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Effects of noise on the WOZ Housing Values Around Schiphol

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Abstract

The paper researches the relevance of noise from the Amsterdam Schiphol Airport on the property values in that area, and whether the noise-reducing measures taken by Schiphol in the period 2011-2016 significantly affected the housing prices of the properties in the areas around Schiphol. Using WOZ and Statline data from 2011 - 2022 multiple hedonic pricing regressions are run, together with the noise variable extracted from the changing noise maps created in 2011 and 2016. The results cannot precisely identify a negative effect of the noise on the property values, but it is proven that for some cases noise has a significant effect on the property values.

Contents

1 Introduction

The presence of airports grants substantial advantages to a region, encompassing employment opportunities and enhanced travel prospects (Brueckner (2003); Sheard (2021); Campante and Yanagizawa-Drott (2018); Cattaneo et al. (2023)). Nevertheless, there is also a downside to them. Every departing and arriving aircraft requires ample space for acceleration and ascent or deceleration and descent. These manoeuvres generate considerable noise, impacting the living conditions of the people living around the airports. Noise has all kinds of effects on a person's well-being, like an increase in sleeping problems, headaches, stress, hypertension, and overall discomfort for the residents of the affected area (Boes et al. (2013); Black et al. (2007); Bronzaft et al. (1998)).
This research however will contribute to the existing literature by investigating whether noise influences the value of surrounding properties and whether these influences on property values can be reversed if the noise disappears or becomes less noticeable. In the end this paper aims to research whether the noise-reducing measures taken by Schiphol in the period 2011-2016 significantly affected the housing prices of the properties in the areas around Schiphol.

In "the article" of IenW (2019), Schiphol's direct and indirect influence on the GDP of The Netherlands is estimated to be 1.3% in 2018. Additionally, jobs related to the airport were altogether good for 57.000 FTEs in that same year. Looking at these numbers, it could be assumed that mostly positive externalities come from the airport. However, the externalities related to noise and air pollution are sometimes overlooked. In recent years, several news reports were published regarding the noise pollution of Schiphol and the urge to do something about this (van der Parre and Meindertsma (2018); OmroepWest (2022)). The article of NOS (2023) states that noise levels were too high during the years 2017-2019, and therefore, the households are being compensated. This indicates that noise has a negative effect on people that live near airports, otherwise they would not have been compensated. These negative effects can be physical and emotional, as earlier mentioned(Boes et al. (2013); Black et al. (2007); Bronzaft et al. (1998)), but also on property value. This research will step away from the first mentioned effects and will focus on the effects of noise on the WOZ values in the Schiphol area. Articles that research the effect of an airport on the housing value have been published for other airports, but for the Schiphol airport this effect remains unknown. There are some papers form before 2010, nonetheless these show no direct interest in the WOZ values. So, this article will be one of the first that will look at the impast vo noise from Schiphol airport on the WOZ housing value. By doing so, awareness of the material effects of the noise will be created.

This paper is structured in the following way. Section 2 provides a literature review and introduces the essential knowledge of the noise regions that surround Schiphol. Next, Section 3 provides an overview of the collected data and the created variables. After this, Section 4 explains what methods are used to evaluate the data of Section 3. Following that, Section 5 displays the results of the previously mentioned methods. Lastly, in Section 6, an overall conclusion is presented together with recommendations for further research and this research's limitations.

2 Literature Review

The paper of Cohen and Coughlin (2009) researches the changing noise levels near the Atlanta Airport. This paper was one of the first to construct estimates of the changing impact of noise, focusing on the change over time. Using a hedonic model, the effects of proximity and noise are evaluated. They find that houses in noisier areas are sold for a lower amount of money than houses in less noisy areas. However, they point out that the noise around airports is measured infrequently, which will influence the quality of research in the area. This also holds for this paper's research field: the area around Amsterdam Schiphol Airport, as the noise contours around Schiphol are only created once every five years. Next to this, the Schiphol data collection method changed some years ago, and therefore, only data for the years 2016 and 2021 are available. Only having noise data from two years, severely limits the research possibilities as the research period is only 12 years, with two noise measurement points. Therefore, the goal of this research will be to see whether noise significantly affects the housing market and try to see if these effects can be reversed over time. In other words, has noise a significant impact on the WOZ value of houses, and if the noise levels change over time, does the WOZ value of that house (on average) will go back to the original value. So, it the WOZ value of houses resilient if it comes to noise? For instance, a WOZ value will decrease if that house is in an area with more noise. Will the WOZ increase again if that house is in a less noisy area later on, due to new regulations, with the same multitude as the decrease?

In the research by Tomkins et al. (1998) on the effect of the expansion of the Manchester city airport, it is concluded that close proximity to the airport outweighs the harmful effects of airport noise in determining the prices of residential properties in the area. This article suggests that there is evidence to assume that close proximity to the airport and the positive attributes, such as good access and employment opportunities, are valued higher than the negative externalities, such as sound and pollution by residents. Next, the number of aircraft movements is not the deciding factor of noise complaints; the constant noise is of more considerable influence. This indicates that to measure the noise, the peak noise is not relevant but rather the overall noise. The research on the expansion of the Chicago O'Hare airport of McMillen (2004) points that expanding the airport by better use of existing runways and adding an extra runway will not decrease housing prices due to increased noise levels because quieter planes are being used compared to before. In other words, quieter aircraft can possibly compensate for an airport's expansion of flying movements in terms of property values.

These papers all research the effects of expanding airports and the noise related to these actions. In this research, the focus will be different, as the focus will not be on an expansion of Schiphol but on the change in the noise regions, measured by the "Ministerie van Infrastructuur en Waterstaat", and how these changes affect the property values. This policy shock will be explained further in this research. This follows with the question of whether these noise effects on the property values are reversible or not. As mentioned before, houses in areas with more noise are expected to have a lower WOZ value compared to houses with the same characteristics in a less noisy area (Cohen and Coughlin (2009)). If a house its locations in a noise region changes, from a noisy area into a less noisy area, the WOZ would increase, and thus the noise effect would be moving to the average WOZ value of such a house, but is that true? Can the effect of the previous noise level be completely erased? For the rest of this research, these assumptions will be mentioned as to whether or not the noise effects can be reversible. To properly research this, it is important that the noise surrounding Schiphol significantly affects housing prices, otherwise the secondary goal of whether noise effects can be reversed is not researchable.

The meta-analyses of Schipper et al. (1998) and Nelson (2004) show that the hedonic pricing method is widely used for studying aircraft noise. This method uses property prices to create a value for the environmental effect, the positives and the negatives. This method, developed by Griliches (1971) and Rosen (1974), works with the idea that both external and internal characteristics influence the monetary value of a good. In this research, the property's location characteristics and the external effect of airport noise are used to research its influence on the WOZ value of the houses in the Schiphol area.

The hedonic pricing model in the paper of Dröes and Koster (2016) controls for differences in housing composition to research the effect of wind turbines on residential property values. This paper uses a difference-in-difference model to capture the differences before and after the placement of a wind turbine (the treatment point). In the research on the noise around Schiphol no such point in time can be found, but changing noise levels could be assumed to react similarly; as new noise-reducing measures are created alongside the noise maps. As the available data could indicate a shift of noise after the year 2016, it is possible to see this year as the treatment point. With the years before 2016 having the same noise levels as found in 2016, and the years afterwards having the noise levels of the noise map of 2021.

Additionally, the papers of Espey and Lopez (2000), Zheng et al. (2020), and Cohen and Coughlin (2008) use the hedonic pricing model in a setting closer related to that of Schiphol. Namely, the studied locations are the airport in the Reno-Sparks area, the Hong Kong Kai Tak Airport, and the Atlanta airport. The research of the Reno-Spark area concluded that houses in noisier areas(60 dB) have a significantly lower value than houses not in that area. For the Hong Kong Kai Tak Airport another approach is used, as this airport has a moment in time, 1998, when the noise dropped significantly. Using a difference-in-difference method, it is found that the disappearance of airport noise led to a significant increase in property value. Lastly, the paper on the Atlanta airport finds that houses in an area with airport noises between 70-75 dB sell for a significantly lower price than houses with a noise level below 65 dB, keeping other characteristics the same.

These findings suggest that this research will show a significant effect of the noise on the WOZ. In section 3, the available data will be introduced and choices regarding the methods used will be discussed. For the resilience of the WOZ value it is hoped that this will be found, as this would create great stimuli to lower the noise levels further.

2.1 Measurement of noise

In 2002, the European Union provided a guideline on environmental noise (2002/49/EG) (European Union, 2002). In this guideline, it is stated that noise data should be collected regularly. The Schiphol area collects data every 5 years, with 2016 and 2021 as the most recent and usable ones. The data is collected by measuring the noise at different points around Schiphol, creating a noise map. Additionally, the definitions of the different noise indicators that should be created, each being an indicator that captures the number of decibels(dB), are provided.

- L_{den}: day-evening-night indicator, the overall noise indicator.
- L_{day}: the day indicator.
- $L_{evening}$: the evening indicator.

- L_{night}: the night indicator.

The exact formula for calculating these indicators can be found in Appendix A. In this research, only L_{den} will be used as an overall noise indication, which is assumed to be sufficient in this kind of research (Tomkins et al. (1998)).

2.2 Schiphol

The next section will focus on Schiphol-specific noise measures and the noise-maps that are created every five years. Firstly, the taken measures are explained and how these may influence the noise. After this, the noise maps and the different noise levels used are introduced.

2.2.1 Noise reducing measures

This paper aims to research whether the noise-reducing measures taken in the period 2011-2016 significantly affected the housing prices of the properties surrounding Schiphol. To better understand what kind of measures the airport has taken, this section will focus on the noise-reducing measures taken by Schiphol in the past years. The government re-evaluates these measures every five years following the noise load maps of the previous year. This is done by comparing the noise reduction to the previous noise levels. In 2008, the goal was set that the noise levels should have decreased with 5% in 2020. For instance, the paper by Ministerie van Infrastructuur en Milieu (2018) describes the results of the previous action plan based on the noise map of 2016, comparing this map to the map of 2011. This way of reviewing the noise around Schiphol and thus the effect of the measures taken has been happening since 2008, with the noise map of 2007, and has happened every five years since. This method follows the European guideline 2002/49-EG. However, the exact methods of noise measuring have changed over the years. Therefore, using older noise data than 2016 is not considered.

In 2006, a consultation table, named Alderstafel Schiphol (later changed to Omgevingsraad Schiphol(ORS)), was created to advise the government on the balance between the growth of Schiphol and the possible obstacles related to the living quality of its surroundings. In 2008, they expected that in 2020, the noise-reducing measures would result in a 5% reduction of extreme hindrance in the 48dB(A) L_{den} area.

In the first few years, significant progress was made using different flight paths. However, changing these routes at some point will not result in less noise nuisance but only in a shift of where the noise is most noticeable. Changing flight routes to be mostly over less population-dense land can result in less noticeable noise. In the paper by Netjasov (2012), different measures for noise reduction are given. The Committee on Aviation Environmental Protection of the International Civil Aviation Organization (ICAO) states that, for noise reduction, airports should not strive for a singular solution but rather integrate various resolution methods. Overall, the various measures can be classified into four distinct categories.

- Decrease of noise at source
- Operational procedures for noise decreasing
- Operating restrictions on air traffic
- Land use, planning and management

In the paper of Netjasov (2012), an analysis is done of the different noise-reducing measures airports took in 2009. A distinction is made of 18 different measures. The five methods that at least 200 airports used are given below, with the frequency in parentheses:

- *Noise Abatement Procedures* (490); This measure creates speed limits and optimises flight paths.
- *Engine Run-Up Restrictions* (406); This measure can ensure the run-up tests are only performed on specific locations or during certain hours.
- *Preferential Runways* (363); This measure creates preferred runways when certain conditions are met. For instance, wind from the north or south can change this.
- *Airport Curfews* (236); This measure is used to create time frames in which aircraft are not allowed to take off or landing.
- *Airport Noise Contour* (234); This measure creates awareness of current and future areas in which the noise can have an impact.

These measures are all taken to better regulate the noise that is generated. By doing so, noise levels can be better predicted and regulated.

In Ministerie van Infrastructuur en Milieu (2018) the measures taken in the period 2013-2018, that had a noise-reducing effect are said to be the following:

- *They created a fixed curve radius between Hoofddorp and Nieuw-Vennep.* By doing so, the planes would fly more accurately over a less populated area. As a result less people would experience the noise. This measure can be placed under the Noise Abatement Procedure method. However, as this research uses neighbourhood and municipality data the effect of flying over less populated areas is not noticeable, as it is uncertain what neighbourhoods or municipalities are exactly effected.

- *Rate distinction.* By changing the different flight rates to be higher for more noise-producing types and by increasing the rates for flights during the night. By doing so, the incentive is created to fly with less noise-polluting aircraft, what will result in less noise, and to fly less during times when people will notice the noise more.
- *NADP2.* A different departure strategy in which aircraft will provide less noise for the areas further away from the airport. This measure can be linked to the Preferential Runways method, as the conditions can influence the departure strategy.

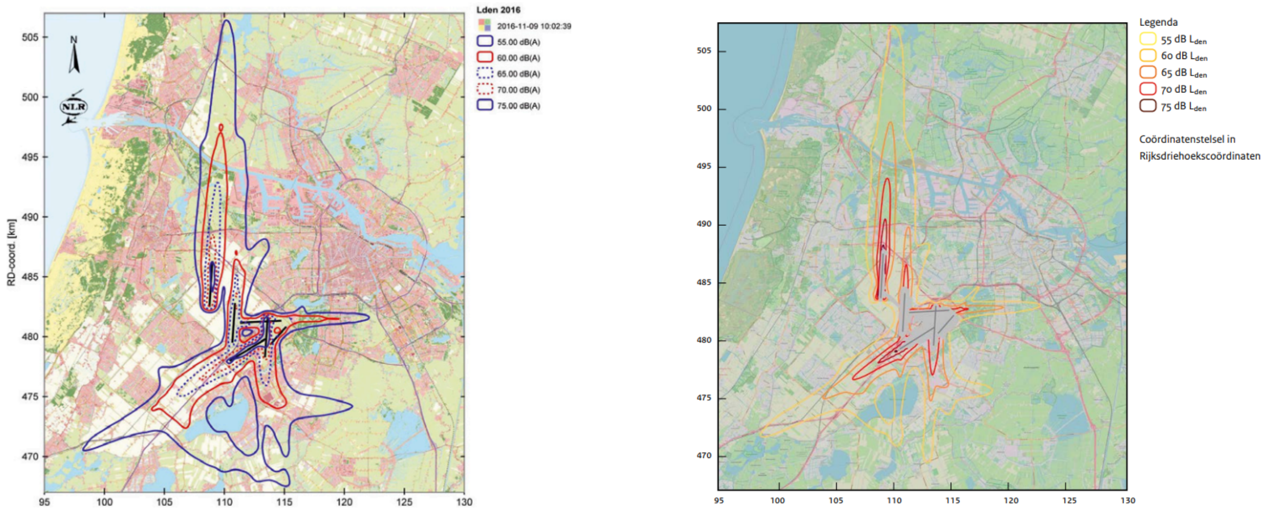
For the period 2018-2023 the following measures were expected to be carried out.

- *Air Traffic Management.* Mandatory measures that are used in the whole of Europe, such as the Single European Sky ATM Research (SESAR) program and initiatives to modernise the ATM system.
- *Microklimaat Leimuiden.* A couple of alternative routes for the eastern take-off route of the Kaagbaan are researched. The research of Anima Project (2019) gives results regarding this microclimate. They mention that the noise mostly shifts to the region of Kudelstaart. Because of this, further research is required, and a conclusion is not made at the moment.

All these measures show that the noise will change continuously through the years, and this list provides insights for future research. As the effects of all these regulations individually can be researched when a sufficient amount of data is available.

2.2.2 Noise around Schiphol

A possible indication of how people experience the noise is the amount of complaints that are registered. However, finding data that is anonymous but still reliable is close to impossible. Therefore, it is decided that the number of complaints will not be an indicator of the noise levels around Schiphol. In the article of Ministerie van Infrastructuur en Waterstaat (2022), the noise measurement map of 2021 is shown. Every year a Maximale Hoeveelheid Geluid (Maximum quantity of noise) is set, to create a boundary for the total amount of noise pollution. The noise is measured all around Schiphol, and noise maps are created with contours for the 55-59, 60-65, 65-69, and 70-75 dB(A) cohorts of the indicator L_{den}. For the indicator L_{night}, the first cohort becomes 50 and the last 70 dB(A), but as explained before, the focus of this research will be on L_{den}. In Figure 1 the two noise maps that are the focus of this research are given. At first glance, it is hard to identify changes in the noise regions over time, but in Section 3 the changes will be discussed using different methods.



(a) L_{den} 2016 (b) L_{den} 2021

Figure 1: The two noise maps portraying the noise regions in 2016 and 2021 around Schiphol.

The main goal of this research is to determine whether the WOZ value of houses is affected by the change in noise level from the nearby Amsterdam Schiphol Airport, and whether or not a decrease in noise will increase property values. To research this, it first needs to be checked that the influence of noise significantly affects the property values.

From the previously mentioned papers and their results, it is expected that a significant effect of the noise regions will be found in this research. After this, whether or not this effect can be "reversed" when a change in the noise level happens is researched. A reversion would mean that the noise levels do not permanently mark the property values, yet this seems unlikely. However, a true reversion will be hard to prove as the available data is likely insufficient. Because most papers used individual housing data, and this paper will not. The municipality and neighbourhood data, explained in Section 3, provide average values of property values and the surrounding characteristics. However, together with the total number of houses in each region, results can be generated. The paper by O'Byrne et al. (1985) suggests that census block data, similar to our municipality and neighbourhood data, and individual housing data give similar results in the research on the effect of noise on the property values around the Atlanta airport. Therefore the municipality and neighbourhood data is expected to be sufficient.

3 Data

To research the effect of noise on the housing market surrounding Amsterdam Schiphol Airport, data is collected from Statline, CBS (2023). From Statline the data regarding the proximity to green, high schools, shops, number of houses, etc. is extracted, both on a municipality level and on a neighbourhood level. All the variables are given in Appendix C. Next, data regarding the WOZ values in these municipalities and neighbourhoods is obtained. Lastly, the inflation numbers of the last years are taken, with 2015 as the base year. After this, all the WOZ values are assumed to be corrected for inflation, with 2015 as the base year. In Ministerie van Infrastructuur en Waterstaat (2017) and Ministerie van Infrastructuur en Waterstaat (2022), noise data is collected from the years 2016 and 2021, providing information on the L_{den} levels in the different municipalities and neighbourhoods.

3.1 Control variables

From Statline the regional key figures are extracted to be used as control variables. As the locational effects of certain regions are of the essence the data regarding the proximity to different facilities is gathered. These facilities can be categorised into sub-groups such as health and well-being, retail, hospitality, childcare, education, green space, traffic and transport, and leisure and culture. To decide which variables from Appendix C to use in this research, the correlation tables for every sub-group were created. The correlation tables, however, showed a correlation between most variables. This high correlation could lead to multicollinearity, hence, multiple variables are deleted using the VIF (Variance Inflation Factor). The book of Vittinghoff et al. (2005) suggests that a VIF value of above 10 should be considered problematic. So, features are deleted until the VIF value is below 10 for all remaining variables. This results in the variables given in Table 1. The descriptive statistics of these variables are given in Appendix B.

Table 1: The variables that give a VIF below 10 together.

Variable	Description	unit	VIF
Gemeente	Gemeente		
Year	Year		
WOZ	WOZ (average inflation corrected)	1000 euro	
D	General practice—Distance to GP practice	km	7.19
M	Hospital (incl. outpatient clinic)—Number of hospitals—Within 20 km	number	5.90
Z	Department store—Distance to department store	km	3.06
AC	Department store—Number of department stores —Within 20 km	number	6.00
AD	Cafes, etc.—Distance to cafe, etc.	km	4.57
AG	Cafes, etc.—Number of cafes etc.—Within 5 km	number	7.35
AP	Hotels etc.—Distance to hotel, etc.	km	3.85
AT	Daycare centres —Distance to daycare centres	km	4.76
BB	Primary education—Distance to school	km	7.04
BJ	Secondary education—Vmbo—Distance to school	k	6.88
CJ	Public green—Distance to forest	km	5.61
CM	Public green—Distance to open natural terrain —Distance to open wet natural terrain	km	2.75
CN	Semi-public green—Distance to semi-public green total	km	3.85
CQ	Semi-public green—Distance to recreational area	km	4.79
CR	Semi-public green—Distance to cemetery	km	6.70
CT	Distance to main highway entrance	km	6.73
CW	Distance to library	km	3.93
CZ	Museum—Distance to museum	km	6.80
DD	Performing arts (excl. festivals)—Total distance to performing arts	km	6.81
DH	Performing arts (excl. festivals)—Distance to pop music venue	km	9.70
DO	Recreation—Distance to attraction	km	8.33
DQ	Recreation—Number of attractions—Within 20 km	number	3.77
DS	Distance to fire station	km	5.21

3.2 Noise variables

The tables in Ministerie van Infrastructuur en Waterstaat (2017) and Ministerie van Infrastructuur en Waterstaat (2022) are used to gather the data for the proper locations on a municipality level. The tables in these papers provide the number of houses in each municipality per noise level. By assuming that houses only change one noise level up or down in 5 years, the two tables together create Table 2. This table gives insights into how the noise regions, looking at municipalities, changed between the years 2016 and 2021. The same is done for the neighbourhood regions, given in Table 4, although these data are manually constructed by comparing the noise maps and maps of the different neighbourhoods in those municipalities. Therefore, it is hard to say how correct this data is, however how the municipality data is generated is also not entirely clear. One thing that is certain is that by creating neighbourhood data the highly and densely populated areas are better taken into account. This would mean that the two datasets are complementary to each other and that it is not possible to say one is better than the other. The exact differences will be explained in Section 3.4.

Table 2: The created groups and the number of houses within these groups between the period 2016 - 2021, for the municipality dataset.

	Houses that stay in the same noise region			Houses that move into a region with more noise			Houses that move into a region with less noise
L_{den}	1	2	3	0 → 1	1→2	2→3	1→0
Number of houses	15600	1300	200	9000	3300	100	1300
Aalsmeer	500 (0.03)	600 (0.46)	100 (0.50)	3600 (0.4)	600 (0.18)	100 (1.0)	-
Amstelveen	3400 (0.22)	100 (0.08)	-	-	1100 (0.33)	-	100 (0.08)
Amsterdam	900 (0.06)	-	-	3300 (0.37)	100 (0.03)	-	-
Haarlemmermeer	4700 (0.30)	500 (0.38)	100 (0.50)	1700 (0.19)	1300 (0.39)	-	-
Uitgeest	-	-	-	100 (0.01)	-	-	-
Uithoorn	5300 (0.34)	-	-	-	-	-	900 (0.69)
Zaanstad	600 (0.04)	100 (0.08)	-	300 (0.03)	200 (0.06)	-	-
Kaag en Braassem	100 (0.01)	-	-	-	-	-	200 (0.15)
Nieuwkoop	100 (0.01)	-	-	-	-	-	100 (0.08)

The different regions with noise of 0 dB, 55-59 dB, 60-64 dB, and 65-69 are given the values 0, 1, 2, and 3, respectively. In the parenthesis, that region's contribution to that group's total is given as a percentage.

Looking at Table 2 it is clear that the municipalities Uitgeest, Kaag en Braassem and Nieuwkoop are only lightly affected by the noise, as only a handful of houses are experiencing noise levels of 55 dB or more. In the first column, the municipalities affected by noise are given. The next three columns provide the number of houses in that specific municipality that remain in the same noise range, either 55-59 dB, 60-64 dB and 65-69 dB, respectively. In the following three columns, the number of houses that move into a region where the noise level is higher in the year 2021 compared to the year 2016, is given. Lastly, in the fifth column, the number of houses that move into a less noisy region is given. This is only one column, as the papers suggest that there are no moves from noise level 65-69 dB to 60-64 dB. However, this still could be the case if the assumption of only moving one noise level was not made, however, due to the number of houses in the different areas this seems very unlikely. It is striking that the number of houses in the fifth column is not substantial. Therefore, the research on whether the WOZ values will change in a ”reversion way”, if the noise level increases the WOZ value decreases and the other way around is hard to perform with this dataset.

Firstly, as stated before, the WOZ values are corrected for inflation to analyse the true impact of noise on the housing market making them not time-dependent. Secondly, all the missing data is created using interpolation and extrapolation in Stata 17. The generated data points are created using at least three observations from that location(municipality or neighbourhood), and as the variables measure distance to locations it can be assumed that these will not change drastically in a couple of years. Therefore, the use of interpolation and extrapolation on these variables will not create any difficulties in the results. For certain variables, municipalities did not have enough values to use interpolation and extrapolation, so these variables are not considered in this research. These variables were all part of subgroups that are still present and therefore the effects of removing these variables will be negligible. For instance, the distance to the closest physiotherapist was available but the number of physiotherapists within 5 km was not, removing the last variable will not impact the results as these two variables are highly correlated.

Data regarding house characteristics is not used, as this research focuses on municipality/neighbourhood data and their characteristics. Not including those variables should be taken into account but is not necessarily negative for the research as all the variables used are averages. As neighbourhoods are part of municipalities, their use is a deeper look in the data behind municipalities. To explain the used data more thoroughly, the next part, Section 3.3, will focus on the municipalities, and after that, Section 3.4 will dive deeper into the creation of the neighbourhood data. But first, the created variables will be explained.

For both datasets it holds that, for the years in which no noise data was collected, the data is used from the next year with that information. So for the year 2014, the noise data of 2016 is used etc.(2022 gets the data of 2021 to create two data groups containing six years). With the inflation correction happening, this means that time can be assumed to be non-existent, as the time-dependent variable is made time-independent.

Additional variables are created to visualise the effect of noise levels on the WOZ values in both the municipality and the neighbourhood datasets. The variables huizen1, huizen2, huizen3, huizen0T1, huizen1T2, huizen2T3, and huizen1T0 correspond with Table 2, and provide all the data points of a municipality with the number of houses in each group. For instance, the municipality of Aalsmeer will have the data 500, 600, 100, 3600, 600, 100, and 0, throughout all the yearly observations, respectively. For the neighbourhood dataset these variables are created as well using Table 4. In this dataset houses moved from noise region two to one and from three to two, as this is not visible in the municipality dataset the neighbourhood dataset has the additional variables huizen2T1 and huizen3T2.

The variables geenNoise, low_noise, med_noise and high_noise corresponds to the values from the tables in Ministerie van Infrastructuur en Waterstaat (2017) and Ministerie van Infrastructuur en Waterstaat (2022). The geenNoise variables is created by substracting the amount of houses in the other groups from the total number of houses in that municipality. Where low_noise, med_noise, and high_noise correspond to 55-59 dB, 60-64 dB, and 65-69 dB, respectively.

Next, the variables nonoise, _59, _64 and _69 are created using the previous mentioned variables low_noise, med_noise, high_noise and geenNoise to created the percentages of houses in that municipality that are in the respective noise regions. These variables are created in the neighbourhood dataset as well, but the generation of these will be explained later.

Lastly, to evaluate the data more thoroughly the variables Noise and Weight are created. This is done by duplicating the dataset multiple times, and thus creating a dataset four times as large, as there are four different noise levels a municipality or neighbourhood can be in. For one of these multiples, the Noise level will be 0, for one 59, and the other two 64 and 69, respectively. The Weight will get the value of the number of houses in that respective noise region.

3.3 Municipality data

Table 3 gives the descriptive statistics of the created noise measuring variables of the municipality dataset. All though, these variables are provided all together, they are not used in regressions all together. There are a total of 108 observations, nine municipalities over a period of 12 years. As expected from Table 2 nonoise can be one, with no noise regions in that year for that municipality.

Lastly, the municipality of "Haarlemmerliede en Spaarnwoude" was merged into the municipality Haarlemmermeer on January first 2019. Therefore, the noise region data of "Haarlemmerliede en Spaarnwoude" is added to the data of Haarlemmermeer before 2019. The data of the municipality of "Haarlemmerliede en Spaarnwoude" is thus not used, but the data of the municipality

Haarlemmermeer instead. This was done to create an even set of data points during all the years, and further investigation suggested that most variable values were highly similar.

Table 3: Descriptive statistics of created variables with municipality data. (these different sets are not used simultaneously)

Variable	Obs	Mean	Std. dev.	Min	Max
WOZgood	108	302.905	83.030	170	570.721
logWOZ	108	5.679	.258	5.136	6.347
aantalHuizen	108	72479.54	128236.9	5179	458397
nonoise	108	.885	.155	.49	1
_59	108	.101	.145	0	.51
_64	108	.012	.024	0	.09
_69	108	.002	.005	0	.02
geenNoise	108	69670.96	128258.3	5179	453813
low_noise	108	2488.889	2403.01	0	6400
med_noise	108	333.333	528.443	0	1800
high_noise	108	27.778	56.093	0	200
huizen1	108	1733.333	2013.227	0	5300
huizen2	108	144.444	222.699	0	600
huizen3	108	22.222	41.768	0	100
huizen0T1	108	640	1075.984	0	3300
huizen1T2	108	366.667	485.298	0	1300
huizen2T3	108	11.111	31.573	0	100
huizen1T0	108	144.444	276.606	0	900

Table 4: The created groups and the number of houses within these groups between period 2016 - 2021, for the neighbourhood dataset.

	Houses that stay in the same noise region				Houses that move into a region with more noise			Houses that move into a region with less noise		
L_{den}	0	1	2	3	$0 \rightarrow 1$	$1 \rightarrow 2$	$2 \rightarrow 3$	$1 \rightarrow 0$	$2 \rightarrow 1$	$3 \rightarrow 2$
Number of houses	554164	34172	11838	8834	11780	4553	4593	14452	3752	2763
Aalsmeer	2557	3712	2319	1103	2205	161	793	359	-	-
	(0.00)	(0.11)	(0.20)	(0.12)	(0.19)	(0.04)	(0.17)	(0.02)	-	-
Amstelveen	34973	3136	-	-	2019	-	-	688	1074	-
	(0.06)	(0.09)	-	-	(0.17)	-	-	(0.05)	(0.29)	-
Amsterdam	417793	3100	8	-	3735	758	-	1802	5	-
	(0.75)	(0.09)	(0.00)	-	(0.32)	(0.17)	-	(0.12)	(0.00)	-
Haarlemmermeer	14418	14364	8843	7731	2256	3634	3800	4012	2026	2763
	(0.03)	(0.42)	(0.75)	(0.88)	(0.19)	(0.80)	(0.83)	(0.28)	(0.54)	(1.00)
Uitgeest	2774	1697	-	-	-	-	-	1077	-	-
	(0.01)	(0.05)	-	-	-	-	-	(0.07)	-	-
Uithoorn	4753	3464	4	-	1524	-	-	2924	11	-
	(0.01)	(0.10)	(0.00)	-	(0.13)	-	-	(0.20)	(0.00)	-
Zaanstad	59879	4014	664	-	-	-	-	1769	636	-
	(0.11)	(0.12)	(0.06)	-	-	-	-	(0.12)	(0.17)	-
Kaag en Braassem	9577	388	-	-	-	-	-	1091	-	-
	(0.02)	(0.01)	-	-	-	-	-	(0.08)	-	-
Nieuwkoop	7440	297	-	-	41	-	-	730	-	-
	(0.01)	(0.01)	-	-	(0.00)	-	-	(0.05)	-	-

The different regions with noise of 0 dB, 55-59 dB, 60-64 dB, and 65-69 are given the values 0, 1, 2, and 3, respectively. In the parenthesis, that region's contribution to that group's total is given as a percentage.

3.4 Neighbourhood data

For the neighbourhood data, there were no tables from Ministerie van Infrastructuur en Waterstaat (2017) and Ministerie van Infrastructuur en Waterstaat (2022). Instead Figures 1a and 1b, together with information on AlleCijfers.nl (2023), was used to allocate neighbourhoods to noise region manually. By comparing neighbourhood maps with the figures, an estimation is made on what percentage of that neighbourhood falls into which noise region, variables nonoise, _59, _64, and _69 represent these percentages. Next, the data on Statline did not contain all the information, not all years and neighbourhoods. Therefore, more data is created using interpolation and extrapolation than in the dataset of the municipalities. As mentioned before this is likely not of significant influence as the distance to facilities will not differ much in consecutive years. Using the total number of houses in each neighbourhood and the percentages in each noise region, the variables low_noise, med_noise, high_noise and geenNoise are created. With the number of houses in each noise region during the whole period, the variables huizen1, huizen2, etc. are created. Lastly, the variables perc0, perc1,..., perc3T2 correspond to the percentage of houses in each group (huizen1, huizen2, etc). The descriptive statistics of these variables are visible in Table 5.

Compared to the municipality, the neighbourhood data has 2064 observations, twelve years and 172 neighbourhoods. However, in the process of manually allocating the percentage of neighbourhoods in each noise region, an adjustment was made for the neighbourhoods in the municipality of Amstelveen. It turned out that Amstelveen has no neighbourhoods but only "buurten" (Dutch), so for this municipality, the buurten are used instead of the neighbourhoods. Lastly, the neighbourhood of Schiphol in the municipality Haarlemmermeer was excluded from the research as there are no WOZ values available for this neighbourhood, and the total number of houses was also missing.

In Table 4 the same groups as in Table 2 are visualised, using the total number of houses in each noise region by neighbourhood for the years 2016 and 2021. The number of houses in each group per neighbourhood is added together to represent municipality data. Comparing the municipality and neighbourhood tables, some resemblance was expected. However, the total number of houses in each group differs considerably. By continuing to use both the datasets the remark that the outcome might not be reliable for either one of them should be made. It is uncertain which datasets represent the true distribution of WOZ values better. The uncertainty of the municipality datasets is present, but the municipality dataset is created manually without the use of GIS data, as this is not available for the noise regions, but by creating smaller sections population density is better accounted for.

From Table 4, it is noticeable that houses move from no noise to a low noise region in every municipality. Compared to Table 4 the second column now contains the number of houses in the no noise region. As stated before, a possible explanation for more houses in each group is that this data is created manually compared to the real data of the municipality.

Table 5: Descriptive statistics of created variables with neighbourhood data.

Variable	Obs	Mean	Std. dev.	Min	Max
WOZgood	2,064	330.861	173.346	65.88	1404.95
logWOZ	2,064	5.691	.461	4.19	7.25
aantalHuizen	2,064	3790.598	3363.016	0	32935
nonoise	2,064	.858	.293	0	1
_59	2,064	.106	.226	0	1
_64	2,064	.051	.147	0	1
_69	2,064	.046	.147	0	1
geenNoise	2,064	3319.994	2672.033	0	13280
low_noise	2,064	283.216	855.764	0	6587
med_noise	2,064	168.829	793.223	0	9881
high_noise	2,064	159.118	782.112	0	9881
perc0	2,064	.827	.324	0	1
perc1	2,064	.071	.165	0	.9
perc2	2,064	.013	.046	0	.27
perc3	2,064	.007	.041	0	.4
perc0T1	2,064	.024	.084	0	.73
perc1T2	2,064	.002	.012	0	.11
perc2T3	2,064	.003	.020	0	.2
perc1T0	2,064	.035	.126	0	1
perc2T1	2,064	.014	.059	0	.4
perc3T2	2,064	.005	.028	0	.23
huizen0	2,064	3238.890	2696.447	0	13280
huizen1	2,064	200.553	709.550	0	10291
huizen2	2,064	66.362	483.267	0	6193
huizen3	2,064	49.124	454.680	0	6193
huizen0T1	2,064	81.339	663.618	0	27149
huizen1T2	2,064	25.460	268.761	0	3687
huizen2T3	2,064	25.559	267.926	0	3687
huizen1T0	2,064	83.363	355.200	0	3047
huizen2T1	2,064	21.849	120.286	0	1009
huizen3T2	2,064	16.108	163.139	0	2133

3.5 Simmilarities between municipality and neighbourhood

In Table 6 the percentages of houses in each group by municipality are given. In each two rows one municipality is given with first the municipality data(Table 2) and in the second row the neighbourhood data (Table 4). Between the two rows seems to be a big difference. A possible explanation for this could be that the population data/ true location of houses is not considered by allocating the percentages to the neighbourhood dataset. As Schiphol tries to fly over less densely populated areas, something that Table 2 uses, and for the neighbourhood data this is not considered. Nonetheless, the exact way of allocating the noise to the municipalities is unknown, so possible mistakes can be made there. In the following sections, the neighbourhood data and the municipality data will be used, but the bias from the manual allocation of the ratios to noise region should not be taken lightly. It is therefore, that this research can only create awareness for the WOZ value of houses and the impact of the Schiphol noise on these, but the found results can not be assumed to be entirely correct. It is of added value to use the neighbourhood dataset as the amount of data is very small when only using the municipality data.

4 Methodology

To research the effect of noise on the WOZ values of properties around Schiphol several regressions are run, both on municipality data as well as on neighbourhood data. For all the regressions, it holds that the logarithm of the property value is regressed upon a range of variables, including some variables regarding the noise. The logarithm of the WOZ is used to make the interpretation clearer. A unit change of the independent variable will result in a percentual change of the WOZ value. The independent variables cannot control for all the aspects that influence the WOZ value, but they should be enough to describe the main determinants. The choice for these variables is based on the literature mentioned in Section 2 and the available data on Statline.

Table 6: The distribution of the houses into the groups of Table 2 and 4 to show (dis)simmilarities.

		Houses that stay in the same noise region				Houses that move into a region with more noise			Houses that move into a region with less noise		
L_{den}		0	1	2	3	$0 \to 1$	$1 \to 2$	$2 \to 3$	$1 \to 0$	$2 \to 1$	$3 \to 2$
Aalsmeer	muni	0.57	0.04	0.05	0.01	0.28	0.05	0.01	0.00	0.00	0.00
	neigh	0.19	0.28	0.18	0.08	0.17	0.01	0.06	0.03	0.00	0.00
Amstelveen	muni	0.89	0.08	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
	neigh	0.83	0.08	0.00	0.00	0.05	0.00	0.00	0.02	0.03	0.00
Amsterdam	muni	0.99	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	neigh	0.98	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Haarlemmermeer	muni	0.87	0.08	0.01	0.00	0.03	0.02	0.00	0.00	0.00	0.00
	neigh	0.23	0.22	0.14	0.12	0.04	0.06	0.06	0.06	0.03	0.04
Uitgeest	muni	0.98	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	neigh	0.50	0.31	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00
Uithoorn	muni	0.52	0.41	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
	neigh	0.37	0.27	0.00	0.00	0.12	0.00	0.00	0.23	0.00	0.00
Zaanstad	muni	0.98	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	neigh	0.89	0.06	0.01	0.00	0.00	0.00	0.00	0.03	0.01	0.00
Kaag en Braassem	muni	0.97	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
	neigh	0.87	0.04	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Nieuwkoop	muni	0.98	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	neigh	0.87	0.03	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00

The model that results from this data can be visualised in the following way:

$$\min_{\beta} \sum_{i=1}^{n} \epsilon_i^2 \tag{1}$$

$$s.t.\ Y_i = \beta_0 + \beta_1 X_{1i} + ... + \beta_m X_{mi} + \epsilon_i \qquad i = 1...n \tag{2}$$

$$\beta_j \in \mathbb{R} \qquad j = 1...m \tag{3}$$

Where i is the observation number, and j is the variable number. β is the unknown parameter and ϵ is the error term of the observation. This model is solved using ordinary least squares (OLS) Heij (2004). This method has seven assumptions that need to be examined.

The first assumption states that the independent variables(x_i) are non-stochasatic. The second, third and fourth assumptions are all error term-related. The error term should have a zero mean, is homoskedastic, and has no correlation. With the data in this research, it can be assumed that these three hold. The last assumptions state that the β term should be constant, the model is linear, and the error terms are jointly normally distributed. The linear model assumption is satisfied as, mentioned in Section 3, the highly correlated variables are deleted.

For the municipality and neighbourhood dataset, three different regressions are created. The first one has variables of interest, geenNoise, low_noise, med_noise, and high_noise. These variables represent the number of houses that are in each noise region. The second regression uses the percentage of houses in each region. The difference between these two is that the municipality's size is considered in the first and not in the second. Lastly, a regression is run using the groups of Table 2 and Table 4. In this one size is considered, but the part of the municipality that does not influence noise is not taken into account. For the neighbourhood data this part is taken into account. These three regressions are used to determine whether or not noise has a significant influence on the WOZ values- of the properties around Schiphol, as for half of the dataset the noise contours of 2016 are used and for the other half the noise contours of 2021.

To research the effect of a change in noise, the dataset is cut in half, the period until 2016 and 2017 and onward. For both datasets and the three different variables, regressions are made. Lastly, the last created variable Noise is regressed on the municipality dataset and neighbourhood dataset for the whole period and for the before and after 2016 periods separately. Lastly, to test whether the found variables differ in this split regression, a Chow test is performed, with the null hypothesis that there is no change in the coefficient (no break).

5 Results

In this Section, the regression results are displayed. Using these results, the hypothesis that noise significantly affects the WOZ value of properties is first evaluated by looking at the significance of the variables of interest in Section 5.1. After that in Section 5.2, it is evaluated whether a change of noise indeed has a similar effect on the WOZ value of the property. In other words, a change to a noisier area will result in a higher coefficient than staying in the same noise area. Lastly, in Section 5.3 the regressions with the numerical noise values are evaluated.

5.1 Significante of noise

Table 7 gives the regression results for both municipality and neighbourhood data, regressing seperately on the three sets of variables explained in Section 3. The first three columns are created by regressing the municipality data, and the last three are from the neighbourhood data. As expected, there are some differences in significance and multitude between the datasets. For columns (1) and (4) geenNoise has the same significance level, but the sign is the other way around. Overall, there seems to be some significance in the regressions by the variables of interest. The second and fifth columns should be considered the most meaningful as these represent the percentage of the groups. However, the difference in municipality and neighbourhood size is not considered. In this research, the neighbourhood dataset is considered to be better as the dataset is larger and manually created. This would mean that looking at the last three columns, a lot of significance is visible.

Looking more into Table 8 for the other control variables, it is clear that most variables are significant on at least a 5% level.

Table 7: Regression results for the logarithm of the WOZ values of the municipality and neighbourhood data, with the variables of interest for the entire period (2011- 2022).

	Municipalities			Neighbourhoods		
	(1)	(2)	(3)	(4)	(5)	(6)
	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ
geenNoise	0.00000281***			-0.0000232***		
	(5.88)			(-6.71)		
low_noise	0.00000473			0.0000355*		
	(0.57)			(2.14)		
med_noise	0.000154***			-0.0000131		
	(4.39)			(-0.17)		
high_noise	0.0000440			-0.0000201		
	(0.10)			(-0.27)		
nonoise		5.629			-0.0384	
		(1.32)			(-0.57)	
_59		5.769			0.385***	
		(1.34)			(4.90)	
_64		9.042*			0.630***	
		(2.09)			(3.40)	
_69		-7.344			-0.796***	
		(-0.94)			(-4.65)	
huizen0						-0.0000267***
						(-7.62)
huizen1			0.0000980			-0.0000276
			(0.53)			(-1.15)
huizen2			-0.00345			0.000168
			(-1.52)			(1.45)
huizen3			0.0109			-0.000187
			(1.66)			(-1.33)
huizen0T1			0			
			(.)			
huizen1T2			-0.000312			0.000131
			(-0.81)			(0.92)
huizen2T3			0.00926			-0.0000505
			(1.04)			(-0.40)
huizen1T0			-0.000841			0.00000725
			(-0.70)			(0.23)
huizen0T1			0.000249*			0.0000407**
			(2.64)			(2.86)
huizen2T1						0.0000977
						(1.14)
huizen3T2						-0.000156
						(-1.79)
_cons	5.579***	-0.152	5.780***	5.848***	5.864***	5.868***
	(26.38)	(-0.04)	(15.81)	(71.51)	(51.74)	(71.71)
Controls ****	YES	YES	YES	YES	YES	YES
N	108	108	108	2064	2064	2064

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

**** in Table 8

Table 8: Regression results for the logarithm of the WOZ values of the municipality and neighbourhood data, with the variables of interest. (continued)

	Municipalities			Neighbourhoods		
	(1)	(2)	(3)	(4)	(5)	(6)
	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ
D	0.0222	-0.000872	0.0361	-0.0350*	-0.0180	-0.0346*
	(0.26)	(-0.01)	(0.34)	(-2.06)	(-1.10)	(-2.04)
M	-0.0406***	-0.0444***	-0.0307***	-0.0458***	-0.0486***	-0.0462***
	(-7.38)	(-6.18)	(-3.57)	(-14.88)	(-15.95)	(-15.06)
Z	0.00531	-0.00867	0.0151	-0.0477***	-0.0482***	-0.0500***
	(0.38)	(-0.48)	(0.72)	(-5.72)	(-5.94)	(-5.98)
AC	0.00382	-0.00175	0.00437	-0.00446**	-0.00469***	-0.00433**
	(1.74)	(-0.72)	(1.41)	(-3.20)	(-3.41)	(-3.11)
AD	-0.104	-0.0223	-0.192	0.0928***	0.101***	0.0963***
	(-1.45)	(-0.28)	(-1.87)	(7.27)	(8.02)	(7.51)
AG	-0.00202***	0.000121	-0.00276***	0.000633***	0.000654***	0.000639***
	(-4.59)	(0.54)	(-4.91)	(18.02)	(18.99)	(18.27)
AP	-0.0419*	-0.0519*	-0.0734***	-0.0318***	-0.0348***	-0.0331***
	(-2.57)	(-2.52)	(-3.96)	(-3.61)	(-4.04)	(-3.79)
AT	0.0595	-0.0155	-0.0184	-0.00212	-0.0168	-0.00444
	(1.20)	(-0.25)	(-0.35)	(-0.09)	(-0.73)	(-0.19)
BB	-0.0188	0.103	0.297	0.0224	0.0308	0.0176
	(-0.19)	(0.81)	(1.77)	(1.04)	(1.45)	(0.82)
BJ	-0.0316*	-0.0363*	-0.0740***	0.0191*	0.0208**	0.0210*
	(-2.39)	(-2.27)	(-4.85)	(2.33)	(2.58)	(2.54)
CJ	-0.0316	-0.0281	-0.0800***			
	(-1.88)	(-1.35)	(-4.06)			
CM	0.0256***	0.0373***	0.0231**			
	(3.48)	(3.96)	(2.82)			
CN	0.0814*	0.0385	-0.0499			
	(2.10)	(0.76)	(-0.98)			
CQ	-0.0662***	-0.0486***	-0.0383**			
	(-5.88)	(-3.96)	(-2.79)			
CR	0.0380***	0.0282***	0.0629***			
	(5.58)	(3.84)	(7.25)			
CT	-0.0427	0.135	0.0856	0.0180*	0.0108	0.0198*
	(-0.55)	(1.16)	(0.71)	(2.07)	(1.25)	(2.26)
CW	0.00275	0.000754	-0.00351	0.0301**	0.0218*	0.0276**
	(0.14)	(0.03)	(-0.16)	(3.10)	(2.27)	(2.82)
CZ	-0.0211**	-0.0312***	-0.0272***	-0.0206***	-0.0304***	-0.0200***
	(-2.89)	(-3.44)	(-3.55)	(-3.91)	(-5.79)	(-3.79)
DD	0.0223*	0.00445	0.0175	0.0202***	0.0252***	0.0210***
	(2.41)	(0.40)	(1.66)	(3.43)	(4.43)	(3.60)
DH	0.00636	0.00723	-0.00366	-0.0163***	-0.0181***	-0.0160***
	(1.30)	(1.22)	(-0.67)	(-4.36)	(-4.95)	(-4.26)
DO	-0.00447	0.00920	-0.00122	0.00157	0.00393	0.00145
	(-0.45)	(0.74)	(-0.09)	(0.75)	(1.88)	(0.69)
DQ	0.0303***	0.0513***	0.0315***	0.0519***	0.0494***	0.0517***
	(5.04)	(8.53)	(5.02)	(24.31)	(23.45)	(24.31)
DS	0.159***	0.144***	0.206	0.0621***	0.0630***	0.0593***
	(5.40)	(3.88)	(1.17)	(7.20)	(7.47)	(6.83)
_cons	5.579***	-0.152	5.780***	5.848***	5.864***	5.868***
	(26.38)	(-0.04)	(15.81)	(71.51)	(51.74)	(71.71)
N	108	108	108	2064	2064	2064

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.2 Change in noise

The same regressions as in the previous section are given in Tables 9 and 11. However, compared to the earlier results, this time, the dataset was split on 2016, as this can be considered as the ”treatment” moment. Most coefficients in Table 9 appear insignificant, except for huizen1T2, huizen2T3, and huizen1T0. These variables, the expected results suggest that being in that group would result (for the first two) in a coefficient after 2016 to lower the WOZ value more. For huizen1T2 this seems to be the case. However, the coefficients of variable huizen1T0 indicate that being in the group from noise level 1 to noise level 0 results in a higher WOZ value before 2016 than after; this contradicts the prediction that moving into a lower noise level region will result in a higher property value. However, the results in the tables regarding the municipality data are not reliable as there are only 54 data points used. To properly test if the variables from before and after 2016 are different the Chow test is performed. The null hypothesis of no difference is never rejected and therefore we can say that there is no change over the different noise regions. For the regressions with huizen0T1 etc., this means that the expected change is not noticeable.

The results using the neighbourhood data are stated in Table 11. Compared to the municipality's result, the variables seem more significant. The houses remaining in the same noise region (huizen0, huizen1, huizen2, and huizen3) are, if significant, somewhat similar. This indicates that the effect remains the same during the entire research period. The coefficients of the geenNoise variable, however, were expected to have a positive sign instead of the visible negative sign. This could possibly be explained by the dataset, as the number of houses in geenNoise are the majority, and this could result, if a lot of the lower valued properties are also in this areas, influence the results.

Table 9: The split dataset regressions on the municipality dataset.

	2011-2016			2017-2022		
	(1)	(2)	(3)	(4)	(5)	(6)
	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ
geenNoise	0.000000720			0.00000228		
	(1.15)			(1.52)		
low_noise	0.0000107			0.0000472		
	(0.55)			(0.98)		
med_noise	0.000671			0.000321		
	(0.95)			(1.67)		
high_noise	-0.000648			-0.00278*		
	(-0.15)			(-2.35)		
nonoise		-0.452			12.49	
		(-0.15)			(1.46)	
_59		-0.442			12.04	
		(-0.14)			(1.42)	
_64		13.60**			16.72	
		(3.68)			(1.83)	
_69		-46.35			-9.248	
		(-1.82)			(-0.86)	
huizen0T1			0.000188			-0.000444
			(1.36)			(-0.80)
huizen1			-0.0000943			0.00165*
			(-0.68)			(2.32)
huizen2			-0.00822*			-0.0138
			(-2.36)			(-1.70)
huizen3			0.0224			0.0474
			(2.01)			(1.26)
huizen0T1			0			
			(.)			
huizen1T2			0.00160**			-0.00470*
			(3.74)			(-2.21)
huizen2T3			0.0240*			0.0391
			(2.51)			(1.79)
huizen1T0			0.000432			-0.0102*
			(0.44)			(-2.25)
huizen0T1						0
						(.)
_cons	6.353***	6.872*	6.249***	4.404***	-8.551	4.850***
	(27.05)	(2.26)	(21.56)	(4.96)	(-1.02)	(4.00)
Controls ****	YES	YES	YES	YES	YES	YEs
N	54	54	54	54	54	54

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

**** in Table 10

Table 10: The split dataset regressions on the municipality dataset. (continued)

	2011-2016			2017-2022		
	(1)	(2)	(3)	(4)	(5)	(6)
	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ
D	0.0292	0.0847	0.00970	0.0869	0.583	-0.0746
	(0.48)	(1.67)	(0.19)	(0.25)	(1.83)	(-0.22)
M	0.00264	0.00634	0.00423	-0.0655**	-0.0614*	-0.0367
	(0.40)	(1.14)	(0.70)	(-2.98)	(-2.50)	(-1.46)
Z	0.0237*	0.0196*	0.0186	0.372*	0.191	0.582**
	(2.46)	(2.15)	(1.87)	(2.51)	(1.23)	(3.07)
AC	-0.00235	-0.00245	-0.00443*	0.0121	0.0139	0.0201*
	(-1.42)	(-2.01)	(-2.76)	(1.51)	(1.63)	(2.38)
AD	-0.370**	-0.328**	-0.250*	-0.137	-0.0742	0.00345
	(-3.27)	(-3.52)	(-2.11)	(-0.93)	(-0.52)	(0.02)
AG	-0.000617	-0.000219	-0.00149	-0.0000436	0.00160*	0.000440
	(-1.22)	(-1.15)	(-2.04)	(-0.03)	(2.18)	(0.17)
AP	0.0537	-0.00731	0.0720*	0.00406	0.0115	0.0487
	(1.78)	(-0.24)	(2.63)	(0.11)	(0.28)	(1.07)
AT	0.120*	0.119*	0.0795	0.0425	-0.0498	-0.0149
	(2.50)	(2.57)	(1.39)	(0.46)	(-0.51)	(-0.16)
BB	0.0742	0.196	0.0195	0.428	0.729**	0.353
	(0.50)	(1.36)	(0.14)	(1.86)	(2.86)	(0.99)
BJ	-0.0797*	-0.0556*	-0.00974	-0.0136	-0.0228	-0.0120
	(-2.13)	(-2.31)	(-0.24)	(-0.72)	(-1.22)	(-0.61)
CJ	-0.0859*	-0.123***	-0.0367	0.00135	-0.000886	-0.0520
	(-2.58)	(-4.26)	(-1.00)	(0.03)	(-0.02)	(-0.95)
CM	0.0327	0.0647***	0.00924	0.0268	0.0452**	0.0385*
	(1.28)	(5.41)	(0.38)	(2.03)	(3.19)	(2.59)
CN	-0.225	-0.237	0.0801	0.108	0.0539	-0.00804
	(-2.01)	(-2.05)	(0.47)	(1.35)	(0.67)	(-0.09)
CQ	-0.0938***	-0.0839***	0.0659	-0.0513*	-0.0179	-0.0442
	(-6.81)	(-5.27)	(1.18)	(-2.39)	(-0.99)	(-1.73)
CR	-0.00460	0.00140	-0.0137	0.0359	0.0347*	0.0484*
	(-0.34)	(0.12)	(-1.16)	(2.02)	(2.11)	(2.57)
CT	0.0480	0.0379	-0.202*	-0.123	0.146	-0.307
	(0.78)	(0.64)	(-2.09)	(-0.57)	(0.70)	(-1.35)
CW	-0.0672**	-0.0483*	-0.0376	0.0977	0.0724	0.144
	(-3.00)	(-2.38)	(-1.60)	(1.34)	(0.98)	(1.97)
CZ	-0.0000668	-0.0189**	0.00874	-0.0560	-0.0598	-0.0507
	(-0.01)	(-2.98)	(1.49)	(-1.46)	(-1.55)	(-1.38)
DD	-0.00117	-0.00387	0.00112	0.00424	-0.0118	0.00252
	(-0.15)	(-0.47)	(0.14)	(0.26)	(-0.67)	(0.16)
DH	0.0000167	0.000194	0.00192	0.0335	0.0126	-0.0785
	(0.01)	(0.08)	(0.76)	(0.81)	(0.32)	(-0.87)
DO	0.00508	0.00189	-0.00426	-0.0816	-0.0755	0.0569
	(0.65)	(0.30)	(-0.53)	(-2.00)	(-2.05)	(0.85)
DQ	-0.00557	-0.00927	-0.00653	0.0241*	0.0237*	0.0386**
	(-0.75)	(-1.47)	(-0.99)	(2.19)	(2.12)	(3.31)
DS	0.0842	0.0574	-0.283	0.0769	0.184	0.205
	(1.35)	(1.23)	(-1.59)	(0.90)	(1.85)	(0.63)
_cons	6.353***	6.872*	6.249***	4.404***	-8.551	4.850***
	(27.05)	(2.26)	(21.56)	(4.96)	(-1.02)	(4.00)
N	54	54	54	54	54	54

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11: The split dataset regressions on the neighbourhood dataset.

	2011-2016			2017-2022		
	(1)	(2)	(3)	(4)	(5)	(6)
	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ
geenNoise	-0.0000250***			-0.0000323***		
	(-5.05)			(-7.22)		
low_noise	-0.000000187			0.0000660**		
	(-0.01)			(3.25)		
med_noise	0.0000789			-0.000163		
	(0.58)			(-1.69)		
high_noise	-0.0000658			0.000134		
	(-0.48)			(1.48)		
nonoise		-0.261**			0.333	
		(-3.23)			(1.24)	
_59		0.181			0.886***	
		(1.77)			(3.37)	
_64		0.760**			0.830	
		(3.14)			(1.74)	
_69		-0.886***			0	
		(-3.83)			(.)	
huizen0			-0.0000271***			-0.0000338***
			(-5.41)			(-7.56)
huizen1			-0.0000326			0.00000696
			(-0.95)			(0.23)
huizen2			-0.0000249			-0.00000629
			(-0.14)			(-0.04)
huizen3			-0.0000333			-0.0000177
			(-0.16)			(-0.10)
huizen0T1			0.000240***			0.0000125
			(5.68)			(0.81)
huizen1T2			-0.000205			-0.0000257
			(-0.97)			(-0.14)
huizen2T3			0.000358			0.0000957
			(1.87)			(0.59)
huizen1T0			0.0000307			0.0000159
			(0.68)			(0.39)
huizen2T1			0.000159			0.000263*
			(1.32)			(2.39)
huizen3T2			-0.0000487			-0.000209
			(-0.40)			(-1.90)
_cons	5.550***	5.859***	5.583***	6.071***	5.700***	6.073***
	(49.26)	(38.36)	(50.00)	(53.47)	(20.14)	(53.21)
N	1032	1032	1032	1032	1032	1032

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12: The split dataset regressions on the neighbourhood dataset. (continued)

	2011-2016			2017-2022		
	(1)	(2)	(3)	(4)	(5)	(6)
	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ
D	-0.0350	-0.0221	-0.0291	-0.0280	0.00113	-0.0235
	(-1.48)	(-0.97)	(-1.24)	(-1.26)	(0.05)	(-1.07)
M	-0.0137**	-0.0151***	-0.0151***	-0.0736***	-0.0820***	-0.0715***
	(-3.22)	(-3.65)	(-3.59)	(-12.33)	(-13.91)	(-11.98)
Z	-0.0444***	-0.0449***	-0.0444***	-0.0173	-0.0160	-0.0220
	(-3.85)	(-4.09)	(-3.89)	(-1.53)	(-1.46)	(-1.93)
AC	-0.00600***	-0.00797***	-0.00597***	0.00363	0.00470	0.00314
	(-3.57)	(-4.77)	(-3.57)	(1.30)	(1.74)	(1.12)
AD	0.101***	0.104***	0.0994***	0.0712***	0.0790***	0.0758***
	(5.31)	(5.61)	(5.27)	(4.38)	(4.99)	(4.62)
AG	0.000454***	0.000453***	0.000499***	0.000905***	0.000996***	0.000891***
	(10.34)	(10.62)	(11.37)	(16.26)	(18.09)	(16.24)
AP	-0.0313**	-0.0431***	-0.0272*	-0.0266*	-0.0121	-0.0297*
	(-2.73)	(-3.88)	(-2.41)	(-2.09)	(-0.97)	(-2.34)
AT	0.0369	0.0296	0.0451	0.0156	-0.0416	0.0158
	(1.32)	(1.09)	(1.63)	(0.35)	(-0.94)	(0.35)
BB	0.0487	0.0433	0.0465	-0.0527	-0.0111	-0.0633
	(1.81)	(1.65)	(1.74)	(-1.42)	(-0.30)	(-1.69)
BJ	0.00474	-0.000945	0.00906	0.0237*	0.0242*	0.0234*
	(0.41)	(-0.08)	(0.78)	(2.19)	(2.28)	(2.14)
CT	0.0184	0.00706	0.0200	0.0122	-0.00622	0.0138
	(1.59)	(0.62)	(1.75)	(1.02)	(-0.53)	(1.14)
CW	0.0546***	0.0556***	0.0457**	-0.00797	-0.0176	-0.00726
	(3.89)	(4.06)	(3.27)	(-0.63)	(-1.43)	(-0.57)
CZ	-0.00873	-0.0223***	-0.00853	-0.0507***	-0.0602***	-0.0524***
	(-1.39)	(-3.52)	(-1.37)	(-5.77)	(-7.09)	(-5.78)
DD	0.0185*	0.0296***	0.0214*	0.0308***	0.0263***	0.0315***
	(2.07)	(3.51)	(2.46)	(4.00)	(3.52)	(4.03)
DH	-0.0106*	-0.0141**	-0.0119*	-0.0104	-0.0102	-0.00855
	(-2.15)	(-2.98)	(-2.45)	(-1.88)	(-1.90)	(-1.54)
DO	-0.00390	-0.000621	-0.00452	0.0348***	0.0405***	0.0340***
	(-1.57)	(-0.25)	(-1.85)	(5.70)	(6.73)	(5.49)
DQ	0.0248***	0.0207***	0.0202***	0.0386***	0.0340***	0.0391***
	(6.59)	(5.44)	(5.22)	(10.69)	(9.61)	(10.79)
DS	0.0218	0.0232*	0.0196	0.0763***	0.0814***	0.0752***
	(1.82)	(2.01)	(1.65)	(6.76)	(7.41)	(6.56)
_cons	5.550***	5.859***	5.583***	6.071***	5.700***	6.073***
	(49.26)	(38.36)	(50.00)	(53.47)	(20.14)	(53.21)
N	1032	1032	1032	1032	1032	1032

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.3 Levels of noise

The previous results did not evaluate the size of the municipalities/neighbourhoods; in this section, the sizes will be evaluated, and therefore, the coefficient will have more meaning. Table 13 gives the weighted regression results. The variable of interest Noise is significant, just like most other variables. The expected sign for noise would be negative, as more noise logically would result in a lower property value. This is not the case except for the last regression. The results that can be extracted from these regressions are that without zero noise levels, the Noise coefficients are much lower, indicating that having a zero noise level increases the WOZ property values.

Table 14 contains the results from the previous regression run on two datasets, one before 2016 and one after 2016, because the noise distribution changes after that year. Still, most coefficients are significant; however, the multitudes differ between the two time periods. The Chow test run on these regressions shows that there is no proof to reject the null hypothesis of equivalent coefficient values. Meaning that it can be assumed that the coefficients are equal.

Table 13: Weighted whole period, first and third column with 0 noise level included, second and forth row without 0 noise level.

	Municipality		Neighbourhood	
	(1)	(2)	(3)	(4)
	logWOZ	logWOZ	logWOZ	logWOZ
Noise	0.0000833***	0.000308***	0.00114***	-0.00387***
	(30.62)	(4.91)	(253.20)	(-101.64)
D	-0.0672***	0.102***	-0.0440***	-0.0590***
	(-117.37)	(82.34)	(-138.84)	(-147.68)
M	-0.0333***	-0.0291***	-0.0464***	-0.0334***
	(-1011.46)	(-222.27)	(-1141.74)	(-425.30)
Z	0.0860***	0.0448***	-0.0450***	-0.0405***
	(717.06)	(94.76)	(-422.42)	(-192.54)
AC	-0.00339***	0.00159***	-0.00194***	0.00463***
	(-339.52)	(38.98)	(-103.03)	(148.12)
AD	-0.273***	-0.0395***	0.0975***	0.00137***
	(-752.49)	(-28.57)	(509.48)	(4.91)
AG	-0.000300***	0.000676***	0.000675***	0.000414***
	(-404.58)	(188.30)	(1478.67)	(141.41)
AP	-0.0692***	-0.0838***	-0.0394***	-0.0386***
	(-520.77)	(-106.22)	(-334.46)	(-191.10)
AT	-0.110***	-0.149***	-0.0475***	-0.0427***
	(-228.67)	(-82.34)	(-108.09)	(-71.03)
BB	0.226***	0.348***	0.113***	0.114***
	(308.68)	(102.06)	(260.62)	(201.68)
BJ	-0.0566***	-0.0326***	0.0299***	0.00489***
	(-461.33)	(-41.94)	(279.98)	(28.23)
CJ	-0.0708***	-0.0581***		
	(-586.14)	(-114.30)		
CM	0.0535***	0.0222***		
	(979.99)	(97.18)		
CN	-0.0483***	-0.0334***		
	(-177.10)	(-49.68)		
CQ	-0.0294***	-0.0108***		
	(-582.63)	(-48.53)		
CR	0.0504***	0.0395***		
	(1408.50)	(318.18)		
CT	0.110***	0.106***	0.0300***	-0.0682***
	(280.20)	(82.93)	(251.34)	(-212.66)
CW	-0.0850***	0.0314***	0.0288***	0.0812***
	(-558.13)	(51.18)	(208.51)	(333.40)
CZ	-0.0176***	-0.00217***	-0.0207***	-0.00119***
	(-283.75)	(-11.85)	(-275.96)	(-11.90)
DD	0.0248***	0.00671***	0.0249***	0.00410***
	(321.14)	(46.40)	(312.48)	(38.55)
DH	0.0222***	0.0209***	-0.0134***	-0.00774***
	(739.55)	(198.91)	(-289.80)	(-115.24)
DO	-0.0506***	-0.00378***	0.00212***	0.000284**
	(-799.32)	(-19.72)	(79.85)	(3.02)
DQ	0.0505***	0.0552***	0.0520***	0.0581***
	(2148.99)	(631.65)	(1862.59)	(970.95)
DS	0.218***	0.224***	0.0704***	0.0613***
	(1299.23)	(352.45)	(586.62)	(248.78)
_cons	5.696***	4.474***	5.523***	5.596***
	(3972.45)	(664.88)	(5045.77)	(1778.59)
N	7827790	307800	8113905	1261438

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 14: Weighted separated periods, first, third, fifth, and seventh column with 0 noise level included, second, fourth, sixth, and eight row without 0 noise level.

	Municipality				Neighbourhood			
	2011-2016		2017-2022		2011-2016		2017-2022	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ	logWOZ
Noise	0.0000188***	0.000596***	-0.0000832***	-0.0000747	0.00155***	0.00127***	0.00278***	-0.00511***
	(21.91)	(15.02)	(-48.72)	(-1.51)	(264.45)	(37.96)	(441.68)	(-83.06)
D	-0.141***	0.00569***	0.245***	0.231***	-0.0323***	-0.0774***	-0.0121***	0.0952***
	(-736.59)	(7.73)	(296.75)	(59.10)	(-85.01)	(-219.13)	(-27.62)	(124.15)
M	0.00271***	0.000567***	-0.0223***	-0.0762***	-0.00883***	0.00544***	-0.0812***	-0.0839***
	(185.63)	(7.07)	(-360.35)	(-294.96)	(-164.89)	(69.06)	(-1118.59)	(-448.53)
Z	0.0120***	-0.00783***	0.0203***	0.171***	-0.0588***	-0.0121***	-0.00842***	-0.0545***
	(334.62)	(-27.96)	(53.97)	(99.40)	(-424.41)	(-59.23)	(-61.99)	(-130.83)
AC	-0.00179***	-0.00453***	0.0214***	0.00511***	-0.00384***	-0.00576***	0.00787***	0.0178***
	(-647.91)	(-126.64)	(1007.41)	(50.23)	(-174.21)	(-208.12)	(237.66)	(233.68)
AD	-0.106***	-0.272***	-0.0620***	0.154***	0.0993***	0.0107***	0.0891***	-0.0103***
	(-585.95)	(-161.84)	(-168.78)	(92.56)	(386.40)	(45.11)	(372.34)	(-19.83)
AG	-0.000331***	-0.000421***	0.000455***	0.00139***	0.000491***	-0.000410***	0.00103***	0.00113***
	(-497.71)	(-104.48)	(189.87)	(130.83)	(925.55)	(-165.17)	(1481.50)	(136.77)
AP	-0.0140***	0.0168***	-0.0176***	-0.0995***	-0.0361***	-0.0373***	-0.0300***	-0.0122***
	(-141.29)	(22.59)	(-104.92)	(-108.23)	(-257.86)	(-213.41)	(-172.49)	(-31.04)
AT	0.0713***	0.0203***	-0.395***	-0.426***	0.0235***	0.0689***	-0.0394***	-0.203***
	(353.21)	(14.58)	(-723.19)	(-130.02)	(50.38)	(136.88)	(-46.17)	(-106.19)
BB	0.672***	-0.421***	0.218***	0.0423***	0.0724***	0.111***	0.0745***	0.160***
	(1092.31)	(-64.54)	(220.46)	(10.37)	(141.18)	(241.98)	(113.78)	(84.70)
BJ	-0.132***	0.0539***	-0.0482***	0.00289***	0.0247***	0.00495***	0.0283***	0.0720***
	(-1416.86)	(49.14)	(-605.77)	(4.60)	(179.28)	(35.18)	(207.02)	(191.14)
CJ	-0.0424***	-0.0650***	-0.133***	-0.0548***				
	(-434.74)	(-110.56)	(-744.11)	(-59.75)				
CM	0.107***	0.0763***	0.0597***	-0.0341***				
	(2371.53)	(306.53)	(941.73)	(-109.56)				
CN	-0.405***	-0.147***	-0.102***	0.0221***				
	(-1096.77)	(-85.97)	(-448.84)	(25.52)				
CQ	-0.114***	-0.0748***	-0.0130***	0.0261***				
	(-2347.12)	(-287.92)	(-268.89)	(91.92)				
CR	-0.00828***	0.00541***	0.0639***	0.0224***				
	(-156.46)	(14.85)	(1333.78)	(102.47)				
CT	-0.00546***	-0.0350***	0.211***	0.313***	0.0190***	-0.0992***	0.00558***	-0.0267***
	(-25.22)	(-26.10)	(439.07)	(118.29)	(120.67)	(-313.02)	(37.95)	(-58.61)
CW	-0.0643***	-0.0547***	0.0263***	0.0557***	0.0667***	0.0554***	-0.00125***	0.0105***
	(-1083.86)	(-156.95)	(86.20)	(35.84)	(352.08)	(200.17)	(-7.39)	(25.89)
CZ	-0.0159***	0.00595***	-0.0231***	-0.0388***	-0.0151***	0.0146***	-0.0542***	-0.0649***
	(-647.84)	(53.88)	(-128.80)	(-35.23)	(-169.62)	(169.89)	(-493.26)	(-242.64)
DD	-0.0141***	-0.0161***	-0.000587***	-0.0112***	0.0266***	-0.00672***	0.0159***	0.0238***
	(-393.99)	(-114.13)	(-8.41)	(-66.97)	(248.68)	(-64.78)	(151.45)	(146.14)
DH	0.00181***	0.00377***	0.0777***	0.0590***	-0.00505***	-0.00204***	-0.000283***	-0.0116***
	(212.54)	(50.70)	(535.90)	(79.59)	(-89.40)	(-34.29)	(-4.20)	(-77.76)
DO	-0.00222***	-0.00970***	-0.0548***	0.0308***	-0.00485***	0.00512***	0.0494***	0.00376***
	(-89.85)	(-84.83)	(-469.27)	(54.34)	(-161.08)	(63.37)	(614.52)	(20.07)
DQ	0.00519***	-0.00362***	0.0363***	0.0329***	0.0271***	0.0000242	0.0345***	0.0392***
	(247.15)	(-21.28)	(1034.08)	(270.37)	(540.08)	(0.27)	(814.48)	(425.90)
DS	-0.00828***	0.103***	0.285***	0.271***	0.0402***	0.0469***	0.0924***	0.0559***
	(-57.92)	(126.83)	(1435.53)	(271.80)	(272.86)	(205.88)	(576.24)	(152.21)
_cons	6.477***	6.571***	3.808***	4.303***	5.149***	5.440***	5.698***	6.288***
	(9212.40)	(932.35)	(1706.41)	(371.83)	(3585.60)	(1989.61)	(3914.68)	(1074.62)
N	3791957	130800	4035833	177000	4078361	786226	4035544	475212

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6 Conclusion

This research examines the effect of noise on the WOZ housing value around Schiphol Airport using a hedonic pricing model. Literature suggested that noise regions could significantly affect the WOZ values around Schiphol. This leads to the hypothesis of whether or not a change in the noise regions around Schiphol affects the WOZ values of the houses in these regions. Additionally, it is examined whether a decrease of noise will result in a price increase. In other words, whether the externalities, the high noise levels, can be ”reversed”. It is found that noise significantly affects the WOZ value of houses at certain noise levels. However, it is not found that every noise level is of significant importance to this dependent variable. With the results found, it is impossible to conclude whether the effect of noise can be ”reversed”, as the effect of noise is not as significant as was hoped for and over the different periods the coefficient does not seem to change.

In this research, several assumptions are made to create the datasets. These assumptions are dependent on the interpreter. The whole dataset of neighbourhoods is created by estimating the part of a neighbourhood in each noise region. This is done in the best possible way with the available resources but could be improved using geodata, this would potentially lead to more reliable results. Additionally, the size of the municipalities and neighbourhoods is only considered in the last results section, even though they could influence other results as well. Yet, as both datasets do not show a significant effect for every noise level, it seems that the datasets might not be the reason but that the noise simply does not affect the WOZ value that strongly.

Overall, this research does provide a first step into the analysis of the noise around Schiphol and the externalities of this on the housing market. NVM data (Dutch association of real estate agents and appraisers) could potentially make the results more reliable as exact location data would be present. However, the noise maps do not have exact location data, concluding that part of the data would still rely on the researcher’s interpretation.

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A Noise Indicators

$$L_{den} = 10log\left(\frac{1}{24}\left(12 * 10^{\frac{L_{day}}{10}} + 4 * 10^{\frac{L_{evening}+5}{10}} + 8 * 10^{\frac{L_{night}+10}{10}}\right)\right) \quad (4)$$

In which:

- L_{day} is the weighted long-term average sound level, determined over the whole year of all day periods.
- $L_evening$ is the weighted long-term average sound level, determined over the whole year of all evening periods.
- L_night is the weighted long-term average sound level, determined over the whole year of all night periods.
- The day contains twelve hours, evening four, and the night eight. By default the day start at 07:00, but these timeslots can change per nation.

B Data analysis

Table 15: Descriptive statistics

	Municipalitydata					Neighbourhooddata				
Variable	Obs	Mean	Std.Dev.	Min	Max	Obs	Mean	Std.Dev	Min	Max
WOZ	108	302.905	83.03	170	570.721	2161	321.784	175.808	-286.697	1404.945
D	108	.942	.27	.5	1.5	2184	.925	.85	-1.3	5.2
M	108	12.232	3.022	6.2	17.5	2184	15.483	3.773	3.2	28.5
Z	108	2.542	.95	1.4	7.5	2184	2.312	1.507	-1.8	8.9
AC	108	31.784	8.38	16.1	48.8	2184	35.198	7.658	-11	75.3
AD	108	1.256	.37	.5	2.1	2184	1.027	1.008	-1.6	6
AG	108	58.008	130.698	3.1	496.3	2184	266.921	329.478	-27.3	1312.7
AP	108	2.289	1.034	.9	6	2184	1.566	1.349	-4	11.4
AT	108	.756	.285	.3	1.7	2184	.643	.545	-.4	4.6
BB	108	.752	.197	.5	1.3	2173	.788	.681	-.5	5.4
BJ	108	2.652	1.435	1	7.9	2173	1.937	1.614	-2.9	10.1
CJ	108	2.593	1.269	.45	8.35					
CM	108	3.376	1.694	.55	10.85					
CN	108	.914	.402	.5	3.1					
CQ	108	3.978	1.85	.6	7.7					
CR	108	4.099	3.531	1.4	20.8					
CT	108	1.393	.32	.9	2.2	2184	1.806	.953	-1.2	9.2
CW	108	2.263	.755	1.1	4.1	2184	1.84	1.264	-2.8	6.6
CZ	108	5.349	2.714	2.2	11.9	2173	3.363	2.56	0	14.6
DD	108	5.307	2.861	1.6	10.3	2173	3.241	2.822	-3.5	13.2
DH	108	8.873	4.704	2.5	18.5	2173	5.429	3.922	-2.1	20.1
DO	108	5.169	2.581	2.2	11.3	2184	5.257	4.468	-14.4	35.2
DQ	108	9.677	2.698	4.7	17.3	2184	10.228	4.088	-2	31.9
DS	108	2.062	.584	1.4	3.2	2184	2.053	1.176	-.7	8

C All the variables

Table 16: all variables

Variable	Description	unit
Gemeente	Gemeente	
Year	Year	
WOZ	WOZ (average inflation corrected)	1000 euro
	Health and wellbeing	
D	General practice—Distance to GP practice	km
G	General practice—Number of GP practices—Within 5 km	number
H	General practice—Distance to GP post	km
I	Distance to pharmacy	km
J	Hospital (incl. outpatient clinic)—Distance to hospital	km
M	Hospital (incl. outpatient clinic)—Number of hospitals—Within 20 km	number
N	Hospital (excl. outpatient clinic)—Distance to hospital	km
Q	Hospital (excl. outpatient clinic)—Number of hospitals—Within 20 km	number
	Retail	
R	Grocery stores—Distance to large supermarket	km
U	Grocery stores—Number of large supermarkets—Within 5 km	number
V	Grocery stores—Distance to shop for other daily food	km
Y	Grocery stores—Number of shops for other daily food—Within 5 km	number
Z	Department store—Distance to department store	km
AC	Department store—Number of department stores—Within 20 km	number
	Hospitality	
AD	Cafes, etc.—Distance to cafe, etc.	km
AG	Cafes, etc.—Number of cafes etc.—Within 5 km	number
AH	Cafeterias, etc.—Distance to cafeteria, etc.	km
AK	Cafeterias, etc.—Number of cafeterias, etc.—Within 5 km	number
AL	Restaurants—Distance to restaurant	km
AO	Restaurants—Number of restaurants—Within 5 km	number
AP	Hotels etc.—Distance to hotel, etc.	km
AS	Hotels etc.—Number of hotels, etc.—Within 20 km	number

Table 17: all variables

Variable	Description	unit
	Childcare	
AT	Daycare centres —Distance to daycare centres	km
AW	Daycare centres —Number of daycare centres—Within 5 km	number
AX	Out-of-school care—Distance to out-of-school care	km
BA	Out-of-school care—Number of out-of-school care—Within 5 km	number
	Education	
BB	Primary education—Distance to school	km
BE	Primary education—Number of schools—Within 5 km	number
BF	Secondary education—Secondary education total—Distance to school	km
BI	Secondary education—Secondary education total—Number of schools—Within 10 km	number
BJ	Secondary education—Vmbo—Distance to school	km
BM	Secondary education—Vmbo—Number of schools—Within 10 km	number
BN	Secondary education—HAVO/VWO—Distance to school	km
BQ	Secondary education—HAVO/VWO—Number of schools—Within 10 km	number
	Employment: number of jobs	
BR	A-U all economic activities—Within 10 km	x 1 000
BS	A-U all economic activities—Within 20 km	x 1 000
BT	A-U all economic activities—Within 50 km	x 1 000
BU	A Agriculture, forestry and fisheries—Within 10 km	x 1 000
BV	A Agriculture, forestry and fisheries—Within 20 km	x 1 000
BW	A Agriculture, forestry and fisheries—Within 50 km	x 1 000
BX	B-F Industry and energy—Within 10 km	x 1 000
BY	B-F Industry and energy—Within 20 km	x 1 000
BZ	B-F Industry and energy—Within 50 km	x 1 000
CA	G-N Commercial services—Within 10 km	x 1 000
CB	G-N Commercial services—Within 20 km	x 1 000
CC	G-N Commercial services—Within 50 km	x 1 000
CD	O-U Non-commercial services—Within 10 km	x 1 000
CE	O-U Non-commercial services—Within 20 km	x 1 000
CF	O-U Non-commercial services—Within 50 km	x 1 000

Table 18: all variables

Variable	Description	unit
	Green areas	
CG	Public green—Distance to public green total	km
CH	Public green—Distance to park or public garden	km
CI	Public green—Distance to recreational terrain	km
CJ	Public green—Distance to forest	km
CK	Public green—Distance to open natural terrain—Distance to open nat. terrain total	km
CL	Public green—Distance to open natural terrain—Distance to open dry natural terrain	km
CM	Public green—Distance to open natural terrain—Distance to open wet natural terrain	km
CN	Semi-public green—Distance to semi-public green total	km
CO	Semi-public green—Distance to sports area	km
CP	Semi-public green—Distance to allotment garden	km
CQ	Semi-public green—Distance to recreational area	km
CR	Semi-public green—Distance to cemetery	km
CS	Distance to recreational inland waters	km
	Transport and transport	
CT	Distance to main highway entrance	km
CU	Train stations—Distance to train stations (all types)	km
CV	Train stations—Distance to important transfer station	km

Table 19: all variables

Variable	Description	unit
	Leisure and culture	
CW	Distance to library	km
CX	Sports—Distance to swimming pool	km
CY	Sports—Distance to artificial ice skating rink	km
CZ	Museum—Distance to museum	km
DC	Museum—Number of museums—Within 20 km	number
DD	Performing arts (excl. festivals)—Total distance to performing arts	km
DG	Performing arts (excl. festivals)—Total performing arts—Within 20 km	number
DH	Performing arts (excl. festivals)—Distance to pop music venue	km
DI	Cinema—Distance to cinema	km
DL	Cinema—Number of cinemas—Within 20 km	number
DM	Recreation—Distance to sauna	km
DN	Recreation—Distance to tanning salon	km
DO	Recreation—Distance to attraction	km
DP	Recreation—Number of attractions—Within 10 km	number
DQ	Recreation—Number of attractions—Within 20 km	number
DR	Recreation—Number of attractions—Within 50 km	number
DS	Distance to fire station	km