Anticipation Effects of Infrastructural Redevelopments on the Owner-Occupier Housing Market

A CASE STUDY ON THE UTRECHT INNER-CITY RAILWAY STATION

Yvon Lustenhouwer, March 2018

ABSTRACT - While earlier studies on the external effects of infrastructural (re)developments mostly focus on accessibility improvements and their capitalization in house prices after the (re)development is completed, this paper aims to research anticipation effects regarding the owner-occupier housing market in the vicinity of an infrastructural redevelopment project. By means of a difference-in-difference hedonic pricing model, transaction prices are regressed on indicators which define the announcement and start of the redevelopment, comparing houses near and farther from the redevelopment project, controlling for a variety of housing and neighborhood characteristics and for time and space. The results of the quantitative analyses show a relative decrease in house prices close to the redevelopment and imply a(n) (anticipated) decrease of area quality during the redevelopment process. These negative effects decay over distance concavely, but no significant general trend effects can be found over time. Compared to fundamental research on external effects of redevelopment projects, these results are in some ways contradictory and have clear policy relevance. A qualitative analysis on the application of the quantitative findings in policy- and decision-making, indicate that external effects are considered to be important in project development. However, despite this expressed importance, interviewees indicate that external effects and anticipation effects are seldom addressed in public financial analyses, due to the common difference between the reach of the external effects and the scope of a project, and the complexity of the different roles played by municipalities regarding redevelopments. Therefore suggested is, that generalized effects for different stages of a (re)development process could be relevant for commercial businesses by enhancing their business cases, rather than for public parties.

KEYWORDS - *Housing market, anticipation, redevelopment, public transport, external effects*

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Preface

Before you lies my Master Thesis, representing the culmination of over a decade of learning and academic development. Starting my secondary education in 2005 in preparation for university, it were the artistic subjects instead of the more academic and theoretical disciplines that interested me the most. After graduation, a period of voluntary work in Borneo inspired me to learn more about the world and its processes and systems, both social and physical. The bachelor Human geography and urban planning, with additional physical geography courses, saturated this urge. This program, focused on research and writing, provided a valuable learning experience. Different student jobs and an internship, however, made me want to develop other practical and analytical skills, which I could use during the rest of my career. The master Real Estate Studies brought me this basic skillset, regarding a variety of topics. Due to my lack of interest in economics and mathematics in high school, and the resulting lack of knowledge concerning these matters, some of the master courses were quite challenging for me. However, with time and effort I managed to pass them quite well.

By combining different aspects of my past education and taking them one step further analytically, this thesis represents the icing on the cake. By conducting mixed method research, using a place I frequented countless times over the past 6 years as a case study, I was able to utilize all the knowledge and personal experiences gained during my time as a student. This thesis addresses different subjects and therefore has the potential to reach a broad audience. At the moment, the housing market in the Netherlands is ‘hot’: its severe saturation influences the living situation of many households in the country, meaning that changing conditions in this market have a great impact and therefore constitute a daily topic of discussion for different actors. Furthermore, the overarching subject of the thesis could be of interest to an international audience, since public infrastructure and policymaking can be found everywhere and will always be subject to change. Moreover, the methodology and research questions touch upon the work of scholars and practitioners in the fields of urban geography, planning and economics.

I gratefully acknowledge my supervisor Mr. Van Duijn for his excellent and very useful guidance during the research process and NVM for providing a comprehensive dataset. Furthermore, I would like to thank the interviewees for sharing their vision and field experience and providing more insight into the policy development process. Finally, I would like to thank my friend Lisan Berk for helping me improve my English writing. Although this thesis marks the completion of my academic education, I hope I will continue learning throughout my professional career. I look forward to the challenges ahead.

Yvon Lustenhouwer

Utrecht, The Netherlands
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1. Introduction

1.1 Motivation

Ever since the steam locomotive was invented, passenger transport has been an important function of Europe's railway system. In the 1830's, the first train stations were built to provide passengers with safe entrance to this railway network. The access to an additional infrastructural network, through these so called 'cathedrals of steam' (The Guardian, 2017), made society more mobile and expanded its living environment. Later on, accessibility through public transport made commuting between jobs and home easier and reduced travelling expenses (CPB and KiM, 2009).

Nowadays, in times of continued population growth and urbanization, the train station as a central hub has become more than just a pass-through on the daily commute. Passengers do not only expect stations to be clean, accessible and effective in fulfilling their core purpose, they also expect them to function as meeting places and shopping centers (The Guardian, 2017). Furthermore, inner-city stations of the 21st century can function as vital drivers of local growth and are even recognized as key anchors for the next generation of urban housing developments by the Department for Communities and Local Government UK (2017). However, in order to meet these diverse expectations, the inner-city station must endure more than just a simple facelift (The Guardian, 2017).

Looking at redevelopments of inner-city stations worldwide, plans generally extend beyond increasing mobility. Enhancing the quality and range of facilities, increasing livability and housing capacity are common redevelopment goals (see for example: BBC, 2017; cu2030, 2017b; Transbay Program, 2017). Besides direct effects, such as improvements on facilities, capacity and travel time for commuters, these type of redevelopments are likely to also produce indirect or external effects. An example of occurring negative external effects is discussed by the NRC (2013) in the case of the redevelopment of Rotterdam's central station (see textbox 1.1).

Textbox 1.1

'Beautiful station, sorry for the damage'

This headline appeared after completion of redevelopment of the central station of Rotterdam, the Netherlands. At least 70 inhabitants of the adjacent neighborhood Provenierswijk submitted a claim for damage to their homes. According to the residents, the long-standing heavy traffic that drove through their neighborhood caused tears in the walls. They also stated that, because of the new roof of the railway station, groundwater would not reach the surface anymore and caused the foundation of the surrounding houses to rot. The municipality said it doubts this causal link; the court needed to decide. (NRC.nl, 2013)

As seen in Rotterdam, The Netherlands, the redevelopment of the central station affected the value of surrounding houses during and after the redevelopment. While damaging a house decreases its value, reviving an area through investments and thereby improving the quality of the neighborhood can increase its value (PBL.nl, 2006). Since more than half of homeowners' wealth is determined by the value of their home (Statistics Netherlands, 2014), redevelopment projects can have major wealth implications. Due to these wealth implications, the possible external effects of infrastructural redevelopment projects on house prices are an important subject to study; important for (future) home-owners as well as for policymakers who serve the public interest.

1.2 Scientific Relevance

Bajic (1983) was one of the first to study the effect of infrastructural development on house prices. He mapped the economic benefits of the improvement of Toronto's transport network, due to the arrival of a new metro line, and found that capitalization of this improvement could be observed in increasing house prices. More recently, Gibbons and Machin (2005) studied the effect of railway access on property prices in London and its outer metropolitan fringe. Efthymiou and Antoniou (2013) focused on both the direct and indirect effects of transportation infrastructure and policies on house prices and rents in Athens, Greece.

Above described papers are only a few examples of the many studies conducted on the interaction between infrastructure and house prices. The majority of these studies is limited to effects of new infrastructural nodes on house prices, with accessibility as their main driver. However as said before, when looking at the redevelopment of already existing inner-city stations, improving accessibility is often not the only goal. External effects of spatially allocated investments of public capital in general are also frequently discussed in academic literature. Studies on public investment, which can differ in project type, often measure if and to what extent adjacent areas are influenced by the changing environment, see for instance Smith (2004), Schwartz et al. (2006), Harding et al. (2007), Rosenthal (2008), Ahlfeldt et al. (2013) and Van Duijn et al. (2016). General conclusions are that urban decline and ageing of the building stock decrease the (social) quality of neighborhoods and property prices (Smith, 2004; Harding et al., 2007; Ahlfeldt et al., 2013), while urban renewal and redevelopment improve social quality of neighborhoods and lead to increasing property prices (Schwartz et al., 2006; Rosenthal, 2008; Van Duijn et al., 2016).

Contrary to studies which focus only on the effects after completion of the redevelopment, Henneberry (1998) researches the effect of a new construction plan in Sheffield from beginning to end. The results show that house prices are influenced by the distance to the development project and phase of the process. Most importantly, he finds that house prices closer to the Supertram decrease slightly (by about 3 per cent) in the period between the announcement and completion of the development, due to the (expected) noise disturbance, while before the announcement of the plan the opposite occurs. Schwartz et al. (2006) also mention these anticipation effects - as observed by Henneberry (1998) - in their theoretical framework, but they do not model these effects. Van Duijn et al. (2016) do investigate the anticipation effects, but consider them only after the reconstruction of their studied projects has started, excluding the period between the announcement of the plan and the beginning of the construction period.

Although above studies focus on different types of projects and (partially) cover anticipation effects in investment situations, none of them specifically research anticipation effects as external effects of redevelopments of inner-city railway stations on house prices and none of them research these effects comprehensively in the period after announcement and before the actual construction work starts. This while in other markets, such as the financial market, anticipation effects are frequently discussed in relation to the moment of announcement or speculations regarding upcoming events. The so called investor sentiment makes actors to over or underestimate future values of a certain asset class on the market, due to their expectations regarding an announced event, which drive prices of those assets in the present (De Long et al., 1990; Shiller, 2003; Da et al., 2010). Because real estate is an alternative tradable asset class to the classical assets on the financial market (such as stocks and bonds), one could wonder if actors on the housing market show the same speculative behavior as actors on the financial market when a changing situation on this market – in this case a redevelopment of an area – is announced, but is not observable yet (the BETWEEN announcement and event period); or if anticipation effects are only detectable, after the construction period has started (the period AFTER the actual event occurred).

This study aims to fill this gap in scientific literature and contribute to a more comprehensive understanding of anticipation effects of redevelopment projects. Therefore, this exploratory paper researches external effects, in the form of anticipation effects on the housing market, of a redevelopment case from prior to the announcement until the (partial) completion of the project, using a mixed method approach. The case study will be shortly introduced in paragraph 1.3, followed by the central research question of this paper.

1.3 Research problem statement

As seen in previous studies, discussed in the previous paragraphs, a redevelopment of a station area might have external effects, affecting the value of housing depending on time and place. The aim of this research is to study whether actors on the housing market anticipate on the changing environment, by analyzing house prices in areas close to and further away from the redevelopment, in the periods before announcement of the redevelopment, between announcement and start of the redevelopment and after start of the construction period. The main goal is to observe if and when external effects on house prices in adjacent areas occur, how big the effects are and how far they reach before the total completion of the redevelopment. Therefore, the central research question is:

> **"What is the impact of a station-area redevelopment on house prices in surrounding neighborhoods and to which extent is this impact considered in policy- and decisionmaking?"**

The main question will be answered by means of the following sub questions:

1. *What is the rationale behind anticipation effects of (re)development projects on local house prices?*
2. *How do anticipation effects of the redevelopment process of Utrecht Central Station impact local house prices over time?*
3. *How do these anticipation effects on house prices differ over distance, relative to Utrecht Central Station?*
4. *To which extent are anticipation effects considered in policy- and decision-making, regarding comprehensive inner-city redevelopment projects, focusing on the redevelopment of Utrecht Central Station?*

1.4 Outline of the paper

The remainder of this paper will start with a theoretical framework in chapter 2, which provides an overview of theories on land value, house prices, redevelopments, external effects and anticipation on the housing market, starting with overarching classical theories. It should answer the first sub question mentioned above. The first paragraphs of the third chapter explain the hedonic pricing model with difference-in-difference application, the composition and transformation of the dataset, and the selected variables regarding the quantitative approach. These paragraphs form the framework to answer sub questions 2 and 3. A second section in the third chapter covers the qualitative approach to answer sub question 4. Chapter 4 discusses the results of the quantitative analyses; providing insight into the effect of the redevelopment of UCS and its surrounding areas on house prices between the moment of announcement and completion of the redevelopment, comparing the target group (transactions close to UCS) with the control group (transactions further away). The results of the qualitative analysis are presented in chapter 5, which discuss the possible application of the quantitative results in practice. Finally, the paper ends with conclusions, recommendations and points of discussion in chapter 6.

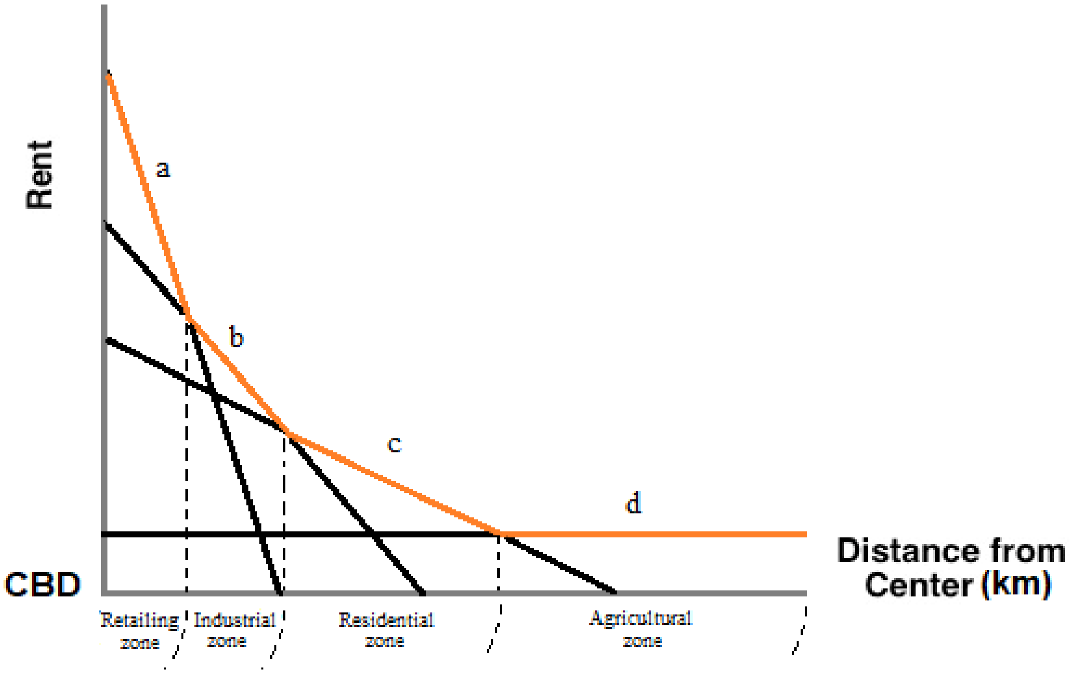
2. Theoretical framework

In order to understand the rationale behind anticipation effects of (re)development projects on house prices in total, it is important to firstly get a hold on the dynamics of house prices and their pattern in general. The classical theories, often based on a variety of assumptions and therefore considering a more simplified representation of reality, form the base of these dynamics and patterns. This chapter, therefore, starts with a short discussion on the fundamental urban economic theories in paragraph 2.1. Building on to this foundation, paragraph 2.2 discusses more contemporary theories regarding the pattern of property prices, and the influence of different amenities including accessibility. Following this expansion, paragraph 2.3 focusses on the impact of redevelopments on house prices, ending the chapter by discussing anticipation effects and formulating the hypotheses to test in the empirical section of this paper.

2.1 Land and its price: the classical theories

In fundamental urban economic theories, location, land and rent prices are seen as inseparable. The early theory on rent and location by Ricardo (1817) concerned itself primarily with agricultural land, since the scholar lived in an agricultural society (Alonso, 1960). Ricardo’s land-rent-theories assume the supply of land is fixed and therefore they emphasize the demand for land. Ricardo (1817) started by analyzing mechanisms between rent and one-product-producing-land. In short, he argues that when demand for, for example, wheat increases, the price of wheat increases due to scarcity and therefore the value of wheat producing land and its rent also increase. Von Thünen expanded on this theory by analyzing different kinds of agricultural land, their pattern around the city and the trade-off between land value and transport costs: the higher the transport costs, the lower the possible profits, the lower the rents (Von Thünen, 1826).

The land-rent approach of Ricardo and Von Thünen formed the premise for Alonso’s urban economics analyses in the 1960’s. In his theories (1960; 1964), the market for agricultural products, as the central point of the city, makes way for the Central Business District (CBD). Residents no longer have to travel to act in the marketplace, but instead they go to work in the more service-oriented industries in the center of the city. The functions of maximum bids for land, derived from the possible profits and transport costs, differ per economic sector. Figure 1 shows these different functions.



Note: The figure maps different functions of maximum bids for land, derived from the possible profits and transport costs, differing per economic sector. Land values of the different functions decrease with different speeds, as lines a, b, c and d display, and substitute each other when an alternative use can generate a higher income. The curve that appears due to this substituting is called the Bid Rent curve. It shows that land and rent prices are highest near the city center and decrease as distance increases. The resulting concentration of functions create concentric zones across the urban landscape.

Figure 1 | Substitution of land use

Each of the different types of land use, retailing, industrial, residential and agriculture, experience their own effects from distance and maximum income. Land values of the different functions therefore decrease with different speeds, as lines a, b, c and d display, and substitute each other when an alternative use can generate a higher income. The curve that appears due to this substituting, reflects the highest bids for land and rent possible per location and is called the Bid Rent curve. It shows that land and rent prices are highest near the city center and decrease as distance increases. Land use concentrates depending on location relative to the CBD, which creates concentric zones across the urban landscape.

2.2 Amenities, accessibility and the pattern of property prices

In the demand-driven analyses of Ricardo, Von Thünen and Alonso, the landowner hardly plays a role in the mechanisms of the market, besides maximizing his income from the land in his possession. But nowadays, landowners sometimes do not go for the highest yield (Evans, 2004). They could be emotionally attached to their land or home (Mulder and Wagner, 2012) and, therefore, they are not willing to rent it out, or they could speculate for higher income in the future (Nozeman and Van der Vlist, 2014). Furthermore, contemporary cities are more than just a working place. Brueckner et al. (1999) incorporated the classical theories into a model, more consistent with real-world observations. Their theory implies that the relative location of different income groups depends on the spatial pattern of amenities in the city. When the city centers amenity advantage is strong, it is more likely that the rich live on central locations and therefore property prices would be higher in the center compared to the suburbs. Inversely, when there is no abundance of amenities in the CBD and its advantage is weak or negative, the rich are more likely to live in the suburbs, and so property prices would be lower. Although they are not directly related to mobility advantages, above studies indicate that the pattern of housing values does not smoothly decrease from one point to another as the classical theories suggest. The pattern can be more capricious.

Other studies concerning the pattern of property values, derived from the important role of transportation costs in the classical theories, focus more on accessibility as a driver of increasing prices. According to Benjamin and Sirmans (1996), changes in accessibility affect property prices by changes in property utilization and commuting costs. Bajic (1983), Voith (1991), Henneberry (1998), Gibbons and Machin (2005), Efthymiou and Antoniou (2013) and Levkovich et al. (2016), found that increasing accessibility of an area, by developing new infrastructural nodes, creates an upward effect on house prices. Because the majority of studies on this topic are in essence comparable, but differ in size, impact magnitude and sometimes even in direction, Debrezion et al. (2007) carried out a meta-analysis on 73 estimation results out of a pool of studies. Keeping in mind that housing markets differ across borders (Gibler et al., 2014), they attempt to explain the variation in findings. Debrezion et al. (2007) conclude in the first place that commuter railway stations have a significantly higher impact on property values than other stations and second, that the residential property prices within a ring of 2 miles (approximately 1600 meters) generally increase with 2.4% for every 250 meters closer to the station.

One can argue that because effects of accessibility on house prices are often found, accessibility can be considered an amenity itself. However, interesting is that although previous studies found that house prices increased with better accessibility, the external effects of nearby train stations and rail transit systems are not always positive. Henneberry (1998) concludes in his study that house prices drop after the announcement of a redevelopment, because of the expected noise disturbance. He states that sagging of land and damage to houses are common in construction processes and would affect house prices. Whether effects of amenities and redevelopments are positive or negative on house prices, findings of above studies at least show that the relationship between housing value and distance is not linear, as said before (see figure 1). Besides this, Henneberry's (1998) conclusion puts forth two other housing-value-related subjects, namely anticipation effects and the effect of redevelopment processes in general. Both will be discussed in the next paragraphs.

2.3 Redevelopment and house prices

House prices, as argued in previous paragraphs, are effected by accessibility. Improvements in accessibility can be accomplished by new developments or by redevelopments of already existing nodes. However, one can imagine that in case of a redevelopment of an already functioning inner-city station, with additional focal points besides mobility, improvements in mobility or accessibility of the area are not the most dominant in affecting house prices. Especially the increasing quality of public space, a better image or atmosphere, new squares, parks, leisure amenities and for instance retail, would be the strongest determinants in affecting property prices (Cheshire and Sheppard, 1995; Brueckner et al., 1999). These factors are all known for their capitalization in housing value (Geoghegan et al., 2003; Daams et al., 2016; Livy and Klaiber, 2016).

Van Duijn et al. (2016) combine the findings of above studies. They argue that when a redevelopment replaces a disamenity or several disamenities, this will bring improvements in appearance and atmosphere of an area and change people's perception of this area. The change of perception can create external effects, in the form of increased property prices in vicinity of the former disamenity (Van Duijn et al., 2016). Other studies that support the role of urban revitalization and amenities in increasing house prices are for instance the studies of Ahlfeldt (2011), Ahlfeldt et al. (2013), Brooks and Philips (2007), Brueckner et al. (1999), Chen and Rosenthal (2008), Cheshire and Sheppard (1995); Ioannides (2003) and Koster and van Ommeren (2013). These studies focus mostly on investments in housing directly, but also highlight the important role of the neighborhood in deriving house prices. Because of their influence, neighborhood characteristics are often included in studies on house prices, besides structural characteristics of the property and of course location.

2.4 Anticipation effects

In addition to factors such as location, changing utility, accessibility and quality of the neighborhood, house prices are also affected by speculative behavior, as implied by Henneberry's (1998) research and Nozeman and Van der Vlist (2014). As can be observed worldwide, house prices certainly do not develop constantly over time. Land price volatility and related fluctuations in house prices are always present due to market forces, caused by endogenous market factors such as supply and demand (Brueggeman and Fisher, 2011). However, macroeconomic movements are not the only possible underlying reason for fluctuations. In the case of speculative demand based on short-term expectations, house prices may temporarily rise or fall without the basis of fundamental macroeconomic factors (Verbruggen et al., 2005).Van Duijn et al. (2016) note that in a world where there is perfect information and there are no mobility costs, households are likely to anticipate upcoming changes in environments. Although their study focusses on industrial heritage, it does measure the impact of a redevelopment project. Given the rather large capital expenditure associated with buying a house, house price fluctuations are of meaning for, and sometimes therefore also caused by future consumers. If potential homeowners expect house prices to rise, demand will increase in a short term and this will have an (extra) upward effect on prices. Conversely, if lower values are expected, households will try to sell their property quickly and the reverse may occur (Boelhouwer et al., 2004; Van Duijn et al., 2016).

These mechanisms, also described as anticipation effects, are also seen in the financial market. Traditional finance exploits models in which economic agents are assumed to be rational, acting efficient and unbiased towards relevant information and therefore their decisions would be consistent with utility maximalization (Byrne and Brooks, 2008). However, these efficient market models were starting to be challenged in the 1980's, due to the existence of a litany of biases, heuristics and inefficiencies in real life (Hammond, 2015). The rather new field of reseach that focusses on these inefficiencies, behavioral finance, mostly discusses aggregate sentiment and traces its effects to stock returns (Baker and Wurgler, 2007). Investor sentiment makes actors on the financial market, comparable as the actors on the housing market as Henneberry (1998), Boelhouwer et al. (2004), Nozeman and Van der Vlist (2014) and Van Duijn et al. (2016) indicate, over or underestimate future values of a certain assest class, due to their speculations and believes regarding an announcened event which is expected or speculated to occur in the future and therefore it drives prices of those assets in the present (De Long et al., 1990; Shiller, 2003; Da et al., 2010). Schwartz et al. (2006) describe this behavior in context of the impact of projects. If housing markets would be characterized by perfect foresight, all project impacts would be capitalized into prices immediately at the time that the project is announced (Poterba, 1984, in Schwartz et al., 2006; McMillen and McDonald 2004).

Although Schwartz et al. (2006) describe this timing of impacts on investments in social housing directly, they measure the effect on surrounding houses as a response to this investment. Looking at previous mentioned studies, which grossly research external effects on house prices caused by various investments, there may be assumed that effects could be likewise when house prices are effected by the redevelopment of an inner-city station and its surrounding areas. The left panel of figure 2 shows the hypothetical timeline of project impacts as Schwartz et al. (2006) describe. It reflects property prices near or adjacent to the projects, compared to prices in the rest of the neighborhood. At the time the project is announced, property values near the investment site may increase, because of the expected increase of quality of the neighborhood. A further jump in value may occur when the construction actually starts on the project. Schwartz et al. (2006) state that at this point, the initial source of blight may be removed or sealed-off and the uncertainty about whether the announced project would actually be built is resolved. After the first construction, property values could increase even more upon completion, when neighbors see the finished project and new occupants begin to move in. Finally, the property values may continue to increase at a slower pace in the years after completion, as population increase spurs further neighborhood change.

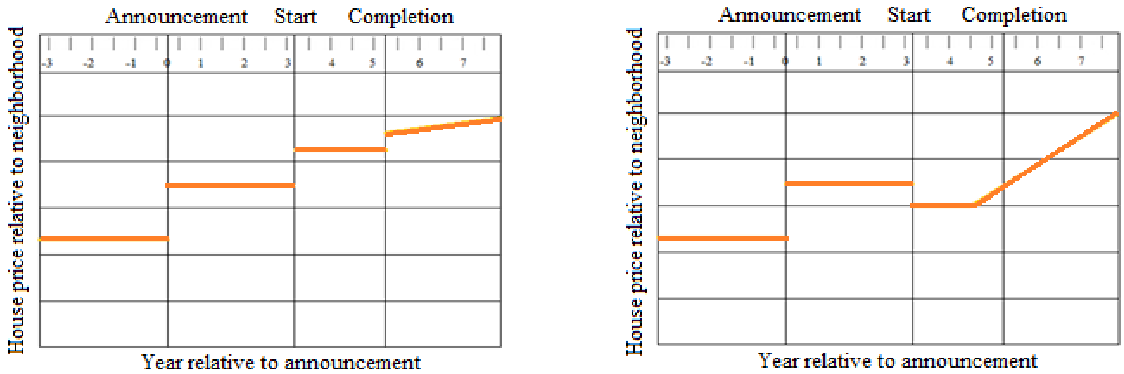


Figure 2 | Hypothetical timeline Schwartz et al. (2006) and alternative timeline Schwartz et al. (2006) and Henneberry (1998) combined

Note: The figure maps the theory of Schwartz et al. (2006) (left panel) and a combination of this theory with Henneberry's (1998) (right panel), concerning the course of relative price effects due to anticipation regarding redevelopment projects.

One of the implicit assumptions of Schwartz et al. (2006) is that prices just after start of the project increase further, due to the decrease of uncertainties regarding the project. However, Henneberry (1998) shows that this assumption is not always valid. He concludes in his study that prices in vicinity of the project at this point in time would decrease, due to the possible rising presence of disturbance in the form of noise, traffic, bad view due to construction work and land sagging. The right panel of figure 2b shows an alternative hypothetical timeline, both studies combined.

2.5 Hypotheses

This research is conducted based on the results of previous empirical studies, indicating externalities and anticipation effects caused by redevelopments. Answering the first research question by setting out the different theories, some expectations have arisen regarding sub research questions 2 and 3. Looking at the redevelopment of UCS, the external effects on house prices would in the first place differ in time. Combining the findings of Schwartz et al. (2006) and Henneberry (1998) (as shown in the right panel of figure 2), expectations regarding the time-depending external effects can be set out as the first three hypotheses below. Secondly, as learned from the findings of Henneberry (1998), Schwartz et al. (2006), Koster and Van Ommeren (2013), Van Duijn et al. (2016), and the results of the meta-analyses from Debrezion et al. (2007), external effects and therefore the anticipation effects in this study, would decay depending on distance relative to the station. This expectation is formulated as hypothesis 4. The approach to testing these hypotheses, will be discussed in chapter 3.

1. *House prices in vicinity of Utrecht Central Station increase prior to the start of the redevelopment, from the moment of announcement of the redevelopment project.*
2. *House prices in vicinity of the Utrecht Central Station decrease after the start of the redevelopment.*
3. *House prices in vicinity of the Utrecht Central Station increase approaching the completion date.*
4. *House price effects caused by the redevelopment of Utrecht Central Station are decaying over distance.*

3. Methodology & Data

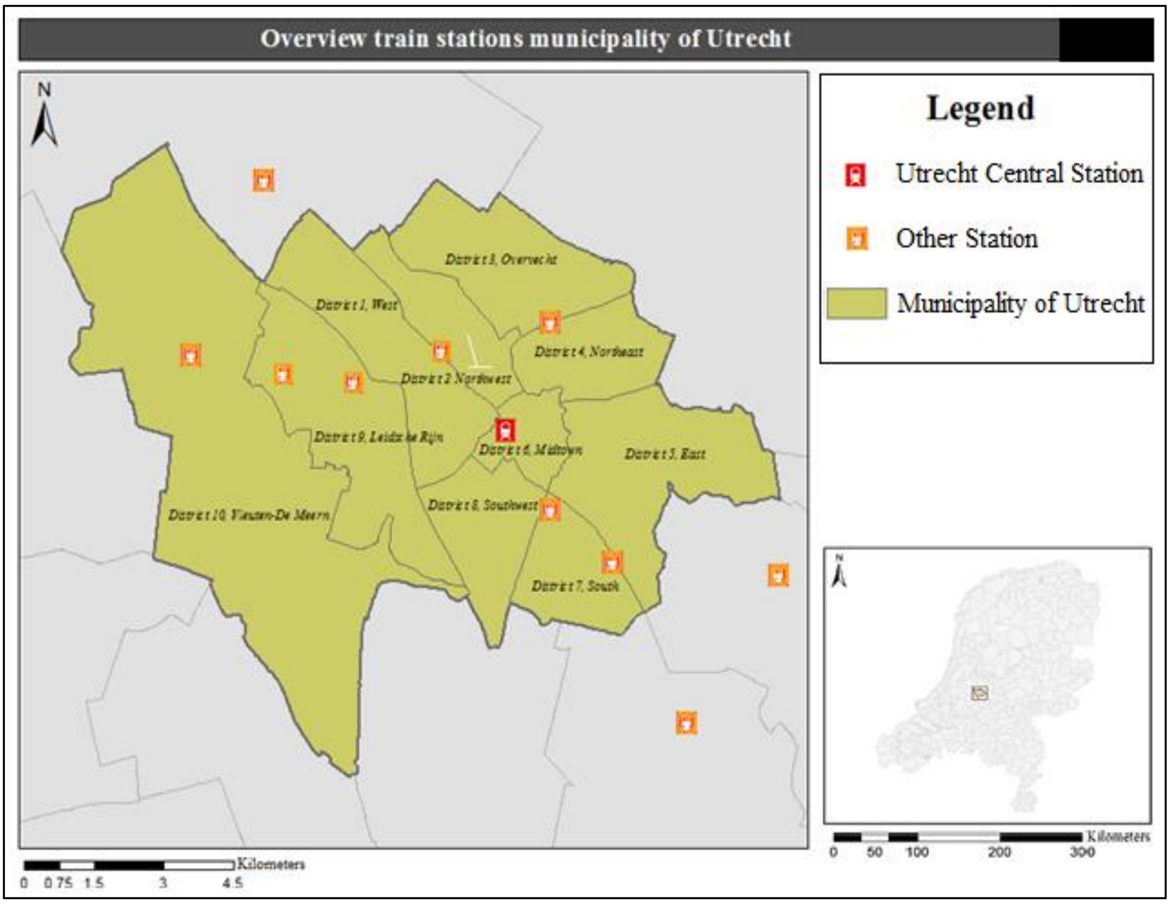
This chapter discusses the different methods which will be used to answer the research questions. Coinciding with the selected mixed method approach, this chapter is divided into two different sections. The first section - paragraphs 3.1 to 3.4 - discusses the quantitative methodology, including a description on the details of the redevelopment process of the case study and the study area, the used dataset, followed by the quantitative research methods, empirical model, and supporting descriptive statistics. These paragraphs form the fundaments to answer sub questions 2 and 3, by testing the hypotheses that are formulated in the previous section. Paragraph 3.5 constitutes the second section and explains the qualitative approach to answering the last sub question of this study, which is used to facilitate a discussion on anticipation effects.

3.1 Case study

After the reconstruction of Rotterdam Central Station (the Netherlands), the city of Utrecht is also redeveloping its central station and adjacent areas. After 'Hoog Catharijne', a shopping mall which connects the city center and the main train station, first opened its doors in the early 1970s, Utrecht's population has grown tremendously. Since more and more people travel by public transport, the strain on mobility resources has greatly increased (cu2030, 2017a). Besides this mobility pressure, the wish to bring back the original canals and the fact that the area around the central station lacked viability, sense of security, maintenance and culture, all played a role in the decision to redevelop (cu2030, 2017a). The aim of the project is to bring these factors back to the area, as well as to add new leisure amenities, retail and new housing (cu2030, 2017a).

In 2002, a referendum was held amongst the inhabitants of Utrecht (cu2030, 2017b). They could vote for what they believed to be the best plan for the train station area. In this study, this moment is seen as the moment of announcement. All residents in and around Utrecht took notice of the future reconstructions of the train station area from this moment on. Important to note is that, while the location of the busstations and the schedule on some railway routes changed, additional bicycle storage is created and the main access roads differ compared to the previous situation, the redevelopment did not lead to a major increase in accessibility of the area. The vast majority of the redevelopment is focused on the enhancement of the social and esthetic quality of the area (cu2030, 2017a); the total redevelopment consists of 50 to 60 larger projects and in total includes about 700 sub-projects. The initial estimated budgeted required investment is approximately 3 billion euro's, where the municipality made additional investments of around 140 million euro's (cu2030, 2017a).

Currently, the municipality of Utrecht consists of 10 districts and holds eight operating train stations (see map 1). Utrecht Central Station is located in the heart of the city of Utrecht, district 6: Midtown. This railway station is the main hub of the railway network in the Netherlands and is therefore the largest in surface and numbers: on a yearly basis the station processes 57 million passengers (Province of Utrecht, 2017). Utrecht's other stations fulfil the more local need for mobility. This means that they are not connected by intercity trains, unlike UCS. The main railroads passing through the city separate the western districts (1, 7, 8, 9, 10) from eastern Utrecht and the city center (2, 3, 4, 5, 6).



Map 1 | Districts municipality of Utrecht (Municipality of Utrecht, 2017)

3.2 Data management

A micro-level cross-sectional dataset on house sale transactions is obtained from the Dutch Association of Real Estate Agents (NVM). The dataset contains 73.257 transaction prices located within the ten districts of the municipality of Utrecht, transaction dates (from January 1996 to December 2016), addresses and a variety of different housing characteristics. In order to make the NVM dataset suitable for a comprehensive hedonic analysis, a distance variable was added. The distance from every individual transaction to the central station was calculated using a Geographical Information System (GIS)[1]. Geocoding the addresses was necessary for plotting the transactions into GIS and computing the straight-line distances to the station. Straight-line distances are not completely accurate in estimating real-life absolute distances, but, assuming all distances face comparable shortening relatively, straight-line distances are considered suitable for this study. Mainly due to the recently

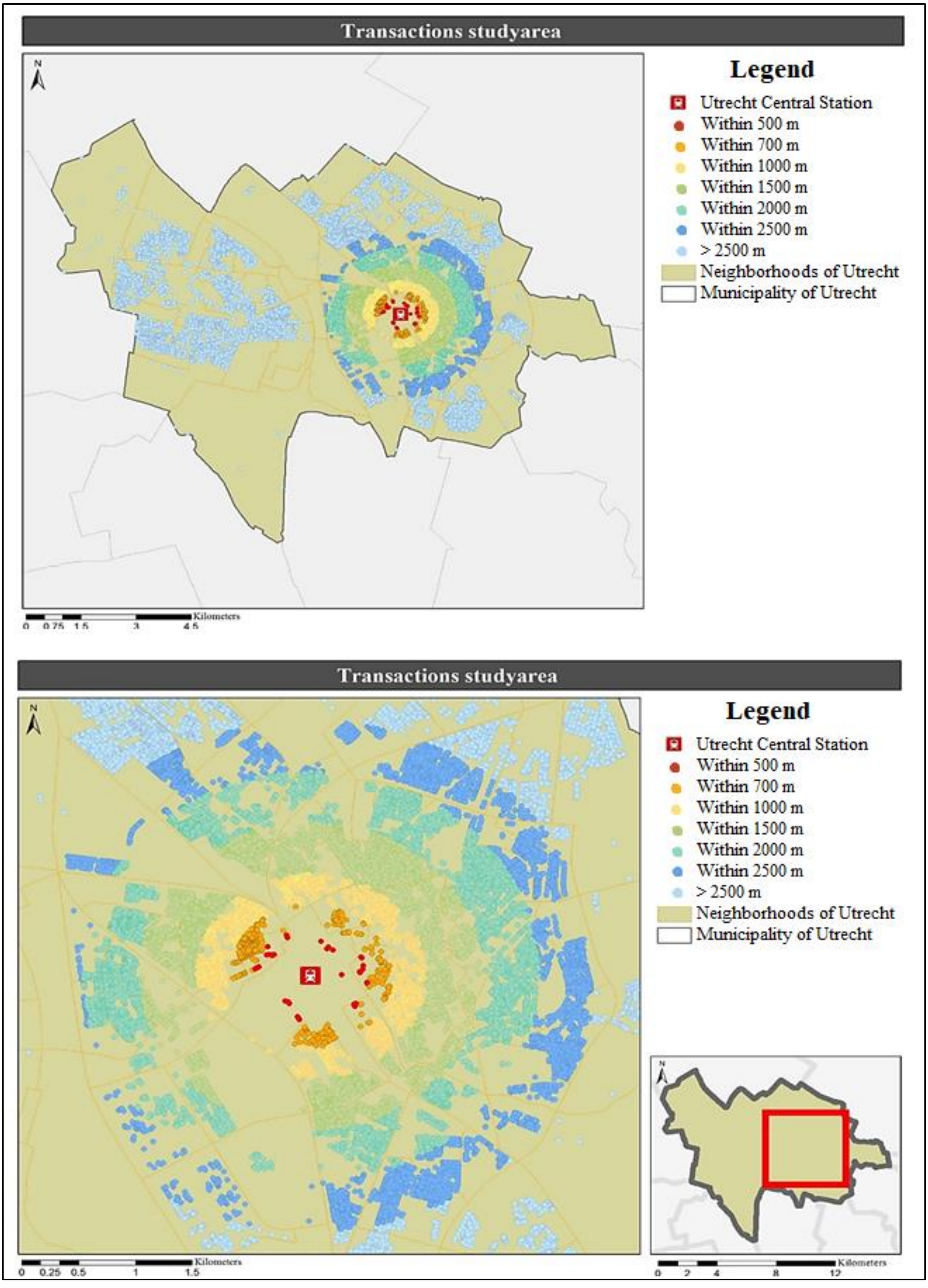
[1] Software used: ArcMap, ESRI

developed neighborhoods in district 9 Leidsche Rijn and the lack of locational updates in the geocoding system, not all addresses could be matched with specific coordinates. After adding the distance variable, this resulted in 72.731 remaining observations. The data management process is displayed in detail in appendix A. Table 1 provides an overview of the included variables, their specific source and, if applicable, the transformation that was necessary to make each variable suitable for analysis (this will be explained further in paragraph 3.3). The initial sample of transactions is plotted on maps 2 and 3. As can be seen on these maps, transactions within 2500 meter from UCS all fall within the central districts of the city of Utrecht. The districts Vleuten-De Meern, which is the most recent addition to the municipality, and Leidsche Rijn, which is still under construction, are scoped out in this radius. Both districts lack government-collected neighborhood data and can be defined as misfits. Due to these missing data, other inconsistencies and outliers in different variables, a number of observations needed to be dropped. Resulting in a functional (merged) dataset of 43.397 observations, all within a range of 0 to 2500 meters from UCS.

Table 1 | Overview variables and sources

VARIABLE	SOURCE	TYPE	FUNCTION IN MODEL
TRANSACTION_PRICE	NVM*	Ratio	Dependent (Transformed in natural logarithm)
DISTANCE_STATION_METERS	Calculated using ArcMap	Ratio	Independent (used for computing target & control groups)
YEAR	NVM	Interval	Independent (dummy & used in computing TREND variables)
MONTH	NVM	Interval	Independent (used in computing TREND variables)
M2	NVM	Ratio	Control (Transformed in natural log)
TYPE OF HOUSE/APPARTMENT	NVM	Ordinal	Control (Transformed in dummies)
NUMBER OF ROOMS	NVM	Ratio	Control (Transformed in natural log)
NUMBER OF BALCONIES	NVM	Ratio	Control (Transformed in dummy)
NUMBER OF ROOFTERRACES	NVM	Ratio	Control (Transformed in dummy)
NUMBER OF KITCHENS	NVM	Ratio	Control (Transformed in dummies)
NUMBER OF TOILETS	NVM	Ratio	Control (Transformed in dummies)
NUMBER OF BATHROOMS	NVM	Ratio	Control (Transformed in dummies)
PARKING	NVM	Nominal	Control (Transformed in dummy)
GARDEN PRESENCE/MAINTENANCE	NVM	Ordinal	Control (Transformed in dummy)
INSIDE MAINTENANCE	NVM	Ordinal	Control (Transformed in dummy)
OUTSIDE MAINTENANCE	NVM	Ordinal	Control (Transformed in dummy)
ISOLATION	NVM	Ordinal	Control (Transformed in dummy)
HEATING	NVM	Nominal	Control (Transformed in dummy)
STREET TYPE	NVM	Ordinal	Control (Transformed in dummy)
GROUND LEASE	NVM	Nominal	Control (Transformed in dummy)
RENTED PARTIALLY	NVM	Nominal	Control (Transformed in dummy)
MONUMENT	NVM	Nominal	Control (Transformed in dummy)
CONSTRUCTION PERIOD	NVM	Ordinal	Control (Transformed in dummies)
POSTAL CODES 4-DIGIT	NVM	Nominal	Control (Transformed in dummies)
POSTAL CODES 4-DIGIT	Municipality of Utrecht	Nominal	Used in creating maps by ArcMap

Note: The table gives an overview of the, in the analyses included, variables, including their sources, function in the empirical model and transformation.



Map 2 and 3 | transactions within the study area between 1996 and 2016

3.2 Quantitative research method

The core of this paper investigates anticipation effects, as external effects of the redevelopment of an infrastructural node and its adjacent areas on the surrounding neighborhoods, in a quantitative manner. By definition, externalities from projects do not have observable market prices (Van Duijn et al., 2016). Most studies researching externalities and effects on house pricing therefore use the first-stage hedonic model by Rosen (1974), or some adapted form of this model. A hedonic analysis is suitable for identifying the influence of one factor among many on price (Henneberry, 1998). House prices are derived from a bundle of characteristics and factors. This means that the price paid for particular properties is a summation of the implicit prices that the market ascribes to the various attributes contained in that bundle (Rosen, 1974). By conducting an analysis based on transaction prices of properties (their market value at selling time) and their varying attributes, it is possible to derive the implicit equilibrium market price – the hedonic price – of each attribute and measure the value and share of externalities (Henneberry, 1998). Hedonic values are estimated by means of a regression analysis, wherein the transaction prices are regressed on the bundle of attributes. This means that in this regression analysis, the price of housing depends on the independent explanatory variables such as the characteristics of the house, neighborhood and relative distance to the redevelopment.

The quantitative empirical research method selected for this study builds upon the work of Henneberry (1998), Schwartz et al. (2006), Koster and Van Ommeren (2013) and Van Duijn et al. (2016). They all exploit the hedonic analysis, creating variations suited to their specific research projects. Overall, their approaches include a difference-in-difference method to estimate the impact of local events on differences in house prices in the vicinity of the event, before and after the event took place, compared to house prices in area's further away from the event. Compared to the basic model by Rosen (1974), a difference-in-difference application (DID) makes it possible to measure interactions between time and distance in a more comprehensive way. Where Rosen's straightforward model is limited to computing a single coefficient that captures the external effect as an average effect, depending on the average distance to the redeveloped station area, the DID application computes multiple coefficients depending on differences in time and distance combined.

Most fundamental studies measure external effects before and after a (re)development, to determine whether the (re)development affected the value of its surrounding areas. However, since this study focusses on anticipation effects regarding a redevelopment, it is relevant to broaden the scope of the study and use the moment of announcement as a starting point for measuring external effects. This consideration is what distinguishes this study from the fundamental studies on which it is built: Schwartz et al. (2006) did not take anticipation effects into account in their analyses and Van Duijn et al. (2016) did not manage to capture anticipation effects before the start of the redevelopments of the industrial heritage sites due to data limitations. Concerning limitations with regard to this study, it is important to mention that some areas surrounding UCS are currently still under construction. This means that this study is limited to two structural breaks, being the moment of announcement and the start of the redevelopment. The two structural breaks divide the total study into three time periods: BEFORE the announcement of the redevelopment, BETWEEN the announcement and start of the redevelopment and AFTER the start of the redevelopment. The applicable model therefore cannot measure the total effect of the project on house prices, which is found to be present up to five years after completion of the project (Schwartz et al., 2006; Van Duijn et al., 2016). Besides roughly generating three time periods, the two structural breaks are also used to calculate the time differences between each transaction and the moment of announcement and the start of the construction period. These timing factors are covered by TREND variables, as described by Van Duijn et al. (2016). The TREND variables will be explained in more depth in paragraph 3.3, which discusses the empirical model.

To control for distance, this paper distinguishes a target and control group. The target group is defined as the group of houses that is impacted by the redevelopment, i.e. a sold house that is located within a certain radius from the redeveloped area of the case study. In previous applications of this method, the analysis was performed for a target group within a radius of either 600 meters (Galster et al., 1999; Santiago et al., 2001; Schwartz et al., 2006) or 1000 meters (Van Duijn et al., 2016). Van Duijn et al. (2016) start with a rather large target group radius of 1 kilometer, to ensure that no treated houses fall within the control group (the group of houses that are farther from the redevelopment and therefore do not receive treatment). Subsequently, they work towards a smaller target area, depending on robustness checks, to see how far the external effects reach and how they decay with distance. This strategy is considered an accurate way to approach distance in this type of study, due to the difficulty to predict the extent of the external effects, if there are any, ex ante. Checking how the effects decay over distance is done by interacting the different dummy variables of the empirical model (BEFORE, BETWEEN, AFTER and TREND) with the distance and squared distance between the transaction and Utrecht Central Station, in meters.

It is important to note the underlying assumption of this method, being: the target and control group(s) are identical. Substantial differences between target and control groups can result in inconsistent estimates of the external effect (Ashenfelter and Card, 1985; Abadie, 2005) and should therefore be minimized. In order to minimize the differences, both Koster and Van Ommeren (2013) and Van Duijn et al. (2016) use a matching procedure. With this procedure, neighborhoods are marked as 'comparable' using a propensity score, which is estimated by means of a probit or logit regression based on several characteristics (Koster and Van Ommeren, 2013; Van Duijn et al., 2016). The method used by Koster and Van Ommeren (2013) and Van Duijn et al. (2016) is practical in cases when it is necessary to select multiple target and control area's based on neighborhoods in a variety of municipalities. However, since this paper focusses on only one case and the effect within one municipality, it uses only one target and one control group. Therefore, the matching method is considered too comprehensive and out of scope. Determining only one control group is possible by means of descriptive statistics, which will be conducted in paragraph 3.4, after expounding the empirical model in paragraph 3.3.

In summary, the selected quantitative research method entails a hedonic pricing model, with DID application based on three time periods and two separate but comparable groups of house transaction prices within different distances from UCS. It estimates the effects of externalities of the redevelopment of UCS and its adjacent areas, amongst the effects of a variation of, observation-depending, structural housing and locational characteristics, on transaction prices near UCS compared to transaction prices further away.

3.3 Empirical model

To prepare the dataset (which is described in paragraph 3.1) for further statistical analyses, different variables need to be checked on normality and the assumptions for linear regression (OLS). Some variables were transformed to obtain the most accurate estimation results, as shown in table 1. The Ordinary Least Squares assumptions and their consequences are described in Appendix D. The most important transformations of the variables are explained below, followed by the empirical model.

Starting with the dependent variable - the transaction prices of the sold houses - plotting the frequency of the different transaction values results in a histogram showing a skewed, non-normal distribution (see appendix D). This problem is a common phenomenon in house price analyses and can be resolved by transforming the variable into a natural logarithm. An advantage of exploiting a log-linear model is that the regression coefficients, the main results of this study, can be interpreted as the percentage of change in house prices over time. The variables M2 (the total surface of the house in square meters) and the number of rooms were transformed in the same manner, since neither displayed a normal distribution. Furthermore, due to the relatively large distributions, these variables are best suited to the analyses in the form of ratio variables. Most of the remaining control variables are transformed into dummy variables to overcome non-normal distributions. By adding time fixed effects (dummy variables based on transaction year) into the model, the need to deflate the transaction prices is dismissed. In addition, by adding neighborhood fixed effects (dummy variables indicating different postal codes), omitted variable bias and correlations in error terms can be minimized. See appendix D for further explanations and procedure regarding of the OLS assumptions.

After describing the applicable quantitative research methods and transforming variables when needed, the empirical model can be specified as follows:

$$\ln(P_{itd}) = \beta_0 + \beta_1 T_i + \beta_2 T_i P_1 + \beta_3 T_i P_2 + \beta_4 T_i D_i + \beta_5 T_i P_1 D_i + \beta_6 T_i P_2 D_i + \beta_7 T_i D_i^2 + \beta_8 T_i P_1 D_i^2 + \beta_9 T_i P_2 D_i^2 + \beta_{10}(t_i - y_a) T_i P_1 + \beta_{11}(t_i - y_s) T_i P_2 + \beta_{12}(t_i - y_a) T_i P_1 D_i + \beta_{13}(t_i - y_s) T_i P_2 D_i + \beta_{14}(t_i - y_a) T_i P_1 D_i^2 + \beta_{15}(t_i - y_s) T_i P_2 D_i^2 + \beta_{16} Y_t + \beta_{17} C_i + \beta_{18} X_{kit} + \beta_{19} N_{it} + \varepsilon_{it} \tag{1}$$

where P_{itd} denotes the transaction price of property *i*, in transaction year *t*, located within a certain distance range *d* from Utrecht central station; β_0 is a constant reflecting a minimum transaction value, if all other variables to estimate were 0; T_i is a dummy variable taking 1 if the sold property is within the target area; P_1 denotes the period between announcement and start of the redevelopment; P_2 denotes the period after start of the redevelopment, where the construction activities are clearly noticeable; D_i is the Euclidean or straight-line distance in meters from the sold property to UCS; y_a reflects the year and month (May, 2002) of the announcement; y_s reflects the year and month (December, 2009) of the start of the redevelopment; Y_t is a vector of dummy variables taking one for year *t* and zero otherwise; C_i is a vector of dummy variables based on 4-digit postal codes, taking 1 if the house is located within the certain postal code; X_{kit} are structural characteristics *k* of property *i* sold in year *t*, which are described in Table 1; N_{it} is a characteristic of the street surrounding the house, measured in year *t*, depending on where property *i* is located; ε_t is an (idiosyncratic) error term; β_1-β_{19} are parameters to be estimated.

As mentioned in paragraph 3.2, the model uses interaction variables, including time and distance (T_i*P_x*D), to investigate the external effect of the redevelopment of Utrecht central station on house price. These variables are considered to generate the main results for this paper and can be explained as follows. First, a distance ring dummy (T_i = BEFORE_A) is included, if the location of property *i* falls within the target group *r*. Second, a dummy (T_i * P_1 = BETWEEN_AS) is included if the location of the property *i* falls within the target group *r* and the year of transaction falls within the period between the moment of announcement and start of the redevelopment y. The BETWEEN variable should capture some of the early anticipation effects without the presence of real changes in the environment. A third dummy is included (T_i * P_2 = AFTER_S) if the location of the property falls within the target group and if the property is sold after start of the redevelopment. This variable should capture the effect of the changing environment on house prices near the central station, up to the opening of the new central hall. It should be noted, however, that the coefficient of this variable can change as the building process progresses.

As mentioned in paragraph 3.2, time TREND variables are included to capture the anticipation effects in more detail over time. The first TREND variable ($(t_i - y_a) * T_i * P_1$) = TREND_ BETWEEN_AS) calculates the time difference between the transaction and the moment of announcement of the redevelopment, if the property is sold after the announcement but before start of the redevelopment and is located within the target area. The second TREND variable ($(t_i - y_s) * T_i * P_2$) = TREND_ AFTER_S) measures the time difference between the transaction and the start of the construction period, if the property is sold after the start of the reconstruction and is located within the target area. Both TREND variables allow to check whether the degree of external effects (or anticipation effects) changes linearly over time (Van Duijn et al., 2016) and they will be measured on a monthly level[2].

In addition, each of the above described distance ring variables are interacted with the straight-line distance to the train station (D) and the square of this distance variable (D^2). These spatial components measure the distance decay of the external effects and check whether the decay is linear, concave or convex.

The next paragraph reviews which group of transactions, within a certain radius farther than 1 kilometer from UCS, is most comparable with the group in the initial target area (all transactions within 1 kilometer from UCS). After defining a suitable control group, equation (1) will be applied to the data. The main results of this quantitative analysis are described in chapter 4.

After estimating the complete model, the assumptions on the error term are checked (see Appendix D). The post-estimation diagnostics indicate that the residuals are heteroscedastic and not normally distributed. To overcome the heteroscedasticity, the different specifications (see results) of equation (1) are estimated with White's robust standard errors. The non-normal distribution of the errors indicate that the estimators might not be BLUE (Best Linear Unbiased Estimators).

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[2] A TREND variable which could estimate the linear price change over time in the period BEFORE the announcement of the redevelopment is left out, due to earlier testing results, which indicated insignificant differences between the target and control group BEFORE the announcement of the redevelopment.

3.4 Descriptive statistics

In order to select a control group that is most comparable with the target group of this study, the descriptive statistics of the included variables of the target group – with transactions within a radius of 0 to 1000 meters from UCS – are compared to the descriptive statistics of three different, circular groups of transactions with a distance farther from UCS. As mentioned before, transactions with a distance larger than 2500 meters from UCS are dropped, mainly due to missing (government) data. An advantage of dropping these transactions is the increase in comparability of the possible control groups with the target group. Due to the adjacency of the old city center - with its specific characteristics such as building period and type of housing - to the station, comparable statistics will more likely be found in a control group that is also located within the city center, as opposed to a control group in the outer districts. In order to test this expectation, the control groups selected for comparison are: 1) transactions between 1001 and 2000 meter from UCS, 2) transactions between 1501 and 2500 meters from UCS and 3) transactions between 1001 and 1500 meter from UCS. The results indicate that control group 3 is most comparable. As shown in table 2, the statistics of the key variables of the target group and control group 3 either have the same value or differ with 1 or 2 percent. The descriptive statistics of the other control groups, which were also highly comparable, are shown in appendix B.

It is important to note that hedonic pricing requires a sufficient amount of transactions in the target and control group, in each estimation period. The total amount of observations in both the target group and control group 3 (6,420 and 11,086, respectively) should meet this requirement, since the model is based on only two structural breaks, as mentioned in paragraph 3.2. In order to examine the common trend assumption of DID models, the average transaction prices of each (half) year in the study period are plotted in figures 3 and 4. These graphs indicate that the average prices of all four groups follow a similar path (see figure 3), but that they differ in terms of volatility (see figure 4, left and right panel). No clear distinction is shown between the paths of the groups between the pre-treatment and after-treatment periods. Therefore, in Appendix C, the right panel of figure 4 is enlarged. This figure in Appendix C shows that the average transaction price of the target group increases relatively steeply after the announcement of the redevelopment (the first after-treatment period). The opposite occurs after the start of the construction period (the second after-treatment period). Whether these results are a direct effect of the redevelopment of UCS, if the possible effects are significant and how far they reach will be examined by means of further analysis.

Table 2 | Descriptive Statistics, micro data transactions, target group and control group 3

	Target group	*6,420 observations*		*Control group 3*	*11,086 observations*	
Variable	**Mean (Std.Dev.)**	**Min**	**Max**	**Mean (Std. Dev.)**	**Min**	**Max**
Transaction_price	233.303 (112.743)	51.731	1.225.000	231.156 (124.696)	53.092	1.600.000
DISTANCE_Station_meters	800(144)	269	1.000	1.271(144)	1001	1.500
Year	2006(5,8)	1996	2016	2007(5,7)	1996	2016
Month	6,6(3,4)	1	12	6,6(3,4)	1	12
M2	94,0(37,5)	26	395	95(37,9)	26	400
Rooms	3,5(1,4)	1	12	3,7(1,4)	1	12
Heating (1=central heating)	0,36(0,48)	0	1	0,82(0,38)	0	1
Street_Type (1=busy)	0,28(0,17)	0	1	0,46(0,21)	0	1
Ground_Lease (1=yes)	0,39(0,49)	0	1	0,27(0,45)	0	1
Rented_partially (1=yes)	0(0,05)	0	1	0(0,03)	0	1
Monument (1=yes)	0,04(0,19)	0	1	0,03(0,16)	0	1
Single_familyDUM (1=yes)	0,29(0,46)	0	1	0,36(0,48)	0	1
ParkingDUM (1=yes)	0,1(0,3)	0	1	0,08(0,27)	0	1
WellMaintainedGardenDUM (1=yes)	0,13(0,33)	0	1	0,16(0,37)	0	1
Inside_maintenanceDUM (1=yes)	0,02(0,12)	0	1	0,01(0,12)	0	1
Outside_maintenanceDUM (1=yes)	0,01(0,1)	0	1	0,01(0,09)	0	1
IsolationDUM (1=yes)	0,69(0,46)	0	1	0,69(0,46)	0	1
BalconyDUM (1=yes)	0,34(0,47)	0	1	0,35(0,48)	0	1
RoofterraceDUM (1=yes)	0,17(0,38)	0	1	0,16(0,37)	0	1
Construction_unknown (1=yes)	0(0,07)	0	1	0(0,04)	0	1
Construction_1500_1905 (1=yes)	0,3(0,46)	0	1	0,22(0,42)	0	1
Construction_1906_1930 (1=yes)	0,34(0,47)	0	1	0,37(0,48)	0	1
Construction_1931_1944 (1=yes)	0,05(0,22)	0	1	0,13(0,33)	0	1
Construction_1945_1959 (1=yes)	0,01(0,09)	0	1	0,03(0,18)	0	1
Construction_1960_1970 (1=yes)	0,01(0,08)	0	1	0,06(0,24)	0	1
Construction_1971_1980 (1=yes)	0,03(0,17)	0	1	0,01(0,08)	0	1
Construction_1981_1990 (1=yes)	0,04(0,21)	0	1	0,03(0,16)	0	1
Construction_1991_2000 (1=yes)	0,17(0,38)	0	1	0,08(0,27)	0	1
Construction_after_2000 (1=yes)	0,05(0,22)	0	1	0,06(0,25)	0	1
House_intermediate (1=yes)	0,25(0,44)	0	1	0,31(0,46)	0	1
House_terraced (1=yes)	0(0,04)	0	1	0(0,04)	0	1
House_corner (1=yes)	0,03(0,18)	0	1	0,05(0,22)	0	1
House_SemiDetached (1=yes)	0(0,05)	0	1	0(0,06)	0	1
House_detached (1=yes)	0(0,06)	0	1	0(0,06)	0	1
Appartment (1=yes)	0,71(0,46)	0	1	0,64(0,48)	0	1
Kitchen0 (1=yes)	0,28(0,45)	0	1	0,27(0,44)	0	1
Kitchen1 (1=yes)	0,69(0,46)	0	1	0,71(0,46)	0	1
Kitchen2 (1=yes)	0,03(0,16)	0	1	0,02(0,16)	0	1
Kitchen3 (1=yes)	0(0,05)	0	1	0(0,05)	0	1
Bathroom0 (1=yes)	0,12(0,32)	0	1	0,13(0,33)	0	1
Bathroom1 (1=yes)	0,84(0,36)	0	1	0,83(0,37)	0	1
Bathroom2 (1=yes)	0,04(0,19)	0	1	0,04(0,19)	0	1
Bathroom3 (1=yes)	0(0,06)	0	1	0(0,04)	0	1
Toilet 0 (1=yes)	0,1(0,3)	0	1	0,09(0,29)	0	1
Toilet 1 (1=yes)	0(0)	0	0	0(0)	0	0
Toilet 2 (1=yes)	0,17(0,38)	0	1	0,16(0,36)	0	1
Toilet 3 (1=yes)	0,49(0,5)	0	1	0,49(0,5)	0	1
Toilet 4 (1=yes)	0,01(0,1)	0	1	0,006(0,08)	0	1
Toilet 5 (1=yes)	0,16(0,37)	0	1	0,19(0,39)	0	1
Toilet 6 (1=yes)	0,04(0,2)	0	1	0,04(0,2)	0	1
Toilet 7 (1=yes)	0,006(0,08)	0	1	0,006(0,08)	0	1
Toilet 8 (1=yes)	0,01(0,1)	0	1	0,01(0,1)	0	1
Toilet 9 (1=yes)	0,004(0,7)	0	1	0,004(0,06)	0	1
Toilet 10 (1=yes)	0,001(0,4)	0	1	0,000(0,26)	0	1

Note: The table reports the descriptive statistics of the transformed variables that are included in the empirical model, with Transaction_price as dependent variable.

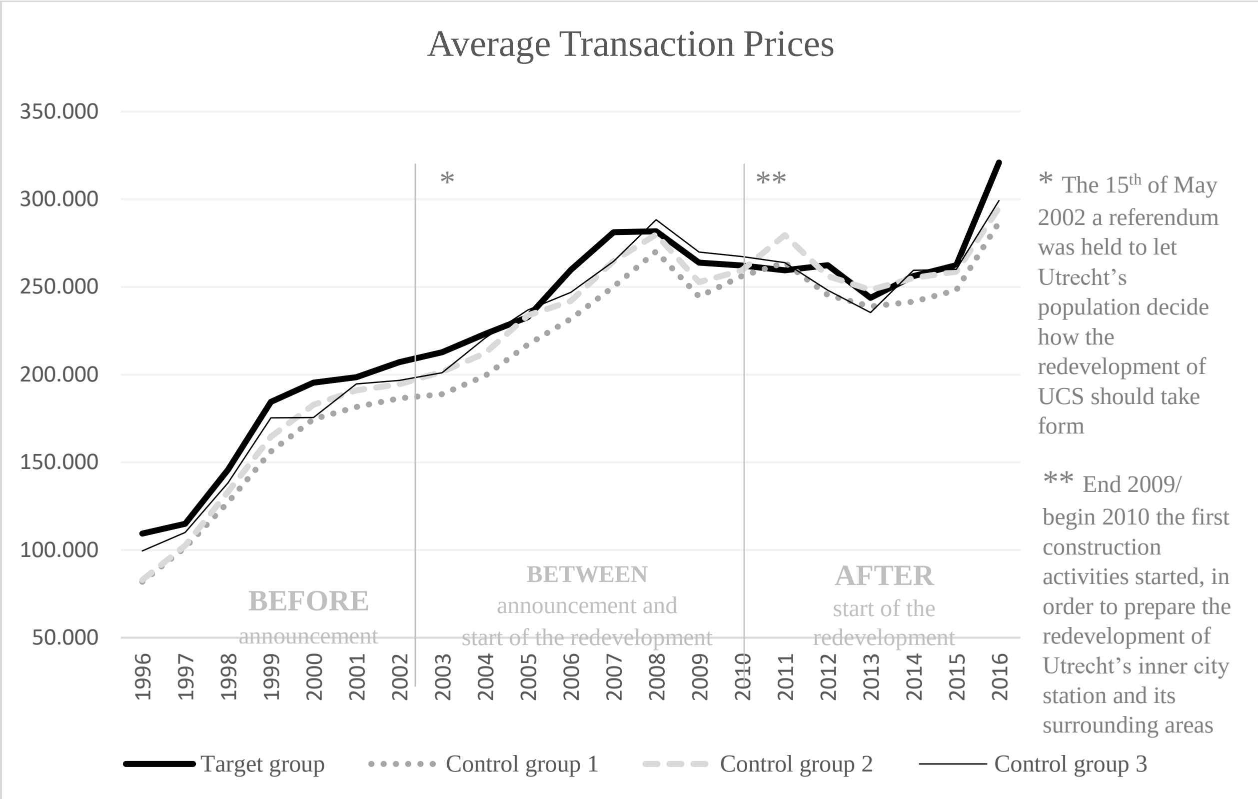


Figure 3 | Average Yearly Transaction Prices of the target group and the control groups

Note: The figure maps the average yearly transaction prices of houses within the target group and the three control groups.

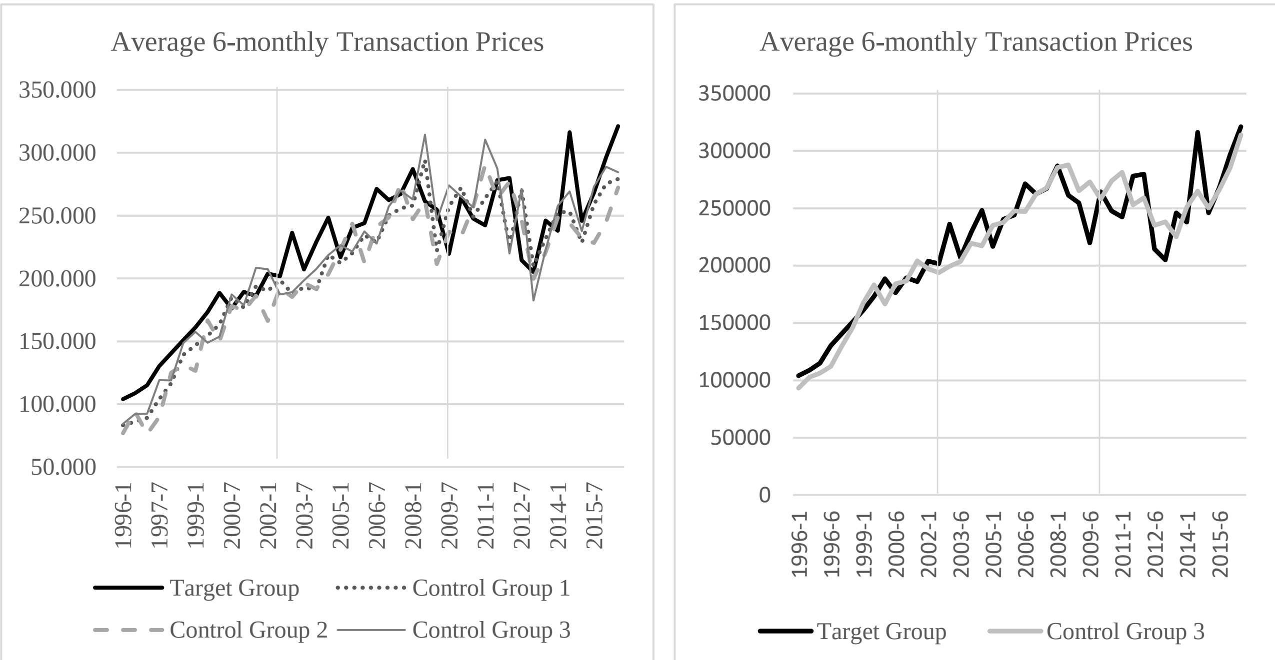


Figure 4 | Average 6-monthly Transaction Prices of the target group and the control groups

Note: The figure maps the average 6-monthly transaction prices of houses within the target group and the three control groups (left panel), and the average 6-monthly transaction prices of houses within the target group and control group 3 (right panel).

3.5 Qualitative research method

This paragraph will discuss the qualitative methodology that is necessary to answer the fourth, supplementary sub question of this thesis:

> "*To which extent are anticipation effects considered in policy- and decision-making regarding comprehensive inner-city redevelopment projects, focusing on the redevelopment of Utrecht Central Station?*'

The inductive character of qualitative research, as a supplement to the deductive approach of the selected quantitative research methods, will provide a more in-depth understanding of this thesis' topic. Conducting interviews with key policymakers regarding the case study, will lead to gaining additional information and new insights, which quantitative methods cannot provide and are perhaps unexpected (Boeije et al. 2009; Fielding, 2012) According to Dunn (2010), interviews not only provide the opportunity to fill gaps in knowledge that cannot be filled by other methods, but they also have several other strengths. Interviews are useful when studying complex motivations, they can provide insights into the diversity of opinions and experiences and they may also present an occasion for the participants to reflect on their experiences and thoughts (Dunn, 2010). This last 'strength' could be very useful regarding external effects of redevelopment projects like Utrecht Central Station. When the discussion concerning the topic is facilitated, this could lead to Aldermen and other policymakers developing new insights, by reflecting on their previous decisions and the course of events.

Since the interviews are intended as an addition to this study's core research method, they will be semi-structured. The intended structure can be described as follows: every interview starts with a discussion regarding ethical considerations, followed by a short personal introduction, a discussion on the role of the participant in the redevelopment of UCS and their professional experience (with other projects), the purpose of the interview, the intended structure of the remainder of the interview, the establishment of consensus about the definitions of the main topics, finalizing with a discussion on the main results of the thesis and the previously formulated questions.

Ethical considerations, such as anonymity of the interviewees and the way of recording and using their statements, are discussed prior to the actual interview, in order to establish a confidential relationship. This could result in gaining more in-depth insights and opinions from the interviewees and guarantees that the processing of the results is ethically justified. By discussing the intended structure and by using an interview guide, interviews become more comparable. Comparability in structure maximizes the reliability of the general results. The challenging task of analyzing and combining different opinions and experiences, keeping in mind that the participants all have or had a different role regarding the case study, would become more difficult if they were not structured in the same way (Boeije et al., 2009).

After the introduction, the six questions shown in textbox 3.1 will be discussed. Questions 3, 4, 5 and 6 form the core of the interviews and will be illustrated with the practical examples in parentheses if necessary. Question 7 gives the participant the opportunity to provide additional information and address sub-topics that might have been overlooked by the interviewer. This enhances objectivity and ensures complete coverage of all the issues regarding the research topic. Since the case study and overarching topics are clearly delineated, differences in length between the interviews and differences in dates conducting the interviews, should not present a problem regarding comparability. In addition, to gain insights in the course of events from different points of view, stakeholders with different roles regarding policy- and decision-making in the redevelopment (the executive secretary of the project organization 'Station Area', responsible for all documentation concerning the redevelopment; the real estate program manager of the station area; the former Alderman, responsible for managing the train station area portfolio) are selected to interview. Due to the fact that these key stakeholders are limited and therefore are unquestionably identifiable, makes selecting respondents clear.

After all interviews have been conducted, the audio recordings are transcribed (see appendix F) and analyzed by means of a three-step-coding system (see appendix G, H and I). The coding system is based on the latent content analysis approach, as described by Hay (2010). This approach suits the content-focused semi-structured interviews - where the questions are ordered but flexible - because it sorts the gathered data based on meanings and topics. This makes combining the different interviews easier and ensures that a certain topic is understood well (Hay, 2010). The operational steps of this method are: 1) the coding of all statements in the transcripts separately, using different colors (i.e. *open coding*), 2) sorting and combining the parts of the different transcripts with the same or comparable codes (i.e. *axially coding)*, and 3) merging possible overlay between the statements of the different transcripts, changing or merging different codes if possible and deleting irrelevant statements or codes (i.e. *selective coding)*. It is important to note that analyzing interviews and transcripts is an iterative process. This means that it might be necessary to go back and forth between the different steps and adjust codes throughout the process, to ensure optimal results. The definitive coding of the transcripts can be found in Appendices G, H and I. Some sections in the transcripts have been given multiple codes and other sections, concerning irrelevant matters, have not been transcribed or coded.

Textbox 3.1

Opening question, before discussing the main results of the study:

1. *What is your knowledge of external effects and anticipation effects and how would you define them?*

Questions after the introduction section of the interview:

2. *Are you familiar with external effects and anticipation effects as described in this thesis (construction noise, view on the work site, road blocks)?*
3. *Why and to what extent do you consider these external effects and anticipation effects to be important?*
4. *Why and to what extent do you, or does your team, take into account such effects in development projects (providing information to the residents about activities, financial consequences such as compensation measures or changing tax income)?*
5. *To what extent do you think external effects and anticipation effects specifically are considered in CBA's or SCBA's (example of the redevelopment of the ZuidasDok in Amsterdam, where external effects are clearly mentioned in the financial analysis)?*
6. *If more research into external effects of redevelopment projects is conducted in the future, and a more generalized effect can be described, why and to what extent/in what form do you think this would lead to a standard inclusion of these effects in CBAs or SCBAs?*
7. *Do you have additional comments?*

4. Results quantitative analyses

This chapter will discuss the estimation results of the difference-in-difference hedonic price model. The effect of the reconstruction of the Utrecht Central Station area on house prices near the station compared to house prices farther from the station, in three different time periods, is analyzed. First, the main estimation results of the core variables – BEFORE, BETWEEN and AFTER – and their interaction with distance are discussed in paragraph 4.1, followed by a discussion on the results of an additional sensitivity analysis in paragraph 4.2.

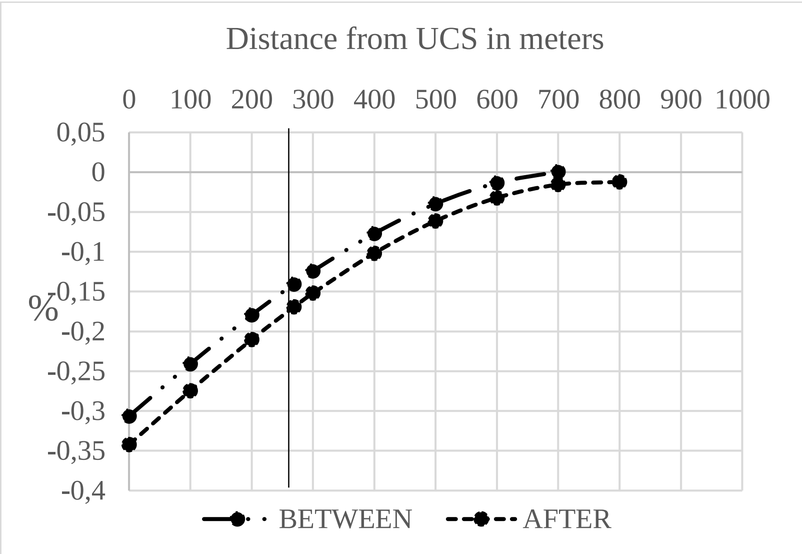
4.1 Main results hedonic price model

Table 3 shows the key coefficients and standard errors for the hedonic price model for the effect of the reconstruction of Utrecht Central Station on surrounding house prices. The results are displayed using various specifications, starting with only the core variables and the time fixed effects in the first (naïve) specification of equation (1) (column 1), followed by adding more control variables throughout the subsequent specifications (2), (3) and (4), until all control variables are included in specification (5). The target area is specified as all transactions between 0 and 1000 meter from Utrecht Central Station; the control area is defined as all transactions between 1001 and 1500 meters from Utrecht Central Station. As shown by the table, adding more control variables results in a higher R-squared, which is close to 0.9 in specification (5). This value is comparable to those in the fundamental studies on which this research is built (see Schwartz et al., 2006 and Van Duijn et al., 2016) and indicates a good fit of the model.

Looking at the different columns in table 3, the main BEFORE variable shows significant positive coefficients in specification (1), (2) and (3). The coefficients remain positive throughout the different specifications, but become smaller and insignificant after adding neighborhood fixed effects (the 4-digit postal codes) in specification (4) and both neighborhood fixed effects and the time-depending neighborhood characteristic in specification (5). The insignificance of the BEFORE variable in the - due to the highest level of explained variance, preferred and most comprehensive – fifth specification, indicates that prior to the announcement of the redevelopment of UCS, there were no significant differences between (the course of) the house prices close to the train station and house prices further away.

The BETWEEN and AFTER variables show contrary behavior throughout the five specifications (see table 3). Starting with the BETWEEN variable, it gives consistently negative estimation results throughout the 5 specifications, however only after controlling for the different housing characteristics the results become significant. The negative estimator of the BETWEEN variable in specification (5), BETWEEN = -0.366, indicates that house prices within a range of 0-1000 meters from Utrecht central station are negatively influenced by the redevelopment in the period between announcement and start of the construction activities. Also the AFTER variable shows consistent negative esimation results in specifications (1) to (5). The negative estimation result of this variable in specification (5), AFTER = -0.419, indicates that house prices are negatively impacted by the redevelopment, from the moment of start of the construction period up to the opening of the new central hall of the trainstation.

Due to the fact that there are no houses located directly adjacent to or above the central hall of Utrecht Central station, the estimated coefficients of the two treatment periods can only be interpreted as relative price effects in actual percentages, after combining the general coefficients of those two time periods with the estimated coefficients of the interaction variables. The smallest distance in the sample is 269 meters. Starting from this point, the combined coefficients indicate that the nearest houses sold for -14.05% (= (Exp(-0.366+0.000969*269+-6.36e-07*269*269)-1)*100) after the announcement of the redevelopment, compared to the houses within a distance of 1001 to 1500 meters from UCS. This effect in the 'BETWEEN' period decays concavely when distance increases, and ceases to exist after 700 meters from the central hall of UCS. In the period after the start of the actual construction activities, up to the opening of the new central hall of the inner-city station, the nearest houses experience a negative price effect of -16.93% (= (Exp(-0.419+0.00105*269+-6.77e-07 *269*269)-1)*100) compared to the houses in the control group. This effect also decays concavely with distance, but reaches houses up to 800 meters from the train station. The slopes of the effects are shown in figure 5. Because both effects are considered to decay within, but closely to the border of the initial target area, no additional analyses are executed with the use of a smaller target area. The negative estimation results imply that a relatively negative price shock occurred in the treatment area after the redevelopment of the UCS area was announced and that house prices of the target group endured an even larger negative shock after the start of the actual construction period.



Note: The figure maps the distance decay of the found price effects for the BETWEEN and AFTER period.

Figure 5 | Distance decay price effects

Table 3 | Estimation results equation (1) Target group & Control group 3

	(1)		(2)		(3)		(4)		(5)	
Sample size	<1501 m		<1501 m		<1501 m		<1501 m		<1501 m	
Target area	0-1000 m		0-1000 m		0-1000 m		0-1000 m		0-1000 m	
Control area	1001-1500 m		1001-1500 m		1001-1500 m		1001-1500 m		1001-1500 m	
BEFORE_announcement	0.559***	(0.116)	1.134***	(0.130)	0.186***	(0.0686)	0.0124	(0.0603)	0.0117	(0.0606)
BETWEEN_announcement and start	-0.117	(0.230)	-0.199	(0.227)	-0.301**	(0.122)	-0.360***	(0.108)	-0.366***	(0.108)
AFTER_start	-0.222	(0.353)	-0.327	(0.328)	-0.340**	(0.156)	-0.420***	(0.147)	-0.419***	(0.147)
BEFORE*distance (in meters)	-0.00169***	(0.000340)	-0.00321***	(0.000370)	-0.000570***	(0.000198)	-5.43e-05	(0.000171)	-5.30e-05	(0.000172)
BEFORE*distance^2	1.29e-06***	(2.48e-07)	2.18e-06***	(2.61e-07)	4.19e-07***	(1.41e-07)	6.88e-08	(1.21e-07)	6.80e-08	(1.21e-07)
BETWEEN*distance	0.000267	(0.000650)	0.000550	(0.000640)	0.000795**	(0.000342)	0.000954***	(0.000301)	0.000969***	(0.000301)
BETWEEN*distance^2	-1.44e-07	(4.57e-07)	-3.67e-07	(4.48e-07)	-5.06e-07**	(2.38e-07)	-6.27e-07***	(2.08e-07)	-6.36e-07***	(2.08e-07)
AFTER*distance	0.000765	(0.000941)	0.00107	(0.000885)	0.000909**	(0.000425)	0.00106***	(0.000397)	0.00105***	(0.000397)
AFTER*distance^2	-6.70e-07	(6.23e-07)	-8.88e-07	(5.91e-07)	-6.29e-07**	(2.86e-07)	-6.79e-07**	(2.66e-07)	-6.77e-07**	(2.66e-07)
TREND_BETWEEN	-0.0439	(0.0534)	-0.0164	(0.0503)	0.0102	(0.0253)	0.00865	(0.0223)	0.00994	(0.0223)
TREND_AFTER	0.0413	(0.0811)	0.0602	(0.0759)	0.0487	(0.0358)	0.0531	(0.0337)	0.0528	(0.0337)
TREND_BETWEEN*distance	0.000146	(0.000147)	7.16e-05	(0.000140)	-1.97e-05	(6.92e-05)	-2.54e-05	(6.16e-05)	-2.86e-05	(6.17e-05)
TREND_BETWEEN*distance^2	-1.23e-07	(1.01e-07)	-7.12e-08	(9.65e-08)	9.65e-09	(4.72e-08)	1.96e-08	(4.20e-08)	2.17e-08	(4.21e-08)
TREND_AFTER*distance	-0.000119	(0.000213)	-0.000175	(0.000202)	-0.000109	(9.57e-05)	-0.000126	(8.97e-05)	-0.000125	(8.97e-05)
TREND_AFTER*distance^2	9.90e-08	(1.39e-07)	1.39e-07	(1.32e-07)	7.05e-08	(6.31e-08)	8.03e-08	(5.89e-08)	7.97e-08	(5.89e-08)
Year dummies/ Time fixed effects	YES		YES		YES		YES		YES	
Construction period dummies	NO		YES		YES		YES		YES	
House characteristics on moment of transaction	NO		NO		YES		YES		YES	
4-digit postcode dummies	NO		NO		NO		YES		YES	
Time depending neighborhood characteristic	NO		NO		NO		NO		YES	
Observations	17,506		17,506		17,506		17,506		17,506	
R-squared	0.285		0.407		0.841		0.886		0.886	

Note: Dependent variable is ln(transaction price). The coefficients of the control variables for specification (5) can be found in Appendix E, together with the coefficients of specification (5) with the other control groups. The other coefficients can be obtained from the author. Robust standard errors are reported between parentheses.

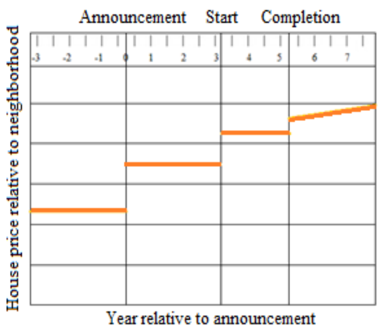
*** p<0.01
** p<0.05
* p<0.1

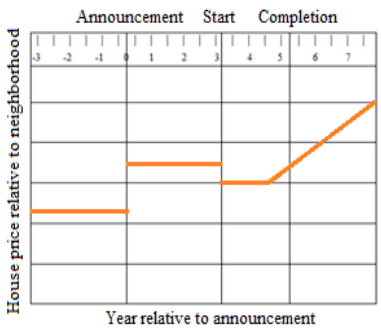
Considering the hypotheses formulated in chapter 2, these results contradict the expectations derived from previous studies in a number of ways. Firstly, in adherence to the study of Schwartz et al. (2006) and the timeline of the right panel of figure 2, house prices in the vicinity of Utrecht Central Station were *expected to increase prior to the start of the redevelopment, from the moment of announcement of the redevelopment project (hypothesis 1).* As discussed above and shown in table 3, this is not the case in the redevelopment of Utrecht Central Station. Henneberry (1998) did find a modest direct positive relationship between the distance of a property to a future tramline and its price, however the size of this effect is non-comparable to the results found in this paper. The significant negative estimation results of the BETWEEN variable reject the first hypothesis on a 99% significance level.

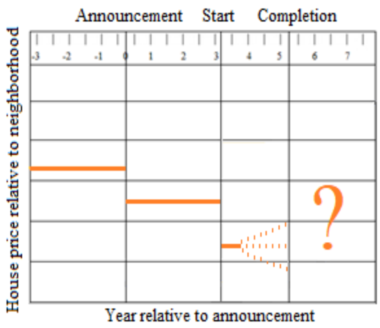
The negative price effects in the announcement period of this case study (the BETWEEN variable) imply that the announcement of the redevelopment has been disadvantageous to nearby houses. While the initiators of the project started the redevelopment (plans) from the point of view that the train station and its surrounding areas represented the disamenity, due to a lack of viability, social security, maintenance and culture (cu2030, 2017a; see paragraph 1.3). It may well be that the residents of the treatment area did not experience the train station (and surrounding areas) as a disamenity just before the announcement. A logical explanation for this could lie in the trade-off between the combination of the high amount of amenities and the high degree of accessibility of the inner-city area surrounding the train station on one hand - as explained in paragraph 2.2 (Brueckner et al., 1999; Benjamin and Sirmans, 1996) -, and the level of experienced social insecurity or disturbance on the other (Smith, 2004; Harding et al., 2007; Ahlfeldt et al., 2013), regarding the attractiveness of the living environment. If this trade-off is the underlying motivation for the choice to own and occupy a home in the area, one might argue that the announcement of the redevelopment shifted the trade-off towards more disturbance and less accessibility and therefore towards more disadvantages than advantages to live in the area around the train station, compared to other areas further away. It is plausible that the change in people's perception of the area, in this case, did not set course in a positive direction, as Van Duijn et al. (2016) suggest in their study. The intended future improvements in appearance and quality that, according to the findings of Ahlfeldt et al. (2011; 2013), Brooks and Philips (2007), Brueckner et al. (1999), Chen and Rosenthal (2008), Cheshire and Sheppard (1995); Ioannides (2003) and Koster and van Ommeren (2013) and Van Duijn et al. (2016), should lead to the creation of external effects in the form of increased property prices, are not anticipated positively by the housing market actors in the pre-construction period of this case study.

The second hypothesis, *'house prices in the vicinity of the Utrecht Central Station decrease after the start of the redevelopment',* cannot be rejected based on the results of this study, since the analyses also result in a negative coefficient for the main AFTER variable. This result is in line with Henneberry's (1998) findings, which discuss the possibility of negative external effects of a redevelopment due to the existence of a variety of disturbances and damages to the environment, caused by the construction work.

Contrary to these findings, as discussed in chapter 2, Schwartz et al. (2006) argue that actors on the housing market would foresee the future revitalization of the area and would therefore positively anticipate on a redevelopment. In addition, they discuss the possibility that insecurities regarding the project could decrease due to the start of the construction activities. Positive anticipation effects, in the form of increasing house prices, could therefore appear even stronger in the AFTER-start-of-construction period. As reported above, the findings of this case study indicate the exact opposite. It is important to consider, however, that the redevelopment is not finished completely and that the case study is rather unique due to the complexity and duration of the project. These considerations make comparison between the findings of this study and the findings of others difficult, because the AFTER coefficient for the total construction period would likely deviate from the AFTER coefficient found for this study's AFTER period. In addition, if home-owners experienced or are still experiencing negative effects from the redevelopment, they would have to endure them for a substantial amount of time. This might outweigh the possible future enhancement of the quality of the area. The two hypotheses and results discussed above are presented in figure 6a to 6c, to provide a clear overview of the contradictory findings.







Note: Figures 6a to 6c show the contradictions between the hypothetical timeline regarding anticipation effects described by Schwartz et al. (2006), the alternative timeline of the combination of the studies from Schwartz et al. (2006) and Henneberry (1998) and the timeline of the anticipation effects found in this study.

Figure 6a | Hypothetical timeline Schwartz et al. (2006)

Figure 6b | Alternative timeline Schwartz et al. (2006) and Henneberry (1998) combined.

Figure 6c | Timeline results

The main TREND variables and the TREND variables interacting with distance all generate insignificant results. This implies that there are no general (linear) time trends in the price effects on a monthly basis, within the two after-treatment-time-periods. A possible explanation can be derived from the graphs in figures 3 and 4 (see chapter 3) and in Appendix C. The timeline of the average house prices per month in the target area is quite volatile. To check whether trend effects could be found on a higher, annual level, new TREND variables($(t_i - y_x) * T_i * P_x$) were included in a new specification of the hedonic price model. Estimating the model with these annual TREND variables, resulted in similar insignificant coefficients. Therefore, the third hypothesis of this study, '*house prices in the vicinity of the Utrecht Central Station increase approaching the completion date'*, cannot be tested. However, when taking a closer look at the figure in appendix C, it can be argued that house prices in the target area indeed started to increase as the construction project progressed. The question remains, whether this trend continues and becomes significant upon completion of the redevelopment in 2030 (or later).

Figure 5 shows that the *house price effects caused by the redevelopment of Utrecht Central Station decay over distance (hypothesis 4).* In addition, this decay is shown to be concave: within the distances of 700 and 800 meters from the train station, house prices decline relatively with 0,5 to 5 and 0,8 to 5,3 percentage points per 100 meters respectively, with a maximum of -14% and -17%. Therefore, the fourth hypothesis of this thesis cannot be rejected. The result that effects of a (re)development decay with distance can be seen throughout different studies, see for example Henneberry (1998), Schwartz et al. (2006), Debrezion et al. (2007), Koster and Van Ommeren (2013), Van Duijn et al. (2016). However, in this case, the effects are negative in both treatment periods, which is in conflict with the results of comparable studies (except the study of Henneberry (1998),which also finds a negative price effect in the BEWTEEN period): Debrezion et al. (2007) find a house price premium of 2.4 percent per 250 meters closer to a commuter train station, within a distance ring of approximately 1600 meters; the findings of Henneberry (1998) and Koster and Van Ommeren (2013) indicate positive house price effects on nearby houses with a maximum of 3 percent and Schwarz et al. (2006) conclude that the redevelopment of subsidized housing leads to the reduction of negative price differences by 15%, between houses in the direct vicinity of the building site and houses further away, within a ring of 600 meters. It is important to note, however, that many of these studies only measure the periods 'before and after construction'. As mentioned before, the extent of similarity between this study and others can only be reviewed properly when the analysis on the AFTER variable is repeated five years after completion of the project, because Schwartz et al. (2006) and Van Duijn et al. (2016) conclude that the effects of a redevelopment can persist up to five years post-completion.

In answer to the second and third sub research questions of this paper, "*How do anticipation effects on house prices behave during the redevelopment process of Utrecht Central Station?"* and "*How do anticipation effects on house prices differ over distance, relative to Utrecht Central Station?'*, it can be concluded that the quantitative results of this study indicate that the redevelopment of Utrecht Central Station is negatively anticipated throughout the redevelopment process, from the moment of announcement to the reopening of the new central hall, and that these - local - negative anticipation effects decay with distance concavely. Above quantitative results provide this thesis with a clear policy relevance. The negative external effects on Utrecht's owner-occupier housing market affect inhabitants near the redevelopment area. Furthermore, if these negative anticipation effects are not considered in the development plan ex ante, a discrepancy may occur between the estimated project value and the actual value. Therefore, one could wonder why and to what extent the found external effects are, or why they are not, included in policy-making and project development. The possible application of the quantitative results of this thesis in decision- and policy making is discussed in chapter 5, fueled by interviews with key stakeholders of the researched redevelopment case.

4.2 Sensitivity analyses

In order to investigate the robustness of the estimation results, a sensitivity analysis is performed on the most comprehensive specification (specification 5), including all control variables. Sensitivity analyses are needed to check whether the estimated coefficients are stable, even when some conditions change. The initial results, as presented in Table 3, are estimated using a target group of transactions within 0-1000 meters from UCS and a control group of transactions within 1001-1500 meters from UCS. The target group proved to be properly defined after the analyses in paragraph 4.1, as the effects of the different time periods desist 700 to 800 meters from the central station. The initial control group was selected by evaluating the descriptive statistics of different possible control groups in the city of Utrecht. Since this method does not consist of precise measuring or statistical testing, the sensitivity of the results is checked by additional estimations of the model, replacing the initial control group with the other two control groups defined in paragraph 3.4. The results from this analysis can determine whether the coefficients hold between different estimations using different control groups. It guarantees that the initial results (using control group 3) are robust, even when another control group was picked beforehand. The results of the additional estimations are reported in table 4.

As shown in table 4, the estimation results differ slightly between control groups. Most striking is the coefficient of the BEFORE announcement variable, which is significant and larger when estimating the data sample containing transactions from the target area and control group 2. This could mean that differences concerning the houses and surrounding areas were (and perhaps still are) too large between both groups, causing significant results to be inevitable. Especially when keeping in mind that control group 2 contains the transaction prices of houses that are not adjacent to the target group, but further away. Despite the minor deviations and changes in significance of the BEFORE variable, the coefficients of all other variables maintain the same direction (mostly negative) when changing control groups. This indicates that the estimation results are robust. Besides changing control groups, new coefficients are also attempted to be estimated by replacing the initial neighborhood fixed effects, the 4-digit postal codes, for 6-digit postal codes. This estimation did not succeed due to the rather large amount (n = 3145) of postal codes in the sample group from 0-2500 meter from UCS.

Table 4 | Estimation results equation (1), specification (5) Target group & Control group 3, 2, 1

	(5) Control group 3		(5) Control group 2		(5) Control group 1	
Sample area	<1501 m		<2501 m		<2001 m	
Target area	0-1000 m		0-1000 m		0-1000 m	
Control area	1001-1501 m		1501-2500 m		1001-2000 m	
BEFORE_A	0.0117	(0.0606)	0.146**	(0.0609)	0.000743	(0.0591)
BETWEEN_AS	-0.366***	(0.108)	-0.337***	(0.111)	-0.369***	(0.108)
AFTER_S	-0.419***	(0.147)	-0.346**	(0.147)	-0.413***	(0.148)
BEFORE_A_D	-5.30e-05	(0.000172)	-0.000269	(0.000173)	2.55e-06	(0.000168)
BEFORE_A_DD	6.80e-08	(1.21e-07)	2.14e-07*	(1.23e-07)	3.61e-08	(1.19e-07)
BETWEEN_AS_D	0.000969***	(0.000301)	0.000870***	(0.000309)	0.000984***	(0.000303)
BETWEEN_AS_DD	-6.36e-07***	(2.08e-07)	-5.64e-07***	(2.14e-07)	-6.48e-07***	(2.09e-07)
AFTER_S_D	0.00105***	(0.000397)	0.000881**	(0.000401)	0.00103**	(0.000401)
AFTER_S_DD	-6.77e-07**	(2.66e-07)	-5.59e-07**	(2.69e-07)	-6.58e-07**	(2.68e-07)
TREND_BETWEEN_AS	0.00994	(0.0223)	0.0127	(0.0223)	0.00809	(0.0220)
TREND_AFTER_S	0.0528	(0.0337)	0.0456	(0.0339)	0.0480	(0.0341)
TREND_BETWEEN_AS_D	-2.86e-05	(6.17e-05)	-3.36e-05	(6.19e-05)	-2.54e-05	(6.12e-05)
TREND_BETWEEN_AS_DD	2.17e-08	(4.21e-08)	2.69e-08	(4.23e-08)	2.07e-08	(4.19e-08)
TREND_AFTER_S_D	-0.000125	(8.97e-05)	-0.000111	(9.07e-05)	-0.000113	(9.11e-05)
TREND_AFTER_S_DD	7.97e-08	(5.89e-08)	7.36e-08	(5.97e-08)	7.25e-08	(5.99e-08)
Year dummies/ Time fixed effects	YES		YES		YES	
Construction period dummies	YES		YES		YES	
House characteristics on moment of transaction	YES		YES		YES	
4-digit postcode dummies	YES		YES		YES	
Time depending neighborhood characteristic	YES		YES		YES	
Observations	17,506		32,069		32,375	
R-squared	0.886		0.874		0.888	

Note: Dependent variable is ln(transaction price). The coefficients of the control variables can be found in Appendix E. Robust standard errors are reported between parentheses.

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

5. Application of the quantitative results in practice

The quantitative results of this study have raised some questions regarding the relevance and importance of external effects on house prices in policy and decision-making. One could wonder why and to what extent the found external effects are, or why they are not, considered in policy-making and project development. In order to understand more about the possible role of external effects in extensive inner city redevelopment projects, several interviews were conducted with key stakeholders involved in real estate program management and political administrators, regarding the redevelopment of Utrecht Central Station. In these interviews, the quantitative results of this thesis and their possible application in practice are discussed. The main results of the interviews are explicated below. The results are derived from a latent content analysis, using a coding system on the transcriptions of the interviews. The (coded) transcriptions are added as appendices F, G, H and I.[3]

5.1 Main results interviews

The importance of the application of external effects and anticipation effects - either positive or negative - in urban planning and policy, is indicated by different studies regarding (re)development projects, see for instance Bajic (1982), Schwartz et al. (2006), Efthymiou and Anthoniou (2013) and van Duijn et al. (2016). The discussion on the role of these effects in decision-making regarding the case study, starts with detecting the level of awareness and knowledge on these effects amongst the involved teams and policymakers within the municipality of Utrecht. After discussing different definitions of external effects, it becomes clear that the existence of external effects, in its many different forms, is well known by the interviewees (and their colleagues). Where one interviewee speaks of intended external effects, in terms of for instance (temporary) increasing employment opportunities, another expresses his sympathy for the inhabitants of surrounding areas, alluding to the variety of disturbances that they need to endure caused by the redevelopment of the Utrecht Central Station area. He refers to the development site as a 'warzone' in time of construction, indicating the gravity of the nuisances and giving a possible explanation for the negative price effects found by the quantitative analysis in chapter 4.

The experienced importance of externalities in project development by the interviewees, becomes particularly evident in relation to compensation, the scope of the project and decision-making. For example, one interviewee argues that:

> "*from a political administrative role you have to think very carefully about the impact of the project on the immediate environment, because not only directly surrounding residents, but also residents living in other parts of the city form opinions about the city center, which* [due to the

[3] If not included, these appendices can be requested from the author.

increased extent of the possible support or resistance] *could have a significant influence on which decisions can be made* [regarding the redevelopment process and the appearance and functionality of the city center, of where the redevelopment site is located]*."*

The above indicated focus on external influence on the project caused by external effects, does not correspond with the suggestions of Schwartz et al. (2006) and Van Duijn et al (2016), who – presumable, due to their overall found positive external effects – mainly link the importance of the application of external effects internally, in financial analysis, to the coverage of costs. Contradictory to these suggestions, external effects are rarely quantified monetarily in the different sub-projects of the redevelopment of the Utrecht Central Station area. In cases where the effects are quantified, they continue to be disregarded and are not incorporated in final financial analyses ex ante. Neither in terms of the possible increasing or decreasing (tax) income for the municipality to finance the governments or municipals subsidies required, as suggested by Schwartz et al. (2007), nor in terms of compensation expenses. While earlier statements of the interviewees indicate that compensation is being provided, when damages or financial losses occur.

A repeated explanation for not quantifying or incorporating external effects in the overarching redevelopment plan is that external effects are considered to be more of a (temporary) locality and opposingly, the redevelopment should be beneficial to the city on a larger scale for an extensive amount of time. That the relative depreciation of housing could influence property tax income for the municipality is refuted by the interviewees, with the argument that the arrival of extra housing units and other real estate, and thus a growth in the volume of real estate in the area, removes or outweighs this temporary reduction in income. In addition, the interviewees state that the possibility of decreasing house prices in the station area during the redevelopment period (including the period from announcement to the start of the construction work) was not considered when planning the redevelopment. Although the interviewees currently acknowledge the existence of negative price effects, by arguing that they noticed that homes located in and near the construction area were unsellable during the redevelopment and that house prices decrease(d) due to disturbances - corroborating the negative external effects found in chapter 4 - they all emphasize the importance of a long term vision concerning effects on real estate markets. All interviewees are convinced that house prices will rise in the future and that, on balance, the project's outcome will be positive.

That external effects would impact housing values only locally is in line with the quantitative results of this thesis, as the negative price effects are shown to decay maximally within 531 meters from the first affected houses (800 – 269 meters) (see paragraph 4.1). This localized impact is consistent with the results of previous, fundamental studies (see Henneberry, 1998; Schwartz et al. 2006). Also the expected long-term effects are found in earlier research, as both Schwartz et al. (2006) and Van Duijn et al. (2016) indicate that positive effects can be measured up to five years after completion of a total redevelopment project. Therefore, in retrospect, one may suggest that the considerations of the initiators of the redevelopment project with regard to scope and scale and the long-term vision, could be justified.

Overall, the found anticipation effects are said to be irrelevant, unless households would have sustained significant financial losses. Households in the impacted area may not have faced financial losses absolutely, however, the results of the quantitative analyses indicate that they are disadvantaged relatively. Despite these relative losses, a former Alderman managing the train station area portfolio indicates that he did not worry about anticipation effects or disturbances regarding the impact on households in the area and that these effects did not affect his decision-making. He states that it is 'all-in-the-game' when you live in a city center. Additionally, he points out that a downward slope in house price development in the train station area was inevitable. He implies that if the area had not been redeveloped, house prices might have relatively decreased even more by this time, due to the declining quality of the area and increasing social insecurity in past decades. Corresponding with this reasoning, Schwartz et al. (2006) theorize on how disamenities could affect surrounding housing values. They indicate that, as in the case of environmental disamenties, a dilapidated building or other eyesore can reduce the value of neighboring homes, because it is visually unappealing or because it invites unwelcome activities like vandalism and crime. In the case of the Utrecht Central Station area, this unwelcome-activities-inviting property would have been the former shopping mall 'Hoog-Catharijne', where drug addicts sought shelter and caused social insecurity according to all interviewees. Besides above theory of Schwartz et al. (2006), the statements of the interviewees are generally also in line with the findings of Smith (2004), Harding et al. (2007) and Ahlfeldt and Richter (2013), which indicate that due to urban decline and ageing of the building stock, social quality of neighborhoods decline and therefore property prices decline.

Furthermore, according to the interviewees, the application of the results of this thesis in policy and financial analyses by public parties is difficult. They indicate that due to the fact that decisions by the municipality affect a great number of households, its course of action is often subject to criticism. Therefore, decision-makers are cautious about invoking matters that are not completely solid, especially when these matters suggest that some inhabitants could be disadvantaged by the municipality's decisions. Moreover, it is expected that the use of numbers, such as the expected decrease of housing values in surrounding areas during a construction period, would only lead to arguments against plans, even if a redevelopment could be beneficial on a larger scale.
However, despite the modest role of anticipation effects and external effects in municipal policy and decision-making, the participants suggest that the quantitative results of this thesis - and anticipation effects in general - can certainly be of interest in a commercial sense. They indicate that if a more general effect on house prices can be described or predicted for different stages of a redevelopment process, commercial parties could enhance their business cases regarding (re)developments in an already built

area. This enhancement, according to the interviewees, could for instance be found in: 1) lower (residual) land values in certain time periods, due to the relative decline of property values (as indicated by the quantitative results of this thesis) and stable construction costs, which could lead to a reduction of initial investments needed, 2) more accuracy in predicting what the first stage of the development will yield and therefore reducing feasibility risk, and 3) related to the first point, timing. By finding the right time to 'enter' – i.e. when land values are relatively low – and 'exit' – i.e. when values peak -, commercial businesses could profit maximally. The above, by the interviewees indicated, possible enhancements are recognized by Brueggeman and Fisher (2011), to be important in optimizing real estate development.

In answer to the fourth sub question, "*To which extent are anticipation effects considered in policy- and decision-making, regarding comprehensive inner-city redevelopment projects, focusing on the redevelopment of Utrecht Central Station?",* it can be concluded that anticipation effects are in a minor way considered in, but do not influence, policy- and decision-making regarding comprehensive inner-city redevelopment projects by public parties. In addition, the results of the qualitative analyses indicate that external effects can be viewed from different angles and on different scales and scopes and because of a municipality's complex social role, different responsibilities and accountability to different stakeholders, it is difficult to envision an unambiguous way to approach these effects in public redevelopment projects. The long-term vision of the municipality regarding the effects on real estate values, and their vision on how the redevelopment would be beneficial for the city as a whole and is going to be on balance monetarily (in the future), for them, reduces the relevance of anticipation effects in financial analyses. Contradictory to the minor role for these effects in public analyses, policy and politics, the effects could be useful for professional and commercial businesses, by enhancing their business cases.

Due to the limited amount of (divers) interviewees, the results and conclusions of the qualitative analysis in this paper are not representative for (the planning and policy- and decision-making of) redevelopment projects in general. The above exploratory results and conclusions, therefore, can be formulated as new hypotheses to investigate in further research:

1) External effects are not considered in financial analyses regarding redevelopment projects initiated by public parties.
2) External effects do not influence policy- and decision-making regarding redevelopment projects initiated by public parties.
3) Public parties find the long term effects of a redevelopment more important than the short term effects.
4) Anticipation effects are incorporated in financial analyses of (re)development projects initiated by commercial parties.
5) Anticipation effects enhance business cases of commercial parties.

6. Conclusions and discussion

In order to fulfill contemporary needs and expectations regarding inner-city railway stations and their surrounding areas, comprehensive redevelopments are being realized worldwide. Redevelopment plans regarding railway stations generally extend beyond increasing mobility. Enhancing the quality and range of facilities and increasing livability and housing capacity are common redevelopment goals. Besides direct effects, such as improvements to facilities, capacity and travel time for commuters, this type of redevelopment is likely to also produce external effects.

This thesis investigates these possible externalities of a comprehensive infrastructural redevelopment project and their effect on the owner-occupier housing market, by means of a mix-method approach, focusing on anticipation effects. Firstly, by using a difference-in-difference hedonic pricing model, relative price comparisons are made between transaction prices of houses near and farther from the redevelopment, analyzing different time periods of the development process and their interaction with distance. The executed model controls for a variation of housing attributes, including a time depending neighborhood characteristic and time and neighborhood fixed effects, which should minimize omitted variable bias. The different time periods of the development process are defined as 'before announcement of the redevelopment project', 'between announcement and start of the redevelopment project and 'after start of the redevelopment project'. The target group, which is investigated on treatment from the redevelopment, is specified as all transactions (between 1996 and 2016) that are located within 1000 meters from Utrecht Central Station. A sensitivity analyses is performed by alternating control groups. This analysis leads to comparable results, indicating that the estimation results are robust.

The results of the quantitative analyses of this study imply that the redevelopment of Utrecht Central Station is negatively anticipated throughout the redevelopment process. From the moment of announcement, transaction prices of houses near the redevelopment site experience a relative decline of 14.05%, compared to houses further away. Therefore, it is not the former train station and its surrounding areas, but the redevelopment itself that seems to be perceived as a disamenity by the actors of the owner-occupier housing market. This finding is in conflict with the expectations derived from fundamental studies, as Schwartz et al. (2006) imply positive price effects after the announcement of a redevelopment project, due to the anticipated increase in quality of the neighborhood. After the start of the construction period, the negative effects of the redevelopment increase to -16.93%. This result indicates that the possible future enhancement of the area is not foreseen or does not outweigh the disruption caused by the construction activities. Henneberry (1998) reports a comparable situation in his study. He argues that the observed negative external effects after the start of the construction period are caused by land sagging and expected noise disturbance. The fact that the anticipation effects in the AFTER period are negative, contradicts the findings of Schwartz et al. (2006), which indicate that the start of the construction activities eliminates uncertainties about the execution of the project plans and allows people to see the advantages and potential of the area, resulting in a further increase in house prices in vicinity of the redevelopment.

In addition to the quantitative analyses, interviews are conducted with key stakeholders regarding the redevelopment case study, to provide a more in-depth understanding of the application of external effects and anticipation effects in redevelopment plans and policy. The transcriptions of the interviews are studied by means of a latent content analysis, using a three-step coding system. The qualitative results indicate that external effects are considered to be important in project development. However, despite this expressed importance, interviewees indicate that external effects and anticipation effects are seldom addressed in public financial analyses, due to the common difference between the reach of the (negative) external effects and the scope of a project and the complexity of the different roles played by municipalities regarding redevelopments. The presumed locality of external effects is supported by the quantitative analyses of this thesis and is in line with the findings of Henneberry (1998) and Schwartz et al. (2006); the difference between the duration of the (temporary) negative external effects in the construction period and the expected positive outcome monetarily on the long-term, corroborate the findings Schwartz et al. (2006) and Van Duijn et al. (2016), as both indicate that positive effects of a total redevelopment project can be measured up to five years after completion.
Furthermore, implied is that a decline in prices of houses nearby Utrecht Central Station was inevitable, due to the decline of the quality of the area. Although this implication corresponds to the findings of Schwartz et al. (2006), Smith (2004), Harding et al. (2007) and Ahlfeldt and Richter (2013), the question remains if this would have been the case in Utrecht, and if this assumption could justify neglecting the relative disadvantages that the house-owners endure(d) due to the negative anticipation effects on the owner-occupier housing market. Finally, suggested is that, due to the earlier mentioned complexity on the different roles a municipality must undertake, generalized effects for different stages of a (re)development process could be relevant for commercial businesses by enhancing their business cases, rather than for public parties.

In answer to the main research question, "*What is the effect of the redevelopment of the Utrecht Central Station area on house prices in surrounding neighborhoods during the period from announcement until completion of the redevelopment?"*, it can be concluded that the effect of the redevelopment of the Utrecht Central Station area on house prices is negative during the period from announcement until *the partial completion* of the project. The negative anticipation effects are highest close to the redevelopment site and decay concavely when distance to the site decreases. In addition, it can be concluded that anticipation effects are in a minor way considered in, but do not influence policy- and decision-making regarding comprehensive inner-city redevelopment projects by public parties.

6.1 Limitations and suggestions

Despite the significance of the (quantitative) results, it is important to consider that this study faces certain shortcomings. First, the average results of the external effects of the redevelopment for the construction period might deviate from the currently found coefficients, when a longer study period is observed, as the construction period is not finished yet. House prices in the vicinity of the central station might increase in the coming years, which would nuance the currently found negative effects regarding the construction period of the redevelopment project. The only partial completion of the redevelopment might also be the explanation for the non-correspondence between the current findings and the findings from earlier studies, with regard to the construction period. Therefore, it is suggested to repeat the quantitative analyses of this paper five years after completion of the project, in order to evaluate the total effect of the redevelopment on the owner-occupier housing market, since effects can be significant until four to five years after completion of a redevelopment project (Schwartz et al., 2006; Van Duijn et al., 2016). Second, this study focusses only on a small segment of the real estate market, meaning that conclusions about the total effect of the redevelopment on surrounding real estate values cannot be drawn. In order to do so, it would be necessary to examine the effects on the commercial market and the rental sector. Third, although neighborhood and time fixed effects are already controlled for in this study, subsequent research efforts are recommended including additional time-related demographic and environmental data to control more extensively for differences in target and control areas, in order to further minimize omitted variable bias. Fourth, the qualitative results of this study are based on the comments of only three stakeholders, regarding one redevelopment. In order to come to more reliable, detailed and in-depth results, suggested is to increase the number of participants and, if possible, compare the results of this case with the results of studies on comparable projects. There should be noted, however, that the uniqueness of the, in this thesis, studied redevelopment and the differing conditions on real estate markets, across borders (Gibler et al. 2014) and over time, makes it difficult to find suitable redevelopment projects for comparison. Finally, it would be interesting and worthwhile to interview commercial project developing parties, in order to investigate their vision on the suggestion of the public policymakers to incorporate anticipation effects in their analyses, to optimize business cases.

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Appendix A – Do file Stata

Open
C:\Users\YLustenhouwer\Documents\Yvon\MasterThesis\Yvon_MasterThesis\Data_vervolg_analyse\
Transactiedata_DistanceStation_woningkenmerken

Merge m:m pc4_ID using
C:\Users\YLustenhouwer\Documents\Yvon\MasterThesis\Yvon_MasterThesis\Data_vervolg_analyse\
buurtkenmerken

save as
C:\Users\YLustenhouwer\Documents\Yvon\MasterThesis\Yvon_MasterThesis\Data_vervolg_analyse\
Transactiedata_DistanceStation_woningkenmerken_buurtkenmerken

drop Match_Score Match_addr _merge
drop if DISTANCE_Station_meters > 3000 (17,497 observations deleted)
drop if TRANSACTIEPRIJS > 5000000 (539 observations deleted)
drop if TRANSACTIEPRIJS < 50000 (120 observations deleted)
drop if PROCVERSCHIL < -25 (38 observations deleted)
drop if PROCVERSCHIL > 25 (58 observations deleted)
drop if NKAMERS <= 0 (76 observations deleted)
drop if M2<25 (988 observations deleted)
drop if WOONOPP<25 (21 observations deleted)
drop if M2>500 (1 observation deleted)
drop if WOONOPP>500 (2,037 observations deleted)
drop if CATEGORIE==4 (0 observations deleted)
drop if BWPER ==-1 (0 observations deleted)

drop PERCEEL INHOUD HUISKLASSE SOORTHUIS KENMERKWONING SOORTAPP SOORTWONING PERMANENT (The variable NVMCIJFERS combines above variables into 1 on a sufficient detail level)

drop OPENPORTIEK KWALITEIT VTRAP ZOLDER VLIER PRAKTIJKR WOONKA INPANDIG VERKOOPCOND DAKKAP NBIJKEUK LIGMOOI LIGCENTR (Too much details, also not available for every type of house/observation)

gen Allochtonous = overigwesters+ Surinamers_Antillianen+ Marokkanen+
Turken+overig_nietwesters (3,137 missing values generated → missing neighborhoods)

rename autochtonen Autochtonous
drop MONUMENTAAL (not certified, but only appearing monumental)
rename MONUMENT Monument

gen Single_family = 0
replace Single_family = 1 if CATEGORIE == 1 (22,303 real changes made → 0 = apartment)

gen Construction_unknown (before 1500 or after transaction) = 0
replace Construction_unknown = 1 if BWPER ==0 (56 real changes made)

gen Construction_1500_1905 = 0
gen Construction_1906_1930 = 0
gen Construction_1931_1944 = 0
gen Construction_1945_1959 = 0
gen Construction_1960_1970 = 0
gen Construction_1971_1980 = 0
gen Construction_1981_1990 = 0

gen Construction_1991_2000 = 0
gen Construction_after_2000 = 0

replace Construction_1500_1905 =1 if BWPER ==1 (8,846 real changes made)
replace Construction_1906_1930 =1 if BWPER ==2 (16,506 real changes made)
replace Construction_1931_1944 =1 if BWPER ==3 (7,197 real changes made)
replace Construction_1945_1959 =1 if BWPER ==4 (3,945 real changes made)
replace Construction_1960_1970 =1 if BWPER ==5 (6,742 real changes made)
replace Construction_1971_1980 =1 if BWPER ==6 (1,198 real changes made)
replace Construction_1981_1990 =1 if BWPER ==7 (1,672 real changes made)
replace Construction_1991_2000 =1 if BWPER ==8 (3,619 real changes made)
replace Construction_after_2000 =1 if BWPER ==9 (2,189 real changes made)

rename WOONOPP User_space
rename TYPE Type_house
rename NVMCIJFERS Type_house_appartment
rename LIFT Elevator
rename NVERDIEP Floors
rename NBALKON Balcony
rename NDAKTERRAS Roofterrace
rename NKEUKEN Kitchen
rename NWC Toilet
rename NBADK Bathroom
rename PARKEER Parking
rename ONBI Inside_maintenance
rename ONBU Outside_maintenance
rename ISOL Isolation
rename VERW Heating
rename LIGDRUKW Street_Type
rename ERFPACHT_TONEN Ground_Lease
rename GED_VERHUURD Rented_partially
rename TUINAFW Garden_maintenance

gen House_intermediate = 0
gen House_terraced = 0
gen House_corner = 0
gen House_SemiDetached = 0
gen House_detached= 0
gen Appartment = 0

replace House_intermediate =1 if Type_house_appartment == 2 (18,585 real changes made)
replace House_terraced = 1 if Type_house_appartment == 3 (102 real changes made)
replace House_corner =1 if Type_house_appartment == 4 (3,164 real changes made)
replace House_SemiDetached = 1 if Type_house_appartment == 5 (275 real changes made)
replace House_detached = 1 if Type_house_appartment == 6 (177 real changes made)
replace Appartment = 1 if Type_house_appartment == 7 (33 real changes made)
replace Appartment = 1 if Type_house_appartment == 8 (14,270 real changes made)
replace Appartment = 1 if Type_house_appartment == 9 (8,336 real changes made)
replace Appartment = 1 if Type_house_appartment ==10 (7,028 real changes made)

```
rename TRANSACTIEPRIJS Transaction_price
rename OORSPRVRKOOPPR Asking_price_start
rename LAATSTVRKOOPPR Asking_prince_end
rename PROCVERSCHIL Process_difference
rename DATUM_AANMELDING Date_start
rename DATUM_AFMELDING Date_end

tabulate Floors
drop if Floors > 5 (13 observations deleted)

gen Floor1 = 0
gen Floor2 = 0
gen Floor3 =0
gen Floor4 =0
gen Floor5=0

replace Floor1 = 1 if Floors ==1 (18,931 real changes made)
replace Floor2 = 1 if Floors==2 (14,324 real changes made)
replace Floor3 =1 if Floors==3 (16,745 real changes made)
replace Floor4 =1 if Floors==4 (1,717 real changes made)
replace Floor5 =1 if Floors==5 (240 real changes made)

rename NKAMERS Rooms
tabulate Rooms
drop if Rooms > 12 (33 observations deleted)

gen Room1= 0
gen Room2=0
gen Room3=0
gen Room4=0
gen Room5=0
gen Room6=0
gen Room7=0
gen Room8=0
gen Room9=0
gen Room10=0
gen Room11=0
gen Room12=0

replace Room1 =1 if Rooms == 1 (598 real changes made)
replace Room2 =1 if Rooms == 2 (6,662 real changes made)
replace Room3 =1 if Rooms == 3 (17,752 real changes made)
replace Room4 =1 if Rooms == 4 (13,331 real changes made)
replace Room5 =1 if Rooms == 5 (7,901 real changes made)
replace Room6 =1 if Rooms == 6 (3,425 real changes made)
replace Room7 =1 if Rooms == 7 (1,220 real changes made)
replace Room8 =1 if Rooms == 8 (537 real changes made)
replace Room9 =1 if Rooms == 9 (257 real changes made)
replace Room10 =1 if Rooms ==10 (145 real changes made)
replace Room11 =1 if Rooms ==11 (62 real changes made)
replace Room12 =1 if Rooms ==12 (34 real changes made)
```

tabulate Balcony
gen BalconyDUM = 0
replace BalconyDUM = 1 if Balcony == 1 (20,071 real changes made)
replace BalconyDUM = 1 if Balcony == 2 (704 real changes made)
replace BalconyDUM = 1 if Balcony == 3 (15 real changes made)

tabulate Roofterrace
gen RoofterraceDUM = 0
replace RoofterraceDUM = 1 if Roofterrace == 1 (6,424 real changes made)
replace RoofterraceDUM = 1 if Roofterrace == 2 (196 real changes made)
replace RoofterraceDUM = 1 if Roofterrace == 3 (5 real changes made)

tabulate Kitchen
drop if Kitchen>3 (19 observations deleted)
gen Kitchen0 = 0
gen Kitchen1 = 0
gen Kitchen2 = 0
gen Kitchen3 = 0
graph box Kitchen

replace Kitchen0 = 1 if Kitchen== 0 (13,958 real changes made)
replace Kitchen1 = 1 if Kitchen==1 (36,862 real changes made)
replace Kitchen2 =1 if Kitchen ==2 (971 real changes made)
replace Kitchen3=1 if Kitchen ==3 (114 real changes made)

tabulate Toilet
drop if Toilet>10 (68 observations deleted)
graph box Toilet

gen Toilet0=0
gen Toilet1=0
gen Toilet2=0
gen Toilet3=0
gen Toilet4=0
gen Toilet5=0
gen Toilet6=0
gen Toilet7=0
gen Toilet8=0
gen Toilet9=0
gen Toilet10=0

replace Toilet0=1 if Toilet==0 (4,866 real changes made)
replace Toilet1=1 if Toilet==1 (0 real changes made)
replace Toilet2=1 if Toilet==2 (7,224 real changes made)
replace Toilet3=1 if Toilet==3 (25,725 real changes made)
replace Toilet4=1 if Toilet==4 (222 real changes made)
replace Toilet5=1 if Toilet==5 (9,994 real changes made)
replace Toilet6=1 if Toilet==6 (2,618 real changes made)
replace Toilet7=1 if Toilet==7 (365 real changes made)
replace Toilet8=1 if Toilet==8 (576 real changes made)
replace Toilet9=1 if Toilet== 9 (210 real changes made)
replace Toilet10=1 if Toilet==10 (37 real changes made)

tabulate Bathroom
drop if Bathroom>3 (7 observations deleted)

gen Bathroom0=0
gen Bathroom1=0
gen Bathroom2=0
gen Bathroom3=0

replace Bathroom0=1 if Bathroom==0 (6,020 real changes made)
replace Bathroom1=1 if Bathroom==1 (44,065 real changes made)
replace Bathroom2=1 if Bathroom==2 (1,672 real changes made)
replace Bathroom3=1 if Bathroom==3 (73 real changes made)

tabulate Parking
gen ParkingDUM = 0
replace ParkingDUM = 1 if Parking==2 (915 real changes made)
replace ParkingDUM = 1 if Parking==3 (979 real changes made)
replace ParkingDUM = 1 if Parking==4 (1,634 real changes made)
replace ParkingDUM = 1 if Parking==6 (55 real changes made)
replace ParkingDUM = 1 if Parking==8 (210 real changes made)

gen WellMaintainedGarden = 0
replace WellMaintainedGarden = 1 if Garden_maintenance == 3 (42,712 real changes made)
replace WellMaintainedGarden = 1 if Garden_maintenance == 4 (3,069 real changes made)
replace WellMaintainedGarden = 1 if Garden_maintenance == 5 (5,482 real changes made)

rename WellMaintainedGarden WellMaintainedGardenDUM

gen Inside_maintenanceDUM = 0
gen Outside_maintenanceDUM = 0

replace Inside_maintenanceDUM = 1 if Inside_maintenance == 5 (4,234 real changes made)
replace Inside_maintenanceDUM = 1 if Inside_maintenance == 4 (229 real changes made)
replace Inside_maintenanceDUM = 1 if Inside_maintenance == 3 (599 real changes made)
replace Inside_maintenanceDUM = 1 if Inside_maintenance == 2 (34 real changes made)
replace Inside_maintenanceDUM = 1 if Inside_maintenance == 1 (86 real changes made)

replace Outside_maintenanceDUM = 1 if Outside_maintenance == 5 (2,382 real changes made)
replace Outside_maintenanceDUM = 1 if Outside_maintenance == 4 (120 real changes made)
replace Outside_maintenanceDUM = 1 if Outside_maintenance == 3 (335 real changes made)
replace Outside_maintenanceDUM = 1 if Outside_maintenance == 2 (19 real changes made)
replace Outside_maintenanceDUM = 1 if Outside_maintenance == 1 (48 real changes made)

gen IsolationDUM = 0
replace IsolationDUM = 1 if Isolation ==1 (21,986 real changes made)
replace IsolationDUM = 1 if Isolation ==2 (5,959 real changes made)
replace IsolationDUM = 1 if Isolation ==3 (2,309 real changes made)
replace IsolationDUM = 1 if Isolation ==4 (1,168 real changes made)
replace IsolationDUM = 1 if Isolation ==5 (4,483 real changes made)

tabulate Ground_Lease
replace Ground_Lease = 1 if Ground_Lease==-1 (8,182 real changes made) → 0 = no Ground Lease or unknown

```
tabulate Street_Type

rename Allochtonous AllochtonousDUM
rename Single_family Single_familyDUM
rename leeftijd_03 Age_03
rename leeftijd_411 Age_411
rename leeftijd_1217 Age_1217
rename leeftijd_1824 Age_1824
rename leeftijd_2534 Age_2534
rename leeftijd_3554 Age_3554
rename leeftijd_5564 AGe_5564
rename leeftijd_65plussers Age_65
rename onveiliginbuurt FeelingUnsafeNeigh
rename onveiligalgemeen FeelingUnsafeGeneral
rename mannen Male
rename vrouwen Female
rename HH_alleenstaand HH_Single
rename HH_paar_zonder_kinderen HH_CoupleNoKids
rename HH_paar_met_kinderen HH_CoupleWithKids
rename HH_eenoudergezin HH_SingleParent
rename HH_overige_gezinnen HH_Remaining
rename Totaal_huishoudens HH_TotalNeighborhood
rename _koop OwnerOccupied
rename _huur_sociaal SocialRent
rename _huur_particulier LiberalRent
rename Rapportcijfer_2015 NeighborhoodScore2015
rename CR UserGreen1000inhab2015
rename CZ ViewGreen1000inhab2015
rename Staat_OR_2015 StatusPS2015
rename Netheid_2015 Cleanliness2015
rename Groenonderhoud_buurt_2015 MaintenanceGreenNeigh2015
rename Schoonheid_straten_2015 CleanStreets2015
rename Onderhoud_straten_2015 MaintenanceStreets2015
rename Crimi_per_1000Inw_2015 Crime1000inhab2015
rename Observatie Observation

gen DistanceSquared = DISTANCE_Station_meters* DISTANCE_Station_meters

gen Year1996=0
gen Year1997=0
gen Year1998=0
gen Year1999=0
gen Year2000=0
gen Year2001=0
gen Year2002=0
gen Year2003=0
gen Year2004=0
gen Year2005=0
gen Year2006=0
gen Year2007=0
gen Year2008=0
gen Year2009=0
```

```
gen Year2010=0
gen Year2011=0
gen Year2012=0
gen Year2013=0
gen Year2014=0
gen Year2015=0
gen Year2016=0

replace Year1996=1 if Year==1996 (968 real changes made)
replace Year1997=1 if Year==1997 (1,208 real changes made)
replace Year1998=1 if Year==1998 (2,176 real changes made)
replace Year1999=1 if Year==1999 (2,292 real changes made)
replace Year2000=1 if Year==2000 (2,666 real changes made)
replace Year2001=1 if Year==2001 (2,879 real changes made)
replace Year2002=1 if Year==2002 (2,903 real changes made)
replace Year2003=1 if Year==2003 (2,998 real changes made)
replace Year2004=1 if Year==2004 (2,821 real changes made)
replace Year2005=1 if Year==2005 (3,083 real changes made)
replace Year2006=1 if Year==2006 (3,171 real changes made)
replace Year2007=1 if Year==2007 (2,974 real changes made)
replace Year2008=1 if Year==2008 (2,797 real changes made)
replace Year2009=1 if Year==2009 (2,236 real changes made)
replace Year2010=1 if Year==2010 (2,287 real changes made)
replace Year2011=1 if Year==2011 (1,973 real changes made)
replace Year2012=1 if Year==2012 (1,800 real changes made)
replace Year2013=1 if Year==2013 (1,767 real changes made)
replace Year2014=1 if Year==2014 (2,660 real changes made)
replace Year2015=1 if Year==2015 (3,084 real changes made)
replace Year2016=1 if Year==2016 (3,087 real changes made)

gen BEFORE_A=0
gen BETWEEN_AS=0
gen TREND_BETWEEN_AS=0
gen AFTER_S=0
gen TREND_AFTER_S=0

gen MonthTm= Month * (1/12)
gen MonthTm2 = Month * (1/12) - (1/12/2)
gen YTm = Year + MonthTm2

histogram Transaction_price, frequency
gen LogTransactionPrice = ln(Transaction_price)
histogram LogTransactionPrice, frequency

histogram User_space
gen LogUserSpace = ln(User_space)
histogram LogUserSpace

gen MonthTm= Month * (1/12)
gen MonthTm2 = Month * (1/12) - (1/12/2)
gen YTm = Year + MonthTm2

drop if DISTANCE_Station_meters > 2500
```

```
gen target_group = 0
replace target_group = 1 if DISTANCE_Station_meters<=1000
gen control_group1 = 0
replace control_group1 =1 if DISTANCE_Station_meters>1000 & DISTANCE_Station_meters<=
2000
gen control_group2=0
replace control_group2=1 if DISTANCE_Station_meters>1500 &
DISTANCE_Station_meters<=2500
gen control_group3=0
replace control_group3=1 if DISTANCE_Station_meters>1000 &
DISTANCE_Station_meters<=1500

replace BEFORE_A=1 if target_group==1
replace AFTER_S=1 if target_group==1 & YTm>2009.958
replace BETWEEN_AS=1 if target_group==1  & YTm>=2002.375 & YTm<=2009.958
replace TREND_BETWEEN_AS = YTm - 2002.375 if BETWEEN_AS==1
replace TREND_AFTER_S = YTm - 2009.958 if AFTER_S==1


destring bovenbenedenwoning flatwoning woning_onbekend luchtvervuilinge_buurt_2008
luchtvervuilinge_buurt_2009 luchtvervuilinge_buurt_2010 luchtvervuilinge_buurt_2011
luchtvervuilinge_buurt_2013 luchtvervuilinge_buurt_2015 Stank_door_verkeer_buurt_2008
Stank_door_verkeer_buurt_2009 Stank_door_verkeer_buurt_2010 Stank_door_verkeer_buurt_2011
Stank_door_verkeer_buurt_2013 Stank_door_verkeer_buurt_2015 Overig_stankexclverkeer_2008
Overig_stankexclverkeer_2009 Overig_stankexclverkeer_2010 Overig_stankexclverkeer_2011
Overig_stankexclverkeer_2013 Overig_stankexclverkeer_2015 Lawaai_verkeer_2008
Lawaai_verkeer_2009 Lawaai_verkeer_2010 Lawaai_verkeer_2011 Lawaai_verkeer_2013
Lawaai_verkeer_2015 Overig_lawaaiexclverkeer_2008 Overig_lawaaiexclverkeer_2009
Overig_lawaaiexclverkeer_2010 Overig_lawaaiexclverkeer_2011 Overig_lawaaiexclverkeer_2013
Overig_lawaaiexclverkeer_2015 _overlast_gevaarlijk_verkeer_20 CA CB CC CD CE
Rapportcijfer_2008 Rapportcijfer_2009 Rapportcijfer_2010 Rapportcijfer_2011 Rapportcijfer_2013
Staat_OR_2008 Staat_OR_2009 Staat_OR_2010 Staat_OR_2011 Staat_OR_2013 StatusPS2015
netheid_2008 Netheid_2009 Netheid_2010 Netheid_2011 Netheid_2013 Cleanliness2015
Groenonderhoud_buurt_2008 Groenonderhoud_buurt_2009 Groenonderhoud_buurt_2010
Groenonderhoud_buurt_2011 Groenonderhoud_buurt_2013 MaintenanceGreenNeigh2015
Schoonheid_straten_2009 Schoonheid_straten_2010 Schoonheid_straten_2011
Schoonheid_straten_2013 CleanStreets2015 Onderhoud_straten_2008 Onderhoud_straten_2009
Onderhoud_straten_2010 Onderhoud_straten_2011 Onderhoud_straten_2013 MaintenanceStreets2015
Crimi_per_1000Inw_2010 Crimi_per_1000Inw_2011 Crimi_per_1000Inw_2012
Crimi_per_1000Inw_2013 Crimi_per_1000Inw_2014 Crime1000inhab2015
Crimi_per_1000Inw_2016, replace

gen BEFORE_A_D = BEFORE_A*DISTANCE_Station_meters
gen BEFORE_A_DD = BEFORE_A* DistanceSquared
gen BETWEEN_AS_D = BETWEEN_AS *DISTANCE_Station_meters
gen BETWEEN_AS_DD = BETWEEN_AS* DistanceSquared
gen AFTER_S_D = AFTER_S* DISTANCE_Station_meters
gen AFTER_S_DD = AFTER_S* DistanceSquared
gen TREND_BETWEEN_AS_D = TREND_BETWEEN_AS*DISTANCE_Station_meters
gen TREND_BETWEEN_AS_DD = TREND_BETWEEN_AS* DistanceSquared
gen TREND_AFTER_S_D = TREND_AFTER_S*DISTANCE_Station_meters
gen TREND_AFTER_S_DD = TREND_AFTER_S* DistanceSquared
```

replace Inside_maintenanceDUM = 0 if Inside_maintenance ==5 (3,631 real changes made)
replace Inside_maintenanceDUM = 0 if Inside_maintenance ==4 (194 real changes made)
replace Outside_maintenanceDUM = 0 if Outside_maintenance ==5 (1,998 real changes made)
replace Outside_maintenanceDUM = 0 if Outside_maintenance ==4 (105 real changes made)
replace WellMaintainedGardenDUM = 0 if Garden_maintenance ==3 (35,563 real changes made)

gen PC3511=0
gen PC3512=0
gen PC3513=0
gen PC3514=0
gen PC3515=0
gen PC3521=0
gen PC3522=0
gen PC3527=0
gen PC3531=0
gen PC3532=0
gen PC3533=0
gen PC3551=0
gen PC3572=0
gen PC3581=0
gen PC3582=0

replace PC3511=1 if pc4_ID==3511 (2,750 real changes made)
replace PC3512=1 if pc4_ID==3512 (1,799 real changes made)
replace PC3513=1 if pc4_ID==3513 (1,427 real changes made)
replace PC3514=1 if pc4_ID==3514 (1,844 real changes made)
replace PC3515=1 if pc4_ID==3515 (282 real changes made)
replace PC3521=1 if pc4_ID==3521 (1,514 real changes made)
replace PC3522=1 if pc4_ID==3522 (779 real changes made)
replace PC3527=1 if pc4_ID==3527 (523 real changes made)
replace PC3531=1 if pc4_ID==3531 (2,711 real changes made)
replace PC3532=1 if pc4_ID==3532 (1,730 real changes made)
replace PC3533=1 if pc4_ID==3533 (521 real changes made)
replace PC3551=1 if pc4_ID==3551 (925 real changes made)
replace PC3572=1 if pc4_ID==3572 (165 real changes made)
replace PC3581=1 if pc4_ID==3581 (268 real changes made)
replace PC3582=1 if pc4_ID==3582 (268 real changes made)

drop Subwijken totaal_inwoners FeelingUnsafeNeigh FeelingUnsafeGeneral Male Female Autochtonous overigwesters Surinamers_Antillianen Marokkanen Turken overig_nietwesters Age_03 Age_411 Age_1217 Age_1824 Age_2534 Age_3554 Age_5564 Age_65 HH_Single HH_CoupleNoKids HH_CoupleWithKids HH_SingleParent HH_Remaining HH_TotalNeighborhood Woonopp_tot_65_m2 woonopp_6599_m2 woonopp_100_m2 woonopp_onbekend eengezinswoning bovenbenedenwoning flatwoning woning_onbekend OwnerOccupied SocialRent LiberalRent bouwjaar_van_voor_1905 bouwjaar_tussen_19051945 Bouwjaar_tussen_19451960 Bouwjaar_tussen_19601980 bouwjaar_van_1980_tot_heden luchtvervuilinge_buurt_2008 luchtvervuilinge_buurt_2009 luchtvervuilinge_buurt_2010 luchtvervuilinge_buurt_2011 luchtvervuilinge_buurt_2013 luchtvervuilinge_buurt_2015 Stank_door_verkeer_buurt_2008 Stank_door_verkeer_buurt_2009 Stank_door_verkeer_buurt_2010 Stank_door_verkeer_buurt_2011 Stank_door_verkeer_buurt_2013 Stank_door_verkeer_buurt_2015 Overig_stankexclverkeer_2008 Overig_stankexclverkeer_2009 Overig_stankexclverkeer_2010 Overig_stankexclverkeer_2011

Overig_stankexclverkeer_2013 Overig_stankexclverkeer_2015 Lawaai_verkeer_2008 Lawaai_verkeer_2009 Lawaai_verkeer_2010 Lawaai_verkeer_2011 Lawaai_verkeer_2013 Lawaai_verkeer_2015 Overig_lawaaiexclverkeer_2008 Overig_lawaaiexclverkeer_2009 Overig_lawaaiexclverkeer_2010 Overig_lawaaiexclverkeer_2011 Overig_lawaaiexclverkeer_2013 Overig_lawaaiexclverkeer_2015 _overlast_gevaarlijk_verkeer_20 CA CB CC CD CE Rapportcijfer_2008 Rapportcijfer_2009 Rapportcijfer_2010 Rapportcijfer_2011 Rapportcijfer_2013 NeighborhoodScore2015 gebruiksgroen_aantalm2_2013 gebruiksgroen_aantalm2_2014 gebruiksgroen_aantalm2_2015 gebruiksgroen_aantalm2_2016 gebruiksgroen_m2per1000inwoners_ CQ UserGreen1000inhab2015 CS zichtgroen_aantalm2_2013 zichtgroen_aantalm2_2014 zichtgroen_aantalm2_2015 zichtgroen_aantalm2_2016 zichtgroen_m2per1000inwoners_201 CY ViewGreen1000inhab2015 DA Staat_OR_2008 Staat_OR_2009 Staat_OR_2010 Staat_OR_2011 Staat_OR_2013 StatusPS2015 netheid_2008 Netheid_2009 Netheid_2010 Netheid_2011 Netheid_2013 Cleanliness2015 Groenonderhoud_buurt_2008 Groenonderhoud_buurt_2009 Groenonderhoud_buurt_2010 Groenonderhoud_buurt_2011 Groenonderhoud_buurt_2013 MaintenanceGreenNeigh2015 Schoonheid_straten_2008 Schoonheid_straten_2009 Schoonheid_straten_2010 Schoonheid_straten_2011 Schoonheid_straten_2013 CleanStreets2015 Onderhoud_straten_2008 Onderhoud_straten_2009 Onderhoud_straten_2010 Onderhoud_straten_2011 Onderhoud_straten_2013 MaintenanceStreets2015 Criminaliteit_aantalinci_2010 Criminaliteit_aantalinci_2011 Criminaliteit_aantalinci_2012 Criminaliteit_aantalinci_2013 Criminaliteit_aantalinci_2014 Criminaliteit_aantalinci_2015 Criminaliteit_aantalinci_2016 Crimi_per_1000Inw_2010 Crimi_per_1000Inw_2011 Crimi_per_1000Inw_2012 Crimi_per_1000Inw_2013 Crimi_per_1000Inw_2014 Crime1000inhab2015 Crimi_per_1000Inw_2016 AllochtonousDUM TUINLIG Elevator

gen PC6_4 = PC6 – 35000000
tabulate PC6_4
gen PCxxxxxx = 0 (for all PC6_4 codes)
replace PCxxxxxx = 1 if PC6_4 = PC6_4

*target group & control group 3 (main results): drop if DISTANCE_Station_meters>1500
*target group & control group 1: drop if DISTANCE_Station_meters>2000
* target group & control group 2: drop if DISTANCE_Station_meters>1000 & DISTANCE_Station_meters<1501

replace Street_Type=0 if Street_Type==1 (24,491 real changes made)
replace Street_Type=1 if Street_Type==2 (1,993 real changes made)

replace Heating=0 if Heating==1 (6,351 real changes made)
replace Heating=0 if Heating==3 (7 real changes made)
replace Heating=1 if Heating==2 (35,349 real changes made)

histogram Toilet, frequency (bin=45, start=0, width=.22222222)
gen LogToilet = ln(Toilet) (2,899 missing values generated)
histogram LogToilet (bin=44, start=.69314718, width=.03657814)

histogram Rooms (bin=45, start=1, width=.24444444)
gen LogRooms = ln(Rooms)
histogram LogRooms (bin=45, start=0, width=.05522015)

ssc install outreg2

set matsize 5000

REGRESSIONS (per target & control group (1, 2, 3) combination), Building up in specification:

(1) reg LogTransactionPrice BEFORE_A BETWEEN_AS AFTER_S BEFORE_A_D BEFORE_A_DD BETWEEN_AS_D BETWEEN_AS_DD AFTER_S_D AFTER_S_DD TREND_BETWEEN_AS TREND_AFTER_S TREND_BETWEEN_AS_D TREND_BETWEEN_AS_DD TREND_AFTER_S_D TREND_AFTER_S_DD Year1997 Year1998 Year1999 Year2000 Year2001 Year2002 Year2003 Year2004 Year2005 Year2006 Year2007 Year2008 Year2009 Year2010 Year2011 Year2012 Year2013 Year2014 Year2015 Year2016

(2) Construction_1500_1905 Construction_1906_1930 Construction_1931_1944 Construction_1945_1959 Construction_1960_1970 Construction_1971_1980 Construction_1981_1990 Construction_1991_2000

(3) LogM2 LogRooms Toilet1 Toilet2 Toilet3 Toilet4 Toilet5 Toilet6 Toilet7 Toilet8 Toilet9 Toilet10 Bathroom0 Bathroom2 Bathroom3 Kitchen0 Kitchen2 Kitchen3 Heating IsolationDUM ParkingDUM Ground_Lease Rented_partially Monument RoofterraceDUM BalconyDUM Outside_maintenanceDUM Inside_maintenanceDUM WellMaintainedGardenDUM House_detached House_SemiDetached House_corner House_intermediate Appartment

(4) A. PC4-codes
PC3511 PC3512 PC3513 PC3514 PC3515 PC3521 PC3522 PC3527 PC3531 PC3532 PC3533 PC3551 PC3572 PC3581 PC3582
B. PC6-codes

(5) Street_Type
,r

replace TREND_BETWEEN_AS = Year-2002 if BETWEEN_AS==1
replace TREND_AFTER_S = Year-2009 if AFTER_S==1

replace TREND_BETWEEN_AS_D = TREND_BETWEEN_AS*DISTANCE_Station_meters
replace TREND_BETWEEN_AS_DD = TREND_BETWEEN_AS* DistanceSquared
replace TREND_AFTER_S_D = TREND_AFTER_S*DISTANCE_Station_meters
replace TREND_AFTER_S_DD = TREND_AFTER_S* DistanceSquared

reg LogTransactionPrice BEFORE_A BETWEEN_AS AFTER_S BEFORE_A_D BEFORE_A_DD BETWEEN_AS_D BETWEEN_AS_DD AFTER_S_D AFTER_S_DD TREND_BETWEEN_AS TREND_AFTER_S TREND_BETWEEN_AS_D TREND_BETWEEN_AS_DD TREND_AFTER_S_D TREND_AFTER_S_DD Year1997 Year1998 Year1999 Year2000 Year2001 Year2002 Year2003 Year2004 Year2005 Year2006 Year2007 Year2008 Year2009 Year2010 Year2011 Year2012 Year2013 Year2014 Year2015 Year2016 Construction_1500_1905 Construction_1906_1930 Construction_1931_1944 Construction_1945_1959 Construction_1960_1970 Construction_1971_1980 Construction_1981_1990 Construction_1991_2000 LogM2 LogRooms Toilet1 Toilet2 Toilet3 Toilet4 Toilet5 Toilet6 Toilet7 Toilet8 Toilet9 Toilet10 Bathroom0 Bathroom2 Bathroom3 Kitchen0 Kitchen2 Kitchen3 Heating IsolationDUM ParkingDUM Ground_Lease Rented_partially Monument RoofterraceDUM BalconyDUM Outside_maintenanceDUM Inside_maintenanceDUM WellMaintainedGardenDUM House_detached House_SemiDetached House_corner House_intermediate Appartment PC3511 PC3512 PC3513 PC3514 PC3515 PC3521 PC3522 PC3527 PC3531 PC3532 PC3533 PC3551 PC3572 PC3581 PC3582 Street_Type

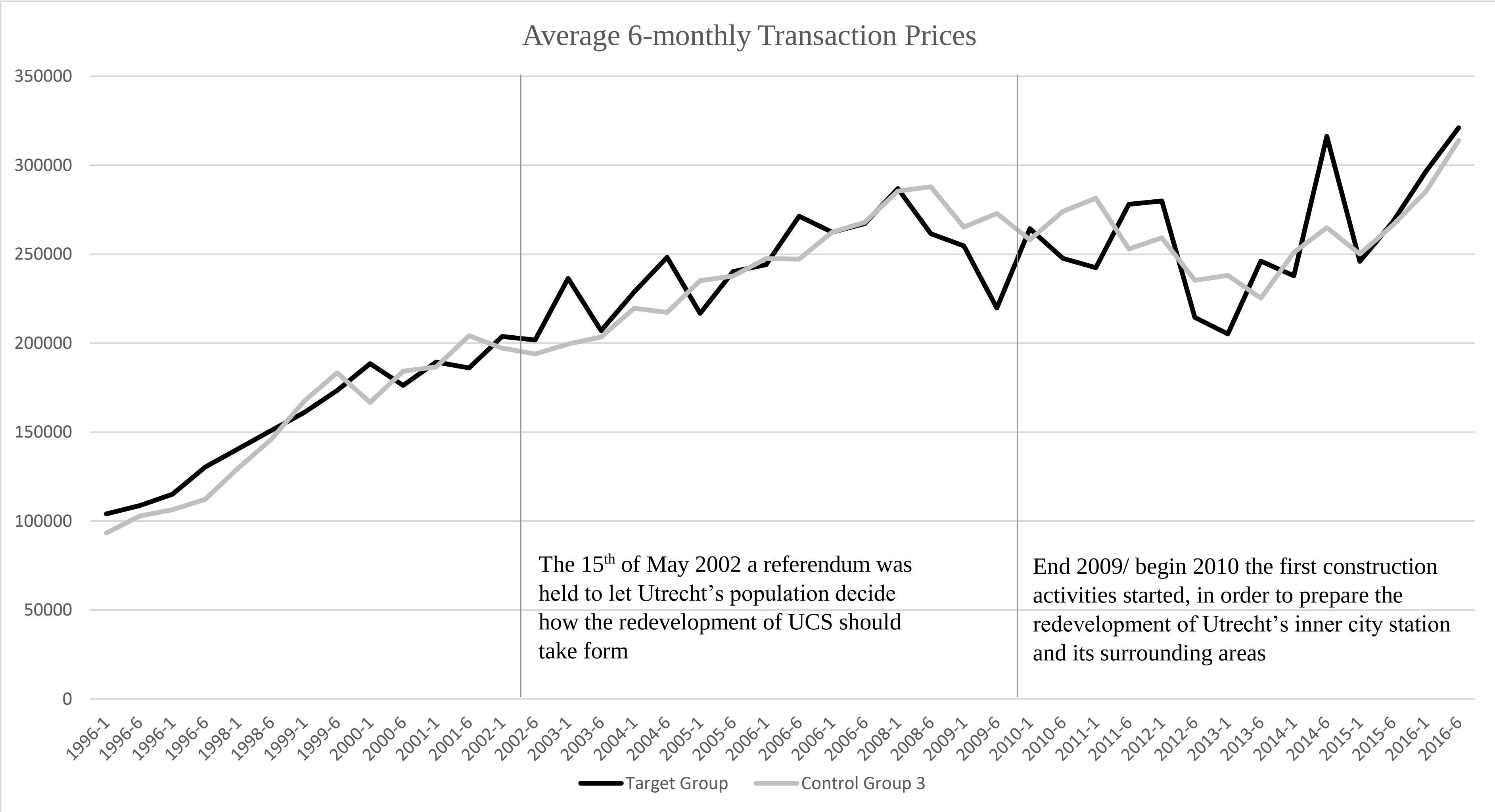
```
estimates store normal
predict r
kdensity r, normal
scatter r lnTransactionPrice
graph matrix LogTransactionPrice M2 Rooms
rvfplot, yline(0)
estat hettest
pnorm r
qnorm r
swilk r
```

Appendix B – Descriptive Statistics control group 1 & 2

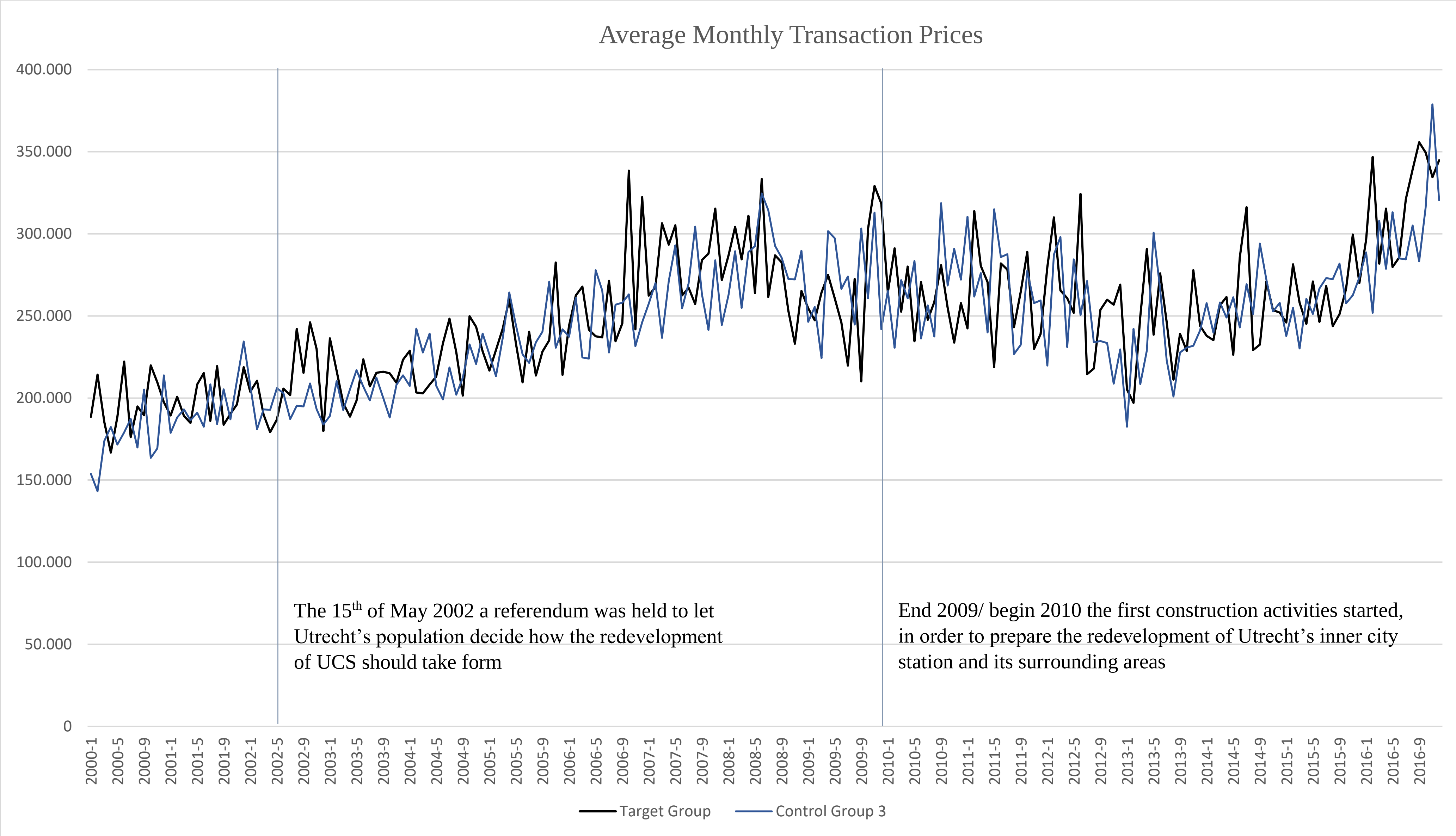
	Control group 1	*Observations 25,955*		*Control group 2*	*25,649 observations*	
Variable	**Mean (Std. Dev)**	**Min**	**Max**	**Mean(Std. Dev.)**	**Min**	**Max**
Transaction_price	223.410(116.130)	50.937	1.600.000	227.954(132.524)	50.937	1.910.000
DISTANCE_Station_meters	1.543(274)	1001	2.000	1.724(532)	1501	2.500
Year	2006,6(5,7)	1996	2016	2006,5(5,7)	1996	2016
Month	6,6(3,4)	1	12	6,6(3,4)	1	12
M2	93,5(35,5)	26	435	96(37,6)	26	450
Rooms	3,8(1,4)	1	12	3,8(1,5)	1	12
Isolation	0,7(0,46)	0	1	1,18(1,26)	0	1
Heating	0,8(0,49)	0	1	0,05(0,21)	0	1
Street_Type	0,047(0,2)	0	1	0,46(0,21)	0	1
Ground_Lease	0,24(0,43)	0	1	0,22(0,41)	0	1
Rented_partially	0(0,04)	0	1	0(0,03)	0	1
Monument	0,02(0,13)	0	1	0,01(0,09)	0	1
ParkingDUM	0,06(0,24)	0	1	0,06(0,24)	0	1
WellMaintainedGardenDUM	0,17(0,38)	0	1	0,18(0,39)	0	1
Inside_maintenanceDUM	0,01(0,12)	0	1	0,01(0,12)	0	1
Outside_maintenanceDUM	0,01(0,09)	0	1	0,01(0,09)	0	1
IsolationDUM	0,7(0,46)	0	1	0,7(0,46)	0	1
Construction_unknown	0(0,03)	0	1	0(0,01)	0	1
Construction_1500_1905	0,22(0,41)	0	1	0,17(0,37)	0	1
Construction_1906_1930	0,37(0,48)	0	1	0,33(0,47)	0	1
Construction_1931_1944	0,12(0,33)	0	1	0,15(0,35)	0	1
Construction_1945_1959	0,08(0,27)	0	1	0,12(0,33)	0	1
Construction_1960_1970	0,09(0,29)	0	1	0,14(0,35)	0	1
Construction_1971_1980	0,01(0,09)	0	1	0,01(0,12)	0	1
Construction_1981_1990	0,02(0,13)	0	1	0,02(0,12)	0	1
Construction_1991_2000	0,05(0,22)	0	1	0,03(0,16)	0	1
Construction_after_2000	0,05(0,22)	0	1	0,03(0,18)	0	1
House_intermediate	0,38(0,49)	0	1	0,42(0,49)	0	1
House_terraced	0(0,03)	0	1	0(0,04)	0	1
House_corner	0,06(0,24)	0	1	0,07(0,26)	0	1
House_SemiDetached	0(0,06)	0	1	0,01(0,07)	0	1
House_detached	0(0,05)	0	1	0(0,06)	0	1
Appartment	0,55(0,5)	0	1	0,49(0,5)	0	1
BalconyDUM	0,34(0,48)	0	1	0,41(0,49)	0	1
RoofterraceDUM	0,14(0,35)	0	1	0,11(0,32)	0	1
Kitchen0	0,27(0,44)	0	1	0,28(0,45)	0	1
Kitchen1	0,71(0,45)	0	1	0,71(0,46)	0	1
Kitchen2	0,02(0,14)	0	1	0,02(0,13)	0	1
Kitchen3	0(0,04)	0	1	0(0,05)	0	1
Bathroom0	0,12(0,33)	0	1	0,12(0,32)	0	1
Bathroom1	0,84(0,37)	0	1	0,85(0,36)	0	1
Bathroom2	0,03(0,18)	0	1	0,03(0,18)	0	1
Bathroom3	0(0,03)	0	1	0(0,03)	0	1
Toilet0	0,09(0,29)	0	1	0,09(0,28)	0	1
Toilet1	0(0)	0	0	0(0)	0	0
Toilet2	0,15(0,36)	0	1	0,13(0,34)	0	1
Toilet3	0,49(0,5)	0	1	0,49(0,5)	0	1
Toilet4	0(0,07)	0	1	0(0,06)	0	1
Toilet5	0,19(0,39)	0	1	0,2(0,4)	0	1
Toilet6	0,05(0,21)	0	1	0,06(0,23)	0	1
Toilet7	0,01(0,08)	0	1	0,01(0,09)	0	1
Toilet8	0,01(0,1)	0	1	0,01(0,11)	0	1
Toilet9	0(0,06)	0	1	0(0,07)	0	1
Toilet10	0(0,03)	0	1	0(0,03)	0	1

Note: The table shows the descriptive statistics of the included variables, for control group 1 & 2

Appendix C – Average transaction prices Target and Control Group (6-)monthly level



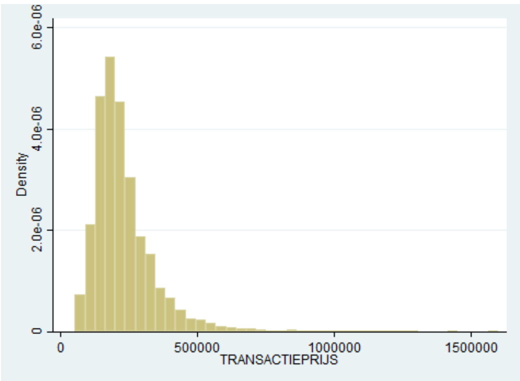
Note: The figure maps the average (6-monthly) transaction prices of the target group and control group 3

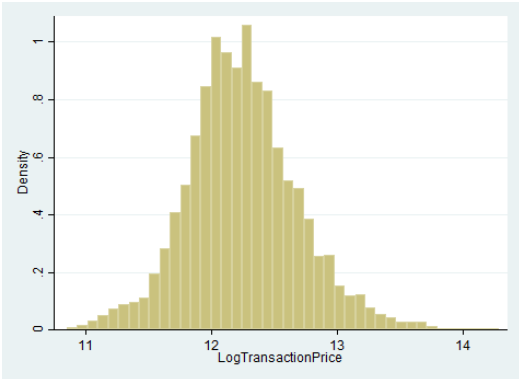


Note: The figure maps the average (monthly) transaction prices of the target group and control group 3

Appendix D – Assumptions OLS

Example effect transforming variable into natural logarithm:



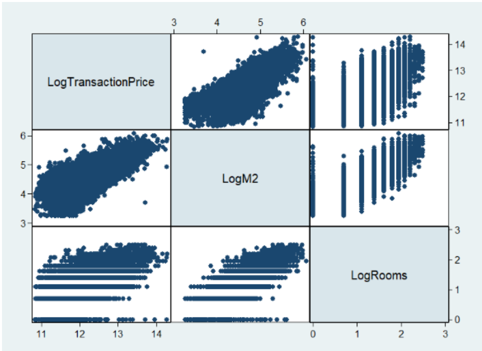


Histogram, Transaction price

Histogram, ln(Transaction price)

The definition and application of each assumption is explained below.

1. **There needs to be a linear relationship between** (a) the dependent variable and each of the independent variables, and (b) the dependent variable and the independent variables collectively. This is checked by different scatter plots and different ordinal variables are transformed into dummy variables.



2. **The data needs to show homoscedasticity,** which is where the variances along the line of best fit remain similar as is moved along the line. The check for homoscedasticity is done by plotting the line of best fit and the unstandardized predicted values and performing the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity.

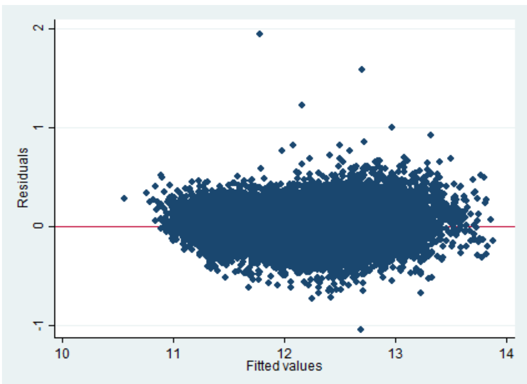
   Looking at the graph below, the residuals seem slightly heteroscedastic. The Breusch-Pagan/Cook-Weisberg test confirms this. In estimating the final regression results this is overcome by using White's robust standard errors, which are typically larger than normal standard errors.

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

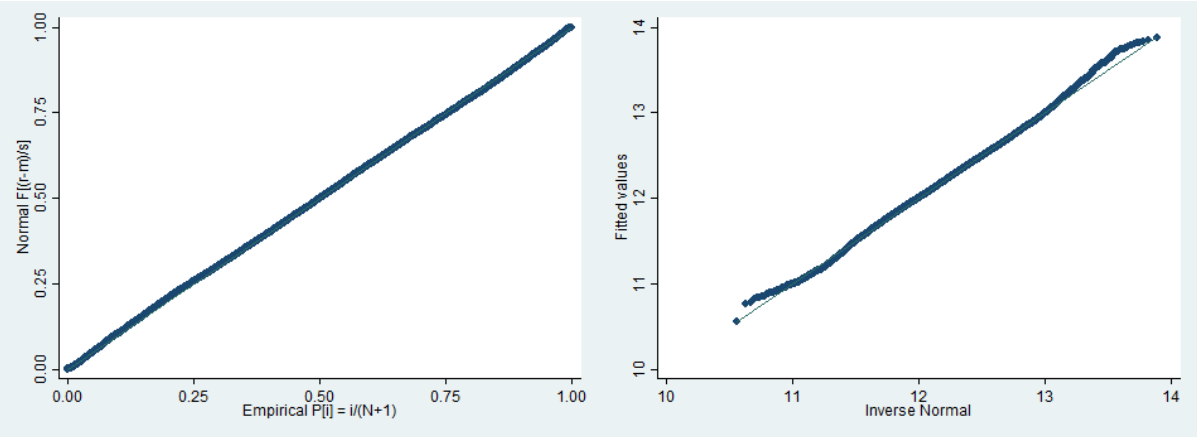
Variables: fitted values of LogTransactionPrice

chi2(1) = 733.89
Prob > chi2 = 0.0000



3. **The data must not contain multicollinearity,** which occurs when there are two or more independent variables that are highly correlated with each other (= endogeneity). Since there were no multi-collinearity issues in estimating the regressors, endogeneity does not seem to occur.
4. **The covariance between errors is zero.** To overcome the possible problem of autocorrelation time and neighborhood fixed effects are included.
5. **There should be no significant outliers.** This is checked by boxplots and tabulating the data per variable and deleting outliers by using upper and lower bounds on the variables (see appendix A).
6. **The residuals should be normally distributed,** which is checked by a Normal P-P plot/Normal Q-Q plot and carrying out Shapiro-Wilk test for normality.

The Normal P-P plot indicates a normal distribution, the Q-Q plot, shows a slight deviation. Confirming this deviation, the Shapiro-Wilk test for normality indicates a non-normal distribution of the error terms. Concluding, the estimators of this study might not be BLUE.



Shapiro-Wilk W test for normaldata

Variable	Obs	W	V	z	Prob>z
r	32,375	0.99886	15.067	7.463	0.00000

Appendix E – Coefficients control variables specification (5) & (6)

	(5)		(5)		(5)	
Sample area	<1501 m		<2501 m		<2001 m	
Target area	0-1000 m		0-1000 m		0-1000 m	
Control are	1001-1501 m		1501-2500 m		1001-2000 m	
BEFORE_A	0.0117	(0.0606)	0.146**	(0.0609)	0.000743	(0.0591)
BETWEEN_AS	-0.366***	(0.108)	-0.337***	(0.111)	-0.369***	(0.108)
AFTER_S	-0.419***	(0.147)	-0.346**	(0.147)	-0.413***	(0.148)
BEFORE_A_D	-5.30e-05	(0.000172)	-0.000269	(0.000173)	2.55e-06	(0.000168)
BEFORE_A_DD	6.80e-08	(1.21e-07)	2.14e-07*	(1.23e-07)	3.61e-08	(1.19e-07)
BETWEEN_AS_D	0.000969***	(0.000301)	0.000870***	(0.000309)	0.000984***	(0.000303)
BETWEEN_AS_DD	-6.36e-07***	(2.08e-07)	-5.64e-07***	(2.14e-07)	-6.48e-07***	(2.09e-07)
AFTER_S_D	0.00105***	(0.000397)	0.000881**	(0.000401)	0.00103**	(0.000401)
AFTER_S_DD	-6.77e-07**	(2.66e-07)	-5.59e-07**	(2.69e-07)	-6.58e-07**	(2.68e-07)
TREND_BETWEEN_AS	0.00994	(0.0223)	0.0127	(0.0223)	0.00809	(0.0220)
TREND_AFTER_S	0.0528	(0.0337)	0.0456	(0.0339)	0.0480	(0.0341)
TREND_BETWEEN_AS_D	-2.86e-05	(6.17e-05)	-3.36e-05	(6.19e-05)	-2.54e-05	(6.12e-05)
TREND_BETWEEN_AS_DD	2.17e-08	(4.21e-08)	2.69e-08	(4.23e-08)	2.07e-08	(4.19e-08)
TREND_AFTER_S_D	-0.000125	(8.97e-05)	-0.000111	(9.07e-05)	-0.000113	(9.11e-05)
TREND_AFTER_S_DD	7.97e-08	(5.89e-08)	7.36e-08	(5.97e-08)	7.25e-08	(5.99e-08)
Year1997	0.104***	(0.0118)	0.0979***	(0.00991)	0.102***	(0.00905)
Year1998	0.229***	(0.0110)	0.194***	(0.00947)	0.215***	(0.00853)
Year1999	0.418***	(0.0109)	0.385***	(0.00941)	0.402***	(0.00835)
Year2000	0.481***	(0.0106)	0.454***	(0.00925)	0.469***	(0.00819)
Year2001	0.534***	(0.0104)	0.503***	(0.00909)	0.520***	(0.00808)
Year2002	0.578***	(0.0105)	0.550***	(0.00926)	0.566***	(0.00813)
Year2003	0.607***	(0.0105)	0.581***	(0.00916)	0.593***	(0.00804)
Year2004	0.668***	(0.0105)	0.645***	(0.00917)	0.662***	(0.00803)
Year2005	0.717***	(0.0107)	0.691***	(0.00933)	0.705***	(0.00820)
Year2006	0.778***	(0.0103)	0.752***	(0.00911)	0.770***	(0.00796)
Year2007	0.874***	(0.0107)	0.858***	(0.00930)	0.867***	(0.00817)
Year2008	0.915***	(0.0109)	0.883***	(0.00961)	0.905***	(0.00831)
Year2009	0.877***	(0.0116)	0.843***	(0.00963)	0.863***	(0.00861)
Year2010	0.870***	(0.0118)	0.845***	(0.00971)	0.863***	(0.00868)
Year2011	0.863***	(0.0115)	0.844***	(0.0101)	0.859***	(0.00878)
Year2012	0.791***	(0.0114)	0.766***	(0.00997)	0.789***	(0.00866)
Year2013	0.752***	(0.0117)	0.726***	(0.0101)	0.746***	(0.00894)
Year2014	0.788***	(0.0110)	0.755***	(0.00963)	0.775***	(0.00847)
Year2015	0.856***	(0.0108)	0.826***	(0.00955)	0.850***	(0.00839)
Year2016	0.961***	(0.0110)	0.933***	(0.00969)	0.959***	(0.00847)
Construction_1500_1905	-0.0383***	(0.00660)	0.0117*	(0.00644)	-0.0485***	(0.00511)
Construction_1906_1930	-0.0833***	(0.00644)	-0.0275***	(0.00610)	-0.0882***	(0.00489)
Construction_1931_1944	-0.0709***	(0.00722)	-0.0217***	(0.00662)	-0.0616***	(0.00542)
Construction_1945_1959	-0.195***	(0.00915)	-0.171***	(0.00651)	-0.161***	(0.00608)
Construction_1960_1970	-0.301***	(0.0122)	-0.226***	(0.00669)	-0.235***	(0.00707)
Construction_1971_1980	-0.210***	(0.0137)	-0.181***	(0.00960)	-0.183***	(0.00997)
Construction_1981_1990	-0.123***	(0.00905)	-0.0928***	(0.00816)	-0.102***	(0.00745)
Construction_1991_2000	-0.0678***	(0.00670)	-0.0310***	(0.00735)	-0.0631***	(0.00577)
LogM2	0.623***	(0.00698)	0.653***	(0.00641)	0.613***	(0.00556)
LogRooms	0.0624***	(0.00647)	0.0687***	(0.00548)	0.0744***	(0.00494)
o.Toilet1	-		-		-	
Toilet2	-0.0240***	(0.00555)	-0.00992**	(0.00463)	-0.0132***	(0.00408)
Toilet3	-0.0279***	(0.00485)	-0.0256***	(0.00394)	-0.0195***	(0.00358)
Toilet4	-0.0604***	(0.0184)	-0.0563***	(0.0194)	-0.0414***	(0.0151)
Toilet5	0.0366***	(0.00571)	0.0469***	(0.00477)	0.0454***	(0.00421)
Toilet6	0.0410***	(0.00859)	0.0780***	(0.00667)	0.0566***	(0.00599)
Toilet7	0.0879***	(0.0194)	0.140***	(0.0174)	0.105***	(0.0146)
Toilet8	0.0734***	(0.0149)	0.157***	(0.0131)	0.0952***	(0.0114)
Toilet9	0.117***	(0.0264)	0.228***	(0.0210)	0.178***	(0.0206)
Toilet10	0.119***	(0.0461)	0.0651	(0.0476)	0.0816*	(0.0433)
Bathroom0	-0.0167***	(0.00424)	-0.00740**	(0.00337)	-0.0102***	(0.00307)
Bathroom2	0.0617***	(0.00966)	0.0950***	(0.00961)	0.0673***	(0.00779)
Bathroom3	-0.00845	(0.0439)	0.0322	(0.0401)	0.0210	(0.0355)
Kitchen0	0.0142***	(0.00346)	0.00967***	(0.00288)	0.0151***	(0.00252)
Kitchen2	-0.0767***	(0.0104)	-0.0980***	(0.00923)	-0.0799***	(0.00790)

Kitchen3	-0.0537	(0.0339)	-0.117***	(0.0347)	-0.0928***	(0.0325)
Heating	0.0688***	(0.00367)	0.0637***	(0.00267)	0.0622***	(0.00246)
IsolationDUM	0.0172***	(0.00281)	0.00468**	(0.00224)	0.0149***	(0.00198)
ParkingDUM	0.110***	(0.00580)	0.0712***	(0.00521)	0.0970***	(0.00464)
Ground_Lease	-0.00655**	(0.00281)	-0.00801***	(0.00239)	-0.00771***	(0.00211)
Rented_partially	-0.133**	(0.0591)	-0.151***	(0.0470)	-0.153***	(0.0437)
Monument	0.0760***	(0.00895)	0.0822***	(0.00893)	0.0883***	(0.00756)
RoofterraceDUM	0.0247***	(0.00338)	0.0134***	(0.00304)	0.0178***	(0.00250)
BalconyDUM	0.0123***	(0.00294)	0.0407***	(0.00255)	0.0189***	(0.00225)
Outside_maintenanceDUM	-0.132***	(0.0196)	-0.0854***	(0.0176)	-0.112***	(0.0144)
Inside_maintenanceDUM	-0.105***	(0.0137)	-0.105***	(0.0117)	-0.100***	(0.0101)
WellMaintainedGardenDUM	0.0872***	(0.00333)	0.0874***	(0.00275)	0.0820***	(0.00235)
House_detached	0.0887*	(0.0469)	0.181***	(0.0442)	0.114***	(0.0434)
House_SemiDetached	0.0706	(0.0453)	0.106***	(0.0382)	0.0762**	(0.0388)
House_corner	-0.0480	(0.0354)	-0.0341	(0.0335)	-0.0506	(0.0323)
House_intermediate	-0.0561	(0.0349)	-0.0488	(0.0332)	-0.0566*	(0.0320)
Appartment	-0.106***	(0.0349)	-0.104***	(0.0333)	-0.111***	(0.0321)
PC3511	0.0458***	(0.0116)	0.148***	(0.00719)	0.267***	(0.00616)
PC3512	0.0724***	(0.0115)	0.143***	(0.00878)	0.302***	(0.00644)
PC3513	-0.172***	(0.0115)	-0.0608***	(0.00822)	0.0442***	(0.00557)
PC3514	-0.0138	(0.0111)	0.120***	(0.00695)	0.219***	(0.00533)
PC3515	-0.138***	(0.0133)	0.0735***	(0.00583)	0.135***	(0.00604)
PC3521	-0.140***	(0.0116)	-0.0149*	(0.00867)	0.0876***	(0.00582)
PC3522	-0.155***	(0.0118)	-0.0585***	(0.00444)	0.0473***	(0.00535)
PC3527	-0.248***	(0.0149)	-0.138***	(0.00450)	-0.0929***	(0.00596)
PC3531	-0.203***	(0.0111)	-0.0941***	(0.00549)	0.0142***	(0.00513)
PC3532	-0.216***	(0.0113)	-0.103***	(0.00646)	0.000785	(0.00525)
PC3533	-0.0921***	(0.0158)	0.0828***	(0.00484)	0.132***	(0.00524)
PC3551	-0.276***	(0.0115)	-0.0977***	(0.00484)	-0.0373***	(0.00519)
o.PC3572	-		0.147***	(0.00418)	0.217***	(0.00541)
PC3581	0.110***	(0.0155)	0.160***	(0.00450)	0.234***	(0.00523)
PC3582	-0.0364**	(0.0153)	0.0520***	(0.00423)	0.110***	(0.00605)
Street_Type	-0.0178***	(0.00624)	-0.0497***	(0.00443)	-0.0336***	(0.00413)
Constant	8.857***	(0.0461)	8.524***	(0.0420)	8.666***	(0.0393)
Observations	17,506		32,069		32,375	
R-squared	0.886		0.874		0.888	

Note: The table reports the estimated coefficients from the initial analysis and the sensitivity analysis, substituting control groups. Dependent variable is ln(transaction price). Robust standard errors are reported between parentheses.

	(6) Control group 2	
Sample area	<2001 m	
Target area	0-1000 m	
Control are	1001-2001 m	
BEFORE_A	0.000791	(0.0591)
BETWEEN_AS	-0.350***	(0.104)
AFTER_S	-0.412***	(0.157)
BEFORE_A_D	2.59e-06	(0.000168)
BEFORE_A_DD	3.61e-08	(1.19e-07)
BETWEEN_AS_D	0.000942***	(0.000291)
BETWEEN_AS_DD	-6.20e-07***	(2.02e-07)
AFTER_S_D	0.00101**	(0.000425)
AFTER_S_DD	-6.34e-07**	(2.85e-07)
TREND_BETWEEN_AS	0.00275	(0.0213)
TREND_AFTER_S	0.0422	(0.0330)
TREND_BETWEEN_AS_D	-1.41e-05	(5.96e-05)
TREND_BETWEEN_AS_DD	1.34e-08	(4.10e-08)
TREND_AFTER_S_D	-9.51e-05	(8.82e-05)
TREND_AFTER_S_DD	5.85e-08	(5.81e-08)
Year1997	0.102***	(0.00906)
Year1998	0.215***	(0.00853)
Year1999	0.402***	(0.00836)
Year2000	0.469***	(0.00819)
Year2001	0.520***	(0.00808)
Year2002	0.565***	(0.00813)
Year2003	0.593***	(0.00804)
Year2004	0.661***	(0.00803)
Year2005	0.705***	(0.00820)
Year2006	0.770***	(0.00796)
Year2007	0.867***	(0.00817)
Year2008	0.905***	(0.00831)
Year2009	0.863***	(0.00862)
Year2010	0.863***	(0.00868)
Year2011	0.859***	(0.00878)
Year2012	0.789***	(0.00866)
Year2013	0.746***	(0.00894)
Year2014	0.775***	(0.00848)
Year2015	0.850***	(0.00839)
Year2016	0.959***	(0.00848)
Construction_1500_1905	-0.0485***	(0.00511)
Construction_1906_1930	-0.0882***	(0.00489)
Construction_1931_1944	-0.0616***	(0.00542)
Construction_1945_1959	-0.161***	(0.00608)
Construction_1960_1970	-0.235***	(0.00708)
Construction_1971_1980	-0.183***	(0.00998)
Construction_1981_1990	-0.102***	(0.00745)
Construction_1991_2000	-0.0632***	(0.00578)
LogM2	0.613***	(0.00557)
LogRooms	0.0744***	(0.00494)
o.Toilet1	-	
Toilet2	-0.0132***	(0.00408)
Toilet3	-0.0195***	(0.00358)
Toilet4	-0.0413***	(0.0151)
Toilet5	0.0454***	(0.00421)
Toilet6	0.0566***	(0.00599)
Toilet7	0.105***	(0.0146)
Toilet8	0.0951***	(0.0114)
Toilet9	0.178***	(0.0206)
Toilet10	0.0814*	(0.0434)
Bathroom0	-0.0102***	(0.00307)
Bathroom2	0.0672***	(0.00779)
Bathroom3	0.0208	(0.0355)

Kitchen0	0.0151***	(0.00252)
Kitchen2	-0.0799***	(0.00790)
Kitchen3	-0.0929***	(0.0325)
Heating	0.0622***	(0.00246)
IsolationDUM	0.0149***	(0.00198)
ParkingDUM	0.0970***	(0.00464)
Ground_Lease	-0.00770***	(0.00211)
Rented_partially	-0.153***	(0.0437)
Monument	0.0884***	(0.00756)
RoofterraceDUM	0.0178***	(0.00250)
BalconyDUM	0.0189***	(0.00225)
Outside_maintenanceDUM	-0.112***	(0.0144)
Inside_maintenanceDUM	-0.100***	(0.0101)
WellMaintainedGardenDUM	0.0820***	(0.00235)
House_detached	0.114***	(0.0434)
House_SemiDetached	0.0761**	(0.0388)
House_corner	-0.0507	(0.0322)
House_intermediate	-0.0567*	(0.0320)
Appartment	-0.111***	(0.0320)
PC3511	0.267***	(0.00616)
PC3512	0.302***	(0.00644)
PC3513	0.0443***	(0.00557)
PC3514	0.219***	(0.00533)
PC3515	0.135***	(0.00604)
PC3521	0.0877***	(0.00582)
PC3522	0.0473***	(0.00535)
PC3527	-0.0929***	(0.00596)
PC3531	0.0142***	(0.00513)
PC3532	0.000756	(0.00525)
PC3533	0.132***	(0.00524)
PC3551	-0.0373***	(0.00519)
PC3572	0.217***	(0.00541)
PC3581	0.234***	(0.00523)
PC3582	0.110***	(0.00605)
Street_Type	-0.0336***	(0.00413)
Constant	8.667***	(0.0392)
Observations	32,375	
R-squared	0.888	

Note: The table reports the estimated coefficients from specification (6), using the adjusted yearly TREND variables. Dependent variable is ln(transaction price). Robust standard errors are reported between parentheses.