Assessing the Impact of Redevelopment of Railway Stations on House Prices

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Abstract – While earlier research on the external effects of railway stations has mostly been limited to the effects of accessibility improvements, this paper aims to investigate whether external effects arise when railway stations are redeveloped for purposes of renovation and replacement of aged and deteriorated station buildings and their direct surroundings. A hedonic pricing model in the context of a difference-in-difference analysis is applied on a dataset of house sale transactions in the Netherlands. The results show that redevelopment efforts impact house prices positively. Impact differences are found between larger cities with a population of more than 100,000 residents and smaller cities in the dataset. Compared to earlier research on the external effects of either accessibility improvements or revitalization of urban areas and neighborhoods, findings suggest that the effects of redevelopment of railway stations are moderate. The findings add evidence to existing research on redevelopment and public investments and add new insights for decision makers on redevelopment projects.

Keywords – railway station; redevelopment; property value; hedonic pricing.

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"Master theses are preliminary materials to stimulate discussion and critical comment. The analysis and conclusions set forth are those of the author and do not indicate concurrence by the supervisor or research staff."

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1. Introduction

Everywhere in the world, railway stations are being redeveloped in order to keep up with new technology and changes in transit demand. A well-known example is the Transbay Transit Center in San-Francisco, a major inner-city redevelopment scheme replacing the former transit center and bringing the commuter railway in the heart of the city, along with adding commercial functions like retail and offices. Furthermore, in China, many railway stations within cities have been redeveloped, such as the Beijing South Railway Station and the Tianjin Railway Station, mainly due to increased passenger numbers and construction of new railway connections and high-speed rail. In Europe, well-known projects are the London Bridge railway station, and the central stations of Stuttgart, Antwerp, Lille, Berlin and Rotterdam.

Redevelopment and spatially allocated investments of public capital are frequently discussed topics in literature, see for instance Nourse (1963), Aschauer (1989), Smith (2004), Schwartz et al. (2006) Harding et al. (2007), Rosenthal (2008), Alhfeldt and Richter (2013), and van Duijn et al. (2016). In past research, this often takes the form of research into external effects, i.e. measuring if and to what extent adjacent areas are influenced by spatially allocated investments. General findings are that that due to urban decline and ageing of the building stock, social quality of neighborhoods and property prices decline (Smith, 2004; Harding et al., 2007; Ahlfeldt and Richter, 2013), and that urban renewal and redevelopment create positive external effects i.e. improving social quality of neighborhoods and increasing property prices (Schwartz et al., 2006; Rosenthal, 2008; van Duijn et al., 2016). Further investigation into this field of research makes clear that so far research dealing with the external effects of railway stations mostly was focused on newly constructed railway links and railway stations on new locations, in which accessibility is the major driver. Examples are the research of Bajic (1983), Voith (1991), Gatzlaff and Smith (1993), and Debrezion et al. (2011) who found that the construction of new transit systems capitalizes in home prices through improved accessibility, and thus have a positive external effect.

However, one can imagine that when railway stations are redeveloped not aimed at accessibility improvements but rather aimed at renewal of the station and improving the functionality, potential external effects might deviate from the earlier mentioned general findings of research on spatially allocated investments and the accessibility features of construction of new railway stations. Reasons for this are twofold. First, due to the vast transport movements and their function as public meeting point, railway stations can be associated with negative external effects. Well-documented negative external effects are (noise) nuisance of transport movements and air pollution (Wilhelmsson, 2000), which is also mentioned in other research on the external effects of railway links and nodes of for instance Bowes and Ihlandfeldt (2001), Hess and Almeida (2007), Portnov et al.(2009), Debrezion et al. (2011, 2007) and Shyr et al. (2013). Second, redevelopment of railway stations aimed at renewal of the station and improving the functionality might attract new amenities and new functions such as offices, retail and catering. Also, the space around redeveloped stations is often improved with new squares and parks, the latter known to capitalize in property prices (Geoghegan et al. 2003). Without significant changes in accessibility, and knowing that amenities are a strong determinant of property prices (Cheshire and Sheppard, 1995; Brueckner et al., 1999), it seems reasonable to hypothesize that the external effects of redevelopment of railway stations are positive.

However, since no specific research into the external effects of redevelopment of railway stations on house prices is known for redevelopments without accessibility improvements, there is no scientific evidence on whether redevelopment of railway stations results in positive or negative external effects on house prices. Also, it would be valuable for policy makers to gain insight into the external effects of redevelopment of existing railway stations, not in the last place because of the high capital expenditure and nuisance of construction works for a city's residents. Therefore, the objective of this study is to contribute to this gap in the research to date, and to gain insight into the external effects of railway station redevelopment. The main question researched is what the effect of redevelopment of railway stations is on nearby property prices.

The remainder of the paper is organized as follows. In section two a theoretical background on external effects of railway transit systems and redevelopment projects is provided. Section three contains a description of the methodology and the dataset utilized for this research. In section four, the estimation results are presented and discussed, which is followed by section five, in which conclusions are drawn and recommendations for further research are formulated.

2. Theoretical framework

This section provides an overview of theory on external effects of accessibility and transit systems, and theory on the external effects of redevelopment projects.

2.1. Accessibility, transit systems, and external effects on property prices

From urban economic theory, it is known that a trade-off exists between land value and transport costs. Close to the Central Business District (CBD), land value is high and transport costs are low, while at the edge of a city, farther away from the CBD, the effect is opposite (Von Thünen, 1842; Alonso, 1960, 1964). This theory, commonly referred to as bid-rent model, was refined throughout the years by Alonso (1960, 1964), Muth (1969), and Oates (1969). However, Brueckner et al. (1999) incorporated the findings of the three researchers into a new concept. Their conclusions were that when the CBD has an abundance of amenities, property prices inversely vary with distance from the CBD, resulting in high property prices close to the CBD and low property prices at the edge of cities. In addition to this amenity-based theory, from research of Ferguson et al. (1988), supported by for example Gatzlaff and Smith (1993) and Benjamin and Sirmans (1996), it can be concluded that also changes in accessibility and transportation shape the urban form and impact the urban land and housing markets. According to Benjamin and Sirmans (1996), accessibility changes impact property prices by changes in property utilization and commuting costs.

The majority of prior research on the external effects of railway transit on property values has been carried out for light-rail and metro systems. For example, Bajic (1983) found that house prices near the stations of the Toronto transit system are significantly higher than elsewhere in the city, and Voith (1991) found that in Philadelphia access to fixed-rail transport amounts to an significant price premium on residential property values. Gatzlaff and Smith (1993) also found an increase of house prices near the Miami Metrorail service, but this is not as strongly pronounced as in the other studies. According to an overview given in the paper of Hess and Almeida (2007), studies focused on the external effects of accessibility improvements report external effects on house prices of up to 12% (Weinstein and Clower, 2002).

Debrezion et al. (2007) carried out a meta-analysis on 73 estimation results out of a pool of studies evaluating the impact of railway station proximity on property values for several countries. They concluded that commuter railway stations show a significantly higher impact on property values than other stations, and that commercial properties show a higher price premium than residential properties. Within a ring of 2 miles (1609 meters), residential property prices increase with 2,4% for every 250 meters closer to the station. Another finding of this meta-analysis is that when the proximity to other modes of transport such as highways is not taken into account in a study, the effects of proximity to railway stations on property values are overestimated.

It is interesting to note that, although past studies found that house prices increased with better accessibility to metro systems, the external effects of nearby train stations and rail transit systems are not only positive. In a study conducted by Portnov et al.(2009), the negative external effects of rail transit systems are clearly recognized. Because of the distinction they make between railway tracks and railway stations, Portnov et al.(2009) found that in a zone of 100 meters beside the railway tracks, a 13% depreciation of property values occurs due to noise nuisance and view obstructions. While Debrezion et al. (2011) did not find consistent effects of noise related nuisance, Bowes and Ihlandfeldt (2001) as well as Simons and Jaouhari (2004) found the same results as Portnov et al.(2009), with a property price depreciation of 5% to 20% within the first hundred meters of the tracks.

2.2. External effects of redevelopment

Redevelopment of land and real estate is a recurring phenomenon. Due to ageing and deterioration of buildings and the cyclical pattern of land values, periodic waves of redevelopment occur (Rosenthal, 2008). Evidence can be found in the heart of cities were land values have increased the most since a city was founded, and where old buildings are often redeveloped or replaced over time. Newer buildings can become economically obsolete over time, due to sharp rises in land values, resulting in redevelopment (Rosenthal, 2008). In addition, past research clearly recognized that due to ageing and deterioration of buildings and their environment, property values of the buildings can decline, and this effect can even be found for buildings in the vicinity (Smith, 2004). Harding et al. (2007) found that due to ageing, house prices depreciate -2,5% to -3% per year, which also has effects on the societal and social level, one example being that aged, less well maintained homes are often occupied by lower-income households. As mentioned in the first chapter, urban renewal and redevelopment can create positive external effects such as improving social quality of neighborhoods and increasing property prices. This can be derived from several studies into the external effects of urban renewal projects and investments in housing and deteriorated buildings and sites in cities. See for instance the work of Alhfeldt and Richter (2013) on urban renewal projects in Berlin, reporting a house price increase of +0,5% to +1,9% per year in a radius of 2000 meters around redevelopment projects. In another study, Schwartz et al. (2006) found that investments in public housing generates externalities in the form of an +8,7% increase in property values within the first 600 meters, as well as improvements in the social quality of a neighborhood. Van Duijn et al. (2016) found that renovation of industrial heritage sites such as gas factories built during the industrial era in the 19th and 20th century result in positive external effects, increasing house prices within a 1000 meters distance ring with +9,5%. From an analysis of Koster and Van Ommeren (2013) into the externalities of place-based public investments in neighborhoods follows that house prices can increase with +2,4% within 250 meters of the targeted area.

For railway station redevelopments, a study of Van der Krabben and Needham (2008) shows that offices within 500 meters of a railway station redevelopment gained roughly between +14% and +17% rental value per square meter. Despite their initial focus on redevelopment of the whole station area and including redevelopment activities like the construction of new open spaces, the three cases included in the research all experienced substantial changes in accessibility such as new high-speed rail. Also, the effect of redevelopment on house prices was not investigated. Hence, the results of their study do not take away the need to further investigate the external effects of railway station redevelopments on house prices. In Table 1, the findings of the aforementioned research are summarized. A further literature search for the specific case of railway station redevelopments that were not aimed to improve accessibility did not yield satisfactory results with regard to external effects on house prices.

Taken together, it seems plausible that despite the presence of negative externalities around railway stations due to traffic streams, the research mentioned in this paragraph points in the direction of positive externalities because of improvements in physical quality, maintenance status, and attraction of new amenities. Therefore, the underlying hypothesis of this research is that railway station redevelopments do create positive external effects.

3. Methodology and data

3.1. Study area

Focus area of this study is the Netherlands. From the Dutch Association of Real Estate Agents (NVM), a dataset is obtained with transaction prices of houses near eight railway station redevelopment projects in a period between 1986 and 2012. This dataset is further described in paragraph four of this chapter. For selection of the redevelopment projects to be included in the research, an analysis of past railway station redevelopment projects was made based on publicly available information from websites, archived newspapers and books. The following criteria were used. First, projects should be completed for more than 4 years, since house prices adjust only slowly to changes due to property market characteristics (Smith et al. 1988; DiPasquale and Wheaton, 1994; Keogh and D'Arcy, 1999), and a certain time period after redevelopment is needed to yield sufficient observations for the analysis. The four years period is derived from the work of Schwartz et al. (2006) and van Duijn et al. (2016), who found significant impacts until respectively five and four years after the completion of redevelopment projects. Second, projects have been selected based on the

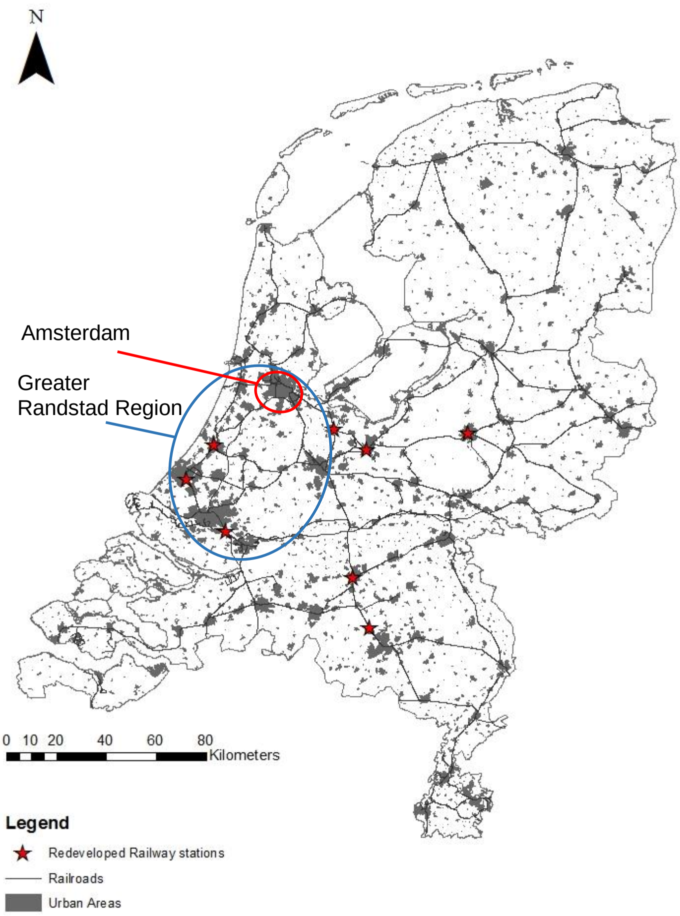


Figure 1: *The selected railway station redevelopment projects in The Netherlands which are included in the analysis.*

scope of the redevelopment scheme. As suggested by van Duijn et al. (2016), when a redevelopment replaces a disamenity, buildings are renovated, and when improvements in appearance and atmosphere change people's perception of a place (Daams et al. , 2016), this might create external effects, that is, increase property prices in the vicinity. Projects with a focus on replacing a disamenity in the form of replacing old buildings, adding nuisance reduction methods, improving the appearance and atmosphere, attracting new amenities, and with the purpose of 'upgrading' the area, were selected. Projects mainly aimed at improving the accessibility of a station by adding railway tracks and overall improving connections, were left out. This way, it is aimed to separate the effect of redevelopment from the effect of accessibility improvement investigated in earlier research. An important notion is that no railway station and redevelopment effort included in this research equals the other, and differences in size and scale, type, and money invested are paramount.

Figure 1 provides an overview of the location of the selected projects within the Netherlands. In Table 2 further information about the selected projects can be found, and appendix A provides a more detailed description of every project.

Table 2: *Overview of redevelopment projects included in the research*

Station	Type	Population size	Period	Costs (€) millions	Redevelopment characteristics
Amersfoort	Intercity Station[1]	120,512	1995-1997	14,1	Station building 1000 sqm, office buildings 19000 sqm, new retail space, new platform with 2 tracks.
Apeldoorn	Intercity Station	155,108	2005-2007	>13,6	Renovation of station building, cycling tunnel, city square, new cycle parking facility, new bus station
Leiden	Intercity Station	116,972	1993-1996	27,2	New station building with pedestrian tunnel, new squares at both sides of station, road adjacent the station in tunnel, new platform with 2 tracks.
Den Bosch	Intercity Station	127,352	1995-1998	46,2	New station building with retail and office functions, passageway to the platforms, new square with car parking garage and bicycle parking facilities
Hilversum	Intercity Station	82,297	1990-1992	3,6	New station building with offices (8000 sqm) and retail functions, new square in front of the station, bus station moved.
Barendrecht	Local Station[2]	24,796	1999-2001	100	New railway station in tunnel, with park and car park on top.
Best	Local Station	24,890	1998-2002	136-175	New railway station in tunnel, with park, car park and square on top.
Rijswijk	Local Station	48,488	1992-1996	75	New railway station in tunnel, with park and square on top.

[1]: An intercity station is a station where long distance trains stop, which run between the largest cities of the Netherlands. [2]: Local stations are only operated by shorter-distance trains which stop at every station in between.

3.2. Methodology

The main objective of this research is to investigate whether redevelopment of a railway station causes house prices in the vicinity to respond to it. This implies an external effect, which means that individuals base their valuation of a house not only on characteristics of the house itself, but also on derived utility from its surroundings (Buchanan and Stubblebine, 1962). When one can measure the utility an individual attaches to all the different characteristics of a house and it surroundings, the size of the external effect can be found.

The research method utilized in this study follows from the work of Rosen (1974) on the hedonic framework. In this seminal work, a model of production differentiation in pure competition based upon hedonic values is specified. Central to hedonic pricing analysis is the hypothesis that goods are valued based on their utility-bearing attributes. Consequently, hedonic values are the implicit prices economic agents apply to goods, based on their utility. With the hedonic framework, it is recognized that goods can be valued by a bundle of characteristics, which matches the heterogeneity of housing goods, and one can measure to which extent a certain characteristic affects price. The external effects spoken of before can in this way be measured, not by their direct market prices, but rather as a characteristic in a bundle of characteristics valued on their utility by an individual. Hedonic values are estimated by a regression analysis, wherein product prices are regressed on a bundle of product characteristics. Product prices thus depend on the independent, explanatory variables, which are a bundle of product characteristics. Because all characteristics are estimated independently from each other with this method, the regression coefficients can be interpreted as the additional impact on price that is contributed by a certain characteristic (Rosen, 1974; Galster et al., 1999).

Operationally, this research builds upon the work of Galster et al. (1999), Santiago et al. (2001), Schwartz et al. (2006) and van Duijn et al. (2016). They all exploit the hedonic framework, with slight variations and improvements when moving forward in time, and adapted to their research. The basic approach is that in order to estimate impacts of locational events, differences in house prices in the vicinity of the redevelopment projects before and after the redevelopment are measured, relative to house prices farther away. Therefore, the difference-in-difference methodology is applied. In practice, this is achieved by comparing the house prices within a certain ring around the redevelopment project with the house prices outside that ring, and this is done before the start and after completion of the project. What is needed first in order to be able to run a regression, is determination of the target and control group (Ashenfelter and Card, 1985; Abadie, 2005). The target group is defined as the sold houses that received treatment, i.e. are located close enough to the redevelopment site to be influenced by it. The control group are the sold houses that are expected to not to be influenced by the redevelopment project. In previous applications of this method, the analysis was performed for a target group ring radius between 600 (Galster et al., 1999; Santiago et al., 2001; Schwartz et al., 2006) and 1000 meters (van Duijn et al., 2016), which yielded significant results. An important notion however is that the assumption underlying this methodology is that the target and control groups are identical. Differences between target and control groups can result in inconsistent estimates of the external effect (Ashenfelter and Card, 1985; Abadie, 2005). Ideally, identical target and control area could be matched with a matching procedure, as done by Van Duijn et al. (2016) and Koster and Van Ommeren (2013). With this procedure, the neighborhoods are matched based on a propensity score, which is estimated with a probit or logit regression based on characteristics such as population density, percentage of elderly people, average household size, etc. (van Duijn et al., 2016). However, since the Statistics Bureau of the Netherlands does not provide this data for the years before 2004 and most of the selected cases were redeveloped before 2004, this procedure cannot be used for this research. Therefore, it is needed to turn to an empirical strategy. If target and control area should be the same, they should at least fall within the same urban area in order to have the same relation to the redeveloped station and be part of the same community. From the selected cases, in appendix B it can be seen that only for the largest cities with a population above 100,000 the size of the urban area reaches far enough to include a 6000 meters sample size, which amounts to a target area of 3000 meters and control area of 3000 to 6000 meters. For the smaller towns included, a maximum sample size of 3000 meters is possible, with a target area of 1500 meters and control area of 1500 to 3000 meters.

Therefore, for the full dataset, initially a target area ring radius of 1000 meter is used, but this is further expanded to 2000 meters and 3000 meters in order to investigate whether results are robust. The target area of 3000 meters is only specified for the four largest cities with a population size of over 100,000, due to the aforementioned small size of the urban areas of the other cases.

After definition of the target and control group, house prices are regressed on a number of property-related characteristics, fixed effects, and a vector variable existing of dummy variables capturing the external effects.

Property-related characteristics are divided into structural characteristics and external characteristics. In Table 3 an overview of the structural characteristics found to be significantly explaining house prices is shown.

Table 3: *Structural characteristics*

	A	B	C	D	E	F	G	H	I	J	K	L	M
Property type				✓					✓	✓	✓	✓	✓
Building age	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓
Lot size	✓	✓	✓		✓	✓	✓	✓				✓	
Floor space		✓	✓		✓	✓		✓	✓	✓		✓	✓
Number of rooms	✓		✓	✓						✓		✓	✓
Number of bathrooms		✓	✓		✓		✓			✓			
Garage		✓	✓					✓		✓	✓		✓
Basement			✓				✓	✓					
Maintenance condition		✓	✓								✓		✓
Heating type		✓					✓			✓		✓	✓

A: Stull (1975); B: Palmquist (1984); C: Bajic (1983); D: Voith (1991); E: Grass (1992); F: Gatzlaff and Smith (1993); G: Bowes and Ihlandfeldt ((2001)); H: Simons and Jouahari (2004); I: Portnov et al.(2009); J: Debrezion et al. (2011); K: Schwartz et al. (2006); L: Daams et al. (2016); M: van Duijn et al. (2016).

External characteristics comprise aspects such as air pollution, noise nuisance and accessibility by different means of transport. Since direct measurements of noise nuisance and air pollution are not available on a neighborhood scale for the years 1986 to 2005, as a proxy a dummy variable capturing whether a house is located within 100 meters of railway tracks are included in the analysis. Accessibility characteristics were included by calculating the distance to the nearest intercity station and highway ramp.

Second, fixed effects were included in the econometric model to overcome correlations in error terms of equations caused by spatial correlations such as attributes of neighboring properties and social- and welfare status of a neighborhood, and correlations over time (Case, 1991; Allison, 2009; Brooks and Tsolacos, 2010). Dummy variables capturing the different neighborhoods were used to control for these unobserved endowments of location. To control for correlations over time, transaction year dummies were included in the analysis.

Third, the dummy variables capturing the external effects relate to a set of variables that depend on the location of a house, transaction year, and treatment radius. These variables measure whether a house is located within the specified distance ring, and if a house sale transaction has taken place before, between or after start and completion of a redevelopment project. Further explanation of these variables is offered in the next paragraph.

3.3. Empirical model

The model specification mainly relies on Schwartz et al. (2006) and van Duijn et al. (2016), but is slightly simplified and adapted to this study, since specific variables of their research are not relevant to this research. For instance, the trend variables used by van Duijn et al. (2016) are left out.

The model is specified as follows:

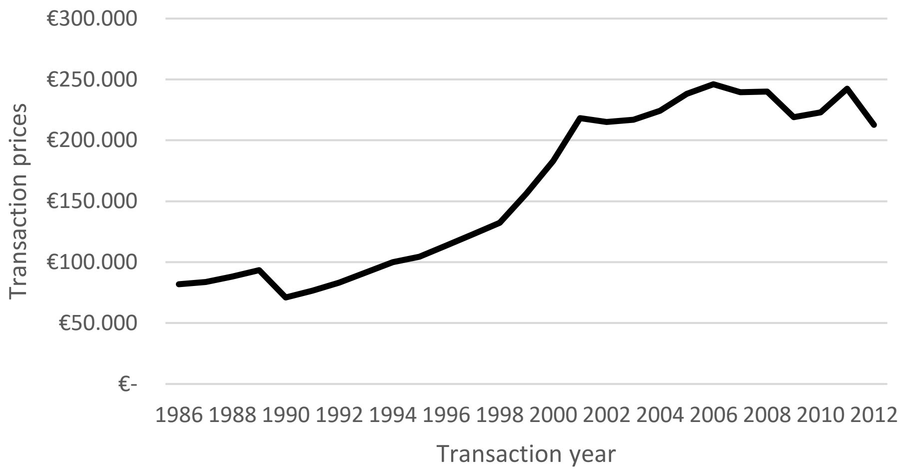
$$\ln(P_{ijt}) = b_0 + \sum_j \alpha_j S_{it} + \sum_j \beta_j E_{it} + \sum_{s=1}^{s} \gamma_s R_{itrs} + \theta_t Y_t + \pi_j N_j + \varepsilon_t \quad (1)$$

The dependent variable P_{ijt} is the transaction price of house *i* located in neighborhood *j at time t.* The right-hand side of the formula presents the independent variables, starting with b_0, a constant. Variable S_{it} and E_{it} capture respectively the structural and external characteristics of house *i* sold in year *t.* This is followed by R_{itrs}, which is the ring variable *s* depending on location of house *i*, transaction year *t* and treatment radius *r.* Variable Y_t is a dummy variable which is one for year *t* and zero otherwise, and dummy variable N_j is one for neighborhood *j* and zero otherwise. The last variable captures the estimation errors, ε_t. The parameters α, β, γ, θ and π are to be estimated.

Variable R_{itrs} captures the external effects, and is constructed as a vector, consisting of three variables. The first variable is a distance ring dummy, measuring if the location of a house sale transaction *i* falls within treatment radius *r.* This is the *before* variable which captures the expected negative external effects before start of the redevelopment. A second variable is included to measure if a transaction *i* falls within treatment radius *r* and takes place between start and completion of the redevelopment project, the *between* variable. Third, a dummy variable is included capturing whether a transaction *i* takes place within treatment radius *r* and after completion of the redevelopment, the *after* variable. In this way, the target group captured by the *between* and *after* variables are compared with the control group captured by the *before* variable.

3.4. Data and descriptive statistics

From the Dutch Association of Real Estate Agents (NVM) a dataset on house sale transactions is obtained. Initially, this cross-sectional dataset contains roughly 88.000 house sale transactions closed between 1986 and 2012, within a ring of 2000 meters around eight specified railway station redevelopment projects. In Figure 2, the average transaction price per year is plotted, overall showing a positive trend in transaction prices from 1986 to 2012.



After the data was prepared for statistical analysis by normalization and removal of outliers, and after selecting the transactions within four kilometers of each redevelopment project, roughly 50,000 observations remained. The remaining dataset includes information such as the exact address, transaction prices and structural characteristics such as surface area, number of rooms, maintenance status, type of house, year of construction, monument status, and parking. Note that these structural characteristics largely overlap with the characteristics presented in Table 1. Additionally, the route distance from each house sale transaction to the nearest highway ramp and intercity station is calculated to control for accessibility (Debrezion et al., 2007; van Duijn et al., 2016). Data for this calculation is obtained from public sources in the form of a road network map, and calculations are performed with a Geographical Information System (GIS). The GIS software is further used to determine whether a house transaction has taken place within 100 meters of a railway track, as a proxy to control for negative external effects of noise nuisance and air pollution (Debrezion et al. 2007).

The descriptive statistics for most variables used in the estimation procedure can be found in Table 4, 5 and 6. Descriptive statistics are given per initial target and control area, in order to be as transparent as possible about the similarities and differences between them.

As can be seen from the descriptive statistics in Table 4, there are no large differences between the first target and control group. Average house size is slightly bigger in the control group, while also the share of apartments is larger. Differentiations also occur in building periods, however differences seem not consistent. For instance, one would expect more recently constructed houses farther away from the city center, but that is not the case, there are only less houses built from 1500 to 1905 in the control group.

Table 4: *Descriptive statistics 0-2000 meters (all cases)*

Target area (in meters)	**0-1000**					
Control area (in meters)				**1000-2000**		
Observations	7,824			16,310		
	Mean (SD)	Min	Max	Mean (SD)	Min	Max
Transaction price (K€)	160578(73559)	22500	400000	169031(78062)	22235	400000
House size (M2)	109.3(37.7)	30	300	114.3(36.4)	32	300
Number of rooms	3.9(1.4)	1	43	4.2(1.3)	1	38
Well-maintained inside (1=yes)	0.11(0.32)	0	1	0.13(0.33)	0	1
Well-maintained outside (1=yes)	0.1(0.3)	0	1	0.1(0.3)	0	1
Bathroom (1=yes)	0.87(0.34)	0	1	0.88(0.33)	0	1
Balcony (1=yes)	0.32(0.47)	0	1	0.31(0.46)	0	1
Garage (1=yes)	0.17(0.38)	0	1	0.19(0.39)	0	1
Garden (1=yes)	0.9(0.3)	0	1	0.88(0.33)	0	1
Terrace (1=yes)	0.06(0.23)	0	1	0.05(0.22)	0	1
Central heating (1=yes)	0.97(0.18)	0	1	0.97(0.18)	0	1
Row house (1=yes)	0.31(0.46)	0	1	0.34(0.47)	0	1
Semi-Detached house (1=yes)	0.1(0.3)	0	1	0.13(0.33)	0	1
Corner house (1=yes)	0.11(0.31)	0	1	0.15(0.35)	0	1
Detached house (1=yes)	0.05(0.21)	0	1	0.07(0.25)	0	1
Apartment (1=yes)	0.43(0.5)	0	1	0.32(0.47)	0	1
Official monument status (1=yes)	0.02(0.13)	0	1	0.01(0.11)	0	1
Distance to nearest intercity station (m)	3427(4228)	0	12273	3666(3479)	0	13250
Distance to nearest highway ramp (m)	2918(990)	0	6640	2906(1089)	0	6559
Within 100 meters of railway line (1=yes)	0.07(0.25)	0	1	0.03(0.16)	0	1
Building period 1500-1905	0.08(0.27)	0	1	0.05(0.23)	0	1
Building period 1906-1930	0.18(0.39)	0	1	0.17(0.37)	0	1
Building period 1931-1944	0.09(0.28)	0	1	0.15(0.36)	0	1
Building period 1945-1959	0.05(0.21)	0	1	0.08(0.27)	0	1
Building period 1960-1970	0.12(0.33)	0	1	0.14(0.34)	0	1
Building period 1971-1980	0.14(0.35)	0	1	0.17(0.38)	0	1
Building period 1981-1990	0.19(0.39)	0	1	0.12(0.32)	0	1
Building period 1991-2000	0.11(0.31)	0	1	0.11(0.32)	0	1
Building period >2000	0.04(0.18)	0	1	0.01(0.1)	0	1

From Table 5, it can be seen that the second target and control group are very similar. In the data, the only notable difference is the share of houses built in the period 1960-1970, which is larger in the control group.

Table 5: *Descriptive statistics 0-4000 meters (all cases)*

Target area (in meters)	**0-2000**					
Control area (in meters)				**2000-4000**		
Observations	24,127			26,040		
	Mean (SD)	Min	Max	Mean (SD)	Min	Max
Transaction price (K€)	166292(76733)	22235	400000	161815 (77114)	22235	400000
House size (M2)	112.7(36.9)	30	300	112.1 (35.7)	30	300
Number of rooms	4.1(1.3)	1	43	4.2 (1.3)	1	14
Well-maintained inside (1=yes)	0.12(0.33)	0	1	0.12 (0.33)	0	1
Well-maintained outside (1=yes)	0.1(0.3)	0	1	0.09 (0.28)	0	1
Bathroom (1=yes)	0.88(0.33)	0	1	0.88 (0.33)	0	1
Balcony (1=yes)	0.31(0.46)	0	1	0.33 (0.47)	0	1
Garage (1=yes)	0.19(0.39)	0	1	0.19 (0.39)	0	1
Garden (1=yes)	0.89(0.32)	0	1	0.89 (0.31)	0	1
Terrace (1=yes)	0.05(0.22)	0	1	0.05 (0.21)	0	1
Central heating (1=yes)	0.97(0.18)	0	1	0.97 (0.17)	0	1
Row house (1=yes)	0.33(0.47)	0	1	0.34 (0.48)	0	1
Semi-Detached house (1=yes)	0.12(0.32)	0	1	0.1 (0.3)	0	1
Corner house (1=yes)	0.13(0.34)	0	1	0.13 (0.34)	0	1
Detached house (1=yes)	0.06(0.24)	0	1	0.06 (0.23)	0	1
Apartment (1=yes)	0.35(0.48)	0	1	0.36 (0.48)	0	1
Official monument status (1=yes)	0.01(0.12)	0	1	0.01 (0.09)	0	1
Distance to nearest intercity station (m)	3588(3740)	0	13250	3631 (3151)	0	15120
Distance to nearest highway ramp (m)	2910(1058)	0	6640	2793 (1108)	0	8112
Within 100 meters of railway line (1=yes)	0.04(0.19)	0	1	0.03 (0.16)	0	1
Building period 1500-1905	0.06(0.24)	0	1	0.01(0.09)	0	1
Building period 1906-1930	0.17(0.38)	0	1	0.04(0.2)	0	1
Building period 1931-1944	0.13(0.34)	0	1	0.1(0.3)	0	1
Building period 1945-1959	0.07(0.26)	0	1	0.08(0.26)	0	1
Building period 1960-1970	0.13(0.34)	0	1	0.31(0.46)	0	1
Building period 1971-1980	0.16(0.37)	0	1	0.18(0.38)	0	1
Building period 1981-1990	0.14(0.35)	0	1	0.12(0.33)	0	1
Building period 1991-2000	0.11(0.31)	0	1	0.13(0.34)	0	1
Building period >2000	0.02(0.13)	0	1	0.03(0.16)	0	1

Table 6 shows the third target and control group. A first thing to notice is that the number of observations of the control group is much smaller than the target group. Another notable difference is that for the control group, the mean transaction price lies almost 30.000 above that of the target group. Also, the mean distance to the nearest intercity station is larger for the control group, and most of the houses are from the building period 1981 to 2000, as opposed to the control group which has a more diverse mix.

Table 6: *Descriptive statistics 0-6000 meters (only cities with population size >100,000)*

Target area (in meters)	**0-3000**					
Control area (in meters)				**3000-6000**		
Observations	32,062			5,216		
	Mean (SD)	Min	Max	Mean (SD)	Min	Max
Transaction price (K€)	161967(76330)	22235	400000	189126(73839)	22800	400000
House size (M2)	110.9(34.9)	30	300	125.9(29.5)	40	300
Number of rooms	4.1(1.3)	1	43	4.5(0.9)	1	14
Well-maintained inside (1=yes)	0.13(0.33)	0	1	0.05(0.21)	0	1
Well-maintained outside (1=yes)	0.09(0.29)	0	1	0.03(0.17)	0	1
Bathroom (1=yes)	0.91(0.29)	0	1	0.97(0.17)	0	1
Balcony (1=yes)	0.36(0.48)	0	1	0.12(0.33)	0	1
Garage (1=yes)	0.18(0.38)	0	1	0.3(0.46)	0	1
Garden (1=yes)	0.9(0.3)	0	1	0.84(0.37)	0	1
Terrace (1=yes)	0.05(0.22)	0	1	0.05(0.21)	0	1
Central heating (1=yes)	0.98(0.15)	0	1	0.99(0.1)	0	1
Row house (1=yes)	0.34(0.48)	0	1	0.47(0.5)	0	1
Semi-Detached house (1=yes)	0.1(0.3)	0	1	0.19(0.39)	0	1
Corner house (1=yes)	0.13(0.34)	0	1	0.19(0.39)	0	1
Detached house (1=yes)	0.06(0.24)	0	1	0.08(0.27)	0	1
Apartment (1=yes)	0.37(0.48)	0	1	0.07(0.26)	0	1
Official monument status (1=yes)	0.01(0.1)	0	1	0(0)	0	1
Distance to nearest intercity station (m)	2336(900)	84	5892	4452(689)	0	16560
Distance to nearest highway ramp (m)	2882(1090)	0	6640	2031(627)	352	8112
Within 100 meters of railway line (1=yes)	0.03(0.17)	0	1	0.02(0.13)	0	1
Building period 1500-1905	0.05(0.21)	0	1	0(0.04)	0	1
Building period 1906-1930	0.13(0.34)	0	1	0.01(0.09)	0	1
Building period 1931-1944	0.11(0.32)	0	1	0.01(0.11)	0	1
Building period 1945-1959	0.07(0.25)	0	1	0.01(0.11)	0	1
Building period 1960-1970	0.24(0.43)	0	1	0.06(0.23)	0	1
Building period 1971-1980	0.17(0.38)	0	1	0.31(0.46)	0	1
Building period 1981-1990	0.12(0.32)	0	1	0.35(0.48)	0	1
Building period 1991-2000	0.09(0.29)	0	1	0.2(0.4)	0	1
Building period >2000	0.02(0.12)	0	1	0.04(0.2)	0	1

4. Results

In this section, the estimation results are reported. First, the results of the regression analyses for a target area of both 1000, 2000 and 3000 meters are reported, from which the latter is only for the four biggest cities with over 100,000 residents. Second, the reach of the external effect and the relation with distance is explored. Third, it is investigated whether the estimated coefficients differ between the selected projects, based on type of redevelopment and location .

4.1. Results for the initial target and control area

Regression results can be found in Table 7. Three regression models were run, so that it can be seen whether results are robust over the three specified target areas. As mentioned before, the target area of 3000 meters is only specified for the four largest cities with a population size of over 100,000, due to the smaller size of the urban areas of the other cases. The adjusted R^2 represents the degree to which the models fit the data, and lies between 0.89 and 0.90. This is in line with other hedonic pricing literature, see for instance van Duijn et al. (2016) and Schwartz et al. (2006). For interpretation of the regression results, it is important to note that a log-linear model is used, meaning that the dependent variable is defined as a natural log of the transaction price.

Table 7: *Regression results of the initial target and control area*

	Model 1	**Model 2**	**Model 3**[1]
Observations	24,161	50,197	37,259
Adj. R-squared	0.8955	0.9048	0.9019
Sample size	0-2000 m.	0-4000 m.	0-6000 m.
Target area	0-1000 m.	0-2000 m.	0-3000 m.
Control area	1000-2000 m.	2000-4000 m.	3000-6000 m.
Before	-0.0293692***	-0.0315186***	-0.0443761***
	(0.0058973)	(0.0043864)	(0.0041466)
Between	-0.0057552	0.0085055**	0.027136**
	(0.0054581)	(0.0032231)	(0.0038988)
After	0.0101675**	0.0216704***	0.0185415***
	(0.0058095)	(0.0035953)	(0.0045093)
Transaction year dummies	✓	✓	✓
Structural characteristics	✓	✓	✓
Building period dummies	✓	✓	✓
Neighborhood dummies	✓	✓	✓

Notes: significance levels: * p<0.10, ** p<0.05, *** p<0.01. ✓: variable included. Dependent variable is a natural log (ln) of the transaction price. Results of the control variables can be found in appendix D. Robust standard errors are reported between parentheses.

[1]: Results of model 3 are only for the four biggest cities with a population of over 100,000.

The regression coefficients should therefore be interpreted as percentage change in house prices. Since post-estimation diagnostics indicate heteroskedasticity, the models were run with robust standard errors. In appendix C, the results of the post-estimation diagnostics are presented.

The results indicate that significant negative external effects occurred before redevelopment of the selected railway stations. For both the target group ring radius of 1000, 2000 and 3000 meters, the *before* variable has a negative coefficient and is significant at the 1% level. For the target area of 1000 meters, the results indicate that before redevelopment, houses in this group sold for -2,3% less than houses in the control group of 1000 to 2000 meters. When the target area is doubled to 2000 meters, the negative external effect increases to -3,1%. The negative external effect is also visible in the results of model 3, which confirms the robustness of the results of the first two models. Together, the outcomes suggests that the railway stations were a disamenity before redevelopment, which can be caused by physical deterioration and maintenance arrears of the railway station and its environment. Also, for instance earlier changes in the spatial structure of the surroundings can lead to sub-optimal traffic streams around a railway station, increasing nuisance.

The *between* variable has a negative sign for the target area of 1000 meters, and a positive sign for the target area of 2000 and 3000 meters. Only for the 2000 and 3000 meters target area, the *between* variable is significant. Based on these inconsistencies, it seems that the *between* variable is sensitive to definition of treatment and control area, and that large differentiations occur when only a smaller part of the dataset is selected.

The *after* variable shows significant positive external effects of redevelopment activities for both the 1000 meter and 2000 meter target area. For the 1000 meter target area, house prices increased with +1% as compared to the control group, while for the 2000 meters area, house prices increased with +2,1% as compared to the control group. When the target area is increased further to 3000 meters in model 3, both the sign and significance level of the *after* variable does not change, indicating that results hold despite differentiations in target and control area.

4.2. Investigating the reach of the external effect

From the results of the initial target and control cannot be derived whether the external effect decreases with distance. Furthermore, differentiation among the before, between and after variables related to distance are imaginable, for instance when construction nuisance during redevelopment can be a more local phenomenon relative to the external effects before and after redevelopment. In Table 8, the results of two separate ring variables for a target area of 1000 meters and a target area of 1000 to 2000 and 2000 to 3000 meters are reported. Again, for the 3000 meters target area this is done only for the four biggest cities with a population

Table 8: *Results of investigating the reach of the external effect*

	Model 4	**Model 5**[1]
Observations	50,197	37,259
Adj. R-squared	0.9047	0.9018
Sample size	0-4000 m.	0-6000 m.
Target area	0-2000 m.	0-3000 m.
Control area	1000-2000 m.	3000-6000 m.
Before (0-1000 m.)	-0.0407679***	-0.0687849***
	(0.0073168)	(0.0100977)
Before (1000-2000 m.)	-0.0142604***	-0.0448293***
	(0.0049383)	(0.0072715)
Before (2000-3000 m.)		-0.0244711***
		(0.0054601)
Between (0-1000 m.)	0.0059438	0.0281503***
	(0.0055856)	(0.0075627)
Between (1000-2000 m.)	0.00050028	0.0342402***
	(0.0039696)	(0.0055111)
Between (2000-3000 m.)		0.0289204***
		(0.0049418)
After (0-1000 m.)	0.0242502***	0.0335827***
	(0.0057327)	(0.0078029)
After (1000-2000 m.)	0.0134856***	0.022458***
	(0.0042725)	(0.0060339)
After (2000-3000 m.)		0.0038087
		(0.0055497)
Transaction year dummies	✓	✓
Structural characteristics	✓	✓
Building period dummies	✓	✓
Neighborhood dummies	✓	✓

Notes: significance levels: * p<0.10, ** p<0.05, *** p<0.01. ✓: variable included. Dependent variable is a natural log (ln) of the transaction price. Results of the control variables can be found in appendix D. Robust standard errors are reported between parentheses.

[1]: Results of model 5 are only for the four biggest cities with a population of over 100,000.

size of over 100,000. Narrower distance rings would have given more insight, however due to a too low number of observations for distance rings of less than 1000 meters, the use of narrower distance rings was not possible.

The results make it clearly visible that the external effect interacts with the linear distance from the redeveloped station. The *before* variable indicates that for the first 1000 meters around redeveloped railway station, houses sold for -4% less, while for the next ring of 1000 to 2000 meters houses sold for -1,4% less. The between variables show no significant results for both the target areas of 1000 and 1000 to 2000 meters, and the values of both coefficients are very small. During construction, the external effects seem to be negligible for both target areas. After redevelopment, the same pattern as before redevelopment occurs. In the target area of the first 1000 meters around a redeveloped station, houses sold for +2,4% more, and in the target area of 1000 to 2000 meters houses sold for +1,3% more, making a pattern visible in which the external effect decreases with distance. The results of model 5 show that the same pattern occurs for only the four biggest cities, indicating that results are robust.

4.3. Sensitivity analysis

Since the outcome of the analysis depends heavily on the selection of cases done beforehand, further investigation is needed to confirm if the results are influenced by differences between the selected projects. As already mentioned in paragraph 3.1, the selected projects are located both in towns and cities, and projects differ in type, size and scale. Also, from the regression results for the initial target and control area, it can be seen that results seem to be different for large cities as opposed to the full dataset including all cases. Therefore, by conducting a Chow (1960) test, it is aimed to investigate whether there are significant differences in the coefficients for different types of redevelopment and different types of location. The null hypothesis fur a Chow (1960) test is that there are no differences in slopes and intercepts of the restricted and unrestricted models. Operationally, the test is performed by running the regression analysis again, but this time including a dummy variable capturing the groups to be compared, after which an F-test is run to see whether the coefficients significantly differ from each other.

In column one and two of Table 9, the results of the regression analysis for both the group of underground stations and those above earth surface can be found, in order to compare this result with the pooled, restricted model 4 in Table 8. Compared to the pooled model, for the cases in which a station went from above earth surface to an underground location, the external effect plays out as an anticipation effect. The negative external effects before redevelopment are present for both distance rings, but is smaller than in the pooled model. Also, anticipation effects were stronger, resulting in +4,3% price increase during redevelopment. The result after redevelopment diminishes and is not significant. Chow's (1960) F-test returns 6.7 and is significant at the 1% level, meaning the null hypothesis of no differences in slopes and intercepts between the restricted and unrestricted models can be rejected. This indicates that the group of underground stations show significant different external effects. Since the stations that were brought underground overlap with the local stations as opposed to intercity stations, it is not possible to separately investigate whether around these larger stations, with a higher service level i.e. more long-distance trains from city to city, different external effects arise. Due to the interaction, in this research it is impossible to separate the effect as it is unknown to which of both features the effect can be attached.

Table 9: *Results of the sensitivity analyses*

	Model 6 (Underground stations)	**Model 7** (Excl. underground stations = Intercity Stations)	**Model 8** (Cities > 100,000 residents)	**Model 9** Excl. cities > 100,000 residents)
Observations	13,020	37,088	36,010	14,089
Adj. R-squared	0.9151	0.9022	0.9025	0.9152
Sample size	0-4000 m.	0-4000 m.	0-4000 m.	0-4000 m.
Target area	0-2000 m.	0-2000 m.	0-2000 m.	0-2000 m.
Control area	1000-2000 m.	1000-2000 m.	1000-2000 m.	1000-2000 m.
Before (0-1000 m.)	-0.0342551**	-0.0509351***	-0.0499691***	-0.0443927***
	(0.0146675)	(0.0087363)	(0.0088127)	(0.0142642)
Before (1000-2000 m.)	0.0087494	-0.026363***	-0.0262797***	0.0021675
	(0.0124089)	(0.0055026)	(0.0055265)	(0.0120407)
Between (0-1000 m.)	0.043354***	0.0138311**	0.0154273**	0.0456683***
	(0.0104253)	(0.0070873)	(0.0071081)	(0.0104939)
Between (1000-2000 m.)	0.0165618*	0.0191861***	0.0206488***	0.0185903**
	(0.0089669)	(0.0048736)	(0.0048802)	(0.0089603)
After (0-1000 m.)	0.0124448	0.032026***	0.0322927***	0.0157145
	(0.0099767)	(0.0071057)	(0.0071339)	(0.0100151)
After (1000-2000 m.)	-0.0074575	0.0207714***	0.0209564***	-0.006921
	(0.0086006)	(0.0051135)	(0.0051388)	(0.0085705)
Transaction year dummies	✓	✓	✓	✓
Structural characteristics	✓	✓	✓	✓
Building period dummies	✓	✓	✓	✓
Neighborhood dummies	✓	✓	✓	✓

Notes: significance levels: * p<0.10, ** p<0.05, *** p<0.01. ✓: variable included. Dependent variable is a natural log (ln) of the transaction price. Results of the control variables can be found in appendix D. Robust standard errors are reported between parentheses.

For differences in location typologies, the most pronounced difference is between the largest cities *Den Bosch, Amersfoort*, *Leiden* and *Apeldoorn* with over 100,000 residents, and the other cases. Model 8 and 9 in Table 9 respectively present the regression results of the four cities versus the other cases located in smaller cities or towns. Differences between the two groups are interesting. The *before* variables for the four cities shows for both distance rings a significant coefficient of respectively -4,9% and -2,6% for distance rings of 0 to 1000 and 1000 to 2000 meters. The *between* variable captures anticipation effects, with a value of respectively +1,5% and +2,0% for the distance rings of 0 to 1000 and 1000 to 2000 meters. Significant external effects *after* redevelopment also occur, with a value of respectively +3,2% and +2,0% for the distance rings of 0 to 1000 and 1000 to 2000 meters. The coefficients are all significant and are larger than the coefficients found in the pooled model 4. Chow's (1960) F-test returns 6.7, and is significant at the 1% level. The null hypothesis of no differences in slopes and intercepts between the restricted and unrestricted models can therefore be rejected, meaning that the results of the pooled model seem to be driven by the four cities. Since the cities with over 100,000 residents for 80% overlap with the intercity stations, these results are straightforward and do indicate that larger cities with intercity stations experience stronger external effects before, during and after redevelopment of the station than other stations.

5. Conclusion

Redevelopment of railway stations is a worldwide phenomenon, driven by a variety of reasons. Since the most prominent function of a railway station is to contribute to the accessibility of an area, earlier research into external effects of railway stations was mostly limited to the effect of accessibility improvements, and other purposes of redeveloping railway stations have not yet been investigated. In this paper, the external effects of redevelopment of railway stations on house prices are investigated for cases focused on renovation and replacement of aged and deteriorated station buildings and their direct surroundings, rather than accessibility improvements. Based on earlier research, the hypothesis underlying the research is that redevelopment of railway stations creates positive external effects. To test this hypothesis, a hedonic pricing model operationalized as a difference-in-difference analysis was employed. Following the analysis, several conclusions and recommendations for further research are drawn in the next paragraphs.

5.1. Conclusions

First, negative external effects before redevelopment are present throughout all specified models, indicating that before redevelopment the railway stations were a disamenity for their surroundings. For external effects during and after redevelopment, differences occur between the largest cities and smaller cities in the dataset. The analysis points out that the results are driven by the largest cities with over 100,000 residents which largely overlaps with the presence of an intercity station. During redevelopment, in the four largest cities the anticipation effect is stronger when moving farther away from the station, which might be explained by construction nuisance. Smaller cities with correspondingly non-intercity stations experience a stronger anticipation effect during redevelopment, which is only present close to the station. Farther away, the effect can only be recognized at a lower significance level. After redevelopment, only for the four largest cities significant external effects are found, reaching up to and including 2000 meters.

Second, compared to research on the external effects of either accessibility improvements or revitalization of urban areas and neighborhoods, the results indicate a relatively modest external effect of redevelopment of railway stations on house prices. For instance, from the overview given in the paper of Hess and Almeida (2007) and the findings of the meta-analysis Debrezion et al. (2007) follows that studies focused on the external effects of accessibility improvements report stronger external effects on house prices. Schwartz et al. (2006), Van der Krabben and Needham (2008), Koster and van Ommeren (2013) and Van Duijn et al. (2016) all found stronger external effects of redevelopment and revitalization of sites and neighborhoods, although the reach of these external effects differs.

Third, the outcomes of this research are relevant from both a societal and scientific viewpoint. Scientific relevance lies in the notion that although there is a large body of research on the effect of accessibility improvements, this research is one of the first to separate the external effects of accessibility from the external effects of other redevelopment goals. Since results confirm the hypothesis of positive external effects after redevelopment, new insights and input are provided for cost-benefit analyses into public spending on railway station redevelopment projects.

5.2. Recommendations

Given the results, several improvements and recommendations for further analysis remain. First and foremost, the analysis in this paper relied heavily on the selection of cases beforehand. While the results clearly indicate differences between large cities with a population of over 100,000 and an intercity stations, it cannot be ruled out that a different selection of cases could lead to different results. A follow-up study with a larger selection of cases seems worthwhile to reexamine the patterns found in this research. Second, despite the selection was aimed at redevelopments mainly focused on replacing disamenities in the form of old buildings and deteriorated and obsolete buildings, changes related to accessibility cannot be ruled out. Especially since for the selection of cases only information from public sources was available. For example, timetable and accessibility optimization could be carried out simultaneously with redevelopment without being publicly communicated. It is highly recommended to tackle this problem in further studies by conducting interviews and using first-hand information about the nature of redevelopments. Third, the underlying assumption of the difference-in-difference analysis is that both the treatment and control areas are identical, which is needed to produce consistent estimates. Despite controlling for neighborhood and time fixed effects, it remains a possibility that certain characteristics of a neighborhood are not captured by the data, which might have influenced results. Further research efforts are recommended to include demographic and environmental data to control for differences in target and control areas.

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Appendix A

Amersfoort

The railway station of Amersfoort was redeveloped from 1995 to 1997. Since the former station, built in 1901, had become too small for the number of travelers in 1995, it was demolished. The new station was built on the same location, together with 19000 square meters of new offices, and retail space. Also, a new platform and two rail tracks were added. Construction costs of the building are estimated at 31 million guilders, approximately 14,1 million euro.

Sources:

P. van Meurs, Vanstiphout, W. (2009), *De Collectie bijzondere stationsgebouwen in Nederland*. Rotterdam: Nai Uitgevers.

http://www.stationsweb.nl/station.asp?station=amersfoort

https://www.cobouw.nl/bouwbreed/nieuws/1994/7/amersfoort-eens-over-aanpak-stationsplein-101107613

http://www.digibron.nl/search/detail/012de6679aaeb540f8ad02a7/station-amersfoort-telt-laatste-uren

http://www.delpher.nl/nl/kranten/view?coll=ddd&query=%28station+amersfoort%29&cql%5B%5D=%28date+_gte_+%2201-01-1990%22%29&cql%5B%5D=%28date+_lte_+%2231-12-1995%22%29&page=1&facets%5Btype%5D%5B%5D=artikel&identifier=ddd%3A010628672%3Ampeg21%3Aa0158&resultsidentifier=ddd%3A010628672%3Ampeg21%3Aa0040

Apeldoorn

In Apeldoorn, redevelopment took place from 2005 to 2007. Built in 1876, the station was changed and renovated several times. During the redevelopment starting in 2005, the building was partially renovated to its original architecture, and a new cycling tunnel was constructed connecting the neighborhoods north and south of the station. In front of the station, a new city square was developed, with newly constructed residential buildings on the northern side. Also, the bus station was renewed and a new cycle shed was built. Construction costs are not publicly available, however the local government spent at least 30 million guilders (13,6 million euro) for redevelopment of the bus station and square.

Sources:

http://www.stationsinfo.nl/Apeldoorn.htm

http://www.stationsweb.nl/station.asp?station=apeldoorn

https://www.architectuur.nl/nieuws/station-apeldoorn-in-oude-staat-hersteld/
http://www.rd.nl/vandaag/binnenland/nieuw-station-apeldoorn-zet-trend-1.1250069
https://www.cobouw.nl/bouwbreed/nieuws/2008/1/oud-en-ultramodern-in-station-apeldoorn-101202597

Leiden

From 1993 to 1996 the former station of Leiden, built in 1953 was demolished and a new station was built on the same location. A new pedestrian tunnel was constructed to reach all the platforms including retail space. The building itself has prominent architecture, and on both sides of the station, new squares were developed. The busy road between the station and the old city center was brought underground into a tunnel, connecting the station directly to the old city on street level. Also, two new rail tracks and a new platform were added. Total construction costs amounted to 60 million guilders, which is approximately 27,2 million euro.

Sources:
P. van Meurs, Vanstiphout, W. (2009), *De Collectie bijzondere stationsgebouwen in Nederland*. Rotterdam: Nai Uitgevers.
http://www.stationsweb.nl/station.asp?station=leiden
http://leiden.courant.nu/issue/LD/1993-10-28/edition/0/page/25?query=Station%20leiden&sort=relevance&f_issuedate%5B0%5D=1900-01-01T00:00:00Z--%2B100YEARS&f_issuedate%5B1%5D=1990-01-01T00:00:00Z--%2B10YEARS
http://leiden.courant.nu/issue/LD/1993-08-20/edition/0/page/13?query=stationsgebouw%20gesloopt&sort=relevance&f_issuedate%5B0%5D=1900-01-01T00:00:00Z--%2B100YEARS&f_issuedate%5B1%5D=1990-01-01T00:00:00Z--%2B10YEARS

https://www.nrc.nl/nieuws/1996/05/04/na-vijf-jaar-verbouwen-is-leiden-centraal-af-7308902-a774015

Den Bosch

Redeveloped between 1995 and 1998, the new station building of Den Bosch replaced the former building constructed in 1953. The new station building comprises both retail and office functions, and a new passageway was constructed to reach the platforms. Below the new square in front of the station and the station itself, a new car parking garage and bicycle parking facility was built. Total construction cost for the station building itself are 62 million guilders (28,1 million euro) and 40 million guilders (18,2 million euro) for the square, parking garage and public spaces.

Sources:
http://leiden.courant.nu/issue/LD/1995-07-05/edition/0/page/3
http://www.stationsweb.nl/station.asp?station=shertogenbosch
https://www.cobouw.nl/bouwbreed/nieuws/1993/9/voor-f-100-mln-werk-rond-ns-station-in-den-bosch-101106643

Hilversum

Between 1990 and 1992, the station of Hilversum was demolished and a new station was built on the same location. The capacity of the former station, constructed in 1873, did not suit the amount of travelers in 1990. In front of the station, a new square and bus station were developed. In addition to the station function, also 8000 square meter of offices were added to the station building, together with a restaurant and bicycle store. The busstation was moved from the side to the station to the front. Total construction costs were estimated at 8 million guilders (3,6 million euro)

Sources:
http://www.stationsinfo.nl/Hilversum1874.htm
http://www.stationsweb.nl/station.asp?station=hilversum
http://www.albertusperk.nl/eigenperk-artikelen/2008.3%20sloop%20station%20Hilversum.pdf

Barendrecht

Redevelopment of the station of Barendrecht was initiated by the construction of both the Hogesnelheidslijn Zuid (HSL) and the Betuwelijn, respectively a highspeed railway and a freight railway. Both railway lines were planned to cross the village of Barendrecht, which led to protests of the local government, eventually resulting in plan to bundle the railways in a landtunnel of 1,5 kilometers length. Constructed from 1999 to 2001, the new station is part of the landtunnel, and replaces the former station built in 1973. On top of the landtunnel, a park was installed, together with parking spots for commuting travelers. Exact construction costs for the station only are not available, however construction costs for the complete landtunnel were approximately 100 million euro.

Sources:
https://movares.nl/project/station-barendrecht/
http://www.verkeerskunde.nl/daktuinlandschap-boven-station-barendrecht.10214.lynkx
http://www.hegeman.com/project/station-barendrecht/
http://educatief.historischbarendrecht.nl/spoorlijnen/articles/de-kap-van-barendrecht.html

Best

In Best, the new station constructed between 1998 and 2002 replaced the former station built in 1977. Because of doubling the railway line from two to four tracks, the local government in cooperation with the Dutch government decided to build an underground station in the tunnel crossing the town of Best. On top of the tunnel, a park, square and parking lot were installed. Total construction costs of the tunnel, including the station lie between 300 and 346 million guilders, which is between 136 and 175 million euro.

Sources:

http://www.stationsweb.nl/station.asp?station=best&vraag=best

http://www.brabantscentrum.nl/oud_archief_2002/archief0202/nieuws/0239_ns.htm

https://www.cobouw.nl/bouwbreed/nieuws/2001/11/de-tunnel-die-eigenlijk-geen-tunnel-is-101160665

http://www.omroepbrabant.nl/?news/11488872/Minister+opent+nieuwe+tunnel+in+Best.aspx

Rijswijk

In 1992, construction work on the new station of Rijswijk started, and the new station was opened in 1996. The new station replaced the former station built in 1965 and was brought underground due to expansion of the railway line from two to four tracks. A new park was placed on top of the tunnel, together with a square at the station entrance. Total construction costs of the tunnel including the station were approximately 165 million guilders (75 million euro).

Sources:

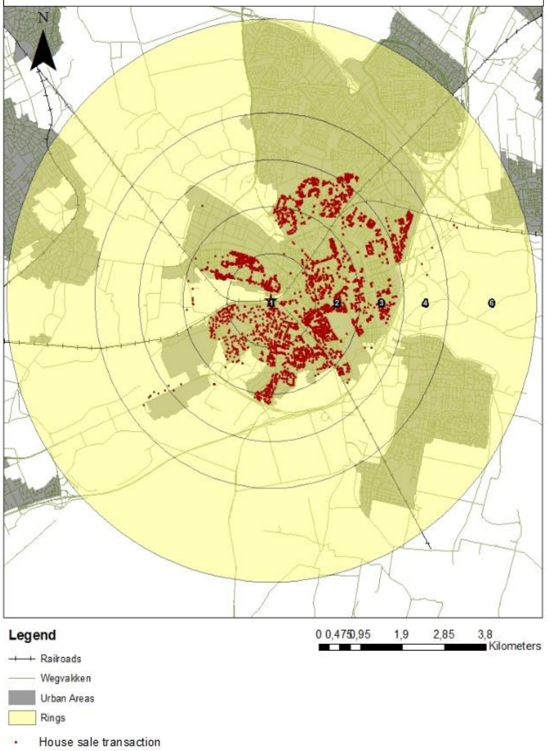
http://www.stationsweb.nl/station.asp?station=rijswijk

https://nl.wikipedia.org/wiki/Spoortunnel_Rijswijk

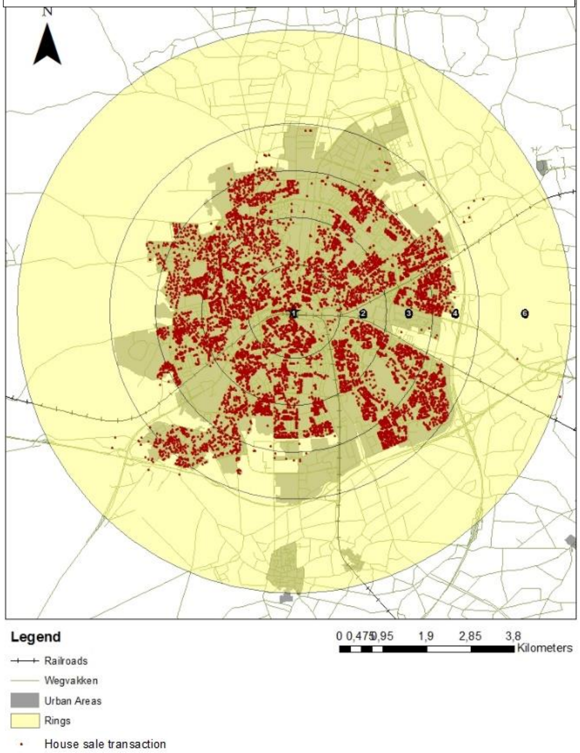
http://www.delpher.nl/nl/kranten/view?cql%5B%5D=%28date+_gte_+%2201-01-1990%22%29&cql%5B%5D=%28date+_lte_+%2231-12-1993%22%29&facets%5Btype%5D%5B%5D=artikel&query=%28station+rijswijk%29&coll=ddd&identifier=KBNRC01%3A000029531%3Ampeg21%3Aa0037&resultsidentifier=KBNRC01%3A000029531%3Ampeg21%3Aa0037

Appendix B

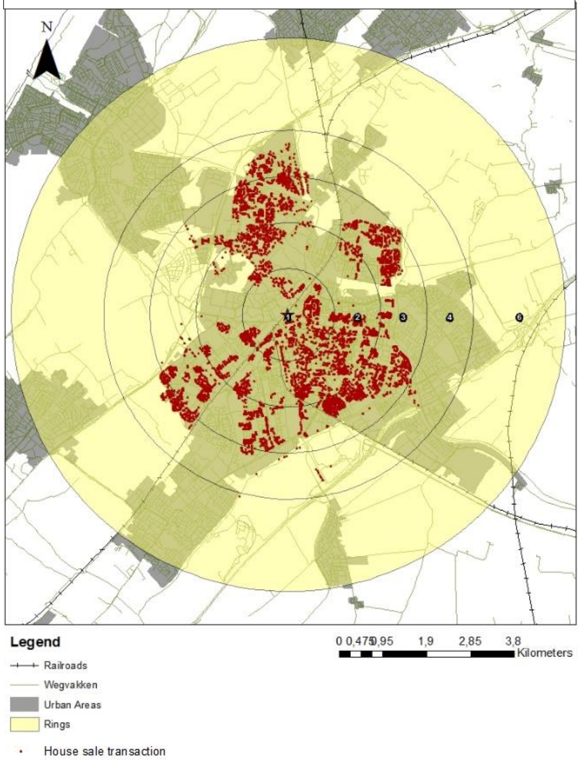
AMERSFOORT



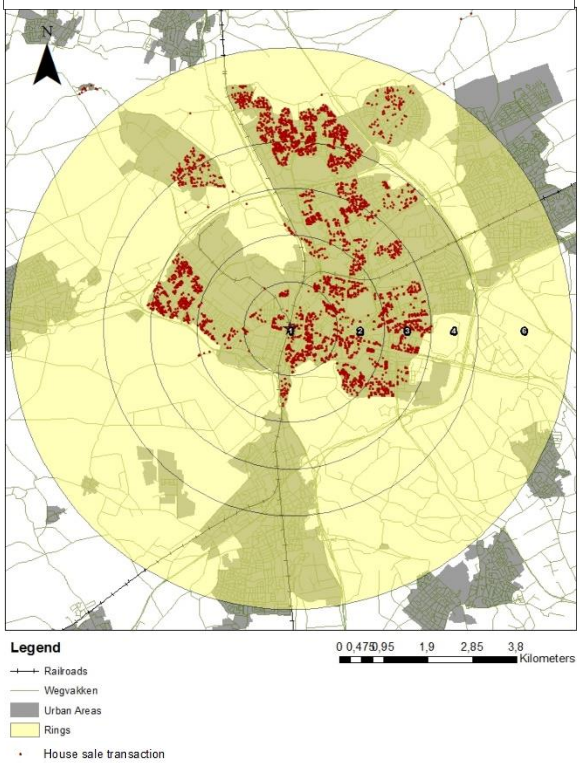
APELDOORN



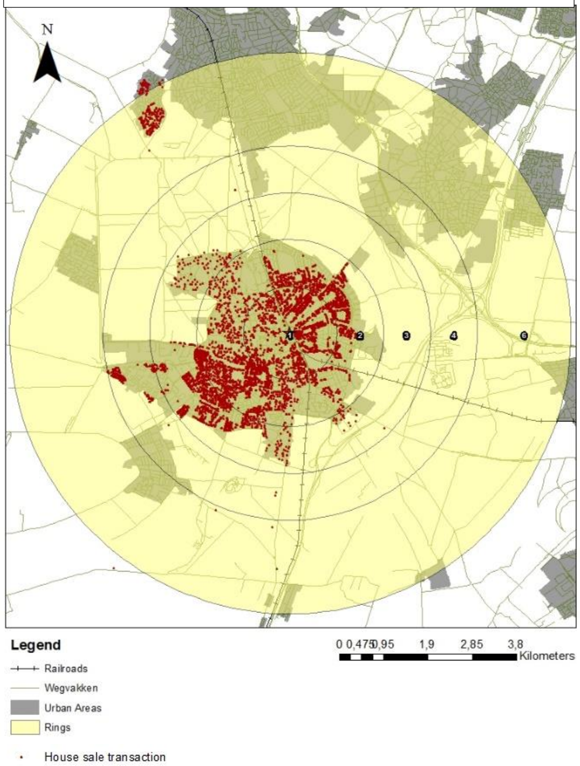
LEIDEN



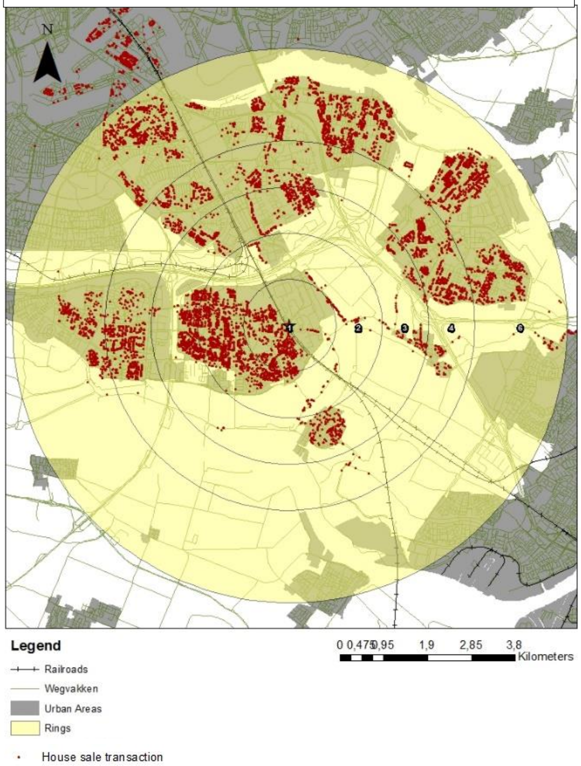
DEN BOSCH



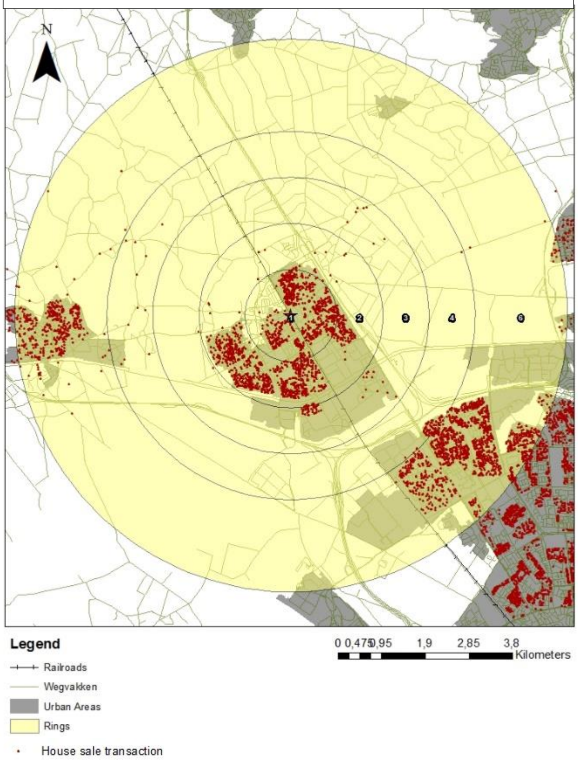
HILVERSUM



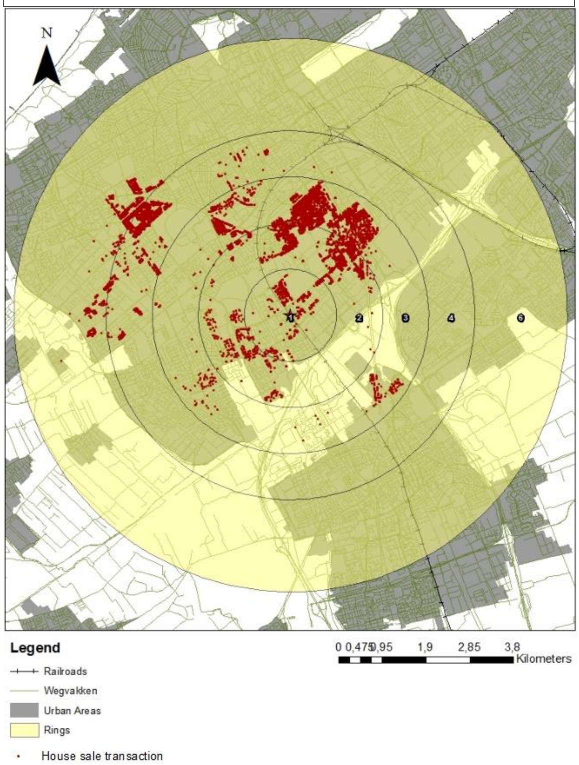
BARENDRECHT



BEST



RIJSWIJK

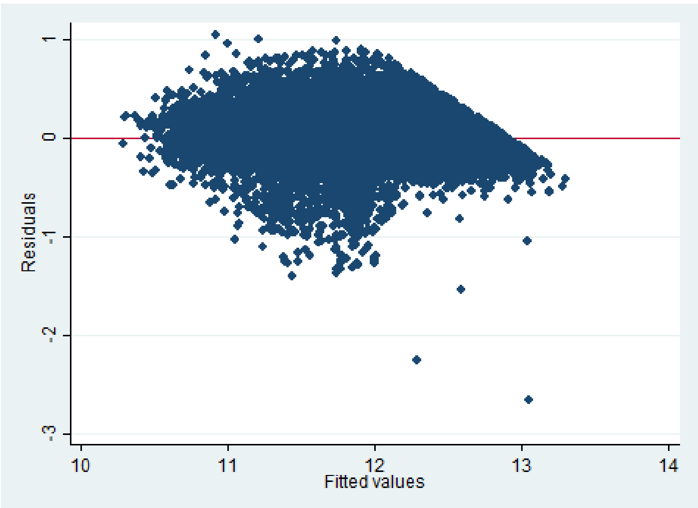


Appendix C

The assumptions for linear regression are the following:

1	Linearity	Average value of residuals is zero
2	Homoscedasticity	Residuals show constant variance
3	Autocorrelation	Covariance between errors is zero
4	Independence	Regressors are not correlated with error term
5	Normality	Residuals are normally distributed

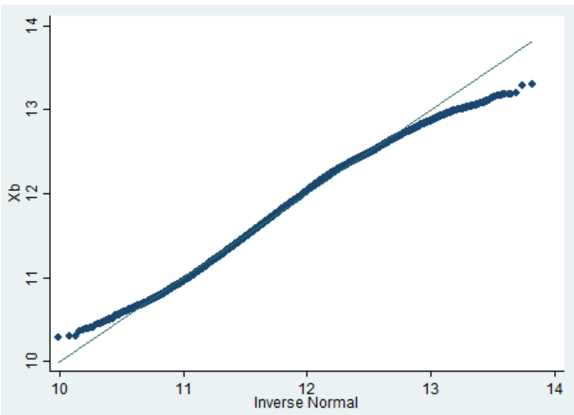
1) The average value of the residuals has to be zero, in order to fulfill the assumption of linearity, i.e. the relationship between the dependent and independent variable is linear. Since a constant term is included in the regression, this assumption is not violated (Brooks and Tsolacos, 2010).
2) Homoscedasticity relates to the variance of the residuals. If these have constant variance, no pattern should be visible when the residuals are plotted against the fitted values. However, since it is not likely that in case of heteroskedasticity the cause is known, it is also needed to perform a statistical test to be sure if the assumption is met (Brooks and Tsolacos, 2010). This is the Breusch-Pagan / Cook-Weisberg and White's test for heteroskedasticity. The results indicate both a pattern in the residuals versus fitted plot and for both tests significant P-values indicating heteroskedasticity. This is corrected for by the use of robust standard errors, which are typically larger than normal standard errors.

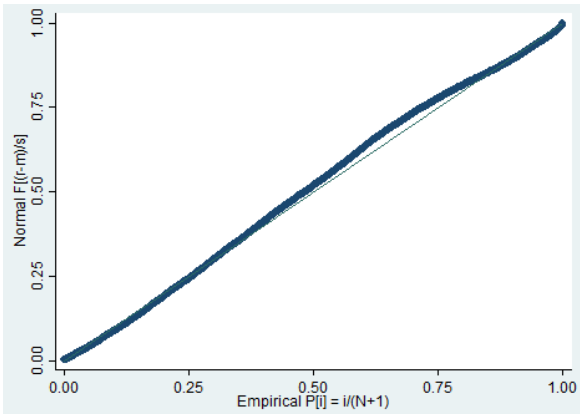


Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of lnprice
chi2(1) = 1018.16
Prob > chi2 = 0.0000

White's test for Ho: homoskedasticity		
	against Ha:	unrestricted heteroskedasticity
	chi2(960)	= 4848.59
	Prob > chi2	= 0.0000

3) The assumption that the covariance between errors is zero is difficult to test. However, it is known that real estate data often is smoothed and exhibits trends (Brooks and Tsolacos, 2010). For spatial autocorrelation is corrected by using neighborhood fixed effects, and time fixed effects are included to control for correlation over time.
4) Correlation of regressors with the error term would lead to an endogeneity issue. Endogeneity does not seem to occur, since no there were no multi-collinearity issues with the used variables.
5) Normality of the residuals is visually examined by a Q-Q-plot and P-P-plot.





A slight deviation of normality can be observed, but it does not seems large. A Shapiro-Wilk test for normality indicates however that the distribution of the residuals significantly deviates from a normal distribution.

Shapiro-Wilk test for normal data				
Variable	Obs W	V	z	Prob>z
r	24,163 0.99294	73.695	11.759	0.00000

Based on the OLS assumption tests, it should be noted that the estimators may not be BLUE, i.e. not the Best Linear Unbiased Estimators.

Appendix D

Table 7 continued

Variables	**Model 1**	**Model 2**	**Model 3**
ln(floorspace in m²)	0.5978467*** (0.008046)	0.60917*** (0.0054631)	0.6083465*** (0.0068913)
Terraced house (ref: Apartment)	0.0798572*** (0.0046872)	0.1076014*** (0.0032597)	0.0893418*** (0.0037889)
Semi detached house	0.226473*** (0.0063312)	0.2610449*** (0.004606)	0.2443101*** (0.0052507)
Corner house	0.1252859*** (0.0052865)	0.1482973*** (0.0036406)	0.1302166*** (0.0042241)
Detached house	0.3688119*** (0.0085023)	0.4114954*** (0.0061809)	0.3967612*** (0.0068404)
Rooms (#)	0.0179936*** (0.0023873)	0.015668*** (0.0013878)	0.0174527*** (0.0019179)
Bathroom	0.0456462*** (0.0041415)	0.0409679*** (0.0028324)	0.0412068*** (0.0035393)
Balcony	0.028472*** (0.0027379)	0.0229256*** (0.001947)	0.0283204*** (0.0022379)
Garages	0.0787363*** (0.0035925)	0.0881781*** (0.0025278)	0.0843371*** (0.0028717)
Maintenance inside (1=good)	-0.090953*** (0.0043217)	-0.0822364*** (0.0028952)	-0.075189*** (0.0032512)
Maintenance outside (1=good)	-0.0742087*** (0.0049636)	-0.0685178*** (0.0035649)	-0.0636495*** (0.0039854)
Garden (1=yes)	0.0017157 (0.0032207)	0.0024081 (0.0021608)	0.0017864 (0.0024857)
Terrace (1=yes)	0.0214684*** (0.0050528)	0.020493*** (0.0036735)	0.0139515*** (0.0041739)
Central heating (1=yes)	-0.0008415 (0.006802)	0.0103859** (0.0049786)	0.0191492*** (0.0067088)
Official monument status (1=yes)	0.1042006*** (0.012783)	0.102878*** (0.0122422)	0.1024823** (0.0124225)
ln(distance to nearest intercity station)	0.0140432*** (0.0052915)	0.0134549*** (0.0047023)	0.0179049*** (0.0048543)

ln(distance to nearest highway ramp)	0.006096 (0.0071396)	0.0075652 (0.0046717)	0.0071867 (0.0055327)
Within 100 meters of railway (1=yes)	-0.0508867*** (0.005835)	-0.0483213*** (0.004666)	-0.0520508*** (0.0051063)
Building period 1906-1930 (ref: 1500-1905)	-0.0341042*** (0.0067583)	-0.0280995*** (0.0064035)	-0.0360856*** (0.0069623)
Building period 1931-1944	-0.0014811 (0.0070628)	0.0069875 (0.006531)	0.0113919 (0.0071417)
Building period 1945-1959	-0.0792378*** (0.0086199)	-0.0623157*** (0.007177)	-0.0699586*** (0.0080823)
Building period 1960-1970	-0.1104375*** (0.0079986)	-0.0814384*** (0.0068846)	-0.1036655*** (0.0077104)
Building period 1971-1980	-0.0323152*** (0.0078221)	-0.0060232 (0.0068516)	-0.0024005 (0.0074649)
Building period 1981-1990	0.0298151*** (0.0070778)	0.0638997*** (0.0065454)	0.0574714*** (0.0070783)
Building period 1991-2000	0.1644017*** (0.0080459)	0.1909345*** (0.0071131)	0.1645307*** (0.0076072)
Building period >2000	0.2286057*** (0.0119847)	0.2581475*** (0.0089189)	0.232848*** (0.0102485)
Transaction year 1987 (ref: 1986)	0.8376381*** (0.0484668)	0.8291288*** (0.1379522)	
Transaction year 1988	0.361771*** (0.079373)	0.3499661*** (0.0794852)	
Transaction year 1989	0.2944579*** (0.0496201)	0.381619*** (0.0945848)	
Transaction year 1990	0.4010749*** (0.0866821)	0.4141779*** (0.0938544)	
Transaction year 1991	0.4654774*** (0.0443239)	0.467288*** (0.0443963)	
Transaction year 1992	0.5574535*** (0.0437125)	0.5419743*** (0.0440846)	0.0766921*** (0.0096669)
Transaction year 1993	0.6861211*** (0.0434607)	0.6574068*** (0.0439989)	0.1787294*** (0.0093106)
Transaction year 1994	0.7756958*** (0.0432356)	0.7454304*** (0.0439338)	0.2646476*** (0.0091742)

Transaction year	0.8386339***	0.7979944***	0.2977033***
1995	(0.042909)	(0.0438386)	(0.0095827)
Transaction year	0.9347767***	0.8950043***	0.3994362***
1996	(0.0428978)	(0.0438463)	(0.0094497)
Transaction year	1.046583***	1.00183***	0.5096138***
1997	(0.0430668)	(0.043934)	(0.0094385)
Transaction year	1.132722***	1.086343***	0.6065157***
1998	(0.0430573)	(0.0439522)	(0.0095035)
Transaction year	1.274799***	1.21868***	0.7549003***
1999	(0.0431144)	(0.0440027)	(0.0098064)
Transaction year	1.393463***	1.34202***	0.8640998***
2000	(0.0431038)	(0.0439905)	(0.0097432)
Transaction year	1.485923***	1.435312***	0.9642443***
2001	(0.0431658)	(0.0440589)	(0.0102929)
Transaction year	1.517463***	1.474096***	0.8433605***
2002	(0.0432501)	(0.0441495)	(0.0478023)
Transaction year	1.543184***	1503412***	0.8701376***
2003	(0.0432943)	(0.0441786)	(0.0478073)
Transaction year	1.585403***	1549679***	0.9181963***
2004	(0.0434191)	(0.044224)	(0.0478422)
Transaction year	1.624309***	1576926***	0.9232259***
2005	(0.0432763)	(0.044217)	(0.0479707)
Transaction year	1.648455***	1600256***	0.9476011***
2006	(0.0433104)	(0.0442304)	(0.0479562)
Transaction year	1.674129***	1629867***	0.9822877***
2007	(0.04335)	(0.0442257)	(0.0480174)
Transaction year	1.653678***	1617187***	0.9832248***
2008	(0.0435717)	(0.044333)	(0.0480342)
Transaction year	1.603055***	1567923***	0.9268245***
2009	(0.0437078)	(0.0444191)	(0.0481529)
Transaction year	1.598044***	1559744***	0.9205828***
2010	(0.0436059)	(0.0443773)	(0.0480934)
Transaction year	1.583911***	1.54586***	0.908518***
2011	(0.0440023)	(0.0445815)	(0.0482302)
Transaction year	1.472459***	1.442898***	0.806636***
2012	(0.04411)	(0.0446244)	(0.0481007)
Constant	7.483357***	7.400669***	7.965052
	(0.0900088)	(0.0735958)	(0.0691048)

Notes: significance levels: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors are reported between parentheses.

Table 8 continued

Variables	**Model 4**	**Model 5**
ln(floorspace in m²)	0.6045291***	0.6084042***
	(0.0050447)	(0.0068579)
Terraced house (ref:	0.1084346***	0.0888703***
Apartment)	(0.0029888)	(0.0037841)
Semi detached house	0.2549079***	0.2442267***
	(0.0041498)	(0.0052518)
Corner house	0.1467486***	0.1299788***
	(0.0033238)	(0.0042228)
Detached house	0.4114997***	0.3961273***
	(0.0056713)	(0.0068403)
Rooms (#)	0.0152848***	0.0173668***
	(0.0012271)	(0.001898)
Bathroom	0.0373542***	0.0409437***
	(0.0026527)	(0.0035416)
Balcony	0.021813***	0.0283396***
	(0.0018143)	(0.0022392)
Garages	0.0885219***	0.0844068***
	(0.0022782)	(0.0028724)
Maintenance inside	-0.0830229***	-0.0755457***
(1=good)	(0.0027066)	(0.0032507)
Maintenance outside	-0.0662251***	-0.062916***
(1=good)	(0.0033302)	(0.0039806)
Garden (1=yes)	0.0000841	0.0018812
	(0.0019584)	(0.0024863)
Terrace (1=yes)	0.0181102***	0.0135749***
	(0.0033816)	(0.0041641)
Central heating	0.0133556***	0.0188958***
(1=yes)	(0.0044131)	(0.0067051)
Official monument	0.1022432***	0.1041201***
status (1=yes)	(0.0120905)	(0.0124623)
ln(distance to nearest	0.0139094***	0.0114137**
intercity station)	(0.0050349)	(0.0050355)
ln(distance to nearest	0.0053014	0.0076633
highway ramp)	(0.0041026)	(0.0055552)
Within 100 meters of	-0.0482292***	-0.0509486***
railway (1=yes)	(0.0046886)	(0.0050806)
Building period 1906-	-0.0260767***	-0,.0362652***
1930 (ref: 1500-1905)	(0.0062174)	(0.0069251)

Building period 1931-1944	0.0051042	0.0100371
	(0.0063332)	(0.0071336)
Building period 1945-1959	-0.0591972***	-0.0706973***
	(0.0068287)	(0.0080704)
Building period 1960-1970	-0.0789148***	-0.105046***
	(0.0065986)	(0.0077072)
Building period 1971-1980	-0.000606	-0.0034338
	(0.0065131)	(0.0074417)
Building period 1981-1990	0.0648858***	0.0566976***
	(0.0063002)	(0.0070598)
Building period 1991-2000	0.1967304***	0.1632646***
	(0.006718)	(0.0075815)
Building period >2000	0.2689607***	0.2350495***
	(0.008434)	(0.0102344)
Transaction year 1987 (ref: 1986)	0.8133134***	
	(0.1117964)	
Transaction year 1988	0.3505764***	
	(0.0843607)	
Transaction year 1989	0.3837522***	
	(0.0952495)	
Transaction year 1990	0.4218677***	
	(0.0851041)	
Transaction year 1991	0.4710458***	
	(0.0458957)	
Transaction year 1992	0.5430712***	0.070818***
	(0.0455875)	(0.0096622)
Transaction year 1993	0.6588635***	0.1704465***
	(0.0454917)	(0.0093891)
Transaction year 1994	0.7465947***	0.2582781***
	(0.0454273)	(0.0092647)
Transaction year 1995	0.8085085***	0.2979919***
	(0.0453599)	(0.0097381)
Transaction year 1996	0.9036208***	0.3994927***
	(0.0453646)	(0.0095975)
Transaction year 1997	1.010737***	0.513611***
	(0.0454473)	(0.0095983)
Transaction year 1998	1.09703***	0.6117537***
	(0.0454689)	(0.0096575)
Transaction year 1999	1.228954***	0.7608623***
	(0.0455132)	(0.0099509)

Transaction year 2000	1.352508***	0.8700457***
	(0.0455047)	(0.0098921)
Transaction year 2001	1.44575***	0.9717056***
	(0.0455499)	(0.0104399)
Transaction year 2002	1.49087***	0.847809***
	(0.0455681)	(0.0479351)
Transaction year 2003	1.519888***	0.875286***
	(0.0455943)	(0.0479538)
Transaction year 2004	1.56196***	0.9222464***
	(0.0456272)	(0.0479941)
Transaction year 2005	1.593924***	0.9243258***
	(0.0456491)	(0.0481845)
Transaction year 2006	1.620861***	0.9491037***
	(0.0456571)	(0.0481584)
Transaction year 2007	1.649007***	0.983551***
	(0.0456707)	(0.0482284)
Transaction year 2008	1.642894***	0.989959***
	(0.0457971)	(0.0482587)
Transaction year 2009	1.603092***	0.9332583***
	(0.0458362)	(0.0483994)
Transaction year 2010	1.592444***	0.9268623***
	(0.0458282)	(0.0483132)
Transaction year 2011	1.571778***	0.9148319***
	(0.0460786)	(0.0484486)
Transaction year 2012	1.468552***	0.8129086***
	(0.0461375)	(0.0483204)
Constant	7.394179***	8.009937
	(0.0722349)	(0.0697471)

Notes: significance levels: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors are reported between parentheses.

Table 9 continued

	Model 6	Model 7	Model 8	Model 9
ln(floorspace in m²)	0.6002718***	0.6059265***	0.6084616***	0.5938184***
	(0.0099806)	(0.0069347)	(0.007001)	(0.0097022)
Terraced house (ref:	0.1454867***	0.0919375***	0.0909202***	0.1449777***
Apartment)	(0.0067299)	(0.0037838)	(0.0038474)	(0.0063677)
Semi detached house	0.2809072***	0.2508013***	0.2507389***	0.2797375***
	(0.009592)	(0.0053034)	(0.0053927)	(0.0091553)
Corner house	0.1791614***	0.1343315***	0.1334516***	0.1791816***
	(0.0074375)	(0.004234)	(0.0042971)	(0.0070954)
Detached house	0.4405751***	0.3985793***	0.3988556***	0.4368928***
	(0.0144744)	(0.0069169)	(0.0070147)	(0.0137085)
Rooms (#)	0.0125274***	0.0181729***	0.0174417***	0.0151229***
	(0.0021308)	(0.0019285)	(0.0019386)	(0.0020178)
Bathroom	0.0382557***	0.0426473***	0.0415115***	0.0435306***
	(0.0053574)	(0.0034154)	(0.0035466)	(0.0049208)
Balcony	0.0074132*	0.0275383***	0.0281628***	0.0073353*
	(0.0043398)	(0.0022103)	(0.0022592)	(0.0039841)
Garages	0.0963373***	0.0877447***	0.0861461***	0.1007309***
	(0.0051531)	(0.002913)	(0.0029626)	(0.0049113)
Maintenance inside	-0.1015768***	-0.0756826***	-0.0760923***	-0.0973637***
(1=good)	(0.0066205)	(0.0031771)	(0.0032679)	(0.0059808)
Maintenance outside	-0.088557***	-0.0629947***	-0.0631836***	-0.0837569***
(1=good)	(0.0085015)	(0.0038856)	(0.0040151)	(0.0075306)
Garden (1=yes)	0.0033011	0.0032886	0.0028988	0.0052636
	(0.0041173)	(0.0025361)	(0.0025564)	(0.0040216)
Terrace (1=yes)	0.0382354***	0.0145865***	0.0144101***	0.0388494***
	(0.0074043)	(0.0042302)	(0.004228)	(0.007383)
Central heating (1=yes)	-0.0043039	0.0192258***	0.0182951***	-0.0011699
	(0.0076667)	(0.0065145)	(0.0067716)	(0.0073458)
Official monument	0.1505274**	0.1047808***	0.1032384***	0.1509522**
status (1=yes)	(0.0683908)	(0.0124841)	(0.0124807)	(0.0707949)
ln(distance to nearest	-0.0332275*	0.0129124***	0.0131781***	-0.018283
intercity station)	(0.0171917)	(0.0049429)	(0.0050298)	(0.0144549)
ln(distance to nearest	0.0199607**	0.0057562	0.0053182	0.0203903**
highway ramp)	(0.0089146)	(0.0055984)	(0.0056228)	(0.0087717)
Within 100 meters of	-0.017967	-0.0516512***	-0.0509676***	-0.0260981**
railway (1=yes)	(0.0125217)	(0.005005)	(0.0050652)	(0.0117626)

Building period 1906-1930 (ref: 1500-1905)	0.0094996 (0.0223148)	-0.035328*** (0.0066869)	-0.0364545*** (0.006924)	0.0025197 (0.0170327)
Building period 1931-1944	-0.0069951 (0.0217759)	0.0116528* (0.0069176)	0.009228 (0.0071387)	0.007306 (0.0170658)
Building period 1945-1959	-0.0709719*** (0.022238)	-0.0643965*** (0.0078181)	-0.0703835*** (0.0080754)	-0.0463656*** (0.0176533)
Building period 1960-1970	-0.0527112** (0.0218658)	-0.0987093*** (0.0075323)	-0.1033919*** (0.0077313)	-0.0351636** (0.0173669)
Building period 1971-1980	-0.0471302** (0.0223033)	0.0008609 (0.0073164)	-0.0049923 (0.0074887)	-0.0199417 (0.0178988)
Building period 1981-1990	0.0593006*** (0.0221189)	0.0628189*** (0.0069291)	0.0584972*** (0.00709)	0.082487*** (0.0176218)
Building period 1991-2000	0.2509026*** (0.0227946)	0.1732125*** (0.0075554)	0.1687263*** (0.0076939)	0.2690817*** (0.0187769)
Building period >2000	0.326823*** (0.0245945)	0.2448212*** (0.0100965)		0.346647*** (0.0210313)
Transaction year 1987 (ref: 1986)		0.8442231*** (0.1410982)		0.8495462*** (0.1268286)
Transaction year 1988		0.3616624*** (0.0828313)		0.3324813*** (0.0762621)
Transaction year 1989		0.39194*** (0.0954911)		0.3873604*** (0.0994683)
Transaction year 1990		0.3498974*** (0.0739774)		0.400764*** (0.0887125)
Transaction year 1991		0.4824602*** (0.0505347)		0.4283832*** (0.0504667)
Transaction year 1992	-0.4132574*** (0.021156)	0.5562797*** (0.050273)	0.0713304*** (0.0096601)	0.5198792*** (0.0560597)
Transaction year 1993	0.0595176 (0.0736254)	0.6686016*** (0.0502132)	0.1832876*** (0.0090781)	0.7206759*** (0.0565511)
Transaction year 1994	-0.2083127*** (0.0530088)	0.7582707*** (0.0501504)	0.2727015*** (0.0089015)	0.7683761*** (0.0443112)
Transaction year 1995	0.0122493 (0.0207035)	0.8021132*** (0.0500863)	0.3165964*** (0.0089394)	0.8252781*** (0.0396628)
Transaction year 1996	0.0676607*** (0.0196863)	0.9046635*** (0.0501003)	0.4170641*** (0.0087975)	0.9124742*** (0.0396738)
Transaction year 1997	0.1733275*** (0.0192799)	1.009326*** (0.0502098)	0.5235778*** (0.008737)	1.00514*** (0.0401857)
Transaction year 1998	0.2282207*** (0.0184914)	1.103118*** (0.0502313)	0.6176227*** (0.0087008)	1.059597*** (0.04038)

Transaction year 1999	0.3370991***	124995***	0.7645975***	1.167816***
	(0.0186888)	(0.0502895)	(0.0089729)	(0.0407036)
Transaction year 2000	0.4801048***	1.359766***	0.8743354***	1.31075***
	(0.0179084)	(0.0502752)	(0.008903)	(0.040718)
Transaction year 2001	0.5631787***	1.461695***	0.9761188***	1.394129***
	(0.0189281)	(0.0503861)	(0.0095054)	(0.0409074)
Transaction year 2002	0.6243733***	135071***	0.8573919***	1.455615***
	(0.0191742)	(0.0653302)	(0.0471003)	(0.04101)
Transaction year 2003	0.6695454***	1.378779***	0.8855589***	1.500696***
	(0.0194375)	(0.0653567)	(0.047109)	(0.0411784)
Transaction year 2004	0.7136257***	1.425293***	0.9320277***	1.544426***
	(0.019389)	(0.0654274)	(0.0471632)	(0.0412105)
Transaction year 2005	0.7448432***	1.445175***	0.9512329***	1.576232***
	(0.0194653)	(0.0654215)	(0.0471673)	(0.0411615)
Transaction year 2006	0.7672602***	1.469989***	0.9760517***	1.598273***
	(0.0192953)	(0.065401)	(0.0471336)	(0.0411153)
Transaction year 2007	0.7783124***	1.504571***	1.010585***	1.610959***
	(0.0195854)	(0.0654453)	(0.0472114)	(0.0410961)
Transaction year 2008	0.7695817***	1.494648***	1.001468***	1.600621***
	(0.0197261)	(0.0655213)	(0.0472255)	(0.0411075)
Transaction year 2009	0.739414***	1.437911***	0.9447851***	1.570421***
	(0.0202371)	(0.0656311)	(0.0473827)	(0.041389)
Transaction year 2010	0.733243***	1.431348***	0.9382715***	1.563649***
	(0.01995)	(0.0655508)	(0.0472803)	(0.0412489)
Transaction year 2011	0.6002718***	1.419543***	0.9265312***	
	(0.0099806)	(0.0656453)	(0.0474355)	
Transaction year 2012	0.1454867***	1.317628***	0.8247035***	
	(0.0067299)	(0.0655325)	(0.0472789)	
Constant	8.486746	7.50732	7.992598	7.530416
	(0.1753043)	(0.0849606)	(0.0710107)	(0.1568312)

Notes: significance levels: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors are reported between parentheses.

Appendix E

<u>Data preparation</u>

```
set matsize 11000
drop if dist_one>2000[1], 4000[2] or 6000[3]          >>> varies for every regression, see footnote
drop if price_tr<0
drop if housesize<10
drop if housesize>300
drop if lotsize>40510
drop if constrperiod==0
drop if price_tr>400000
drop if housetype_inclapp==1
drop if nrooms<=0
gen lnprice = ln(price_tr)
drop if lnprice<10
gen lnsize = ln(housesize)
gen lnd = ln(dist_one)
gen lnds = ln(d_ic)
gen lndh = ln(d_ramp)
gen tracknuis = 0
replace tracknuis = 1 if d_tracks>0
gen dsq = dist_one^2
gen bath = 0
replace bath = 1 if inlist(nbathr,1,2,3,4)
gen terracedh = 0
replace terracedh = 1 if inlist(housetype_inclapp,2,3)
gen semidetached = 0
replace semidetached = 1 if housetype_inclapp==5
gen cornerhouse = 0
replace cornerhouse = 1 if housetype_inclapp==4
gen detachedh = 0
replace detachedh = 1 if housetype_inclapp==6
gen apartment = 0
replace apartment = 1 if inlist(housetype_inclapp,7,8,9,10)
gen bperiod0 = 0
replace bperiod0 = 1 if constrperiod==1
gen bperiod1 = 0
replace bperiod1 = 1 if constrperiod==2
gen bperiod2 = 0
replace bperiod2 = 1 if constrperiod==3
gen bperiod3 = 0
replace bperiod3 = 1 if constrperiod==4
gen bperiod4 = 0
replace bperiod4 = 1 if constrperiod==5
gen bperiod5 = 0
replace bperiod5 = 1 if constrperiod==6
gen bperiod6 = 0
replace bperiod6 = 1 if constrperiod==7
gen bperiod7 = 0
replace bperiod7 = 1 if constrperiod==8
gen bperiod8 = 0
replace bperiod8 = 1 if constrperiod==9
gen parking = 0
replace parking =1 if inlist(parktype,2,3,4,6,8)
gen terrace = 0
replace terrace =1 if inlist(nterraces,1,2)
```

---

[1] 2000 meters for model 1,

[2] 4000 meters for model 2, 4 and 6 to 9.

[3] 6000 meters for model 3 and 5

```
gen maintins = 0
replace maintins =1 if inlist(maintin,1,2,3,4,5)
gen maintouts = 0
replace maintouts =1 if inlist(maintout,1,2,3,4,5)
gen garages = 0
replace garages =1 if inlist(garage,1,2,3,4,5)
gen heating = 0
replace heating =1 if inlist(heatingtype,1,2,3)
gen balcony = 0
replace balcony =1 if inlist(nbalconies,1,2,3)
gen garden = 0
replace garden =1 if inlist(garden_q,3,4)
```

Defining *before, between* and *after* variables for model 1 to 3

Variable dist_one, *indicating the linear distance from the station, is varied for the different initial distance rings: it takes 1000 for model 1, 2000 for model 2, and 3000 for model 3.*

```
*Amersfoort*
gen before = 0
replace before =1 if dist_one<1000
gen between = 0
replace between =1 if year_tr>=1995 &  year_tr<=1997 & dist_one<1000
gen after = 0
replace after = 1 if dist_one<1000 & year_tr>1997

*Apeldoorn*
gen before = 0
replace before =1 if dist_one<1000
gen between = 0
replace between =1 if year_tr>=2005 &  year_tr<=2007 & dist_one<1000
gen after = 0
replace after = 1 if dist_one<1000 & year_tr>2007
gen trend_after = 0

*Barendrecht*
gen before = 0
replace before =1 if dist_one<1000
gen between = 0
replace between =1 if year_tr>=1999 &  year_tr<=2001 & dist_one<1000
gen after = 0
replace after = 1 if dist_one<1000 & year_tr>2001

*Best*
gen before = 0
replace before =1 if dist_one<1000
gen between = 0
replace between =1 if year_tr>=1998 &  year_tr<=2002 & dist_one<1000
gen after = 0
replace after = 1 if dist_one<1000 & year_tr>2002

*Den Bosch*
gen before = 0
replace before =1 if dist_one<1000
gen between = 0
replace between =1 if year_tr>=1995 &  year_tr<=1998 & dist_one<1000
gen after = 0
replace after = 1 if dist_one<1000 & year_tr>1998

*Hilversum*
```

```
gen before = 0
replace before =1 if dist_one<1000
gen between = 0
replace between =1 if year_tr>=1990 &  year_tr<=1992 & dist_one<1000
gen after = 0
replace after = 1 if dist_one<1000 & year_tr>1992

*Leiden*
gen before = 0
replace before =1 if dist_one<1000
gen between = 0
replace between =1 if year_tr>=1993 &  year_tr<=1996 & dist_one<1000
gen after = 0
replace after = 1 if dist_one<1000 & year_tr>1996

*Rijswijk*
gen before = 0
replace before =1 if dist_one<1000
gen between = 0
replace between =1 if year_tr>=1992 &  year_tr<=1996 & dist_one<1000
gen after = 0
replace after = 1 if dist_one<1000 & year_tr>1996
```

Defining *before, between* and *after* variables for model 4 to 9

Variable before 3 is only used for model 5. After defining the variables, the function 'append' is used to join the datasets of the different cases together.

```
*Amersfoort*
gen before1 = 0
replace before1 =1 if dist_one<1000
gen between1 = 0
replace between1 =1 if year_tr>=1995 &  year_tr<=1997 & dist_one<1000
gen after1 = 0
replace after1 = 1 if year_tr>1997 & dist_one<1000

gen before2 = 0
replace before2 =1 if dist_one>1000 & dist_one<2000
gen between2 = 0
replace between2 =1 if year_tr>=1995 &  year_tr<=1997 & dist_one>1000 & dist_one<2000
gen after2 = 0
replace after2 = 1 if year_tr>1997 & dist_one>1000 & dist_one<2000

gen before3 = 0
replace before3 =1 if dist_one>2000 & dist_one<3000
gen between3 = 0
replace between3 =1 if year_tr>=1995 &  year_tr<=1997 & dist_one>2000 & dist_one<3000
gen after3 = 0
replace after3 = 1 if year_tr>1997 & dist_one>2000 & dist_one<3000

*Apeldoorn*
gen before1 = 0
replace before1 =1 if dist_one<1000
gen between1 = 0
replace between1 =1 if year_tr>=2005 &  year_tr<=2007 & dist_one<1000
gen after1 = 0
replace after1 = 1 if year_tr>2007 & dist_one<1000

gen before2 = 0
```

```
replace before2 =1 if dist_one>1000 & dist_one<2000
gen between2 = 0
replace between2 =1 if year_tr>=2005 &  year_tr<=2007 & dist_one>1000 & dist_one<2000
gen after2 = 0
replace after2 = 1 if year_tr>2007 & dist_one>1000 & dist_one<2000

gen before3 = 0
replace before3 =1 if dist_one>2000 & dist_one<3000
gen between3 = 0
replace between3 =1 if year_tr>=2005 &  year_tr<=2007 & dist_one>2000 & dist_one<3000
gen after3 = 0
replace after3 = 1 if year_tr>2007 & dist_one>2000 & dist_one<3000

*Best*
gen before1 = 0
replace before1 =1 if dist_one<1000
gen between1 = 0
replace between1 =1 if year_tr>=1998 &  year_tr<=2002 & dist_one<1000
gen after1 = 0
replace after1 = 1 if year_tr>2002 & dist_one<1000

gen before2 = 0
replace before2 =1 if dist_one>1000 & dist_one<2000
gen between2 = 0
replace between2 =1 if year_tr>=1998 &  year_tr<=2002 & dist_one>1000 & dist_one<2000
gen after2 = 0
replace after2 = 1 if year_tr>2002 & dist_one>1000 & dist_one<2000

gen before3 = 0
replace before3 =1 if dist_one>2000 & dist_one<3000
gen between3 = 0
replace between3 =1 if year_tr>=1998 &  year_tr<=2002 & dist_one>2000 & dist_one<3000
gen after3 = 0
replace after3 = 1 if year_tr>2002 & dist_one>2000 & dist_one<3000

*Den Bosch*
gen before1 = 0
replace before1 =1 if dist_one<1000
gen between1 = 0
replace between1 =1 if year_tr>=1995 &  year_tr<=1998 & dist_one<1000
gen after1 = 0
replace after1 = 1 if year_tr>1998 & dist_one<1000

gen before2 = 0
replace before2 =1 if dist_one>1000 & dist_one<2000
gen between2 = 0
replace between2 =1 if year_tr>=1995 &  year_tr<=1998 & dist_one>1000 & dist_one<2000
gen after2 = 0
replace after2 = 1 if year_tr>1998 & dist_one>1000 & dist_one<2000

gen before3 = 0
replace before3 =1 if dist_one>2000 & dist_one<3000
gen between3 = 0
replace between3 =1 if year_tr>=1995 &  year_tr<=1998 & dist_one>2000 & dist_one<3000
gen after3 = 0
replace after3 = 1 if year_tr>1998 & dist_one>2000 & dist_one<3000

*Leiden*
gen before1 = 0
replace before1 =1 if dist_one<1000
```

```
gen between1 = 0
replace between1 =1 if year_tr>=1993 &  year_tr<=1996 & dist_one<1000
gen after1 = 0
replace after1 = 1 if year_tr>1996 & dist_one<1000

gen before2 = 0
replace before2 =1 if dist_one>1000 & dist_one<2000
gen between2 = 0
replace between2 =1 if year_tr>=1993 &  year_tr<=1996 & dist_one>1000 & dist_one<2000
gen after2 = 0
replace after2 = 1 if year_tr>1996 & dist_one>1000 & dist_one<2000

gen before3 = 0
replace before3 =1 if dist_one>2000 & dist_one<3000
gen between3 = 0
replace between3 =1 if year_tr>=1993 &  year_tr<=1996 & dist_one>2000 & dist_one<3000
gen after3 = 0
replace after3 = 1 if year_tr>1996 & dist_one>2000 & dist_one<3000

*Barendrecht*
gen before1 = 0
replace before1 =1 if dist_one<1000
gen between1 = 0
replace between1 =1 if year_tr>=1999 &  year_tr<=2001 & dist_one<1000
gen after1 = 0
replace after1 = 1 if year_tr>2001 & dist_one<1000

gen before2 = 0
replace before2 =1 if dist_one>1000 & dist_one<2000
gen between2 = 0
replace between2 =1 if year_tr>=1999 &  year_tr<=2001 & dist_one>1000 & dist_one<2000
gen after2 = 0
replace after2 = 1 if year_tr>2001 & dist_one>1000 & dist_one<2000

gen before3 = 0
replace before3 =1 if dist_one>2000 & dist_one<3000
gen between3 = 0
replace between3 =1 if year_tr>=1999 &  year_tr<=2001 & dist_one>2000 & dist_one<3000
gen after3 = 0
replace after3 = 1 if year_tr>2001 & dist_one>2000 & dist_one<3000

*Rijswijk*
gen before1 = 0
replace before1 =1 if dist_one<1000
gen between1 = 0
replace between1 =1 if year_tr>=1992 &  year_tr<=1996 & dist_one<1000
gen after1 = 0
replace after1 = 1 if year_tr>1996 & dist_one<1000

gen before2 = 0
replace before2 =1 if dist_one>1000 & dist_one<2000
gen between2 = 0
replace between2 =1 if year_tr>=1992 &  year_tr<=1996 & dist_one>1000 & dist_one<2000
gen after2 = 0
replace after2 = 1 if year_tr>1996 & dist_one>1000 & dist_one<2000

gen before3 = 0
replace before3 =1 if dist_one>2000 & dist_one<3000
gen between3 = 0
replace between3 =1 if year_tr>=1992 &  year_tr<=1996 & dist_one>2000 & dist_one<3000
```

gen after3 = 0
replace after3 = 1 if year_tr>1992 & dist_one>1996 & dist_one<3000

Hilversum
gen before1 = 0
replace before1 =1 if dist_one<1000
gen between1 = 0
replace between1 =1 if year_tr>=1990 & year_tr<=1992 & dist_one<1000
gen after1 = 0
replace after1 = 1 if year_tr>1992 & dist_one<1000

gen before2 = 0
replace before2 =1 if dist_one>1000 & dist_one<2000
gen between2 = 0
replace between2 =1 if year_tr>=1990 & year_tr<=1992 & dist_one>1000 & dist_one<2000
gen after2 = 0
replace after2 = 1 if year_tr>1992 & dist_one>1000 & dist_one<2000

gen before3 = 0
replace before3 =1 if dist_one>2000 & dist_one<3000
gen between3 = 0
replace between3 =1 if year_tr>=1990 & year_tr<=1992 & dist_one>2000 & dist_one<3000
gen after3 = 0
replace after3 = 1 if year_tr>1992 & dist_one>2000 & dist_one<3000

Regression models

Model 1-3
Full model - 1 ring
xi: areg lnprice before between after lnsize terracedh semidetached cornerhouse detachedh nrooms bath balcony garages maintins maintouts garden terrace heating monument lnds lndh tracknuis bperiod1 bperiod2 bperiod3 bperiod4 bperiod5 bperiod6 bperiod7 bperiod8 i.year_tr, robust absorb(buurtcode)

Model 4
*(2*1000 mtr)*
xi: areg lnprice before1 before2 between1 between2 after1 after2 lnsize terracedh semidetached cornerhouse detachedh nrooms bath balcony garages maintins maintouts garden terrace heating monument lnds lndh tracknuis bperiod1 bperiod2 bperiod3 bperiod4 bperiod5 bperiod6 bperiod7 bperiod8 i.year_tr, robust absorb(buurtcode)

Model 5, 6 to 9
*(3*1000 mtr)*
xi: areg lnprice before1 before2 before3 between1 between2 between3 after1 after2 after3 lnsize terracedh semidetached cornerhouse detachedh nrooms bath balcony garages maintins maintouts garden terrace heating monument lnds lndh tracknuis bperiod1 bperiod2 bperiod3 bperiod4 bperiod5 bperiod6 bperiod7 bperiod8 i.year_tr, robust absorb(buurtcode)

Chow tests

Chow test for group of underground stations
gen group = 0
replace group = 1 if inlist(case_code,"Apeldoorn","Amersfoort","Leiden","Den Bosch","Best","Barendrecht","Rijswijk","Apeldoorn")

gen group2 = 0
replace group2= 1 if inlist(case_code,"Best","Barendrecht","Rijswijk")

xi: areg lnprice before1 before2 between1 between2 after1 after2 i.year_tr lnsize terracedh semidetached cornerhouse detachedh nrooms bath balcony garages maintins maintouts garden terrace heating monument lnds lndh tracknuis bperiod1 bperiod2 bperiod3 bperiod4 bperiod5 bperiod6 bperiod7 bperiod8 group group2, robust absorb(buurtcode)

test _b[group]=0, notest
test _b[group2]=0, accum

Chow test for group of cities with population of >100,000 residents
gen group = 0
replace group = 1 if inlist(case_code,"Apeldoorn","Amersfoort","Leiden","Den Bosch","Best","Barendrecht","Rijswijk","Apeldoorn")

gen group2 = 0
replace group2 = 1 if inlist(case_code,"Amersfoort","Leiden","Den Bosch","Apeldoorn")

xi: areg lnprice before1 before2 between1 between2 after1 after2 i.year_tr lnsize terracedh semidetached cornerhouse detachedh nrooms bath balcony garages maintins maintouts garden terrace heating monument lnds lndh tracknuis bperiod1 bperiod2 bperiod3 bperiod4 bperiod5 bperiod6 bperiod7 bperiod8 group group2, robust absorb(buurtcode)

test _b[group]=0, notest
test _b[group2]=0, accum

Regression assumption tests

estimates store normal
predict r
kdensity r, normal
pnorm r
qnorm r
rvfplot, yline(0)
avplots
swilk r
estat hettest
scatter r lnprice
estat imtest, white