ERASMUS UNIVERSITY ROTTERDAM
Erasmus School of Economics
Bachelor Thesis Economics & Business Economics
Major Urban, Port and Transport Economics

The influence of the proximity to various transport modes on house prices in the Netherlands

Name student: Fien van de Kar
Student ID number: 472706
Supervisor: Zhiling Wang

Abstract

In this paper the influence of the proximity to various transport modes on house prices in the Netherlands is investigated, with a focus on transportation by train and car. Previous research on this topic suggests that the house prices go up when a house is located closer to a railway station, and prices go down when located closer to a highway. Possible reasons for this are on the one hand improved accessibility and on the other hand negative externalities. These findings are tested using the hedonic pricing model and a fixed effects regression analysis. This analysis, using data collected by Statistics Netherlands, confirms these findings. It has been found that the average WOZ value decreases by 1,570 euros when the average distance to the nearest railway station increases by one kilometre. The average WOZ value increases by 8,770 euros when the average distance to the nearest highway entrance increases by one kilometre. These findings suggest that people are willing to pay more to live closer to a railway station, but also to live further away from a highway.

Index

1 Introduction

House prices in the Netherlands have been growing rapidly. Over the last year there has been an increase of 15 per cent, which is the highest increase in the last 20 years (Van den Eerenbeemt, 2021). Many factors can be of influence on house prices and corresponding changes in prices. For instance, the accessibility by various modes of transport. This can have a great impact on what jobs and amenities are easily accessible. Therefore, this research attempts to define the influence of the distance to the nearest railway station and nearest highway entrance on house prices, while concentrating on the Netherlands.

Investigating the influence of the proximity to transport modes on house prices can be helpful in identifying the preferences of current and future homeowners regarding this topic. These preferences can be used to make sure that houses are built in places that are attractive to potential buyers. Being able to identify buyers' preferences is especially relevant in a time where new houses have to be built, due to the current housing shortage in the Netherlands. According to the Rijksoverheid (2020), the shortage concerned 331,000 houses which was 4.2 per cent of the housing stock in 2020. To meet the growing demand, 845,000 houses must be built between 2020 and 2030. In the recent elections, the housing shortage was frequently discussed. For instance, the political party JA21 proposed to build a completely new city (NOS, 2021). They mentioned that to decide where this city should be build, there should be a referendum (Winterman, 2021). However, the outcome of this referendum is unlikely to represent the views of the entire population, as not every individual will vote. This problem can be partially solved by using the results of this research to help with the decision of where to build new houses, as it will show revealed preferences instead of stated preferences. The main drawback of using stated preferences is that the stated preferences do not closely match the actual preferences, as opposed to revealed preferences (Wardman, 1988).

Besides providing insights into the location preferences of potential inhabitants of new houses, this research also adds to the existing literature. Previous studies have examined the influence of the proximity to railway stations and other forms of public transport, but hardly any conclusions were drawn concerning the influence of the proximity to highways on the house prices. In addition, there have been very few studies on the influence of transport on house prices focused on the Netherlands. Furthermore, this study will look at variation over time, using panel data relating to multiple years. In contrast, previous papers mostly performed a linear regression using data relating to only one year.

Concluding, it is very relevant to investigate the relation between the proximity to various transport modes and house prices. This leads to the following research question:

To what extent is there an influence of the proximity to various transport modes on house prices in the Netherlands, and what are possible reasons behind this?

To help to find an answer to the main question, a set of sub-questions has been developed:

- What is the influence of the proximity to a railway station on house prices?
- What is the influence of the proximity to a highway on house prices?
- Why does the distance to various transport modes affect house prices?

To provide an answer to these questions, this thesis is divided in two main parts: a literature review and an empirical research. Firstly, a theoretical framework will be presented, including a literature study. Based on the literature, hypotheses are formed which will be tested using data. Furthermore, the models that will be used to perform the analysis are explained. Next, the data used in the empirical research will be described. After the data section, the methodology used for the analysis will be explained. Subsequently, the results of the analysis will be presented. This will be followed by a discussion of the limitations, and recommendations for further research will be made. Lastly, the hypotheses will be discussed in the conclusion. In addition, the sub-questions and the main research question will be answered.

2 Theoretical Framework

Firstly, this theoretical framework will present the conclusions from previous research regarding the influence of the proximity to various transport modes on house prices. Secondly, the hypotheses constructed based on this literature are presented. Next, the importance of the proximity to transport modes will be discussed. Furthermore, negative externalities relating to transport modes will be examined. Lastly, the theoretical background of the various models that are used for the analysis is described. This includes the hedonic pricing model and the fixed effects regression model.

Influence of proximity to transport modes on house prices

Several studies have been conducted on the influence of the proximity of transport modes on house prices. So et al. (1997) looked at the influence of transport accessibility on house prices in a residential area in Hong Kong. They used the hedonic pricing model and concluded that accessibility to transport is in fact an important determinant of house prices. The results showed that when the property was within ten minutes walking distance to the metro and minibus, the house price increased significantly. A comparable study has been conducted for the city of Naples, Italy. Gallo (2018) concluded that only the high-frequency metro lines had a significant effect on house prices, while low-frequency metro lines and bus lines showed no significant impacts. This indicates that only high-frequency transport systems influence property values in Naples, where the contribution to real estate values can be up to 22 per cent in some areas. It should be taken into consideration that these studies did not focus on transportation by train specifically. However, they do concern public transport, so the effects are likely to be similar as the various transport modes serve the same purpose, which is to provide an alternative to private vehicles.

On travelling by train specifically, Debrezion et al. (2010) conducted research regarding the influence of rail transport on house prices in three metropolitan areas in the Netherlands, namely Amsterdam, Rotterdam and Enschede. They did not only use the distance to a station to measure railway accessibility, but also took the quality of the available services into account. Negative coefficients were found, meaning that the house price decreases when the distance to the railway station increases. In addition, they concluded that house prices are influenced more by the most frequently chosen railway station than by the nearest railway station. Likewise, a paper by Dubé et al. (2013) estimated the effect of the implementation of a new train service on house prices in Montreal, Canada using a difference-in-difference estimator. They concluded that the implementation generated a location premium for houses that were located closely to the relevant train station, in comparison to houses that did not experience improved accessibility. For these closely located houses, the implementation generated an overall market premium of 2.6 per cent on the mean house price. A different result comes from research conducted using data from Athens, Greece by Efthymiou and Antoniou (2013). They calculated the impact of multiple transport modes on house prices but concluded that proximity to national rail stations has a negative effect. A possible reason for this is the presence of negative externalities such as noise, which will be discussed later. On the contrary, for metro, tram, suburban railway and bus was found that they impact the house price positively. Chica-Olmo et al. (2019) concluded that the impact of the railway on house prices depends on whether a house is located inside or outside a specific buffer zone. Due to negative externalities, the railway affects the house price negatively inside this zone.

Research conducted regarding the influence of the proximity to the highway on the house price will now be discussed. Tillema et al. (2012) concluded that house prices are negatively correlated to the distance to the nearest highway entrance, due to negative externalities. Consequently, house prices rise when moving away from the highway. Because the externalities reduce with distance, the house prices reach a maximum and then decline as the distance to be travelled increase. Similarly, Brouwer et al. (2007) found a positive effect of the distance to a highway on the house price, meaning an increase in house price when a property is located further away from the highway. Another research conducted in the Netherlands showed that close proximity to a highway leads to lower house prices in cities, due to nuisance of noise and smell. The opposite was concluded in more rural areas, where house prices increase when there is a highway nearby. Reason for this is the fact that the accessibility decreases with greater distance (Planbureau voor de Leefomgeving, 2008). Boarnet and Chalermpong (2001) investigated the effect on the construction of toll roads on house prices. In contrast to previous conclusions, they found that the new roads created an accessibility premium, meaning buyers are willing to pay more for the increased access.

Hypotheses

Looking at the results from previous research about the influence of the proximity to transport modes on house prices, hypotheses can be constructed. An overview of this previous research can be found in Appendix 1. The first sub-question regards the influence of the proximity to a railway station on house prices. Previous studies found mostly positive correlations between the distance to public transport modes and the house price. However, for the studies focusing on railway stations specifically contradicting results were found. Since the study conducted by Debrezion et al. (2010) in the Netherlands found that house prices are positively impacted when located close to the railway station, the first hypothesis is as follows:

Hypothesis 1: The influence of the proximity to the railway station on the house prices is positive, meaning the house prices go up when located close to a station.

The second sub-question regards the influence of the proximity to a highway on house prices. Earlier research mostly found that house prices increased when moving away from the highway, due to negative externalities. The second hypothesis is therefore as follows:

Hypothesis 2: The influence of the proximity to the highway on the house prices is negative, meaning the house prices go down when located close to a highway.

These hypotheses are constructed to help form an answer to the main research question and will be tested later using empirical research.

Importance of the proximity to transport modes for inhabitants

The proximity to transport modes can be of value for inhabitants for several reasons. First of all, public transport accessibility has a considerable impact on life satisfaction. Accessibility can be defined as facilitation in accessing a specific area or location. Furthermore, improved accessibility gives rise to additional job opportunities, and helps to prevent social exclusion (Saif et al., 2019). In addition, proximity to transport may result in lower transportation costs because less distance has to be covered (Al-Mosaind et al., 1993). In contrast to accessibility levels for public transport, accessibility levels by car are generally a lot higher. Accessibility for public transport is interrupted by areas where public transport is almost or completely missing. Only in some city centres public transport is able to reach as high accessibility levels as the levels for cars. (Biosca et al., 2013). When living closer to a highway entrance or railway station, you are less at risk for commuting stress. This stress, associated with congestion while driving or discomfort in public transport, can have an adverse effect on a person's physical wellbeing. On the other hand, increased accessibility is associated with higher mobility. (Novaco & Gonzalez, 2009). Similarly, Stutzer and Frey (2008) researched the effect of commuting on well-being. They found that there was a large negative effect of commuting time on people's life satisfaction. This could be explained by the fact that commuting causes stress that does not pay off. In line with the previous conclusion, Sha et al. (2019) found that commuting over 60 minutes is associated with negative life satisfaction. They even concluded that commuting time over 90 minutes causes a higher risk of obesity. These results show that the proximity to transport modes matters for most inhabitants. Therefore, it is probable that this importance is included in the house prices, as these prices are made up of attributes that matter to residents according to the hedonic pricing model. Further on, this model will be explained in more detail.

Negative externalities relating to transport modes

Although there are benefits to living in close proximity to transport modes, there are also downsides to it. When living close to the highway or railway, negative externalities such as noise nuisance and air pollution can be experienced (Tassi et al., 2010). Furthermore, congestion and visual impacts may play a role. These negative externalities can have a negative impact on quality of life, and possibly cause a fall in property prices (Tillema et al., 2012). Likewise, Chica-Olmo et al. (2019) found that house prices around railway lines decrease due to these externalities.

One of the negative externalities that can be experienced is noise. Both highways and railways produce noise, where rail noise is usually valued as less annoying than road noise because of the lower frequency (Bristow et al., 2015). Defined as "unwanted sound", noise can cause both auditory and non-auditory effects. For instance, noise can cause sleep disturbance, impair performance, modify behaviour and contribute to cardiovascular disease (Stansfeld & Matheson, 2003). Sahu et al. (2020) also stated that noise can cause severe health effects. Similarly, they concluded that living near railway tracks can lead to hearing loss, increased blood pressure and insomnia. Likewise, Hammer et al. (2014) stated that chronic noise can have unfavourable health effects, such as annoyance, disturbed sleep, loss of hearing and increased chance of diabetes. To conclude, it is clear that noise can have detrimental effects on one's health. These negative effects could incur various costs, such as loss of productivity and medical costs (Demir et al., 2015).

Transportation by railway and highway obviously generates emissions, which can also damage human health. In particular, gaseous pollutions can cause several health problems such as respiratory and heart diseases. The reason is that these fine particles are easier to inhale and enter deeper into the lungs (Demir et al., 2015). Emissions have also been associated with increased mortality and cases of asthma (Colvile et al., 2001). When emissions are reduced, life expectancy is found to increase slightly (Cesaroni et al., 2012). Furthermore, a reduction in air pollution is said to improve productivity and can even improve test scores (Gehrsitz, 2017). Cepeda et al. (2017) found that of all transport modes, cyclist and pedestrians are the most affected by air pollution. This group had the highest inhalation because of increased respiratory rates. Consequently, the people that are impacted most by the emissions are those who live closest to the source, as they are most likely to use their bike and walk in that area.

Hedonic pricing model

To analyse the effect of the proximity to transport modes on house prices, the hedonic pricing model will be used in this research. Hedonic prices are defined by Rosen (1974) as implicit prices of product attributes. These prices are revealed from observed prices of differentiated products and the specific number of associated characteristics. The implicit prices can be estimated by a regression analysis, regressing product price on product characteristics (Rosen, 1974). This model is very suitable to apply to houses, as they are made up of many characteristics that all affect its value. When the model is applied to the demand side of housing, it is assumed that a property is sold as a package of its attributes (So et al., 1997). This way, the hedonic pricing model can be used to estimate the contribution of each of these characteristics (Sirmans et al., 2005).

Fixed effects model

A fixed effects regression model is used to limit selection bias. This model is able to eliminate time-invariant variables in panel data (Mummolo & Peterson, 2018). Fixed effects can control for variables that have not been or cannot be measured. This way, using a fixed effects regression can address the problem of omitted variable bias. The basic idea is to use each individual, in this case each neighbourhood, as its own control (Allison, 2009). According to Allison (2009) there are two data requirements to using a fixed effects model. The first requirement is that the dependent variable must be measured for each individual, in this case a neighbourhood, on at least two occasions and those measurements should be directly comparable. Furthermore, the variables of interest have to change in value across those multiple occasions.

3 Data

To investigate the relation between the proximity to various transport modes and house prices, a quantitative research will be conducted. Information on the house prices and the average distances to the nearest highway entrance and nearest railway station is needed. By using a fixed effects regression with panel data, it is made sure that factors that usually remain constant over time, such as the characteristics of houses and the population density of neighbourhoods, do not have to be accounted for. A new set of data is created by merging multiple databases from different years, which will be named below. All used data is retrieved from Statistics Netherlands (Centraal Bureau voor de Statistiek), a governmental institution whose task is to gather and publish statistical information about the Netherlands. The variables used are divided into three groups, which will be explained in detail below. The most recent data used relates to the year 2016, because after this year the dataset used to retrieve the independent variables changed the way it named neighbourhoods. Due to this change, it is not possible to compare data from beyond 2016 to data from previous years. The data collected ranges from 2008 up to and including 2016. The year 2008 is chosen as this is the earliest year from which data about the independent variables is available. The timespan is taken as broad as possible, as infrastructure projects tend to take a long time and enough variation in distance to the railway station and highway is needed for this research. In addition, it is required that the variables are measured on at least two occasions, to be able to perform a fixed effects regression. Descriptive statistics of the data are presented in Table 1. More detailed descriptive statistics, broken down per year, can be found in Appendix 2.

Dependent variable

First data on the dependent variable, the house price, is needed. This can be measured by using either the average WOZ values or the average selling prices of the houses. Average selling prices are defined by Statistics Netherlands (Centraal Bureau voor de Statistiek, 2021b) as the average of the transaction prices of all sold, existing houses in a year. A downside to using average selling prices is that they are only available per municipality and not per neighbourhood. In 2016, the Netherlands consisted of 390 municipalities (Centraal Bureau voor de Statistiek, 2021a) and more than 12,000 neighbourhoods. Therefore, when using WOZ values compared to selling prices, there are a lot more data points available, as these are available per neighbourhood. WOZ is an abbreviation for Waardering Onroerende Zaken, meaning real estate valuation. WOZ values are based on market values, so they are in fact an estimation of the selling prices. WOZ values are namely based on the selling prices of nearby houses and the characteristics of the house itself (Waarderingskamer, n.d.). Furthermore, it has been concluded that the WOZ values follow the actual selling prices with a delay of one year (Centraal Bureau voor de Statistiek, 2020). Because a lot more observations are available when using WOZ value, and because it doesn't deviate too much from the actual selling price, average WOZ value will be used as the dependent variable in this research, the house price. The average WOZ values are measured in thousands of euros and descriptive statistics can be found in Table 1 for all years together. More detailed descriptive statistics, broken down per year, can be found in Appendix 2. The corresponding datasets are called Kerncijfers wijken en buurten (key figures districts and neighbourhoods) 2008 up to and including and 2016 (Centraal Bureau voor de Statistiek, 2011a, 2011b, 2011c, 2011d, 2011e, 2016a, 2016b, 2016c, 2016d). What stands out is the relatively low number of observations for the average WOZ values, that can be seen in Table 1, compared to the number of observations for the remaining variables. This can be explained by the fact that the WOZ value is not recorded under certain circumstances. For 2008, the WOZ value is not recorded for neighbourhoods that have less than 5 houses or less than 50 WOZ objects (Centraal Bureau voor de Statistiek, 2011a). For 2016, this is the case if a neighbourhood has less than 20 houses or less than 50 WOZ objects (Centraal Bureau voor de Statistiek, 2016d). The average WOZ value is 265,930 euros, for all years combined.

Independent variables

Furthermore, data on the distance to the nearest highway entrance and to the nearest railway station, the independent variables, is required. Descriptive statistics can be found in Table 1 for all years together, and all distances are measured in kilometres. More detailed descriptive statistics, broken down per year, can be found in Appendix 2. The corresponding datasets where the variables can be found are called Nabijheid voorzieningen wijk- en buurtcijfers (proximity to amenities district and neighbourhood figures) 2008 up to and including 2016 (Centraal Bureau voor de Statistiek, 2014a, 2014b, 2014c, 2016e, 2016f, 2016g, 2016h, 2016i, 2017). These datasets include average travel distances for all inhabitants in an area from their home address to the nearest services. All distances are calculated via the road. In the datasets, the average distance of the inhabitants to the nearest entrance of the highway is included. Regarding the distance to the nearest railway station, two variables are available. First, the average distance to the nearest railway station, and second, the average distance to the nearest important transfer station. This means a railway station of a significant size or a railway station with important transfer possibilities (Centraal Bureau voor de Statistiek, 2017). The decision is made to use the second option to account for the average distance to the nearest railway station. This decision was made because it is likely that a railway station with more possible destinations will have a bigger influence on the house price. Having a railway station close by is only an advantage if it enables you to travel to the desired destination. This is also in line with the conclusion made by Debrezion et al. (2010) that house prices are influenced more by the most frequently chosen railway station than by the nearest one. What stands out from Table 1, is that the average distance to the nearest railway station is much higher than to the nearest highway entrance. This can be explained by the fact that the Netherlands is home to more than 400 railway stations (Nederlandse Spoorwegen, n.d.), but the highway can be entered from far more places.

Control variables

In addition, control variables are needed to prevent omitted variable bias. These variables should have an influence on the dependent variable, the house price, as well as on the independent variables, the average distance to various transport modes. First, the average income per inhabitant is used as a control variable. Furthermore, the average numbers of the following amenities within 3 kilometres of the inhabitants of a neighbourhood are included. The amenities are big supermarkets, other shops for daily foodstuffs (such as a bakery, butchery and greengrocer), cafés and restaurants. The distance of 3 kilometres was chosen because the average distances (in 2016) to the nearest big supermarket, other shops for daily foodstuffs, café and restaurant were 1.6, 1.3, 1.6 and 1.2 kilometres respectively. Consequently, the decision of not using 1 kilometre was made to have less zero observations, and 5 kilometres was not chosen because this is a long distance to travel for these amenities, as they can usually be found closer by. The average incomes are extracted from the Kerncijfers wijken en buurten 2008 up to and including 2016 datasets. The distance variables are found in the corresponding Nabijheid voorzieningen wijk- en buurtcijfers datasets. The descriptive statistics of all years together can be found in Table 1. More detailed descriptive statistics, broken down per year, are presented in Appendix 2. What stands out from Table 1 is the relatively low number of observations for the average income per inhabitant. This can be explained by the fact that the average income is only recorded under certain circumstances. The average income is only recorded if a neighbourhood has a minimum of 200 inhabitants, for 2008 (Centraal Bureau voor de Statistiek, 2011a). For 2016, this is the case if a neighbourhood has at least 100 inhabitants (Centraal Bureau voor de Statistiek, 2016d).

Table 1: Descriptive statistics of the dependent, independent and control variables for 2008 up to and including 2016

Variable	Observations	Mean	Std. dev.	Min.	Max.
WOZ	82,711	265.93	120.08	25	2019
Distance railway station	102,997	13.29	9.89	.2	71.9
Distance highway	102,998	1.83	1.81	.07	46.4
Average income	85,629	22.25	6.07	-4.6	105.5
Number of supermarkets	102,998	5.91	7.55	0	96.8
Number of other shops	102,998	28.69	54.63	0	745.2
Number of cafés	102,998	17.17	46.10	0	755.8
Number of restaurants	102,998	28.1	78.18	0	1473.5

Note: WOZ value gives the average WOZ value in thousands of euros. Distance railway station and distance highway give the average distance to the nearest highway entrance and nearest important railway station in kilometres, respectively. Average income gives the average income per inhabitant in thousands of euros. The last four variables each give the average number of the specific amenity within 3 kilometres for the inhabitants of a neighbourhood.

4 Methodology

As described in the theoretical framework, a fixed effects regression model will be used to estimate the influence of the proximity to transport modes on the house prices in the Netherlands. A regression model is feasible for this analysis because the hedonic pricing model tells us that houses are made up of characteristics that all affects its price. As mentioned, there are two requirements that have to be fulfilled before using a fixed effects model. As the dependent variable is measured for each neighbourhood for 9 years and these measurements are directly comparable, the first requirement is fulfilled. In addition, the variables of interest change in value across the years, fulfilling the second requirement (Allison, 2009). Both requirements are met for the data used, thus it seems plausible to use a fixed effects regression model for this analysis. The following regression equations are used, without and with control variables respectively:

$$WOZ_{i,t} = \beta_0 + \beta_1 DR_{i,t} + \beta_2 DH_{i,t} + d_t + \varepsilon \tag{1}$$

$$WOZ_{i,t} = \beta_0 + \beta_1 DR_{i,t} + \beta_2 DH_{i,t} + \beta_3 AI_{i,t} + \beta_4 NS_{i,t} + \beta_5 NO_{i,t} + \beta_6 NC_{i,t} + \beta_7 NR_{i,t} + d_t + \varepsilon \tag{2}$$

The equations where the dummy variables are added one by one can be found in Appendix 3. In each of the equations, $WOZ_{i,t}$ gives the average WOZ value in thousands of euros. $DR_{i,t}$ and $DH_{i,t}$ give the average distance to the railway station and nearest highway entrance in kilometres, respectively. For the control variables, AI_i is the average income per inhabitant in thousands of euros. $NS_{i,t}$ and $NO_{i,t}$ stand for the average number of big supermarkets and average number of other shops for daily foodstuffs within three kilometres. Likewise, $NC_{i,t}$ and $NR_{i,t}$ respectively give the average number of cafés and restaurants within three kilometres.

Furthermore, the variable d_t represents dummy variables for each of the years 2009 up to and including 2016. A dummy variable for a specific year takes on the value 1 if the observation belongs to that year and 0 if not. They are all measured against the base year, 2008. These are needed because they account for yearly trends that occur for all house prices across all neighbourhoods in the Netherlands, and so these variables can be called year fixed effects. These dummies capture for example changes in the economy and housing market of the Netherlands.

In Equations 1 and 2, the coefficient β_1 indicates by what amount the value of $WOZ_{i,t}$ will increase or decrease when the value of $DR_{i,t}$ increases by one. Likewise, the coefficient β_2 indicates by what amount the value of $WOZ_{i,t}$ will change when the value of $DH_{i,t}$ increases by one. This way, the change in the house price due to an increase by one kilometre in distance to the highway or railway station will be found.

5 Results

As mentioned in the methodology section, the following regression equations are used:

$$WOZ_{i,t} = \beta_0 + \beta_1 DR_{i,t} + \beta_2 DH_{i,t} + d_t + \varepsilon \quad (1)$$

$$WOZ_{i,t} = \beta_0 + \beta_1 DR_{i,t} + \beta_2 DH_{i,t} + \beta_3 AI_{i,t} + \beta_4 NS_{i,t} + \beta_5 NO_{i,t} + \beta_6 NC_{i,t} + \beta_7 NR_{i,t} + d_t + \varepsilon \quad (2)$$

The results of performing a fixed effects regression on the panel data using Equation 1 and 2 can be found in Table 2. The results of the equations where the control variables are added one by one can be found in Appendix 4.

Table 2: Results of fixed effects regression with average WOZ value as dependent variable

Variable	**(1)**	**(2)**
Distance railway station	-0.19 (0.24)	-1.57 (0.25) ***
Distance highway	9.21 (0.39) ***	8.77 (0.38) ***
Average income		1.03 (0.05) ***
Number of supermarkets		-0.53 (0.11) ***
Number of other shops		-0.42 (0.02) ***
Number of cafés		-0.18 (0.02) ***
Number of restaurants		0.17 (0.02) ***
Year 2009	8.85 (0.32) ***	0.02 (0.48)
Year 2010	9.91 (0.32) ***	0.38 (0.49)
Year 2011	3.37 (0.32) ***	-6.31 (0.51) ***
Year 2012	-3.66 (0.32) ***	-14.00 (0.52) ***
Year 2013	-14.19 (0.32) ***	-25.01 (0.53) ***
Year 2014	-29.43 (0.32) ***	-41.30 (0.56) ***
Year 2015	-36.40 (0.32) ***	-49.57 (0.61) ***
Year 2016	-35.14 (0.33) ***	-49.12 (0.63) ***
Constant	263.14 (3.10) ***	282.53 (3.48) ***
R^2	0.419	0.444
F-statistic	5046.52	3609.52
Number of observations	82,418	80,184
Number of neighbourhoods	12,381	12,258

Note: The first column shows the results of Equation 1, the second column shows the results of Equation 2. In both fixed effect regressions, the dependent variable is the average WOZ value and the independent variables are the average distance to the nearest railway station and nearest highway entrance. The values in the table are the regression coefficients, the values between brackets are the standard errors. The stars indicate the significance level, such that * indicates $p < 0.10$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.

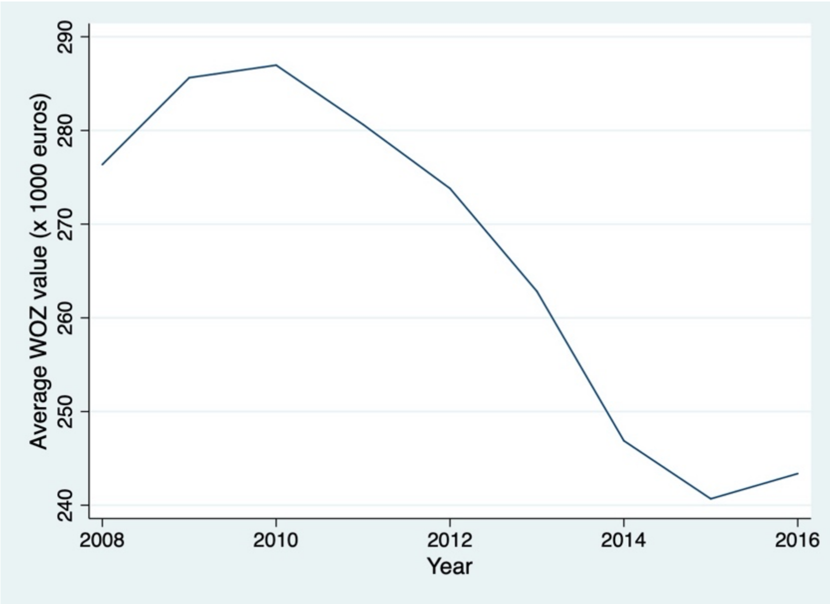
The results of Equation 2 indicate that there is a negative correlation between the average WOZ value and the average distance to the nearest railway station. This means that when the average distance to the nearest railway station increases by one kilometre, the average WOZ value decreases by 1,570 euros. This indicates that people are willing to pay more to live closer to a railway station. The average WOZ value and average distance to the nearest highway entrance are positively correlated. When the average distance to the nearest highway entrance increases by one kilometre, the average WOZ value increases by 8,770 euros. This means that people are willing to pay more to live further away from a highway entrance.

Regarding the control variables, a positive coefficient can be found for the average income per inhabitant and the average number of restaurants within three kilometres, when looking at the results of Equation 2 in Table 2. This means that when one of these variables increases, the average WOZ value also increases. Specifically, the average WOZ value increases by 1,030 euros if the average income increases by 1,000. Likewise, the average WOZ value increases by 170 euros of the average number of restaurants within three kilometres increases by one.

Oppositely, the average number of big supermarkets, average number of other shops for daily foodstuffs and the average number of cafés within three kilometres of the house all have a negative influence on the house price. This means that when the average number of one of these amenities within three kilometres increases, the average WOZ value decreases. Specifically, the average WOZ value decreases by 530 euros if the average number of supermarkets increases by one. Similarly, the average WOZ value decreases by 420 euros if the average number of other shops for daily foodstuffs increases by one. The average WOZ value decreases by 180 euros if the average number of cafés within three kilometres increases by one.

All year dummies that have a significant result for Equation 2, have a negative coefficient in Table 2. This means that in comparison to the base year, 2008, the average WOZ value is lower for these specific years. This can partially be explained by the fact that the average WOZ values have decreased each year from 2011 onwards, as can be seen in Figure 1. The exact values for the average WOZ value per year can also be seen in the descriptive statistics presented in Appendix 2.

Figure 1: Development of the average WOZ value, measured in thousands of euros.



6 Discussion

This section will discuss the limitations of this research and recommendations for further research. As any empirical research, this one is subject to some limitations. First of all, this research only examined the effect of the railway station and highway on the house prices, but there are of course more transport modes that can have an influence. For example, the proximity to the airport and the accessibility by other forms of public transport such as bus and metro. Further research could explore these topics.

Second, this research used the average distance to the nearest highway entrance and nearest railway station as independent variables. However, it is not only the station or the entrance that can have an impact on the house prices. Especially because of negative externalities, one can imagine that the distance to the actual highway and actual railway matters as least as much. In further research, one could include these as independent variables to measure their effect on the house prices.

Another limitation of this research is the fact that by using a regression it is assumed that the effect of the independent variables on the dependent variable is linear. However, it might be that this is not the case. It could be that there is a buffer zone around for example the railway station, as has been mentioned in the literature. This would mean that in a zone around the station the prices will be lower, but then increase when the influence of the negative externalities decreases. From this point onwards, the house prices could be higher due to increased accessibility. Further research could investigate this topic using a non-linear approach.

Furthermore, this research was focused on the Netherlands only, and made use of WOZ values that were available on the neighbourhood level. To get a more general answer to what the influence of the proximity to various transport modes on the price is, data from more countries should be considered in further research. In addition, more precise results can be achieved when data per individual house is available and using selling prices can prevent the delay of one year that comes with using WOZ values. Using prices at the house level and incorporating the characteristics of the houses is also more standard in hedonic pricing models, and can improve the precision of the results. What time span is chosen could also be of influence on the results, as infrastructure projects usually take a long time, and factors like the economy of a country and the housing market can also play a role.

Last, further research could try to control for whether people have the ability to make use of various transport modes. For instance, whether a person owns a car, receives one from their employer, or gets a discount on public transport can have a great impact on their commuting choice. This will then reflect on their choice of where to live, which can in turn be reflected in the house prices.

7 Conclusion

This paper attempts to answer the following research question:

To what extent is there an influence of the proximity to various transport modes on house prices in the Netherlands, and what are possible reasons behind this?

A set of three sub-questions has been developed to help form an answer. The first two questions will be answered using the results of the empirical analysis, using the hedonic pricing model and a fixed effects regression. The last question will be answered using the results of the literature review.

The first question asked what the influence is of the proximity to a railway station on house prices. After performing a fixed effects regression on panel data from the years 2008 up to and including 2016, an answer can be given. The coefficient of the average distance to the nearest important railway station on the average WOZ value is found to be negative, meaning that the average WOZ value decreases when a house is located further away from the railway station. This means that in general there is a preference to live close to the station. As a result, the first hypothesis, saying that the house prices go up when located close to a station, is accepted.

The second question asked what the influence is of the proximity to a highway on house prices. The coefficient resulting from the fixed effects regression is positive, using average WOZ value as the dependent variable and the average distance to the nearest highway entrance as the independent variable. This means that the average WOZ value goes up if a house is located further away from the highway, meaning that people prefer to live further away from the highway. Consequently, the second hypothesis, stating that the house prices go down when located close to a highway, is also accepted.

Reasons for why these results could occur are found when considering the third question. The third question asked why the distance to various transport modes affects house prices. The reason that the distance can have a positive influence on the house prices, is related to improved accessibility. Improved accessibility can have a positive impact on life satisfaction and job opportunities, prevents social exclusion, lowers transport costs and causes less commuting stress. On the other hand, living in close proximity to transport modes can negatively impact house prices through negative externalities. Examples of these externalities are noise and pollution. These can have a negative impact on quality of life, cause sleep disturbance and hearing loss and have other unfavourable health effects.

Regarding the impact of the proximity of transport modes on house prices, contrasting evidence was found for railway stations and highways. Specifically, the results suggests that people prefer to live closer to the railway station and further away from the highway. A possible reason for this is that rail noise is usually valued as less annoying than road noise. Furthermore, around railway stations trains tend to speed down, while near highway entrances cars typically speed up, causing additional noise. In addition, this contrast could be explained by the fact that there are around 400 railways stations but many more highway entrances in the Netherlands. This can have an influence on the relative distances.

To answer the main question, the proximity to a railway station has a positive impact on house prices and the proximity to a highway has a negative impact. This means that in general people prefer to live closer to the railway station and further away from the highway. Possible reasons for this can be found in improved accessibility and negative externalities.

Bibliography

Al-Mosaind, M. A., Dueker, K. J., & Strathman, J. G. (1993). *Light-rail transit stations and property values: A hedonic price approach*.

Allison, P. D. (2009). *Fixed Effects Regression Models*. SAGE Publications, Inc. https://doi.org/10.4135/9781412993869

Biosca, O., Spiekermann, K., & Stępniak, M. (2013). Transport accessibility at regional scale. *Europa XXI*, *24*(24), 5-17. https://doi.org/10.7163/eu21.2013.24.1

Boarnet, M. G., & Chalermpong, S. (2001). New highways, house prices, and Urban development: A case study of toll roads in orange county, Ca. *Housing Policy Debate*, *12*(3), 575-605. https://doi.org/10.1080/10511482.2001.9521419

Bristow, A. L., Wardman, M., & Chintakayala, V. P. K. (2015). International meta-analysis of stated preference studies of transportation noise nuisance. *Transportation*, *42*(1), 71-100. https://doi.org/10.1007/s11116-014-9527-4

Brouwer, R., Hess, S., Wagtendonk, A., & Dekkers, J. (2007). De baten van wonen aan water: Een hedonische prijsstudie naar de relatie tussen huizenprijzen, watertypen en waterkwaliteit.

Centraal Bureau voor de Statistiek. (2011a). *Kerncijfers wijken en buurten 2008*. https://www.cbs.nl/nl-nl/maatwerk/2011/48/kerncijfers-wijken-en-buurten-2008

Centraal Bureau voor de Statistiek. (2011b). *Kerncijfers wijken en buurten 2009*. https://www.cbs.nl/nl-nl/maatwerk/2011/48/kerncijfers-wijken-en-buurten-2009

Centraal Bureau voor de Statistiek. (2011c). *Kerncijfers wijken en buurten 2010*. https://www.cbs.nl/nl-nl/maatwerk/2011/48/kerncijfers-wijken-en-buurten-2010

Centraal Bureau voor de Statistiek. (2011d). *Kerncijfers wijken en buurten 2011*. https://www.cbs.nl/nl-nl/maatwerk/2011/48/kerncijfers-wijken-en-buurten-2011

Centraal Bureau voor de Statistiek. (2011e). *Kerncijfers wijken en buurten 2012*. https://www.cbs.nl/nl-nl/maatwerk/2011/48/kerncijfers-wijken-en-buurten-2012

Centraal Bureau voor de Statistiek. (2014a). *Nabijheid voorzieningen; buurtcijfers 2008*. https://www.cbs.nl/nl-nl/maatwerk/2016/17/nabijheid-voorzieningen-buurtcijfers-2008

Centraal Bureau voor de Statistiek. (2014b). *Nabijheid voorzieningen; buurtcijfers 2009*. https://www.cbs.nl/nl-nl/maatwerk/2016/17/nabijheid-voorzieningen-buurtcijfers-2009

Centraal Bureau voor de Statistiek. (2014c). *Nabijheid voorzieningen; buurtcijfers 2010*. https://www.cbs.nl/nl-nl/maatwerk/2016/17/nabijheid-voorzieningen-buurtcijfers-2010

Centraal Bureau voor de Statistiek. (2016a). *Kerncijfers wijken en buurten 2013*. https://www.cbs.nl/nl-nl/maatwerk/2015/36/kerncijfers-wijken-en-buurten-2013

Centraal Bureau voor de Statistiek. (2016b). *Kerncijfers wijken en buurten 2014*. https://www.cbs.nl/nl-nl/maatwerk/2015/48/kerncijfers-wijken-en-buurten-2014

Centraal Bureau voor de Statistiek. (2016c). *Kerncijfers wijken en buurten 2015*. https://www.cbs.nl/nl-nl/maatwerk/2015/48/kerncijfers-wijken-en-buurten-2015

Centraal Bureau voor de Statistiek. (2016d). *Kerncijfers wijken en buurten 2016*. https://www.cbs.nl/nl-nl/maatwerk/2016/30/kerncijfers-wijken-en-buurten-2016

Centraal Bureau voor de Statistiek. (2016e). *Nabijheid voorzieningen; buurtcijfers 2011*. https://www.cbs.nl/nl-nl/maatwerk/2014/08/nabijheid-voorzieningen-buurtcijfers-2011

Centraal Bureau voor de Statistiek. (2016f). *Nabijheid voorzieningen; buurtcijfers 2012*. https://www.cbs.nl/nl-nl/maatwerk/2014/08/nabijheid-voorzieningen-buurtcijfers-2012

Centraal Bureau voor de Statistiek. (2016g). *Nabijheid voorzieningen; buurtcijfers 2013*. https://www.cbs.nl/nl-nl/maatwerk/2015/31/nabijheid-voorzieningen-buurtcijfers-2013

Centraal Bureau voor de Statistiek. (2016h). *Nabijheid voorzieningen; buurtcijfers 2014*. https://www.cbs.nl/nl-nl/maatwerk/2015/37/nabijheid-voorzieningen-buurtcijfers-2014

Centraal Bureau voor de Statistiek. (2016i). *Nabijheid voorzieningen; buurtcijfers 2015*. https://www.cbs.nl/nl-nl/maatwerk/2016/16/nabijheid-voorzieningen-buurtcijfers-2015

Centraal Bureau voor de Statistiek. (2017). *Nabijheid voorzieningen; buurtcijfers 2016*. https://www.cbs.nl/nl-nl/maatwerk/2017/32/nabijheid-voorzieningen-buurtcijfers-2016

Centraal Bureau voor de Statistiek. (2020). *WOZ-waarde gemiddeld 8,9 procent hoger*. https://www.cbs.nl/nl-nl/nieuws/2020/37/woz-waarde-gemiddeld-8-9-procent-hoger

Centraal Bureau voor de Statistiek. (2021a). *Gemeentelijke indeling op 1 januari 2016*. https://www.cbs.nl/nl-nl/onze-diensten/methoden/classificaties/overig/gemeentelijke-indelingen-per-jaar/indeling-per-jaar/gemeentelijke-indeling-op-1-januari-2016

Centraal Bureau voor de Statistiek. (2021b). *Gemiddelde verkoopprijs koopwoning in 2020 gestegen tot 334 duizend euro*. https://www.cbs.nl/nl-nl/nieuws/2021/12/gemiddelde-verkoopprijs-koopwoning-in-2020-gestegen-tot-334-duizend-euro

Cepeda, M., Schoufour, J., Freak-Poli, R., Koolhaas, C. M., Dhana, K., Bramer, W. M., & Franco, O. H. (2017). Levels of ambient air pollution according to mode of transport: a systematic review. *The Lancet Public Health*, *2*(1), e23-e34. https://doi.org/https://doi.org/10.1016/S2468-2667(16)30021-4

Cesaroni, G., Boogaard, H., Jonkers, S., Porta, D., Badaloni, C., Cattani, G., Forastiere, F., & Hoek, G. (2012). Health benefits of traffic-related air pollution reduction in different socioeconomic groups: the effect of low-emission zoning in Rome. *Occupational and Environmental Medicine*, *69*(2), 133. https://doi.org/10.1136/oem.2010.063750

Chica-Olmo, J., Cano-Guervos, R., & Tamaris-Turizo, I. (2019). Determination of buffer zone for negative externalities: Effect on housing prices. *The Geographical Journal*, *185*(2), 222-236. https://doi.org/https://doi.org/10.1111/geoj.12289

Colvile, R. N., Hutchinson, E. J., Mindell, J. S., & Warren, R. F. (2001). The transport sector as a source of air pollution. *Atmospheric Environment*, *35*(9), 1537-1565. https://doi.org/https://doi.org/10.1016/S1352-2310(00)00551-3

Debrezion, G., Pels, E., & Rietveld, P. (2010). The Impact of Rail Transport on Real Estate Prices: An Empirical Analysis of the Dutch Housing Market. *Urban Studies*, *48*(5), 997-1015. https://doi.org/10.1177/0042098010371395

Demir, E., Huang, Y., Scholts, S., & Van Woensel, T. (2015). A selected review on the negative externalities of the freight transportation: Modeling and pricing. *Transportation Research Part E: Logistics and Transportation Review*, *77*, 95-114. https://doi.org/https://doi.org/10.1016/j.tre.2015.02.020

Dubé, J., Thériault, M., & Des Rosiers, F. (2013). Commuter rail accessibility and house values: The case of the Montreal South Shore, Canada, 1992–2009. *Transportation Research Part A: Policy and Practice*, *54*, 49-66. https://doi.org/https://doi.org/10.1016/j.tra.2013.07.015

Efthymiou, D., & Antoniou, C. (2013). How do transport infrastructure and policies affect house prices and rents? Evidence from Athens, Greece. *Transportation Research Part A: Policy and Practice*, *52*, 1-22. https://doi.org/https://doi.org/10.1016/j.tra.2013.04.002

Gallo, M. (2018). The Impact of Urban Transit Systems on Property Values: A Model and Some Evidences from the City of Naples. *Journal of Advanced Transportation*, *2018*, 1-22. https://doi.org/10.1155/2018/1767149

Gehrsitz, M. (2017). The effect of low emission zones on air pollution and infant health. *Journal of Environmental Economics and Management*, *83*, 121-144. https://doi.org/https://doi.org/10.1016/j.jeem.2017.02.003

Hammer, M. S., Swinburn, T. K., & Neitzel, R. L. (2014). Environmental Noise Pollution in the United States: Developing an Effective Public Health Response. *Environmental Health Perspectives*, *122*(2), 115-119. https://doi.org/doi:10.1289/ehp.1307272

Mummolo, J., & Peterson, E. (2018). Improving the Interpretation of Fixed Effects Regression Results. *Political Science Research and Methods*, *6*(4), 829-835. https://doi.org/10.1017/psrm.2017.44

Nederlandse Spoorwegen. (n.d.). *Stationsontwikkelingen*. https://www.ns.nl/over-ns/activiteiten/stationsontwikkelingen.html

NOS. (2021). JA21 wil nieuwe stad bouwen en discussie over abortus. https://nos.nl/artikel/2364903-ja21-wil-nieuwe-stad-bouwen-en-discussie-over-abortus

Novaco, R. W., & Gonzalez, O. I. (2009). Commuting and well-being. *Technology and well-being*, *3*.

Planbureau voor de Leefomgeving. (2008). *Kwaliteit woonomgeving bepaalt groot deel van huizenprijs*. https://www.pbl.nl/persberichten/20060412-Kwaliteit-woonomgeving-bepaalt-groot-deel-van-huizenprijs#:~:text=Tot%20deze%20bevindingen%20komt%20het,De%20prijs%20van%20de%20plek.&text=Naast%20woningkenmerken%2C%20zoals%20grootte%20en,de%20verkoopprijs%20van%20de%20woning.

Rijksoverheid. (2020). *Staat van de woningmarkt 2020*. https://www.rijksoverheid.nl/actueel/nieuws/2020/06/15/staat-van-de-woningmarkt-2020

Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, *82*(1), 34-55. https://doi.org/10.1086/260169

Sahu, P., Galhotra, A., Raj, U., & Ranjan, R. V. (2020). A study of self-reported health problems of the people living near railway tracks in Raipur city. *Journal of family medicine and primary care*, *9*(2), 740.

Saif, M. A., Zefreh, M. M., & Torok, A. (2019). Public Transport Accessibility: A Literature Review. *Periodica Polytechnica Transportation Engineering*, *47*(1), 36-43. https://doi.org/10.3311/PPtr.12072

Sha, F., Li, B., Law, Y. W., & Yip, P. S. F. (2019). Associations between commuting and well-being in the context of a compact city with a well-developed public transport system. *Journal of Transport & Health*, *13*, 103-114. https://doi.org/https://doi.org/10.1016/j.jth.2019.03.016

Sirmans, S., Macpherson, D., & Zietz, E. (2005). The Composition of Hedonic Pricing Models. *Journal of Real Estate Literature*, *13*(1), 1-44. https://doi.org/10.1080/10835547.2005.12090154

So, H. M., Tse, R. Y. C., & Ganesan, S. (1997). Estimating the influence of transport on house prices: evidence from Hong Kong. *Journal of Property Valuation and Investment*, *15*(1), 40-47. https://doi.org/10.1108/14635789710163793

Stansfeld, S. A., & Matheson, M. P. (2003). Noise pollution: non-auditory effects on health. *British Medical Bulletin*, *68*(1), 243-257. https://doi.org/10.1093/bmb/ldg033

Stutzer, A., & Frey, B. S. (2008). Stress that doesn't pay: The commuting paradox. *Scandinavian Journal of Economics*, *110*(2), 339-366.

Tassi, P., Rohmer, O., Schimchowitsch, S., Eschenlauer, A., Bonnefond, A., Margiocchi, F., Poisson, F., & Muzet, A. (2010). Living alongside railway tracks: Long-term effects of nocturnal noise on sleep and cardiovascular reactivity as a function of age. *Environment international*, *36*(7), 683-689. https://doi.org/10.1016/j.envint.2010.05.001

Tillema, T., Hamersma, M., Sussman, J. M., & Arts, J. (2012). Extending the Scope of Highway Planning: Accessibility, Negative Externalities and the Residential Context. *Transport Reviews*, *32*(6), 745-759. https://doi.org/10.1080/01441647.2012.724726

Van den Eerenbeemt, M. (2021). Huizenprijzen sprinten met 15 procent in een jaar nóg harder omhoog: grootste toename in 20 jaar. *De Volkskrant*. https://www.volkskrant.nl/gs-bf3c3f5d

Waarderingskamer. (n.d.). *Hoe de WOZ-waarde tot stand komt*. https://www.waarderingskamer.nl/klopt-mijn-woz-waarde/totstandkoming-woz-waarde/

Wardman, M. (1988). A Comparison of Revealed Preference and Stated Preference Models of Travel Behaviour. *Journal of Transport Economics and Policy*, *22*(1), 71-91. http://www.jstor.org/stable/20052836

Winterman, P. (2021). Eerdmans (JA21) wil compleet nieuwe stad voor 150.000 inwoners: 'Kan niet oneindig in de hoogte bouwen'. *AD*. https://www.ad.nl/politiek/eerdmans-ja21-wil-compleet-nieuwe-stad-voor-150-000-inwoners-kan-niet-oneindig-in-de-hoogte-bouwen~a4b3c094/

Appendix

Appendix 1

Table 3: Previous research on the influence of proximity to transport modes on house prices

Autor(s)	Year	Country	Transport mode(s)	Research design	Influence on house prices
So et al.	1997	China	Metro and minibus	Hedonic pricing model	Positive
Gallo	2018	Italy	Metro	Hedonic pricing model	Positive
Debrezion et al.	2010	Netherlands	Train (railway)	Hedonic pricing model	Positive
Dubé et al.	2013	Canada	Train	Difference-in-difference	Positive
Efthymiou & Antoniou	2013	Greece	Train (national)	Hedonic pricing model & spatial econometric model	Negative
			Metro, tram, train (suburban)		Positive
Chica-Olma et al.	2019	Colombia	Train	Hedonic pricing model	Positive and negative (buffer zone)
Tillema et al.	2012		Car (highway)	Literature review	Negative
Brouwer et al.	2007	Netherlands	Car	Hedonic pricing model	Negative
Planbureau voor de leefomgeving	2008	Netherlands	Car	Hedonic pricing model	Negative (cities) Positive (rural areas)
Boarnet & Chalermpong	2001	United States of America	Car	Hedonic pricing method	Positive

Note: Negative influence on the house prices means that the house prices go down when the house is located close to a certain transport mode, for example close to the highway or railway. The transport mode car relates to the highway and the transport mode train relates to the railway.

Appendix 2

Table 4: Descriptive statistics for the variables of the panel data used in the fixed effects regression, broken down by year

Variable	Year	Observations	Mean	Std. Dev.	Min	Max
WOZ	2008	8,799	276.36	122.82	26	1868
Distance railway station	2008	11,068	13.37	9.92	0.2	69
Distance highway	2008	11,069	1.80	1.79	0.1	43.4
Average income	2008	8,156	13.50	2.73	5.7	44.8
Number of supermarkets	2008	11,069	5.54	6.47	0	58.1
Number of other shops	2008	11,069	29.84	55.07	0	736.1
Number of cafés	2008	11,069	18.15	46.49	0	755.8
Number of restaurants	2008	11,069	25.01	63.77	0	1166.1
WOZ	2009	8,913	285.63	128.68	75	2019
Distance railway station	2009	11,05	13.36	9.92	0.2	69
Distance highway	2009	11,05	1.80	1.79	0.1	43.3
Average income	2009	8,295	21.43	5.06	-4.6	64.9
Number of supermarkets	2009	11,05	5.55	6.49	0	59.1
Number of other shops	2009	11,05	29.19	54.11	0	723.8
Number of cafés	2009	11,05	17.97	46.10	0	745
Number of restaurants	2009	11,05	24.98	63.59	0	1158.3
WOZ	2010	9,005	286.97	128.38	78	1941
Distance railway station	2010	11,151	13.34	9.90	0.2	69
Distance highway	2010	11,151	1.81	1.79	0.1	43.3
Average income	2010	8,542	21.73	5.05	-3.8	67.1
Number of supermarkets	2010	11,151	5.56	6.58	0	64.1
Number of other shops	2010	11,151	28.30	51.76	0	697.3
Number of cafés	2010	11,151	17.05	43.54	0	715.7
Number of restaurants	2010	11,151	25.33	65.22	0	1197.3
WOZ	2011	9,109	280.63	125.48	67	1897
Distance railway station	2011	11,347	13.25	9.87	0.2	68.9
Distance highway	2011	11,347	1.80	1.74	0.1	43.3
Average income	2011	9,938	22.13	5.00	0.3	69.9
Number of supermarkets	2011	11,347	5.78	7.00	0	74.7
Number of other shops	2011	11,347	27.93	50.78	0	702.9
Number of cafés	2011	11,347	16.93	43.59	0	731.4
Number of restaurants	2011	11,347	26.07	66.75	0	1229.5
WOZ	2012	9,193	273.81	121.98	56	1838
Distance railway station	2012	11,465	13.33	9.91	0.3	69
Distance highway	2012	11,465	1.83	1.78	0.1	43.3
Average income	2012	9,992	22.66	5.06	0.2	72.2
Number of supermarkets	2012	11,465	5.84	7.14	0	76.9
Number of other shops	2012	11,465	27.63	50.49	0	698

Number of cafés	2012	11,465	16.57	42.86	0	715.7
Number of restaurants	2012	11,465	26.51	68.09	0	1259.1
WOZ	2013	9,249	262.82	116.10	25	1699
Distance railway station	2013	11,511	13.28	9.83	0.3	69
Distance highway	2013	11,511	1.83	1.81	0.1	43.4
Average income	2013	10,06	22.88	5.12	0.1	73.5
Number of supermarkets	2013	11,511	5.92	7.34	0	80.3
Number of other shops	2013	11,511	27.44	50.27	0	692.3
Number of cafés	2013	11,511	16.27	42.27	0	705
Number of restaurants	2013	11,511	26.98	69.19	0	1279.5
WOZ	2014	9,199	246.88	108.07	34	1600
Distance railway station	2014	11,517	13.36	9.89	0.3	71.9
Distance highway	2014	11,517	1.85	1.89	0.1	46.3
Average income	2014	9,99	23.67	5.36	7.5	78.2
Number of supermarkets	2014	11,517	5.90	7.51	0	88.8
Number of other shops	2014	11,517	27.07	50.39	0	699
Number of cafés	2014	11,517	15.75	41.39	0	697.8
Number of restaurants	2014	11,517	27.35	70.30	0	1294.9
WOZ	2015	9,399	240.69	107.00	38	1523
Distance railway station	2015	11,702	13.31	9.86	0.3	71.9
Distance highway	2015	11,702	1.86	18.5	0.1	46.4
Average income	2015	10,102	24.73	5.97	6.1	105.5
Number of supermarkets	2015	11,702	5.99	7.73	0	88.4
Number of other shops	2015	11,702	26.93	50.00	0	713.6
Number of cafés	2015	11,702	15.30	39.91	0	678.5
Number of restaurants	2015	11,702	28.20	73.33	0	1373.5
WOZ	2016	9,845	243.38	109.79	33	1598
Distance railway station	2016	12,186	13.01	9.89	0.23	71.88
Distance highway	2016	12,186	1.87	1.82	0.07	46.35
Average income	2016	10,554	25.52	6.25	7	96.4
Number of supermarkets	2016	12,186	7.00	10.47	0	96.8
Number of other shops	2016	12,186	33.63	73.09	0	745.2
Number of cafés	2016	12,186	20.45	63.17	0	675.8
Number of restaurants	2016	12,186	41.32	131.68	0	1473.5

Note: WOZ value gives the average WOZ value in thousands of euros. Distance railway station and distance highway give the average distance to the nearest highway entrance and nearest important railway station in kilometres, respectively. Average income gives the average income per inhabitant in thousands of euros. The last four variables each give the average number of the specific amenity within 3 kilometres for the inhabitants of a neighbourhood.

Appendix 3

The regression equations when adding the dummy variables one by one are:

$$WOZ_{i,t} = \beta_0 + \beta_1 DR_{i,t} + \beta_2 DH_{i,t} + \beta_3 AI_{i,t} + d_t + \varepsilon \quad (3)$$

$$WOZ_{i,t} = \beta_0 + \beta_1 DR_{i,t} + \beta_2 DH_{i,t} + \beta_3 AI_{i,t} + \beta_4 NS_{i,t} + d_t + \varepsilon \quad (4)$$

$$WOZ_{i,t} = \beta_0 + \beta_1 DR_{i,t} + \beta_2 DH_{i,t} + \beta_3 AI_{i,t} + \beta_4 NS_{i,t} + \beta_5 NO_{i,t} + d_t + \varepsilon \quad (5)$$

$$WOZ_{i,t} = \beta_0 + \beta_1 DR_{i,t} + \beta_2 DH_{i,t} + \beta_3 AI_{i,t} + \beta_4 NS_{i,t} + \beta_5 NO_{i,t} + \beta_6 NC_{i,t} + d_t + \varepsilon \quad (6)$$

Appendix 4

Table 5: Results of the fixed effects regressions presented in Equation 3 up to and including 6 in Appendix 3, with average WOZ value as the dependent variable

Variable	**(3)**	**(4)**	**(5)**	**(6)**
Distance railway station	-0.44 (0.24) *	-0.45 (0.243) *	-1.64 (0.25) ***	-1.69 (0.25) ***
Distance highway	8.90 (0.38) ***	8.90 (0.38) ***	8.95 (0.38) ***	8.86 (0.38) ***
Average income	1.08 (0.05) ***	1.08 (0.05) ***	1.07 (0.05) ***	1.05 (0.05) ***
Number of supermarkets		-0.02 (0.08)	0.34 (0.08) ***	0.20 (0.08) **
Number of other shops			-0.50 (0.02) ***	-0.39 (0.02) ***
Number of cafés				-0.19 (0.02) ***
Year 2009	-0.01 (0.49)	-0.01 (0.49)	-0.29 (0.48)	-0.11 (0.48)
Year 2010	0.88 (0.50) *	0.89 (0.50) *	0.21 (0.49)	0.34 (0.49)
Year 2011	-5.51 (0.51) ***	-5.51 (0.51) ***	-6.51 (0.51) ***	-6.34 (0.51) ***
Year 2012	-13.02 (0.52) ***	-13.01 (0.53) ***	-14.13 (0.52) ***	-13.96 (0.52) ***
Year 2013	-23.85 (0.53) ***	-23.84 (0.53) ***	-25.09 (0.53) ***	-24.94 (0.53) ***
Year 2014	-39.88 (0.56) ***	-39.87 (0.56) ***	-41.23 (0.56) ***	-41.13 (0.56) ***
Year 2015	-47.94 (0.60) ***	-47.93 (0.61) ***	-49.34 (0.61) ***	-49.30 (0.61) ***
Year 2016	-47.39 (0.63) ***	-47.38 (0.63) ***	-48.87 (0.63) ***	-48.84 *** (0.63)
Constant	250.40 (3.13) ***	250.63 (3.28) ***	280.93 (3.47) ***	283.02 (3.48) ***
R^2	0.437	0.437	0.442	0.443
F-statistic	4787.54	4388.52	4141.99	3854.03
Number of observations	80,184	80,184	80,184	80,184
Number of neighbourhoods	12,258	12,258	12,258	12,258

Note: The first column shows the results of Equation 3, the second column shows the results of Equation 4, and so forth. In all fixed effect regressions, the dependent variable is average WOZ value and the independent variables are the average distance to the nearest railway station and nearest highway entrance. The values in the table are the regression coefficients, the values between brackets are the standard errors. The stars indicate the significance level, such that * indicates $p < 0.10$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.