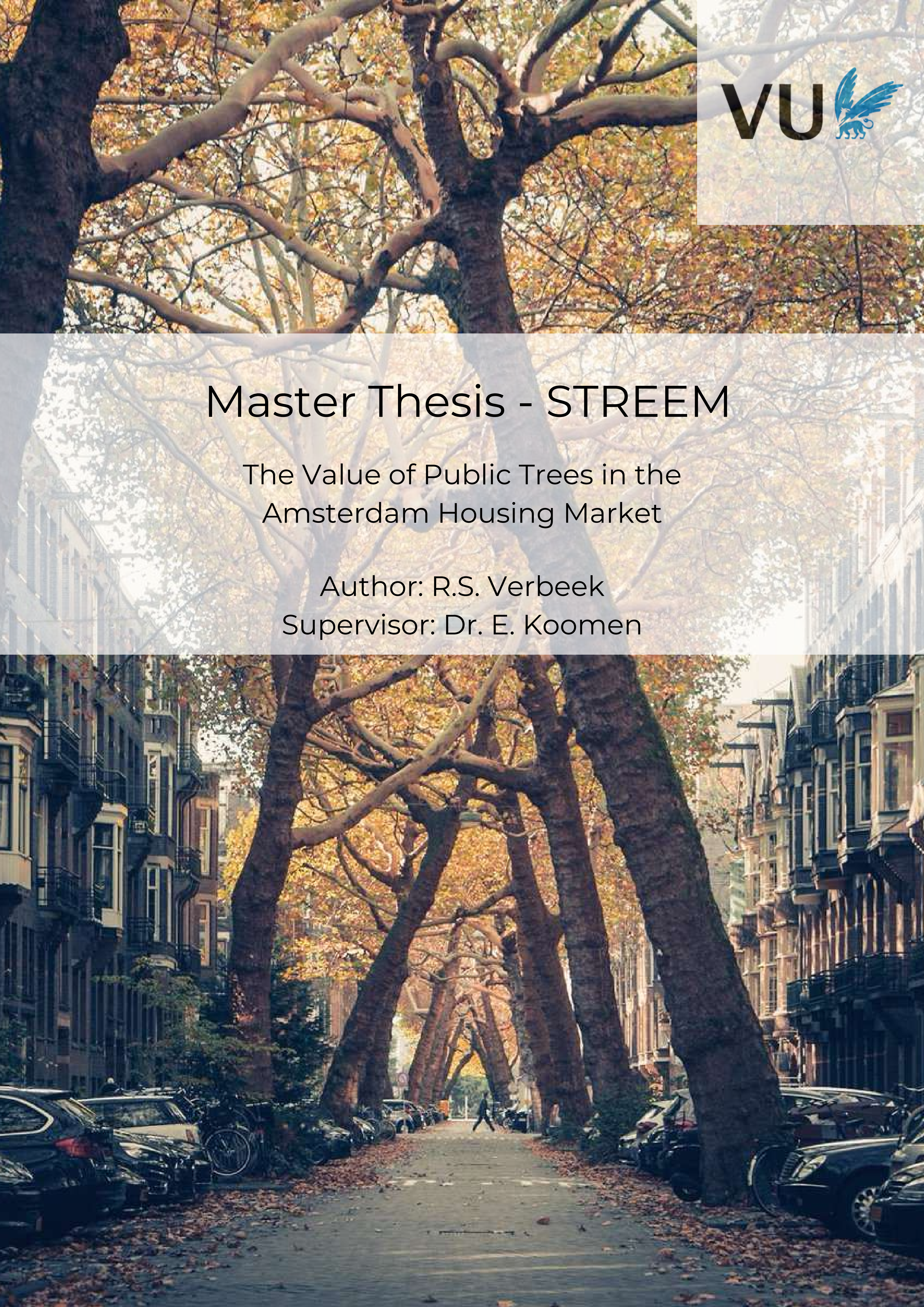

Master Thesis - STREEM

The Value of Public Trees in the Amsterdam Housing Market

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Abstract

This study examines the effect of public trees on both the sales price as well as the time-on-the-market for residential properties within the municipality of Amsterdam. A rich dataset ranging from 2005 up to 2020, covering transactions characteristics, housing characteristics, spatial variables as well as the number of public trees within a specific radius of the transacted house has been constructed. Given non-linearity issues regarding the number of public trees as variable, this measure can be considered as unsuitable. Therefore, a dummy variable has been constructed which equals unity in case a public tree is present within a specific radius. Based on a basic OLS regression including several type of control variables and fixed effects, there appears to be a strong and positive effect between the presence of public trees and the sales price. There also appears to be a statistically strong and negative effect between the presence of public trees and time-on-the-market. Given possible endogeneity issues regarding the OLS regression, an IV-estimation has been conducted. This IV-approach leads to stronger statistical significance compared to the OLS regression. As expected, due to the overestimation bias, the coefficients in the sales price regressions become smaller. The effect of public trees on both sales price and time-on-the-market can neither be considered as constant over time (2005-2020) nor constant across space (city areas within the municipality of Amsterdam). Finally, robustness checks using different measures for public green show that the effects of the initial analysis can be considered as robust.

Keywords

Public Trees, Green Volume, Residential Real Estate, Transaction Prices, Time-on-the-market, Hedonic Pricing Models, Urban Economics, Real Estate Economics, Amsterdam Housing Market, Public Goods, Instrumental Variables, Simultaneous Optimization Problem, Urban Forestry

"Real Estate is an excuse to study how people live and behave"

Dror Poleg (2020)

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Table of Contents

Introduction

The city of Amsterdam has grown rapidly over the last decade. This positive net migration resulted in a denser populated city with growing pressure on public spaces, green areas and public trees (Gemeente Amsterdam, 2019). The decision on how available land should be used should not only be motivated by economic or social motivations, but should also include environmental motivations given the growing pressure on public green. According to Rafiee, et al. (2013), urban green has positive effects on people's life by improving the health and wellbeing of those people. Given these possible benefits, it is important to understand the relationship between both ecological factors such as public trees and socio-economic factors. A quantification of the ecological value could support policy makers in their decision-making regarding the further densification of cities such as in Amsterdam. One way that is often used to quantify the value of environmental amenities is by examining the economic premium or discount that these amenities have on housing prices. A premium can, subsequently, be considered as positive socio-economic significance of the ecological factors, whereas a discount would indicate the opposite (Luttik, 2000). These premia or discounts related to a specific variable can be obtained by Hedonic pricing methods. These models are often used in research regarding real estate and assume a direct relationship between characteristics and prices.

This study tries to identify the possible effect that public trees have on housing market variables in Amsterdam, The Netherlands. The focus of this study is on the effect of public trees on both the transaction price of a residential property as well as the time-on-the-market. Additionally, this study examines whether the effects have been constant over time (2005-2020) and across space (city areas in Amsterdam). In order to identify the unbiased effect, an IV-approach is executed instead of solely an OLS-estimation. Moreover, robustness checks are applied in order to cross check the initial results.

This study is structured as follows. In Section 1, the literature regarding Hedonic Pricing Models in a real estate setting as well as various previous studies that examined the effect of public green on housing prices and time-on-the-market are discussed. Additionally, the so-called simultaneous optimization problem is explained based on the paper by Dubé & Legros (2016). The research sample as well as the applied methodology is, subsequently, discussed in Section 2. Section 3 shows an extensive overview of the data used in this study. In Section 4, the empirical results of the effect of public trees on the housing market in Amsterdam are discussed. Additionally, this Section makes a distinction between the results obtained by using an OLS-approach and an IV approach. The possible differences between these two approaches are highlighted as well. It also checks whether the effects of public trees on sales prices and time-on-the-market are constant across space and over time. Subsequently, Section 5 explains the various robustness checks that are conducted in this study and compares the main results of this study with the results found by using an alternative measure for tree cover. Section 6 discusses the main limitations of this research as well as potential topics for further research. The concluding remarks are made in Section 7.

1. Literature Review

This chapter is structured in the following way. Section 1.1 briefly discusses the general theory behind hedonic pricing methods and shows some applications of this method in a real estate setting. Secondly, section 1.2 reviews the literature regarding the effect of urban green areas and trees on sale prices of residential real estate. Additionally, section 1.3 discusses the relationship between urban green and time-on-the-market. This section also explains the endogeneity issues between time-on-the-market and sales price when both are present in the same econometric specification (i.e. Hedonic pricing model). Moreover, a solution to this endogeneity issue is discussed. Finally, the hypotheses are formed in section 1.4. These hypotheses are based on theories and empirical results of other studies mentioned in the literature review.

1.1 Hedonic Pricing Methods and Applications

Statistical models, such as the Hedonic pricing model, assume a direct relationship between characteristics (independent variables) and prices (dependent variables). This automatically means that differences in prices can be explained by differences in characteristics. The Hedonic pricing model originates from a paper by Court (1939) in which he measured the enjoyment that individual car buyers received from specific features of a car. Hedonic price theory assumes that buyers and sellers maximize their utility. Each consumer (buyer) has a specific demand function that indicates how much that consumer is willing to pay for a specific feature. The variables that drive these demand equation are the income of the consumer, the utility and the preferences for the specific features. On the other side, there are producers (sellers) with a specific supply equation that indicates the minimum amount the producers want to receive for a specific feature. This supply function is driven by the expected profit that the supplier would make, the cost function of the supplier and the level of production. The hedonic price function can, ultimately, be obtained by an interplay between the supply and demand equations described above. The marginal price of a feature can be found by taking the first derivative of the hedonic price function with respect to the specific feature (Rosen 1974, Francke 2019). This marginal price of a feature is also known as the marginal willingness to pay (MWTP).

There are many applications of hedonic pricing methods within the real estate sector. One example is the study by Theebe (2004), who examined the effect of traffic noise on property prices. He concluded that traffic noise affects property prices in a negative way. The average discount that properties face when subject to traffic noise is estimated to be around 5%. Another interesting research was conducted by Martinez & Viegas (2009). They estimated the relationship between the availability of transportation services and the house prices in Lisbon, Portugal. They found that proximity to one or two metro lines results in a significant positive premium on house prices. In other words, accessibility by public transport is capitalized in real estate prices. A study by Koster & Rouwendal (2017) examined the effect that investments in cultural heritage in the Netherlands have on the house prices in the surrounding. In other words, they tried to estimate the external effects that these investments in cultural heritage have. They found that when the investments in cultural heritage within one km^2 of the property increased by € 1 million, the house prices tend to increase by around 1.5%. This implies that neighbouring cultural heritage does have a positive effect on other properties. A study by Black (1999) examined the effect of school quality on property prices. He argues that a 5% increase in test scores would result in a situation in which parents are willing to pay 2.5% more for their property. In other words, there should be a positive relationship between the two. Finally, Pivo & Fisher (2011) argue that there is a walkability premium in real estate. Walkability can be considered as the degree to which an area encourages walking for recreational or functional purposes. They found that a higher walkability score tends to increase the values of apartments significantly. Given the significant outcomes of the studies described above, this study uses various spatial variables as additional control variables in order to decrease the potential of an omitted variable bias.

1.2 Urban Green and Sale Prices

There are numerous studies that examined the effect of green areas or trees on residential property prices. These studies used various statistical methods, ranging from very simple ones to quite extensive models and the findings of these studies differ quite substantially.

One of the oldest study that tries to examines the relationship between trees and residential property values is the study by Morales (1980). He estimated the value of trees on property prices in Manchester, Connecticut and found that "good tree cover" may lead to a 6% increase in property value. This study has, however, quite some limitations. First of all, it has a sample size of only 60 properties. Secondly, "good tree cover" is considered to be a binary variable which equals unity in case the author decided that, based on his own observation, the property had a substantial amount of mature tree cover. A study by Donovan & Butry (2010), on the other hand, examined the effect of public street trees on sales price in Portland. They visited all the houses that were sold in the east-side of 4 Portland between July 2006 and April 2007 and recorded the number of trees that fronted the property manually. Additionally, they recorded other characteristics of the trees such as the diameter of the tree as well as the height. They also examined different characteristics of the house that was sold such as the condition, age, size, and the number of rooms. By making use of a Hedonic pricing method, they were able to estimate the value that trees add to the final sale price of a house. On average, trees within 100 feet of the house contribute $8,870 to the sale price of a house. This implies that the added-value of street trees easily outweigh the extra maintenance costs associated with trees. The finding that urban trees contribute to higher housing prices was, however, not fully confirmed in a study by Donovan, Landry, & Winter (2019). They examined the relationship between urban trees and sale price of residential properties in Tampa, Florida. They chose Tampa because the city of Tampa experiences rapid urban growth and strong pressure for redevelopment of existing properties. A common believe among real estate developers in the city of Tampa is that trees significantly increase redevelopment costs, which would ultimately result in a price-penalty for properties with trees situated on it (Northrop, et al., 2014). By using sale prices of single family homes between May 2015 and May 2016, as well as the tree canopy cover, based on aerial imagery taken between December 1, 2015 and January 18, 2016, the authors were able to examine the effect of trees on house prices. They extended the study of Donovan & Butry (2010), by not only using a simple hedonic model, but adding a spatial lag, spatial error as well as a spatial joint lag-and-error hedonic model. The results show that neither tree cover within 100 feet nor tree cover on the lot of a house are significantly different from zero. This implies that trees within this range do not contribute to higher (or lower) property prices. However, by adjusting the range of tree-cover to 500 feet, the authors find that an one percentage point increase in the tree-cover leads to a total house price increase between $9,271 and $9,836, depending on the model used. A recent study by the Staats & Swain (2020) evaluated to what extent people appreciate living in a street with more street trees and a lower parking density. According to the literature, the benefits of street trees can be divided into three subsets: physical benefits, psychological benefits and economic benefits. Examples of physical benefits are improved air quality, stabilized micro-climate as well as wind reduction (Smardon, 1988). Physiological benefits occur because the majority of people enjoy natural vegetation in a number of different ways such as the change of vegetation over the seasons and the way (urban) greenery smells and sounds (Smardon, 1988). Most studies show that there is a positive or insignificant relationship between the (density of) street trees and property prices. However, the extent of these benefits remain unclear as they vary largely over different studies. Most of the studies that examine the effect of street trees on property prices use a Hedonic pricing model. However, Staats & Swain (2020) used a psychological experiment of 281 participants recruited from Leiden University in the Netherlands. The participants received four different photographs of streets in a random order. However, the photos were digitally modified to display different densities of parked cars and trees. Subsequently, participants were asked to rate photos based on safety, beauty, friendliness. Additionally, they were asked to estimate the sales price of the house shown on the picture, as well as the income of the current owner or tenant. The participants estimated that buildings in streets with trees have a 5% higher price compared to buildings in streets without trees (Staats & Swain, 2020).

Daams, Sjitsma, & Veneri (2019), combined a Hedonic pricing model with the data of an online value mapping-based survey. This survey, with 723 participants, contains the attractiveness of all the green spaces (N = 29) in the metropolitan area of Amsterdam. This level of attractiveness is, subsequently, used as a variable in the hedonic pricing model to estimate the effect of greenery on housing prices. It seems that housing nearby attractive green spaces is more expensive than housing further away and that this premium decays with distance (ceteris paribus). The estimated price-effect for housing within 250 metre of the attractive green area is between 7.1% and 9.3%. This gradually declines as the distance to the green area decreases. For example, houses located between 750 metre and one kilometre of the green area tend to have only a 1.7% up to 2.3% premium compared to housing further away. After one kilometre, the effect is not statistically different from zero, which implies that the effect is negligible after one kilometre.

1.3 Urban Green and Time-on-the-Market

A variable that is inherent to the sale price of a house is the time-on-the-market. For example, a seller of a house faces a trade-off between a high list price and a short time-on-the-market. A relatively high list price may result in a longer time-on-the-market, while a relatively low list price may result in the opposite. There exist, however, only a small number of studies that examined the effect of urban greenery on the time-on-the-market of residential property.

One of the studies that tries to examine the effect is the study by Donovan & Butry (2010). They do find a negative relationship between trees in Portland and the time-on-the-market. In other words, when the number of trees increased, the time-on-the-market decreased by 1.7 days. These results were also found by Culp (2008), who examined the effect of environmental objects on housing prices and time-on-the-market in Lehigh County, eastern Pennsylvania between 1999 and 2005. He found that trees can reduce the time-on-the-market by at least 50%. Possible explanations for this large deviations in outcomes can be attributed to the following reasons. First of all, the underlying real estate market that both authors studied may be different. Secondly, Culp (2008) used dummies for various densities of tree cover, while Donovan & Butry (2010) used a continuous scale. Finally, Culp (2008) used trees on a house's lot as variable, while Donovan & Butry (2010) used (public) street trees.

An econometric and methodological problem often overseen when estimating effects between time-on-the-market and pricing is the fact that both the time-on-the-market and the sale price of a property are "simultaneously determined". When an individual is willing to sell his or her house, the seller faces a so called "simultaneous optimization problem". In other words, the seller wants to maximize the sale price, but wants to minimize the time-on-the-market. The final sale price of a house, together with the time-on-the-market thus reflects a "simultaneous solution" in which the seller may be willing to accept a lower price to sell the house quickly, or is willing to wait for a higher offer, which then subsequently increases the time-on-the-market (Dubé & Legros, 2016). This "simultaneous optimization problem" may lead to bias results when both sale price and time-on-the-market are at the same time present in a hedonic pricing model. Given the fact that the literature suggests a negative relationship between sale price and time-on-the-market, the effect would thus, due to the bias, be overestimated (Sirmans, MacDonald, & MacPherson 2010, Dubé & Legros 2016). This problem can be solved by making use of a spatiotemporal instrumental variable (IV) approach. In the first stage of the IV, the sale price and the time-on-the-market are regressed on instrumental variables such as the mean listing price occurring in the vicinity, the mean sale price of houses in a given vicinity, but in a previous time period or the mean time-on-the-market before houses have been sold. These instrumental variables are also known as "spatiotemporal lagged variables". In the second stage of the IV-method, the predicted values from the first stage are being used in the model of the time-on-the-market and in the hedonic pricing model, which ultimately solves the endogeneity issues between time-on-the-market and sale price (Dubé & Legros, 2016).

1.4 Hypotheses

Based on the theories and empirical studies discussed earlier in this chapter, several hypotheses are constructed. According to studies by Morales (1980), Donovan & Butry (2010), Daams, Sjitsma, & Veneri (2019) and Staats & Swain (2020), there should be a positive relationship between the amount of trees in the direct vicinity of a house and the sale price of a house. Additionally, Culp (2008) and Donovan & Butry (2010) pointed out that there is a negative relationship between trees and time-on-the-market. The first hypotheses can therefore be stated in the following way:

Hypothesis 1: Public trees have a positive effect on housing prices in Amsterdam.

Hypothesis 2: Public trees have a negative effect on time-on-the-market in Amsterdam.

However, a study by Donovan, Landry, & Winter (2019) pointed out that in cities with rapid urban growth and strong (re)development pressure, there might not be an effect. In Amsterdam, the population growth from the year 2000 up to the financial crisis (2008) was on average 0.49% per year, while after the financial crisis up to the year 2020, the population growth was on average 0.77%[1]. Given this large increase in average population growth, it is interesting to examine whether there is a change in the effect that public trees have on the Amsterdam housing market. The third hypothesis can therefore be stated in the following way:

Hypothesis 3: The effect that public trees have on housing prices and time-on-the-market is constant over time.

[1] https://worldpopulationreview.com/world-cities/amsterdam-population

Finally, it is interesting to examine whether the effect of public trees on housing prices and time-on-the-market is the same across all city areas ("Stadsdelen"). The fourth hypothesis can therefore be stated in the following way:

Hypothesis 4: The effects that public trees have on housing prices and time-on-the-market is constant across city areas.

2. Methodology

This chapter specifies the methodology that is used to examine the earlier discussed hypothesis. Section 2.1 gives an overview and brief explanation of the research sample. The key variables in this study relate to the amount of public trees within a certain radius from a transacted property and a dummy variable which equals unity in case a public tree is present within a specific radius of a transacted property. The method used to obtain the spatial variables used in this study is extensively discussed in Section 2.2. Finally, Section 2.3 discusses the hedonic pricing model that is used in this study. Additionally, other econometric and statistical tools used are explained in this section. By applying these methods, this study could examine the possible relationship that public trees have on house prices and time-on-the-market.

2.1 Research Sample

To examine the possible effects that public trees may have on housing prices and time-on-the-market, a dataset is constructed with a sample period between January 2005 and December 2020. This fifteen year period is chosen because by examining the effect over a longer period of time, one could better examine possible changes related to preferences. For example, Amsterdam has a long history of housing shortage. This implies that there is continuously pressure on existing green and/or undeveloped land. This continuous pressure makes it interesting to examine changes in preferences over time. The end date of the sample period is chosen as per 31 December 2020, in order to prevent a possible distorted effect of COVID-19. Amsterdam is chosen to study because of the earlier discussed continuous pressure on land. Additionally, it can be considered as the largest city of the Netherlands with the most active real estate market (in absolute terms). Finally, the municipality of Amsterdam is very transparent regarding their data and enables easily free-accessible data for scientific purposes.

2.2 Spatial Variables

Given that the spatial variables are not included in the NVM dataset (the dataset which contains the housing transaction and housing characteristics data), these variables are constructed in QGIS (Quantum Geographical Information System) by using different datasets from the municipality of Amsterdam and boomregister.nl. Various variables regarding public trees have been constructed. Based on the database of the municipality of Amsterdam, the number of public trees within 10 meter, 25 meter, 50 meter and 100 meter of the transacted property have been constructed. Additionaly, a dummy variable that equals unity when there are public trees present within the distances mentioned above has been created. Finally, the volume of the tree cover within the distances mentioned above has been constructed. These variables are obtained in the following way. First, the geographical data are obtained from the database of the municipality of Amsterdam. All trees in the database have unique geographical points (longitude, latitude). These geographical points are transformed into the projected CSR (Amersfoort – New RD (EPSG: 28992)) to make sure that they match the geographical points used in the NVM dataset. Subsequently, buffers of all transacted properties and public trees are made. The buffers of the transacted properties are made based on a radius of 10 meter, 25 meter, 50 meter and 100 meter, while the buffers of the public trees are based on the radius of the tree as stated in the dataset. This implies that larger (older) trees tend to have a larger buffer than smaller (younger) trees. Finally, the number of public trees variables are constructed based on the amount of tree buffers that intersect with the transacted property buffer, conditional on the requirement that the year of planting of the tree is earlier than the year of transaction. The dummy variable is created based on the number of public trees within a specific radius. If there is one or more tree present within the radius of a transacted property, the dummy equals unity. The database of boomregister.nl is used to construct the volume of green within a specific radius of the transacted property. The dataset covers the total volume (in cubic meters) of green, based on a 5x5 meter grid. This dataset does not only take public trees into account but also covers private trees, bushes, shrubs and grass. The benefit of using this dataset is that larger trees automatically result in a larger green volume compared to smaller trees or other types of smaller green. This dataset is also used by Rafiee, et al. (2016).

Other spatial variables used in this study are distance to public transport facilities, distance to the city centre, distance to recreational areas, and distance to the closest main road or highway (A- & N-wegen). These variables tend to be important determinants for property prices according to earlier research by Dekkers & Koomen (2008) and Koster & Rouwendal (2017). The distance to a specific spatial attribute is constructed in QGIS by calculating the Euclidean distance between each house and the nearest spatial point or polygon.

2.3 Hedonic Pricing Model

The regression models used in this study to examine the effect public trees have on housing prices and time-on-the-market is formulated as follows:

$$Ln(P_i) = \alpha + \beta T_i + \gamma C_i + \theta S_i + \varepsilon_i \tag{2.1}$$

$$Ln(TOM_i) = \alpha + \beta T_i + \gamma C_i + \theta S_i + \varepsilon_i \tag{2.2}$$

In equation 2.1 and 2.2, The dependent variable is an (n x 1) vector of either sales prices or time-on-the-market. The α is the constant in the model. T is an (n x i) matrix of transaction characteristics. Examples of transaction characteristics are date of sale, time-on-the-market or sales price (time-on-the-market is excluded when the dependent variable equals time-on-the-market, the same holds for sales price). C is an (n x j) matrix of structural characteristics of the property such as size, construction period, number of rooms and availability of outdoor space. S is an (n x k) matrix of spatial attributes such as the number of public trees or other spatial variables[2],

[2] The public tree variables are the number of trees, a dummy which equals unity in case public trees are present within a specific radius of a transacted property and the total green volume in a specific radius. Only one of these variables is used in each regression in order to prevent multicollinearity issues. Other spatial variables are the distance to various amenities such as public transport facilities, recreational areas (parks), and the distance to the city centre. The distance to highways is also used in this study.

distance to public transport facilities, distance to city centre and distance to recreational areas. Finally, there an (n x 1) vector of random error terms. The α, β, γ and θ are associated parameter vectors. As functional form, a log-linear specification is chosen because of four reasons. First of all, by representing the dependent variable in the form of a natural logarithm, the model becomes multiplicative. In other words, price changes are represented in percentages instead of absolute values which is important in case of housing price research. Secondly, the error term is closer to normality. Thirdly, the relative standard deviation is minimized instead of the absolute standard deviation. Finally, the value of a house is less than proportional to the house size. This is known as the law of diminishing returns. By using the natural logarithm instead of the absolute value, we correct for this phenomena (Francke, 2019). The number of variables used in this analysis is determined by using econometrics and statistical tools.

Given that our specification faces a spatiotemporal optimization problem because of the presence of both house price and time-on-the-market in the regression, a spatiotemporal instrumental variable (IV) approach is used as discussed in Dubé & Legros (2016). In the first stage of this approach (equation 2.3 and 2.4), the dependent variable (sales price or time-on-the-market) is regressed on a set of instruments Z which are either the mean listing price in the four number postcode area (PC4) lagged by one-year, the mean time-on-the-market per PC4 area lagged by one-year, the number of houses sold per PC4 area and year, and, the mean of the ratio between the listing price and the sales price per PC4 area and year. Additionally, the dependent variable is regressed on a set of control variables which include transaction characteristics, property characteristics as well as spatial characteristics as described above. These control variables are all denoted as matrix X (n x i).

$$Ln(P) = \theta_0 + \theta_1 Z_{i,t} + \theta_2 X_i + \zeta_{i,t} \tag{2.3}$$

$$Ln(TOM) = \theta_0 + \theta_1 Z_{i,t} + \theta_2 X_i + \zeta_{i,t} \tag{2.4}$$

In the second stage of the IV (equation 2.5 and 2.6), the predicted values of the first stage are used in the general specification (equation 2.1 and 2.2) in order to solve the possible endogeneity of the initial regression.

$$Ln(P)_i = \alpha + \delta \widehat{Ln(TOM)}_i + \beta T_i + \gamma C_i + \theta S_i + \varepsilon_i \tag{2.5}$$

$$Ln(TOM)_i = \alpha + \delta \widehat{Ln(P)}_i + \beta T_i + \gamma C_i + \theta S_i + \varepsilon_i \tag{2.6}$$

In order to examine whether the effect that public trees may have on either house prices or time-on-the-market is constant across city area or over time, two separate regressions are made including interaction variables. By using an F-test, one could examine whether the effects are constant over time and/or across space. If possible, the regressions use robust standard errors to correct for possible heterogeneity. Additionally, the models are tested on multicollinearity by using variance inflation factors (VIFs). Variables that are not specifically mentioned in the literature as important variables and that have a VIF score larger than ten are omitted from the regression. The fixed effects (PC4 area, city area, year) which are potentially be used in the models, are also tested. The different intercept groups need to be significantly different from each other in order to use them in the regression analysis. Checks on the distribution of the residuals are also done. Other checks that are applied in this research relate to heteroscedasticity. Finally, it is important that both the variables of interest (number of public trees, public tree dummy, or green volume variables) and the dependent variables (price and time-on-the-market) are normally distributed. This can be achieved by transforming both price and time-on-the-market to logarithmic functions as described earlier in this section. In the IV-regression, various checks are also conducted such as an endogeneity check, a weak instrument check and an overidentification check.

3. Data Description

This chapter discusses the sample data used in this study. Section 3.1 explains the collection of the data and its sources. Thereafter, the descriptive statistics are shown and discussed in section 3.2.

3.1 Data collection

The required data needed to answer the hypotheses discussed in section 1.4 are obtained by various sources. The majority of the data is provided by the NVM. The NVM (Dutch Association of Real Estate Brokers) is the largest association of real estate brokers in the Netherlands. Approximately 3,500 real estate brokers and 2,200 real estate companies are member of this association (NVM, 2021). The data received from the NVM consists of micro-data on housing transaction within the municipality of Amsterdam between January 2005 and December 2020 executed by real estate brokers that are linked to the NVM. The property transactions done by NVM members cover about 75% of all housing transactions in the Netherlands. This high level dataset consists of detailed information about the transactions such as list price, transaction price and time-on-the-market. Additionally, the dataset offers detailed property specific characteristics such as size of interior space, number of rooms, type of building, heating, maintenance level and size of exterior space. It also gives information about the monumental status of a property (if applicable) and the building year. This type of dataset is often used for spatial analysis. For example, Koster & Rouwendal (2017) and Dekkers & Koomen (2008) also used datasets consisting of micro-data of housing property transactions provided by the NVM. The gross dataset received from the NVM consists out of 140,753 observations. However, some of the observations have missing values, which means that the net dataset (after omitting these observations) consists out of less observations.

The data regarding public trees and other spatial attributes is obtained from the open geographical data website of municipality of Amsterdam[3]. These datasets are

[3] https://maps.amsterdam.nl/open_geodata/

managed by the Spatial and Sustainability department of the municipality. This large dataset consists out of approximately 260,000 trees managed by the municipality of Amsterdam and gives information about variables related to these trees such as type, height, planting year, radius and location. Additionally, there are other datasets provided by the municipality of Amsterdam that provide geographical data on public transport facilities, recreational areas and highways. The dataset regarding the green volume is obtained through the Vrije Universiteit Amsterdam. This dataset is based on data from boomregister.nl and shows the total volume of green in cubic meters on a 5x5 meter grid.

3.2 Descriptive statistics

The descriptive statistics of the spatial variables used in this study is shown in figure 3.1. The mean, standard deviation, minimum and maximum values are reported. The data is this table is based on the datasets of boomregister.nl and the municipality of Amsterdam.

Figure 3.1: Summary statistics of Spatial Variables

	Mean	Std. Dev.	N	min	max
Dummy Tree 10M	.35	.48	135092	0	1
Dummy Tree 25M	.78	.42	135092	0	1
Dummy Tree 50M	.92	.28	135092	0	1
Dummy Tree 100M	.97	.16	135092	0	1
#Trees 10M	.51	.81	135086	0	10
#Trees 25M	3.71	3.37	135086	0	36
#Trees 50M	13.89	11.06	135086	0	103
#Trees 100M	55.11	35.29	135086	0	275
Green Volume 10M	120.96	434.77	135086	0	20,503
Green Volume 25M	2,651.18	3,430.79	135086	0	66,028
Green Volume 50M	13,546.19	14,152.33	135086	0	234,156
Green Volume 100M	59,321.48	52,552.22	135086	0	890,383
Distance Public Transport	382.65	506.60	135085	10	7526.7
Distance City Centre	3559.72	2081.87	135085	50	11761.5
Distance Main Road	1569.51	883.14	135085	22.4	5132.6
Distance Park	1656.76	1102.21	135085	1	5101

The descriptive statistics of the non-spatial variables used in this study are presented in figure 3.2. The mean, standard deviation, minimum and maximum values after winsorizing (at the 1th percentile and the 99.99th percentile) are reported. The data of this table is based on the NVM dataset.

Figure 3.2: Summary Statistics of Property and Transactional Variables

	Mean	Std. Dev.	min	max
Price	355,318	263,298	75,000	4,710,000
TOM	92.07	145.78	0	1,746
Listing Price	356,537	258,977	79,000	3,250,000
Size	88.75	42.35	26	529
Apartment	0.87	0.34	0	1
Terraced	0.09	0.29	0	1
Semidetached	0.03	0.18	0	1
Detached	0.01	0.10	0	1
Parking	0.13	0.33	0	1
#Bathrooms	0.90	0.49	0	7
#Kitchens	0.76	0.47	0	5
#Balconies	0.55	0.54	0	5
#Roofterraces	0.13	0.35	0	3
Maint. Good	0.92	0.27	0	1
Maint. Outside Good	0.98	0.14	0	1
Isolation	1.75	1.84	0	5
Central Heating	0.88	0.32	0	1
Monumental Status	0.03	0.17	0	1
Newly Built	0.05	0.22	0	1
Leasehold	0.59	0.49	0	1
Year of Transaction	2012.8	4.6	2005	2020
PC4 Area	1059.4	27.26	1011	1108
Construction: <1905	0.16	0.37	0	1
1906 - 1930	0.26	0.44	0	1
1931 - 1944	0.09	0.28	0	1
1945 - 1959	0.04	0.21	0	1
1960 - 1970	0.09	0.28	0	1
1971 - 1980	0.03	0.18	0	1
1981 - 1990	0.09	0.29	0	1
1991 - 2000	0.10	0.31	0	1
> 2000	0.13	0.33	0	1
Amsterdam Centrum	0.14	0.35	0	1
Amsterdam Noord	0.09	0.29	0	1
Amsterdam West	0.24	0.43	0	1
Amsterdam Nieuw-West	0.12	0.32	0	1
Amsterdam Zuid	0.20	0.40	0	1
Amsterdam Oost	0.16	0.37	0	1
Amsterdam Zuid-Oost	0.05	0.23	0	1

Three correlation matrices of the main property related variables used in this study combined with the number of trees (figure 3.2), the tree dummy variables (figure 3.3) and the green volume (figure 3.4) are shown below. As shown in the first matrix, there seems to be a negative correlation between the number of trees within a specific radius of a house and the transaction price of a house. Additionally, there is a negative correlation between the time-on-the-market (TOM) and the number of trees within a specific radius of a house. However, these correlation coefficients seem to be very small (i.e. close to zero). Size seems to be strongly correlated with the price of a property. Additionally, there is a small but positive relationship between size and time-on-the-market. Finally, there is a strong positive correlation between the number of trees on various distances from the house – which is logical. As shown in the second matrix, the negative relationship between trees and transaction prices becomes somewhat more positive. However, the correlation coefficients are so small that they can also be considered as neglectable. The time-on-the-market and the various dummy variables become more negatively correlated compared to the earlier correlation. The correlation coefficients between the price and the green volume is closely related to the correlation between the dummy tree variable and the price, which makes sense. Additionally, the correlations between the different radiuses of green volume are also strong. This also makes sense given the partially overlap between the different radiuses.

Figure 3.3: Matrix of correlations (A)

Variables	(1) Price	(2) TOM	(3) Size (in sqm)	(4) Trees (10m)	(5) Trees (25m)	(6) Trees (50m)	(7) Trees (100m)
(1) Price	1.000						
(2) TOM	-0.064	1.000					
(3) Size (in sqm)	0.739	0.073	1.000				
(4) Trees (10m)	0.006	-0.042	-0.041	1.000			
(5) Trees (25m)	-0.095	-0.017	-0.061	0.489	1.000		
(6) Trees (50m)	-0.127	0.004	-0.048	0.277	0.785	1.000	
(7) Trees (100m)	-0.142	-0.011	-0.062	0.216	0.622	0.831	1.000

Figure 3.4: Matrix of correlations (B)

Variables	(1) Price	(2) TOM	(3) Size (in sqm)	(4) Dummy Tree 10M	(5) Dummy Tree 25M	(6) Dummy Tree 50M	(7) Dummy Tree 100M
(1) Price	1.000						
(2) TOM	-0.064	1.000					
(3) Size (in sqm)	0.739	0.073	1.000				
(4) Dummy Tree 10M	0.021	-0.049	-0.044	1.000			
(5) Dummy Tree 25M	-0.030	-0.043	-0.060	0.393	1.000		
(6) Dummy Tree 50M	0.000	-0.045	-0.037	0.219	0.558	1.000	
(7) Dummy Tree 100M	0.024	-0.036	-0.018	0.122	0.311	0.557	1.000

Figure 3.5: Matrix of correlations (C)

Variables	(1) Price	(2) TOM	(3) Size (in sqm)	(4) Ln(Green Volume (10m))	(5) Ln(Green Volume (25m))	(6) Ln(Green Volume (50m))	(7) Ln(Green Volume (100m))
(1) Price	1.000						
(2) TOM	-0.064	1.000					
(3) Size (in sqm)	0.739	0.073	1.000				
(4) Ln(Green Volume (10m))	0.082	-0.015	0.058	1.000			
(5) Ln(Green Volume (25m))	0.096	0.029	0.069	0.357	1.000		
(6) Ln(Green Volume (50m))	0.105	-0.019	0.091	0.211	0.696	1.000	
(7) Ln(Green Volume (100m))	0.105	0.018	0.107	0.142	0.464	0.742	1.000

As shown in figure 3.1 and figure 3.2, the average sale price during the sample period of a residential property is equal to approximately € 355,000. This corresponds to an average size of approximately 89 sqm. Most of the properties within the sample are apartments (86.5%), while terraced housing (9.4%), semidetached housing (3.2%) and detached housing (1%) are far less common in Amsterdam (see figure 3.6).

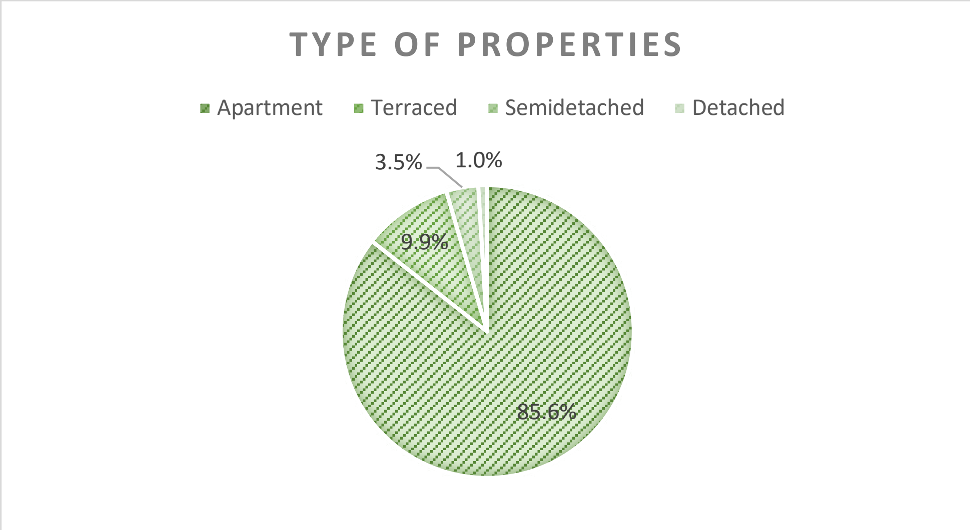

Figure 3.6: Type of transacted residential properties within the sample.

The average number of bathrooms, kitchens and balconies are respectively 0.89, 0.76 and 0.55. The reason why the average number of bathrooms and kitchens is smaller than one is due to the fact that some transacted properties are studios (that do not have a separate kitchen) or low-quality (to-be-renovated) properties where the realtor did not take the existing bathroom/kitchen into account due to an extremely low quality. Approximately 13% of the sold properties had access to private parking facilities. Additionally, the average number of roof top terraces equals approximately 0.13. More than 88% of the properties had central heating facilities. The level of interior and exterior maintenance is in respectively 92% and 98% of the cases considered to be average or better than average. This consideration was executed by the realtor who transacted the specific property at the time of sale. In the sample, 3% of the properties has a monumental status while approximately 5% is considered as newly-built. 59% of the total sample was situated on leasehold. The time-on-the-market is on average 92 days. However, the time-on-the-market is relatively volatile based on the conditions of the market. During a buyer's market, the time-on-the-market is generally higher than during a seller's market. Based on this knowledge, we could roughly say that the Amsterdam housing market could be considered as a buyer's market in 2005 and 2010-2014, while it could be classified as a seller's market from 2006-2009 and 2015-2020. During periods of a buyer's market, we see that the list price tend to be higher than or equal to the final sales price, while the opposite holds during periods of a seller's market.

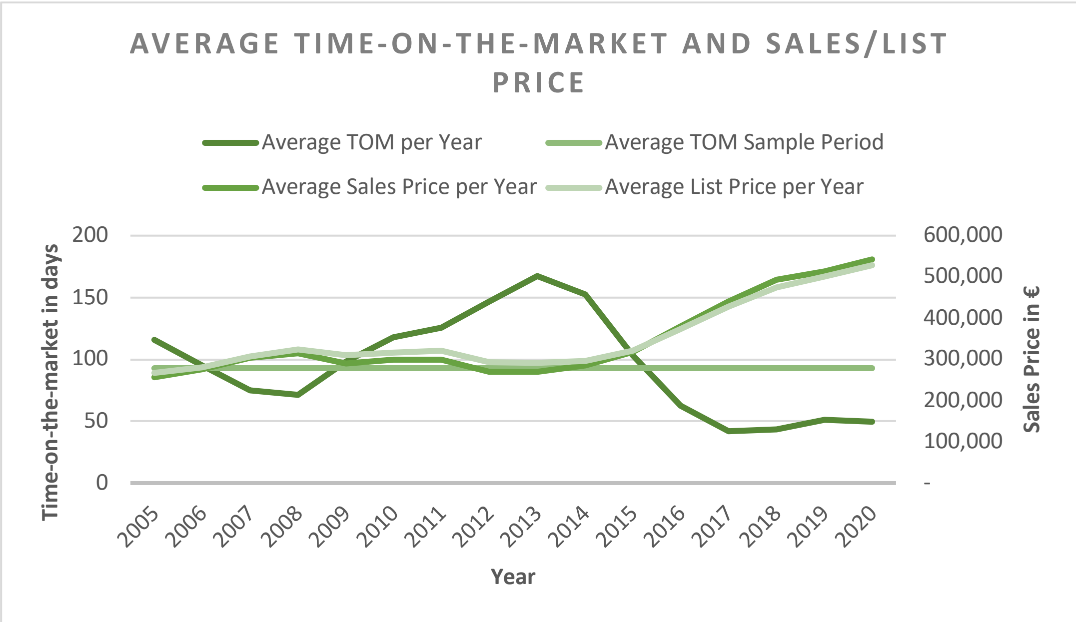

Figure 3.7: Average time-on-the-market (TOM) per year, average time-on-the-market during the sample period and average sales price per year.

Another variable relevant for this study is the constructing period of the transacted properties. The exact construction year was not available in the NVM dataset. However, a set of construction periods, ranging from before 1905 up to after 2000 is available. Based on these periods, it becomes clear that approximately 50% of the transacted properties was built before World War Two. From this 50%, half was constructed during 1906-1930. This period is known for its large development of residential buildings. During this period, Amsterdam expanded the city by developing new neighbourhoods such as Rivierenbuurt, Hoofddorppleinbuurt, and Indische Buurt (Smid, 2019). The relative number of transacted properties within the sample that are built in the specific construction period is graphically presented in figure 3.8.

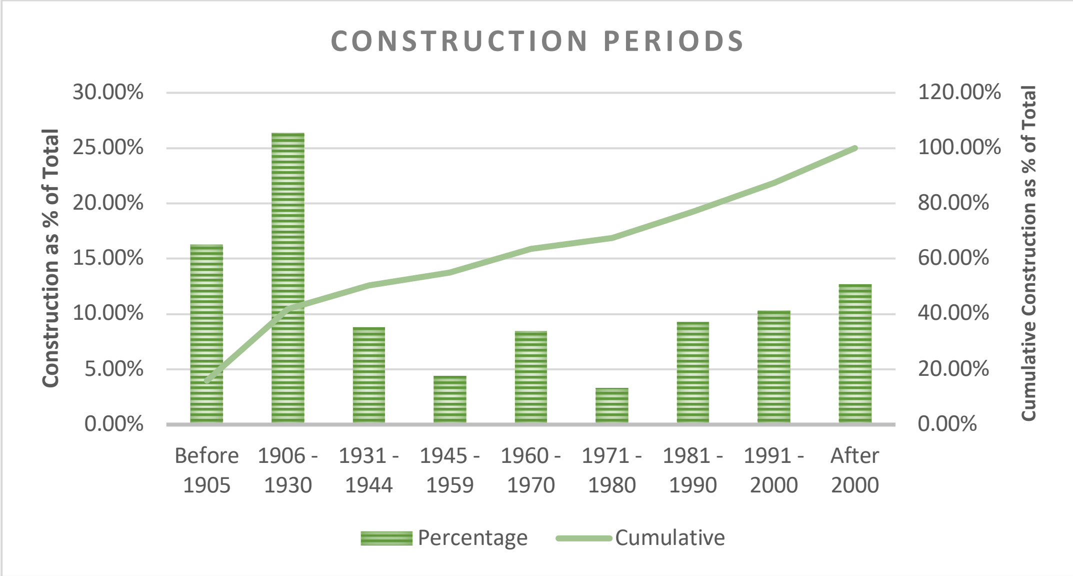

Figure 3.8: Construction Periods of the transacted residential properties within the sample.

Based on the PC4 area data, dummy variables related to city area (Stadsdeel) can be constructed. Based on this conversion, it becomes clear that most properties are transacted during 2005-2020 in Amsterdam West (23.6%), followed by Amsterdam Zuid (19.9%) and Amsterdam Oost (16.4%). Least properties are sold in Amsterdam Zuid-Oost (5.4%) and Amsterdam Noord (9.1%). Given that these city areas are relatively large in size, one could question why there are so few properties transacted in these areas. A possible explanation for this relatively low amount of transacted properties can be found in the fact that the majority of the properties in these city areas tend to be public housing. In other words, the stock private owner-occupied housing is relatively small in these areas, which could explain the relatively low amount of transacted properties. In 2010, the amount of public housing relative to the total housing stock equalled 63% in Zuid-Oost and 70% in Noord. In 2020, these percentages decreased to 49% in Zuid-Oost and 51% in Noord. Besides this increase, these numbers are still much higher compared to other city areas. Amsterdam West, Zuid and Center have, for example, a public housing share of 34%, 24% and 25% respectively (Nul20, 2021). The average sales price across city areas differs substantially, but follows the same pattern over time. Housing prices have been relatively stable from 2005 up to 2012. In 2013, the average sales price slightly increased, followed by larger increases in subsequent years. As can be seen in figure 3.9, Centrum and Zuid are the most expensive areas, followed by Oost and West. The city areas Zuid-Oost and Nieuw-West are, on average, the relative cheaper neighbourhoods. At the beginning of the sample, the differential between the most expensive and the cheapest city area appear to be approximately 105% relative to the prices in the cheapest city area. This gradually increased to more than 200% in 2016. After 2016, the differential decreased to 123%. The revival of the initial cheaper areas (all areas except Centrum & Zuid) relative to the more expensive areas (Centrum & Zuid) after 2016 could be explained by the phenomena of endogenous gentrification (Guerrieri, Hartley & Hurst, 2013). This phenomena can be explained as follows: after a positive economic shock, cities tend to see an inflow of higher educated people. Given higher demand for initially rich areas, these areas tend to see shortages which results in a situation in which the new higher educated people spread over contiguous neighbourhoods. This inflow leads to larger price increases in the contiguous neighbourhoods.

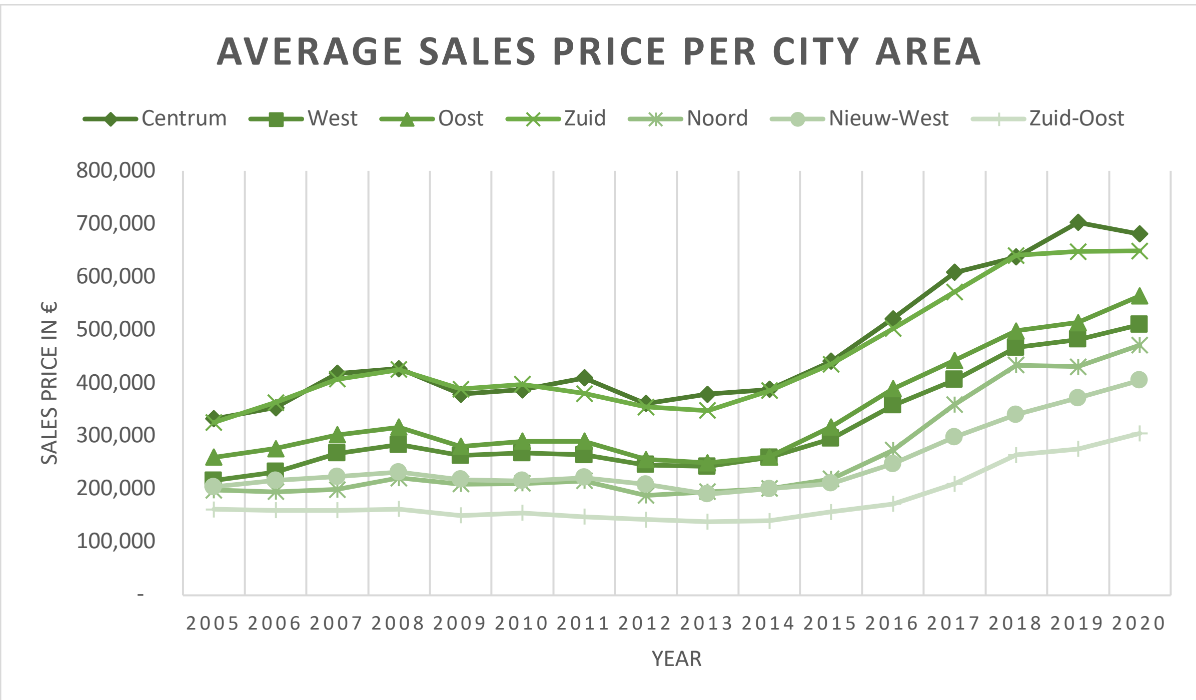

Figure 3.9: Average Sales Price per city area between 2005 – 2020.

The spatial control variables used in this study are the distance to main roads (N- and A-wegen), distance to public transport facilities (excluding bus-stations), distance to the city centre (Dam Square) and distance to recreational areas. The distance between the transacted properties and the specific spatial variables is measured by the Euclidean distance. On average, properties are approximately 383 meter away from the closest public transport station. Additionally, properties are around 3,560 meter, 1,570 meter and 1,657 meter away from respectively the city centre, the main roads and recreational areas. In figure 3.10, an overview of the spatial control variables is presented.

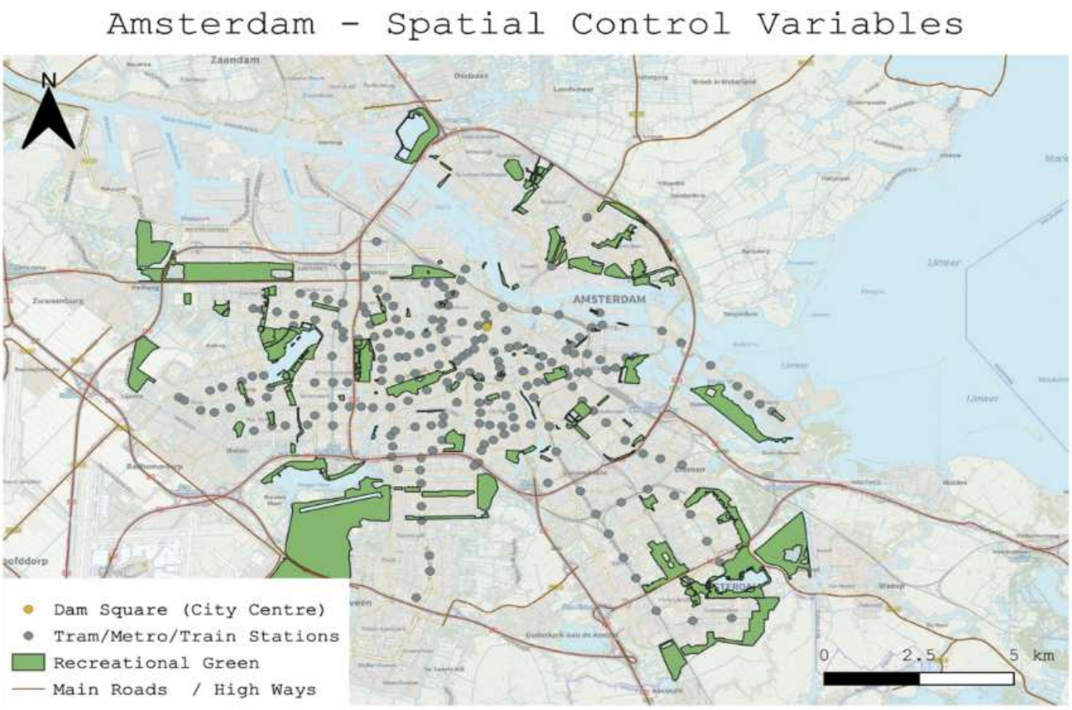

Figure 3.10: Spatial Control Variables

Another interesting descriptive statistic to examine is the distributions of public trees across city area. This distribution is shown in the pie chart below (figure 3.11). City areas Nieuw-West and Noord tend to have the largest amount of trees within the sample (29% and 22% respectively). This can be explained by the fact that these city areas are the largest city areas in Amsterdam. The smallest amount of trees can be found in Zuid-Oost and Centrum (5% and 3% respectively). A map in which all the public trees of the dataset are shown can be found in figure 3.12. This map indeed shows a relative low tree cover in the Zuid-Oost area and Centrum, while Nieuw-West and Noord tend to have the largest cover, followed by Oost, Zuid and West. The large empty space between Oost and Zuid-Oost is due to the fact that the municipalities of Duivendrecht and Diemen are located in this large open space (they are located in between Oost and Zuid-Oost). Given that data about housing transactions and public trees within these municipalities are not present in the used datasets, these municipalities are not part of this study.

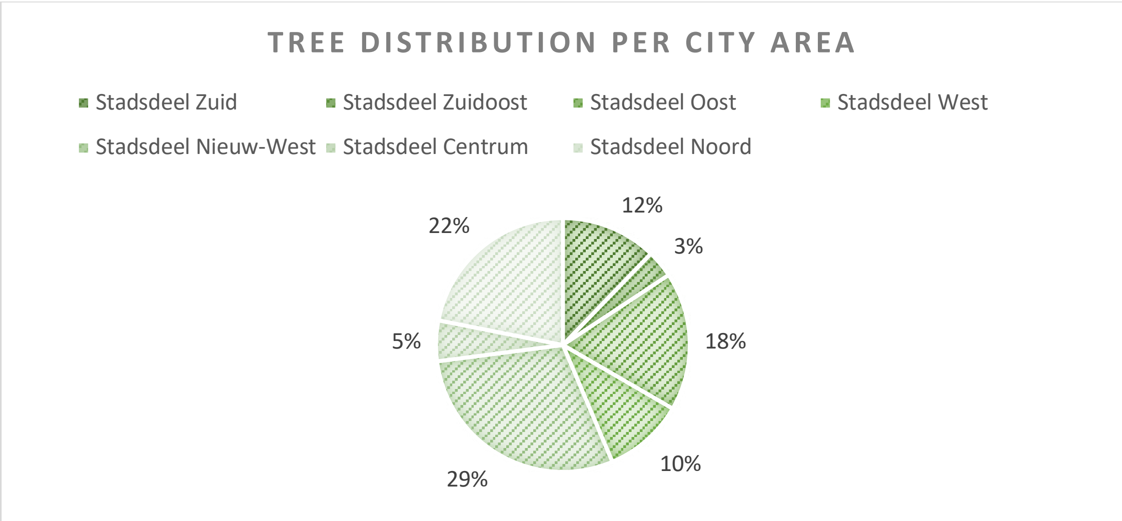

Figure 3.11: Tree distribution per City Area

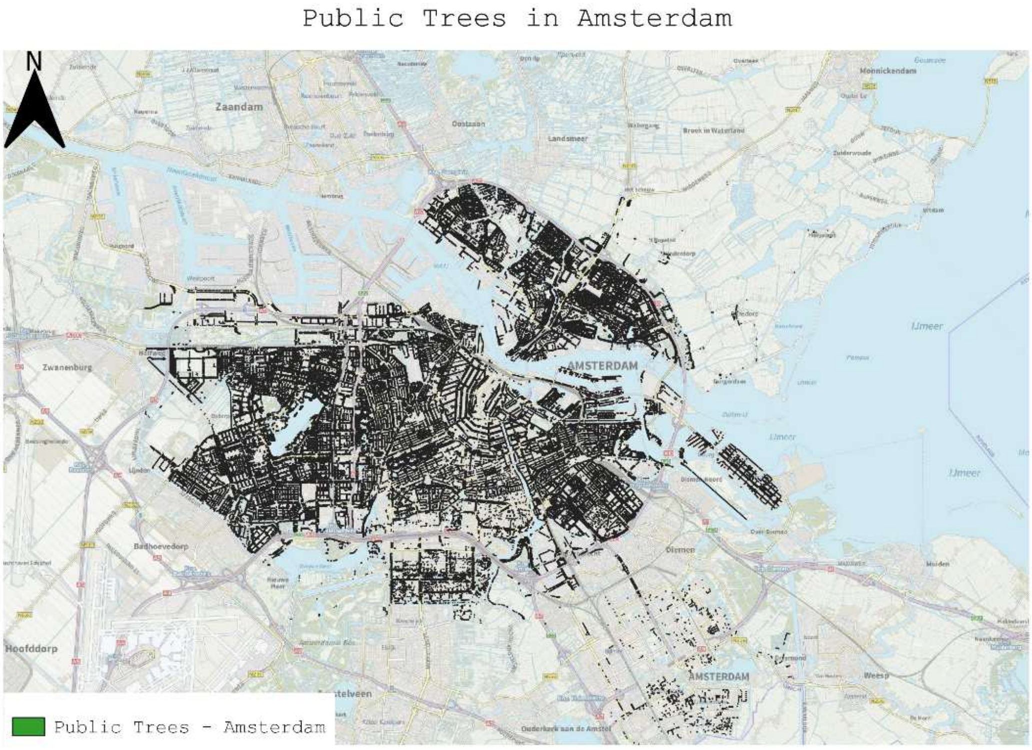

Figure 3.12: Public Tree distribution per City Area

The final variables to discuss are the variables of interest in this study: the number of trees within a certain radius of the transacted properties, the tree dummy variable, and the green volume within a certain radius of the transacted properties. Four different distances are examined, starting with a radius of ten meter up to a radius of 100 meter. The minimum amount of trees within a ten meter radius from a transacted property is zero, while the maximum is ten. In case of a 25 meter radius, the minimum amount is still zero, however the maximum amount increases to 36 trees. On average, there are 3.5 public trees within a 25 meter radius of a transacted property and 0.50 public trees within a ten meter radius. The number of public trees increases as the radius becomes larger. The average number of public trees within a 50 meter and 100 meter radius is respectively 13.9 and 55.1. The maximum amount of public trees within a 100 meter radius is 275, while the minimum is zero. The dummy variable indicates that in 35% of the transactions, there was at least one public tree within a ten meter radius from the transacted property. This gradually increases as the radius becomes larger. For example, in 78% of the transactions there was at least one tree within 25 meter and in 92% of the transactions there was at least a tree within 75 meter. By using a radius of 100 meter, this percentage increases even further to 97%. The green volume measure, which is used as robustness check, is measured as cubic meters of green in a 5x5 meter grid. Subsequently, the total volume of green within the different radiuses of the transacted properties has been calculated. Figure 3.13 shows the map of the green volume in nightvision, in order to get a good view about the volume of green. The greener a specific area is, the higher the tree volume.

Figure 3.13: Green Volume in Amsterdam.

In figure 3.14, a close up of the Indische Buurt neighborhood in Amsterdam is shown. In this map, the buffers of public trees and transacted properties are shown. The buffers of the transacted properties in the map below are based on a ten meter radius, while the buffers of the public trees are based on the radius of the specific tree. The fact that some residential blocks in the map below do not show any transaction during 2005-2020 is due to the fact that those residential blocks are public/social housing.

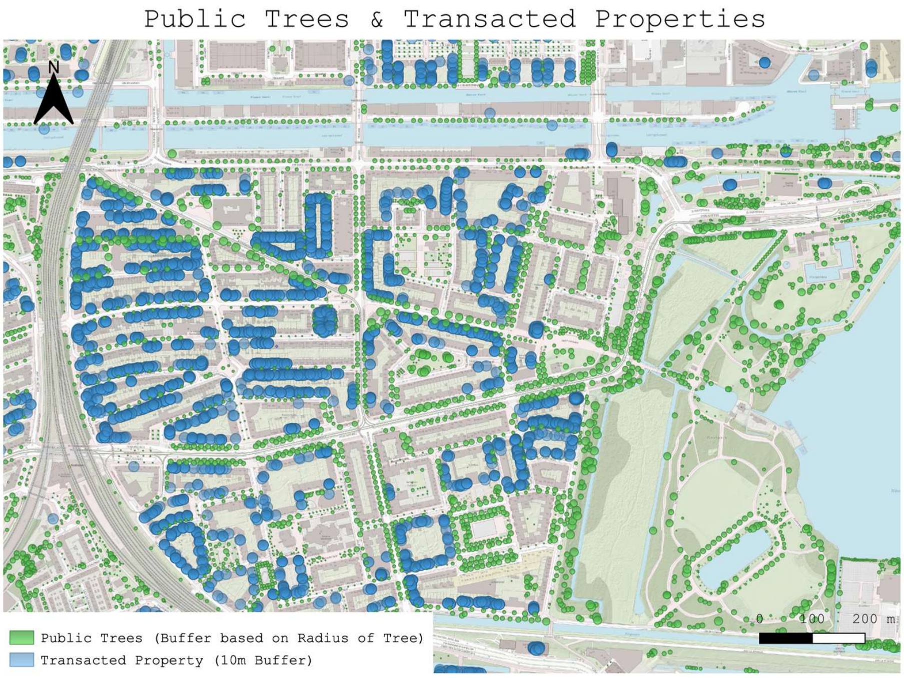

Figure 3.14: Public Trees and Transacted Property buffers (10 M) in the Indische Buurt neighbourhood in Amsterdam.

4. Empirical Results

This chapter discusses the empirical results of the study. Section 4.1 shows the basic OLS regressions and discusses the effect that public trees have on sales prices and time-on-the-market. Public trees are either measured as the number of public trees within a specific radius of the property or as a dummy which equals unity in case one or more public trees were present within a specific radius of the transacted property. Given that there are possible endogeneity issues between sales price and time-on-the-market, Section 4.2 uses an Instrumental Variable (IV) approach in order to find the unbiased effects and compares them to the results in Section 4.1. Thereafter, Section 4.3, covers the questions whether the possible effects of public trees on sales price and time-on-the-market tend to be constant across time (year) and space (city areas). In order to calculate these effects, the IV-approach is used.

4.1 OLS Regression Results

The statistical results of the basic OLS regressions are shown in figure 4.1 up to figure 4.8. In these tables, the regression results of the hedonic pricing model including various control variables, such as property controls, transaction controls, and spatial controls as well as fixed effects are shown. The dependent variables are either the natural logarithm of the transaction price or the natural logarithm of the time-on-the-market. The OLS regressions are executed for the number of trees within a radius of ten meter, 25 meter, 50 meter and 100 meter of the transacted property. However, given that this might not be a good measure, dummy variables are created. The full regression results of the dummy approach (including the full overview of control variables[4]) are shown in the Appendix.

According to figure 4.1, one additional tree within the ten meter radius of a transacted property would result in a 0.1% lower transaction price. By looking at the

[4] The transactional and property control variables used in this study are the natural logarithm of size, the type of housing, the number of bathrooms, kitchens, balconies and roof terraces, the maintenance level, the availability of central heating, the monumental status of the property, the fact whether it is newly built, sold on an auction, located on leasehold and the construction year. There are also spatial control variables such as the distance to public transport facilities, the distance to the city centre, the distance to the closest main road and the distance to recreational areas.

effect of the number of public trees within 25 meter of the transacted property (figure 4.2), we find somewhat similar results. An additional tree would lead to a 0.3% lower transaction price, which is significant at the 1% level. This effect is significant at the 5% level. According to figure 4.3, one additional tree within the 50 meter radius of a transacted property would result in a 0.1% lower transaction price. This effect is significant at the 1% level. An additional tree within the 100 meter radius (figure 4.4) would result in a 0.01% lower transaction price, while this result is statistically very strong it does not say much economically.

The effect that the control variable have on the sales price is almost fully in line with expectations. For example, there is a positive and very strongly statistical effect of the size on the sales price. Additionally, terraced and (semi)detached housing tends to sell at a premium compared to apartment buildings. The level of maintenance also has a positive relationship with the sales price, as well as the availability of central heating and monumental status. Properties situated on leasehold or sold at an auction tend to have a discount compared to properties sold without an auction or situated on freehold. Properties built between 1931 and 2000 tend to sell at a discount compared to properties built between 1905 and 1930. Properties built before 1905 or after 2000, on the other hand, tend to sell at a premium compared to this reference category. The spatial control variables also make sense. When, for example, the distance to the city centre increases, the sales price tends to decrease, while the distance to highways has a negative relationship with the price. Finally, we could argue that a house taking 10% longer to be sold would result in a lower final sales price of 0.17%[5]. Additionally, an 10% increase in the price would result in a 5.99% shorter time-on-the-market[6]. These latter findings confirm the results of Dubé & Legros (2016), who argue that houses with better amenities (i.e. higher prices) take less time to be sold.

[5] Exp(-0.018*log(1.1))-1 = -0.17%

[6] Exp(-0.648*log(1.1))-1 = -5.99%

According to figure 4.5, one additional tree within the ten meter radius would result in a decrease of 0.11% in time-on-the-market. This coefficient is statistically significant at the 1% level. The same negative relationship holds for trees within the 25 meter radius. However, this effect is closer to zero than the ten meter radius. One additional tree within the 25 meter radius would result in a 0.02% shorter time-on-the-market (figure 4.6). By increasing the radius of the transacted properties, the effect of trees on time-on-the-market decreases even more. In both the 50 meter radius and the 100 meter radius, one additional tree would result in a decrease of 0.1% in time-on-the-market (figure 4.7 and figure 4.8). In both regressions, these results are statistically significant at the 1% level. The control variables in the time-on-the-market regressions do, in general, also make sense. Larger properties tend to have a larger time-on-the-market. Moreover, properties sold on an auction tend to have a time-on-the-market which is more than 50% lower than during normal transactions. Additionally, monumental buildings tend to have a longer time-on-the-market as well as newly built dwellings. The larger the distance to the city centre, the longer the time-on-the-market is.

Overall, the regressions show that the effect of the number of trees on prices and time-on-the-market becomes very small as the number of control variables and fixed effects increases. This would mean that the estimated coefficients cannot be considered to be economically significant. For example, the average monetary effect of trees on sales prices within the ten meter radius equals €181.21[7]. The largest change in estimated coefficient happens between regressions 4 and 5. This has to do with the inclusion of PC4 fixed effects. This would mean that part of the variability in public trees is captured by the PC4 fixed effects. The fact that the number of trees have a negative coefficient as opposed to other studies such as Donovan & Butry (2010), could mean that the number of trees is not a good indicator. A large number of trees within a short distance of the transacted property could mean that there are a lot of smaller trees. This could result in a complex non-linear effect, i.e. trees do

[7] -0.1%*€355,318*0.51 = €181.21

have a positive impact, but an area with less and larger trees may be better than an area with more and smaller trees. In order to test this, the dummy variable approach is used.

The price index and the time-on-the-market index based on the hedonic pricing model, holding quality constant, is shown in in the graph below. As shown in the graph, the time-on-the-market tends to be more volatile than the sales prices. Additionally, it seems that over time, the time-on-the-market moves first, followed by a change in price instead of the other way around.

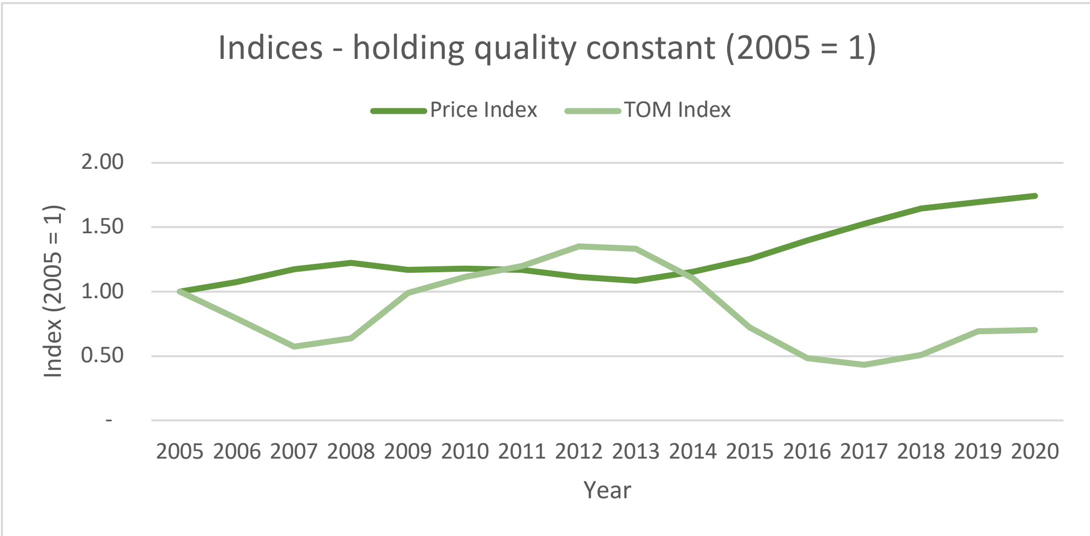

Figure 4.1: OLS Regression Price and Trees (10M)

The regressions below show the effect of the number of trees within the 10 meter radius of a transacted property on the sales price of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year and per PC4 area).

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Ln(Price)	Ln(Price)	Ln(Price)	Ln(Price)	Ln(Price)
#Trees (10M)	0.005***	0.018***	-0.003***	-0.005***	-0.001**
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	12.599***	8.864***	8.978***	8.691***	8.699***
	(0.002)	(0.014)	(0.012)	(0.009)	(0.013)
Observations	134,813	130,482	130,481	130,481	130,481
R-squared	0.000	0.619	0.710	0.849	0.909
Property Controls	No	Yes	Yes	Yes	Yes
Transaction Controls	No	Yes	Yes	Yes	Yes
Spatial Controls	No	No	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes
PC4 FE	No	No	No	No	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 4.2: OLS Regression Price and Trees (25M)

The regressions below show the effect of the number of trees within the 25 meter radius of a transacted property on the sales price of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year and per PC4 area).

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Ln(Price)	Ln(Price)	Ln(Price)	Ln(Price)	Ln(Price)
#Trees (25M)	-0.019***	-0.009***	-0.010***	-0.010***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	12.671***	8.924***	9.031***	8.739***	8.710***
	(0.002)	(0.014)	(0.012)	(0.009)	(0.013)
Observations	134,813	130,482	130,481	130,481	130,481
R-squared	0.013	0.621	0.714	0.853	0.909
Property Controls	No	Yes	Yes	Yes	Yes
Transaction Controls	No	Yes	Yes	Yes	Yes
Spatial Controls	No	No	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes
PC4 FE	No	No	No	No	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 4.3: OLS Regression Price and Trees (50M)

The regressions below show the effect of the number of trees within the 50 meter radius of a transacted property on the sales price of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year and per PC4 area).

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Ln(Price)	Ln(Price)	Ln(Price)	Ln(Price)	Ln(Price)
#Trees (50M)	-0.008***	-0.005***	-0.004***	-0.004***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	12.710***	8.942***	9.039***	8.749***	8.714***
	(0.003)	(0.014)	(0.012)	(0.009)	(0.013)
Observations	134,813	130,482	130,481	130,481	130,481
R-squared	0.024	0.627	0.717	0.856	0.909
Property Controls	No	Yes	Yes	Yes	Yes
Transaction Controls	No	Yes	Yes	Yes	Yes
Spatial Controls	No	No	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes
PC4 FE	No	No	No	No	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 4.4: OLS Regression Price and Trees (100M)

The regressions below show the effect of the number of trees within the 100 meter radius of a transacted property on the sales price of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year and per PC4 area).

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Ln(Price)	Ln(Price)	Ln(Price)	Ln(Price)	Ln(Price)
#Trees (100M)	-0.003***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	12.741***	8.960***	9.068***	8.777***	8.723***
	(0.003)	(0.014)	(0.012)	(0.009)	(0.013)
Observations	134,813	130,482	130,481	130,481	130,481
R-squared	0.026	0.626	0.718	0.857	0.909
Property Controls	No	Yes	Yes	Yes	Yes
Transaction Controls	No	Yes	Yes	Yes	Yes
Spatial Controls	No	No	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes
PC4 FE	No	No	No	No	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 4.5: OLS Regression TOM and Trees (10M)

The regressions below show the effect of the number of trees within the 10 meter radius of a transacted property on the time-on-the-market of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year and per PC4 area).

VARIABLES	(1) Ln(TOM)	(2) Ln(TOM)	(3) Ln(TOM)	(4) Ln(TOM)	(5) Ln(TOM)
#Trees (10M)	-0.065***	-0.023***	-0.028***	-0.029***	-0.011***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)
Constant	3.917***	10.668***	11.448***	7.814***	8.805***
	(0.004)	(0.081)	(0.091)	(0.125)	(0.169)
Observations	130,737	130,482	130,481	130,481	130,481
R-squared	0.002	0.125	0.128	0.182	0.195
Property Controls	No	Yes	Yes	Yes	Yes
Transaction Controls	No	Yes	Yes	Yes	Yes
Spatial Controls	No	No	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes
PC4 FE	No	No	No	No	Yes

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Figure 4.6: OLS Regression TOM and Trees (25M)

The regressions below show the effect of the number of trees within the 25 meter radius of a transacted property on the time-on-the-market of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year and per PC4 area).

VARIABLES	(1) Ln(TOM)	(2) Ln(TOM)	(3) Ln(TOM)	(4) Ln(TOM)	(5) Ln(TOM)
#Trees (25M)	-0.009***	-0.010***	-0.011***	-0.006***	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	3.919***	10.777***	11.582***	7.927***	8.823***
	(0.005)	(0.082)	(0.092)	(0.127)	(0.169)
Observations	130,737	130,482	130,481	130,481	130,481
R-squared	0.001	0.125	0.129	0.182	0.195
Property Controls	No	Yes	Yes	Yes	Yes
Transaction Controls	No	Yes	Yes	Yes	Yes
Spatial Controls	No	No	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes
PC4 FE	No	No	No	No	Yes

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Figure 4.7: OLS Regression TOM and Trees (50M)

The regressions below show the effect of the number of trees within the 50 meter radius of a transacted property on the time-on-the-market of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year and per PC4 area).

VARIABLES	(1) Ln(TOM)	(2) Ln(TOM)	(3) Ln(TOM)	(4) Ln(TOM)	(5) Ln(TOM)
#Trees (50M)	-0.000	-0.003***	-0.003***	-0.001***	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	3.891***	10.823***	11.607***	7.900***	8.824***
	(0.005)	(0.082)	(0.092)	(0.128)	(0.170)
Observations	130,737	130,482	130,481	130,481	130,481
R-squared	0.000	0.125	0.129	0.182	0.195
Property Controls	No	Yes	Yes	Yes	Yes
Transaction Controls	No	Yes	Yes	Yes	Yes
Spatial Controls	No	No	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes
PC4 FE	No	No	No	No	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 4.8: OLS Regression TOM and Trees (100M)

The regressions below show the effect of the number of trees within the 100 meter radius of a transacted property on the time-on-the-market of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year and per PC4 area).

VARIABLES	(1) Ln(TOM)	(2) Ln(TOM)	(3) Ln(TOM)	(4) Ln(TOM)	(5) Ln(TOM)
#Trees (100M)	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	3.922***	10.886***	11.712***	8.043***	8.899***
	(0.006)	(0.082)	(0.092)	(0.129)	(0.170)
Observations	130,737	130,482	130,481	130,481	130,481
R-squared	0.000	0.126	0.130	0.182	0.195
Property Controls	No	Yes	Yes	Yes	Yes
Transaction Controls	No	Yes	Yes	Yes	Yes
Spatial Controls	No	No	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes
PC4 FE	No	No	No	No	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results of the dummy regressions show a different relationship between trees and both sales price and time-on-the-market. To show the effect that trees have on either sales prices or time-on-the-market, it is valid to omit the PC4 area fixed effects, because these fixed effects tend to capture a large part of the variability. By not including the PC4 fixed effects, the effect of the tree dummy on sales prices can be considered as positive and statistically significant for all radiuses (see figure 4.9). However, the extent of the effect differs per radius. For example, the presence of trees within a radius of ten meter from the transacted property tend to result in a 4% higher sales price, while trees within a radius of 50 meter from the transacted property tend to result in a 10% higher sales price. The opposite holds for the relationship between the tree dummy and the time-on-the-market (see figure 4.10). The presence of a tree within a radius of 25 meter tend to result in a 6.5% lower time-on-the-market. Again, the extent differs per radius. The regressions shows that the results are in line with expectations. In other words, trees tend to have a positive effect on house prices and a negative effect on time-on-the-market. This is in line with the outcomes of other studies such as Donovan & Butry (2010), Staats & Swain (2020), and Culp (2008). Given that both sales price and time-on-the-market are used as variables in the regressions, there might be an overestimation bias given the simultaneously optimization problem described earlier. In order to tackle this bias, section 4.2 uses an instrumental variable (IV) approach, which is in line with the paper by Dubé & Legros (2016).

Figure 4.9: OLS Regression Price and Trees (Dummy)

The regressions below (in figure 4.9 and figure 4.10) show the effect of the presence of public trees within the 10 meter, 25 meter, 50 meter, and 100 meter radius of a transacted property on the sales price and the time-on-the-market of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year and per PC4 area).

	(1)	(2)	(3)	(4)
VARIABLES	Ln(Price)	Ln(Price)	Ln(Price)	Ln(Price)
Dummy Tree (10M)	0.040***			
	(0.001)			
Dummy Tree (25M)		0.029***		
		(0.002)		
Dummy Tree (50M)			0.101***	
			(0.004)	
Dummy Tree (100M)				0.225***
				(0.006)
Constant	8.486***	8.486***	8.408***	8.285***
	(0.011)	(0.011)	(0.011)	(0.012)
Observations	130,481	130,481	130,481	130,481
R-squared	0.774	0.774	0.776	0.777
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	No	No	No	No

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 4.10: OLS Regression TOM and Trees (Dummy)

	(1)	(2)	(3)	(4)
VARIABLES	Ln(TOM)	Ln(TOM)	Ln(TOM)	Ln(TOM)
Dummy Tree (10M)	-0.078***			
	(0.006)			
Dummy Tree (25M)		-0.114***		
		(0.007)		
Dummy Tree (50M)			-0.143***	
			(0.011)	
Dummy Tree (100M)				-0.157***
				(0.020)
Constant	8.245***	8.322***	8.292***	8.327***
	(0.103)	(0.103)	(0.103)	(0.103)
Observations	130,481	130,481	130,481	130,481
R-squared	0.168	0.169	0.168	0.168
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	No	No	No	No

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.2 Instrumental Variable (IV) Results

The results in Section 4.1 show that there is an economically neglectable, but negative statistical effect of public trees on sales prices when the number of trees is used as variable. However, once the number of trees variable is changed to a dummy variable, the results tend to be positive and economically as well as statistically significant. The coefficients might, however, be considered as biased given the presence of both sales price and time-on-the-market in the same specification. This bias occurs due to the spatiotemporal optimization problem between sales price and time-on-the-market. This study tries to solve this problem by applying an IV-approach. The possible instruments that are used to solve the endogeneity problems are the mean time-on-the-market per PC4 area, the mean list price per PC4 area, the annual number of houses sold in the PC4 area and the ratio between the mean sales price and the mean listing price per PC4 area.

The highest correlation among the newly created (instrumental) variables is equal to 0.73 and can be found between the natural logarithm of price and the mean list price per PC4 area. The second highest correlation coefficient is -0.627 and occurs between the natural logarithm of price and the mean time-on-the-market per PC4 area. Possible multicollinearity problems within the IVs are not really applicable.

Figure 4.11: Matrix of correlations

Variables	(1) Ln(Price)	(2) Ln(TOM)	(3) Mean TOM	(4) Mean List Price	(5) Ln(Houses Sold)	(6) Ratio Mean Listing/ Sales
(1) Ln(Price)	1.000					
(2) Ln(TOM)	-0.136	1.000				
(3) Mean TOM	-0.374	0.426	1.000			
(4) Mean List Price	0.730	-0.180	-0.425	1.000		
(5) Ln(Houses Sold)	0.086	-0.130	-0.213	0.101	1.000	
(6) Ratio Mean Listing/Sales	0.400	-0.291	-0.627	0.474	0.216	1.000

Using the instruments described above, together with year fixed effects, the public tree dummy of a certain radius and other (spatial) control variables, a first stage regression can be conducted for both the sales price and the time-on-the-market. The first stage regressions are not meant for major interpretations. The goal of the first stage regressions is to obtain an exogeneous versions of the sales price and the time-on-the-market. The instruments in the price regression are average time-on-the-market per year per PC4 area, the number of houses sold per year per PC4 area, and the ratio between the list price and the sales price per year per PC4 area. The instruments for the time-on-the-market regression are the ratio between the list price and the sales price per year per PC4 area and the list price per year per PC4 area. The exogenous (logarithmic) variables of the sales price and the time-on-the-market are finally obtained by using the predicted values of the regressions. In order to test whether the initial variables (sales price and time-on-the-market) are indeed endogenous, the residuals of the first stage regression are added as independent variables in the initial regressions stated in section 4.1. By doing this, these new variables seem to be highly significant. This means that there is a correlation between the unobserved, and thus, unmeasured components in the regression, which induces an endogeneity problem. The reason to include an IV-regression is therefore considered to be valid[8]. Additionally, a test[9] for weak instruments has been conducted. This tests rejects the null hypothesis that the instruments are weak.

The regression results of the full IV-regression are shown in figure 4.12 and figure 4.13. It can be concluded that, in general, the signs of the coefficients did not change in the IV-setting compared to the OLS-setting. However, the magnitude of the coefficients changed -in some cases- significantly. The relatively high positive effects found in the OLS price regression decreased in the IV-setting to a more plausible magnitude. The initial high coefficients could be caused by the overestimation bias in the OLS-setting, which is solved in the IV-setting. Based on the results, we could argue that the presence of public trees within a ten meter radius,

[8] This can also be done by using the *estat endog* tests in STATA. The null hypothesis (H0) tests whether the initial regression – before IV – can be considered as exogenous. Both the Durban score and the Wu-Hausman score clearly indicate that the initial regression suffers from an endogeneity problem, given that the null hypothesis is clearly rejected.

[9] This can be done by using the *estat firststage* module in STATA. The null hypothesis (H0) tests whether the instruments are weak. Given that the eigenvalue statistics are significantly higher than the critical values, we can argue that the instruments are not weak.

a 25 meter radius, a 50 meter radius and a 100 meter radius would change the prices of transacted properties with respectively 0.6%, -1.5%, 3.5% and 13.1%. The 25 meter radius as well as the 50 meter radius and the 100 meter radius tree dummies are significant at the 1% level, while the 10 meter radius tree dummy is significant at the 5% level. This means that public trees contribute, on average, between -€5,330 and €46,547 to the final sales price, depending on the radius used. These results are in line with the outcomes of other studies such as Donovan & Butry (2010). They find an increase in prices of around $8,870. Daams, et al. (2019) find that the presence of trees increases the sales price of a property by 7.1% up to 9.3%. The results also show that public trees tend to decrease the time-on-the-market with 8.5%, 11.9%, 16% or 19.5%, depending on the radius used. This means that, on average, public trees tend to decrease the time-on-the-market by 7.8 days up to 17.9 days, depending on the radius used. All public tree dummy coefficients of the time-on-the-market regressions are significant at the 1% level. Again, this is in line with previous studies. Culp (2008) found, for example, that the presence of trees could reduce the time-on-the-market by at least 50%, while Donovan & Butry (2010) found a much smaller, but still negative, effect of 1.7 days. An important note regarding these studies has, however, to be made. Both Donovan & Butry (2010) and Culp (2008) use the natural logarithm of price in their time-on-the-market regression and vice versa. They do, however, not take the simultaneous optimization problem between those two variables into account, which could lead to biased estimators as mentioned in Sirmans, et al. (2010), and Dubé & Legros (2016).

Finally, the majority of the control variables make sense. For example, there is a positive relationship between the size of the property and its price. Additionally, terraced housing, semidetached housing or detached housing is sold at a premium compared to apartment buildings. Central heating facilities, as well as good maintenance leads to a higher price. Also, monumental status increases the price of the property, while leasehold, on the other hand, has a negative effect on the price. The price of a property also decreases as the distance to public transport facilities increases, while the price increases as the distance to main roads increases. Properties sold at an auction tend to have a lower time-on-the-market, while monumental properties tend to have a higher time-on-the-market. Larger properties also tend to have a higher time-on-the-market, just as detached housing relative to apartments. The full IV regression results are shown in the Appendix.

Figure 4.12: IV Regression Price and Trees

The IV regressions below show the effect of the presence of public trees within the 10 meter, 25 meter, 50 meter, and 100 meter radius of a transacted property on the sales price and the time-on-the-market of the specific property. The instruments in the Price regression are average TOM per year per PC4 area, the number of houses sold per year per PC4 area, and the ratio between the list price and the sales price per year per PC4 area. The instruments for the TOM regression are the ratio between the list price and the sales price per year per PC4 area and the list price per year per PC4 area.

VARIABLES	(1) Ln(Price)	(2) Ln(Price)	(3) Ln(Price)	(4) Ln(Price)
Dummy Tree (10M)	0.006**			
	(0.003)			
Dummy Tree (25M)		-0.015***		
		(0.003)		
Dummy Tree (50M)			0.035***	
			(0.004)	
Dummy Tree (100M)				0.131***
				(0.007)
Constant	9.505***	9.539***	9.459***	9.346***
	(0.022)	(0.023)	(0.023)	(0.023)
Observations	130,481	130,481	130,481	130,481
R-squared	0.426	0.417	0.436	0.448
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	No	No	No	No

Figure 4.13: IV Regression TOM and Trees

VARIABLES	(1) Ln(TOM)	(2) Ln(TOM)	(3) Ln(TOM)	(4) Ln(TOM)
Dummy Tree (10M)	-0.085***			
	(0.006)			
Dummy Tree (25M)		-0.119***		
		(0.007)		
Dummy Tree (50M)			-0.160***	
			(0.010)	
Dummy Tree (100M)				-0.195***
				(0.018)
Constant	7.032***	7.108***	6.981***	7.002***
	(0.141)	(0.141)	(0.142)	(0.142)
Observations	130,481	130,481	130,481	130,481
R-squared	0.167	0.168	0.167	0.166
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3 Effects over time and across space

The results of section 4.2 show that there is a statistically significant and positive effect of public trees on the sales price, while there is a statistically significant and negative effect of public trees on the time-on-the-market. This holds in both the OLS-approach as well as the IV-approach. However, in the IV-approach, the magnitude of the effects tend to decrease due to a possible overestimation bias in the OLS setting. Given these results, it is interesting to examine whether the effects that public trees have on either sales price or time-on-the-market tends to be constant across space and over time. This is tested by using interaction effects between either the specific years or the city areas (*stadsdelen*). Given that the IV-regression including the 50 meter radius tree dummy can be considered as the best regression, the possible constant effects across space and over time are tested based on this regression. Additionally, the year 2005 is used as base category, as well as Amsterdam Centrum. The results of the regressions are shown in figure 4.14 and figure 4.15. As shown in figure 4.14, there are slightly positive effects of the interaction variables on the transaction price in almost every year compared to the base year (2005). These positive interaction effect decrease slightly over time. In 2018, the interaction effect becomes insignificant (i.e. not different compared to the base year). There is another pattern regarding the effect of the interaction variables on the time-on-the-market. Up to 2015, there is no difference in effect compared to the base year (except for 2011). However, after 2015, there appears to be a stronger negative effect. In other words, the negative effect that trees have on time-on-the-market becomes stronger over time.

As shown in figure 4.15, there is an insignificant or negatively and significant effect between the interaction variables of city-areas and the tree dummy on the transaction price. This means that the effects are not constant across space. This also holds regarding time-on-the-market. In the majority of the city-areas, the effect that the presence of public trees have on time-on-the-market is stronger in other areas compared to the city centre. By conducting a statistical test, we can reject the null hypothesis that the effects that trees have on either transaction prices or time-on-the-market is constant across space[10] or constant over time[11]. In both regressions, the control variables that were also present in Section 4.2 are used. Additionally, there is controlled for different types of fixed effects (year, city area). PC4 fixed effects, which were initially used, are omitted in this analysis given the large multicollinearity with city area fixed effects.

[10] This is done by using *Testparm* in STATA. The Chi-squared test score equals 62,149.96 for the regression with Ln(Price) as dependent variable and 1,104.72 for the regression with Ln(TOM) as dependent variable which both result in a P-value of 0.0000. This means that we can reject the null-hypothesis that the effect is constant across space for both the price and the time-on-the-market.

[11] This is done by using *Testparm* in STATA. The Chi-squared test score equals 70,687.67 for the regression with Ln(Price) as dependent variable and 8,131.50 for the regression with Ln(TOM) as dependent variable which both result in a P-value of 0.0000. This means that we can reject the null-hypothesis that the effect is constant across space for both the price and the time-on-the-market.

Figure 4.14: Interaction Effects (Year)

The IV regressions show the interaction effects between the presence of public trees within the 10 meter, 25 meter, 50 meter, and 100 meter radius of a transacted property and the year of transaction on the sales price and the time-on-the-market of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year). The base category of this regression is the transaction year 2005.

VARIABLES	(1) Ln(TOM)	(2) Ln(Price)
2006 * Tree Dummy (50M)	0.060	0.021
	(0.060)	(0.013)
2007 * Tree Dummy (50M)	-0.049	0.039***
	(0.060)	(0.013)
2008 * Tree Dummy (50M)	-0.041	0.051***
	(0.061)	(0.013)
2009 * Tree Dummy (50M)	0.073	0.045***
	(0.065)	(0.014)
2010 * Tree Dummy (50M)	0.104	0.052***
	(0.066)	(0.014)
2011 * Tree Dummy (50M)	0.149**	0.080***
	(0.067)	(0.014)
2012 * Tree Dummy (50M)	0.099	0.058***
	(0.065)	(0.014)
2013 * Tree Dummy (50M)	-0.025	0.052***
	(0.066)	(0.014)
2014 * Tree Dummy (50M)	0.094	0.114***
	(0.058)	(0.012)
2015 * Tree Dummy (50M)	-0.246***	0.119***
	(0.057)	(0.012)
2016 * Tree Dummy (50M)	-0.203***	0.092***
	(0.057)	(0.012)
2017 * Tree Dummy (50M)	0.021	0.086***
	(0.059)	(0.012)
2018 * Tree Dummy (50M)	-0.149***	0.005
	(0.057)	(0.012)
2019 * Tree Dummy (50M)	-0.183***	0.014
	(0.058)	(0.012)
2020 * Tree Dummy (50M)	-0.183***	-0.008
	(0.058)	(0.012)
Constant	4.958***	8.875***
	(0.317)	(0.016)
Observations	130,481	130,481
R-squared	0.168	0.854
Controls	Yes	Yes
Year FE	Yes	Yes
Neighbourhood FE	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 4.15: Interaction Effects (City Area)

The IV regressions show the interaction effects between the presence of public trees within the 10 meter, 25 meter, 50 meter, and 100 meter radius of a transacted property and the city area of the transacted property on the sales price and the time-on-the-market of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year). The base category of this regression is the Amsterdam Centrum.

VARIABLES	(1) Ln(TOM)	(2) Ln(Price)
Amsterdam Noord * Tree Dummy (50M)	-0.286***	-0.274***
	(0.046)	(0.010)
Amsterdam West * Tree Dummy (50M)	0.228***	-0.009
	(0.050)	(0.011)
Amsterdam N-West * Tree Dummy (50M)	0.173**	0.004
	(0.075)	(0.016)
Amsterdam Zuid * Tree Dummy (50M)	0.254***	-0.007
	(0.034)	(0.007)
Amsterdam Oost * Tree Dummy (50M)	-0.001	-0.041***
	(0.045)	(0.010)
Amsterdam Z-Oost * Tree Dummy (50M)	0.394***	0.035***
	(0.036)	(0.008)
Constant	5.723***	8.868***
	(0.315)	(0.015)
Observations	130,481	130,481
R-squared	0.171	0.847
Controls	Yes	Yes
Year FE	Yes	Yes
Neighbourhood FE	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Robustness Checks

In this study, several robustness checks have been executed. First of all, the linearity of the variables is checked by constructing several scatterplots between the dependent variables (price and time-on-the-market) and independent variables. Based on these scatterplots, the price and time-on-the-market is logarithmic transformed. Additionally, the size of the transacted properties is changed into a logarithmic function. After that, the distribution of the variables of interest is examined by making use of histograms including a normal distribution line. The normal distribution of the residuals is also checked. Subsequently, the property specific variables are -if needed- winsorized at the appropriate levels with a maximum of 0.1% on the left side and 0.05% on the right side. The spatial variables are -if needed- winsorized at a maximum of 5%. Additionally, several checks have been conducted on the multicollinearity between the variables. The fixed effects are also tested. Based on these tests, it became clear that the PC4 Area fixed effects as well as the year fixed effects need to be included in the specification. Finally, robust standard errors are applied to correct for possible heterogeneity issues.

In order to check whether the results presented in Section 4 are robust, a different variable related to the amount of public green is constructed. This variable is constructed as the total green volume (in cubic meters) that is located within the different buffers (10m, 25m, 50m, and 100m) of the transacted properties. The dataset is initially created by boomregister.nl and covers all types of green. However, older (larger) trees tend to result in a higher green volume than younger (shorter) trees. Bushes, plants, and grass are also taken into account in this dataset. However, given the low volume of these green objects, they do not have a significant contribution to the total green volume. The total volume of green within a specific radius is transformed into a logarithmic function. This means that the relationship between green volume and sales price or time-on-the-market can be considered as an elasticity. Additionally, the same IV method as discussed in section 4 is used. Therefore, both time-on-the-market and sales price can be present in the same regression despite the simultaneous optimization problem and the ensuing overestimation bias. The initial results of this study, as shown in section 4, could be considered robust when the regressions with the green volume variable would result in the same outcomes as the initial analysis.

Figure 5.1 shows the effect of the total volume of green within different radiuses on the sales price of a house. The initial results in section 4 showed that there is a positive effect on presence of trees on house prices. What also becomes clear from this figure is that their appears to be a statistically strong and positive effect between green volume and price. The effects range from 0.003% up to 0.019%. This means, for example, that when green volume within a 100 meter radius increases by 1%, the sales price increases by 0.019%. These positive and statistically very strong results are in line with previous estimates. Based on the average sales price within the sample, a 10% increase of green volume within a 100 meter radius of the transacted property, would increase the sales price by € 675.10.

In figure 5.2, the effect of the total volume of green within a specific radius on the time-on-the-market is shown. Previous estimations showed a negative effect between the presence of trees within a specific radius of the house and time-on-the-market. What becomes clear from figure 5.2 is that there is indeed a statistically strong negative relationship between green volume and time-on-the-market. The effects range from -0.05% up to -0.038%. In other words, when the green volume within the 50 meter radius increases by 1%, the time-on-the-market tends to decrease by 0.038%. Based on the average time-on-the-market within the sample, a 10% increase in the green volume within the 50 meter radius of a transacted property, would decrease the time-on-the-market by approximately 0.35 day (8 or 9 hours).

Figure 5.3 and 5.4 show that there is indeed no constant effect over time or across space. In other words, the effects differ per year and per city area. These findings are also in line with the initial results of section 4. This is tested by the Testparm function in STATA. In case of the effects over space, The Chi-squared test score equals 1029.79 for the regression with the natural logarithm of sales price as dependent variable and 35.62 for the regression with the natural logarithm of time-on-the-market as dependent variable, which both result in a P-value of 0.0000. This means that we can reject the null-hypothesis that the effect is constant across space for both the price and the time-on-the-market. This also holds for the regressions where the effect over time is measured. The Chi-squared test score equals 1,414 for the regression with the logarithm of price as dependent variable and 221.61 for the regression with the natural logarithm of time-on-the-market as dependent variable which both result in a P-value of 0.0000. We could therefore argue that the effects are – just as in the initial regression – not constant over time or across space. There, thus, seems to exist differences regarding the preferences of buyers and sellers over time. Additionally, the extent to which green volume is valued (via a higher sales price or shorter time-on-the-market) differs per city area. This could be explained by the fact that the green volume is unequal distributed across the city. In city areas with lots of green volume, an individual might be willing to pay less for additional green volume compared to a city area where there is not a lot of public green. This is, for example, the case in Amsterdam Centrum. Based on the outcomes of the robustness check compared to the initial analysis, we can consider the initial analysis to be robust. The full regression results of the Robustness checks are shown in the Appendix.

Figure 5.1: IV Regression Price and Green Volume

The IV regressions below (in figure 5.1 and figure 5.2) show the effect of the total volume of green within the 10 meter, 25 meter, 50 meter, and 100 meter radius of a transacted property on the sales price and the time-on-the-market of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year).

	(1)	(2)	(3)	(4)
VARIABLES	Ln(Price)	Ln(Price)	Ln(Price)	Ln(Price)
Green Volume (10M)	0.003***			
	(0.001)			
Green Volume (25M)		0.008***		
		(0.001)		
Green Volume (50M)			0.012***	
			(0.001)	
Green Volume (100M)				0.019***
				(0.001)
Constant	8.831***	8.812***	8.733***	8.651***
	(0.025)	(0.019)	(0.019)	(0.020)
Observations	59,845	110,831	116,507	117,522
R-squared	0.901	0.896	0.894	0.892
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 5.2: IV Regression TOM and Green Volume

	(1)	(2)	(3)	(4)
VARIABLES	Ln(TOM)	Ln(TOM)	Ln(TOM)	Ln(TOM)
Green Volume (10M)	-0.005			
	(0.003)			
Green Volume (25M)		-0.029***		
		(0.003)		
Green Volume (50M)			-0.038***	
			(0.004)	
Green Volume (100M)				-0.032***
				(0.005)
Constant	5.965***	6.923***	6.978***	6.897***
	(0.253)	(0.183)	(0.177)	(0.176)
Observations	59,845	110,831	116,507	117,522
R-squared	0.172	0.179	0.179	0.180
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	No	No	No	No

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 5.3: Effects across Space

The IV regressions show the interaction effects between the total volume of green within the 10 meter, 25 meter, 50 meter, and 100 meter radius of a transacted property and the city area of the transacted property on the sales price and the time-on-the-market of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year). The base category of this regression is Amsterdam Centrum.

VARIABLES	(1) Ln(TOM)	(2) Ln(Price)
Amsterdam Noord * Green Volume (50M)	0.025*	-0.032***
	(0.015)	(0.003)
Amsterdam West * Green Volume (50M)	-0.015	-0.014***
	(0.012)	(0.002)
Amsterdam N-West * Green Volume (50M)	0.003	-0.003
	(0.013)	(0.002)
Amsterdam Zuid * Green Volume (50M)	0.037***	0.010***
	(0.013)	(0.002)
Amsterdam Oost * Green Volume (50M)	-0.027**	0.016***
	(0.012)	(0.002)
Amsterdam Z-Oost * Green Volume (50M)	0.046**	0.016***
	(0.019)	(0.004)
Constant	5.865***	8.615***
	(0.359)	(0.021)
Observations	116,507	116,507
R-squared	0.181	0.885
Controls	Yes	Yes
Year FE	Yes	Yes
Neighborhood FE	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 5.4: Effects over time

The IV regressions show the interaction effects between the total volume of green within the 10 meter, 25 meter, 50 meter, and 100 meter radius of a transacted property and the year of transaction on the sales price and the time-on-the-market of the specific property. Various control variables (property specific, transactional, spatial) are incorporated as well as fixed effects (per year). The base category of this regression is the transaction year 2005.

VARIABLES	(1) Ln(TOM)	(2) Ln(Price)
2006 * Green Volume (50M)	0.006	0.002
	(0.020)	(0.004)
2007 * Green Volume (50M)	0.008	0.001
	(0.019)	(0.004)
2008 * Green Volume (50M)	0.019	0.007*
	(0.020)	(0.004)
2009 * Green Volume (50M)	-0.017	0.003
	(0.021)	(0.004)
2010 * Green Volume (50M)	0.010	0.005
	(0.021)	(0.004)
2011 * Green Volume (50M)	-0.011	0.008**
	(0.021)	(0.004)
2012 * Green Volume (50M)	0.053**	0.012***
	(0.021)	(0.004)
2013 * Green Volume (50M)	0.017	-0.008*
	(0.021)	(0.004)
2014 * Green Volume (50M)	-0.006	0.005
	(0.019)	(0.004)
2015 * Green Volume (50M)	0.012	0.008**
	(0.018)	(0.003)
2016 * Green Volume (50M)	0.014	0.019***
	(0.019)	(0.004)
2017 * Green Volume (50M)	0.074***	0.024***
	(0.019)	(0.004)
2018 * Green Volume (50M)	0.036*	0.005
	(0.020)	(0.004)
2019 * Green Volume (50M)	-0.005	-0.006
	(0.019)	(0.004)
2020 * Green Volume (50M)	0.033*	-0.001
	(0.019)	(0.004)
Constant	5.969***	8.669***
	(0.376)	(0.029)
Observations	116,507	116,507
R-squared	0.181	0.884
Controls	Yes	Yes
Year FE	Yes	Yes
Neighborhood FE	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

6. Limitations and Future Research

As the previous section showed, the results are roughly verifiable after applying robustness checks. Based on the initial measure of the number of trees, the effects appear to be slightly negative, but not economically significant. After applying the same method with another measure of tree cover (i.e. a dummy which equals unity if there are public trees present within the radius), it appears that the effect becomes both statistically as well as economically significant. We could therefore say that public trees do contribute economically to both the time-on-the-market and the sales price. Public trees tend to have a positive effect on the sales price of a house, while they have a negative effect on the time-on-the-market. There are, however, some limitations regarding this study. First of all, the database consisting of the public tree data is computed on a fixed point in time (2020). The database shows the year of planting per individual public tree. A tree was, for a specific housing transaction, only taken into account when the year of planting was earlier than the year of transaction. We do, however, not have information about public trees that were cut down in the past. This study, therefore, assumes that trees that were cut down in the past did not contribute to different outcomes compared to the outcomes of the study as they are now. Another important limitation is that this study only covers housing transactions executed by the NVM. The NVM covers roughly 75% of the transactions. However, the remaining 25% may be sold off-market or by smaller or less experienced brokers, which could result in different pricing and time-on-the-market. Furthermore, this study focusses only on the effect that public trees have on sales prices and time-on-the-market within the municipality of Amsterdam. Given that there is no similar research conducted in in other cities in the Netherlands, we cannot validate the results externally at this stage. Future research on this topic could focus on other cities in the Netherlands. It is, for example, interesting to examine whether public trees may have the same relationship with sales prices and time-on-the-market in other large cities in the Netherlands such as Rotterdam, The Hague or Utrecht. Another interesting aspect to examine further is to compare the outcomes of larger cities with outcomes from rural areas.

7. Conclusion

This study examined the relationship between public trees and both the sales price and time-on-the-market in the Amsterdam housing market. The study is conducted based on various data sources such as a spatial database consisting of the public trees within the municipality of Amsterdam, property data from the NVM between the start of 2005 and the end of 2020 and other self-estimated spatial variables such as the distance to the city centre and the distance to public transport facilities. Additionally, spatial data from boomregister.nl is used as robustness check.

First, OLS regressions have been conducted. Based on these results, one could argue that the number of public trees is not a good measure to estimate the true effect that public trees have on housing prices and time-on-the-market. A large number of trees within a short distance of the transacted property could mean that there are a lot of smaller trees. This could result in a complex non-linear effect, i.e. trees do have a positive impact, but an area with less and larger trees may be better than an area with more and smaller trees. In order to test this, the dummy variable approach is used. By using this different measure, there appears to be a positive and significant effect on the sales price of houses. Additionally there is a somewhat stronger negative effect on the time-on-the-market. Given the possible endogeneity issues in the OLS-setting due to the so called "simultaneous optimization problem", which may cause biased estimators, an instrumental variable approach has been conducted based on the method described by Dubé & Legros (2016). Based on this approach, the coefficients regarding the sales price regression become statistically more significant and smaller. The coefficients in the time-on-the-market regressions become slightly stronger negative and much more statistically significant. Public green does contribute to changes in both the sales price and the time-on-the-market (i.e. they are economically significant). The outcomes are in line with previous research regarding this subject.

Given the developments over time in both consumer preferences, awareness regarding the climate and densification of cities, this study also conducted an analysis whether the effects of public trees on both sales price and time-on-the-market are constant across space and over time. By using the year 2006 and the Amsterdam Centre area as reference category, it appears that the effects are not constant across space nor are they over time. Finally, a robustness check has been conducted using data from boomregister.nl. This dataset enables measuring the green volume and also takes bushes, grass and plants into account instead of solely public trees. By using this measure, the same results as in the initial estimation have been found. In other words, there exists a positive relationship between public green (trees) and sales prices, while there exists a negative relationship between public green and time-on-the-market. This means that this study does not reject the first hypothesis, which stated that public trees may have a positive effect on sales price. Additionally, it does not rejects the second hypothesis stated that public trees have a negative relationship with time-on-the-market. However, this study rejects the third and fourth hypothesis given that the effects of public trees on house prices and time-on-the-market are neither constant over time nor constant across space.

Further research could focus on other large cities in the Netherlands such as Rotterdam, Utrecht or the Hague. Another interesting subfield to examine is to study whether there are differences regarding the effect between cities and sub-urban or rural areas. One could also examine the effect of neighbouring private trees (trees on the lot of neighbour's property) on the sales price and time-on-the-market of other houses.

To conclude, understanding the effect of public trees on sales prices and time-on-the-market of houses can be considered to be important for both real estate practitioners as well as policymakers. For example, valuers within the real estate sector could use these results in their daily valuation practices. Policymakers could, on the other hand, use these results in their decision making regarding urban renewal, place-based policies, as well as public investments in green areas.

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Appendix

OLS Regression (Price)

VARIABLES	(1) Ln(Price)	(2) Ln(Price)	(3) Ln(Price)	(4) Ln(Price)
Ln(TOM)	-0.042***	-0.042***	-0.041***	-0.041***
	(0.001)	(0.001)	(0.001)	(0.001)
Dum Tree (10M)	0.040***			
	(0.001)			
Ln(Size)	0.876***	0.874***	0.875***	0.874***
	(0.002)	(0.002)	(0.002)	(0.002)
Terraced	-0.079***	-0.078***	-0.079***	-0.080***
	(0.003)	(0.003)	(0.003)	(0.003)
Semidetached	-0.032***	-0.030***	-0.029***	-0.030***
	(0.005)	(0.005)	(0.005)	(0.005)
Detached	0.234***	0.238***	0.241***	0.239***
	(0.010)	(0.010)	(0.010)	(0.010)
1.nbathrooms	0.007***	0.007***	0.008***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
2.nbathrooms	0.185***	0.186***	0.185***	0.186***
	(0.005)	(0.005)	(0.005)	(0.005)
3.nbathrooms	0.243***	0.244***	0.245***	0.248***
	(0.015)	(0.015)	(0.015)	(0.015)
4.nbathrooms	0.168***	0.170***	0.170***	0.173***
	(0.032)	(0.032)	(0.032)	(0.032)
5.nbathrooms	0.295***	0.297***	0.298***	0.298***
	(0.067)	(0.066)	(0.065)	(0.066)
6.nbathrooms	-0.015	-0.011	-0.019	-0.014
	(0.139)	(0.135)	(0.130)	(0.131)
7.nbathrooms	0.444**	0.447**	0.448**	0.454**
	(0.206)	(0.196)	(0.196)	(0.195)
1.nkitchen	0.037***	0.037***	0.037***	0.036***
	(0.002)	(0.002)	(0.002)	(0.002)
2.nkitchen	-0.005	-0.004	-0.005	-0.007
	(0.009)	(0.009)	(0.009)	(0.009)
3.nkitchen	-0.098***	-0.096***	-0.099***	-0.101***
	(0.022)	(0.022)	(0.022)	(0.022)
4.nkitchen	-0.218***	-0.220***	-0.224***	-0.225***
	(0.044)	(0.044)	(0.044)	(0.044)
5.nkitchen	-0.125*	-0.122	-0.121	-0.126*
	(0.074)	(0.075)	(0.074)	(0.076)
1.nbalcony	-0.028***	-0.028***	-0.030***	-0.029***
	(0.002)	(0.002)	(0.002)	(0.002)
2.nbalcony	0.086***	0.086***	0.084***	0.085***
	(0.005)	(0.006)	(0.006)	(0.006)

3.nbalcony	0.076**	0.074**	0.074**	0.076**
	(0.033)	(0.033)	(0.033)	(0.033)
4.nbalcony	0.127	0.135	0.129	0.133
	(0.088)	(0.088)	(0.089)	(0.090)
5.nbalcony	-0.277***	-0.303***	-0.305***	-0.293***
	(0.071)	(0.073)	(0.073)	(0.074)
1.nroofterraces	0.109***	0.110***	0.109***	0.108***
	(0.002)	(0.002)	(0.002)	(0.002)
2.nroofterraces	0.130***	0.131***	0.128***	0.130***
	(0.012)	(0.012)	(0.012)	(0.012)
3.nroofterraces	0.118*	0.119*	0.113*	0.118*
	(0.066)	(0.066)	(0.065)	(0.065)
Maintinside_good	0.100***	0.100***	0.100***	0.101***
	(0.003)	(0.003)	(0.003)	(0.003)
Centralheating	0.032***	0.031***	0.028***	0.025***
	(0.003)	(0.003)	(0.003)	(0.003)
Monumental	0.144***	0.144***	0.143***	0.143***
	(0.004)	(0.004)	(0.004)	(0.004)
Auction	-0.264***	-0.265***	-0.264***	-0.260***
	(0.025)	(0.025)	(0.025)	(0.025)
Leasehold	-0.179***	-0.181***	-0.179***	-0.177***
	(0.002)	(0.002)	(0.002)	(0.002)
ProximityOV1	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
ProximityRoad_1	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Proximitypark_Num	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
2006.year	0.083***	0.084***	0.084***	0.083***
	(0.004)	(0.004)	(0.004)	(0.004)
2007.year	0.178***	0.179***	0.179***	0.179***
	(0.004)	(0.004)	(0.004)	(0.004)
2008.year	0.236***	0.238***	0.238***	0.238***
	(0.004)	(0.004)	(0.004)	(0.004)
2009.year	0.203***	0.205***	0.205***	0.206***
	(0.004)	(0.004)	(0.004)	(0.004)
2010.year	0.217***	0.219***	0.218***	0.219***
	(0.004)	(0.004)	(0.004)	(0.004)
2011.year	0.216***	0.218***	0.217***	0.217***
	(0.004)	(0.004)	(0.004)	(0.004)
2012.year	0.148***	0.150***	0.151***	0.151***
	(0.004)	(0.004)	(0.004)	(0.004)
2013.year	0.117***	0.119***	0.118***	0.118***
	(0.004)	(0.004)	(0.004)	(0.004)

2014.year	0.188***	0.190***	0.189***	0.189***
	(0.004)	(0.004)	(0.004)	(0.004)
2015.year	0.255***	0.256***	0.257***	0.259***
	(0.004)	(0.004)	(0.004)	(0.004)
2016.year	0.389***	0.391***	0.392***	0.394***
	(0.004)	(0.004)	(0.004)	(0.004)
2017.year	0.519***	0.520***	0.521***	0.521***
	(0.004)	(0.004)	(0.004)	(0.004)
2018.year	0.643***	0.645***	0.648***	0.646***
	(0.004)	(0.004)	(0.004)	(0.004)
2019.year	0.695***	0.697***	0.699***	0.699***
	(0.004)	(0.004)	(0.004)	(0.004)
2020.year	0.747***	0.749***	0.750***	0.752***
	(0.004)	(0.004)	(0.004)	(0.004)
Dummy Tree (25M)		0.029***		
		(0.002)		
Dummy Tree (50M)			0.101***	
			(0.004)	
Dummy Tree (100M)				0.225***
				(0.006)
Constant	8.486***	8.486***	8.408***	8.285***
	(0.011)	(0.011)	(0.011)	(0.012)
Observations	130,481	130,481	130,481	130,481
R-squared	0.774	0.774	0.776	0.777
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	No	No	No	No

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

OLS Regression (TOM)

VARIABLES	(1) Ln(TOM)	(2) Ln(TOM)	(3) Ln(TOM)	(4) Ln(TOM)
Ln(Price)	-0.607***	-0.609***	-0.602***	-0.605***
	(0.011)	(0.011)	(0.011)	(0.011)
Dummy Tree (10M)	-0.078***			
	(0.006)			
Ln(Size)	0.785***	0.786***	0.784***	0.789***
	(0.013)	(0.012)	(0.013)	(0.013)
terraced	0.033***	0.030**	0.033***	0.034***
	(0.012)	(0.012)	(0.012)	(0.012)
semidetached	0.103***	0.098***	0.098***	0.099***
	(0.018)	(0.018)	(0.018)	(0.018)
detached	0.509***	0.489***	0.498***	0.508***
	(0.034)	(0.035)	(0.035)	(0.035)
1.nbathrooms	-0.021**	-0.020**	-0.022**	-0.022**
	(0.009)	(0.009)	(0.009)	(0.009)
2.nbathrooms	0.144***	0.145***	0.142***	0.142***
	(0.017)	(0.017)	(0.017)	(0.017)
3.nbathrooms	0.275***	0.278***	0.269***	0.267***
	(0.054)	(0.054)	(0.054)	(0.054)
4.nbathrooms	0.000	-0.000	-0.006	-0.009
	(0.109)	(0.109)	(0.109)	(0.109)
5.nbathrooms	0.073	0.076	0.064	0.064
	(0.275)	(0.278)	(0.279)	(0.276)
6.nbathrooms	-0.275	-0.279	-0.272	-0.283
	(0.779)	(0.785)	(0.794)	(0.794)
7.nbathrooms	-0.485	-0.473	-0.499	-0.508*
	(0.307)	(0.305)	(0.305)	(0.304)
1.nkitchen	-0.107***	-0.107***	-0.107***	-0.107***
	(0.008)	(0.008)	(0.008)	(0.008)
2.nkitchen	-0.170***	-0.171***	-0.170***	-0.169***
	(0.033)	(0.033)	(0.033)	(0.033)
3.nkitchen	-0.206**	-0.210**	-0.206**	-0.207**
	(0.085)	(0.085)	(0.085)	(0.085)
4.nkitchen	-0.488***	-0.484***	-0.479***	-0.482***
	(0.153)	(0.153)	(0.153)	(0.154)
5.nkitchen	-0.322	-0.328	-0.329	-0.327
	(0.286)	(0.287)	(0.290)	(0.289)
1.nbalcony	-0.058***	-0.054***	-0.055***	-0.058***
	(0.006)	(0.006)	(0.006)	(0.006)
2.nbalcony	-0.090***	-0.087***	-0.089***	-0.093***
	(0.022)	(0.022)	(0.022)	(0.022)

3.nbalcony	-0.037	-0.027	-0.035	-0.039
	(0.113)	(0.113)	(0.114)	(0.113)
4.nbalcony	0.240	0.232	0.230	0.221
	(0.293)	(0.296)	(0.295)	(0.295)
5.nbalcony	-0.375	-0.311	-0.323	-0.338
	(0.263)	(0.262)	(0.265)	(0.264)
1.nroofterraces	-0.011	-0.013	-0.013	-0.013
	(0.009)	(0.009)	(0.009)	(0.009)
2.nroofterraces	0.007	0.007	0.007	0.004
	(0.045)	(0.045)	(0.045)	(0.045)
3.nroofterraces	-0.061	-0.055	-0.056	-0.065
	(0.296)	(0.296)	(0.294)	(0.294)
maintinside_good	0.261***	0.258***	0.260***	0.262***
	(0.011)	(0.011)	(0.011)	(0.011)
centralheating	-0.104***	-0.098***	-0.098***	-0.100***
	(0.010)	(0.010)	(0.010)	(0.011)
monumental	0.101***	0.104***	0.102***	0.100***
	(0.017)	(0.017)	(0.017)	(0.017)
auction	-0.579***	-0.577***	-0.575***	-0.578***
	(0.071)	(0.071)	(0.071)	(0.071)
leasehold	-0.116***	-0.114***	-0.113***	-0.114***
	(0.006)	(0.006)	(0.006)	(0.006)
ProximityOV1	0.000	0.000*	0.000*	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
ProximityRoad_1	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Proximitypark_Num	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
2006.year	-0.206***	-0.207***	-0.207***	-0.206***
	(0.016)	(0.016)	(0.017)	(0.017)
2007.year	-0.442***	-0.445***	-0.446***	-0.445***
	(0.016)	(0.016)	(0.016)	(0.016)
2008.year	-0.392***	-0.395***	-0.397***	-0.396***
	(0.016)	(0.016)	(0.016)	(0.016)
2009.year	-0.036**	-0.038**	-0.040**	-0.040**
	(0.018)	(0.018)	(0.018)	(0.018)
2010.year	0.101***	0.099***	0.097***	0.096***
	(0.018)	(0.018)	(0.018)	(0.018)
2011.year	0.197***	0.194***	0.193***	0.194***
	(0.018)	(0.018)	(0.018)	(0.018)
2012.year	0.362***	0.359***	0.357***	0.358***
	(0.018)	(0.018)	(0.018)	(0.018)
2013.year	0.364***	0.361***	0.361***	0.361***
	(0.019)	(0.019)	(0.019)	(0.019)

2014.year	0.128***	0.122***	0.123***	0.124***
	(0.018)	(0.018)	(0.018)	(0.018)
2015.year	-0.262***	-0.265***	-0.267***	-0.267***
	(0.017)	(0.017)	(0.017)	(0.017)
2016.year	-0.501***	-0.505***	-0.508***	-0.507***
	(0.016)	(0.016)	(0.016)	(0.016)
2017.year	-0.541***	-0.544***	-0.548***	-0.546***
	(0.016)	(0.016)	(0.016)	(0.016)
2018.year	-0.444***	-0.449***	-0.454***	-0.449***
	(0.017)	(0.017)	(0.017)	(0.017)
2019.year	-0.263***	-0.267***	-0.273***	-0.270***
	(0.017)	(0.017)	(0.017)	(0.017)
2020.year	-0.283***	-0.287***	-0.293***	-0.290***
	(0.017)	(0.017)	(0.017)	(0.017)
Dummy Tree (25M)		-0.114***		
		(0.007)		
Dummy Tree (50M)			-0.143***	
			(0.011)	
Dummy Tree (100M)				-0.157***
				(0.020)
Constant	8.245***	8.322***	8.292***	8.327***
	(0.103)	(0.103)	(0.103)	(0.103)
Observations	130,481	130,481	130,481	130,481
R-squared	0.168	0.169	0.168	0.168
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

IV Regression Price

VARIABLES	(1) Ln(Price)	(2) Ln(Price)	(3) Ln(Price)	(4) Ln(Price)
Ln(TOM)	-0.363***	-0.367***	-0.358***	-0.353***
	(0.005)	(0.005)	(0.005)	(0.004)
Dummy Tree (10M)	0.006**			
	(0.003)			
Ln(Size)	0.959***	0.959***	0.959***	0.957***
	(0.004)	(0.004)	(0.004)	(0.004)
terraced	-0.052***	-0.052***	-0.053***	-0.054***
	(0.005)	(0.005)	(0.005)	(0.005)
semidetached	0.008	0.009	0.008	0.007
	(0.007)	(0.007)	(0.007)	(0.007)
detached	0.355***	0.353***	0.356***	0.355***
	(0.013)	(0.013)	(0.013)	(0.013)
1.nbathrooms	-0.001	-0.001	-0.001	-0.001
	(0.004)	(0.004)	(0.004)	(0.004)
2.nbathrooms	0.196***	0.196***	0.195***	0.195***
	(0.007)	(0.007)	(0.007)	(0.007)
3.nbathrooms	0.285***	0.287***	0.284***	0.285***
	(0.020)	(0.020)	(0.020)	(0.019)
4.nbathrooms	0.134***	0.135***	0.135***	0.137***
	(0.041)	(0.041)	(0.040)	(0.040)
5.nbathrooms	0.260***	0.262***	0.261***	0.261***
	(0.086)	(0.087)	(0.085)	(0.084)
6.nbathrooms	-0.103	-0.102	-0.104	-0.102
	(0.214)	(0.215)	(0.212)	(0.209)
7.nbathrooms	0.195	0.198	0.197	0.204
	(0.249)	(0.251)	(0.247)	(0.244)
1.nkitchen	-0.006*	-0.006*	-0.005	-0.005*
	(0.003)	(0.003)	(0.003)	(0.003)
2.nkitchen	-0.060***	-0.060***	-0.059***	-0.060***
	(0.013)	(0.013)	(0.013)	(0.013)
3.nkitchen	-0.146***	-0.147***	-0.146***	-0.148***
	(0.032)	(0.032)	(0.032)	(0.031)
4.nkitchen	-0.336***	-0.337***	-0.336***	-0.336***
	(0.053)	(0.054)	(0.053)	(0.052)
5.nkitchen	-0.206*	-0.206*	-0.205*	-0.206*
	(0.121)	(0.122)	(0.120)	(0.119)
1.nbalcony	-0.041***	-0.041***	-0.042***	-0.042***
	(0.003)	(0.003)	(0.003)	(0.003)
2.nbalcony	0.039***	0.040***	0.039***	0.039***
	(0.009)	(0.009)	(0.009)	(0.009)

3.nbalcony	0.049	0.050	0.048	0.049
	(0.039)	(0.039)	(0.038)	(0.038)
4.nbalcony	0.181*	0.185*	0.179*	0.178*
	(0.100)	(0.101)	(0.099)	(0.098)
5.nbalcony	-0.345	-0.345	-0.350	-0.344
	(0.439)	(0.443)	(0.435)	(0.430)
1.nroofterraces	0.083***	0.083***	0.083***	0.083***
	(0.004)	(0.004)	(0.004)	(0.004)
2.nroofterraces	0.106***	0.106***	0.105***	0.106***
	(0.019)	(0.019)	(0.019)	(0.019)
3.nroofterraces	0.075	0.077	0.073	0.074
	(0.118)	(0.119)	(0.117)	(0.115)
maintinside_good	0.166***	0.166***	0.165***	0.165***
	(0.005)	(0.005)	(0.005)	(0.005)
centralheating	-0.008**	-0.008*	-0.010**	-0.012***
	(0.004)	(0.004)	(0.004)	(0.004)
monumental	0.149***	0.150***	0.148***	0.147***
	(0.007)	(0.007)	(0.007)	(0.007)
auction	-0.402***	-0.404***	-0.400***	-0.394***
	(0.029)	(0.029)	(0.028)	(0.028)
leasehold	-0.182***	-0.182***	-0.181***	-0.179***
	(0.003)	(0.003)	(0.003)	(0.003)
ProximityOV1	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
ProximityRoad_1	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Proximitypark_Num	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
2006.year	-0.001	-0.002	0.000	0.001
	(0.007)	(0.007)	(0.007)	(0.007)
2007.year	-0.004	-0.006	-0.001	0.002
	(0.007)	(0.007)	(0.007)	(0.007)
2008.year	0.060***	0.058***	0.062***	0.065***
	(0.007)	(0.007)	(0.007)	(0.007)
2009.year	0.151***	0.151***	0.152***	0.153***
	(0.007)	(0.007)	(0.007)	(0.007)
2010.year	0.207***	0.207***	0.207***	0.207***
	(0.007)	(0.007)	(0.007)	(0.007)
2011.year	0.238***	0.238***	0.238***	0.237***
	(0.007)	(0.007)	(0.007)	(0.007)
2012.year	0.238***	0.240***	0.237***	0.236***
	(0.007)	(0.007)	(0.007)	(0.007)
2013.year	0.213***	0.215***	0.212***	0.210***
	(0.007)	(0.007)	(0.007)	(0.007)

2014.year	0.192***	0.192***	0.192***	0.192***
	(0.007)	(0.007)	(0.007)	(0.006)
2015.year	0.117***	0.116***	0.120***	0.124***
	(0.007)	(0.007)	(0.007)	(0.007)
2016.year	0.146***	0.143***	0.150***	0.155***
	(0.007)	(0.007)	(0.007)	(0.007)
2017.year	0.236***	0.233***	0.241***	0.245***
	(0.008)	(0.008)	(0.008)	(0.008)
2018.year	0.368***	0.364***	0.373***	0.378***
	(0.008)	(0.008)	(0.008)	(0.008)
2019.year	0.469***	0.466***	0.473***	0.478***
	(0.008)	(0.008)	(0.008)	(0.007)
2020.year	0.504***	0.501***	0.508***	0.513***
	(0.008)	(0.008)	(0.008)	(0.008)
Dummy Tree (25M)		-0.015***		
		(0.003)		
Dummy Tree (50M)			0.035***	
			(0.004)	
Dummy Tree (100M)				0.131***
				(0.007)
Constant	9.505***	9.539***	9.459***	9.346***
	(0.022)	(0.023)	(0.023)	(0.023)
Observations	130,481	130,481	130,481	130,481
R-squared	0.426	0.417	0.436	0.448
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	No	No	No	No

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

IV Regression (TOM)

VARIABLES	(1) Ln(TOM)	(2) Ln(TOM)	(3) Ln(TOM)	(4) Ln(TOM)
Ln(Price)	-0.462***	-0.463***	-0.444***	-0.442***
	(0.016)	(0.016)	(0.016)	(0.017)
Dummy Tree (10M)	-0.085***			
	(0.006)			
Ln(Size)	0.660***	0.661***	0.647***	0.649***
	(0.016)	(0.016)	(0.016)	(0.016)
terraced	0.045***	0.042***	0.046***	0.047***
	(0.011)	(0.011)	(0.011)	(0.011)
semidetached	0.109***	0.103***	0.103***	0.105***
	(0.017)	(0.017)	(0.017)	(0.017)
detached	0.477***	0.457***	0.462***	0.471***
	(0.031)	(0.031)	(0.031)	(0.031)
1.nbathrooms	-0.022**	-0.021**	-0.023***	-0.024***
	(0.009)	(0.009)	(0.009)	(0.009)
2.nbathrooms	0.117***	0.119***	0.113***	0.112***
	(0.016)	(0.016)	(0.016)	(0.016)
3.nbathrooms	0.240***	0.243***	0.231***	0.227***
	(0.048)	(0.048)	(0.048)	(0.048)
4.nbathrooms	-0.025	-0.026	-0.033	-0.038
	(0.098)	(0.098)	(0.098)	(0.098)
5.nbathrooms	0.029	0.032	0.016	0.015
	(0.207)	(0.206)	(0.207)	(0.207)
6.nbathrooms	-0.274	-0.279	-0.270	-0.282
	(0.512)	(0.512)	(0.512)	(0.512)
7.nbathrooms	-0.554	-0.543	-0.575	-0.588
	(0.596)	(0.596)	(0.596)	(0.597)
1.nkitchen	-0.113***	-0.113***	-0.114***	-0.113***
	(0.008)	(0.008)	(0.008)	(0.008)
2.nkitchen	-0.170***	-0.171***	-0.170***	-0.169***
	(0.031)	(0.031)	(0.031)	(0.031)
3.nkitchen	-0.193**	-0.197***	-0.191**	-0.191**
	(0.076)	(0.076)	(0.076)	(0.076)
4.nkitchen	-0.459***	-0.454***	-0.446***	-0.447***
	(0.128)	(0.128)	(0.128)	(0.128)
5.nkitchen	-0.305	-0.312	-0.312	-0.308
	(0.290)	(0.290)	(0.290)	(0.290)
1.nbalcony	-0.054***	-0.050***	-0.051***	-0.053***
	(0.006)	(0.006)	(0.006)	(0.006)
2.nbalcony	-0.103***	-0.100***	-0.103***	-0.107***
	(0.022)	(0.022)	(0.022)	(0.022)

3.nbalcony	-0.049	-0.038	-0.047	-0.052
	(0.093)	(0.093)	(0.093)	(0.093)
4.nbalcony	0.223	0.214	0.211	0.200
	(0.239)	(0.239)	(0.239)	(0.239)
5.nbalcony	-0.336	-0.268	-0.276	-0.291
	(1.052)	(1.052)	(1.052)	(1.053)
1.nroofterraces	-0.027***	-0.029***	-0.031***	-0.031***
	(0.009)	(0.009)	(0.009)	(0.009)
2.nroofterraces	-0.013	-0.013	-0.014	-0.018
	(0.046)	(0.046)	(0.046)	(0.046)
3.nroofterraces	-0.079	-0.073	-0.074	-0.085
	(0.282)	(0.282)	(0.282)	(0.282)
maintinside_good	0.248***	0.245***	0.245***	0.247***
	(0.011)	(0.011)	(0.011)	(0.011)
centralheating	-0.109***	-0.103***	-0.103***	-0.105***
	(0.010)	(0.010)	(0.010)	(0.010)
monumental	0.080***	0.083***	0.079***	0.077***
	(0.017)	(0.017)	(0.017)	(0.017)
auction	-0.543***	-0.541***	-0.536***	-0.539***
	(0.068)	(0.068)	(0.068)	(0.068)
leasehold	-0.091***	-0.087***	-0.085***	-0.085***
	(0.007)	(0.007)	(0.007)	(0.007)
ProximityOV1	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
ProximityRoad_1	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Proximitypark_Num	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
2006.year	-0.220***	-0.220***	-0.222***	-0.221***
	(0.016)	(0.016)	(0.016)	(0.016)
2007.year	-0.472***	-0.474***	-0.478***	-0.478***
	(0.016)	(0.016)	(0.016)	(0.016)
2008.year	-0.430***	-0.433***	-0.438***	-0.439***
	(0.017)	(0.017)	(0.017)	(0.017)
2009.year	-0.066***	-0.069***	-0.074***	-0.075***
	(0.017)	(0.017)	(0.017)	(0.017)
2010.year	0.069***	0.067***	0.062***	0.060***
	(0.017)	(0.017)	(0.017)	(0.017)
2011.year	0.166***	0.162***	0.159***	0.159***
	(0.018)	(0.018)	(0.018)	(0.018)
2012.year	0.342***	0.339***	0.335***	0.335***
	(0.017)	(0.017)	(0.017)	(0.017)
2013.year	0.349***	0.345***	0.344***	0.343***
	(0.017)	(0.017)	(0.017)	(0.017)

2014.year	0.100***	0.095***	0.093***	0.094***
	(0.016)	(0.016)	(0.016)	(0.016)
2015.year	-0.302***	-0.305***	-0.310***	-0.312***
	(0.016)	(0.016)	(0.016)	(0.016)
2016.year	-0.562***	-0.567***	-0.575***	-0.576***
	(0.017)	(0.017)	(0.017)	(0.017)
2017.year	-0.622***	-0.625***	-0.636***	-0.636***
	(0.019)	(0.019)	(0.019)	(0.019)
2018.year	-0.542***	-0.548***	-0.563***	-0.560***
	(0.020)	(0.020)	(0.020)	(0.020)
2019.year	-0.368***	-0.373***	-0.388***	-0.388***
	(0.020)	(0.020)	(0.020)	(0.020)
2020.year	-0.396***	-0.400***	-0.416***	-0.417***
	(0.021)	(0.021)	(0.021)	(0.021)
Dummy Tree (25M)		-0.119***		
		(0.007)		
Dummy Tree (50M)			-0.160***	
			(0.010)	
Dummy Tree (100M)				-0.195***
				(0.018)
Constant	7.032***	7.108***	6.981***	7.002***
	(0.141)	(0.141)	(0.142)	(0.142)
Observations	130,481	130,481	130,481	130,481
R-squared	0.167	0.168	0.167	0.166
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	No	No	No	No

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

Robustness Check - IV Regression (Price)

VARIABLES	(1) Ln(Price)	(2) Ln(Price)	(3) Ln(Price)	(4) Ln(Price)
Ln(TOM)	-0.093***	-0.095***	-0.095***	-0.098***
	(0.005)	(0.004)	(0.004)	(0.004)
Green Volume (10M)	0.003***			
	(0.001)			
Ln(Size)	0.841***	0.832***	0.837***	0.841***
	(0.003)	(0.002)	(0.002)	(0.002)
terraced	0.118***	0.099***	0.092***	0.087***
	(0.003)	(0.002)	(0.002)	(0.002)
semidetached	0.187***	0.159***	0.152***	0.149***
	(0.004)	(0.004)	(0.004)	(0.004)
detached	0.428***	0.390***	0.383***	0.379***
	(0.008)	(0.007)	(0.007)	(0.007)
1.nbathrooms	0.002	0.002	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.002)
2.nbathrooms	0.082***	0.092***	0.089***	0.090***
	(0.004)	(0.003)	(0.003)	(0.003)
3.nbathrooms	0.109***	0.109***	0.111***	0.111***
	(0.012)	(0.009)	(0.009)	(0.009)
4.nbathrooms	0.056**	0.056***	0.035*	0.036**
	(0.023)	(0.019)	(0.018)	(0.018)
5.nbathrooms	0.067	0.097**	0.123***	0.159***
	(0.049)	(0.040)	(0.039)	(0.039)
6.nbathrooms	-0.364***	-0.148	-0.139	-0.138
	(0.128)	(0.091)	(0.092)	(0.092)
7.nbathrooms	0.362**	0.141	0.156	0.170
	(0.181)	(0.107)	(0.107)	(0.107)
1.nkitchen	-0.002	-0.006***	-0.005***	-0.004***
	(0.002)	(0.002)	(0.002)	(0.002)
2.nkitchen	-0.064***	-0.078***	-0.080***	-0.080***
	(0.008)	(0.006)	(0.006)	(0.006)
3.nkitchen	-0.169***	-0.130***	-0.134***	-0.130***
	(0.019)	(0.015)	(0.014)	(0.014)
4.nkitchen	-0.273***	-0.276***	-0.276***	-0.269***
	(0.031)	(0.025)	(0.023)	(0.023)
5.nkitchen	0.068	-0.127**	-0.158***	-0.175***
	(0.085)	(0.057)	(0.054)	(0.053)
1.nbalcony	-0.006***	-0.005***	-0.004***	-0.005***
	(0.002)	(0.001)	(0.001)	(0.001)
2.nbalcony	-0.002	0.012***	0.012***	0.011***

	(0.005)	(0.004)	(0.004)	(0.004)
3.nbalcony	0.060***	-0.018	-0.003	-0.001
	(0.023)	(0.018)	(0.017)	(0.017)
4.nbalcony	0.107*	0.054	0.053	0.036
	(0.065)	(0.050)	(0.049)	(0.046)
5.nbalcony	-0.372*	-0.186	-0.175	-0.195
	(0.195)	(0.188)	(0.189)	(0.189)
1.nroofterraces	0.047***	0.054***	0.052***	0.051***
	(0.002)	(0.002)	(0.002)	(0.002)
2.nroofterraces	0.061***	0.083***	0.076***	0.075***
	(0.013)	(0.009)	(0.009)	(0.009)
3.nroofterraces	0.045	0.081	0.076	0.074
	(0.074)	(0.052)	(0.053)	(0.055)
maintinside_good	0.110***	0.112***	0.112***	0.112***
	(0.003)	(0.002)	(0.002)	(0.002)
centralheating	0.059***	0.059***	0.061***	0.057***
	(0.003)	(0.002)	(0.002)	(0.002)
auction	-0.216***	-0.210***	-0.200***	-0.199***
	(0.019)	(0.014)	(0.013)	(0.013)
leasehold	-0.047***	-0.044***	-0.044***	-0.043***
	(0.002)	(0.002)	(0.001)	(0.001)
monumental	0.030***	0.047***	0.047***	0.048***
	(0.005)	(0.003)	(0.003)	(0.003)
newbuilt	0.009	0.018***	0.015***	0.021***
	(0.006)	(0.004)	(0.004)	(0.004)
constr19061930	-0.027***	-0.027***	-0.024***	-0.024***
	(0.003)	(0.002)	(0.002)	(0.002)
constr19311944	-0.030***	-0.030***	-0.028***	-0.028***
	(0.004)	(0.003)	(0.003)	(0.003)
constr19451959	-0.142***	-0.121***	-0.119***	-0.119***
	(0.005)	(0.004)	(0.004)	(0.004)
constr19601970	-0.217***	-0.196***	-0.188***	-0.191***
	(0.005)	(0.004)	(0.003)	(0.003)
constr19711980	-0.133***	-0.141***	-0.140***	-0.136***
	(0.006)	(0.004)	(0.004)	(0.004)
constr19811990	-0.124***	-0.113***	-0.110***	-0.111***
	(0.004)	(0.003)	(0.003)	(0.003)
constr19912000	-0.054***	-0.020***	-0.015***	-0.013***
	(0.004)	(0.003)	(0.003)	(0.003)
constrgt2000	0.027***	0.036***	0.040***	0.038***
	(0.005)	(0.003)	(0.003)	(0.003)
ProximityOV1	-0.000*	0.000	-0.000	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
ProximityRoad_1	0.000***	0.000***	0.000***	0.000***

	(0.000)	(0.000)	(0.000)	(0.000)
2006.year	0.057***	0.053***	0.053***	0.052***
	(0.004)	(0.003)	(0.003)	(0.003)
2007.year	0.142***	0.130***	0.133***	0.132***
	(0.005)	(0.004)	(0.004)	(0.004)
2008.year	0.199***	0.186***	0.189***	0.188***
	(0.005)	(0.004)	(0.004)	(0.004)
2009.year	0.167***	0.165***	0.165***	0.164***
	(0.005)	(0.003)	(0.003)	(0.003)
2010.year	0.193***	0.186***	0.187***	0.188***
	(0.004)	(0.003)	(0.003)	(0.003)
2011.year	0.193***	0.184***	0.186***	0.188***
	(0.005)	(0.003)	(0.003)	(0.003)
2012.year	0.148***	0.145***	0.146***	0.149***
	(0.005)	(0.003)	(0.003)	(0.003)
2013.year	0.121***	0.114***	0.118***	0.123***
	(0.005)	(0.003)	(0.003)	(0.003)
2014.year	0.170***	0.160***	0.161***	0.162***
	(0.004)	(0.003)	(0.003)	(0.003)
2015.year	0.242***	0.232***	0.232***	0.233***
	(0.005)	(0.003)	(0.003)	(0.003)
2016.year	0.368***	0.349***	0.351***	0.352***
	(0.006)	(0.004)	(0.004)	(0.004)
2017.year	0.485***	0.466***	0.469***	0.468***
	(0.006)	(0.004)	(0.004)	(0.004)
2018.year	0.606***	0.590***	0.591***	0.592***
	(0.006)	(0.005)	(0.005)	(0.005)
2019.year	0.658***	0.645***	0.645***	0.647***
	(0.006)	(0.004)	(0.004)	(0.004)
2020.year	0.703***	0.690***	0.692***	0.690***
	(0.006)	(0.004)	(0.004)	(0.004)
1012.pc4	0.016	0.002	-0.008	-0.028***
	(0.015)	(0.009)	(0.008)	(0.007)
1013.pc4	-0.049***	-0.027***	-0.012*	-0.017***
	(0.010)	(0.007)	(0.006)	(0.006)
1014.pc4	-0.052	0.029	0.056***	0.049***
	(0.039)	(0.028)	(0.016)	(0.016)
1015.pc4	0.129***	0.127***	0.132***	0.124***
	(0.010)	(0.007)	(0.006)	(0.006)
1016.pc4	0.166***	0.163***	0.167***	0.161***
	(0.011)	(0.007)	(0.006)	(0.006)
1017.pc4	0.189***	0.167***	0.166***	0.154***
	(0.011)	(0.007)	(0.006)	(0.006)
1018.pc4	-0.051***	-0.048***	-0.041***	-0.049***

	(0.010)	(0.006)	(0.006)	(0.006)
1019.pc4	-0.040***	-0.034***	-0.032***	-0.028***
	(0.012)	(0.007)	(0.007)	(0.006)
1021.pc4	-0.334***	-0.334***	-0.322***	-0.327***
	(0.012)	(0.008)	(0.008)	(0.008)
1022.pc4	-0.340***	-0.380***	-0.389***	-0.398***
	(0.018)	(0.013)	(0.011)	(0.011)
1023.pc4	-0.156***	-0.148***	-0.133***	-0.139***
	(0.015)	(0.012)	(0.011)	(0.011)
1024.pc4	-0.270***	-0.281***	-0.285***	-0.295***
	(0.014)	(0.010)	(0.010)	(0.010)
1025.pc4	-0.308***	-0.299***	-0.297***	-0.317***
	(0.013)	(0.009)	(0.009)	(0.009)
1026.pc4	-0.084***	-0.049**	-0.037	-0.025
	(0.030)	(0.024)	(0.023)	(0.023)
1027.pc4	-0.145***	-0.199***	-0.186***	-0.152***
	(0.037)	(0.029)	(0.028)	(0.027)
1028.pc4	-0.210***	-0.206***	-0.190***	-0.170***
	(0.033)	(0.030)	(0.028)	(0.028)
1029o.pc4	-	-		
1031.pc4	-0.123***	-0.076***	-0.025***	0.002
	(0.014)	(0.010)	(0.010)	(0.009)
1032.pc4	-0.392***	-0.379***	-0.367***	-0.369***
	(0.013)	(0.010)	(0.009)	(0.009)
1033.pc4	-0.373***	-0.363***	-0.346***	-0.332***
	(0.016)	(0.012)	(0.011)	(0.012)
1034.pc4	-0.351***	-0.362***	-0.357***	-0.360***
	(0.013)	(0.009)	(0.009)	(0.009)
1035.pc4	-0.329***	-0.326***	-0.285***	-0.277***
	(0.018)	(0.013)	(0.013)	(0.013)
1036.pc4	-0.498***	-0.478***	-0.463***	-0.602***
	(0.023)	(0.017)	(0.027)	(0.020)
1037.pc4	-0.179*	-0.156*	-0.131	-0.128
	(0.092)	(0.091)	(0.091)	(0.092)
1041o.pc4	-			
1043.pc4	0.097	0.293***	0.315***	0.320***
	(0.128)	(0.024)	(0.024)	(0.024)
1046o.pc4	-	-	-	-
1051.pc4	-0.008	-0.000	0.008	0.005
	(0.011)	(0.007)	(0.007)	(0.007)
1052.pc4	-0.012	0.001	0.004	-0.000

	(0.011)	(0.007)	(0.007)	(0.007)
1053.pc4	0.039***	0.042***	0.050***	0.046***
	(0.011)	(0.007)	(0.007)	(0.007)
1054.pc4	0.125***	0.132***	0.138***	0.130***
	(0.011)	(0.007)	(0.007)	(0.007)
1055.pc4	-0.069***	-0.063***	-0.058***	-0.063***
	(0.013)	(0.008)	(0.008)	(0.008)
1056.pc4	-0.037***	-0.031***	-0.025***	-0.032***
	(0.012)	(0.008)	(0.008)	(0.008)
1057.pc4	-0.009	-0.004	0.000	-0.004
	(0.012)	(0.008)	(0.008)	(0.008)
1058.pc4	0.071***	0.088***	0.092***	0.084***
	(0.012)	(0.008)	(0.008)	(0.008)
1059.pc4	0.089***	0.112***	0.114***	0.107***
	(0.013)	(0.009)	(0.009)	(0.009)
1060.pc4	-0.443***	-0.415***	-0.394***	-0.393***
	(0.013)	(0.009)	(0.008)	(0.008)
1061.pc4	-0.202***	-0.215***	-0.216***	-0.224***
	(0.019)	(0.011)	(0.011)	(0.010)
1062.pc4	-0.187***	-0.166***	-0.166***	-0.172***
	(0.021)	(0.010)	(0.010)	(0.010)
1063.pc4	-0.278***	-0.262***	-0.263***	-0.268***
	(0.014)	(0.010)	(0.009)	(0.009)
1064.pc4	-0.288***	-0.281***	-0.255***	-0.259***
	(0.014)	(0.010)	(0.009)	(0.008)
1065.pc4	-0.239***	-0.246***	-0.237***	-0.240***
	(0.013)	(0.009)	(0.009)	(0.009)
1066.pc4	-0.325***	-0.295***	-0.287***	-0.285***
	(0.013)	(0.009)	(0.009)	(0.008)
1067.pc4	-0.353***	-0.348***	-0.341***	-0.344***
	(0.015)	(0.010)	(0.009)	(0.009)
1068.pc4	-0.340***	-0.372***	-0.382***	-0.387***
	(0.015)	(0.008)	(0.007)	(0.007)
1069.pc4	-0.448***	-0.454***	-0.457***	-0.461***
	(0.012)	(0.007)	(0.007)	(0.007)
1071.pc4	0.312***	0.323***	0.325***	0.314***
	(0.011)	(0.008)	(0.007)	(0.007)
1072.pc4	0.083***	0.102***	0.106***	0.099***
	(0.011)	(0.007)	(0.007)	(0.007)
1073.pc4	0.055***	0.061***	0.067***	0.060***
	(0.011)	(0.007)	(0.007)	(0.007)
1074.pc4	0.031***	0.048***	0.049***	0.044***
	(0.012)	(0.008)	(0.007)	(0.007)
1075.pc4	0.290***	0.242***	0.245***	0.238***

	(0.012)	(0.008)	(0.008)	(0.008)
1076.pc4	0.170***	0.176***	0.176***	0.169***
	(0.013)	(0.009)	(0.009)	(0.009)
1077.pc4	0.391***	0.383***	0.385***	0.374***
	(0.012)	(0.009)	(0.008)	(0.008)
1078.pc4	0.146***	0.157***	0.158***	0.149***
	(0.012)	(0.008)	(0.008)	(0.008)
1079.pc4	0.109***	0.120***	0.124***	0.119***
	(0.012)	(0.008)	(0.008)	(0.008)
1081.pc4	0.034**	0.018*	0.036***	0.023**
	(0.014)	(0.010)	(0.010)	(0.010)
1082.pc4	0.001	-0.008	-0.008	-0.006
	(0.013)	(0.008)	(0.008)	(0.008)
1083.pc4	-0.004	0.005	-0.006	-0.018*
	(0.014)	(0.009)	(0.009)	(0.009)
1086.pc4	-0.258***	-0.197***	-0.179***	-0.247***
	(0.022)	(0.015)	(0.016)	(0.024)
1087.pc4	-0.315***	-0.271***	-0.261***	-0.223***
	(0.013)	(0.008)	(0.008)	(0.012)
1091.pc4	-0.066***	-0.060***	-0.051***	-0.057***
	(0.010)	(0.007)	(0.006)	(0.006)
1092.pc4	-0.112***	-0.103***	-0.099***	-0.110***
	(0.011)	(0.008)	(0.007)	(0.007)
1093.pc4	-0.122***	-0.114***	-0.108***	-0.115***
	(0.011)	(0.007)	(0.007)	(0.007)
1094.pc4	-0.153***	-0.147***	-0.142***	-0.146***
	(0.010)	(0.007)	(0.007)	(0.006)
1095.pc4	-0.147***	-0.143***	-0.136***	-0.148***
	(0.012)	(0.008)	(0.008)	(0.008)
1096.pc4	-0.111***	-0.044***	-0.013	-0.014
	(0.016)	(0.011)	(0.010)	(0.010)
1097.pc4	-0.036***	-0.036***	-0.028***	-0.036***
	(0.013)	(0.009)	(0.009)	(0.009)
1098.pc4	0.047***	0.030***	0.029***	0.018**
	(0.011)	(0.008)	(0.008)	(0.008)
1101o.pc4	-	-	-	-
1102.pc4	-0.509***	-0.510***	-0.506***	-0.513***
	(0.013)	(0.008)	(0.008)	(0.008)
1103.pc4	-0.505***	-0.535***	-0.590***	-0.601***
	(0.015)	(0.010)	(0.010)	(0.010)
1104.pc4	-0.560***	-0.536***	-0.512***	-0.541***
	(0.015)	(0.010)	(0.010)	(0.010)
1106.pc4	-0.502***	-0.495***	-0.492***	-0.499***

	(0.013)	(0.009)	(0.009)	(0.009)
1107.pc4	-0.545***	-0.536***	-0.529***	-0.532***
	(0.013)	(0.009)	(0.009)	(0.009)
1108.pc4	-0.421***	-0.397***	-0.407***	-0.441***
	(0.017)	(0.012)	(0.013)	(0.014)
Green Volume (25M)		0.008***		
		(0.001)		
1041.pc4		-0.281	-0.250	-0.214
		(0.180)	(0.181)	(0.182)
Green Volume (50M)			0.012***	
			(0.001)	
1029.pc4			-0.113	-0.133
			(0.181)	(0.182)
Green Volume (100M)				0.019***
				(0.001)
Constant	8.831***	8.812***	8.733***	8.651***
	(0.025)	(0.019)	(0.019)	(0.020)
Observations	59,845	110,831	116,507	117,522
R-squared	0.901	0.896	0.894	0.892
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	No	No	No	No

Robustness Check - IV Regression (TOM)

	(1)	(2)	(3)	(4)
VARIABLES	Ln(TOM)	Ln(TOM)	Ln(TOM)	Ln(TOM)
Ln(Price)	-0.307***	-0.387***	-0.386***	-0.377***
	(0.030)	(0.022)	(0.021)	(0.021)
Green Volume (10M)	-0.005			
	(0.003)			
Ln(Size)	0.440***	0.506***	0.517***	0.510***
	(0.030)	(0.021)	(0.021)	(0.020)
terraced	0.094***	0.051***	0.024*	0.022*
	(0.016)	(0.012)	(0.012)	(0.012)
semidetached	0.155***	0.107***	0.090***	0.088***
	(0.022)	(0.019)	(0.019)	(0.019)
detached	0.571***	0.492***	0.508***	0.519***
	(0.039)	(0.035)	(0.034)	(0.034)
1.nbathrooms	0.014	0.007	0.003	0.002
	(0.013)	(0.009)	(0.009)	(0.009)
2.nbathrooms	0.156***	0.162***	0.157***	0.155***
	(0.023)	(0.018)	(0.017)	(0.017)
3.nbathrooms	0.225***	0.306***	0.298***	0.310***
	(0.065)	(0.052)	(0.049)	(0.049)
4.nbathrooms	0.115	0.088	0.093	0.044
	(0.128)	(0.105)	(0.099)	(0.099)
5.nbathrooms	-0.223	0.123	0.108	0.264
	(0.269)	(0.221)	(0.212)	(0.214)
6.nbathrooms	-1.316*	-0.172	-0.196	-0.192
	(0.700)	(0.505)	(0.504)	(0.503)
7.nbathrooms	-0.540	-0.332	-0.379	-0.407
	(0.989)	(0.591)	(0.588)	(0.587)
1.nkitchen	-0.076***	-0.081***	-0.073***	-0.068***
	(0.011)	(0.008)	(0.008)	(0.008)
2.nkitchen	-0.025	-0.102***	-0.072**	-0.069**
	(0.042)	(0.033)	(0.032)	(0.032)
3.nkitchen	-0.022	-0.083	-0.072	-0.066
	(0.106)	(0.082)	(0.079)	(0.078)
4.nkitchen	-0.369**	-0.477***	-0.315**	-0.286**
	(0.171)	(0.138)	(0.129)	(0.127)
5.nkitchen	0.307	-0.314	-0.228	-0.251
	(0.464)	(0.313)	(0.299)	(0.288)
1.nbalcony	-0.028***	-0.034***	-0.041***	-0.044***
	(0.009)	(0.007)	(0.006)	(0.006)
2.nbalcony	-0.058**	-0.025	-0.036	-0.052**
	(0.029)	(0.023)	(0.023)	(0.022)
3.nbalcony	0.172	0.053	0.008	0.045
	(0.123)	(0.098)	(0.094)	(0.094)
4.nbalcony	0.434	0.083	0.083	0.178
	(0.353)	(0.276)	(0.267)	(0.249)
5.nbalcony	-0.428	-0.102	-0.198	-0.330

	(1.068)	(1.041)	(1.038)	(1.035)
1.nroofterraces	-0.030**	-0.022**	-0.019**	-0.021**
	(0.013)	(0.010)	(0.009)	(0.009)
2.nroofterraces	0.016	0.018	-0.030	-0.026
	(0.070)	(0.051)	(0.051)	(0.050)
3.nroofterraces	0.059	-0.028	-0.136	-0.073
	(0.405)	(0.289)	(0.289)	(0.301)
maintinside_good	0.140***	0.149***	0.150***	0.148***
	(0.015)	(0.012)	(0.012)	(0.012)
centralheating	0.021	-0.012	-0.010	-0.016
	(0.014)	(0.011)	(0.011)	(0.011)
auction	-0.351***	-0.466***	-0.414***	-0.425***
	(0.103)	(0.074)	(0.072)	(0.071)
leasehold	-0.101***	-0.097***	-0.088***	-0.085***
	(0.010)	(0.008)	(0.007)	(0.007)
monumental	0.085***	0.140***	0.141***	0.142***
	(0.025)	(0.018)	(0.017)	(0.017)
newbuilt	0.359***	0.375***	0.343***	0.418***
	(0.030)	(0.020)	(0.019)	(0.018)
constr19061930	-0.038***	-0.051***	-0.047***	-0.044***
	(0.014)	(0.010)	(0.010)	(0.010)
constr19311944	-0.021	-0.027*	-0.024*	-0.016
	(0.018)	(0.014)	(0.013)	(0.013)
constr19451959	-0.017	-0.020	0.002	0.013
	(0.024)	(0.018)	(0.018)	(0.018)
constr19601970	0.029	0.078***	0.093***	0.089***
	(0.024)	(0.017)	(0.017)	(0.017)
constr19711980	0.180***	0.170***	0.112***	0.085***
	(0.029)	(0.022)	(0.022)	(0.022)
constr19811990	0.028	-0.021	-0.023	-0.017
	(0.021)	(0.015)	(0.015)	(0.015)
constr19912000	0.153***	0.139***	0.140***	0.161***
	(0.022)	(0.014)	(0.014)	(0.014)
constrgt2000	0.239***	0.230***	0.228***	0.228***
	(0.025)	(0.016)	(0.015)	(0.014)
ProximityOV1	0.000	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
ProximityRoad_1	-0.000*	-0.000	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
2006.year	-0.229***	-0.239***	-0.246***	-0.249***
	(0.023)	(0.017)	(0.017)	(0.017)
2007.year	-0.503***	-0.513***	-0.505***	-0.511***
	(0.024)	(0.017)	(0.017)	(0.017)
2008.year	-0.434***	-0.451***	-0.451***	-0.452***
	(0.025)	(0.018)	(0.018)	(0.018)
2009.year	-0.078***	-0.070***	-0.072***	-0.070***
	(0.025)	(0.018)	(0.018)	(0.018)
2010.year	0.061**	0.057***	0.057***	0.055***
	(0.025)	(0.018)	(0.018)	(0.018)

2011.year	0.150***	0.130***	0.133***	0.128***
	(0.025)	(0.019)	(0.018)	(0.018)
2012.year	0.315***	0.330***	0.312***	0.309***
	(0.025)	(0.018)	(0.018)	(0.018)
2013.year	0.303***	0.295***	0.289***	0.292***
	(0.025)	(0.018)	(0.018)	(0.018)
2014.year	0.023	0.025	0.027	0.015
	(0.023)	(0.017)	(0.017)	(0.017)
2015.year	-0.363***	-0.351***	-0.364***	-0.363***
	(0.024)	(0.018)	(0.017)	(0.017)
2016.year	-0.623***	-0.623***	-0.623***	-0.629***
	(0.026)	(0.019)	(0.019)	(0.019)
2017.year	-0.700***	-0.708***	-0.705***	-0.703***
	(0.029)	(0.021)	(0.021)	(0.020)
2018.year	-0.645***	-0.638***	-0.650***	-0.641***
	(0.032)	(0.023)	(0.022)	(0.022)
2019.year	-0.468***	-0.463***	-0.466***	-0.466***
	(0.032)	(0.023)	(0.023)	(0.023)
2020.year	-0.480***	-0.477***	-0.483***	-0.482***
	(0.033)	(0.024)	(0.023)	(0.023)
Green Volume (25M)		-0.029***		
		(0.003)		
Green Volume (50M)			-0.038***	
			(0.004)	
Green Volume (100M)				-0.032***
				(0.005)
Constant	5.965***	6.923***	6.978***	6.897***
	(0.253)	(0.183)	(0.177)	(0.176)
Observations	59,845	110,831	116,507	117,522
R-squared	0.172	0.179	0.179	0.180
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
PC4 FE	No	No	No	No