressiemethode maakt het mogelijk om de transactieprijzen van woningen in statistisch verband te brengen met de hoeveelheid en hoogte van hoogbouw in de omgeving. De methode werd op de volgende vijf middelgrote Nederlandse steden toegepast: Amersfoort, Groningen, ’s-Hertogenbosch, Nijmegen en Tilburg. Deze steden zijn gekozen omdat ze ongeveer even groot zijn en een vergelijkbare bevolkingsopbouw hebben. Om de onderzoeksvraag te beantwoorden, werden eerst alle vastgoedobjecten hoger dan 15 meter in de genoemde steden in kaart gebracht en geclassificeerd als hoogbouw. Er is gebruik gemaakt van geografische informatiesystemen (GIS) en 3D (gebouw-)hoogtekaarten van Nederland. Vervolgens werd voor elke woning in de buurt van hoogbouw met behulp van GIS en aan de hand van goniometrische functies de hoek berekend tussen de woning en de top van het dichtstbijzijnde hoogbouwobject (verder *hoogbouwhoek*). Deze hoogbouwhoek is groter als hoogbouw hoger is of als de woning dichter bij hoogbouw staat. De hoogbouwhoek werd gebruikt als een proxy voor de mate waarin hoogbouw uitstralingseffecten heeft op de woning (bijvoorbeeld door de zichtverstoring). De op deze manier opgemaakte data werden samengevoegd met een transactiedataset van De Nederlandse Vereniging van Makelaars en Taxateurs in onroerende goederen (NVM) over de jaren 2016 tot en met 2018. Voor de resulterende dataset van ongeveer 16 duizend eengezinswoningen werden meerdere specificaties van het hedonische prijzenmodel geschat, waaronder een met fixed effects op viercijferig postcodeniveau.

Resultaten

Ten eerste blijkt dat aanwezigheid van hoogbouw in de omgeving van 50 meter van een woning samengaat met een prijsdaling van een woning van ca 2.9%. Dit is in lijn met de bestaande literatuur die laat zien dat hoogbouw geassocieerd wordt met negatieve externe effecten zoals een hoge parkeerdruk, veranderde zichtlijnen of schaduwwerking.

Ten tweede suggereert dit onderzoek – onverwachts – een zwakke maar positieve relatie tussen de hoogbouwhoek en de transactieprijs van vastgoed in de omgeving, dit voor de woningen in de buurt van hoogbouw. Met andere woorden, lijkt de uitstraling van hoogbouw minder negatief te worden als hoogbouw hoger is. Reden hiervoor zou kunnen zijn dat hogere hoogbouwobjecten in de data watertorens, kerktorens en andere gebouwen monumentale objecten zijn. De absolute waarde van de gestandaardiseerde coëfficiënt is echter laag. Ook werd een positieve relatie gevonden tussen het aantal hoogbouwobjecten in een postcode zes gebied en de transactieprijs van woningen. Echter is ook hier de gestandaardiseerde coëfficiënt erg laag.

Conclusie & aanbevelingen

De resultaten van dit onderzoek suggereren dat hoewel aanwezigheid van hoogbouw in de omgeving van een woning negatief wordt gewaardeerd, noch de dichtheid van hoogbouw noch de hoogbouwhoek additioneel negatief effect sorteren. Reden hiervoor kan zijn dat de nabijheid van hoogbouwobjecten ook baten kan hebben voor de omwonenden. Dit kan veroorzaakt worden door de eerder genoemde monumentale objecten zoals watertorens of kerktorens dan wel het huisvesten van meer dan één functie en daardoor in verband kunnen worden gebracht met de toevoeging van nieuwe functies in een gebied. Deze bevindingen zouden beleidsmakers kunnen helpen bij het ontwikkelen van beleid rondom hoogbouw in stedelijke gebieden.

Echter is er ook een aantal beperkingen dat gedurende dit onderzoek aan het licht kwam. Ten eerste is de bijdrage van hoogbouw in de buurt aan de woningprijzen relatief laag. Dit zou kunnen suggereren dat hoogbouw een relatief geringe rol speelt en andere factoren zwaarder wegen bij de woningkeuze van mensen. Ten tweede onderzocht deze studie slechts vijf middelgrote Nederlandse steden met relatief weinig hoogbouw. Het zou goed kunnen dat de aanwezigheid van hoogbouw in grotere steden als Rotterdam of Amsterdam een andere relatie heeft met de woningprijs. Ten derde is voor de definitie van hoogbouw een ondergrens van vijftien meter gebouwhoogte gebruikt, wat relatief laag is. Hierdoor werden vastgoedobjecten soms onterecht gemarkeerd als hoogbouw omdat deze overschaduwd werden door bomen. Daarom is het aanbevolen dat de inhoud van de 3D kaarten wellicht op een andere manier gevalideerd dienen te worden om tot betere metingen te komen. Ten vierde kon in deze dataset geen onderscheid worden gemaakt tussen de functies van de hoogbouw. In het bijzonder bevatte de dataset een aantal watertorens, torenspitsen of schoorstenen die als hoogbouw waren geclassificeerd. In het vervolg is het daarom raadzaam om gebouwen te classificeren aan de hand van de bestemmingsplannen en zich daarnaast te focussen op woon- of kantoorgebouwen.

Contents

1 Introduction

This study aims to identify the relationship between housing value and high-rise buildings within the proximity of land-bound dwellings in five medium-sized Dutch cities. The current Dutch housing market is overheated and suffers from high real estate prices. Because of overheating and high prices it is important that new developments occur in order to provide a decent supply and to reduce the current price pressure. A solution towards a price reduction could be the expansion of the current housing stock, where a larger supply could cool down the current market. However, such high-rise developments are often controversial and lead to protests from neighboring residents as it could obstruct views or cause privacy objections (Bouma, 2019). Therefore, this study tries to determine whether high-rise buildings have a relationship on the local housing values of land-bound dwellings.

1.1. Background

The overheating of the Dutch housing market is a result of the 2008 economic crisis and the following euro crisis, which affected the Netherlands and Europe significantly. Many banks had to be rescued by national governments. However, due to bankruptcies of certain banks, people lost large sums of money. Furthermore, the 2008 financial crisis caused a significant change to the Dutch housing market which suffered a decline for five years. Between the second quartile of 2008 and the second quartile of 2013, the Dutch housing values decreased by nearly 20% (Nijskens & Lohuis, 2019). The recovery of the financial crisis started slowly after the second quartile of 2013 and it took until the second quartile of 2018 to regain the same values as before the crises (Nijskens & Lohuis, 2019). However, this recovery period for larger cities was much different than for the rest of the Netherlands. The four largest cities in the Netherlands experienced a much stronger recovery in the same period. The growth of these cities varied between 35% for The Hague, around 40% for Rotterdam and Utrecht, and nearly 50% for Amsterdam (Nijskens & Lohuis, 2019).

The large comeback of the four major cities can be explained by the large amount of urbanization the Netherlands experiences, which in turn causes a serious housing shortage. During the last decade, the Netherlands experienced significant growth in urbanization rates, from 86,3% in 2009 towards 91,9% in 2019 (O'Neill, 2020), which exceeds the continental Europe's urbanization rate of 74% in 2019 (Population Reference Bureau, 2019). This data shows that the cities in the Netherlands experienced a major attraction of people moving to urban areas, which can be translated into a growing housing market for such areas. Apart from this big growth towards the city, the Netherlands also experiences an enormous shortage in the housing stock. It is estimated that the housing stock in 2020 lacked approximately 331.000 dwellings (4,2% of total housing stock) and the shortage likely rises towards 419.000 dwellings by 2025 (5,1% of housing stock) (ABF Research, 2020). Furthermore, it is projected that until 2035, there need to be developed over one million new dwellings within the Netherlands (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2020a). The scarcity of the Dutch housing market has caused a so-called sellers' market, which allows homeowners to ask for higher prices due to the high demands.

Other reasons for the strong increase in housing values can be explained by the many new investors who entered the real estate market. These investors consider real estate as a relatively safe investment since people always need a place to live (van Doorn et al., 2019). Furthermore, the investors are looking for new opportunities in the real estate markets as their current savings are not profitable in their bank accounts. Therefore, they aim to expand their portfolios and obtain higher returns for their money. This increasing competition within the housing market leads to a tighter market since private investors are competing with regular buyers. However, the addition of people in the same market should not be considered a bad thing, as this might help the rental market by providing an increased supply and eventually lower rental prices. However, it should be noted that Dutch policies are currently aimed at homeownership, and being a homeowner is still encouraged by providing mortgage interest deductions.

Besides, the construction sector is currently not able to keep up with the high demands since it came to a standstill in the previous crisis. As a result of the 2008 financial crisis, there were about 80,000 jobs in the construction sector that vanished causing a shortage in construction workers (Economisch Instituut voor de Bouw, 2015). Furthermore, the Dutch construction sector had a hard time making adaptions towards new nitrogen regulations, which caused even further delays in construction projects.

1.2. Research focus

In recent studies, it has become clear that there was a relation between building densities and the housing values within the Netherlands (Meijers, 2018). Although, one could argue that dwellings located in higher densities are often also closely located to facilities and can have a higher value. Furthermore, Jim & Chen (2009) tried to capture the price effect of mountain and harbor views on property prices in Hong Kong and found a positive effect for houses with a view on the harbor while mountain views were negatively affected. Similar relationships were found for houses that were located nearby water and greenspaces in the Netherlands (Luttik, 2000). On the same level, Thibodeau (1990) observed a change in housing value when a new high-rise office building was developed.

All of the points mentioned in the previous section caused the drastic changes, scarcity, and high demands in real estate that the Dutch residential housing market is experiencing. To reduce the high demands, prices, and scarcity, it is important to increase the supply. However, new building plots are scarce in the Netherlands. Therefore, the majority of the new developments must take place in and around existing cores (Ministry of Infrastructure and the Environment, 2011). Furthermore, densification and the developments of high-rise buildings can help to accommodate more people on the same plot of land and offer sustainable land use. However, the addition of high-rise in Dutch cities is often controversial given that the Netherlands currently has very few high-rise buildings. This knowledge, combined with already existing studies that are presented in the paragraph above, leads to a relevant case. Many researchers have studied the effects of certain items on housing values (e.g. mountains, green, or building densities), but fairly little is known about the effects of tall buildings on the surrounding areas and what it does to the housing values in the surrounding areas. Therefore, this study tries to quantify the presence of tall buildings on the surrounding housing values in the following five medium-sized cities: Amersfoort, Groningen, ‘s-Hertogenbosch, Nijmegen and Tilburg.

1.3. Problem statement

This study tries to extend the existing literature, while it also adds useful information regarding urbanization and the perception of high-rise developments. It is a significant challenge in the Dutch housing sector to overcome the current shortages in housing while the governmental policies are aimed at urban developments. Furthermore, the present literature studies mainly focuses on the relations of sold transactions and a given item or building in its surroundings instead of a variety of buildings within a city. This study tries to pave the way towards a solution and develops a model where the building heights and housing values are studied. Specifically, research shall be conducted on five Dutch cities which are all part of the “Stedelijk Netwerk Nederland” (urban network Netherlands) by using transaction data from 2017 to 2019 from NVM the Association of Dutch Real Estate Agents, a building height map of the Netherlands, and applying a fixed effect model. The main goal is to combine all these datasets in order for them to provide an outcome to the research question, which is as follows:

"What effect does the existence of nearby high-rise buildings have on the transaction value of the closely located residential real estate?"

To answer the main question, five sub-questions are developed to identify the functioning of the Dutch residential market. First the presence and history of high-rise buildings are discussed, followed by describing which externalities can be found. Second, an exploration is made on how to include the building heights within a hedonic price model to find out what relationship is present on the transaction price. Third, it is aimed to derive the building heights by using 3D building maps. Fourth, the effects of distance towards the tall buildings will be studied to find whether the effects decay when distances are rising. Finally, it aims to discover whether there are differences among the different studied cities. All the points mentioned above are formulated into the next sub-questions:

1. "Which functions do high-rise buildings have in cities and what externalities can be found?"
2. "In what way can the building heights be incorporated in a hedonic price model to predict the transaction prices?"
3. "How can 3D mappings be used to derive building height information?"
4. "What price effects can be observed as a result of a nearby high-rise building?"
5. "How do transaction prices in different cities compare to each other?"

1.4. Academic relevance

This study tries to discover whether there are any noticeable price jumps in the close vicinity of high-rise building objects. This is achieved by extending the current present knowledge on the hedonic price model and adding new contributions towards integrating 3D mapping models. The 3D model maps from the Netherlands are relatively new and present information regarding the building heights. Therefore, this study aims to extend existing knowledge by using 3D models while calculating housing values. Fleming et al. (2018) used similar models to capture the effect of the number of solar hours on the housing values within their studies in New Zealand. However, this study tries to extend their knowledge by capturing the price effects as a result of the presence of tall building structures nearby low-rise residential areas. This is achieved by setting a range around the tall objects and adding low-rise surroundings to the dataset, while the scientists in New Zealand mainly focused on the solar projections for every two degrees resulting in 180 observations per building. Therefore this study seems to be vastly different regarding the inclusion of the local surroundings of the sold transactions.

1.5. Practical relevance

In terms of the practical relevance, this study is relevant as it attempts to discover whether there are any differences in housing values nearby tall building structures. This particular field of study is of interest because the current market developments focuses on the expansion and densification of existing city centers where space is often costly and limited. Furthermore, it is expected that the degree of urbanization grows in the coming years (United Nations, 2018), which also might affect the degree of high-rise structures in Dutch cities. Therefore, this study considers the question to what extent the degree of high-rise buildings might influence the (pre-existing) surrounding housing values. Therefore, this study tries to identify this relationship and discover what effects are noticeable. Furthermore, it can mean that policymakers can use outcomes of similar studies for compensations for the homeowners who might suffer from negative externalities from nearby newly built high-rise objects.

1.6. Reading guide

First, the literature study explores the Dutch urban and economic developments of recent years. Then, the housing market and its functioning in a European context is considered. Second, chapter three covers the literature on the hedonic pricing model and its main principles and applications of the model. Chapter four introduces the hedonic price model that was used for this study and describes how the building angle is connected to the hedonic price model. Chapter five explains the GIS mappings and the different processing methods. The sixth chapter presents the dataset, its incorporated variables and the removal of outlying values. Chapter seven presents the final results and presents a robustness study to make sure the variables are behaving as expected. Last, the conclusion, discussion and recommendations are given in chapter eight.

2 Literature review

To get closer to answering the research question, the following subdivision is made into different topics. First, the urban and economic developments in the Dutch housing market are considered, after which the residents within the Dutch cities are studied. Second, the European real estate markets are studied, after which the stance on high-rise developments within Europe throughout the years is considered. Besides, the focus slowly zooms in from a broad European context to a municipal scale for the five studied Dutch cities.

2.1 Urban Developments in the Netherlands

This section covers the subjects of urban developments and urbanization within the Netherlands. First, the economic position of the Netherlands is discussed. Second, urbanization and previous urban developments are considered. Third, the residents of the largest Dutch cities are studied to create an understanding of which people choose to live in a city and what motivates them.

2.1.1 Economic developments of the Netherlands

The Netherlands is currently in a really strong position regarding the economy, but also regarding its geographical location. The Dutch economy has recently been ranked as the most competitive economy of Europe and has been placed in the fourth position worldwide (Schwab, 2019). The Netherlands obtained this strong economy as a result of the strong geographic positions in infrastructure. Schiphol Airport functions as a hub for people entering Europe and allows them to continue their way anywhere else in Europe. Additionally, the port of Rotterdam is among the global top 10. Both the air- and seaports allow the Netherlands to export great amounts to the neighboring countries Germany and Belgium. Both these countries are also the two biggest trading partners of the Netherlands (CBS, 2019). As a result of this, both cities and their hinterlands bring a large amount of employment to the areas. For example, the port of Rotterdam brings in over 100,000 direct jobs into the area of a city of roughly 650,000 residents (Van Der Lugt et al., 2018). Furthermore, the Netherlands has been focusing on developments in new areas such as the Brainport region around Eindhoven or the Foodvalley near Wageningen (Ministry of Infrastructure and the Environment, 2011). All these kinds of regions have gained more significance and attention over the last few years and are nearly all part of a larger geographical (servicing) area. The ports of Amsterdam and Rotterdam are very well connected to the Randstad, a metropolitan region comprising the Netherlands' four largest cities. This was also partly in line with the fifth memorandum of spatial planning which was proposed in 2001 and identified six national urban networks (Ministry of Housing, 2001). Within the memorandum, there has also been an understanding of the importance of a connection with other European urban alliances, such as the Flemish Diamond and the Rhine-Ruhr metropolitan area. Dieleman & Faludi (1998) learned in the late 1990s that there was an urgency of transnational (urban) planning since the Netherlands functioned as a gateway towards the rest of Europe.

The Netherlands' strong economy cannot always be taken for granted, as the country has transformed heavily over the past decades. Where there used to be local industrial areas, as mentioned in the previous paragraph, these have now nearly vanished and have been replaced by more knowledge-based jobs. During the periods of economic growth in the 1960s, the Netherlands experienced a period of urban growth. The growth had to be managed, so the Dutch government developed the concentrated deconcentration policy in the Second policy document on spatial planning in 1966 to create a bundled growth outside existing towns and cities (Ministerie van Volkshuisvesting en Ruimtelijke ordening, 1966). This document also presented several growth locations where municipalities could expand and perseverance areas for corridors towards the cities. Furthermore, during the 1960s there was an expansion of the Dutch housing stock, as a result of developments of high-rise apartment buildings (Turkington et al., 2004). This was not only common in the Netherlands but occurred all over Europe, as Turkington et al. (2004) concluded.

Later on, the Netherlands adopted the spatial plans and focused on the developments near the largest cities, which in turn experienced some decays as a result of the agglomeration within the areas. An example is the experience of negative effects like congestion and pollution as caused by the present industries. Other declines around the high-rise buildings were caused by social problems, middle-class families could afford better housing and moved out, while the people who could not afford better housing remained (Turkington et al., 2004). The Dutch government tried to reduce congestions by lowering the number of movements in traffic and starting housing developments in places close to jobs within the Randstad. To achieve this, the Dutch government created the VINEX (Fourth Memorandum Spatial Planning Extra) where they maintained the following principle: "*proximity over accessibility*" (van der Cammen & de Klerk, 2003). The new policies focused on construction in and around existing cities and their surroundings, paired with extra investments in public transportation such as urban and regional transportation.

In the last decade, the Netherlands suffered heavily from the 2007 financial crisis and the housing market got disrupted heavily. The real estate market experienced a major decline as a result of the global financial crisis and the total number of housing transactions plummeted shortly afterwards (figure 1). The aftermath of this financial crisis caused large disruptions in the construction sector which eventually came to a standstill and led to many people leaving the construction industry (van Doorn et al., 2019). This eventually caused a major decline in newly developed housing too. Centraal Planbureau (2019) concluded that until 2010 about 20,000 dwellings were being delivered every quartile and this number dropped significantly below 15,000 in the following years. However, in recent years the housing market became overheated due to the lack of new supply and the growing demand for housing. This, together with the drop in newly developed housing stock, caused a high demand on the Dutch housing market. It has been estimated that there will be a need for nearly 1 million new houses by 2035 (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2020a).

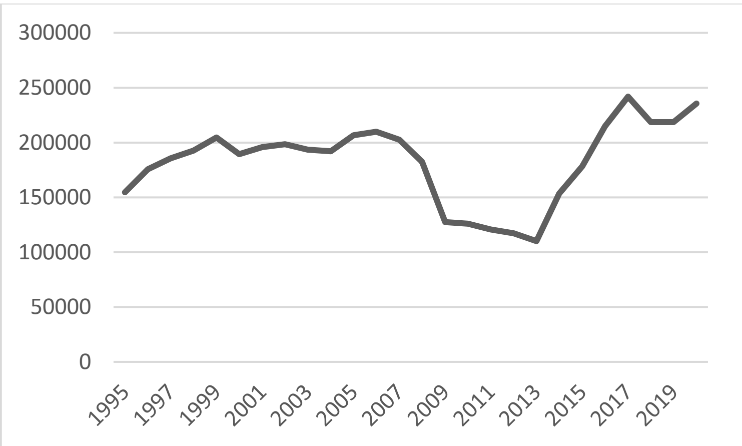


Figure 1: housing transactions in the Netherlands over time (from: CBS, 2018a)

To reduce the scarcity on the current market, it is therefore important to expand the current housing stock. This also implicates that it is important to develop houses in higher densities to house all these people, which is also recognized by the Dutch national government. The government has recently presented the ladder of sustainable development, which focuses on giving new purpose to a pre-existing building instead of permitting greenfield developments

(Ministry of Infrastructure and the Environment, 2011). Furthermore, the idea of developing in higher densities is also recognized by the Organization for Economic Cooperation and Development (OECD) (2012), which claims that higher densities also allow cheaper investments in infrastructure and better connectivity to an area. Besides, building in higher densities also implicates that there is less land used to house a large number of people (figure 2). Finally, the higher densities also allow better connections to mass rapid transit corridors which is denoted by the red line.

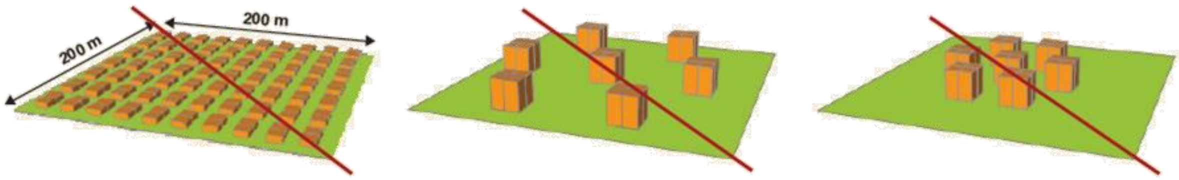


Figure 2: left low-density land use – right high-density compact land use (image: OECD, 2012)

However, there is also a downside of living in high-rise buildings. Larcombe et al. (2019) found that living in high-rise buildings might cause negative mental health issues for people in poor areas. Furthermore, it is also found that residents of high-rise objects are not highly related to the nature facilities which could lead to health issues such as increased stress levels (Larcombe et al., 2018). Other negative high-rise effects can be experienced with the housing of children, who require parental supervision to play outside (Gifford, 2007). Also, the residents of high-rise buildings appear to have less cohesion as the residents have fewer friendships in the high-rise buildings (Gifford, 2007).

2.1.2. Residents of Dutch cities

The previous paragraphs focused on the Dutch economic position and the functioning of the Dutch policies in the past decades. However, these paragraphs did not reflect the behavior of people moving towards the city and their reasoning in moving towards a particular city. This section tries to identify the moving tendencies of Dutch people and which steps they take before buying a house within the cities.

A recent study by the Dutch Environmental Assessment Agency (PBL) showed that the majority of the people moving towards the six largest cities of the Netherlands (Amsterdam, Rotterdam, The Hague, Utrecht, Eindhoven and Groningen) were either people aged between 18-24 and 25-29, while the majority of older people are leaving the city behind (Husby et al., 2019). Furthermore, their study showed that the inflow of foreign people aged between 18-64 increased sharply in the last five years and was responsible for over 40% of the total incoming persons of the six largest cities. This group seems to replace the people that were coming from surrounding areas of the cities and other parts of the Netherlands, so these two groups show a significant drop in presence. The majority of the foreigners that are entering the Dutch cities are young people, the other foreign people that are entering these cities are likely expats who come for job opportunities in, for example, Amsterdam, Rotterdam and The Hague (Husby et al., 2019).

Younger people moving towards the city is nothing new. According to Husby et al. (2019), the people between 18-24 have been the biggest demographic group that moved to the city in the last two decades. The reason why young adults are moving towards cities is described by Fielding (1992), who labeled the city in the South East of the UK as an escalator where young adults enter the city and climb up the socioeconomic ladder and leave the city later on a higher level. These young adults presumably move towards the city to finish their educations and will, later on, find their first jobs in or around this city. They will eventually leave the city when they have accumulated more wealth and look for more space. Other scholars seem to agree with the shaped picture that students come to cities and remain there with like-minded people. A great example is sketched by Glaeser (2011), who described the development of Silicon Valley and links it to the students that were attracted to Stanford University. These students lingered to found companies like Intel and Cisco. The Dutch Environmental Assessment Agency (PBL) (2015) endorses the escalator theorem and mentions that it can be used to explain the migration flows towards the city.

It is clear that young adults hold the largest share of inflow towards the larger Dutch cities, since these cities can provide a step towards their adult life by providing educational facilities. Furthermore, it is known that young adults are in a phase of life where they are expressing themselves and therefore look for people with similar interests. The young adults were also suffering from increased loneliness as a result of the imposed measures to combat the spread of Covid-19 and the loss of their social life (I&O Research, 2020). Adults older than 35 seem to experience less feelings of loneliness, which might be explained due to the fact that those people are already further in life and do not have the needs of younger people to express themselves.

When the moving patterns of adults above 30 are considered, it becomes clear that these people are leaving the cities for the neighboring suburban areas. Adults seem to have different preferences when it comes to housing. According to a British survey among people that were living in and around cities, it became clear that people aged over 30 prefer to live in suburbs since they can get more value for their money, they are close to good schools and they feel safe in their neighborhoods (Thomas et al., 2015). This movement towards the suburbs has also been recognized by Husby et al. (2019), who noticed that during the last two decades people in their thirties were leaving the cities for the surrounding areas. However, there was one exception, which was during the 2008 financial crisis, which caused a drop in the departure rates of people in their thirties. This could be a result of the increased insecurities caused by the financial crisis and the paired decline. After the financial crisis in 2008, the residential market started to pick up again, which caused a departure of people in their thirties between 2013 and 2018 (Husby et al., 2019).

2.2 The European real estate context

To gain a better understanding of how the housing markets and high-rise policies are functioning throughout Europe, the following subdivision is made. First of all, an explanation is given on the overall different housing typologies throughout Europe, followed by the different housing financing structures in the different countries. Afterwards, the policies around the different types of high-rise are considered in a European context, gradually zooming in towards a Dutch context and even municipal contexts. Last, the different functionalities and effects of high-rise buildings are considered.

2.2.1 European housing typologies

The real estate markets in each of the European countries seem to differ a lot and do not appear to be homogenous at all. When comparing the various types of dwellings within each country, it can be noted that the Netherlands has a very different distribution than neighboring countries like Belgium or Germany. Moreover, if cities such as Barcelona, Copenhagen, or Paris are considered, it appears that these cities have a large number of apartment buildings containing approximately four to six building layers. Meanwhile, the Dutch housing market appears to differ from that image and has about half of the average number of flat buildings throughout Europe. When this is compared to the European counterparts, the Netherlands differs fundamentally. When considering Spain and Germany, the population living in flat buildings is amongst the highest in Europe, roughly between 55% and 65% of all dwellings, as shown in figure 3 (Eurostat, 2020). This could allow new opportunities for the Dutch market to facilitate new housing with a more sustainable footprint.

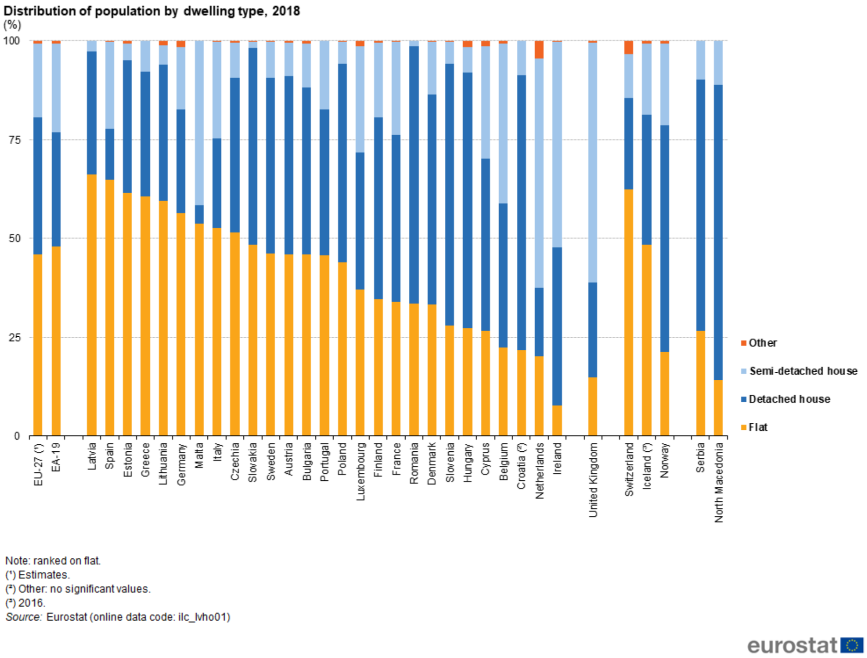


Figure 3: Population distribution by dwelling type (from: Eurostat, 2020)

To place the number of flats in perspective throughout the other housing typologies, it can be noted that the Netherlands differs a lot in the semi-detached house category. The Dutch housing stock in semidetached dwellings is the largest within the European Union, and only second if the UK is also considered.

2.2.2 Housing financing throughout Europe

Aside from the different housing typologies within Europe, the Netherlands also differs considerably in terms of financing the housing market. First of all, the Dutch tend to spend a large sum of their disposable income on the costs of housing. Second, the percentage of bought houses in the Netherlands is relatively high compared to other European countries. This is likely the result of policies that promoted homeownership with measures such as mortgage interest tax deductions. However, the mortgage interest tax deductions were as of 2017 still in place in Belgium, the Czech Republic, Denmark, Estonia, Finland, Italy, Luxemburg, Netherlands, and Sweden (Barrios et al., 2019). Furthermore, the number of owners with a loan or mortgage is very high in the Netherlands compared to other European countries. The number of Dutch homeowners with a loan or mortgage ranks far above the European average of 25% with 60.4% (Eurostat, 2021). Meanwhile, the share of owner-occupied housing without any mortgages or loans is the lowest of the entire European Union with only 8.5% compared to the European average of 44.8% (Eurostat, 2021).

Aside from the differing degree of homeownership within the Netherlands, another thing was noticeable: the loan to value ratio that Dutch households have for their mortgages. This value had been very high in the past but seems to decrease as a result of new regulations. Nonetheless, the loan-to-value ratios were respectively 100% in 1996; 125% in 2006, and 101% in 2017 (Barrios et al., 2019). Meaning that the mortgages were higher than the value of the collateral housing value. This can be seen as a potential risk as highly indebted households will need to reduce their consumption to avoid defaults during periods when house prices decline (André, 2016). Moreover, the Netherlands experienced such periods in 2013 where nearly 40% of the households that had a mortgage were in negative equity (Kierzenkowski et al., 2014).

2.2.3 High-rise policies in Europe

In past decades, there have been several policies that have changed throughout the years when it comes to high-rise developments. Back in the day, there was no such thing as high-rise in the European Union and it was argued that the first high-rise object was constructed in the Netherlands. The office building The White House (in Dutch: Het Witte Huis) in Rotterdam is argued to be the first skyscraper with its 45 meters and was delivered by the end of the 19th century (Top010, 2012). The building itself was inspired by the high-rise office buildings of New York but is nowadays surpassed in height by other tall buildings in its proximity (Rijksdienst voor het Cultureel erfgoed, 2020).

The general the landscaping of Europe did not feature many skyscrapers, whereas the landscape of the United States commonly featured high-rise buildings. European cities relatively often had an older central city or historic buildings while American counterparts were missing this. As a result of the lack of history, the Americans decided to develop tall structures within their cities (Pietrzak, 2013). Up until the 1950s, it was uncommon within Europe to develop high-rise buildings, but it became more common after that. However, this did not mean it was not completely neglected. For instance, renowned architect Le Corbusier started experimenting with mass-produced concrete elements back in 1914 (van der Cammen & de Klerk, 2003). Later on, during the 1930s, it was argued that high-rise buildings with escalators could function as streets in the sky and also provide more space, comfort, and collective facilities (van der Cammen & de Klerk, 2003).

The expansion of the high-rise housing stock started to take place after the Second World War and can be explained as a result of the shortage in housing back then (Pietrzak, 2013). The trend of building massive high-rise apartments did not only occur in the Netherlands but occurred all over Europe (Turkington et al., 2004). Drozdz et al. (2018) explain that these large-scale urban planning and developments were also a result of heavily centralized governmental influences. These policies were mainly developed in the post-war period where the Dutch population experienced a large growth, better known as the baby boom period, which required a large number of houses. Both the results of technological developments as well as the general policies that belonged to a welfare state allowed the development of larger apartment building blocks.

The political and technological developments resulted in large-scale high-rise (social) housing projects. These projects, however, mainly focused on the expansion of housing stock. In the period between 1945 and 1960, the Dutch social housing stock increased from 140,000 to 540,000 (van Weesep & van Kempen, as cited in Turkington et al., 2004). The majority of the delivered dwellings were apartments situated in high-rise apartment buildings. Later on in the 1970s, the high-rise buildings started to dominate the skyline on the outskirts of Dutch cities (van der Cammen & de Klerk, 2003). The reasoning behind the specific location on the edges of the city is relatively easy to explain as it offered attractive views and marked the city from a distance (van der Cammen & de Klerk, 2003). However, when considering the European high-rise market during the 1970s and 1980s, there was a period of noticeable decline as a result of demonization and stigmatization (Drozdz et al., 2018). This could possibly be the result of the oil crisis in the 1980s that echoed in the housing market, causing a rapid decline in the house price-income ratio (Statista, 2021). Furthermore, the social housing systems were largely decentralized throughout Europe in the same period (Drozdz et al., 2018). For the Netherlands, this meant that the social housing institutions were bought out by the government in 1992. Furthermore, this period was characterized by the growing reactions against high-rise developments throughout Europe. Besides, a growing emphasis was put on the conservation of historical centers. Glauser (2016), for instance, mentioned the growing protests against high-rise developments in Paris and Vienna due to possible harm to their historical images. In addition, it was mentioned that cities such as Florence and Siena are in no way comparable to cities such as Paris and Vienna because the history of these cities continues to shape their city structures.

In more recent years there has been a growing emphasis on high-rise developments in urban areas. At first, new high-rise complexes found their way into European cities in areas nearby international financial centers as a result of easier regulations (Drozdz et al., 2018). A major (Dutch) example is the Amsterdam Zuidas area, which has become a large hub for financial institutions during the last twenty years. However, later on, many cities allowed high-rise developments in their city centers as it could improve deprived areas by large-scale investments (Appert, 2011). Furthermore, it is mentioned that these areas are often regenerated by applying new urbanism principles with the integration of nearby transportation nodes.

2.2.4 Defining high-rise buildings in the Netherlands

The previous section mainly focused on the developments of high-rise in a European context. The high-rise developments throughout Europe have matured over the years and went through several phases. This section tries to narrow down that gap and focuses more on a local, Dutch context and gradually moves towards the five specific cities of this study. To achieve this, the Dutch policies are briefly discussed and the local municipal plans on high-rise are presented. Furthermore, the actual policies on high-rise are presented on a political level as well as a local municipal level for the five studied cities.

When one considers the historical data that explains the completions of high-rise buildings (in this case taller than 70 meters), a significant growth over the last couple of years in the Netherlands becomes visible. From the 1960s until the present day there is a significant growth in the development of high-rise buildings (figure 4). It is estimated that there are currently 220 towers that are all taller than 70 meters in the five largest and 40 other larger cities of the Netherlands (Dutch council on tall buildings, 2021). Furthermore, it is expected that this trend will continue and more high-rise buildings will be developed and constructed with projects like de Zalmhaventoren in Rotterdam, which is projected to be 215 meters tall upon delivery.

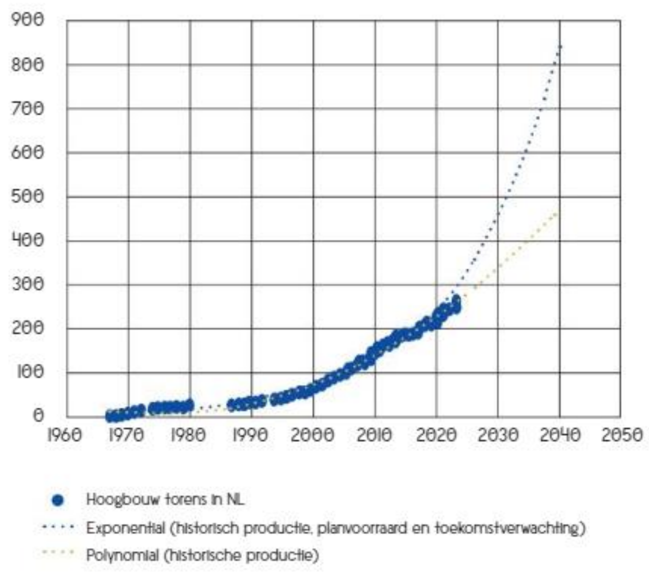


Figure 4: Number of buildings taller than 70m over time (from: Dutch council on tall buildings, 2021)

Aside from the number of high-rise developments, it is important to define high-rise. However, the particular definition of high-rise varies wildly among the different Dutch governmental institutions. The reason behind this is that there is not a predefined amount of high-rise in the Dutch Building Codes that can be seen as high-rise. The 2012 version of the Dutch Building Codes only require buildings taller than 70 meters to have additional fire safety measures (art. 2.127 in *Bouwbesluit 2012*). Furthermore, other functional regulations from the Building Codes require an elevator in buildings taller than 12.5 meters (art. 4.24 in *Bouwbesluit 2012*). The 12.5 meters translates roughly towards a five-story building when one uses a floor height of three meters.

When one considers the municipal vision documents on high-rise developments among the five different cities that are used as an example for this study, it can be noticed that each city has its own implementation and definition of high-rise. Both the municipalities of Amersfoort and Tilburg seem somewhat reluctant to high-rise developments. The municipality of Tilburg defines high-rise as buildings taller than 15 meters (Gemeente Tilburg, 2021) and states that new high-rise developments should take place nearby corridors or main structures of the city (Gemeente Tilburg, 2015). The municipality of Amersfoort has a similar approach when it comes to the development of high-rise objects. The municipality of Amersfoort classifies buildings with five to eight stories as mid-high buildings and buildings with nine to sixteen stories as high-rise. Buildings with more than 16 stories are classified as high-rise+ in their documents (Gemeente Amersfoort, 2019). The municipality of Groningen appears to be more willing in terms of high-rise developments and is still studying possibilities to create new opportunities for high-rise within their municipality (Gemeente Groningen, 2020). The city of Nijmegen remains fairly unclear about their quantification of high-rise buildings. However, the municipality does mention that high-rise could contribute towards densification, the neighborhood identity and the creation of landmarks (Gemeente Nijmegen, 2020). Last, the city of ‘s Hertogenbosch does not quantify high-rise in their vision documents, but they do mention that buildings taller than 40 meters and buildings taller than 60 meters should be applied selectively (Gemeente ’s-Hertogenbosch, 2014). Nevertheless, the Dutch council on tall buildings (2021) provides an overview of the lower limits of what was considered high-rise in the various municipalities (figure 5).

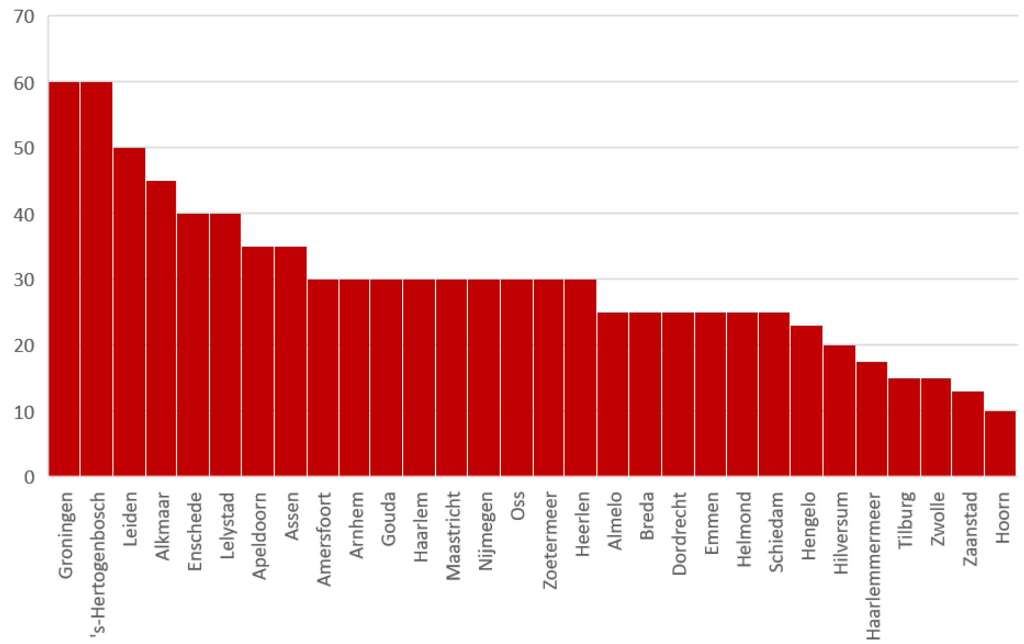


Figure 5: Lower boundaries of high-rise in G40 municipalities in meters (adapted from: Dutch council on tall buildings, 2021*)*

Even though all cities have different definitions of how they classify high-rise developments, they still show similarities within their policies. The cities often mention that future high-rise developments might come with certain threats or obstacles. The following items are frequently mentioned in the municipal policy and/or vision documents as possible negative externalities:

- The city silhouette
- Historical lines of sight
- Present monuments
- Landscape qualities
- Shadowing
- Wind
- The human factor
- Integration towards surroundings

Many of the aforementioned cities try to reduce or mitigate these externalities by examining new building plans with a mandatory "high-rise effect report" (Dutch: Hoogbouweffectrapportage) for real estate developers. Such reports study effects such as future wind circulations, shadowing effects in the surroundings, and the spatial and functional relations to the area (Gemeente Amersfoort, 2019). In other words, the reports present an overview to the municipality of the possible downsides of externalities caused by the high-rise developments.

Based on these policy documents and the aforementioned different thresholds for what municipalities classify as high-rise, it seems useful to pick one lower boundary. For this study, the lower boundary is 15 meters. The main reason behind this threshold is to identify buildings that are taller than single-family homes, which comprise about 64% of the Dutch housing stock (CBS, PBL, RIVM, WUR; 2020). Besides, it fits the earlier mentioned trends of densification and expansion nearby urban cores. Furthermore, it implies that a modern-day five-story apartment is often above the threshold and falls in the "high-rise building" category.

The previous paragraphs show that there is not one clear definition of high-rise in the Netherlands because there is a little presence of high-rise in Dutch cities. Therefore, the addition of high-rise to Dutch cities is often controversial and often makes headlines when new building plans are presented. A good example is the municipality of Utrecht that wants to build higher than the Dom tower, which sparked a great controverse among residents. Other examples are the residents of Amsterdam that were able to reduce the length of a new tower by 18 meters since they were afraid that it would interrupt the human factor and social interactions (Bouma, 2019).

2.2.5 Functions and effects of high-rise buildings

This section tries to identify the functioning and effects of high-rises within the urban areas. First, the functional elements are presented of the high-rise and second, a broader explanation is given of the experienced effects of high-rise buildings on their direct surroundings. Last, a short example is given of the importance of social measures nearby large-scale housing developments.

The development of high-rise buildings is often favorable for cities since it allows the housing of a large number of people on a small plot of land. In turn, the people in cities get the chance to run into each other and develop business plans or conduct research together like Glaeser (2011) described. Furthermore, Drozdz et al. (2018) and Pietrzak (2013) showed that the main functions of high-rise developments in urban areas are primarily used for housing and offices. However, other possible functions are leisure activities such as shopping and tourism or a mixture of these aforementioned functions.

It should be noted that the development of high-rise buildings also comes with certain downsides (negative externalities). These externalities can arise just shortly after delivery and might be temporary while others can maintain over longer periods. A well-known example is the Empire State Building in New York that stood vacant for a long time after the completion as a result of the great depression. It even got a second name: “the empty state building” (Glaeser, 2011). The moral of the story is that the completion of the building can result in an overflow of supply on the local real estate market and can therefore result in a large number of vacancies. For this reason, it is important that the supply of new real estate does not exceed the market demands and should be planned carefully.

Another hinder that can be found as a result of developing tall buildings is the traffic flows it might generate since tall buildings attract relatively large amounts of people (Zandbelt et al., 2008). However, when these buildings are developed with awareness of the environment, they can also provide great opportunities, such as close connections to transportation facilities, which is common in the New Urbanism architectural style. Nevertheless, it should not be forgotten that these real estate developments also demand sufficient numbers of parking spaces for residents, visitors, or employees in such a building, while the creation of such spaces is fairly expensive for real estate developers. Therefore, public infrastructure must be considered before the high-rise development takes place.

Besides the infrastructure and market supply, there is also another, less tangible side that needs to be taken into account for the development of high-rise buildings. Meijers (2018) describes that high-rise buildings might cause an oppressed feeling, although it might depend on someone’s personal taste. Furthermore, high-rise buildings might cause a certain amount of winds and shadows while obstructing the views towards the distance (Zandbelt et al., 2008). Furthermore, building in and around urban cores might also cause other problems like heat stress in urban cores. In large cities, it is common for there to be a noticeable difference in temperature between the urban and rural areas, better known as the urban heat island effect (Wouters et al., 2017). This heat stress should be mitigated to let the cities remain livable and to protect inhabitants from the negative side effects caused by climate change. Finally, many of the aforementioned externalities in section 2.2.4 and this section are also underwritten by Gregoletto et al. (n.d.) who found that high-rise buildings are often linked with changes of urban landscape, traffic flows and changes of urban microclimate while negatively affecting the city landscape.

2.2.6 Social environments

Apart from the direct externalities, it is also important to shed a light on the more social aspects of housing in large-scale developments. It became clear that there were many large-scale housing developments in place after the Second World War throughout Europe. However, these projects were not always as successful as they were meant to be. Therefore, this paragraph highlights two of these large-scale high-rise projects and how they failed in these periods of large demands. The reason behind this is that the socio-economic status appeared to be overlooked at the beginning of these housing projects. Meanwhile, it could have a strong effect on the living conditions of these residents as well as the success of the entire housing project.

On this occasion, the social environments within the proximity of large-scale housing projects play a crucial role in their success. More specifically, the socioeconomic statuses of the areas within the new housing projects are important. Notorious historical examples are the Robin Hood Gardens in London in the United Kingdom or the Bijlmer area in Amsterdam that were developed in the post-war recovery periods. The former one was developed in the Poplar area of London to fulfill different demands of working-class families. However, periods of decline followed and the manufacturing jobs moved away causing an economic decline in the area. Furthermore, there was a toxic mixture between racial groups and poor living conditions that made the proposed plans a failure (Furse, 1982).

Surprisingly, the Dutch Bijlmer project closely followed its British counterpart. The Bijlmer area was developed with an emphasis on public (green)spaces but became fairly anonymous (Obbink, 2016). Furthermore, the proposed target groups that were intended to live there found their places elsewhere. This was mainly in places where they could obtain terraced houses with gardens instead of an apartment. In addition, there was a large group of immigrants coming to the Netherlands who found their place in the (already vacant) Bijlmer apartments. However, these people often came without any jobs or opportunities, disrupting the area even more (Koolhaas, 2016).

2.3 conclusion

To summarize, all the literature mentioned above is in one way or the other connected to this study. The Netherlands currently holds a strong position in highly advanced jobs and is looking further to expand that knowledge by providing sufficient spaces for particular industries to flourish. In recent days, the Dutch economy has experienced a strong growth while the development of houses came to a standstill as a result of the 2008 financial crisis, resulting in high demand for housing while the supply grew scarce. Furthermore, the Dutch government has also been reluctant to approve greenfield developments but is instead looking to repurpose already existing buildings. Besides, Dutch cities mainly attract young people since universities function as a pull factor. Besides, these cities can assist young people in their search for like-minded people and help them climb the socioeconomic ladder when they are older. Furthermore, there has also been a large inflow of expats moving into these cities, who are there for job and career opportunities. Last, a noticeable pattern is that people above the age of 30 are more likely to leave the cities and seek more space in the suburbs, which offer more value for their money.

When one considers the Dutch housing market, it deviates quite a lot from the European averages, especially when it comes to financing and ownership constructions. This is the result of past historical policies such as the mortgage interest tax deduction. Besides, the Dutch housing market also differs in terms of housing typologies, which can be characterized out of largely semi-detached houses. Meanwhile, there are very few flats in the Netherlands when compared to other European countries. Furthermore, the European housing market does not consist out of a lot of high-rises. The first high-rise objects in Europe were often inspired by American buildings and the first high-rise object was arguably built in the Netherlands. As time passed, new technologies arose and policies started changing, which allowed the development of large-scale housing objects. Meanwhile, central governments often had an influence on these policies as the housing projects were often state-led to fulfill the large housing demands after the Second World War. Later on, however, the high-rise developments started to decline and social housing projects throughout Europe were privatized. In addition, there was a greater appreciation of the historic elements that had been present in European cities, making it more difficult to develop high-rise buildings in historic city centers. In recent years, the high-rise has found its way into the financial districts and also in deprived areas.

In modern-day Europe and the Netherlands, the developments of high-rise seem to find their way into the city. However, the definition of high-rise developments is ambiguous and differs very strongly. More specifically, the five different cities that are used in this study have varying heights that function as lower boundaries on what is considered as high-rise. Furthermore, the definition of high-rise is also weakly discussed by the Dutch Building Codes. Therefore, this study used the 15-meter threshold which was used by Tilburg. It is also closely related to the Dutch Building Codes, which require an elevator for a building taller than 12.5 meters or for buildings with more than four floors. Additionally, many of these five cities mentioned similar objections when it came to high-rise developments and mentioned that it could have a potential influence on the surroundings if it was not scrutinized thoroughly. Last, the section about the social environments tried to highlight the importance of the social environments of new high-rise developments. The two presented housing projects were typical for post-war mass housing projects. However, both projects suffered heavily from the lack of socioeconomic opportunities for their residents. Unemployment and poverty were relatively common and in some cases, racial tensions or criminality arose in these areas. Furthermore, there was a decline in social housing investments during these periods, which later on resulted in a privatized housing market in both countries. Eventually, these precipitating factors resulted in a bad name for the areas, and revitalization of the areas was very much needed. Therefore, it is important not to overlook these social aspects when large-scale housing complexes are being developed.

DUO office, Groningen

3 Hedonic pricing in existing literature

This chapter presents the applications of the hedonic price model throughout the different fields of expertise. First, a general introduction of the hedonic price model is given to describe the main principles of this calculation method. Second, the different use cases in which the hedonic price model was applied are presented. Furthermore, the different use cases of the hedonic price model are mentioned and it is explained how prizes behave as certain characteristics change.

3.1 Hedonic pricing principles

The hedonic price model is argued to be developed by Lancaster (1966) and Rosen (1974). Lancaster mainly developed a microeconomic theory that allowed scientists to focus on the demand sides of the market. Within his study, he emphasized the end-users utility that was based on the product's characteristics instead of goods (Malpezzi, 2002). Rosen focused on the development of the price determination instead of the users' utility (Sirmans, Macpherson & Zietz, 2005). Therefore, both Lancaster and Rosen can be seen as the earlier explorers of the hedonic pricing model as it is known nowadays.

In the existing literature, there has been a wide understanding of the willingness to pay for certain attributes when it comes to housing. Many scientists use the hedonic pricing model, which was developed by Rosen (1974), to derive economic information from an untransparent market. This theory seems to work specifically for housing transactions, as it allows economists to derive market data from the already established behavior of consumers instead of predicting certain patterns. Besides, the hedonic pricing can measure the change of housing value over time as a result of a certain event (e.g. before and after a connection to a highway) or at the moment when physical change takes place. In general, it is argued that the following formula is most commonly used as the hedonic price model, albeit in a logarithmic manner (Sirmans et al., 2006). The logic behind the application of a log-linear model lies in the fact that it allows to capture the change in price in percentages which is demonstrated in the formula below:

[1]

$$ln\ (P_i) = \alpha + \sum_{c=1}^{C} \beta_c X_{ci} + \varepsilon_i$$

In this formula P_i denotes the natural logarithmic of the transaction value of property i, while the α value is the constant and β_c the regression coefficients for housing characteristics c. X_{ci} denotes the value of property i on housing characteristics c. ε_i is the error term.

To measure the relation to the price, many authors make distinctions in their added parameters such as structural, locational, neighborhood, environmental and other attributes (Xiao, 2017). Structural characteristics are those related to the real estate object such as age, height, size, etc. while the locational elements are classified as the distance to certain facilities as the city center or a supermarket. The neighborhood attributes are measured with indicators such as the average income levels and education levels.

3.2 Hedonic pricing applications

There is already a wide range of literature measuring the effects of changes in location characteristics, using a hedonic pricing model. A good example is the development of a highway nearby an already existing town, where Cotteleer & Peerlings (2011) studied the decision-making process over time. In times where the highway development seemed definitive, the prices were decreasing while in periods of protest and uncertainty there was not any price gain visible.

Therefore, it can be noted that the uncertainty echoes further into the land values and people were taking these developments into account. Another example is given by De Groot et al. (2010) who used the hedonic pricing to observe the popularity of urban areas within the Netherlands during a 22 year time period where they found a greater appreciation for cities and the Randstad specifically.

Aside from the behavioral component, the hedonic pricing model is also used to measure the effects of the more physical changes that take place. It was found that the change of flight patterns influence the housing value in an area causing a 0.5% decline in housing value for every decibel added in the study period (Boes & Nüesch, 2011). Another example of a changed physical element that reflected in the housing transaction price was found by Ossokina & Verweij (2015), who found that the reduction of urban traffic resulted in an increased housing price. This can also be said for a difference in internet speeds, where a property will experience a 2.8% decline in value when it goes from a fast to slow broadband connection while it only gains a maximum premium of 1% when it has a faster (more than 24 Mbit/s) connection (Ahlfeldt et al., 2017).

Some other examples of measuring willingness to pay for a certain amenity can be found when it comes to nature. The housing values of houses nearby open green spaces seem to experience a price jump, while houses close to an apartment building experience a decrease in value (Luttik, 2000). Besides, people also seem to give a negative value towards externalities of living nearby an industrial estate, although the effect is fairly limited (de Vor & de Groot, 2011). This was more extensively substantiated by Boyle & Kiel (2001), who presented an extensive overview on the environmental externalities on environmental qualities such as air quality, water quality and the distances to (potential) toxic areas.

Further examples of valuating certain physical attributes of a dwelling can be found for the degree of sustainability (Walls et al., 2013). Or more permanent, whether the location of a building is in a conservation area or not. For instance, in the Dutch city of Zaanstad it is estimated that people are willing to pay a nearly 27% price premium for houses with the status of a listed dwelling. Houses within a conservation area gain premiums of 26% (Lazrak et al., 2014). Other studies found changes in price as a result of the presence of facilities and amenities such as nearby religious buildings (Brandt et al., 2014) or the proximity to higher-ranked schools (Black, 1999).

In more recent years, many other researchers have been working to expand the existing knowledge on external effects nearby existing real estate. Kurvinen & Wiley (2019) studied the externalities as a result of retail developments and found a positive relation on property prices within 500 meters of said retail developments and weaker price increase in a 1-kilometer range. Meanwhile, Aydin, Crawford & Smith (2010) conducted a much broader study and identified the spillover effects caused by commercial developments. Last, Song & Knaap (2003) tried to capture the urban form of new urbanism housing into the transaction prizes throughout different neighborhoods. New urbanism, mainly characterized by higher densities and better transit facilities, appears to have characters that are outperforming other areas, and could be expected in more traditional American neighborhoods.

Another example where the (physical) surroundings of real estate was measured occurred in New Zealand, where the projection of the sun on housing locations was studied. Fleming et al., (2018) tried to quantify the amount of sunlight exposure of sold dwellings. Their measurements were done by using 3D building maps. In their study, they tried to measure the obstacles present in the surroundings by looking around the sold dwelling in steps of two degrees to cover the full 360 degrees. So by making measurements for every two degrees around the dwelling, it delivered them 180 observations per sold house. This information was used to obtain information on the shadow of the objects that were being projected on the sold dwelling. Eventually, their measurements allowed them to compute the number of solar hours which had a positive relationship on the price. It was found that every additional hour of sunlight per day added 2.6% on the price (Fleming et al., 2018).

Furthermore, Thibodeau (1990) used a hedonic price model to show that the residential property prices changed when a new high-rise office building was built. The prices decreased in close proximity but gained a premium when the distances became longer and the positive externalities took over the negative ones. Moreover, Ooi & Le (2013) showed that property values were not negatively affected when apartment buildings were built on brownfield locations in Singapore, but instead showed a positive price effect. Furthermore, they also found that spillover effects were stronger when an infill development was done at a location where the former building was demolished and replaced by a new building.

Other studies that measured the change of housing values as a result of real estate developments are presented by Kurvinen & Vihola (2016), who studied the new real estate developments of apartment blocks on already existing residential areas nearby Helsinki. They found that the average values were positively affected as a result of the completion of a multi-story apartment building while there was not any significant change in the price trend. However, it seems that there is very little information regarding such cases within the Netherlands. Meijers (2018) tried to explain the difference in price with the use of different densities of urban areas. This, however, seems to be on a rougher scale level. In his study, Meijers recommended to focus more on a local approach and study the price effects on a more building approach.

3.3 Conclusion

To summarize, there is already a wide range of literature present using the hedonic pricing model to obtain information and measure the behavior of consumers. The pricing theory can obtain loads of information in all kinds of markets, whether it is real estate or cars. In both cases the methodology allows scientists to derive price information of an additional attribute or feature. However, when applied to real estate it is mainly used to derive information regarding certain attributes. Moreover, the hedonic pricing model does obtain this information by measuring the actual behavior of people by looking at historical transaction data. Many researchers tried to give value to items such as connectivity or views of the dwelling by applying such hedonic research methods. Furthermore, other researchers already tried to identify what price changes were noticeable as a result of an additional hour of sun. This study tries to make use of these existing studies by using a comparable approach to that of Fleming et al. (2018), but instead measures the entire surroundings within the direct proximity of a high-rise object to see how it affects the local real estate values.

4 Methodology

This chapter presents the methodology used for this study and tries to explain which choices were made ahead of this study. First, the main principles are explained on how the relationship between the building heights and distances are covered. Second, the collected data is briefly discussed. Third, the studied locations are presented. Then, the data preparation and GIS processing is explained and last, the hedonic price model is presented.

4.1 Computing the building height – distance relation

The main principle for this study was to measure the angle between the high-rise objects and the direct surroundings within a range of fifty meters. This way of working is further elaborated in the next sections, where the relation between the building height and angle is explained. Second, the computations and transformations from the arctangent to degrees are explained. This should function as an indicator towards the high-rise in the areas.

To obtain information regarding building height and the distance relationship, certain computations were made. It is somewhat expected that the externalities that were found in the literature (e.g. shadowing or historical views) could influence the price of the surrounding dwellings. Besides, it is assumed that these negative effects could decay as the distance between the dwelling and tall object increases (figure 6). It is expected that the left image encounters larger externalities over the picture on the right. The logic behind it is that the left image has a larger building angle which might cause more negative externalities, while the high-rise building on the right is further away, causing a smaller angle. Therefore, this study tries to capture these externalities by measuring the angle of high-rise within the direct surroundings and use this information to develop a hedonic pricing model around it.

In order to measure the relation between the distance and angle, the arctangent was used first. The reason behind this is that it would not affect the model severely in case the distances became larger or a building was taller. In both cases the ratios would have remained fairly similar. However, it should be noted that this specific calculation method assumes that there will not be any differences in surface height and that the soil is located on the same level, given that the Netherlands is a relatively flat country. The rationale behind it is that when the sold dwelling has a larger angle in relation to the tall building, the building will be tall and/or closer situated to the sold property than when there is a smaller angle. Besides, this way of working tried to obtain information regarding the possible nuisance that might be expected (e.g. shadowing or increased demand for parking spaces) nearby a tall building.

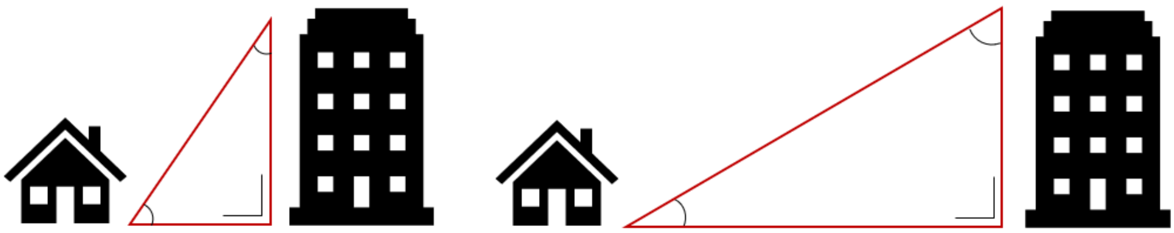


Figure 6: Left: wide building angle as a result of a tall building nearby, right: narrow building angle as distance decays.

In order to compute the different angles of all the measured tall buildings and distances, the following steps were taken. The building height was divided by the distance to the building which can be recognized as an inversed tangent function, better known as the arctangent:

[2]

$$\theta = tan^{-1}\left(\frac{opposite}{adjacent}\right)$$

The reason why the arctangent was picked over the regular tangent can be found in the values they represent. The regular tangent presents the slope of the relations between building height and distances, while the arctangent presents the angle between those two. However, one sidenote needed to be considered. The arctangent function displays its results in radians. Therefore, the results of each tangent function were transformed into degrees by using the following function:

[3]

$$\theta = tan^{-1}\left(\frac{opposite}{adjacent}\right) * \frac{180}{\pi} = angle\ in\ degrees$$

The function above transformed the radians from the arctangent into degrees. This made the function more comprehensible, given that the maximum angle could not exceed the 90 degrees angle, as it would imply that it was directly connected to each other. Furthermore, all of the aforementioned steps were repeated later on to obtain the maximum arctangent in a postal code area. The results were maximized to find out how the model would behave in case the model contained many higher arctangent values.

4.2 Hedonic pricing model

The hedonic pricing model seems suitable for this study as it tries to derive economic information from an untransparent market. In other words, the hedonic pricing model captures the price of each (additional) housing attribute (e.g. floorspace) and gives a certain value to it. This was also supported by Palmquist (1984), who stated that often these characteristics are not traded on regular markets, but their prices can be revealed with the use of hedonic regressions. Therefore, it seems useful to apply a hedonic pricing model to reveal what changes there can be found nearby tall building structures.

The hedonic price model that was developed for this study is as follows:

[4]

$$\ln(P_{ijt}) = \alpha + \beta_1 D_i + \beta_2 N_i + \sum_{k}^{K} \beta_k S_{ikt} + \beta_j + \varepsilon_{ijt}$$

Within the formula, the transaction price of property i in neighborhood j in year t is denoted as P_{ijt} and is transformed into a natural logarithmic (ln) scale as this reduces the distances and or skewedness between the lowest and highest transaction values. Furthermore, the use of ln values allows the obtainment of a better model fit and make comparisons using percentages. The constant is denoted as (α), D_i represents the corresponding degrees of the building angle that relate to the sold property i. The N_i variable represents the dummy variable which is equal to one when there are no high-rise objects nearby and equal to zero, otherwise. The variables S_{itk} denote the structural characteristics of dwelling i during year t. β_j denotes the constant price effect for neighborhood j of the sold dwelling for the neighborhood fixed-effect model, which comprises all postal codes in the dataset to measure price differences between the different areas and cities. This fixed-effect model allows the comparison of neighborhoods on a four-digit postal code level. Meanwhile all β values denote the regression coefficients for the independent variables. Last, the ε_{ijt} value is the error term and presents the residuals from the predictions based on independent variables on the transactions of property i in neighborhood j during year t. The complete list of included variables is presented in the next chapter as it gives an explanation of which variables are included and how they are processed during the data study.

4.3 Studied locations

This study focused on housing transactions of land bound houses that took place between 2016 to 2018 for five cities that are situated in the Netherlands. The reason for these types of dwellings can be found in the relation of the angle between the tall objects nearby and the sold dwelling (section 4.1). In other words, apartments that are elevated on a higher level could have a different relation towards the building height than apartments on the ground level. This thesis focused on the following five cities: Amersfoort, Groningen, 's-Hertogenbosch, Nijmegen and Tilburg. All five cities are part of Stedelijk Netwerk Nederland (Urban Network Netherlands) and have a significant influence on the Dutch economy and potential urban growth (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2020b). Furthermore, these five cities have roughly the same population size with numbers varying between 154,205 and 231,299 while the cities are considered as either a very strong urbanized area (≥2500 addresses in a 500*500m area) or as strong urbanized area (between 1500 – 2500 addresses in the area) (CBS in uw buurt, n.d.). Besides, these cities have a footprint that vary from 5,763 hectares up to 11,813 hectares. However, it should be noted that after 2018 the municipality of Groningen became much larger as a result of a merger between municipalities. In case one considers the age composition (Figure 7) of these five cities, it becomes clear that most of the cities are following the same patterns. However, the city of Groningen seems to have a minor outlier with a larger share of relatively young people, but fewer of those aged between 45 and 65. The reason behind this is that the amount of student households in Groningen was among the largest in comparison with the other Dutch cities (CBS, 2018b).

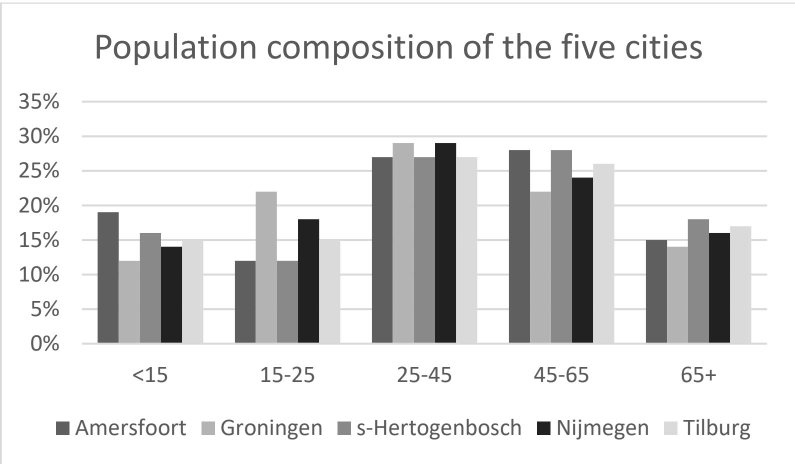


Figure 7: Age composition in the corresponding cities (adapted from: CBS, 2018b)

4.4 Data collection

This study used a transaction dataset which was provided by the Association of Dutch Real Estate Agents (NVM). It contained more than 30,000 housing transactions. The timeframe of all these transactions lied between 2016, 2017 & 2018 in order to avoid any interference of the Covid-19 pandemic, which started by the end of 2019. The NVM dataset was used because it contained a lot of information regarding the property characteristics such as building age, size and housing type. Besides, the dataset of the NVM covers approximately 75% of the total Dutch housing transactions (NVM, n.d.). Furthermore, this data was complemented with 3D height statistics maps which were downloaded from Publieke Dienstverlening Op de Kaart (PDOK) (2021), which also provided the relationship between building height and distance. Last, the maps were merged with zip code maps (ESRI Nederland, 2021) that contained the zip codes on a six-digit level for each area in the Netherlands. The reason why the zip code maps were added was that the building height maps did not contain the required postal code information.

4.5 Conclusion

To conclude, the applied methodology allows the measurement of the building angles and the capturing of the relation of nearby high-rise on the price. The first computations that needed to be executed were done to measure the arctangent values to gain an insight in the angles. Besides, this way of working compensated for either a tall building that is further away, or a tinier building that stands very close. Second, the arctangent was transformed into degrees as that made it easier to interpret and compare results than when it remained in radians.

Since the building angles can be derived, it was possible to develop a hedonic price model that incorporated the characteristics of the dwellings. The most important variable for this study was this building angle in degrees. Second were the housing characteristics. Furthermore, the hedonic price model also needed to include the direct areas in which the buildings were located, which is done using the fixed-effect model that compared transactions to each other. Figure 8 tries to operationalize the steps for this study in more detail.

Furthermore, the selected cities for this study were picked based on their size, but they also have a similar population composition. Besides, it was mentioned in recent policy documents (e.g. Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2020b) that these cities have potential for growth in the coming years. Last, the data that was used were maps that were provided by PDOK for the building heights, by ESRI for the postal codes areas and by the NVM for the housing transaction data during the 2016-2018 timeframe.

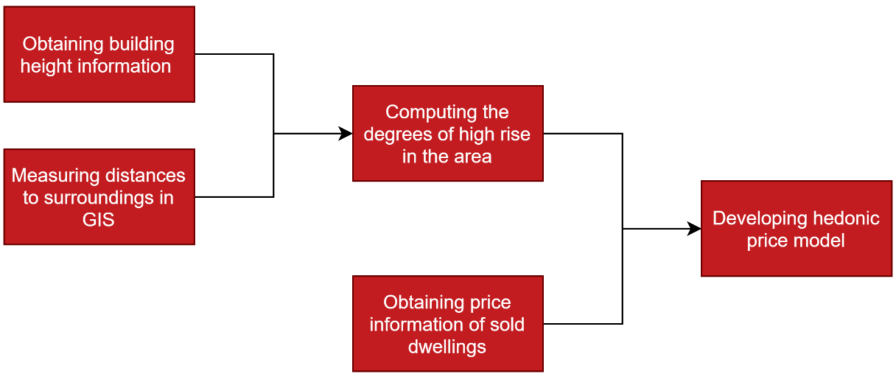


Figure 8: Operationalization scheme

5 GIS Transformations

The data processing contained two major resources as mentioned in the previous chapter: (1) the GIS 3D building height maps and (2) the NVM housing transaction dataset. In order to derive all the necessary information to come to a conclusion, all the final steps are presented in the following chapters. This chapter zooms in on how the building heights and the additional information were derived by describing all the different GIS functions that were used and by further elaborating on the distance calculations.

5.1 GIS Data processing

The data processing started by adjusting the 3D building maps of the Netherlands in QGIS. The maps were made usable by removing unnecessary information and by dividing them into five different maps, one for every city. This particular way gave each city its own map layer with all the building heights in that city. Subsequently, for each city the maps were further divided because the heights were registered in two different ways. In fact, PDOK constructed the maps as follows:

1. Measuring by means of the height based on the BGT registration by the municipalities
2. The use of 3D LIDAR scans

In the first method, there was no absolute height directly measurable because the heights were obscured by the height of the ground level, which was included. Therefore, a new layer was first created in which the ground level was subtracted from the maximum height to obtain the absolute height. This finally resulted in a layer with the building heights based on the municipal BGT administration.

In the second method, a new layer was created for the buildings that had been scanned with LIDAR scans, but these buildings already indicated the absolute building height. Finally, it became possible to use the filter function in QGIS and create two new layers of buildings that were taller than 15 meters. One layer is based on the municipal BGT data, the other layer is based on 3D LIDAR scans.

5.2 Measuring distances

After the high-rise buildings were filtered from all other buildings in the 3D maps, it became possible to study the surrounding areas. In order to study the surrounding buildings more closely, several steps were taken using the "processing modeler" (figure 9) function in QGIS. First, the layers with buildings higher or equal to 15 meters were merged using a union function. The union function ensured that all objects taller or equal to the 15-meter threshold were included in this new layer. Second, a buffer function was applied to the newly developed tall building layer. The buffer function allowed to create a boundary in order to intercept all surrounding buildings. For this study, a fifty-meter boundary was used to capture the direct environment of the tall object. Third, a clip function was used to filter out all the buildings within the range of 50 meters of the high-rise object. Ultimately, a new map appeared that showed all buildings in the range of 50 meters to the high-rise object. All these mentioned steps were repeated for the five different cities. These maps contained the information regarding which buildings fell inside the fifty meters threshold, but they did not say anything about the distances between buildings.

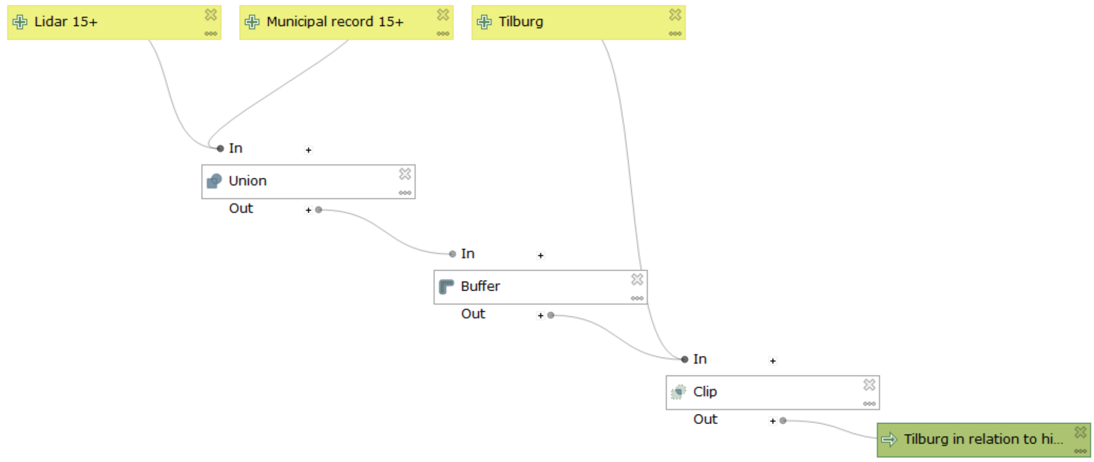


Figure 9: Processing modeler script in QGIS

Since the buildings nearby the high-rise objects were identified and filtered from the rest of the buildings it was necessary to transform the polygon shapes into point data. The transformation to point data was necessary to run a script that measured the distances between all tall buildings and other buildings in the nearby surroundings (the previously made new map). The transformation to point data changed the polygon shapes into points which allowed the measuring of distances between these points. The centroid function was repeated on both the tall building layers as well as the direct surroundings layer. Next, the separate layers containing the taller buildings, which were measured by LIDAR and the municipal administration, were merged using the "merge vector layers" function in QGIS. This resulted in one overall layer containing the building heights of buildings equal to or larger than 15 meters of both the municipal administration, as well as the LIDAR scans.

After the layers were merged in the previous step, it became possible to create a "distance matrix" in QGIS, which was a demanding task that required a lot of computational power because this function measured all distances to all objects within the selected layers. This also implied that the script in QGIS measured many distances of more than 50 meters in the dataset between the tall buildings and other buildings in the dataset. After the measurements were completed, it was necessary to filter out this obsolete data and leave results with distances less than or equal to 50 meters. Besides, there were also several faulty observations present in the building height data which were filtered. This is further explained in the next chapter.

Since the distances and heights of the buildings were identified, it became possible to derive the building angles using the formulas that were described in the previous chapter. However, the measures of high-rise were paired on a six-digit postal code level in either an average or maximum value. Meaning that the degree of high-rise was generalized throughout the postal code in that street or area.

5.3 Conclusion

To obtain the necessary information from the GIS maps that were used, certain data transformations were carried out. The data was separated to make a distinction between 3D LIDAR scans and data from municipal records. This was needed as the latter one needed to have the ground level to be removed to obtain the actual building heights. Meanwhile, the LIDAR scans already displayed the actual building heights. After this information was established, it became possible to measure the distances in GIS using point data of all objects in the maps. Last, it became possible to measure the building angles on a six-digit postal code area.

6 Data preparation & descriptive analysis

The main preparations for the GIS data study were described in the previous chapter. This chapter will elaborate more on the descriptive data and the data preparations to derive the price information from the price model. First, a brief overview is given on the distribution of the high-rise throughout the various cities in this study. Second, the transaction dataset by the NVM is introduced, after which the different variables are explained.

6.1 Distribution of high-rise within the cities

After the GIS dataset preparation was completed, it was possible to identify the spatial distributions of high-rise throughout the five different cities. This distribution mainly shows where the high-rise locations of objects taller than 15 meters are located (figures 10 to 14). The largest frequencies of high-rise can be found in the city cores of 's-Hertogenbosch which has appears to have the most objects marked as high-rise followed by Groningen and Nijmegen. The cities with the lowest frequencies of high-rise in the city core were Tilburg and Amersfoort. However, there is also one other area that stands out with a large presence of high-rise, which is in Nijmegen. This particular area is not directly located nearby the city center, while it has over sixty observations of buildings taller than the set 15 meters. This area is located south of the city center and houses the university and hospital of Nijmegen.

There is, however, one minor drawback that needs to be considered for this study. When these GIS methods were used, it was only possible to identify the height of the buildings, but not the actual function of each high-rise structure. This resulted in a dataset that contained a mixture of several functions varying from housing or offices to church towers, transmission towers, or (industrial) chimneys. Nonetheless, the largest presence of high-rise is noticeable within the different heatmaps nearby the city centers. It is remarkable that the majority of these cities have a historical inner city, which is often characterized by the presence of water or canals and on certain occasions also typical historical items such as hooks in their facades. Furthermore, the rationale behind the close proximity to water within these city cores can often be found into the transportation by boat to other cities.

6.2 The transaction dataset

The used dataset comprised in total 30,699 transactions in the selected cities and their close surroundings. However, not all of these sold houses were located within the municipal boundaries of the selected cities and were removed. Furthermore, the sold dwellings in the database also contained housing categories like "apartments" or a "building plot". Therefore, these categories of transactions were removed, as these dwellings do not contain a ground floor level which is required to measure the angle between the houses and high-rise correctly. Removing these different building categories and locations resulted in nearly a halving of the dataset. Another step was to match 1233 zip codes containing high-rise buildings to the six-digit zip codes in the transaction dataset, resulting in 2651 matching transactions that were located in an area with high-rise buildings nearby. The next step was to validate the included variables and determine which models were included in the statistical model. During these steps, it was important to check the frequencies of the variables and take into account the correlations between the variables. The list of included variables from the NVM dataset is described in the next section.

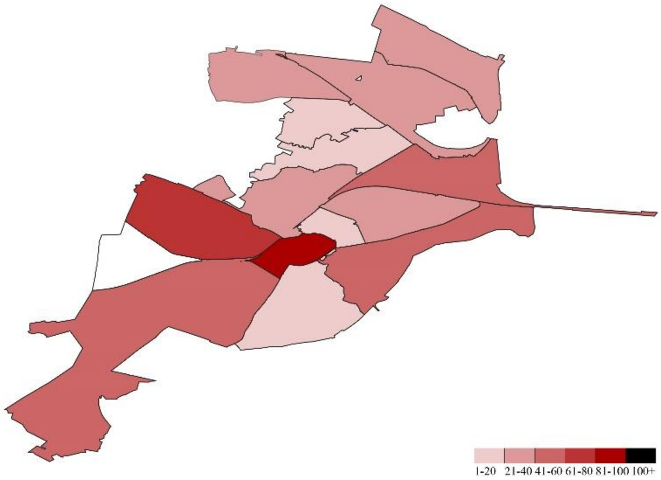


Figure 10: Tall buildings Amersfoort

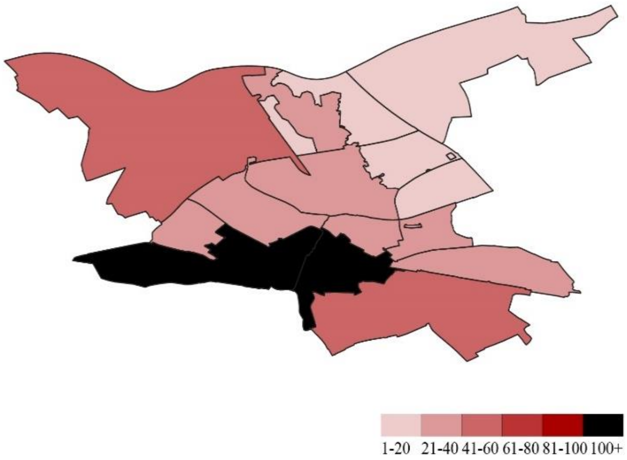


Figure 11: Tall Buildings 's-Hertogenbosch

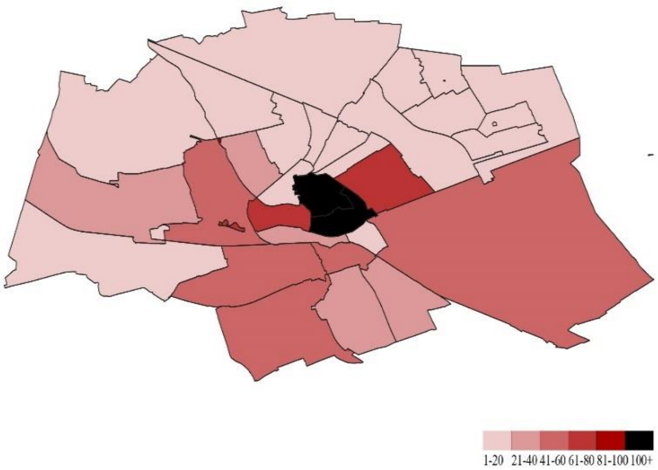


Figure 12: Tall buildings Groningen

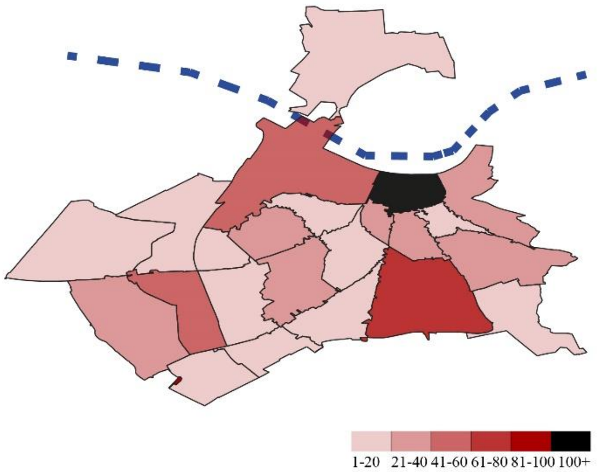


Figure 13: Tall buildings Nijmegen

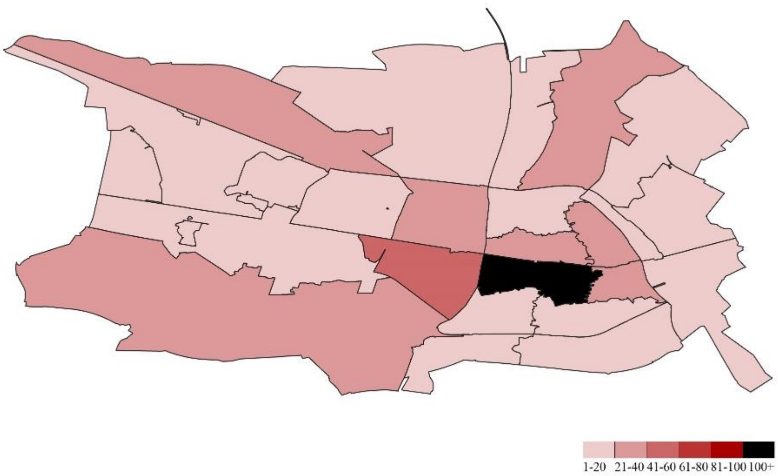


Figure 14: Tall buildings Tilburg

6.2.1 Selecting the independent input variables

Before obtaining the final results it was important to inspect all variables to identify and remove outlying values. This was done by accounting for the frequency matrices for each variable and by looking towards the distribution of each variable. For variables that were either dummies or dichotomous, this could be either a 1 or 0 value. Meanwhile, variables or features of the dwellings that could be counted were not transformed and plugged into the formula, but just validated on the frequencies of which they occurred (e.g. number of rooms). Last, the variables that had large numbers (e.g. transaction price and floorspace) were first checked for outliers. The outlying values were detected by using the 3 sigma limits as described by Gülbay & Kahraman (2005). This method covers more than 99% of the variables. A few observations per thousand were left out as they fell out of these thresholds. Furthermore, these variables were transformed into natural logarithms. The reason why the natural logarithmic values were used can be found in the fact that it often reduces the skewness and often creates a better model that is consistent with a normal distribution (Curran-Everett, 2018). Finally, all included variables and their descriptive statistics are presented in table 2.

When the results of the descriptive statistics (table 2) are considered, the following items stand out. The majority of the transactions were located in houses that were not in the direct vicinity of high-rise buildings. Meanwhile, the maximum value of the computed building angle is nearly 61 degrees, which means that there is a relatively steep angle between the dwelling and a closely located high-rise object. Furthermore, the minimum value of the building angles on a location nearby a high-rise object is 16.8 degrees. The opposite can be said for the dummy of the no high-rise variable. In this case, all dwellings without the high-rise were assigned a 1 resulting in a relatively high mean value of 0.87 since the majority of the dwellings in the dataset were not closely located to high-rise buildings.

Table 1: Descriptive statistics of included variables

Descriptive Statistics				
	Minimum	Maximum	Mean	Std. Deviation
Ln transaction price	11.277	13.548	12.447	0.384
Building angle	0	60.736	3.611	9.168
No high-rise	0	1	0.857	0.350
Built between 1500 and 1930	0	1	0.152	0.359
Built between 1931 and 1959	0	1	0.154	0.361
Built between 1960 and 1980	0	1	0.240	0.427
Built between 1981 and 2000	0	1	0.327	0.469
Ln plotsize	2.485	8.255	5.150	0.534
Ln m2	3.401	5.493	4.792	0.261
Ln volume	4.554	7.378	5.978	0.290
Semi detached house	0	1	0.037	0.188
Corner house	0	1	0.195	0.396
Half of a double house	0	1	0.139	0.346
Detached	0	1	0.052	0.222
nStories	1	8	2.777	0.569
nRooms	1	13	4.929	1.147
Attic (zolder)	0	1	0.240	0.427
Loft (vliering)	0	1	0.061	0.240
Balcony	0	1	0.110	0.313
Dormer	0	1	0.210	0.407
Rooftop terrace	0	1	0.106	0.308
nKitchens	0	4	0.946	0.274
Pantry	0	1	0.188	0.391
nBathrooms	0	6	0.876	0.498
Own parkingspace	0	1	0.353	0.478
Garden orientation other	0	1	0.476	0.499
Garden orientation south	0	1	0.405	0.491
Gas/coal heating	0	1	0.012	0.109
Boiler, block, district heating, master fireplace, hot air	0	1	0.960	0.195
AC or solarpanels	0	1	0.001	0.026
Somewhat insulated	0	1	0.278	0.448
Well insulated	0	1	0.399	0.490
Basement	0	1	0.090	0.286
Monumental status	0	1	0.006	0.074
Sold in 2016	0	1	0.345	0.475
Sold in 2017	0	1	0.344	0.475
Valid N (listwise)				

The city variable

The studied locations for this study were as earlier mentioned Amersfoort, Groningen, 's-Hertogenbosch, Nijmegen and Tilburg. However, as mentioned earlier, a small number of transactions were in close proximity to one of the mentioned cities. Examples of these smaller towns are Hoogland, nearby Amersfoort, or Lent nearby Nijmegen. Therefore, these transactions were removed to only maintain the dwellings that were located within the main city boundaries. This eventually led to the following distribution (figure 15) of 16,251 transactions among the five different cities.

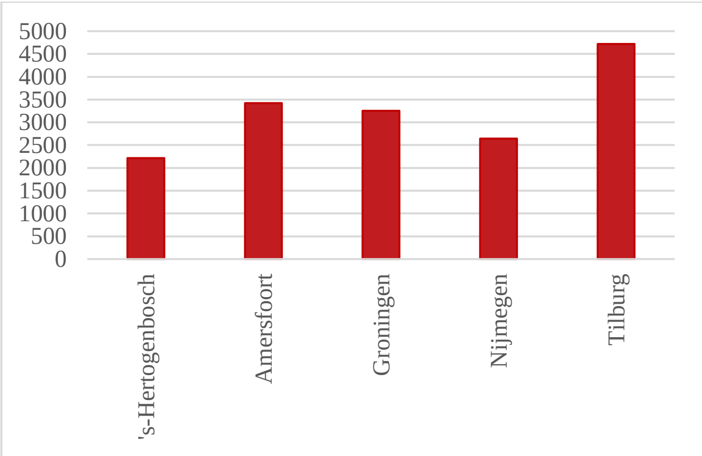


Figure 15: Distribution of transactions per city

The transaction values

After all the unnecessary information of transactions in other cities were filtered out of the dataset, the transaction price was considered as this is the dependent variable. Given that these transaction values were very large, it was first decided to apply the three-sigma rule here. However, due to a certain skewness, it was not possible to determine a clear lower boundary for the transaction price. Therefore, all transactions with a housing value below €70,000 were removed as it would be nearly impossible to obtain a dwelling for such a small amount of money. This implicated that the lowest transaction price in the dataset was €79,000 while the highest was about €765,000. In total about 340 transactions were removed that were either below or above the aforementioned thresholds. After this was completed, the transactions were transformed into the natural logarithmic values. In case one considers figure 16 it can be noticed that the logarithmic values of the transaction price are well distributed among the normal curve. This distribution was expected given that a logarithmic transformation can make the distribution of values consistent with a normal distribution (Curran-Everett, 2018).

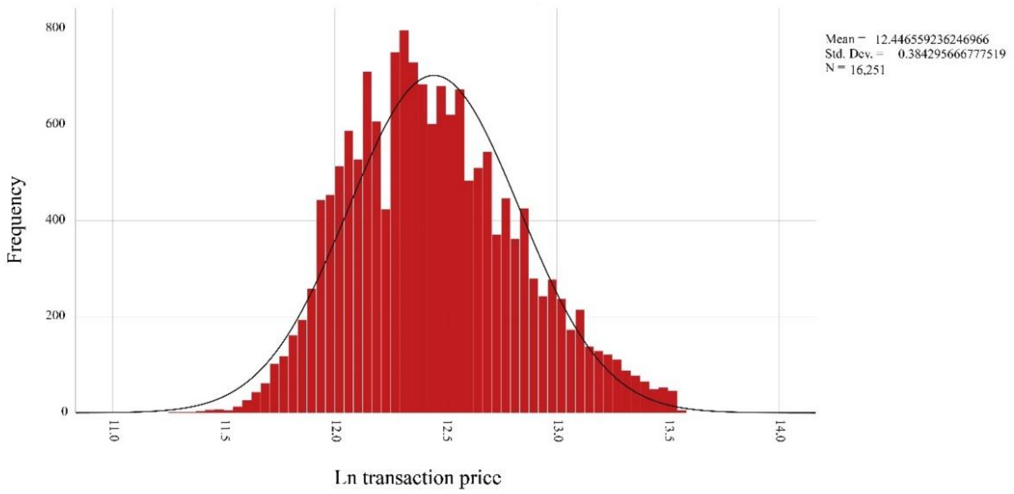


Figure 16: Normal distribution of the logarithmic transaction price

The building angle

The most unique independent variable for this study was the building angle, which presented the angle between the tall objects and the building ground level in the area of the sold object. The variable is a rational number and can be included in the regression model as a numeric value, implying that a greater angle is a bigger degree of high-rise. In case only the buildings nearby the high-rise objects are considered, the following distribution can be observed (figure 17). However, to obtain this distribution, a manual check was conducted. All frequencies above one time the standard deviation were validated by checking whether there was a presence of high objects within the marked area. In 34 cases this resulted in a faulty measurement, implying that there was a tall structure to be found, while in reality items like a shed could be overshadowed by a tree (figure 18). Furthermore, heatmaps were created to show the degree of high-rise in the different postal code areas (appendix 1). For the map, this meant that the color gets darker, when there is a larger angle.

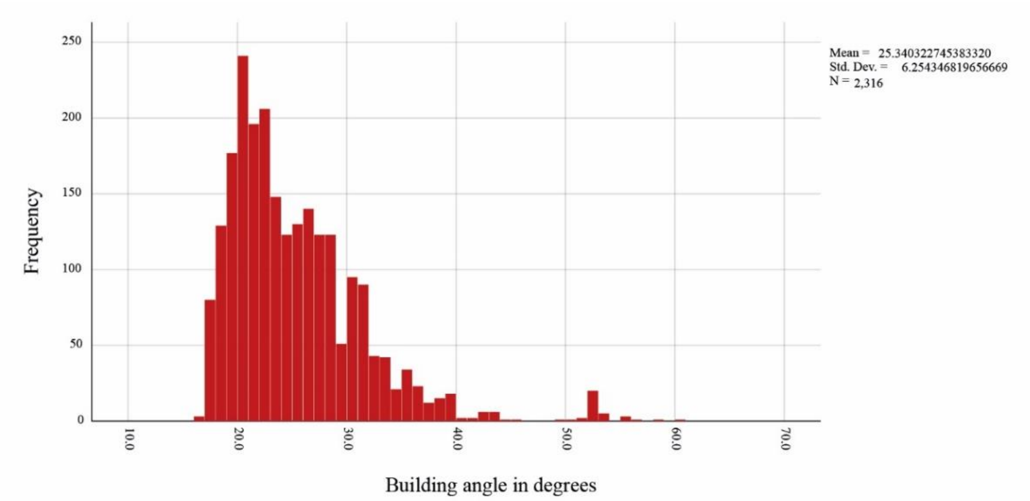


Figure 17: Frequencies of the building angle in sold transactions

Figure 18: Left the marked high-rise, right the actual appearance

After all of the angles that were greater than one time the standard, deviation was manually validated. The rest of the dataset was complemented with a new dummy variable. For all transactions that were not in the 50-meter buffer or in a postal code area with high-rise, there was a dummy created that captured the sense of no nearby high-rise objects in the price model. In this case the dwellings nearby high-rise buildings would be assigned a zero value, while the buildings without nearby high-rise would obtain a one value and thus would indicate the result of no nearby presence of high-rise. The assignment of these dummy values resulted in 13,935 dwellings assigned a 1 implicating that they were located without nearby high-rise while 2,316 dwellings were assigned a 0. The same steps were repeated for the maximum angle of the buildings that were computed.

Housing category and building periods

The housing category was used to only include ground-leveled houses, filtering out all other values than the houses. In case of the construction period, there was also a dummy coding applied. However, before this was applied a frequency table was made, regarding the distributions of building ages. However, it should be noted that nine transactions were left out as these had either an unknown building year or were built before 1500. The frequency table (appendix 2) presents that there were certain groups underrepresented while others had a larger presence. Therefore, some of the building years have been merged into new subsets of building years and were transformed into dummy variables later on. In this case, the equal to or newer than 2001 category was used as the reference category.

Table 2: Building period recoding

Old coding	New coding
1500-1905 1906-1930	1500-1930
1931-1944 1945-1959	1931-1959
1960-1970 1971-1980	1960-1980
1981-1990 1991-2000	1981-2000
≥2001	≥2001

Dwelling and plot sizes

The dwelling and plot sizes of each sold house were also considered. These values were originally natural numbers that also required a conversion into a logarithmic value. The transformation towards the ln values was also executed for the building volumes and square meters. In all three of the mentioned variables, notice was taken of the normal distribution. The outlying values were removed using three times the standard deviation as a boundary. Besides, in certain cases, it did not cover outlying values like zero, one and two which were then deleted manually. The smallest dwelling had a surface of 30 m^2 while the largest dwelling in the dataset had a surface of 243m^2. The smallest volume was 95m^3 while the largest volume was 1600m^3. Furthermore, the plot sizes were between 12m^2 and 3845m^2. Last, the correlation between these variables was studied (appendix 3), resulting in a very strong correlation between the square meters and volumes which could be somewhat expected since the volume is a sum of the square meters multiplied by the floor height. Therefore, only one of these two variables is included in the regression models later to avoid multicollinearity.

Housing typology

The housing type variable was, like the city and building period, also transformed into dummy values whereby the terraced house was used as the reference category. The reason why the terraced house was used as a reference is that it was the most commonly found housing type within the dataset. Furthermore, the number of stories and number of rooms were included directly as these were natural numbers. Also, these two variables were checked for outliers, but seemed nicely distributed and remained the same. Next were the variables describing whether there is a presence of either an attic (Dutch: zolder) or loft (Dutch: vliering). These variables had 3897 occurrences for the attics and 993 for the lofts. Therefore, these numbers seemed fairly significant to include in the dataset. Furthermore, the attic and loft variables were already dichotomous and did not require any transformation before entering into the dataset.

Balconies, dormers and rooftop terraces

Regarding the number of balconies, number of dormers and number of rooftop terraces, a dummy variable conversion was used. The reason behind this was the fact that none of these variables had many transactions with more than one balcony, dormer, or rooftop terrace. More specifically, there were 85 observations with two balconies and 1 observation with three balconies. The number of dormers only has 118 appearances of two dormers and the rooftop terrace variable only had 42 cases with more than one rooftop terrace. Therefore, it seemed more valuable to discover whether the presence of any of these attributes were reflected in the transaction price.

Kitchens & pantries

For the kitchens, the natural numbers were used, since it is not unusual to have more than one kitchen in larger houses. Therefore, this variable was left untouched. For the pantries, however, a dummy transformation was used, since the number of more than one pantry present in a house occurred in only five transactions. Consequently, it seemed more meaningful to measure the presence of a pantry on the housing values than the actual number of pantries.

Bathrooms & parking facilities

The number of bathrooms was taken into account and remained unchanged as it was already in natural numbers. The parking facilities, however, have been transformed into dummy variables as the original values could not be directly used in the pricing model. This transformation implicated that there was made a distinction between either a privately owned parking space or no parking space available. This dummy transformation resulted in 5,738 houses that had their own parking space available within the dataset.

Garden orientation & maintenance status
The orientation of the garden was also identified and classified. However, this was originally done with numerical values for each orientation (e.g. 1: north, 2: north-east, 3: east, etc.). The orientations were transformed into two different dummy categories where the reference category was the unknown or no garden possible category. In the new situation the south(west/east)-ern orientation was taken as one category as the southern orientation points towards the sun, given that more sun hours also provide a higher housing value (Fleming et al., 2018). Furthermore, the maintenance status of the buildings was considered. However, these variables appeared to be very poorly distributed or incomplete. Therefore, it was decided to leave these variables out of the regressions.

Heating & insulation
When it came to the indoor heating and insulation variables, both attributes were transformed. The heating variables were transformed from categorical variables into dummies where no heating was the reference category. Furthermore, both the "*Gas/Coal heating*" category and the "*Boiler, block heating, district heating, master fireplace or hot air*" category were transformed into separate dummy variables. Regarding the insulation, the original categorical variables were merged into new categories. In this case, the zero and one type of insulation were classified as poor insulation, two and three types of insulation got the label somewhat insulated, and four and five sorts of insulation were considered as well insulated. Furthermore, these variables were transformed into dummies where the poorly insulated buildings were the reference category and the somewhat/well insulation both received a 1 value in their own (separate) columns.

Basement & monumental status
The last dummy transformations were in the basement variable as this variable had different options. The options were as follows: no cellar, no storage and boiler room, storage cellar, boiler room, storage and boiler room. The majority of the sold dwellings did not have any basement. Furthermore, 763 dwellings did not have a storage or boiler room but suggested that there was a different kind of basement in place. These transactions were merged with the other kinds of basement options as a dummy variable, resulting in 1464 dwellings with a basement (which are denoted with 1) and the rest without a basement (0). Furthermore, the monumental variable has remained unchanged as this already was a dummy variable where the one value implied that it had a monumental status while zero meant the opposite. Last, the year variable was considered and transformed into a dummy variable. In this case the year 2018 was the reference category.

Neighborhood fixed-effects
In case one considers the results of the descriptive statistics in table 2, it includes the descriptive statistics of all variables mentioned above. However, it does not include postal codes or locational characteristics of the areas yet. Therefore, the four-digit postal codes were used as part of a fixed-effect model. In other words, this meant that the neighborhoods and their attractiveness were being compared to each other. Effectively this implicated that for each zip code a new dummy variable was created, except for the zip code 5045, which was used as a reference category, given that it was the area with the most transactions in Tilburg which also happened to be the city with the most transactions.

6.3 Conclusion
To summarize, the distribution from the high-rise in different cities appeared to be overall very similar. More specifically, the high-rise locations in this study were mainly located in the city centers. Furthermore, it was characterizing for Nijmegen to have a large share of high-rise outside of its inner city due to the presence of hospitals and university on the southern parts of the city.

Also, the transaction data was studied and prepared for the data-analysis by removing outlying values using the three sigma rule. Furthermore, the numerical values like size and transaction price were transformed into natural logarithms as this reduced skewness and created a well-fitting normal distribution. Besides, using log-log or log-linear data allowed a better comparison since the changes in percentages can be observed. The categorical variables such as building periods, typologies or the presence of an own parking space were transformed into dummy variables. In many cases it was sufficient to measure the presence of such parking space instead of measuring the counts as it was uncommon to have more than one parking space.

Finally, the fixed-effect model was created. These were essentially a large set of dummy variables comparing the four digit postal codes to a reference area in Tilburg. The referential category contained the most transactions in its four digit postal code area from Tilburg. This also happened to be the city with the most transactions.


High-rise near Waalkade, Nijmegen

7 Results

In order to obtain the results for the earlier presented hedonic price model, a linear regression with two different methods was applied. First, a basic model was developed using the enter and backward methods which are compared. Second, the contribution of the building angles on the price is discussed. Third, the fixed-effect model was studied and discussed to reflect the neighborhood effects on the price. Last, the main model is checked for its reliability and robustness using three different methods to see how high-rise could influence the price and find out how certain adjustments to the baseline regression models behave.

7.1 Computing the effect of the average building angles on the price

The hedonic price model that was presented in chapters three and four (formula 4) was applied to the dataset to find out whether there was a noticeable change in price nearby the identified tall objects. The first regressions were applied by using the enter method (model A, table 3) which meant that all variables were included in the regression model at the same time. This way of working resulted in a model with a very high R-Square adjusted value. To be more precise, this value was 0.859, which implied that the price model explains a large amount of the variance. Even though the R square values for the enter regressions were high, it still included statistically insignificant variables in the dataset. Therefore, the same regression analysis were repeated, but then with a backward variable-selection method (model B, table 3) . In that way, the statistically insignificant variables were stepwise removed.

Table 3: Model summary enter & backward method

Model Summary					
Model	Nr. of variables	R	R square	Adjusted R Square	Std. Error of the Estimate
(A) Enter	139	0.928	0.860	0.859	0.144
(B) Backward	121	0.928	0.860	0.859	0.144

In case one considers the first model, it could be argued that this model explains the transaction prices pretty well. In case the backward model was considered, it could be noted that the R square values remained (approximately) unchanged while the model used fewer input variables. In other words, the backward applied regression model had a higher efficiency, using fewer input variables than the original price model while contributing towards a similar amount of variance.

Aside from the results of the regression analysis, the distribution of the residual standard errors from the hedonic price model was also taken into consideration (figure 19). The scatterplot of the backward price model shows that it follows a linear trend, albeit nearly flat horizontal. Therefore, it appears that it follows a homoscedastic distribution, meaning that the variance of the error term is constant. Therefore, the regression model meets the assumption for regression analysis. The standard errors of the estimates remained nearly unchanged in both the enter *(A)* and backward *(B)* model (table 3).

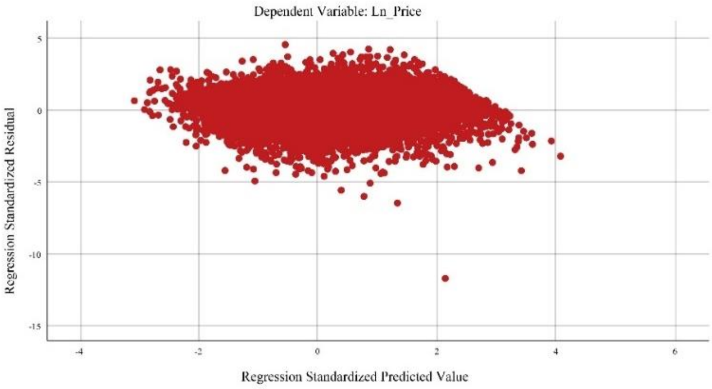


Figure 19: Scatterplot of error terms in backward model

7.2 Understanding the relationship between high-rise and transaction price

After the model performances were considered by comparing the enter and backward regressions, the price effects are discussed in this paragraph. This paragraph presents the price effect caused by the building angles, but also the effects of having no nearby high-rise present.

7.2.1 Importance of high-rise

First of all, the "*no high-rise*" dummy has a positive coefficient of 0,029 in the backward regression model, which is in line with expectations (table 4, full tables appendix 4+5). This suggests that proximity of a high-rise building is negatively valued by home owners. A house with a high-rise building in 50 meter proximity is valued, on average 2.9% lower than an exactly identical house with no high-rise in the proximity.

Second, the building angle shows a weak, but positive relationship with transaction price with a coefficient of 0.001 (table 4). This positive relation was not expected since the sketched externalities in chapter 2 showed that people could experience a certain amount of hinder as a result of the nearby high-rise. The statistical significance of the building angle is acceptable on a five percent level due to its p-value at 0.019. The value of the unstandardized beta is 0.001 which means that for every additional degree of high-rise the price is likely to increase with 0.1%. However, in case one considers the standardized beta for the building angles, it can be noticed that it is fairly low compared to other housing characteristics such as the square meters, plot size or even certain neighborhoods. Therefore, the building angles appear to have very little influence on the transaction price. Furthermore, the VIF value of above ten for the building angle and no high-rise variables could indicate collinearity (Franke, 2010).

The positive coefficient by the building angle suggests that the valuation of high-rise proximity becomes less negative when high-rise increases in height. For very tall or closely located buildings (building angle larger than 29 degrees) the resulting effect becomes positive, indicating that people might value living near very high buildings. A possible reason can be that very high buildings are special – for example monuments like church towers or water towers, and have a cultural and esthetic value. Finally, these results suggest that there is a certain equilibrium noticeable when the building angle is equal to 29 degrees.

Table 4: Abbreviated results of backward regressions

Coefficients					
Model: Backward		Unstandardized Coefficients		Standardized Coefficients	Sig.
		B	Std. Error	Beta	
B	(Constant)	8.904	0.034		0.000
	Building angle	0.001	0.000	0.027	0.019
	No high-rise	0.029	0.013	0.026	0.026
	Built between 1500 and 1930	-0.099	0.007	-0.092	0.000
	Built between 1931 and 1959	-0.095	0.007	-0.089	0.000
	Built between 1960 and 1980	-0.164	0.006	-0.183	0.000
	Built between 1981 and 2000	-0.077	0.005	-0.095	0.000
	Ln plotsize	0.154	0.004	0.214	0.000
	Ln m2	0.530	0.007	0.360	0.000
	Semi detached house	0.081	0.006	0.040	0.000
	Corner house	0.010	0.003	0.010	0.002
	Half of a double house	0.097	0.004	0.087	0.000
	Detached	0.185	0.007	0.107	0.000
	nStories	0.013	0.003	0.020	0.000
	nRooms	0.014	0.001	0.042	0.000
	Attic (zolder)	-0.021	0.003	-0.024	0.000
	Balcony	0.032	0.004	0.026	0.000
	Dormer	0.028	0.003	0.030	0.000
	Rooftop terrace	0.024	0.004	0.019	0.000
	nKitchens	0.016	0.004	0.011	0.000
	nBathrooms	0.019	0.002	0.025	0.000
	Own parkingspace	0.034	0.003	0.043	0.000
	Garden orientation other	-0.012	0.002	-0.015	0.000
	Gas/coal heating	-0.124	0.011	-0.035	0.000
	Somewhat insulated	0.050	0.003	0.059	0.000
	Well insulated	0.066	0.004	0.085	0.000
	Basement	0.040	0.005	0.030	0.000
	Sold in 2016	-0.158	0.003	-0.196	0.000
	Sold in 2017	-0.071	0.003	-0.088	0.000
	*[1]	…	…	…	...

7.2.2 The locational fixed-effects on the transaction price

The locational effects that were measured using the fixed-effect model were considered to answer the fourth sub-question. The original enter model had all postal codes except one included in its regressions in order to create a reference category. This method was applied to quantify the performances of one neighborhood versus all others in the dataset. The neighborhood with postal code 5045 in Tilburg was used as a reference category.

When the other neighborhoods are considered, it can be seen that the pricing varies strongly between each area and city (figures 20 to 24). The relations for Tilburg appear to be partly consistent, which appears to be fairly normal as it lies within the same city. However, three postal code areas stand out from this city: 5017, 5018 and 5037. The first two of these three areas were

[1] Table is shortened, postal codes for fixed-effect model are left out. The full corresponding table is presented in appendix 5

recently renovated and part of the Piushaven area with new brownfield developments and a shopping center. The 5037 area could benefit from the university area that is located within the same postal code which could have an influence on the price. In the case of the Tilburg city center with postal code 5038, an outperformance is visible when it is compared to the reference postal code area of 5045. However, the outperformance is not as strong as the other postal code areas within the same city.

For the other cities in this study, the biggest price jumps are most commonly visible nearby the city centers. The area that outperforms the reference category the strongest is the city center of ‘s-Hertogenbosch, which is closely followed by the city centers of Amersfoort and Nijmegen. Meanwhile, the city center of ‘s-Hertogenbosch with postal code 5211 appeared to have a 75% price premium over the 5045 area in Tilburg. For the city center of Amersfoort with postal code 3811, a similar thing occurs, albeit a price jump of 62% compared to the 5045 postal code in Tilburg. Similar things can be said about the other cities which were being included in these calculations. However, the appeared price jumps compared to the reference category are smaller. Furthermore, the surrounding areas closely located to the city centers experience a stronger, positive price effect in comparison to the reference category. This result could be somewhat expected, as the city center often offers more facilities such as theaters or fine dining. Last, this method was not very suitable to compare the transaction prices from city to city very well, it mainly showed how the transactions behaved in comparison to the reference in Tilburg.

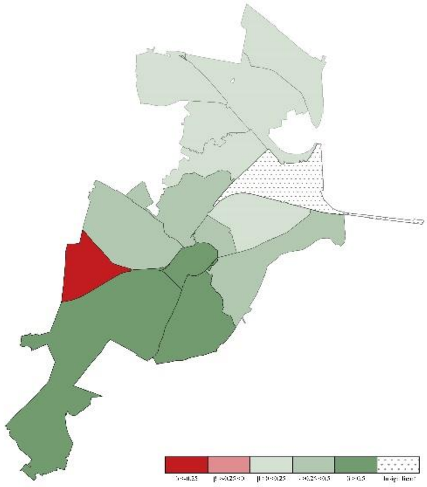


Figure 20: Neighborhoods in Amersfoort compared to the 5045 area in Tilburg

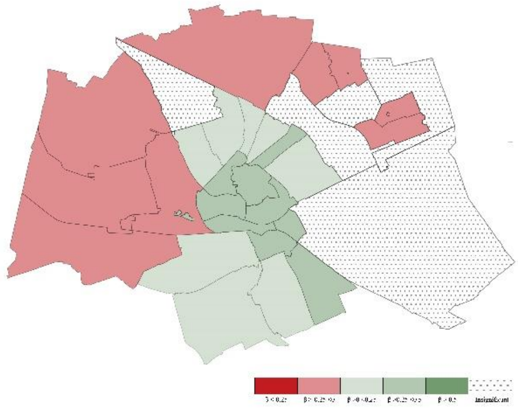


Figure 21: Neighborhoods in Groningen compared to the 5045 area in Tilburg

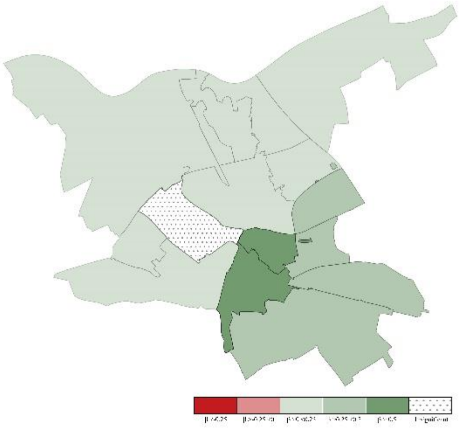


Figure 22: Neighborhoods in 's-Hertogenbosch compared to the 5045 area in Tilburg

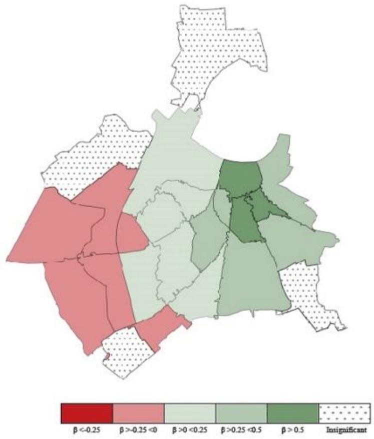


Figure 23: Neighborhoods in Nijmegen compared to the 5045 area in Tilburg

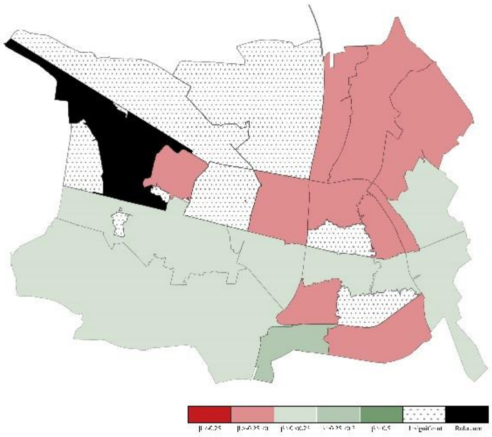


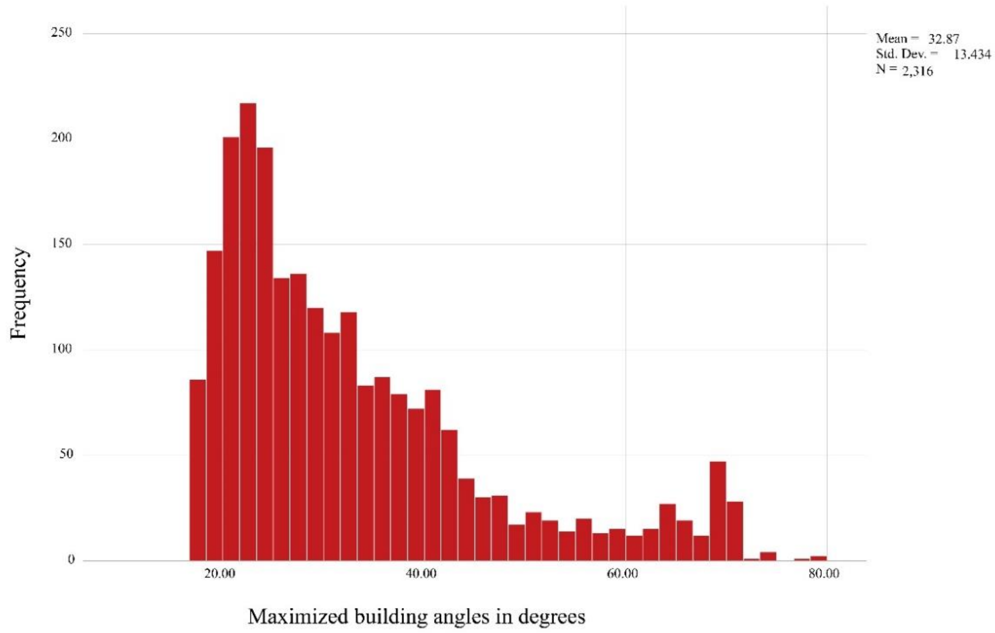
Figure 24: Neighborhoods in Tilburg compared to the 5045 postal code area

7.3 Robustness

In order to obtain more information on how the model behaved when certain items were changed, the following things were replaced. The maximum building angle values were used instead of using the average values in a postal code area. Second, instead of using the building angles, the number of high-rise objects per postal code area were used to measure the frequencies of high-rise.

7.3.1 Maximum building angles

In case one considers the maximum building angles instead of the average angles of the studied buildings and their surrounding areas, the following items can be noted. The frequency table is a little more "skewed" or stretched out towards the right given that average values were replaced by the largest values.



Second, the model with the maximum building angles appears to show similar results to the average building angle study. The overall performance of the model is nearly identical to the original model using the average values. The model summary (table 5) displays roughly the same results for both the enter model as well as the backward regression model.

Table 5: Model summary maximized angles

Model Summary					
Model	Nr. of variables	R	R square	Adjusted R Square	Std. Error of the Estimate
(C) Enter	139	0.928	0.861	0.859	0.144
(D) Backward	121	0.928	0.860	0.859	0.144

In this case, the same applies to the statistical model with the average values. The adjusted R square remains unchanged when using fewer variables. This effect could have been expected as only one variable of the model is replaced by a maximized one and the input thus remains identical for all other variables. Therefore, the results of the backward model are further discussed in the rest of this section.

In case one considers the overall results of the hedonic price model with the maximum building angle values (appendix 6), it seems that the relationship of the price on the maximum building angles is statistically significant on a 1% level (P=0.001). Meanwhile, this is not the case for the original price model where the 1% level threshold was exceeded. Furthermore, the significance of the dummy variable representing the no high-rise category appears to have a greater statistical significance and is also acceptable on a 1% level (P=0.003). However, even though the significance improves a bit, the coefficients show little change. The values for the building angle remain unchanged for the unstandardized coefficients beta *(β building angle = 0.001),* implicating that the price would increase with 0.1% for every additional degree of high-rise. Meanwhile, the unstandardized beta for the no presence of high-rise variable decreases *(β no high-rise = 0.024),* which means that the turning point becomes smaller than in the average angle situation. A possible explanation behind this could lay in the fact that the relations of the building angles are further expanded and overall much bigger than in the average situation. This would mean that an angle equal to 24 degrees could result in an equilibrium between the building angles and the no high-rise variable.

After both the average angles and the maximum angles were calculated, it became clear how the model behaved and that they remained fairly unchanged. Another key factor that could declare this lack of change might be the fact that the standardized coefficients are small in both scenarios, 0.025 for the building angle and 0.022 for no high-rise variable. In the average building angle model, this is 0.027 for the building angle and 0.026 for the no high-rise variable. This means that the contribution of the building angle on the price remains very little. Variables such as the plot size or square meters still have a much bigger value for these standardized coefficients, implicating that these variables explain a larger share of the transaction price.

7.3.2 Relationship between the number of high-rise in the neighborhood and the transaction price

The second items for this robustness study were the numbers of high-rise. The angles were replaced by measuring the counts of high-rise within each six-digit postal code area. However, in this case, only the numbers of high-rise within these areas were counted, which would implicate that the bordering or adjacent postal code areas of each postal code would not be treated with the effect of high-rise. Nevertheless, this particular model was carried out and is discussed below.

The collection of the data for this particular model was similar to the collection of the data for the average and maximized building angles. However, in this case, a function in GIS was used to filter all objects taller than the 15 meters threshold and was laid over the postal codes. Eventually, this resulted in 660 different postal codes that had buildings taller than 15 meters in their area, which ranged between one and six tall objects. The results of these regressions (appendix 7) are generally comparable to the other regression models with similar adjusted R square values of 0.859 (table 6) and also a positive relationship on the price. This resulted in an unstandardized beta value of 0.008 while the p-value of the frequency of high-rise was acceptable on a 5 percent level. These results suggest once more that there is a positive relation between the housing price and high-rise buildings. Nevertheless, a certain caution is advised as the standardized coefficients are even lower (0.007) than in the average and maximized pricing models, implicating that the influence on the price is lower. Furthermore, it should be noted that this is also in a model where the squared meters values are applied instead of the volumes. In case the volumes are considered, the significance of the model drops as it is completely insignificant with a value of 0.302.

Table 6: Model summary number of high-rise objects per postal code

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.928[a]	0,860	0,859	0,144

In other words, the results of this regression model suggest that the frequencies of high-rise are linked with a positive relation on the price. When one places this into context of this study it would mean that for every additional high-rise building in a postal code area, the price goes up by 0.8% of said dwelling in that specific postal code area. Therefore, these results seem to relate to Alonso's (1964) statements on the land prices in his bid-rent theory, as it appears that areas with high-rise in the urban areas have higher land values than land on the outskirts.

7.4 Conclusion

The overall results of the hedonic price models show a negative relationship between the presence of high-rise buildings and the transaction price. It was found that the presence of a tall object in the proximity of 50 meters negatively affects the housing transaction price with a reduction of 2.9% in housing value. Additionally it was found that houses situated in areas with a high-rise building object in their vicinity would experience a price increase of 0.1% for every additional degree of the building angle. This suggests that in occasions where the building angle was larger than 29 degrees it would result in a positive relationship on the transaction value. Moreover, the negative externalities that were expected might be outweighed by the presence of very tall buildings or very close high-rise objects. These results suggest that people might value living near very high buildings, which might also be explained by the fact that tall historic buildings such as church towers and water towers provide cultural and esthetic value. However, the contribution of the building angle variable and the presence of high-rise variable on the transaction price is very small.

Apart from the high-rise, the location also plays a crucial role in real estate. The fixed effect estimations confirm that houses in postal code areas nearby the city centers command a higher housing price. These price premia are likely explained by to the presence of certain amenities or facilities which make certain areas more popular than others.

Last, two robustness checks were carried out. At first, the building angles were maximized, which resulted in fairly similar results as the original computations. Furthermore, the statistical significance of the building height variables in this model is higher and equals one percent level. However, the standardized coefficients are very similar to the baseline model, which implies that the contribution of building height to the transaction price is still not as substantial as expected. The second robustness check that was conducted replaced the building angle of high-rise by the numbers of high-rise objects in a six-digit postal code area. In short, this showed that the price does react positively to an increase in number of tall objects in the surroundings, albeit very little. However, this way of working only counted the number of high-rise objects in the corresponding postal codes areas. In case there was no high-rise present in said area, the frequency remains zero. This means that certain adjacent areas might still have been affected by the high-rise of a neighboring postal code area, but were classified as an area without high-rise. .

8 Conclusion

This study tried to identify the relationship between housing values and the presence of nearby high-rise buildings that were taller than 15 meters. First, the Dutch housing market was studied by comparing it to European counterparts. The literature showed that the Dutch residential market differs strongly when compared to its European counterparts in terms of housing typologies and financing, resulting in large homeownership rates. Secondly, the functioning of high-rise buildings in cities was studied as well as negative externalities might arise with new high-rise real estate developments, such as an obstruction of view or shadowing effects..

In modern days, it is possible to identify certain of the aforementioned externalities by creating 3D maps to measure solar or shadowing effects. Similar maps were used for this study to derive building height information. Two methods to measure buildings heights which were either LIDAR scans or municipal records. The LIDAR scans presented the actual building heights, while the municipal records needed a minor transformation to subtract the ground level to get the absolute building height. After this was completed, it became possible to derive the building heights and distances to nearby located objects using GIS.

The final maps that were generated with the use of GIS allowed the inclusion of the building heights as a part of a variable. By applying trigonometric functions in GIS, it became possible to derive the angles of high-rise and merge them into the six-digit postal code areas. Furthermore, the transaction data was linked and processed in a six-digit postal code level. This allowed the development of a hedonic pricing model where the building angle was incorporated, while the six-digit postal code was used to identify areas with or without high-rise. This way of working ensured the closest approach to capture the relationship between the building heights and the transaction price by using a hedonic price model.

The results that were found during this study showed that dwellings without nearby high-rise buildings gained a price increase of 2.9% over similar dwellings that were located nearby high-rise buildings. This suggested that the valuation of nearby high-rise buildings is overall negatively perceived. However, in case one considered the building angles it resulted in a price jump of 0.1% for every additional degree of high-rise. This price jump implied that with a large enough building angle (larger than 29 degrees), the relationship with the transaction price might become positive. Furthermore, these results suggest that the perceived externalities of living nearby high-rise buildings might be experienced to a certain extent. However, people seemed to appreciate living nearby high-rise objects when the high-rise buildings were either very tall or very closely located.

When the results of the fixed-effect model are considered, it became noticeable that the transaction prices within the urban cores were much higher than surrounding areas. Furthermore, the transaction prices in Amersfoort and 's-Hertogenbosch were generally higher than the transaction prices in Tilburg. Meanwhile Groningen and Nijmegen showed mixed results when their prices were compared to the reference category in Tilburg. Last, the city of Tilburg was also much divided and showed some mixed results when compared to the referential 5045 postal code area.

The main conclusion of this study is that the presence of high-rise has a mixed relationship to the transaction price of houses. Moreover, housing values seemed to be negatively related to high-rise buildings when the angle of the building is relatively small, but with a larger angle, a positive relationship appeared to emerge on the transaction price. Besides, it should be noted that relationship between the transaction price and high-rise is very small and is largely surpassed by other variables such as the dwelling size. Nevertheless, this study developed and presented a new and functioning framework using 3D height maps which were released recently. Moreover, scientists can interpret this model and use it for further research, as developments in the field of 3D models are still in progress.

Discussion

The results of this study suggested that the high-rise buildings in the nearby vicinity can have a negative but also a positive relationship with the transaction price. The negative relationship supports the existence of negative externalities from high-rise objects. The positive relationship that occurs in the proximity of very high buildings, might be explained by the fact that these buildings have special cultural or historic value.

There are some possible explanations behind the positive relation of the high-rise to the transaction price. One of the reasons behind the positive relationship with the transaction price might be the influence of cultural or historical buildings that were largely present in the dataset. Another reason might be the mixture of functions that might be present in high-rise buildings, providing access to nearby facilities such as supermarkets or gyms.

Furthermore, it was found that the majority of the high-rise objects were located in the urban (historical) centers of the cities. The location or area in which the dwellings were located were taken into account, using the fixed-effect model. However, it could very well happen that living near high-rise buildings might give residents a certain feel of urbanism, which might influence their willingness to pay positively. Also other kinds of omitted variables may be present. For example, the methodology of this thesis incorporated the high-rise objects as if they were visible from all areas out of the house. In other words, it could happen that a high-rise object is next to one's house and would be marked with a relatively high building angle, while it is not even visible through the window as it is attached to the side of the house. Therefore, the building angle could be interpreted in different manners.

In case one wants to capture the aforementioned high-rise buildings in their direct surroundings on a house level, it requires the exact location data of said dwelling, which was not available. The housing transaction dataset was provided anonymously by the NVM on a six-digit postal code area level, which made this way of working the closest approach towards reality. Approaching houses on an individual level might deliver more precise results.

Considering the GIS mappings, the following needs to be taken into account. The use of 3D maps allowed the derivation of valuable building height information which was used to compute the price effects. However, these maps required certain transformations before they were usable. An example of these transformations is the fact that the municipal records had the ground levels included while the LIDAR scans did not. So these ground levels needed to be removed to maintain comparable results. Furthermore, the maps contained a lot of tall objects such as water towers, chimneys or spires that were all taller than 15 meters and marked as high-rise. However, there was no clear way to identify them and leave them out of the study. Also, there were certain measurement errors in the maps that were caused by items overshadowing the building object. The largest errors in the dataset were caused by either wrongly measured buildings that caused, in some occasions, the marking of a shed as high-rise, while it actually had a tree overshadowing it. These faulty measured items were removed manually. Last, working in GIS required considerable computational power to generate the distances between the tall objects and their direct surroundings to measure the angles. However, for future research, it could be expected that these processes might be done more efficiently as computational powers are likely to increase.

Recommendations

This study showed that it was possible to use the hedonic price model to measure the relationship between high-rise buildings and the transaction price. However, there were some drawbacks as mentioned in the discussion. Therefore, the following items are recommended for future research.

The conclusion that living next to high-rise may be positively valued by residents was unexpected. This method used actual behavioral patterns from transaction data of the past. However, it did not reflect the actual opinions of people on high-rise developments. This could be studied by surveying people on their preferred types of living to measure the actual demands. However, one side note to such studies could be that it could deviate from the actual behavior that was observed in this study.

Second, the data study was applied to all high-rise objects within the five Dutch cities. However, it could be more useful in the future to try to make a better distinction in functionalities of the high-rise. The literature study showed that the majority of the high-rise objects in European cities were either developed for housing or office purposes. Therefore, it might be helpful to use buildings that have a zoning plan for either of these two functions. Meanwhile, items such as a water tower or spire should not be included.

Third, the 15-meter threshold that was used in this study to define a high-rise building was relatively low. For future research, it might be helpful to have access to better 3D building height maps that do not contain any pollution of the building heights caused by overshadowing trees. Also, it might be recommended for other countries to take into account the ground levels since the Netherlands is relatively flat. Moreover, this means that areas on hills or mountains may use a different method. Another option to mitigate the problem of the overshadowing trees might be the use of a higher cutoff value. However, this might cause other difficulties such as a very low presence of very tall buildings in Dutch cities. Finally, it could be an option to repeat this study in cities with a larger share of high-rise buildings. These are cities as Amsterdam, Rotterdam, The Hague, or Eindhoven, where high-rise developments are becoming more common and could influence the price more.

Practical implications

This study presented a new methodology to measure the relationship of high-rise buildings nearby surrounding low rise housing. This is a relatively new field of interest as the height maps of the Netherlands were only released recently. In the future this framework can be used to assess for different cities how the housing values react to the presence of high-rise.

Second, the use of the 3D building height maps was relatively new in this field of interest, but the maps might become a very helpful tool for future research as well. They are already being used to measure solar hours like mentioned in the literature study, but could also be very helpful in the planning phase of, for example, wind turbines in order to measure shadows and distances to the built-up surroundings.

Last, the collected information could be very helpful to governmental institutions like municipalities and other legislative bodies that have to review building plans, especially in the current market situation where the demands for housing are high and policies aim for densification and brownfield (re-)developments. For example, this study could help to determine a fair amount of compensation in cases when high-rise developments cause negative externalities such as obstruction of view.

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Images

Cover page: Bagno, A. (2020, September 19). Morning light on streets of European city. [Photo]. Unsplash. https://unsplash.com/photos/BhJLPa_QWWY

Page 23: Groningen, the Netherlands. (2019, April 14). [Photo]. Unsplash. https://unsplash.com/photos/Ze9ykREkuVA

Page 40: de Bruijn, S. (2019, May 21). Sunset on building, Nijmegen, The Netherlands [Photo]. Unsplash. https://unsplash.com/photos/tKnda8e9ejM

Housing transaction data:

Nederlandse Vereniging van Makelaars en Taxateurs in onroerende goederen (NVM). (2021). Housing transaction dataset between 2016, 2017 & 2018

Appendix 1: Heatmaps with spread of high-rise in each city

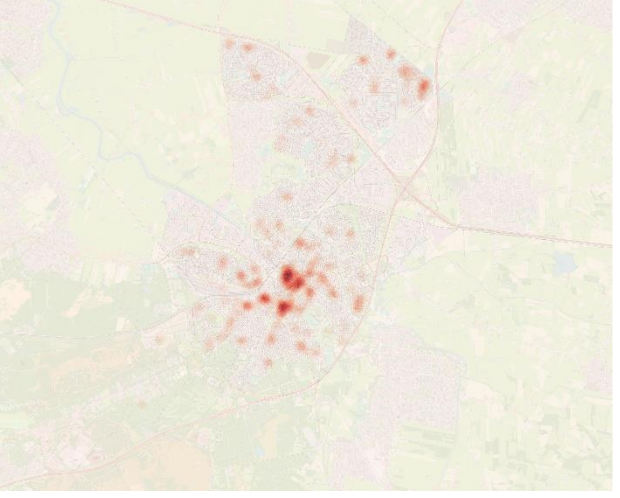

Figure 25: Building angle heatmap Amersfoort

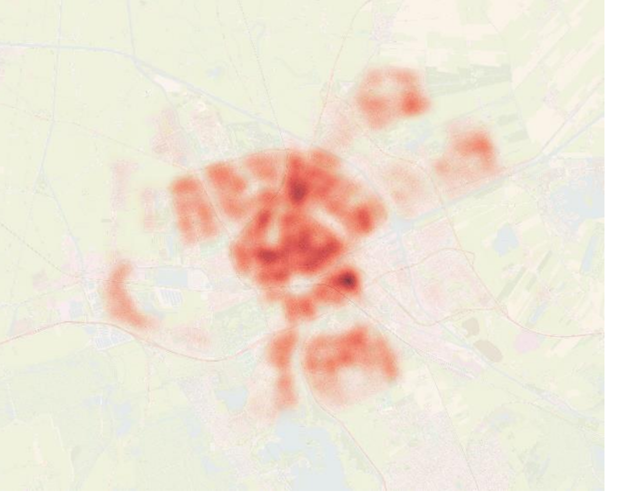

Figure 26: Building angle heatmap Groningen

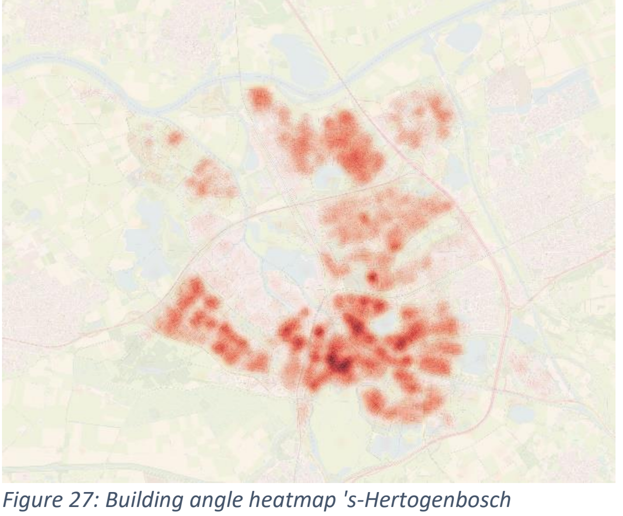

Figure 27: Building angle heatmap 's-Hertogenbosch

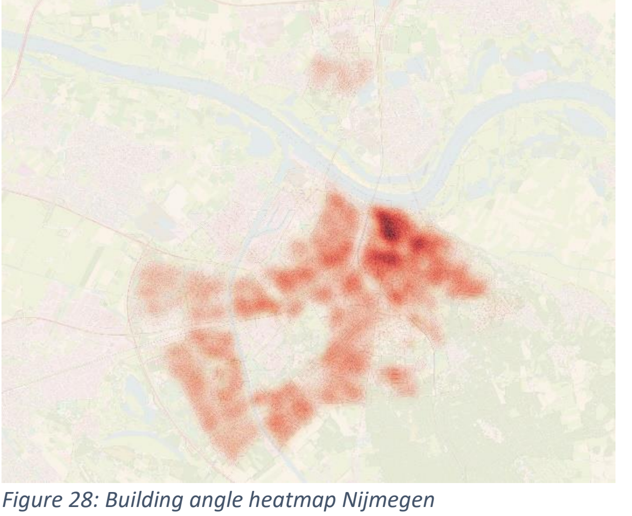

Figure 28: Building angle heatmap Nijmegen

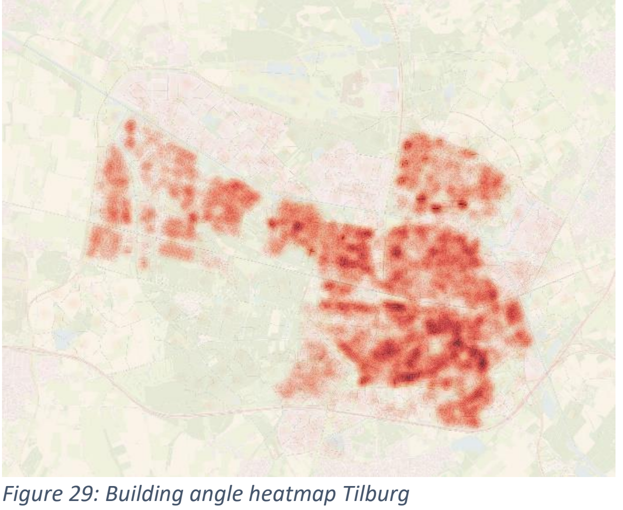

Figure 29: Building angle heatmap Tilburg

Appendix 2: Frequency table building periods

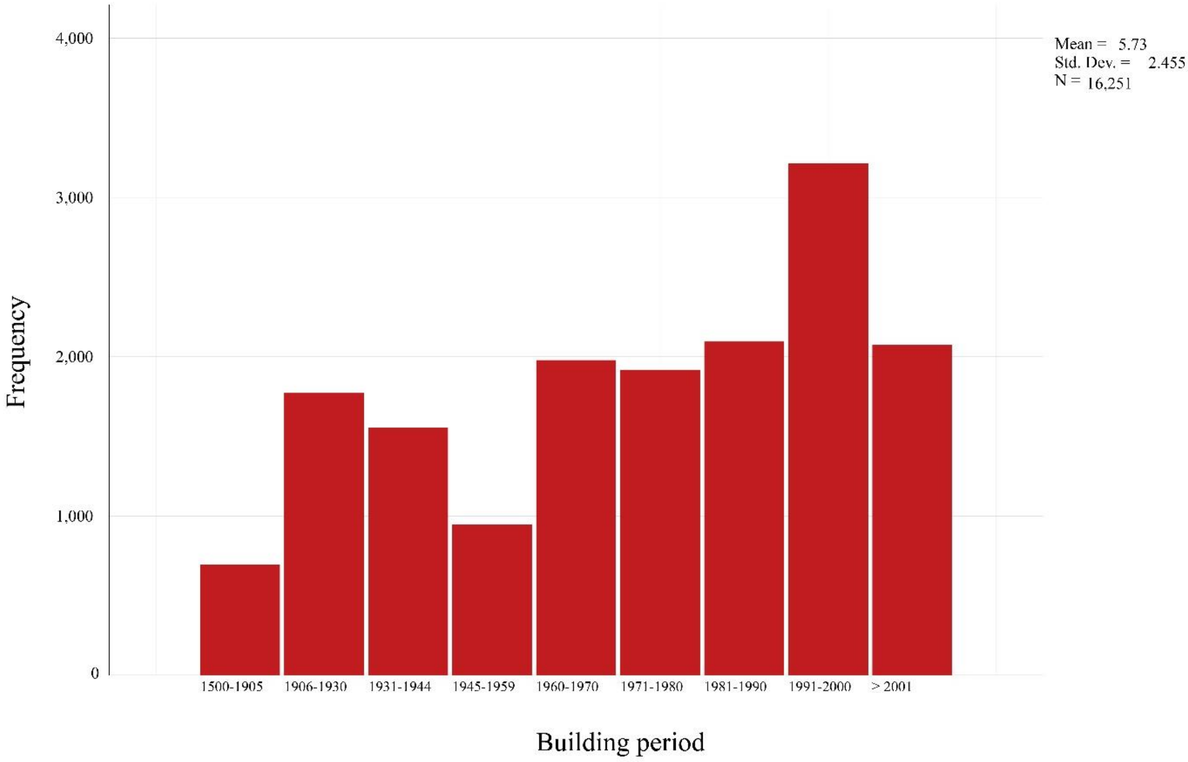

Figure 30: Building periods of houses in transaction dataset

Appendix 3: Correlation matrix

Correlations

		Ln of transaction price	Building angle	No buildings larger than 15m in surroundings	Amersfoort	Groningen	sHertogenbosch	Nijmegen	Built between 1500 and 1930	Built between 1931 and 1959	Built between 1960 and 1980	Built between 1981 and 2000	Ln plot size	Ln floorspace	Ln volume	Linked house	Corner house	Semi detached house	Detached house	Number of floors	Number of rooms	Attic
Ln of transaction price	Pearson Correlation	1	.086**	-.083**	.311**	-.134**	.118**	-.034**	.028**	.052**	-.240**	.012	.494**	.688**	.727**	.061**	-.033**	.303**	.317**	.234**	.454**	-.101**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.000	.000	.000	.125	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Building angle	Pearson Correlation	.086**	1	-.966**	.020**	.034**	.027**	-.079**	.148**	-.002	-.063**	-.136**	-.137**	.052**	.065**	-.019*	-.007	-.053**	-.021**	.044**	.019*	-.028**
	Sig. (2-tailed)	.000		.000	.009	.000	.000	.000	.000	.838	.000	.000	.000	.000	.000	.014	.365	.000	.008	.000	.015	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
No buildings larger than 15m in surroundings	Pearson Correlation	-.083**	-.966**	1	-.025**	-.014	-.035**	.072**	-.157**	-.006	.065**	.137**	.135**	-.047**	-.060**	.022**	.009	.056**	.023**	-.040**	-.015	.026**
	Sig. (2-tailed)	.000	.000		.002	.069	.000	.000	.000	.412	.000	.000	.000	.000	.000	.006	.234	.000	.003	.000	.054	.001
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Amersfoort	Pearson Correlation	.311**	.020**	-.025**	1	-.258**	-.205**	-.227**	-.020**	-.041**	-.191**	.095**	-.009	.075**	.115**	-.038**	.017*	.020**	-.026**	.079**	.073**	-.132**
	Sig. (2-tailed)	.000	.009	.002		.000	.000	.000	.009	.000	.000	.000	.254	.000	.000	.000	.032	.009	.001	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Groningen	Pearson Correlation	-.134**	.034**	-.014	-.258**	1	-.199**	-.220**	.079**	-.148**	.034**	.016*	-.070**	-.109**	-.157**	.023**	-.033**	.001	.055**	-.122**	-.089**	-.129**
	Sig. (2-tailed)	.000	.000	.069	.000		.000	.000	.000	.000	.000	.045	.000	.000	.000	.004	.000	.881	.000	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
sHertogenbosch	Pearson Correlation	.118**	.027**	-.035**	-.205**	-.199**	1	-.175**	-.110**	.013	.106**	-.012	.023**	.063**	.055**	.033**	-.016*	.055**	.031**	.041**	.026**	.009
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000	.000	.092	.000	.131	.003	.000	.000	.000	.041	.000	.000	.000	.001	.229
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Nijmegen	Pearson Correlation	-.034**	-.079**	.072**	-.227**	-.220**	-.175**	1	-.005	.091**	.171**	-.126**	.093**	.000	.009	-.029**	.047**	-.010	-.030**	.011	.049**	.048**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		.553	.000	.000	.000	.000	.952	.260	.000	.000	.189	.000	.168	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Built between 1500 and 1930	Pearson Correlation	.028**	.148**	-.157**	-.020**	.079**	-.110**	-.005	1	-.181**	-.238**	-.295**	-.172**	-.146**	-.123**	-.057**	-.008	-.008	-.026**	-.092**	-.147**	-.008
	Sig. (2-tailed)	.000	.000	.000	.009	.000	.000	.553		.000	.000	.000	.000	.000	.000	.000	.308	.303	.001	.000	.000	.289
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Built between 1931 and 1959	Pearson Correlation	.052**	-.002	-.006	-.041**	-.148**	.013	.091**	-.181**	1	-.240**	-.297**	-.023**	-.071**	-.053**	-.068**	.027**	-.030**	-.029**	.095**	.012	.119**
	Sig. (2-tailed)	.000	.838	.412	.000	.000	.092	.000	.000		.000	.000	.003	.000	.000	.000	.001	.000	.000	.000	.136	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Built between 1960 and 1980	Pearson Correlation	-.240**	-.063**	.065**	-.191**	.034**	.106**	.171**	-.238**	-.240**	1	-.391**	.068**	-.016*	-.044**	.014	.053**	-.099**	-.010	-.054**	.060**	.020**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.040	.000	.065	.000	.000	.197	.000	.000	.009
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Built between 1981 and 2000	Pearson Correlation	.012	-.136**	.137**	.095**	.016*	-.012	-.126**	-.295**	-.297**	-.391**	1	.100**	.044**	.021**	.065**	-.041**	.093**	.038**	-.005	.016*	-.032**
	Sig. (2-tailed)	.125	.000	.000	.000	.045	.131	.000	.000	.000	.000		.000	.000	.009	.000	.000	.000	.000	.508	.036	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Ln plot size	Pearson Correlation	.494**	-.137**	.135**	-.009	-.070**	.023**	.093**	-.172**	-.023**	.068**	.100**	1	.517**	.534**	.094**	.034**	.334**	.488**	-.048**	.314**	.004
	Sig. (2-tailed)	.000	.000	.000	.254	.000	.003	.000	.000	.003	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.567
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Ln floorspace	Pearson Correlation	.688**	.052**	-.047**	.075**	-.109**	.063**	.000	-.146**	-.071**	-.016*	.044**	.517**	1	.923**	.078**	-.034**	.251**	.266**	.366**	.620**	-.026**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.952	.000	.000	.040	.000	.000		.000	.000	.000	.000	.000	.000	.000	.001
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Ln volume	Pearson Correlation	.727**	.065**	-.060**	.115**	-.157**	.055**	.009	-.123**	-.053**	-.044**	.021**	.534**	.923**	1	.082**	-.036**	.255**	.292**	.356**	.615**	-.025**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.260	.000	.000	.000	.009	.000	.000		.000	.000	.000	.000	.000	.000	.001
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Linked house	Pearson Correlation	.061**	-.019*	.022**	-.038**	.023**	.033**	-.029**	-.057**	-.068**	.014	.065**	.094**	.078**	.082**	1	-.096**	-.078**	-.046**	-.105**	.003	-.032**
	Sig. (2-tailed)	.000	.014	.006	.000	.004	.000	.000	.000	.000	.065	.000	.000	.000	.000		.000	.000	.000	.000	.706	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Corner house	Pearson Correlation	-.033**	-.007	.009	.017*	-.033**	-.016*	.047**	-.008	.027**	.053**	-.041**	.034**	-.034**	-.036**	-.096**	1	-.198**	-.115**	-.004	-.011	.011
	Sig. (2-tailed)	.000	.365	.234	.032	.000	.041	.000	.308	.001	.000	.000	.000	.000	.000	.000		.000	.000	.598	.158	.154
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Semi detached house	Pearson Correlation	.303**	-.053**	.056**	.020**	.001	.055**	-.010	-.008	-.030**	-.099**	.093**	.334**	.251**	.255**	-.078**	-.198**	1	-.094**	.071**	.130**	.003
	Sig. (2-tailed)	.000	.000	.000	.009	.881	.000	.189	.303	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.675
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Detached house	Pearson Correlation	.317**	-.021**	.023**	-.026**	.055**	.031**	-.030**	-.026**	-.029**	-.010	.038**	.488**	.266**	.292**	-.046**	-.115**	-.094**	1	-.113**	.118**	-.018*
	Sig. (2-tailed)	.000	.008	.003	.001	.000	.000	.000	.001	.000	.197	.000	.000	.000	.000	.000	.000	.000		.000	.000	.022
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Number of floors	Pearson Correlation	.234**	.044**	-.040**	.079**	-.122**	.041**	.011	-.092**	.095**	-.054**	-.005	-.048**	.366**	.356**	-.105**	-.004	.071**	-.113**	1	.498**	.275**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.168	.000	.000	.000	.508	.000	.000	.000	.000	.598	.000	.000		.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Number of rooms	Pearson Correlation	.454**	.019*	-.015	.073**	-.089**	.026**	.049**	-.147**	.012	.060**	.016*	.314**	.620**	.615**	.003	-.011	.130**	.118**	.498**	1	-.018*
	Sig. (2-tailed)	.000	.015	.054	.000	.000	.001	.000	.000	.136	.000	.036	.000	.000	.000	.706	.158	.000	.000	.000		.019
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Attic	Pearson Correlation	-.101**	-.028**	.026**	-.132**	-.129**	.009	.048**	-.008	.119**	.020**	-.032**	.004	-.026**	-.025**	-.032**	.011	.003	-.018*	.275**	-.018*	1
	Sig. (2-tailed)	.000	.000	.001	.000	.000	.229	.000	.289	.000	.009	.000	.567	.001	.001	.000	.154	.675	.022	.000	.019	
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Loft	Pearson Correlation	.001	-.011	.004	.019*	-.011	-.035**	-.002	.072**	.056**	-.045**	-.031**	.037**	-.032**	-.017*	-.013	-.003	.007	.058**	-.166**	-.046**	-.096**
	Sig. (2-tailed)	.917	.180	.603	.013	.148	.000	.835	.000	.000	.000	.000	.000	.000	.029	.099	.696	.350	.000	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Balcony	Pearson Correlation	.251**	.061**	-.058**	.065**	-.042**	.013	.071**	.017*	.107**	.021**	-.094**	.079**	.212**	.224**	-.010	.004	.053**	.042**	.146**	.203**	-.043**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.097	.000	.030	.000	.009	.000	.000	.000	.000	.193	.587	.000	.000	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Dormer	Pearson Correlation	.125**	-.019*	.012	.015	-.110**	.026**	.036**	.059**	.188**	-.046**	-.080**	.022**	.046**	.050**	-.054**	.008	.065**	-.017*	.153**	.079**	.064**
	Sig. (2-tailed)	.000	.013	.126	.060	.000	.001	.000	.000	.000	.000	.000	.005	.000	.000	.000	.313	.000	.027	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Rooftop terrace	Pearson Correlation	.147**	.109**	-.097**	.056**	.034**	-.011	-.065**	.036**	-.012	-.115**	.012	-.059**	.154**	.153**	.020*	.009	.009	.006	.154**	.091**	-.066**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.145	.000	.000	.122	.000	.111	.000	.000	.000	.011	.262	.246	.450	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Number of kitchens	Pearson Correlation	.109**	.036**	-.037**	.064**	.025**	-.011	.002	.048**	-.007	-.052**	.015	-.012	.065**	.078**	-.004	.000	.017*	.002	.086**	.060**	-.026**
	Sig. (2-tailed)	.000	.000	.000	.000	.002	.167	.787	.000	.381	.000	.055	.115	.000	.000	.587	.958	.026	.806	.000	.000	.001
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Pantry	Pearson Correlation	.112**	.007	-.006	-.078**	.076**	-.030**	-.083**	.113**	.112**	-.066**	-.051**	.204**	.121**	.128**	.034**	-.021**	.105**	.191**	-.041**	.040**	.038**
	Sig. (2-tailed)	.000	.349	.428	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.006	.000	.000	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Number of bathrooms	Pearson Correlation	.230**	.016*	-.014	.102**	-.035**	.014	-.043**	.023**	-.014	-.073**	.054**	.088**	.169**	.191**	.016*	-.013	.043**	.088**	.064**	.109**	-.042**
	Sig. (2-tailed)	.000	.043	.076	.000	.000	.074	.000	.003	.070	.000	.000	.000	.000	.000	.036	.090	.000	.000	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Other garden orientation	Pearson Correlation	-.098**	-.041**	.038**	-.096**	-.029**	-.013	.010	-.002	.054**	-.008	.013	-.037**	-.059**	-.063**	-.006	.006	.000	-.114**	.025**	-.016*	.048**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.096	.217	.802	.000	.281	.103	.000	.000	.000	.408	.477	.990	.000	.002	.036	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Southern orientated garden	Pearson Correlation	.031**	.014	-.013	.088**	-.001	-.004	.008	-.034**	-.050**	.020*	.012	-.021**	.018*	.020**	.012	.007	.014	-.064**	.029**	.017*	-.027**
	Sig. (2-tailed)	.000	.082	.104	.000	.858	.613	.314	.000	.000	.011	.126	.007	.022	.009	.127	.389	.085	.000	.000	.034	.001
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Indoor maintenance status	Pearson Correlation	.241**	.015	-.010	.024**	.033**	-.021**	-.084**	-.063**	-.068**	-.137**	.095**	-.002	.128**	.119**	.035**	-.023**	.044**	.026**	.046**	.025**	-.056**
	Sig. (2-tailed)	.000	.062	.191	.002	.000	.006	.000	.000	.000	.000	.000	.752	.000	.000	.000	.003	.000	.001	.000	.001	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Outdoor maintenance status	Pearson Correlation	.231**	.012	-.009	.027**	.022**	-.030**	-.056**	-.074**	-.061**	-.121**	.081**	.010	.133**	.126**	.028**	-.022**	.044**	.024**	.058**	.043**	-.040**
	Sig. (2-tailed)	.000	.121	.273	.000	.005	.000	.000	.000	.000	.000	.000	.189	.000	.000	.000	.005	.000	.002	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Gas or Coal heating	Pearson Correlation	-.072**	.019*	-.024**	-.016*	.031**	-.023**	.008	.129**	.057**	-.041**	-.076**	-.053**	-.108**	-.094**	-.019*	-.009	-.013	-.006	-.048**	-.068**	.003
	Sig. (2-tailed)	.000	.014	.002	.047	.000	.004	.315	.000	.000	.000	.000	.000	.000	.000	.018	.258	.086	.479	.000	.000	.735
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Boiler, block heating, district heating, master fireplace or hot air	Pearson Correlation	.076**	-.006	.009	.029**	.019*	.019*	.001	-.091**	-.059**	.012	.078**	.025**	.075**	.065**	.013	.007	.015	-.001	.095**	.074**	-.032**
	Sig. (2-tailed)	.000	.431	.275	.000	.018	.016	.886	.000	.000	.133	.000	.001	.000	.000	.105	.402	.058	.910	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
AC_Solar	Pearson Correlation	-.001	-.010	.011	.010	-.007	-.003	-.005	-.011	.015	-.015	.012	-.004	.003	.004	-.005	.017*	-.004	-.006	.006	-.005	.019*
	Sig. (2-tailed)	.877	.191	.176	.213	.365	.660	.520	.160	.054	.062	.121	.615	.708	.567	.517	.030	.644	.437	.442	.560	.018
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Somewhat insulated	Pearson Correlation	-.023**	.009	-.014	-.084**	-.039**	-.012	.156**	.139**	.197**	.164**	-.246**	-.036**	-.061**	-.063**	-.035**	.049**	-.046**	-.037**	.032**	.013	.054**
	Sig. (2-tailed)	.004	.273	.076	.000	.000	.142	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.102	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Well insulated	Pearson Correlation	.214**	-.028**	.036**	.215**	-.028**	-.055**	-.204**	-.264**	-.290**	-.333**	.443**	.093**	.200**	.212**	.057**	-.052**	.106**	.058**	.058**	.065**	-.092**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Basement	Pearson Correlation	.239**	.037**	-.042**	-.061**	-.097**	-.092**	.394**	.185**	.223**	-.062**	-.193**	.123**	.156**	.185**	-.036**	.016*	.050**	.053**	.094**	.143**	.038**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.042	.000	.000	.000	.000	.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Has a monumental status	Pearson Correlation	.040**	.066**	-.064**	.000	.054**	.004	-.006	.135**	-.002	-.042**	-.045**	-.038**	-.024**	-.009	-.010	-.005	.006	.016*	-.015	-.013	-.013
	Sig. (2-tailed)	.000	.000	.000	.990	.000	.595	.452	.000	.801	.000	.000	.000	.002	.228	.195	.495	.449	.040	.064	.105	.103
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Sold in 2016	Pearson Correlation	-.142**	-.003	.007	.011	-.001	.019*	-.012	-.003	.001	-.015	.023**	.009	-.010	-.040**	.006	-.004	.005	.016*	-.013	-.019*	.007
	Sig. (2-tailed)	.000	.723	.342	.152	.882	.018	.141	.740	.865	.058	.004	.235	.208	.000	.425	.627	.530	.041	.097	.015	.397
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Sold in 2017	Pearson Correlation	-.005	.003	-.005	-.020**	.004	-.018*	-.002	.008	-.009	-.006	.003	-.009	-.010	-.007	-.002	-.008	-.005	.002	-.002	-.007	-.004
	Sig. (2-tailed)	.519	.715	.491	.009	.598	.021	.756	.298	.245	.435	.668	.254	.207	.404	.761	.291	.500	.756	.776	.351	.583
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254

		Loft	Balcony	Dormer	Rooftop terrace	Number of kitchens	Pantry	Number of bathrooms	Other garden orientation	Southern orientated garden	Indoor maintenance status	Outdoor maintenance status	Gas or Coal heating	Boiler, block heating, district heating, master fireplace or hot air	AC_Solar	Somewhat insulated	Well insulated	Basement	Has a monumental status	Sold in 2016	Sold in 2017
Ln of transaction price	Pearson Correlation	.001	.251**	.125**	.147**	.109**	.112**	.230**	-.098**	.031**	.241**	.231**	-.072**	.076**	-.001	-.023**	.214**	.239**	.040**	-.142**	-.005
	Sig. (2-tailed)	.917	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.877	.004	.000	.000	.000	.000	.519
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Building angle	Pearson Correlation	-.011	.061**	-.019*	.109**	.036**	.007	.016*	-.041**	.014	.015	.012	.019*	-.006	-.010	.009	-.028**	.037**	.066**	-.003	.003
	Sig. (2-tailed)	.180	.000	.013	.000	.000	.349	.043	.000	.082	.062	.121	.014	.431	.191	.273	.000	.000	.000	.723	.715
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
No buildings larger than 15m in surroundings	Pearson Correlation	.004	-.058**	.012	-.097**	-.037**	-.006	-.014	.038**	-.013	-.010	-.009	-.024**	.009	.011	-.014	.036**	-.042**	-.064**	.007	-.005
	Sig. (2-tailed)	.603	.000	.126	.000	.000	.428	.076	.000	.104	.191	.273	.002	.275	.176	.076	.000	.000	.000	.342	.491
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Amersfoort	Pearson Correlation	.019*	.065**	.015	.056**	.064**	-.078**	.102**	-.096**	.088**	.024**	.027**	-.016*	.029**	.010	-.084**	.215**	-.061**	.000	.011	-.020**
	Sig. (2-tailed)	.013	.000	.060	.000	.000	.000	.000	.000	.000	.002	.000	.047	.000	.213	.000	.000	.000	.990	.152	.009
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Groningen	Pearson Correlation	-.011	-.042**	-.110**	.034**	.025**	.076**	-.035**	-.029**	-.001	.033**	.022**	.031**	.019*	-.007	-.039**	-.028**	-.097**	.054**	-.001	.004
	Sig. (2-tailed)	.148	.000	.000	.000	.002	.000	.000	.000	.858	.000	.005	.000	.018	.365	.000	.000	.000	.000	.882	.598
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
sHertogenbosch	Pearson Correlation	-.035**	.013	.026**	-.011	-.011	-.030**	.014	-.013	-.004	-.021**	-.030**	-.023**	.019*	-.003	-.012	-.055**	-.092**	.004	.019*	-.018*
	Sig. (2-tailed)	.000	.097	.001	.145	.167	.000	.074	.096	.613	.006	.000	.004	.016	.660	.142	.000	.000	.595	.018	.021
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Nijmegen	Pearson Correlation	-.002	.071**	.036**	-.065**	.002	-.083**	-.043**	.010	.008	-.084**	-.056**	.008	.001	-.005	.156**	-.204**	.394**	-.006	-.012	-.002
	Sig. (2-tailed)	.835	.000	.000	.000	.787	.000	.000	.217	.314	.000	.000	.315	.886	.520	.000	.000	.000	.452	.141	.756
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Built between 1500 and 1930	Pearson Correlation	.072**	.017*	.059**	.036**	.048**	.113**	.023**	-.002	-.034**	-.063**	-.074**	.129**	-.091**	-.011	.139**	-.264**	.185**	.135**	-.003	.008
	Sig. (2-tailed)	.000	.030	.000	.000	.000	.000	.003	.802	.000	.000	.000	.000	.000	.160	.000	.000	.000	.000	.740	.298
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Built between 1931 and 1959	Pearson Correlation	.056**	.107**	.188**	-.012	-.007	.112**	-.014	.054**	-.050**	-.068**	-.061**	.057**	-.059**	.015	.197**	-.290**	.223**	-.002	.001	-.009
	Sig. (2-tailed)	.000	.000	.000	.122	.381	.000	.070	.000	.000	.000	.000	.000	.000	.054	.000	.000	.000	.801	.865	.245
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Built between 1960 and 1980	Pearson Correlation	-.045**	.021**	-.046**	-.115**	-.052**	-.066**	-.073**	-.008	.020*	-.137**	-.121**	-.041**	.012	-.015	.164**	-.333**	-.062**	-.042**	-.015	-.006
	Sig. (2-tailed)	.000	.009	.000	.000	.000	.000	.000	.281	.011	.000	.000	.000	.133	.062	.000	.000	.000	.000	.058	.435
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Built between 1981 and 2000	Pearson Correlation	-.031**	-.094**	-.080**	.012	.015	-.051**	.054**	.013	.012	.095**	.081**	-.076**	.078**	.012	-.246**	.443**	-.193**	-.045**	.023**	.003
	Sig. (2-tailed)	.000	.000	.000	.111	.055	.000	.000	.103	.126	.000	.000	.000	.000	.121	.000	.000	.000	.000	.004	.668
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Ln plot size	Pearson Correlation	.037**	.079**	.022**	-.059**	-.012	.204**	.088**	-.037**	-.021**	-.002	.010	-.053**	.025**	-.004	-.036**	.093**	.123**	-.038**	.009	-.009
	Sig. (2-tailed)	.000	.000	.005	.000	.115	.000	.000	.000	.007	.752	.189	.000	.001	.615	.000	.000	.000	.000	.235	.254
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Ln floorspace	Pearson Correlation	-.032**	.212**	.046**	.154**	.065**	.121**	.169**	-.059**	.018*	.128**	.133**	-.108**	.075**	.003	-.061**	.200**	.156**	-.024**	-.010	-.010
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.022	.000	.000	.000	.000	.708	.000	.000	.000	.002	.208	.207
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Ln volume	Pearson Correlation	-.017*	.224**	.050**	.153**	.078**	.128**	.191**	-.063**	.020**	.119**	.126**	-.094**	.065**	.004	-.063**	.212**	.185**	-.009	-.040**	-.007
	Sig. (2-tailed)	.029	.000	.000	.000	.000	.000	.000	.000	.009	.000	.000	.000	.000	.567	.000	.000	.000	.228	.000	.404
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Linked house	Pearson Correlation	-.013	-.010	-.054**	.020*	-.004	.034**	.016*	-.006	.012	.035**	.028**	-.019*	.013	-.005	-.035**	.057**	-.036**	-.010	.006	-.002
	Sig. (2-tailed)	.099	.193	.000	.011	.587	.000	.036	.408	.127	.000	.000	.018	.105	.517	.000	.000	.000	.195	.425	.761
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Corner house	Pearson Correlation	-.003	.004	.008	.009	.000	-.021**	-.013	.006	.007	-.023**	-.022**	-.009	.007	.017*	.049**	-.052**	.016*	-.005	-.004	-.008
	Sig. (2-tailed)	.696	.587	.313	.262	.958	.006	.090	.477	.389	.003	.005	.258	.402	.030	.000	.000	.042	.495	.627	.291
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Semi detached house	Pearson Correlation	.007	.053**	.065**	.009	.017*	.105**	.043**	.000	.014	.044**	.044**	-.013	.015	-.004	-.046**	.106**	.050**	.006	.005	-.005
	Sig. (2-tailed)	.350	.000	.000	.246	.026	.000	.000	.990	.085	.000	.000	.086	.058	.644	.000	.000	.000	.449	.530	.500
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Detached house	Pearson Correlation	.058**	.042**	-.017*	.006	.002	.191**	.088**	-.114**	-.064**	.026**	.024**	-.006	-.001	-.006	-.037**	.058**	.053**	.016*	.016*	.002
	Sig. (2-tailed)	.000	.000	.027	.450	.806	.000	.000	.000	.000	.001	.002	.479	.910	.437	.000	.000	.000	.040	.041	.756
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Number of floors	Pearson Correlation	-.166**	.146**	.153**	.154**	.086**	-.041**	.064**	.025**	.029**	.046**	.058**	-.048**	.095**	.006	.032**	.058**	.094**	-.015	-.013	-.002
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.002	.000	.000	.000	.000	.000	.442	.000	.000	.000	.064	.097	.776
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Number of rooms	Pearson Correlation	-.046**	.203**	.079**	.091**	.060**	.040**	.109**	-.016*	.017*	.025**	.043**	-.068**	.074**	-.005	.013	.065**	.143**	-.013	-.019*	-.007
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.036	.034	.001	.000	.000	.000	.560	.102	.000	.000	.105	.015	.351
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Attic	Pearson Correlation	-.096**	-.043**	.064**	-.066**	-.026**	.038**	-.042**	.048**	-.027**	-.056**	-.040**	.003	-.032**	.019*	.054**	-.092**	.038**	-.013	.007	-.004
	Sig. (2-tailed)	.000	.000	.000	.000	.001	.000	.000	.000	.001	.000	.000	.735	.000	.018	.000	.000	.000	.103	.397	.583
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Loft	Pearson Correlation	1	-.006	.013	-.037**	.013	.070**	.021**	.001	-.004	-.014	-.009	.019*	.001	-.007	-.012	-.025**	.057**	-.002	-.010	.008
	Sig. (2-tailed)		.438	.102	.000	.095	.000	.007	.857	.566	.083	.273	.016	.870	.397	.139	.002	.000	.826	.203	.326
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Balcony	Pearson Correlation	-.006	1	.059**	.005	.078**	.027**	.081**	-.021**	.004	-.001	.005	.022**	-.001	.014	.046**	-.066**	.175**	.000	.008	-.013
	Sig. (2-tailed)	.438		.000	.543	.000	.001	.000	.007	.651	.920	.533	.004	.871	.085	.000	.000	.000	.978	.285	.109
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Dormer	Pearson Correlation	.013	.059**	1	-.041**	.069**	.053**	.054**	.031**	-.004	.042**	.039**	.005	.039**	-.009	.135**	-.090**	.110**	.012	-.009	.002
	Sig. (2-tailed)	.102	.000		.000	.000	.000	.000	.000	.568	.000	.000	.500	.000	.332	.000	.000	.000	.114	.227	.755
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Rooftop terrace	Pearson Correlation	-.037**	.005	-.041**	1	.060**	.024**	.054**	-.035**	.015	.065**	.059**	-.009	.025**	.014	-.044**	.101**	.016*	.007	.012	-.004
	Sig. (2-tailed)	.000	.543	.000		.000	.003	.000	.000	.057	.000	.000	.268	.002	.072	.000	.000	.040	.395	.136	.631
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Number of kitchens	Pearson Correlation	.013	.078**	.069**	.060**	1	.029**	.273**	.031**	.036**	.089**	.086**	.001	.150**	.005	.013	.046**	.055**	-.003	-.013	-.024**
	Sig. (2-tailed)	.095	.000	.000	.000		.000	.000	.000	.000	.000	.000	.865	.000	.510	.101	.000	.000	.668	.096	.002
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Pantry	Pearson Correlation	.070**	.027**	.053**	.024**	.029**	1	.052**	.008	-.034**	.016*	.009	.012	.018*	.000	.067**	-.079**	.028**	.000	-.007	.010
	Sig. (2-tailed)	.000	.001	.000	.003	.000		.000	.293	.000	.043	.249	.136	.019	.956	.000	.000	.000	.998	.389	.223
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Number of bathrooms	Pearson Correlation	.021**	.081**	.054**	.054**	.273**	.052**	1	.009	.032**	.102**	.092**	-.027**	.144**	.002	.025**	.090**	.053**	-.008	-.047**	.002
	Sig. (2-tailed)	.007	.000	.000	.000	.000	.000		.246	.000	.000	.000	.001	.000	.825	.001	.000	.000	.304	.000	.770
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Other garden orientation	Pearson Correlation	.001	-.021**	.031**	-.035**	.031**	.008	.009	1	-.786**	-.010	-.015	.002	-.046**	-.001	.030**	-.018*	.008	-.021**	.003	.005
	Sig. (2-tailed)	.857	.007	.000	.000	.000	.293	.246		.000	.183	.050	.797	.000	.899	.000	.025	.330	.007	.669	.560
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Southern orientated garden	Pearson Correlation	-.004	.004	-.004	.015	.036**	-.034**	.032**	-.786**	1	.023**	.033**	-.013	.061**	.007	.001	.042**	-.019*	-.011	-.015	.002
	Sig. (2-tailed)	.566	.651	.568	.057	.000	.000	.000	.000		.004	.000	.093	.000	.344	.870	.000	.018	.162	.052	.815
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Indoor maintenance status	Pearson Correlation	-.014	-.001	.042**	.065**	.089**	.016*	.102**	-.010	.023**	1	.835**	-.148**	.160**	.011	.019*	.233**	-.036**	-.007	.006	.017*
	Sig. (2-tailed)	.083	.920	.000	.000	.000	.043	.000	.183	.004		.000	.000	.000	.147	.019	.000	.000	.343	.472	.026
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Outdoor maintenance status	Pearson Correlation	-.009	.005	.039**	.059**	.086**	.009	.092**	-.015	.033**	.835**	1	-.126**	.160**	.014	.010	.221**	-.029**	.003	.005	.016*
	Sig. (2-tailed)	.273	.533	.000	.000	.000	.249	.000	.050	.000	.000		.000	.000	.072	.193	.000	.000	.732	.516	.036
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Gas or Coal heating	Pearson Correlation	.019*	.022**	.005	-.009	.001	.012	-.027**	.002	-.013	-.148**	-.126**	1	-.545**	-.003	-.037**	-.080**	.060**	.045**	.000	.001
	Sig. (2-tailed)	.016	.004	.500	.268	.865	.136	.001	.797	.093	.000	.000		.000	.714	.000	.000	.000	.000	.952	.934
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Boiler, block heating, district heating, master fireplace or hot air	Pearson Correlation	.001	-.001	.039**	.025**	.150**	.018*	.144**	-.046**	.061**	.160**	.160**	-.545**	1	-.128**	.089**	.135**	-.017*	-.019*	-.021**	-.001
	Sig. (2-tailed)	.870	.871	.000	.002	.000	.019	.000	.000	.000	.000	.000	.000		.000	.000	.000	.033	.016	.007	.929
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
AC_Solar	Pearson Correlation	-.007	.014	-.009	.014	.005	.000	.002	-.001	.007	.011	.014	-.003	-.128**	1	-.011	.008	-.008	-.002	-.004	.006
	Sig. (2-tailed)	.397	.085	.332	.072	.510	.956	.825	.899	.344	.147	.072	.714	.000		.166	.320	.297	.804	.614	.441
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Somewhat insulated	Pearson Correlation	-.012	.046**	.135**	-.044**	.013	.067**	.025**	.030**	.001	.019*	.010	-.037**	.089**	-.011	1	-.506**	.126**	.030**	-.015	-.006
	Sig. (2-tailed)	.139	.000	.000	.000	.101	.000	.001	.000	.870	.019	.193	.000	.000	.166		.000	.000	.000	.057	.477
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Well insulated	Pearson Correlation	-.025**	-.066**	-.090**	.101**	.046**	-.079**	.090**	-.018*	.042**	.233**	.221**	-.080**	.135**	.008	-.506**	1	-.177**	-.040**	-.004	.006
	Sig. (2-tailed)	.002	.000	.000	.000	.000	.000	.000	.025	.000	.000	.000	.000	.000	.320	.000		.000	.000	.598	.476
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Basement	Pearson Correlation	.057**	.175**	.110**	.016*	.055**	.028**	.053**	.008	-.019*	-.036**	-.029**	.060**	-.017*	-.008	.126**	-.177**	1	.026**	.000	-.006
	Sig. (2-tailed)	.000	.000	.000	.040	.000	.000	.000	.330	.018	.000	.000	.000	.033	.297	.000	.000		.001	.997	.459
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Has a monumental status	Pearson Correlation	-.002	.000	.012	.007	-.003	.000	-.008	-.021**	-.011	-.007	.003	.045**	-.019*	-.002	.030**	-.040**	.026**	1	.003	.017*
	Sig. (2-tailed)	.826	.978	.114	.395	.668	.998	.304	.007	.162	.343	.732	.000	.016	.804	.000	.000	.001		.663	.026
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Sold in 2016	Pearson Correlation	-.010	.008	-.009	.012	-.013	-.007	-.047**	.003	-.015	.006	.005	.000	-.021**	-.004	-.015	-.004	.000	.003	1	-.526**
	Sig. (2-tailed)	.203	.285	.227	.136	.096	.389	.000	.669	.052	.472	.516	.952	.007	.614	.057	.598	.997	.663		.000
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254
Sold in 2017	Pearson Correlation	.008	-.013	.002	-.004	-.024**	.010	.002	.005	.002	.017*	.016*	.001	-.001	.006	-.006	.006	-.006	.017*	-.526**	1
	Sig. (2-tailed)	.326	.109	.755	.631	.002	.223	.770	.560	.815	.026	.036	.934	.929	.441	.477	.476	.459	.026	.000	
	N	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254	16254

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 4: Regression model with enter method

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2064.997	139	14.856	714.779	.000
	Residual	334.854	16111	0.021		
	Total	2399.851	16250			

Coefficients							
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity
		B	Std. Error	Beta			VIF
1	(Constant)	8.889	0.035		250.834	0.000	
	Building angle	0.001	0.000	0.027	2.274	0.023	15.865
	No hirise	0.028	0.013	0.026	2.215	0.027	15.714
	Built between 1500 and 1930	-0.100	0.007	-0.094	-14.251	0.000	5.004
	Built between 1931 and 1959	-0.097	0.007	-0.091	-13.952	0.000	4.919
	Built between 1960 and 1980	-0.164	0.006	-0.182	-26.027	0.000	5.670
	Built between 1981 and 2000	-0.075	0.006	-0.092	-13.339	0.000	5.468
	Ln plotsize	0.154	0.004	0.214	41.565	0.000	3.059
	Ln m2	0.531	0.007	0.361	74.010	0.000	2.740
	Semi detached house	0.081	0.007	0.040	12.435	0.000	1.171
	Corner house	0.010	0.003	0.010	3.158	0.002	1.199
	Half of a double house	0.097	0.004	0.087	22.976	0.000	1.660
	Detached	0.187	0.007	0.108	26.347	0.000	1.938
	nStories	0.013	0.003	0.019	4.536	0.000	1.984
	nRooms	0.014	0.001	0.043	10.046	0.000	2.081
	Attic (zolder)	-0.021	0.003	-0.024	-7.137	0.000	1.271
	Loft (vliering)	-0.005	0.005	-0.003	-0.974	0.330	1.081
	Balcony	0.032	0.004	0.026	8.182	0.000	1.180
	Dormer	0.028	0.003	0.030	9.576	0.000	1.133
	Rooftop terrace	0.024	0.004	0.019	5.995	0.000	1.137
	nKitchens	0.015	0.004	0.011	3.479	0.001	1.156
	Pantry	0.000	0.003	0.000	0.060	0.952	1.213
	nBathrooms	0.019	0.002	0.025	7.720	0.000	1.174
	Own parkingspace	0.034	0.003	0.042	11.434	0.000	1.593
	Garden orientation other	-0.007	0.004	-0.009	-1.763	0.078	3.102
	Garden orientation south	0.006	0.004	0.007	1.376	0.169	3.037
	Gas/coal heating	-0.124	0.013	-0.035	-9.723	0.000	1.518
	Boiler, block, district heating, master fireplace, hot air	0.000	0.007	0.000	-0.020	0.984	1.669
	AC or solarpanels	0.010	0.044	0.001	0.234	0.815	1.034
	Somewhat insulated	0.050	0.003	0.058	16.415	0.000	1.463
	Well insulated	0.067	0.004	0.085	18.051	0.000	2.559
	Basement	0.041	0.005	0.030	7.858	0.000	1.710
	Monumental status	0.018	0.016	0.003	1.118	0.263	1.111
	Sold in 2016	-0.158	0.003	-0.196	-56.222	0.000	1.402

	Sold in 2017	-0.071	0.003	-0.088	-25.279	0.000	1.396
	PC_3811	0.621	0.018	0.114	34.922	0.000	1.240
	PC_3812	0.343	0.012	0.109	29.084	0.000	1.635
	PC_3813	0.284	0.010	0.095	27.103	0.000	1.407
	PC_3814	0.333	0.016	0.068	20.854	0.000	1.235
	PC_3815	0.254	0.014	0.063	18.277	0.000	1.353
	PC_3816	0.333	0.014	0.076	23.160	0.000	1.244
	PC_3817	0.563	0.011	0.207	52.158	0.000	1.813
	PC_3818	0.587	0.012	0.177	48.633	0.000	1.521
	PC_3819	-0.273	0.065	-0.012	-4.180	0.000	1.024
	PC_3821	0.092	0.084	0.003	1.096	0.273	1.010
	PC_3822	0.232	0.011	0.069	20.478	0.000	1.301
	PC_3823	0.237	0.009	0.097	26.186	0.000	1.572
	PC_3824	0.196	0.008	0.091	23.449	0.000	1.748
	PC_3825	0.209	0.010	0.088	20.206	0.000	2.186
	PC_3826	0.241	0.012	0.084	20.822	0.000	1.868
	PC_5011	-0.085	0.013	-0.023	-6.614	0.000	1.397
	PC_5012	-0.033	0.016	-0.007	-2.040	0.041	1.209
	PC_5013	-0.127	0.033	-0.012	-3.833	0.000	1.057
	PC_5014	-0.016	0.011	-0.006	-1.462	0.144	1.780
	PC_5015	0.084	0.027	0.010	3.135	0.002	1.076
	PC_5017	0.214	0.015	0.048	14.366	0.000	1.282
	PC_5018	0.242	0.019	0.042	12.988	0.000	1.196
	PC_5021	0.019	0.011	0.007	1.749	0.080	1.738
	PC_5022	-0.036	0.014	-0.009	-2.625	0.009	1.292
	PC_5025	-0.016	0.011	-0.006	-1.439	0.150	1.801
	PC_5026	0.264	0.145	0.005	1.827	0.068	1.005
	PC_5032	0.194	0.011	0.059	17.241	0.000	1.355
	PC_5035	0.001	0.010	0.000	0.060	0.952	1.370
	PC_5036	0.085	0.012	0.028	7.281	0.000	1.731
	PC_5037	0.229	0.012	0.067	18.756	0.000	1.463
	PC_5038	0.140	0.013	0.038	10.780	0.000	1.420
	PC_5041	0.019	0.012	0.006	1.614	0.107	1.541
	PC_5042	-0.042	0.012	-0.012	-3.473	0.001	1.489
	PC_5043	-0.050	0.010	-0.017	-4.983	0.000	1.404
	PC_5044	-0.012	0.016	-0.002	-0.718	0.473	1.228
	PC_5046	-0.031	0.011	-0.011	-2.948	0.003	1.682
	PC_5047	-0.138	0.102	-0.004	-1.343	0.179	1.009
	PC_5049	-0.073	0.016	-0.015	-4.556	0.000	1.193
	PC_5211	0.752	0.016	0.158	47.008	0.000	1.309
	PC_5212	0.579	0.013	0.156	43.547	0.000	1.480
	PC_5213	0.288	0.014	0.068	19.881	0.000	1.351
	PC_5215	0.269	0.018	0.049	15.356	0.000	1.188
	PC_5216	0.489	0.016	0.099	30.256	0.000	1.247
	PC_5221	0.152	0.012	0.042	12.383	0.000	1.340
	PC_5222	0.027	0.145	0.001	0.187	0.852	1.005
	PC_5223	0.212	0.017	0.040	12.603	0.000	1.188

	PC_5224	0.040	0.012	0.012	3.346	0.001	1.493
	PC_5231	0.124	0.013	0.032	9.422	0.000	1.369
	PC_5232	0.430	0.041	0.032	10.555	0.000	1.039
	PC_5233	0.133	0.012	0.040	11.201	0.000	1.487
	PC_5234	0.150	0.084	0.005	1.798	0.072	1.007
	PC_5235	0.142	0.012	0.041	12.191	0.000	1.310
	PC_5236	0.187	0.012	0.054	15.769	0.000	1.335
	PC_5237	0.145	0.010	0.052	14.738	0.000	1.458
	PC_6511	0.544	0.040	0.041	13.633	0.000	1.070
	PC_6512	0.460	0.023	0.062	19.639	0.000	1.160
	PC_6521	0.533	0.018	0.098	29.638	0.000	1.256
	PC_6522	0.493	0.021	0.074	23.565	0.000	1.133
	PC_6523	0.432	0.018	0.080	24.627	0.000	1.224
	PC_6524	0.565	0.018	0.104	31.445	0.000	1.269
	PC_6525	0.304	0.014	0.074	21.712	0.000	1.327
	PC_6531	0.353	0.013	0.096	26.912	0.000	1.481
	PC_6532	0.192	0.015	0.044	13.032	0.000	1.297
	PC_6533	0.153	0.011	0.051	13.571	0.000	1.625
	PC_6534	0.124	0.021	0.019	5.943	0.000	1.120
	PC_6535	-0.056	0.015	-0.013	-3.820	0.000	1.330
	PC_6536	0.019	0.014	0.004	1.305	0.192	1.340
	PC_6537	-0.151	0.013	-0.039	-11.252	0.000	1.387
	PC_6538	-0.118	0.013	-0.033	-9.214	0.000	1.462
	PC_6541	0.243	0.017	0.046	14.282	0.000	1.188
	PC_6542	0.190	0.015	0.043	12.579	0.000	1.336
	PC_6543	0.175	0.015	0.039	11.783	0.000	1.282
	PC_6544	-0.061	0.016	-0.013	-3.868	0.000	1.228
	PC_6545	-0.096	0.013	-0.025	-7.344	0.000	1.335
	PC_6546	-0.138	0.010	-0.048	-13.662	0.000	1.446
	PC_9711	0.435	0.021	0.066	20.519	0.000	1.184
	PC_9712	0.474	0.020	0.077	23.166	0.000	1.262
	PC_9713	0.236	0.015	0.055	15.885	0.000	1.382
	PC_9714	0.341	0.027	0.039	12.630	0.000	1.083
	PC_9715	0.141	0.021	0.022	6.854	0.000	1.139
	PC_9716	0.138	0.035	0.012	3.969	0.000	1.048
	PC_9717	0.426	0.015	0.097	27.971	0.000	1.387
	PC_9718	0.374	0.016	0.079	23.413	0.000	1.327
	PC_9721	0.211	0.013	0.053	15.893	0.000	1.306
	PC_9722	0.314	0.014	0.077	22.967	0.000	1.300
	PC_9723	0.027	0.018	0.005	1.489	0.136	1.139
	PC_9724	0.402	0.015	0.091	26.118	0.000	1.399
	PC_9725	0.353	0.024	0.046	14.685	0.000	1.136
	PC_9726	0.341	0.030	0.034	11.200	0.000	1.070
	PC_9727	0.164	0.019	0.027	8.728	0.000	1.096
	PC_9728	0.178	0.011	0.053	15.517	0.000	1.322
	PC_9731	0.005	0.011	0.001	0.435	0.664	1.367
	PC_9732	-0.121	0.014	-0.029	-8.719	0.000	1.318

	PC_9733	-0.092	0.019	-0.016	-4.884	0.000	1.164
	PC_9734	0.015	0.014	0.004	1.100	0.271	1.179
	PC_9735	0.036	0.046	0.002	0.791	0.429	1.017
	PC_9736	-0.231	0.015	-0.048	-14.954	0.000	1.172
	PC_9737	-0.162	0.012	-0.048	-13.893	0.000	1.356
	PC_9738	-0.221	0.055	-0.012	-4.015	0.000	1.019
	PC_9741	0.059	0.018	0.010	3.296	0.001	1.168
	PC_9742	0.040	0.016	0.008	2.527	0.011	1.237
	PC_9743	-0.082	0.013	-0.022	-6.397	0.000	1.403
	PC_9744	-0.085	0.012	-0.026	-7.406	0.000	1.472
	PC_9745	-0.122	0.016	-0.024	-7.470	0.000	1.146
	PC_9746	-0.017	0.011	-0.005	-1.503	0.133	1.468

Appendix 5: Regression model backward with m²

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
19	Regression	2064.652	121	17.063	821.044	.000
	Residual	335.199	16129	0.021		
	Total	2399.851	16250			

Coefficients[a]							
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity
		B	Std. Error	Beta			VIF
19	(Constant)	8.904	0.034		264.111	0.000	
	Building angle	0.001	0.000	0.027	2.340	0.019	15.840
	No hirise	0.029	0.013	0.026	2.228	0.026	15.676
	Built between 1500 and 1930	-0.099	0.007	-0.092	-14.294	0.000	4.784
	Built between 1931 and 1959	-0.095	0.007	-0.089	-13.995	0.000	4.662
	Built between 1960 and 1980	-0.164	0.006	-0.183	-26.447	0.000	5.501
	Built between 1981 and 2000	-0.077	0.005	-0.095	-14.179	0.000	5.133
	Ln plotsize	0.154	0.004	0.214	41.924	0.000	2.997
	Ln m2	0.530	0.007	0.360	74.458	0.000	2.703
	Semi detached house	0.081	0.006	0.040	12.431	0.000	1.168
	Corner house	0.010	0.003	0.010	3.155	0.002	1.197
	Half of a double house	0.097	0.004	0.087	23.078	0.000	1.646
	Detached	0.185	0.007	0.107	26.958	0.000	1.819
	nStories	0.013	0.003	0.020	4.785	0.000	1.923
	nRooms	0.014	0.001	0.042	10.019	0.000	2.074
	Attic (zolder)	-0.021	0.003	-0.024	-7.196	0.000	1.254
	Balcony	0.032	0.004	0.026	8.189	0.000	1.178
	Dormer	0.028	0.003	0.030	9.606	0.000	1.129
	Rooftop terrace	0.024	0.004	0.019	6.054	0.000	1.129
	nKitchens	0.016	0.004	0.011	3.651	0.000	1.129
	nBathrooms	0.019	0.002	0.025	7.850	0.000	1.158
	Own parkingspace	0.034	0.003	0.043	11.471	0.000	1.587
	Garden orientation other	-0.012	0.002	-0.015	-5.055	0.000	1.057
	Gas/coal heating	-0.124	0.011	-0.035	-11.619	0.000	1.058
	Somewhat insulated	0.050	0.003	0.059	16.760	0.000	1.426
	Well insulated	0.066	0.004	0.085	18.276	0.000	2.474
	Basement	0.040	0.005	0.030	7.723	0.000	1.699
	Sold in 2016	-0.158	0.003	-0.196	-56.242	0.000	1.400
	Sold in 2017	-0.071	0.003	-0.088	-25.260	0.000	1.394
	PC_3811	0.610	0.017	0.113	36.536	0.000	1.095
	PC_3812	0.331	0.010	0.106	32.672	0.000	1.208
	PC_3813	0.276	0.009	0.092	29.521	0.000	1.123
	PC_3814	0.323	0.015	0.066	21.644	0.000	1.075
	PC_3815	0.245	0.013	0.060	19.282	0.000	1.130
	PC_3816	0.324	0.013	0.074	24.237	0.000	1.073

	PC_3817	0.552	0.009	0.203	60.867	0.000	1.280
	PC_3818	0.578	0.011	0.174	54.036	0.000	1.193
	PC_3819	-0.283	0.065	-0.013	-4.348	0.000	1.017
	PC_3822	0.226	0.011	0.067	21.504	0.000	1.116
	PC_3823	0.231	0.008	0.094	28.884	0.000	1.222
	PC_3824	0.189	0.007	0.088	26.454	0.000	1.282
	PC_3825	0.201	0.009	0.084	22.616	0.000	1.605
	PC_3826	0.232	0.010	0.081	22.718	0.000	1.454
	PC_5011	-0.094	0.012	-0.025	-8.108	0.000	1.133
	PC_5012	-0.041	0.015	-0.008	-2.724	0.006	1.071
	PC_5013	-0.139	0.033	-0.013	-4.283	0.000	1.019
	PC_5014	-0.027	0.009	-0.010	-2.927	0.003	1.260
	PC_5015	0.074	0.026	0.008	2.800	0.005	1.028
	PC_5017	0.203	0.014	0.045	14.798	0.000	1.090
	PC_5018	0.231	0.018	0.040	13.121	0.000	1.066
	PC_5022	-0.046	0.013	-0.011	-3.634	0.000	1.080
	PC_5025	-0.027	0.009	-0.010	-2.956	0.003	1.260
	PC_5026	0.254	0.144	0.005	1.762	0.078	1.003
	PC_5032	0.187	0.010	0.057	18.240	0.000	1.121
	PC_5036	0.076	0.010	0.025	7.365	0.000	1.375
	PC_5037	0.219	0.011	0.064	20.278	0.000	1.146
	PC_5038	0.129	0.012	0.035	11.115	0.000	1.137
	PC_5042	-0.052	0.011	-0.015	-4.850	0.000	1.151
	PC_5043	-0.056	0.009	-0.020	-6.182	0.000	1.158
	PC_5046	-0.041	0.009	-0.015	-4.646	0.000	1.195
	PC_5049	-0.081	0.015	-0.016	-5.376	0.000	1.066
	PC_5211	0.742	0.015	0.156	50.248	0.000	1.117
	PC_5212	0.567	0.012	0.153	48.006	0.000	1.170
	PC_5213	0.276	0.013	0.065	20.977	0.000	1.119
	PC_5215	0.260	0.017	0.048	15.684	0.000	1.063
	PC_5216	0.479	0.015	0.097	31.829	0.000	1.082
	PC_5221	0.144	0.011	0.040	12.797	0.000	1.123
	PC_5223	0.202	0.016	0.039	12.763	0.000	1.055
	PC_5224	0.032	0.011	0.009	2.954	0.003	1.174
	PC_5231	0.115	0.012	0.030	9.642	0.000	1.123
	PC_5232	0.423	0.040	0.031	10.475	0.000	1.019
	PC_5233	0.125	0.011	0.038	11.849	0.000	1.164
	PC_5234	0.144	0.083	0.005	1.729	0.084	1.004
	PC_5235	0.135	0.011	0.039	12.630	0.000	1.101
	PC_5236	0.179	0.011	0.051	16.550	0.000	1.112
	PC_5237	0.139	0.009	0.050	15.658	0.000	1.183
	PC_6511	0.531	0.039	0.041	13.496	0.000	1.043
	PC_6512	0.451	0.023	0.061	19.914	0.000	1.084
	PC_6521	0.523	0.017	0.096	30.743	0.000	1.123
	PC_6522	0.484	0.020	0.072	23.953	0.000	1.057
	PC_6523	0.422	0.017	0.078	25.417	0.000	1.095
	PC_6524	0.554	0.017	0.102	32.620	0.000	1.134

	PC_6525	0.295	0.013	0.071	22.802	0.000	1.132
	PC_6531	0.343	0.012	0.094	29.049	0.000	1.202
	PC_6532	0.183	0.014	0.042	13.367	0.000	1.113
	PC_6533	0.143	0.010	0.048	14.597	0.000	1.227
	PC_6534	0.115	0.020	0.017	5.733	0.000	1.045
	PC_6535	-0.064	0.013	-0.015	-4.780	0.000	1.127
	PC_6537	-0.160	0.012	-0.041	-13.075	0.000	1.146
	PC_6538	-0.127	0.011	-0.035	-11.039	0.000	1.173
	PC_6541	0.233	0.016	0.044	14.529	0.000	1.059
	PC_6542	0.179	0.014	0.040	12.883	0.000	1.140
	PC_6543	0.166	0.014	0.037	12.038	0.000	1.106
	PC_6544	-0.069	0.015	-0.014	-4.687	0.000	1.081
	PC_6545	-0.105	0.012	-0.027	-8.764	0.000	1.112
	PC_6546	-0.145	0.009	-0.051	-15.876	0.000	1.178
	PC_9711	0.423	0.020	0.064	20.826	0.000	1.089
	PC_9712	0.463	0.019	0.075	23.987	0.000	1.124
	PC_9713	0.227	0.014	0.053	16.783	0.000	1.143
	PC_9714	0.330	0.026	0.037	12.555	0.000	1.029
	PC_9715	0.131	0.020	0.020	6.618	0.000	1.057
	PC_9716	0.129	0.034	0.011	3.759	0.000	1.019
	PC_9717	0.415	0.014	0.094	29.591	0.000	1.174
	PC_9718	0.363	0.015	0.077	24.543	0.000	1.137
	PC_9721	0.203	0.012	0.051	16.657	0.000	1.096
	PC_9722	0.305	0.013	0.075	24.331	0.000	1.092
	PC_9724	0.390	0.014	0.088	27.629	0.000	1.179
	PC_9725	0.346	0.023	0.045	14.984	0.000	1.047
	PC_9726	0.330	0.030	0.033	11.048	0.000	1.030
	PC_9727	0.157	0.018	0.026	8.634	0.000	1.035
	PC_9728	0.171	0.011	0.050	16.271	0.000	1.105
	PC_9732	-0.129	0.013	-0.031	-10.137	0.000	1.107
	PC_9733	-0.100	0.018	-0.017	-5.576	0.000	1.060
	PC_9736	-0.237	0.015	-0.049	-16.087	0.000	1.072
	PC_9737	-0.169	0.011	-0.050	-15.983	0.000	1.122
	PC_9738	-0.230	0.055	-0.012	-4.195	0.000	1.010
	PC_9741	0.050	0.017	0.009	2.932	0.003	1.054
	PC_9742	0.032	0.015	0.006	2.104	0.035	1.085
	PC_9743	-0.091	0.012	-0.025	-7.860	0.000	1.138
	PC_9744	-0.094	0.010	-0.029	-9.232	0.000	1.152
	PC_9745	-0.130	0.016	-0.025	-8.335	0.000	1.048
	PC_9746	-0.025	0.010	-0.008	-2.406	0.016	1.199

Appendix 6: Maximized building angles and m² backward

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
19	Regression	2064.766	121	17.064	821.368	.000[t]
	Residual	335.085	16129	0.021		
	Total	2399.851	16250			

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
19	(Constant)	8.908	0.032		277.085	0.000
	Max building angle	0.001	0.000	0.025	3.311	0.001
	No hirise	0.024	0.008	0.022	2.949	0.003
	Built between 1500 and 1930	-0.099	0.007	-0.092	-14.349	0.000
	Built between 1931 and 1959	-0.095	0.007	-0.089	-14.018	0.000
	Built between 1960 and 1980	-0.164	0.006	-0.183	-26.471	0.000
	Built between 1981 and 2000	-0.078	0.005	-0.095	-14.214	0.000
	Ln plotsize	0.154	0.004	0.214	41.997	0.000
	Ln m2	0.530	0.007	0.360	74.426	0.000
	Semi detached house	0.081	0.006	0.040	12.433	0.000
	Corner house	0.010	0.003	0.010	3.125	0.002
	Half of a double house	0.097	0.004	0.087	23.095	0.000
	Detached	0.185	0.007	0.107	26.914	0.000
	nStories	0.013	0.003	0.019	4.685	0.000
	nRooms	0.014	0.001	0.043	10.053	0.000
	Attic (zolder)	-0.021	0.003	-0.024	-7.165	0.000
	Balcony	0.032	0.004	0.026	8.151	0.000
	Dormer	0.028	0.003	0.030	9.612	0.000
	Rooftop terrace	0.023	0.004	0.019	6.009	0.000
	nKitchens	0.016	0.004	0.012	3.704	0.000
	nBathrooms	0.019	0.002	0.025	7.869	0.000
	Own parkingspace	0.034	0.003	0.042	11.414	0.000
	Garden orientation other	-0.012	0.002	-0.015	-5.020	0.000
	Gas/coal heating	-0.124	0.011	-0.035	-11.622	0.000
	Somewhat insulated	0.051	0.003	0.059	16.780	0.000
	Well insulated	0.066	0.004	0.085	18.295	0.000
	Basement	0.039	0.005	0.029	7.659	0.000
	Sold in 2016	-0.158	0.003	-0.196	-56.271	0.000
	Sold in 2017	-0.071	0.003	-0.088	-25.265	0.000
	PC_3811	0.608	0.017	0.112	36.409	0.000
	PC_3812	0.331	0.010	0.106	32.659	0.000
	PC_3813	0.276	0.009	0.092	29.522	0.000
	PC_3814	0.324	0.015	0.066	21.701	0.000
	PC_3815	0.245	0.013	0.060	19.276	0.000
	PC_3816	0.324	0.013	0.074	24.256	0.000

	PC_3817	0.552	0.009	0.203	60.875	0.000
	PC_3818	0.578	0.011	0.174	54.063	0.000
	PC_3819	-0.283	0.065	-0.013	-4.357	0.000
	PC_3822	0.226	0.011	0.067	21.522	0.000
	PC_3823	0.231	0.008	0.094	28.900	0.000
	PC_3824	0.189	0.007	0.088	26.483	0.000
	PC_3825	0.201	0.009	0.084	22.634	0.000
	PC_3826	0.227	0.010	0.079	22.033	0.000
	PC_5011	-0.093	0.012	-0.025	-8.054	0.000
	PC_5012	-0.041	0.015	-0.008	-2.706	0.007
	PC_5013	-0.142	0.033	-0.013	-4.352	0.000
	PC_5014	-0.028	0.009	-0.010	-2.979	0.003
	PC_5015	0.073	0.026	0.008	2.794	0.005
	PC_5017	0.203	0.014	0.045	14.754	0.000
	PC_5018	0.231	0.018	0.040	13.153	0.000
	PC_5022	-0.046	0.013	-0.011	-3.610	0.000
	PC_5025	-0.027	0.009	-0.010	-2.942	0.003
	PC_5026	0.254	0.144	0.005	1.758	0.079
	PC_5032	0.187	0.010	0.057	18.229	0.000
	PC_5036	0.076	0.010	0.025	7.344	0.000
	PC_5037	0.219	0.011	0.064	20.298	0.000
	PC_5038	0.130	0.012	0.035	11.156	0.000
	PC_5042	-0.051	0.011	-0.015	-4.787	0.000
	PC_5043	-0.056	0.009	-0.020	-6.189	0.000
	PC_5046	-0.041	0.009	-0.015	-4.652	0.000
	PC_5049	-0.082	0.015	-0.016	-5.389	0.000
	PC_5211	0.740	0.015	0.156	50.055	0.000
	PC_5212	0.567	0.012	0.153	47.921	0.000
	PC_5213	0.277	0.013	0.065	21.011	0.000
	PC_5215	0.260	0.017	0.048	15.716	0.000
	PC_5216	0.479	0.015	0.098	31.863	0.000
	PC_5221	0.143	0.011	0.039	12.657	0.000
	PC_5223	0.202	0.016	0.039	12.781	0.000
	PC_5224	0.032	0.011	0.010	3.013	0.003
	PC_5231	0.114	0.012	0.030	9.631	0.000
	PC_5232	0.422	0.040	0.031	10.464	0.000
	PC_5233	0.125	0.011	0.038	11.839	0.000
	PC_5234	0.144	0.083	0.005	1.732	0.083
	PC_5235	0.135	0.011	0.039	12.621	0.000
	PC_5236	0.180	0.011	0.051	16.562	0.000
	PC_5237	0.139	0.009	0.050	15.666	0.000
	PC_6511	0.523	0.039	0.040	13.248	0.000
	PC_6512	0.452	0.023	0.061	19.955	0.000
	PC_6521	0.523	0.017	0.096	30.747	0.000
	PC_6522	0.484	0.020	0.072	23.963	0.000
	PC_6523	0.421	0.017	0.078	25.385	0.000
	PC_6524	0.555	0.017	0.102	32.637	0.000

	PC_6525	0.295	0.013	0.071	22.827	0.000
	PC_6531	0.344	0.012	0.094	29.085	0.000
	PC_6532	0.183	0.014	0.042	13.371	0.000
	PC_6533	0.143	0.010	0.048	14.628	0.000
	PC_6534	0.115	0.020	0.017	5.731	0.000
	PC_6535	-0.065	0.013	-0.015	-4.790	0.000
	PC_6537	-0.160	0.012	-0.041	-13.065	0.000
	PC_6538	-0.127	0.011	-0.035	-11.062	0.000
	PC_6541	0.233	0.016	0.044	14.547	0.000
	PC_6542	0.180	0.014	0.041	12.918	0.000
	PC_6543	0.166	0.014	0.037	12.023	0.000
	PC_6544	-0.069	0.015	-0.014	-4.682	0.000
	PC_6545	-0.105	0.012	-0.027	-8.785	0.000
	PC_6546	-0.145	0.009	-0.051	-15.885	0.000
	PC_9711	0.418	0.020	0.063	20.485	0.000
	PC_9712	0.459	0.019	0.074	23.715	0.000
	PC_9713	0.227	0.014	0.053	16.799	0.000
	PC_9714	0.330	0.026	0.038	12.563	0.000
	PC_9715	0.131	0.020	0.020	6.617	0.000
	PC_9716	0.129	0.034	0.011	3.751	0.000
	PC_9717	0.415	0.014	0.094	29.606	0.000
	PC_9718	0.361	0.015	0.077	24.450	0.000
	PC_9721	0.204	0.012	0.052	16.793	0.000
	PC_9722	0.305	0.013	0.075	24.360	0.000
	PC_9724	0.390	0.014	0.088	27.647	0.000
	PC_9725	0.346	0.023	0.045	14.984	0.000
	PC_9726	0.331	0.030	0.033	11.069	0.000
	PC_9727	0.157	0.018	0.026	8.624	0.000
	PC_9728	0.171	0.011	0.050	16.320	0.000
	PC_9732	-0.129	0.013	-0.031	-10.139	0.000
	PC_9733	-0.100	0.018	-0.017	-5.582	0.000
	PC_9736	-0.237	0.015	-0.049	-16.091	0.000
	PC_9737	-0.170	0.011	-0.050	-15.994	0.000
	PC_9738	-0.230	0.055	-0.012	-4.202	0.000
	PC_9741	0.050	0.017	0.009	2.946	0.003
	PC_9742	0.033	0.015	0.007	2.191	0.028
	PC_9743	-0.091	0.012	-0.025	-7.848	0.000
	PC_9744	-0.094	0.010	-0.029	-9.237	0.000
	PC_9745	-0.130	0.016	-0.025	-8.336	0.000
	PC_9746	-0.025	0.010	-0.008	-2.419	0.016

Appendix 7: Number of high-rise on the price

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2067.440	138	14.981	726.151	.000
	Residual	332.412	16112	.021		
	Total	2399.851	16250			

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.920	0.033		272.248	0.000
	Frequency of high-rise	0.008	0.004	0.007	2.104	0.035
	Built between 1500 and 1930	-0.101	0.007	-0.094	-14.362	0.000
	Built between 1931 and 1959	-0.097	0.007	-0.091	-14.032	0.000
	Built between 1960 and 1980	-0.164	0.006	-0.182	-26.123	0.000
	Built between 1981 and 2000	-0.075	0.006	-0.092	-13.399	0.000
	Ln plotsize	0.154	0.004	0.214	41.594	0.000
	Ln m2	0.530	0.007	0.360	74.007	0.000
	Semi detached house	0.081	0.007	0.040	12.463	0.000
	Corner house	0.010	0.003	0.010	3.216	0.001
	Half of a double house	0.097	0.004	0.087	23.077	0.000
	Detached	0.187	0.007	0.108	26.388	0.000
	nStories	0.013	0.003	0.019	4.535	0.000
	nRooms	0.014	0.001	0.043	10.052	0.000
	Attic (zolder)	-0.021	0.003	-0.024	-7.115	0.000
	Loft (vliering)	-0.005	0.005	-0.003	-1.000	0.318
	Balcony	0.032	0.004	0.026	8.200	0.000
	Dormer	0.028	0.003	0.030	9.574	0.000
	Rooftop terrace	0.024	0.004	0.019	6.055	0.000
	nKitchens	0.015	0.004	0.011	3.463	0.001
	Pantry	0.000	0.003	0.000	0.085	0.933
	nBathrooms	0.019	0.002	0.025	7.749	0.000
	Own parkingspace	0.034	0.003	0.042	11.365	0.000
	Garden orientation other	-0.007	0.004	-0.009	-1.722	0.085
	Garden orientation south	0.006	0.004	0.007	1.403	0.161
	Gas/coal heating	-0.124	0.013	-0.035	-9.745	0.000
	Boiler, block, district heating, master fireplace, hot air	0.000	0.007	0.000	-0.018	0.986
	AC or solarpanels	0.011	0.044	0.001	0.246	0.806
	Somewhat insulated	0.050	0.003	0.058	16.434	0.000
	Well insulated	0.067	0.004	0.085	18.052	0.000
	Basement	0.040	0.005	0.030	7.820	0.000
	Monumental status	0.019	0.016	0.004	1.161	0.245
	Sold in 2016	-0.158	0.003	-0.196	-56.202	0.000

	Sold in 2017	-0.071	0.003	-0.088	-25.284	0.000
	PC_3811	0.619	0.018	0.114	35.070	0.000
	PC_3812	0.342	0.012	0.109	29.040	0.000
	PC_3813	0.284	0.010	0.095	27.131	0.000
	PC_3814	0.333	0.016	0.068	20.848	0.000
	PC_3815	0.254	0.014	0.063	18.276	0.000
	PC_3816	0.333	0.014	0.076	23.196	0.000
	PC_3817	0.563	0.011	0.207	52.222	0.000
	PC_3818	0.587	0.012	0.176	48.604	0.000
	PC_3819	-0.273	0.065	-0.012	-4.183	0.000
	PC_3821	0.092	0.084	0.003	1.096	0.273
	PC_3822	0.231	0.011	0.068	20.390	0.000
	PC_3823	0.237	0.009	0.097	26.161	0.000
	PC_3824	0.196	0.008	0.091	23.459	0.000
	PC_3825	0.209	0.010	0.088	20.197	0.000
	PC_3826	0.237	0.012	0.082	20.294	0.000
	PC_5011	-0.085	0.013	-0.023	-6.636	0.000
	PC_5012	-0.032	0.016	-0.007	-2.014	0.044
	PC_5013	-0.129	0.033	-0.012	-3.903	0.000
	PC_5014	-0.017	0.011	-0.006	-1.559	0.119
	PC_5015	0.085	0.027	0.010	3.145	0.002
	PC_5017	0.214	0.015	0.048	14.419	0.000
	PC_5018	0.242	0.019	0.042	13.002	0.000
	PC_5021	0.019	0.011	0.007	1.707	0.088
	PC_5022	-0.036	0.014	-0.009	-2.620	0.009
	PC_5025	-0.016	0.011	-0.006	-1.492	0.136
	PC_5026	0.264	0.145	0.005	1.827	0.068
	PC_5032	0.194	0.011	0.059	17.247	0.000
	PC_5035	0.001	0.010	0.000	0.091	0.927
	PC_5036	0.085	0.012	0.028	7.298	0.000
	PC_5037	0.229	0.012	0.067	18.792	0.000
	PC_5038	0.140	0.013	0.038	10.816	0.000
	PC_5041	0.019	0.012	0.006	1.577	0.115
	PC_5042	-0.042	0.012	-0.013	-3.519	0.000
	PC_5043	-0.050	0.010	-0.017	-4.966	0.000
	PC_5044	-0.012	0.016	-0.002	-0.724	0.469
	PC_5046	-0.031	0.011	-0.011	-2.940	0.003
	PC_5047	-0.142	0.102	-0.004	-1.387	0.166
	PC_5049	-0.074	0.016	-0.015	-4.590	0.000
	PC_5211	0.747	0.016	0.157	46.449	0.000
	PC_5212	0.579	0.013	0.156	43.625	0.000
	PC_5213	0.287	0.014	0.068	19.839	0.000
	PC_5215	0.268	0.017	0.049	15.335	0.000
	PC_5216	0.488	0.016	0.099	30.281	0.000
	PC_5221	0.151	0.012	0.042	12.305	0.000
	PC_5222	0.027	0.145	0.001	0.190	0.850
	PC_5223	0.210	0.017	0.040	12.525	0.000

	PC_5224	0.040	0.012	0.012	3.355	0.001
	PC_5231	0.123	0.013	0.032	9.398	0.000
	PC_5232	0.431	0.041	0.032	10.562	0.000
	PC_5233	0.133	0.012	0.040	11.191	0.000
	PC_5234	0.150	0.084	0.005	1.799	0.072
	PC_5235	0.142	0.012	0.041	12.190	0.000
	PC_5236	0.187	0.012	0.054	15.753	0.000
	PC_5237	0.145	0.010	0.052	14.738	0.000
	PC_6511	0.544	0.040	0.042	13.687	0.000
	PC_6512	0.460	0.023	0.062	19.637	0.000
	PC_6521	0.533	0.018	0.098	29.628	0.000
	PC_6522	0.491	0.021	0.074	23.511	0.000
	PC_6523	0.432	0.018	0.080	24.587	0.000
	PC_6524	0.566	0.018	0.104	31.462	0.000
	PC_6525	0.303	0.014	0.073	21.667	0.000
	PC_6531	0.353	0.013	0.096	26.907	0.000
	PC_6532	0.192	0.015	0.044	13.023	0.000
	PC_6533	0.153	0.011	0.051	13.565	0.000
	PC_6534	0.124	0.021	0.019	5.948	0.000
	PC_6535	-0.056	0.015	-0.013	-3.837	0.000
	PC_6536	0.019	0.014	0.004	1.320	0.187
	PC_6537	-0.151	0.013	-0.039	-11.228	0.000
	PC_6538	-0.118	0.013	-0.033	-9.218	0.000
	PC_6541	0.242	0.017	0.046	14.234	0.000
	PC_6542	0.190	0.015	0.043	12.570	0.000
	PC_6543	0.174	0.015	0.039	11.746	0.000
	PC_6544	-0.061	0.016	-0.013	-3.878	0.000
	PC_6545	-0.096	0.013	-0.025	-7.339	0.000
	PC_6546	-0.138	0.010	-0.048	-13.665	0.000
	PC_9711	0.433	0.021	0.065	20.556	0.000
	PC_9712	0.472	0.020	0.076	23.269	0.000
	PC_9713	0.236	0.015	0.055	15.881	0.000
	PC_9714	0.341	0.027	0.039	12.636	0.000
	PC_9715	0.142	0.021	0.022	6.885	0.000
	PC_9716	0.139	0.035	0.012	3.988	0.000
	PC_9717	0.427	0.015	0.097	28.020	0.000
	PC_9718	0.374	0.016	0.079	23.633	0.000
	PC_9721	0.213	0.013	0.054	16.063	0.000
	PC_9722	0.314	0.014	0.077	23.005	0.000
	PC_9723	0.028	0.018	0.005	1.564	0.118
	PC_9724	0.402	0.015	0.091	26.162	0.000
	PC_9725	0.353	0.024	0.046	14.696	0.000
	PC_9726	0.339	0.030	0.034	11.146	0.000
	PC_9727	0.163	0.019	0.027	8.696	0.000
	PC_9728	0.177	0.011	0.052	15.468	0.000
	PC_9731	0.005	0.011	0.002	0.447	0.655
	PC_9732	-0.121	0.014	-0.029	-8.695	0.000

	PC_9733	-0.092	0.019	-0.016	-4.892	0.000
	PC_9734	0.016	0.014	0.004	1.113	0.266
	PC_9735	0.037	0.046	0.002	0.799	0.424
	PC_9736	-0.231	0.015	-0.048	-14.945	0.000
	PC_9737	-0.162	0.012	-0.048	-13.886	0.000
	PC_9738	-0.222	0.055	-0.012	-4.029	0.000
	PC_9741	0.058	0.018	0.010	3.243	0.001
	PC_9742	0.043	0.016	0.009	2.721	0.007
	PC_9743	-0.082	0.013	-0.022	-6.369	0.000
	PC_9744	-0.085	0.012	-0.026	-7.417	0.000
	PC_9745	-0.123	0.016	-0.024	-7.510	0.000
	PC_9746	-0.017	0.011	-0.005	-1.490	0.136

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