Living at the office:

A study on the external effects of the transformation of office space into housing on local housing markets

Bob Kramers, June 2018

Abstract

In the past decades, a large number of office buildings has been transformed into housing. A considerable part of these office buildings is left vacant for several years before transformation, during which they are often poorly maintained. As such they may become a disamenity to the surrounding area. After transformation, the visual appearance may change and new residents will enter the area. This may affect the living environment in the area as well as the local economy.

The external effects of seventeen transformation projects on the surrounding house prices are estimated using a difference-in-difference hedonic framework. It was found that prior to the transformation, these offices were a disamenity and caused negative price externalities for the surrounding area. During the transformation there was an anticipation effect resulting in positive price externalities. After the transformation projects were completed the positive external effect increased, indicating that the positive effect was not fully anticipated.

Controlling for year fixed effects (FE), structural characteristics, building period, and neighborhood FE, house prices in the target area (0-1000 m) were found to be 2.25% lower prior to the transformation, 1.96% higher during the transformation and 4.02% higher after the transformation was completed compared to the control area (1000-2000 m). These results are significantly different from zero at a 1% level. When checking for heterogeneity, we found that the results are driven by projects located in the G5 cities, that experienced vacancy before transformation, and where a severe change in appearance was realized.

"*Time makes the high building costs of one generation the bargains of a following generation. Time pays off original capital costs, and this depreciation can be reflected in the yields required from a building. Time makes certain structures obsolete for some enterprises, and they become available to others*." (Jacobs, 1961)

COLOFON

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

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Preface

Before you lies the thesis I wrote for the completion of the master Real Estate Studies at the University of Groningen. This thesis marks the end of my scientific education as well as the start of my professional career in real estate. As such I am very excited about starting this new chapter in life, yet I also look back on a very pleasant and formative time as a student.

This thesis would not have been the same if it weren't for the guidance and support of a few people, whom I would like to thank. First and foremost my mentor, dr. Mark van Duijn, who guided me through the problems I encountered and provided me with constructive feedback throughout the process. Secondly all the developers and contractors who provided me with the project information needed for the regression. Finally my family and girlfriend who supported and motivated me along the way.

I sincerely hope that this thesis may be educative to you, the reader, and add to our understanding of the external effects of office buildings on house prices.

1. Introduction

1.1. Motivation

In the past decade a substantial number of office buildings has become vacant and it is often difficult or not possible to find new tenants. Transformation of office space into housing can offer a solution, especially when there is a shortage on the housing market in the surrounding area. An example of this can be found in the former headquarters of ING in Amsterdam South East. This 65,000 square meter building was bought by a consortium of real estate companies and will be transformed into apartments in the near future.[1] A second example can be found in the old KPN headquarters in The Hague. This 80,000 square meter office building will be transformed into apartments and possibly a hotel.[2] The transformation of vacant office buildings into housing is experiencing growth in The Netherlands. In 2015 a record of 720,000 square meters of office space was transformed to housing.[2]

The high number of offices being transformed into housing demonstrates that this type of transformation is a relevant theme in the Dutch real estate industry. When analyzing a transformation of office space into housing, there are internal and external effects to be distinguished. Internal effects, such as the profitability of the transformation, have an impact on the project itself while external effects have an impact outside the project. The transformation of office space into housing may have an impact on the surrounding area. On the one hand, it will increase the supply of housing. On the other hand, new residents will move into the neighborhood, which may improve the local economy. If the neighborhood becomes more (or less) attractive, this should be reflected in a change in house prices (Li & Brown, 1980).

Because of the negative effect of vacant buildings on their surroundings, planning authorities throughout the world have initiated policies that aim to prevent vacancy and promote the transformation of vacant office buildings (Heath, 2001; StratAct, 2015; Remøy & Street, 2016). One of the tools used by governments is a reduction of the plan capacity in order to prevent the development of an unhealthy oversupply of office buildings (StratAct 2015). Besides preventing oversupply, governments also encourage the transformation of offices into housing. An example of this can be found in the policy document on the transformation of offices from the province of Utrecht. The province has taken a pro-active approach in stimulating the transformation of vacant office buildings by promoting locations, offering broad support throughout the transformation process, connecting different actors, and short-term financing of transformations (StratAct, 2015).

Research into the external price effects generated by the transformations may serve as a useful tool in evaluating these policies. Therefore it would be relevant and useful to conduct research on this subject. This study will focus on the transformation of office buildings located in the Netherlands into housing

[1] https://fd.nl/ondernemen/1130624/zandkasteel-van-ing-wordt-appartementencomplex
[2] https://fd.nl/ondernemen/1169041/voormalig-kpn-hoofdkantoor-wordt-appartementencomplex

and the external effects of these transformations on the value of the surrounding homes. The results from this research will give insight in the effectiveness of improving neighborhoods through the transformation of vacant office buildings.

1.2 Review of literature

Existing literature on the topic of office vacancy and transformation into housing is focused mainly on explaining vacancy and assessing the transformation potential from the owner's perspective (Remøy & Van Der Voordt, 2007; Scheublin & Betrams, 2007; Schmidt, 2012). In the Netherlands transformation of office space to housing is attractive because of the tight housing market (Remoy & van der Voordt, 2007). The housing market in the Netherlands is characterized by a big demand surplus and a scarcity of land (Remøy & Van Der Voordt, 2007).

For the owner of a vacant office building that may be transformed into housing, the crucial factor in decision making is the financial feasibility of the transformation (Schmidt, 2012). Schmidt (2012) concludes that the financial feasibility is subject to the combination of the quality of location, the user demand and the required alterations to the building. However, Remoy & van der Voordt (2007) find that, besides the financial problems for the owners, vacancy of office buildings is furthermore associated with (social) problems for the neighborhood. Vacant office buildings attract crimes such as break-ins, illegal occupancy and vandalism (Remøy & Van Der Voordt, 2007). This will cause deterioration of the surrounding area and devaluation of its real estate (Remøy & Van Der Voordt, 2007). So besides the financial feasibility of the transformation there are also external effects to be expected which have an influence on the (societal) desirability of a transformation. When a vacant office building is transformed and inhabited, these disamenities and the external financial effects stemming from it, may be reversed.

In recent years there has been extensive research on the price externalities of transformations and housing investments. A selection of the research that served as inspiration for this study includes the paper by Schwartz et al. (2006) who researched the external effects of subsidized housing investments. Through a difference-in-difference hedonic framework it is found that significant external effects emerged as a result of these investments. Van Duijn et al. (2016) have examined the external effects of investments in the redevelopment of industrial heritage sites on the housing price in the surrounding residential areas. The researchers find that the negative external effects before the investments can be reversed or even turned into positive external effects. Leonard et al. (2017) investigated the external price effects of a governmental policy aimed at rehabilitating foreclosed homes. They found negative external effects prior to rehabilitation and positive external effects after rehabilitation. No research has been done on the external effects of the transformation of office space into housing, whilst research on the external effects of investments in subsidized housing, industrial heritage and foreclosed homes have revealed an interesting pattern in the development of housing prices in the surrounding area. Through this research the existence of a similar pattern with the transformation of office space can be determined.

1.3. Research problem statement

As is made clear in the motivation and the review of existing literature, the transformation of office space into housing is a relevant topic in the real estate industry of the Netherlands. The aim of this study is to fill the gap in existing literature by determining the external effects of the transformation of office space into housing. This aim has led to the formation of the following main research question and three sub-questions:

> **What are the external house price effects of the transformation of office buildings into housing on local housing markets?**
>
> *1: What external effects can be expected as a result of a transformation and how can these effects be measured?*
>
> *2: What is the effect of the transformation of office buildings into housing on the value of the surrounding homes?*
>
> *3: What is the difference in external house price effects based on the characteristics of the transformation projects?*

The first sub-question will be answered by conducting a literature review. The literature database of the University of Groningen will be used as well as external literature sources.

The second sub-question will be answered by conducting empirical quantitative research on the transformation of a selection of offices throughout the Netherlands. A difference-in-difference hedonic framework is used to assess the change in house prices in the area surrounding the transformations that were caused by the transformations. This will be executed by comparing a ‘target area’ close to the transformation with a ‘control area’ further away. As is shown in the conceptual model (figure 1) we aim to determine the extent to which external effects caused by the transformation (X-variable) influence the surrounding house prices (Y-variable). When we account for all other variables that influence house prices (Z-variables) we will be able to determine which part of the change in house prices was caused by the transformation of office buildings into housing. In order to execute this research design, data on residential property transactions will be used. The change in housing prices are assessed three times: before, during and after the transformation took place.

The third sub-question will be answered by examining if there is heterogeneity in the selected transformation projects and the external price effects caused by these projects. The external effects are likely depending on certain project characteristics (e.g. vacancy, change in appearance), as is shown in the conceptual model (figure 1). Separate regressions are run based on these characteristics. When there are significantly different house price effects based on certain project characteristics, this information can serve to explain what causes the external house price effects.

The projects selected for this research project are seventeen transformed office buildings throughout the Netherlands. These buildings had an office function prior to transformation and a housing function after transformation, were transformed between 1999 and 2014, are in a close proximity to a residential area, and comprise at least twenty housing units. These criteria were set in order to select homogenous projects that are of sufficient size to generate expected price externalities and are completed at least three years before 2017 in order to be able to fully measure the external price effect.

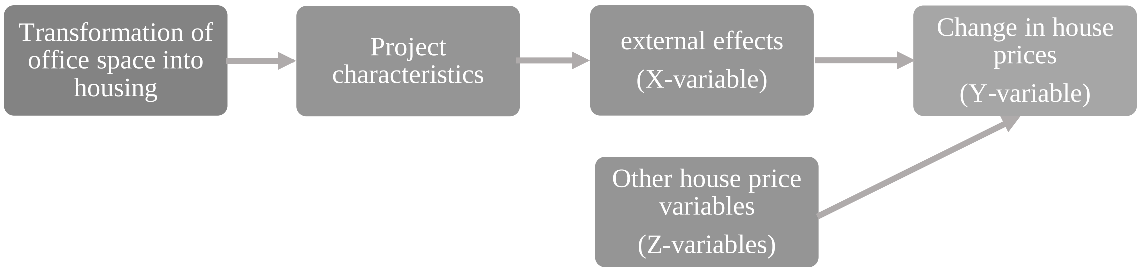

Figure 1. Conceptual model

1.4 Definitions

Throughout literature, different terms are used to describe the transformation of office space into housing. The terms that are used in recent literature include 'conversion' (Remøy & Van Der Voordt, 2007), 'adaptive reuse' (Bullen & Love, 2010), 'repurposing' (Schmidt, 2012), and 'transformation' (Remøy, 2010). There is no consensus among authors on the correct term and definition. In this thesis the term 'transformation' will be used, along the definition by Remøy (2010): "the functional transformation from offices into housing and changes that have to be made in the building structure to accommodate the new function".

1.5 Reading guide

The remainder of this paper is structured as follows. Chapter 2 describes the theoretical framework along five topics: house prices, external price effects, house price determinants, heterogeneity, and office market research. Building on this theory, chapter 2 concludes with hypotheses. Chapter 3 describes the methodology, including the baseline model specification and the robustness analysis, as well as the data that are used. Chapter 4 sets out the results that are obtained from the baseline specification as well as the robustness analysis. In chapter 5 conclusions are drawn based on the obtained results. The results are furthermore discussed in the light of previous studies and recommendations for future research are made.

2. Theoretical framework

In this chapter the theoretical framework on which the research is based will be set forth. The structure of this chapter follows the conceptual model as depicted in Chapter 1. The first paragraph of the chapter describes the theory on the determination of house prices and the underlying mechanisms. The second paragraph of the chapter describes the underlying motivation why external effects are expected by transforming office buildings. The third paragraph of the chapter lists and compares control variables that are used in other hedonic studies to determine the house prices. The fourth paragraph of the chapter discusses heterogeneity in the results. The fifth paragraph summarizes the main themes of office market research. The last paragraph sets forth the hypotheses that are derived from the theory.

2.1 House prices

In order to answer the main research question and establish what the effect of the transformation of office buildings into housing is on local house prices, we must analyze the formation of house prices and the underlying mechanisms. In essence house prices, like the price of all goods that are traded in an open market environment, are determined through the mechanism of supply and demand. However, house prices mechanisms are more complex than those of most other goods as they are influenced by a great amount of (macro-) economic factors.

There are two submarkets to be distinguished in the housing market; the market for the existing housing stock and the market for newly constructed houses (Poterba, et al., 1991). House prices are determined in the market for existing housing stock, whereas the level of investment is determined in the market for newly constructed houses (Poterba, et al., 1991). Poterba et al. (1991) consider home owners as investors and therefore equilibrium in the market for existing housing stock is reached when homeowners earn the same return on their investment in housing as on other assets. In the constructed model, house prices are determined by the tax rate, the nominal interest rate, the property tax rate, the depreciation rate on housing capital, the risk premium for housing assets, the maintenance cost, and the expected house price appreciation (Poterba, et al., 1991). All these parameters are exogenous to the housing market, except for the house price appreciation (Poterba, et al., 1991). The expected house price appreciation is influenced by future housing investments, which in turn is determined by the construction costs relative to current house prices (Poterba, et al., 1991).

However, an important shortcoming in the aforementioned model is that it ignores the high level of heterogeneity within the housing market. Houses are not a uniform good like for example a barrel of crude oil. Houses that are transacted can be seen as an aggregate of different attributes such as construction materials, size, age, plot area, location, and neighborhood characteristics. This principle is explained in the bid rent theory, where the rent a household or business is willing to pay decreases as distance to the central business district decreases (Alonso, 1960). At each given distance from the CBD, a household or business will experience equal utility as a result of the trade-off between rent and distance (i.e. transport costs) and is thus indifferent to the location (Alonso, 1960). This theory can be expanded to include other house characteristics, for example the trade-off between rent and size. Alonso (1960) defines his theory for rent, however the same mechanisms can also be applied to house prices, as Poterba et al. (1991) show that house prices and rents are firmly interconnected.

The bid rent theory, where the rent or property values are based on the distance to the CBD, serves as the conceptual basis for hedonic pricing (Damm, et al., 1980). An important distinction between the bid rent theory and hedonic pricing is that the bid rent reflects the willingness to pay for certain attributes by the highest bidder, whereas hedonic pricing only reflects the marginal evaluation of the highest bidder (Damm, et al., 1980). The underlying assumption of hedonic pricing is that "goods are valued for their utility-bearing attributes or characteristics" (Rosen, 1974). Building on this, when we account for all variables that determine house prices in our hedonic model, we will be able to identify the price effect for treatment by the transformation of an office building into housing.

2.2 External price effects caused by transformation of offices into housing

External house price effects reflect either positive or negative changes that occurred in area Y as a result of event X. In this case we want to know what external house price effects occur when an office building is transformed into housing. In order for any external effects to exist, the transformation has to affect the neighborhood. Otherwise, if the neighborhood is not affected by the transformation, there will be no external price effect. Before we establish the variables that will be used to estimate the external price effect, we have to theorize in what way the transformation of office building X will affect the surrounding area Y. The effects can be categorized in three periods; before the transformation took place, while the transformation was taking place and after the transformation was completed. An overview of the effects is found in table 1.

Before

The transformation of office buildings into housing is often times related to vacancy. We may assume that the owners of office buildings are looking to maximize their income. When an office building is fully rented out, the owner would have no incentive to transform the office building into housing as this brings considerable costs, uncertainty, and a loss of rental income during the transformation. When an office building is faced with vacancy, however, the owner will have a financial incentive to consider transformation. The longer an office building is vacant, the more likely it is that the owner will sell the building or initiate a functional transformation (Remøy & Van Der Voordt, 2007). The office buildings threatened by vacancy are often part of the mediocre segment of the building stock (Remoy & van der Voordt, 2007). Remoy & van der Voordt (2007) find that the transformation of nondescript and inarticulate buildings is feasible in the context of urban regeneration.

The negative effects on local housing markets associated with vacant buildings are widely recognized. Spelman (1993) shows that crime rates on blocks with open vacant buildings are twice as high as those on similar blocks without vacant buildings. Vacant buildings are often times poorly maintained and can serve as an instigator of vandalism and other destructive behavior in a neighborhood (Kraut, 1999). Furthermore, vacant buildings will diminish investments in the neighborhood as a whole (Duncan et al., 1975). Similar to infectious diseases, the negative effects caused by vacant buildings spread at a faster rate and to a larger group when they exceed a certain threshold (Kraut, 1999). The United States Department of Housing and Urban Development (1973) estimate this vacancy threshold to be between three and six percent. When vacancy levels rise above this threshold residents will start to leave the neighborhood and the problems deteriorate (Kraut, 1999). After this point reversal of the abandonment process will only be possible with major external intervention (Hughes & Bleakly, 1975). In light of the negative effects that vacant buildings have on their surroundings, these buildings are often considered as negative financial externalities. Numerous studies have shown that vacant buildings have a lowering effect on the prices of surrounding real estate (Greenberg et al., 1990; Gold, 1998).

Similar to vacant office space, foreclosed homes are often left vacant for considerable amounts of time and poorly maintained. External effects on local housing markets that are caused by foreclosed homes, may therefore also exist in housing markets with vacant office buildings. For foreclosed homes, Lee (2008) identifies three mechanisms that cause negative financial externalities for surrounding homes; blight, valuation and supply. Blight occurs because owners with delinquent mortgages cannot afford to properly maintain their homes, and because foreclosed homes are frequently left vacant for a considerable amount of time (Lee, 2008). Secondly, foreclosed homes cause negative financial externalities through valuation. Foreclosed homes sell at a discount, which effects the valuation (based on prior sales) of surrounding houses. Third, foreclosed homes cause negative externalities through supply because a high concentration of foreclosures will raise the local housing supply and thus lower prices (Lee, 2008). Of these three mechanisms recognized in foreclosed homes, valuation will not be a factor when considering the transformation of offices into housing. Blight will be an important factor, especially if the office building is vacant for a substantial period. The third mechanism, supply, is also a relevant factor to consider as the transformation of offices into housing will generate a new supply of housing.

During

Various previous studies on the external price effects of spatial investments have shown the existence of an anticipation effect in house prices (Damm et al., 1980; Van Duijn et al., 2016). After the transformation of an office building into housing is announced to the public, they might anticipate that the associated disamenities will be removed by the project and that the project will create new amenities for the neighborhood. As a result of this, prices can be expected to rise before the project is completed. However, the existence of an anticipation effect in earlier research on other types of investments does not mean that a similar effect will be visible with the transformation of offices into housing. The expected benefit generated by the construction of a new public transport system or the redevelopment of industrial heritage sites might be more easy to comprehend than that of an office building.

Another way in which the surrounding area may be affected during the transformation projects is through construction nuisance. Construction work may produce disturbing sounds as well as dust and visual nuisance. Previous research has shown that construction works can have a depressing effect on house prices in the surrounding area in anticipation of construction as well as during construction work (Henneberry, 1998). However, Henneberry (1998) found this depressing effect on house prices for a large public transport project where construction lasted several years. Construction works on the transformation of office buildings into housing will be less evasive because there is no demolition nor groundwork needed. The most notable construction nuisance may be expected when a new façade is built, but in most cases the construction works are concentrated on the inside of the building. Therefore the nuisance will also be less severe.

After

Apart from removing disamenities, the transformation of an office building into housing may also have a positive impact on the surrounding area. Schwartz et al. (2016) find that newly constructed buildings may have a positive effect on the neighborhood because of their attractive appearance and design features. A similar effect may also be expected when an outdated office building is transformed into a modern apartment building. However, not all transformation projects will involve a noticeable improvement on the outside of the building, as facades may take up between 25 and 33% of construction costs (Scheublin & Betrams, 2007). It is therefore relevant to study the visual appearance of the office buildings before and after the transformation.

After the transformation is completed, new residents will enter the neighborhood. These new inhabitants will increase street traffic and therefore safety may improve (Schwartz, et al., 2006). New inhabitants may also increase the retail spending and stimulate the neighborhood economy (Schwartz, et al., 2006). Depending on whether the office building is still in use, jobs may disappear from the area which may negatively affect the neighborhood economy. It is important to distinguish between different types of residents. When the transformation targets students as residents, the positive effect may be smaller since students will have less attachment to the neighborhood, spend less resources on maintenance of their apartment and may cause nuisance. Home owners will likely be more desirable residents, as they remain in their homes for a longer period of time and are more likely to invest in maintenance of their homes and become active in neighborhood organizations (Ellen, et al., 2002). The targeted resident type of the transformation is also an important factor in determining the transformation budget. The average construction costs for student apartments are substantially lower than those of luxury apartments (Geraedts & van der Voordt, 2007). A lower transformation budget will likely result in a lower visual quality of the building.

Another positive effect on the surrounding area after the transformation of office buildings into housing is that the projects may attract other investments in the area. This phenomenon is known as the demonstration effect; a successful pioneering investment in for example housing in a neighborhood may be an incentive for other investors to make similar investments (Caplin & Leahy, 1998).

When an office building is transformed into housing, this may introduce new functions or amenities (besides housing) to the neighborhood such as retail space, coffee shops, restaurants from which the neighborhood may benefit. The addition of functions to an area may improve the livelihood in the area and the living quality for its residents (Jacobs, 1961). However, the addition of functions may also have a negative effect on the living quality if it puts pressure on the neighborhood infrastructure or if the new functions do not serve the interest of the local residents.

The transformation of offices into housing will result in an increase of the housing supply in the area, which may cause a negative price effect. The price of real estate is determined through supply and demand; when supply increases, the price will decrease (DiPasquale & Wheaton, 1992). The classical supply and demand theory consists of two linear functions; the supply function and the demand function. The supply function indicates that as the quantity supplied increases, the price will decrease. The demand function indicates that as the quantity demanded increases, the price increases. These two functions intersect at the equilibrium price. When there is a sudden increase of supply, the supply function will shift to the right and at a given demand, this will lower the equilibrium price (see figure 2). Although this is a simplified rendition of the real estate market, it may be expected that the new housing supply as a result of office transformations will generate a negative financial externality and will therefore have a moderating effect of the positive externalities caused by the transformation (e.g. blight removal).

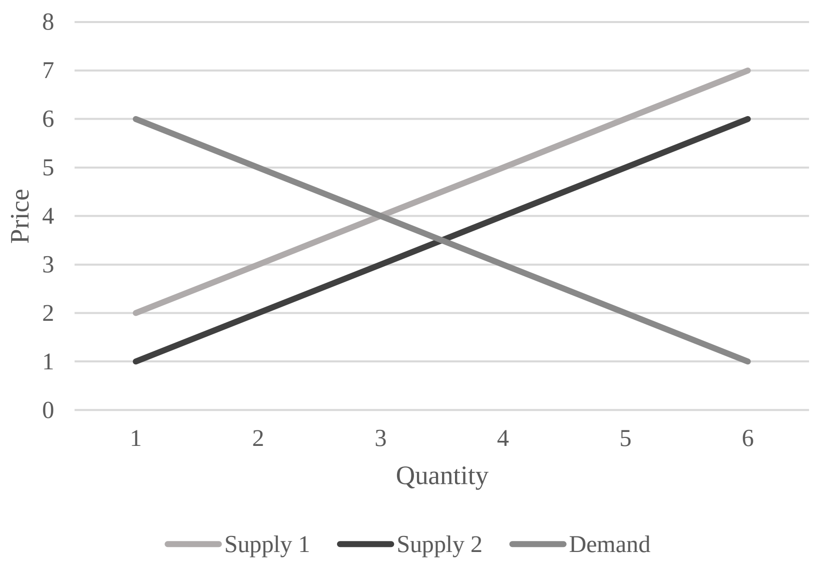

Figure 2. Price effect of a shift in housing supply.

Table 1. Overview possible external effects before, during and after the transformation of an office building into housing

Before	**During**	**After**
Vacancy	Anticipation	Visual quality
• Poor maintenance	Construction nuisance	New residents
• Crime		Attract investments
• Vandalism		New functions / amenities
• Disinvestment		Increase supply

2.3 House price determinants

Besides treatment by the external effects of the transformation, house prices may be determined by a wide set of characteristics. Previous hedonic price research gives insight into the various factors and their relevance in determining house prices. Table 2 summarizes different characteristics that were included as control variables in previous research. These characteristics have proven to be explanatory for house prices in previous research. The most used variables will be included for constructing the baseline model of this study. This will be further discussed in Chapter 3.

Table 2. Structural and neighborhood characteristics used in previous research

Structural characteristics	I	II	III	IV	V
House condition (inside / outside)	✓	✓			
Number of stories	✓				
Fireplace	✓				✓
Pool	✓				
Number of bathrooms	✓				✓
Floor space	✓	✓	✓	✓	
Lot size	✓		✓		✓
House age	✓	✓		✓	✓
Foreclosure sale	✓				
Number of rooms		✓	✓		✓
Housing type		✓	✓	✓	
Balcony		✓			
Terrace		✓			
Parking		✓		✓	✓
Well-maintained garden		✓			
Central heating		✓	✓		
Monument		✓			
Number of buildings on lot				✓	
Vandalized				✓	
Abandoned				✓	
Odd shape				✓	
Extension				✓	
Major alteration				✓	
Includes commercial space				✓	
Basement					✓
Patio					✓
Noise level					✓
On-site visual quality					✓

Leonard, Jha, & Zhang, 2017 (I),
Van Duijn & Boersema, 2016 (II),
Daams, 2016 (III),
Schwartz, Ellen, Voicu, & Schill, 2006 (IV),
Li & Brown, 1980 (V)

2.4 Heterogeneity

Previous research on the external effects of industrial heritage redevelopments has shown a difference in the external effects between the largest cities and smaller municipalities (Van Duijn, et al., 2016). For projects located in the largest cities, a positive external effect emerges after redevelopment, whereas in smaller municipalities there is no substantial positive external effect after redevelopment (Van Duijn, et al., 2016). This implies a link between an urban environment and positive external effects after redevelopment (Van Duijn, et al., 2016).

Another study, on the external effects of historic district designation in New York City, further examines the heterogeneity in the results. The historic district designation limits development in the area, as it introduces building restrictions (Been, et al., 2016). It is found that the increase in property values is largest in the areas where the initial development potential was low and the amenity level was high (Been, et al., 2016). Insight in the heterogeneity in the results is very useful, as it improves understanding of the driving forces underlying the external effects, and can help policy makers with targeting specific projects that will generate the desired policy outcomes.

2.5 Office market research

Research on office markets tends to be focused on four (interconnected) themes; supply and demand, vacancy, rents, and valuation. Of the top-ten most cited articles on ‘office markets’, 90% are focused on one or more of these four themes. These four themes are also found in the renowned article by DiPasquale & Wheaton (1992), where the processes on the real estate asset market and the real estate space market are discussed. When we follow the diagram (figure 3), the transformation of an office into housing will result in higher office values. The transformation will take office space out of the market, lowering supply. At a given demand this will result in higher rents, which at a given capitalization rate will result in higher office values.

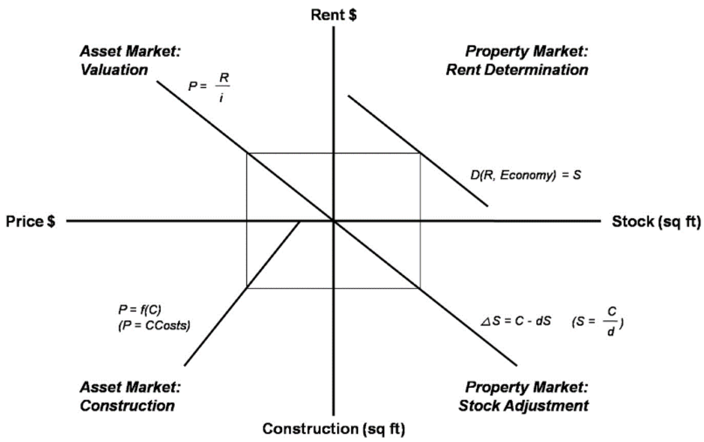

Figure 3. 4-Quadrant diagram *(DiPasquale & Wheaton, 1992)*

The focus on these four themes illustrates the tendency of office market research to be focused on the investor’s and tenant’s perspective. However these are not the only stakeholders to be considered. The residents of the surrounding neighborhood are likely to be affected by the offices, especially when an office building is located in a residential area.

2.6 Hypotheses

The theory presented in this chapter suggests that the transformation of office buildings into housing may influence the surrounding house prices. Based on the theory, four hypotheses are formulated.

H1: Prior to transformation into housing, office buildings have a negative external effect on surrounding house prices.

Before transformation, the office buildings may have a negative external effect on house prices. Especially office buildings that were left vacant for a substantial time prior to transformation may cause strong negative external effects as these buildings are poorly maintained, attract crime and vandalism, and cause disinvestment in the area.

H2: During the transformation into housing, office buildings have a moderate positive effect on surrounding house prices

Theory further suggests that there may be a positive anticipation effect present whilst the transformation is taking place. This effect takes place because people anticipate the removal of disamenities and the creation of new amenities. However this positive effect may be moderated because of construction nuisance

H3: After transformation into housing, office buildings have a positive external effect on surrounding house prices

After transformation, the transformed office buildings may have a positive external effect on house prices because of a positive change in appearance, the entrance of new residents in the area, new investments as a result of the demonstration effect, and possibly the addition of new functions to the area.

H4: The external effects created by the transformation of office buildings into housing are heterogenous

The external price effects may differ based on certain project characteristics. Previous studies on the external house price effects of spatial investments has shown that the external price effects may vary based on the location of the projects.

3. Methodology & Data

3.1 Methodology

As is mentioned in the previous chapter, house prices can be considered an aggregate of different characteristics of the house, its location and amenities derived from ownership. As such, house prices reflect how well the residents like their living space. In other words, when people experience positive external effects, the demand for houses in the area will increase. And when people experience negative external effects, the demand in the area will decrease. Previous research has shown that house prices can serve as an indicator of the effect investments in housing, transportation systems, or the redevelopment of industrial heritage sites have on the surrounding area (Damm et al., 1980; Schwartz et al., 2006; Van Duijn, et al., 2016). When assessing the impact of a transformed office building on the surrounding neighborhood, house prices are therefore likely to be a suitable indicator of the effect of the transformation on the surrounding area.

In order to estimate external effects of transformed office buildings on surrounding house prices, a difference-in-difference hedonic model will be used. The objective of this model is to establish whether there is a significant difference in housing prices based on treatment by the transformation of an office building into housing. The model is based on the model used by Van Duijn et al. (2016) who conducted a similar research on the external effects of the redevelopment of industrial heritage sites. Van Duijn et al. (2016) used data from the same database used for this research, making their model specification especially useful.

A distinction will be made between three phases; before the transformation, during the transformation and after the transformation (see figure 4). The period 'before' will measure the externalities that were present before the transformation. The period 'during' will measure the externalities as a result of anticipation that were present during the transformation as well as possible construction nuisance. The period 'after' will measure the externalities that were present after the transformation. Similar as to the model used by Van Duijn et al. (2016), a distance ring dummy (Before) will be included for houses sold within the target area before the transformation. A similar variable (After) will be included to capture the properties that are sold after completion of the transformation. The dummy variable (During) will be included to capture the properties that were sold in the target area during the transformation. The period during which the transformations took place is difficult to determine because it is not always known when the transformation works started, especially with projects that took place over twenty years ago. It is also possible that there was already an anticipation effect from the moment the transformation project was announced (Damm et al., 1980; Van Duijn et al., 2016). The period 'during' is defined as the year the construction work started until the year the project was finished. For projects where the author was unable to determine the starting year of construction work, a construction period of two years is assumed.

Figure 4. Three phases of transformation

A target group including the properties that were affected by the external effects from the office transformations will have to be established. Additionally, a control group with similar properties that were not affected by the external effects will have to be formed. In order to distinguish these groups, the distance to which the surrounding houses were affected by the external effects has to be determined.

3.2 Baseline specification

The research design has led to a baseline specification which is based on the model used by Van Duijn et al. (2016). This model is adapted and simplified in order to fit the scope of this research. The dependent variable of the model is the natural logarithm of the transaction price of houses sold. Amongst the independent variables, a set of housing characteristics is included. The selection is based on the summary in table 2 and includes floor space, construction period, number of rooms, house type, house condition inside, house condition outside, and the type of heating. These are the most common house characteristics used in previous research and we found no notable increase in the R^2 of the baseline model specification by adding more than these seven characteristics. Furthermore, transaction year dummies are included to capture the time fixed effects, as well as neighborhood dummies to capture neighborhood fixed effects. The baseline model is specified as follows:

$$\ln P_{ijt} = b_0 + b_1 Target + b_2 Target * During + b_3 Target * After + \beta_k X_{kit} + \gamma_t Y_t + \pi_j N_j + \varepsilon_{it}$$

Where P_{ijt} constitutes the transaction price of house *i* located in neighborhood *j* at time *t*. *Target* represents the target area (experimentally set at 1000m.), *During*, and *After* represent the periods during which the transformation project was taking place, and after the transformation was completed. X_{kit} are the structural characteristics *k* of house *i* sold in transaction year *t*. Y_t is a vector of dummy variables created for each transaction year *t*. N_j is a dummy variable created for each neighborhood *j*. ε_{it} is the error term. The coefficients of interest are b_1, b_2, and b_3; indicating the external price effect.

One of the benefits of using a difference-in-difference hedonic model including three time periods is that we are able to distinguish anticipation effects instead of only before and after effects. By including transaction year dummies we account for price differences throughout time, eliminating the need to adjust prices for inflation. Similarly, the neighborhood dummies capture the price differences based on neighborhood characteristics. For a higher level of distinction, neighborhood data may be enriched with specific geographic data on a neighborhood level. However, these data were not available for the required time period and areas, therefore these were not included. The distance of the target area (i.e. the extent of the external effects) is experimentally set at 1000 meters. Through different robustness checks, the accuracy of this definition is verified. The main concern of hedonic price modelling is omitted variable bias, which may be overcome by including as many housing and neighborhood characteristics as possible (Kuminoff et al., 2010).

3.3 Robustness analysis

Several alternative model specifications are tested in order to check the robustness of the results. In order to test if the reach of the external effect is estimated correctly, and if the external effect decays as distance increases, three alternative model specifications are made. The target radius is experimentally set at 1000 meters in the baseline specification and the control group is formed using a concentric circle with a distance of 1000 to 2000 meters to the project, similar to the baseline specification used by Van Duijn et al. (2016).

Van Duijn et al. (2016) demonstrate that it is relatively easy to find the boundaries of the target area by changing the target radius in the model and comparing the results. In the sensitivity analysis they use a set of ring variables (0 – 250m, 250 – 500m, etc.) and calculate treatment coefficients for each ring variable. In this way the extent of the external effect can be determined. A similar model specification will be used in this study. Furthermore, a model specification with interaction variables between the periods 'before', 'during', and 'after' and distance from the transformation projects will be included. The estimated coefficients for these interaction variables give insight into the change in the external effect when distance from the projects increases (Van Duijn, et al., 2016).

Leonard et al. (2016) used a gap between the target area and the control area, as is illustrated in figure 5. Because it is difficult to establish the exact distance at which a property will receive some extent of treatment by the transformation, the use of such a 'doughnut shaped' control group will lower the chance of including untreated properties in the treatment group and vice versa. A model specification with a 'doughnut shaped' control group will be included in this study as a third robustness check. However, it is important to note that increasing the distance between the target group and the control group will also increase the possibility that the control group is not identical to the target group.

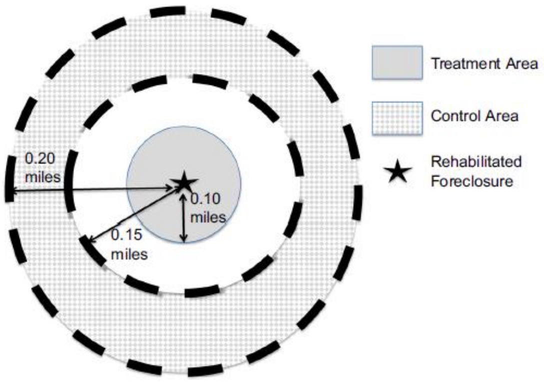

Figure 5. Doughnut shaped control group (Leonard et al., 2016)

Besides the robustness checks for the reach and distance decay of the external effects, we will check if there is heterogeneity in the results based on project characteristics. Several separate regression models will be estimated. The tested characteristics are based on three possible characteristic that were identified in paragraph 2.2:

- Located in the big 5 cities
- Change in appearance (scale 1 to 3)
- Vacancy before transformation

If the results of the baseline specification show a significant difference in house prices in the target versus the control group, this alternative specification will serve to explain the project characteristics that caused these differences.

For the projects located in the G5 cities and those outside the G5 cities, two groups are made. Two separate regressions for each group are run. The change in appearance will be assessed based on pictures taken before and after the transformation (see appendix A). A number of one to three will be assigned, where one will constitute no notable change in appearance and three will constitute a severe change in appearance (e.g. new façade). Three separate regressions for each level of change are run. For each project, the years of vacancy prior to transformation is established. The projects are then divided into two groups; group one includes all projects where the office building was at least two years completely vacant prior to start of transformation, group two includes all the remaining projects. Two separate regressions for each group are run.

In order to verify that the results based on these characteristics are significantly different, three Chow F-tests are performed. The null hypotheses of the Chow F-test is that the slope and intercept of the two groups are identical (Chow, 1960). When the null hypothesis is rejected, and the slope and intercept are significantly different there is a structural break in the data.

3.4 Data

The data that are used in this research comprise transaction data for residential properties provided by the Dutch Association of Real Estate Agents (NVM). The transaction data are recorded by real estate agents registered with the NVM and account for 70% of all residential property transactions. Newly built properties and investment properties are not included in the data. The dataset contains information on the location (e.g. street address, neighborhood code) of the property as well as information describing the physical aspects of the property (e.g. type of house, floor area, plot area, maintenance).

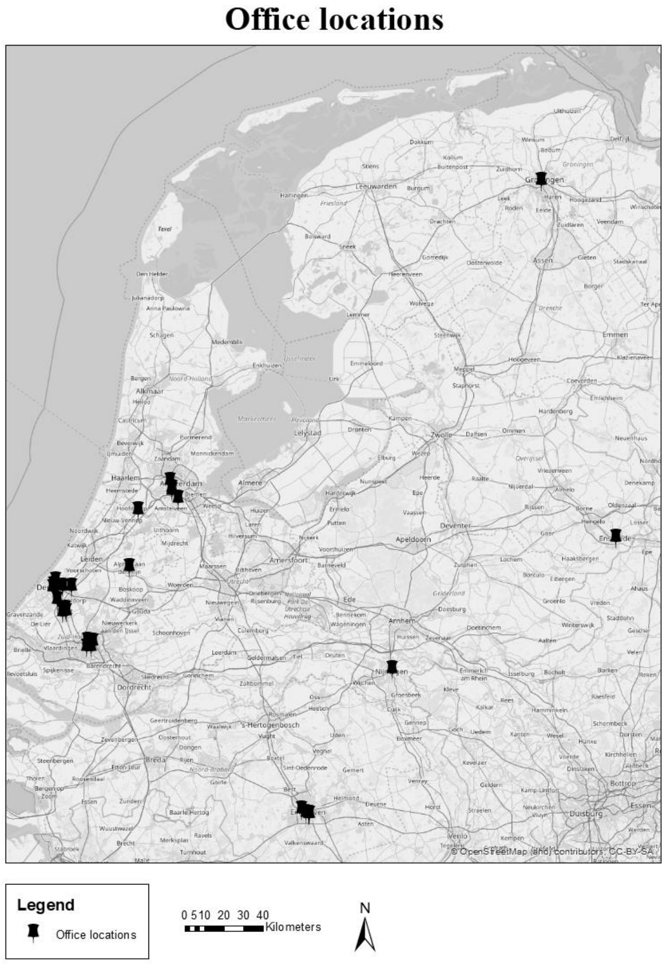

Figure 6. Map of office buildings transformed into housing

Several steps were taken to prepare the data for the hedonic regressions. First the data were cleaned by removing outliers, missing values and incorrect values. New variables were created and the house price and floorspace variables were transformed using the natural logarithm. The distance for each transaction to the polygons of the transformation projects was calculated using GIS software. All transactions with a proximity greater than 2000 meters to the nearest transformation project were dropped. With some of the selected projects, there was overlap between the target group of one project and the control group of another project. In order to eliminate contamination in the results, all the transactions in these overlapping areas were dropped, leaving a total of 78,925 transactions.

Seventeen transformed offices are selected for this study. In order for the results to be comparable, it is important that the selected cases are as homogenous as possible. A list of transformed offices was established based on the book on transformed offices from Van der Voordt (2007) as well as internet searches and personal knowledge. From this list a selection was made based on several criteria:

- Buildings that had an office function prior to transformation
- Buildings that were fully or for the major part transformed into housing units
- The transformation was completed between 1999 and 2014
- Projects are in close proximity of a residential area
- Comprise at least twenty housing units after transformation

The selection method can be considered unorthodox, as the cases were obtained from different sources and data on these cases was collected and combined partially by the author. This was necessary because there is no centralized database of transformed office buildings available in the Netherlands. The period in which the projects are selected (1999 to 2014) is based on the available transaction data provided by the NVM. Since the data on the surface area of the office buildings is obtained from non-public databases or estimates, the sample can be considered non-representative.

As is shown in figure 6, the vast majority of the transformed offices are located in the Randstad area. Six out of seventeen are located outside the Randstad area. Most of the office buildings were vacant for a substantial amount of time prior to the transformation. However there are a few exceptions to this; several buildings were transformed within months after the office tenant left the building. Table 3 gives a detailed overview of the project information that was collected.

Figure 7 shows the development of the transaction price in the target and control group. Certain macro-economic developments such as the Great Recession are clearly visible in the trend lines. The average transaction prices in the target and control group are very similar and develop along the same trend, although there are slight deviations noticeable. This indicates that the housing market in both the target and control group are similar.

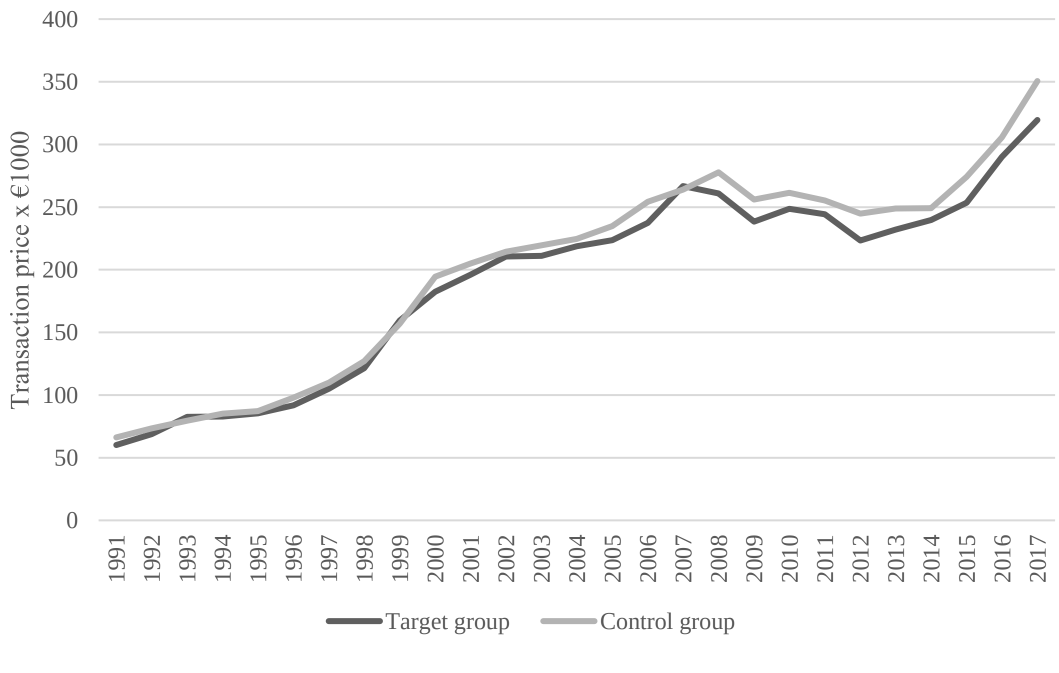

Figure 7. Average transaction price per year in target and control group

In order to further compare the target and control group, the descriptive statistics for both groups are shown in table 4. The target group holds a total 28,636 transactions and the control group holds a total of 50,289 transactions. When divided by the number of projects, we find an average of 1,684 transactions per project for the target group and 2,958 transactions for the control group. The statistics for both groups are found to be very similar. There are some slight differences; the mean transaction price is a little higher in the control group, as is the mean floorspace. Furthermore the portion of semi-detached and detached houses is a little higher in the control group. These differences might be explained by the fact that the projects are mostly situated on central, densely populated locations. A considerable part of the control groups would therefore be located further from the center, where space is more readily available. The statistics for all other variables show nearly identical values. Overall we may therefore conclude that the housing markets in the target and control groups are very similar and comparable.

Table 3. Project information

Building name	City	Monument status	# houses	C. year	T. start	T. complete	Resident type	Extra function	Vacancy years	ID
De Stadhouder	Alphen a.d. Rijn		70	1974	2004	2005	Starter owner-occupied		Partially	1
Van Heenvlietlaan	Amsterdam		354	1975	2014	2014	Shortstay		Partially	2
Lightfactory	Amsterdam		69	1900	1997	1999	Owner-occupied		2	3
Schuttersveld	Delft	National	104	1915	2001	2003	Owner-occupied		-	4
Billitongebouw	Den Haag	Municipal	22	1938	2002	2004	Owner-occupied		Partially	5
The Beech	Eindhoven		192		2013	2014	Students rental		5	6
Studio 56	Eindhoven		134		2013	2014	Students rental		5	7
Twentec Residentie	Enschede		87	1960	2001	2002	Rental property	Supermarket, shops	6	8
Eendrachtskade	Groningen		83	1980	2002	2004	Students rental		-	9
HQ023	Hoofddorp		60	1987	2004	2006	Starter owner-occupied		2	10
Arcade	Leidschemdam		145	1972	1999	2002	Owner-occupied		2	11
Oud Postkantoor	Nijmegen	Municipal	28	1910	2008	2010	Rental property	Supermarket	Partially	12
Atlantic Huis	Rotterdam	National	50		2007	2009	Rental property		Partially	13
Westerhoek	Amsterdam		185		2013	2014	Rental property		-	14
Octrooibureau	Eindhoven		46	1972	2008	2009	Shortstay students		5	15
The Student Hotel	Rotterdam		252	1946	2012	2012	Shortstay students	Restaurant	3	16
Johannes de Dichter	Rotterdam		24	1893	2009	2010	Rental property		-	17

Table 4. Descriptive statistics (0-2000 m)

	0-1000 m: 28,636 transactions				**1000-2000 m: 50,289 transactions**			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Transaction price (in k euros)	214.369	158.827	16	2260	225.512	196.510	16	4500
Floorspace (in m^2)	101.515	48.997	18	493	108.886	51.898	19	499
House type								
Terraced house (1 = yes)	0.183	0.386	0	1	0.195	0.397	0	1
Semi-detached house (1 = yes)	0.027	0.161	0	1	0.048	0.214	0	1
Corner house (1 = yes)	0.047	0.212	0	1	0.061	0.239	0	1
Detached house (1 = yes)	0.013	0.113	0	1	0.017	0.130	0	1
Number of rooms (#)	3.726	1.531	1	15	3.954	1.668	1	15
Maintenance inside								
Good – excellent (1 = yes)	0.001	0.028	0	1	0.001	0.027	0	1
Good (1 = yes)	0.017	0.127	0	1	0.017	0.129	0	1
Fair - good or unknown (1 = y	0.005	0.068	0	1	0.004	0.062	0	1
Fair (1 = yes)	0.091	0.288	0	1	0.098	0.297	0	1
Mediocre – fair (1 = yes)	0.026	0.160	0	1	0.028	0.165	0	1
Mediocre (1 = yes)	0.690	0.462	0	1	0.695	0.461	0	1
Mediocre – bad (1 = yes)	0.027	0.163	0	1	0.027	0.163	0	1
Bad (1 = yes)	0.140	0.346	0	1	0.129	0.335	0	1
Maintenance outside								
Good – excellent (1 = yes)	0.000	0.017	0	1	0.000	0.021	0	1
Good (1 = yes)	0.007	0.085	0	1	0.008	0.088	0	1
Fair - good or unknown (1 = y	0.001	0.033	0	1	0.001	0.038	0	1
Fair (1 = yes)	0.050	0.219	0	1	0.054	0.226	0	1
Mediocre – fair (1 = yes)	0.019	0.137	0	1	0.020	0.141	0	1
Mediocre (1 = yes)	0.794	0.405	0	1	0.794	0.405	0	1
Mediocre – bad (1 = yes)	0.019	0.137	0	1	0.022	0.145	0	1
Bad (1 = yes)	0.108	0.310	0	1	0.100	0.300	0	1
Heating type								
Gas or cole (1 = yes)	0.082	0.275	0	1	0.078	0.268	0	1
Central heating (1 = yes)	0.863	0.343	0	1	0.865	0.341	0	1
Airconditioning or solar	0.000	0.020	0	1	0.000	0.021	0	1
Construction period								
1906 – 1930 (1 = yes)	0.216	0.411	0	1	0.203	0.402	0	1
1931 – 1944 (1 = yes)	0.162	0.368	0	1	0.172	0.377	0	1
1945 – 1959 (1 = yes)	0.109	0.312	0	1	0.119	0.324	0	1
1960 – 1970 (1 = yes)	0.139	0.346	0	1	0.129	0.336	0	1
1971 – 1980 (1 = yes)	0.077	0.266	0	1	0.089	0.285	0	1
1981 – 1990 (1 = yes)	0.088	0.284	0	1	0.083	0.275	0	1
1991 – 2000 (1 = yes)	0.067	0.251	0	1	0.070	0.256	0	1
>2000 *(1 = yes)*	0.046	0.209	0	1	0.049	0.215	0	1

4. Results

4.1 Results baseline specification

The results for the baseline model are presented in table 5. For model 1, only year fixed effects are included. Model 2 includes year fixed effects as well as structural characteristics. Model 3 includes year fixed effects, structural characteristics and building period dummies. By including these control variables, it is found that the adjusted R-squared increases. We find the best model fit in model 4 where year fixed effects, structural characteristics, building period dummies as well as neighborhood fixed effects are included (adjusted R^2 .9033).

The results for model 4 show that the coefficients for the periods ‘before’, ‘during’ and ‘after’ are significantly different from zero at a 1% level. The coefficient ‘before’ indicates that houses located in the target area (0-1000 m) sold for 2.25% (=(exp$^{(-.0227552)}$-1)*100) less than houses in the control area (1000-2000 m). This is similar to Van Duijn et al. (2016), who also find a negative external effect for industrial heritage sights prior to redevelopment. This indicates that houses in the target area were negatively affected by the office buildings prior to the transformation. This supports theory of Remoy & Van der Voordt (2007), stating that the office buildings that are transformed are often nondescript buildings of mediocre quality. The coefficient ‘during’ indicates that houses in the target area sold for 1.96% more than houses in the control area. This implies the existence of an anticipation effect while the office buildings were transformed. These findings are in line with Damm et al. (1980) and Van Duijn et al. (2016) who find an increase in house prices in anticipation of investments in public transport and industrial heritage, respectively. The anticipation effect is smaller than the effect found by Van Duijn et al. (2016), which implies that the positive effects of the transformation of office space into housing are more difficult to anticipate for homeowners than the positive effects of the redevelopment of industrial heritage. The coefficient ‘after’ indicates that houses in the target area sold for 4,02% more than houses in the control area. This effect is similar to the one found by Duijn et al. (2016), but smaller than effect found by Leonard et al. (2017). The rise in house prices indicates that the area surrounding the transformations experienced positive effects after the transformation was completed. This is in accordance with Remoy & Van der Voordt (2007), who state that transformation of office buildings into housing may contribute to urban regeneration. The fact that the coefficient for the period after the transformation is higher than the coefficient for the period during the transformation tells us that the positive effect was not fully anticipated.

Table 5. Estimation results for the baseline specification

	Model 1		Model 2		Model 3		Model 4	
Sample size	<2000 m		<2000 m		<2000 m		<2000 m	
Target area	0-1000 m		0-1000 m		0-1000 m		0-1000 m	
Control area	1000-2000 m		1000-2000 m		1000-2000 m		1000-2000 m	
Before	-0.05580***	(0.00539)	0.01211***	(0.00331)	0.01378***	(0.00324)	-0.02275***	(0.00263)
During	0.04742***	(0.01085)	0.02449***	(0.00664)	0.00655	(0.00648)	0.01945***	(0.00393)
After	0.07059***	(0.00714)	0.06329***	(0.00437)	0.04104***	(0.00429)	0.03943***	(0.00317)
Year FE	YES		YES		YES		YES	
Structural characteristics	NO		YES		YES		YES	
Building period dummies	NO		NO		YES		YES	
Neighborhood FE	NO		NO		NO		YES	
Observations	78,925		78,925		78,925		78,925	
Adjusted R^2	0.3429		0.7542		0.7663		0.9033	

Note: Dependent variable is log of transaction price. Robust standard errors in parentheses. *** , **, * indicating significant at 1%, 5% and 10%, respectively.

4.2 Robustness analysis

The results for the robustness analysis are split into two categories; the model specifications regarding the reach and distance decay of the external effects and the model specifications regarding heterogeneity in the results.

Distance

The model specifications regarding the reach and distance decay of the external effects include model 5, model 6, and model 7, for which the results are shown in table 6.

The external effects that occur before, during and after the transformation are likely to decrease when distance from the project increases. The baseline model only captures the average external effect that takes place within the specified target area. In order to determine the reach of the external effects, and check the robustness of the model, an alternative specification is made. Instead of defining one 'before', 'during', and 'after' variable, distance rings of 250 meters from the projects are drawn. From these distance rings, four 'before', 'during', and 'after' variables are defined. For each of these variables a coefficient is estimated. These results show that the negative effect before the transformations decreases from around -4% in the distance ring 'before250' to a little under -1% in the distance ring 'before1000'. The coefficients for the 'during' rings show a different pattern. The positive (anticipation) effect during the transformation varies between 2% and 3% for the distance rings 'during250', 'during500' and 'during750'. The coefficient for 'during1000' is considerably smaller and insignificant. The positive effects after the transformation show a similar pattern as the 'before' coefficients, however the extent is found to be greater. When another distance ring was included ('after1250'), it is found that the external effects gradually decrease from around 6% in the distance ring 'after250' to under 1% in the distance ring 'after1250'. Although the effect from the period 'after' reaches a bit further, it seems that the average reach of the external effects of 1000 meters was set accurately in the baseline specification. Van Duijn et al. (2016), who constructed the same model to determine the reach of the external effects, found a mostly similar pattern. The reach of the external effects for the redevelopment of industrial heritage and the transformation of office space into housing is therefore similar.

It can be expected that the effect of the transformation decreases over distance at a different rate across the determined periods. The alternative specification with four 250 meter distance rings indicates that the distance decay of the external effects differs per period. In order to get a deeper understanding of the behavior of the external effects over distance, an interaction with the 'before', 'during' and 'after' variables with distance and distance^2 was made. The results of this model specification are shown in table 6. The interaction variables of the periods 'during' and 'after' with distance and distance^2 yield insignificant coefficients. These findings are different from those of Van Duijn et al. (2016) who find a pattern of distance decay for the periods during and after redevelopment. This indicates that the positive effects during and after the transformations are experienced over the entirety of the target area. The interaction of the period 'before' with distance yields a significant coefficient, however the interaction of 'before' with distance^2 yields an insignificant coefficient. Based on these estimators we can conclude that there is a negative effect of 5.42% $(=(\exp^{(-.0557278)}-1)*100)$ that is visible directly surrounding the transformations, where distance equals 0. This effect will decrease non-linearly with .68% $(=(\exp^{(.0000707*100-2.44e-08*10000)}-1)*100)$ over the first 100 meter. This decrease will continue up to 4,74% at 1000 meters, where the negative effect will be less than 1%, as is shown in figure 8.

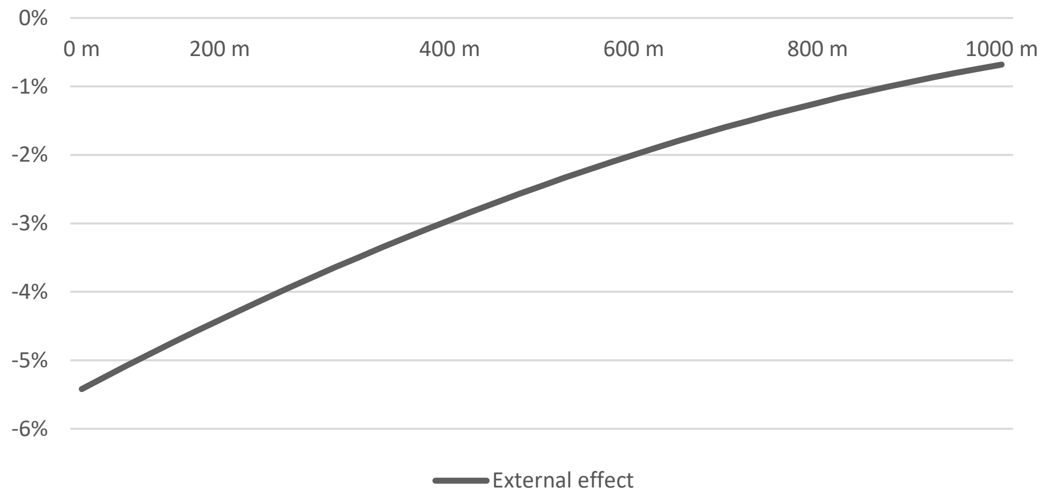

Figure 8. Distance decay of the external effect before transformation

In model 7 the target and control areas are formed in a doughnut shape, with a gap of 250 meters between the target and control group in order to prevent possible contamination of target and control groups. The estimated coefficients are similar to the ones estimated in the baseline specification. This tells us that there is no significant contamination in the baseline specification.

Table 6. Estimation results alternative specifications model 5, model 6, model 7

	Model 5			Model 6			Model 7	
Sample size	<2000 m		Sample size	<2000 m		Sample size	<2250 m	
Target area	0-1000 m		Target area	0-1000 m		Target area	0-1000 m	
Control area	1000-2000 m		Control area	1000-2000 m		Control area	1250-2250 m	
Before250	-0.04407***	(0.00516)	Before	-0.05572***	(0.00834)	Before	-0.03193***	(0.00290)
Before500	-0.03156***	(0.00430)	Before*D	0.00007**	(0.00003)	During	0.01209***	(0.00365)
Before750	-0.02548***	(0.00400)	Before*D^2	-2.44e-08	(2.90e-08)	After	0.02799***	(0.00298)
Before1000	-0.00833**	(0.00364)	During	0.01782	(0.01744)			
During250	0.02330**	(0.01107)	During*D	0.00006	(0.00007)			
During500	0.02955***	(0.00738)	During*D^2	-9.33e-08	(6.04e-08)			
During750	0.02522***	(0.00679)	After	0.07035***	(0.01136)			
During1000	0.00675	(0.00664)	After*D	. -0.00006	(0.00004)			
After250	0.06060***	(0.00731)	After*D^2	6.94e-09	(3.87e-08)			
After500	0.05721***	(0.00526)						
After750	0.03509***	(0.00504)						
After1000	0.02622***	(0.00485)						
After1250	0.00798**	(0.00351)						
Year FE	YES		Year FE	YES		Year FE	YES	
Structural characteristics	YES		Structural characteristics	YES		Structural characteristics	YES	
Building period dummies	YES		Building period dummies	YES		Building period dummies	YES	
Neighborhood FE	YES		Neighborhood FE	YES		Neighborhood FE	YES	
Observations	78,925		Observations	78,925		Observations	105,484	
Adjusted R^2	0.9034		Adjusted R^2	0.9033		Adjusted R^2	0.9018	

Note: Dependent variable is log of transaction price. Robust standard errors in parentheses. *** , **, * indicating significant at 1%, 5% and 10%, respectively.

Heterogeneity

Separate regressions are run in order to identify heterogeneity in the results. These results are presented in the tables below.

Table 7. Estimation results G5 cities

	G5 cities		Non G5	
Sample size	<2000 m		<2000 m	
Target area	0-1000 m		0-1000 m	
Control area	1000-2000 m		1000-2000 m	
Before	-0.03191***	(0.00328)	0.02852***	(0.00433)
During	0.01638***	(0.00613)	-0.00993*	(0.00536)
After	0.02494***	(0.00452)	0.01174***	(0.00451)
Year FE	YES		YES	
Structural characteristics	YES		YES	
Building period dummies	YES		YES	
Neighborhood FE	YES		YES	
Observations	43,413		35,512	
Adjusted R^2	0.9024		0.9093	

Note: Dependent variable is log of transaction price. Robust standard errors in parentheses. The resulting Chow test produced the statistic F(2,78,859) = 18,846***. *** , **, * indicating significant at 1%, 5% and 10%, respectively.

Table 7 shows varying results for projects in the G5 cities and projects outside of the G5 cities. Similar to the findings of Van Duijn et al. (2016), we find that the results of the baseline model seem to be driven by the transformations in the largest cities. The results for the G5 cities show a negative external effect (-3.14%) before, a positive external effect (1.65%) during and a stronger positive effect (2.53%) after the transformation, all significant at the 1% level. The results for the projects excluding the G5 cities show a very different pattern. There is a positive external effect (2.89%) present before transformation and a smaller positive external effect (1.18%) after the transformation, both significant at the 1% level. During the transformation there is a small negative effect (-0.98%) present, however this effect is significant only at the 10% level.

Table 8. Estimation results vacancy

	Vacancy		No vacancy	
Sample size	<2000 m		<2000 m	
Target area	0-1000 m		0-1000 m	
Control area	1000-2000 m		1000-2000 m	
Before	-0.04584***	(0.00328)	-0.00704**	(0.00314)
During	0.01562**	(0.00613)	0.00399	(0.00490)
After	0.05272***	(0.00452)	0.02073***	(0.00394)
Year FE	YES		YES	
Structural characteristics	YES		YES	
Building period dummies	YES		YES	
Neighborhood FE	YES		YES	
Observations	30,604		48,321	
Adjusted R^2	0.9053		0.9059	

Note: Dependent variable is log of transaction price. Robust standard errors in parentheses. The resulting Chow test produced the statistic F(2,78,859) = 14,478***. *** , **, * indicating significant at 1%, 5% and 10%, respectively.

When we look at the regression results for office buildings that experienced vacancy and office buildings that did not, we again find a difference in the external effects (see table 8). For the projects where the office buildings were vacant, we find a strong negative external effect (-4.48%) before, a positive anticipation effect (1.57%) during and a strong positive external effect (5.41%) after transformation. When we look at the projects where there was no vacancy, we see a very small negative external effect (-0.70%) before the transformation and a modest positive external effect (2.09%) after the transformation was completed. There is also a very small positive anticipation effect, however this coefficient is not significant. It appears that the negative external effect prior to transformation is strongly related to vacancy. This is in accordance with United States Department of Housing and Urban Development (1973), Duncan et al. (1975), Greenberg et al (1990), Spelman (1993), Gold (1998), Kraut (1999), and Lee (2008), who attribute negative external effects to vacancy.

Table 9. Estimation results change in appearance

	Severe change		Moderate change		No notable change	
Sample size	<2000 m		<2000 m		<2000 m	
Target area	0-1000 m		0-1000 m		0-1000 m	
Control area	1000-2000 m		1000-2000 m		1000-2000 m	
Before	-0.05848***	(0.00492)	0.01740***	(0.00517)	-0.00135	(0.00378)
During	0.03931***	(0.00726)	-0.00913	(0.00653)	0.00478	(0.00697)
After	0.06029***	(0.00547)	0.01095**	(0.00532)	0.01879***	(0.00553)
Year FE	YES		YES		YES	
Structural characteristics	YES		YES		YES	
Building period dummies	YES		YES		YES	
Neighborhood FE	YES		YES		YES	
Observations	26,046		22,439		30,440	
Adjusted R^2	0.9057		0.9219		0.8984	

Note: Dependent variable is log of transaction price. Robust standard errors in parentheses.
The resulting Chow test produced the statistic F(3,78,858) = 11,291***.
*** , **, * indicating significant at 1%, 5% and 10%, respectively.

Schwartz et al. (2006) find that newly constructed buildings generate positive external effects. Newly constructed buildings constitute a big change in appearance. Building on this, the change in appearance of the transformed office buildings is also expected to have an impact on the external effects. When we look at the regression results in table 9 we see that the external effects are greatest for buildings that experienced a severe change in appearance. In this category we see a strong negative external effect (-5.68%) before, a strong positive anticipation effect (4.01%) during, and an even stronger positive external effect (6.21%) after the transformation, all significant at the 1% level. The results for the projects where a moderate change in appearance was realized through the transformation are less severe and less significant. There is a small positive external effect (1.76%) before and a smaller positive external effect (1.10%) after transformation. During the transformation there is a very small negative external effect, however this coefficient is insignificant. For the projects where no notable change in appearance was realized, we find insignificant results for the periods before and during the transformation. For the period after the transformation was completed we find a moderate positive external effect (1.90%), significant at the 1% level. These findings are in line with the findings by Schwartz et al. (2006).

A Chow (1960) test was performed for the separate regression models for G5 cities, vacancy, and change in appearance in order to test whether these groups generate significantly different coefficients. The null hypothesis for the Chow (1960) test is that the slope and intercepts of both groups (e.g. G5 cities and non-G5 cities) are identical. The Chow (1960) F-statistic for G5 cities (18,846), vacant buildings (14,478), and change in appearance (11,291) are all in the rejection region and significant at the 1%

level. Therefore the null hypothesis is rejected and it is established that the slope and intercepts for these projects are significantly different from the remaining projects.

Table 10. Estimation results high impact projects

	High impact	
Sample size	<2000 m	
Target area	0-1000 m	
Control area	1000-2000 m	
Before	-0.09438***	(0.00614)
During	0.00933	(0.01062)
After	0.04828***	(0.00718)
Year FE	YES	
Structural characteristics	YES	
Building period dummies	YES	
Neighborhood FE	YES	
Observations	15,769	
Adjusted R^2	0.9099	

Note: Dependent variable is log of transaction price. Robust standard errors in parentheses. *** , **, * indicating significant at 1%, 5% and 10%, respectively.

Based on the results from table 7, 8, and 9 a selection of 3 projects was made with a high expected impact. These projects:

- Are located in the G5 cities
- Were vacant prior to transformation
- Experienced a severe change in appearance

A separate regression was run with these projects, for which the results are presented in table 10. We see a very high negative external effect (-9.01%) prior to transformation as well as a high positive external effect (4.95%) after the transformation was completed. Both of these coefficients are significant at the 1% level. For the period during the transformation there is a small positive external effect, however this effect is insignificant.

5. Conclusion

5.1 Conclusions

This study explored the transformation of office buildings into housing and the external effects of these transformations on house prices. By conducting a literature study, an overview of the possible external effects generated by these transformations was made. Furthermore, we reviewed the methods for measuring these external effects. Seventeen cases were selected for the empirical analysis, consisting of office buildings throughout the Netherlands that were transformed into housing. A difference-in-difference hedonic framework was constructed to estimate the external effects of these seventeen projects on surrounding house prices, using transaction data of 78,925 houses that were sold between 1991 and 2017. The external effects were estimated during three periods; before, during and after the transformation was completed. Besides the baseline specification, several alternative model specifications were used as robustness checks. This was done to determine the reach of the external effects and the decay over distance as well as to check for heterogeneity in the results.

We have found a negative external price effect prior to the transformation; house prices in the target area were found to be 2.25% lower than those in the control area prior to the transformation. This indicates that the office buildings were a disamenity to the surrounding area. These results are in line with the findings of Van Duijn et al (2016), who also find a small negative external effect prior to redevelopment. While the transformations were taking place, the house prices in the target area were 1.96% higher than those in the control area. Based on this we can assume that there was anticipation effect; house prices rose in expectation of the positive effects generated by the transformation. These results are in line with the findings of Damm et al. (1980) and Van Duijn et al. (2016). The external effect is, however, smaller than the effect found by Van Duijn et al. (2016), indicating that the positive effects of the transformation of office space into housing are more difficult to anticipate for home owners than the positive effects of the redevelopment of industrial heritage. After the transformations were completed, house prices in the target area were 4.02% higher than those in the control area, similar to the findings of van Duijn et al. (2016), but smaller than the findings of Leonard et al. (2017). These results confirm hypothesis one, two, and three. The coefficients were estimated using model 4 where we controlled for year fixed effects, structural characteristics, building period, and neighborhood fixed effects. The estimated external effects for the 'before', 'during', and 'after' period were all significantly different from zero at a 1% level. The adjusted R-squared was high (.9033) and comparable to Schwartz et al. (2006), Van Duijn et al. (2016), and Leonard et al. (2017).

The alternative specification where distance rings of 250 m per period were used (model 5) indicated that the extent of the external price effect differs per period. For the periods 'before' and 'during', the external effect disappeared around 1000 m. For the period after the transformation the reach of the external effect appeared slightly larger, disappearing around 1250 m. The interaction with distance yielded insignificant results for the periods 'during' and 'after'. These findings are conflicting with the findings of Van Duijn et al. (2016), who find a clear distance decay for the periods 'during' and 'after'. Based on this we may conclude that the external effects of the transformation during and after transformation are present relatively even throughout the target area instead of locally close to the project. This can be explained by the fact that a lot of the expected positive effects such as the improvement of the local economy as a result of new residents, the improvement of amenities and inflow of investments as a result of the demonstration effect are not bound to the project location. For the period 'before', however, the interaction with distance provided significant results, indicating a non-linear decrease of the negative external effect. This indicates that the negative external effect prior to transformation is more local. This can be explained by the fact that the expected negative effects prior to transformation were mainly caused by vacancy-related deterioration of the project location, which would be experienced locally. The alternative specification with a doughnut shaped target and control area provided similar results as the baseline specification, suggesting that the target area of 1000 m is set accurately and that there is minimal contamination of the target and control area.

We checked for heterogeneity in the results by running separate regressions with selections of cases based on characteristics regarding location, vacancy, and the extent of change in appearance. Previous research on the redevelopment of industrial heritage suggested that external effects were strongest for redevelopment projects in the largest cities of the Netherlands (Van Duijn, et al., 2016). The regression results for projects in the G5 cities showed similar results as were found in the baseline model. However the projects outside of the G5 cities showed a positive external effect before as well as after transformation. Previous research by the United States Department of Housing and Urban Development (1973), Duncan et al. (1975), Greenberg et al (1990), Spelman (1993), Gold (1998), Kraut (1999), and Lee (2008) suggests that the negative externalities are a result of vacancy. Separate regressions for projects where the office buildings were vacant and projects where the office buildings were not vacant were run. The results for vacant office buildings showed a strong negative external effect before, a moderate anticipation effect during, and a strong positive external effect after transformation. For the office buildings that were not vacant, we found considerably smaller and less significant external effects before, during, and after transformation. Additionally, three separate regressions were run for projects with a severe, moderate, or no notable change in appearance. For the projects where a severe change in appearance was realized, we found a strong negative effect before, a strong anticipation effect during and a stronger positive external effect after transformation. For the projects were a moderate change in appearance was realized we found small positive external effects before, during and after transformation. For projects where no notable change in appearance was realized we found a small negative external effect before, and a small positive effect during transformation, however both coefficients are insignificant. For the period after transformation we found a small, significant positive external effect. These findings are in line with previous research by Schwartz et al. (2006), finding that newly constructed buildings (i.e. big change in appearance) generate positive external effects.

The results of these separate regressions suggest that the results from our baseline model are driven by projects located in the G5 cities, that experienced vacancy before transformation, and where a severe change in appearance was realized. This is verified by the results of three Chow F-tests, which showed that the coefficients for the projects meeting these conditions were significantly different from the coefficients of the remaining projects. This confirms hypothesis four. Another regression model was run using only the projects that met all three of these conditions. There were strong external effects estimated for these projects; a negative effect of -9.01% prior to transformation and a positive effect of 4.95% after transformation.

Based on the results from the literature study as well as the empirical analysis, the research question *"What are the external house price effects of the transformation of office buildings into housing on local housing markets?"* can be answered. The outcome of this research suggests that the transformation of office buildings into housing has a positive external effect on house prices in the surrounding area. Prior to transformation the office buildings have a negative external effect and a positive external house price effect emerges during transformation in anticipation of the positive effects of the transformation. These effects are strongest for projects located in the G5 cities, that were vacant prior to transformation, and where a severe change in appearance was realized.

5.2 Discussion

When we consider the results of this study from a societal viewpoint, it is shown that besides financial gain for the owner of the real estate, these transformation projects also create value for the surrounding area. This information may serve as an argument for developers that face opposition to transformation plans from local residents or municipalities, or homeowners that are forming their opinion regarding these transformations. This outcome serves as a confirmation for governmental policies that aim to promote similar transformations, as it provides proof that the transformation of office buildings into housing generates a positive external effect for the surrounding area. With regard to these policies it is important to pay attention to the project characteristics that appear to be the driving force behind the external effects in order to promote the right kind of transformations.

The results of this study further strengthen the understanding of the external effects caused by transformation projects and adds to the literature on hedonic pricing. An important first step is made in discovering the external effects caused by the transformations of office space into housing and the mechanisms underlying these effects. There are, however, certain limitations to this study as well as suggestions for further research.

As is mentioned in chapter 3, omitted variable bias is the main concern for hedonic price modelling. Although neighborhood fixed effects were used to capture certain neighborhood-specific characteristics, the chance of omitted variable bias could be further reduced by including detailed neighborhood and demographic data.

It is furthermore of great importance that the target and control group are as identical as possible. In this study the target and control group were selected by drawing concentric circles around the projects. Based on the transaction data the target and control group seemed very similar. Another approach for selecting the control group is through propensity score matching (PSM) (Van Duijn, et al., 2016). Neighborhoods are scored based on characteristics such as population density, share of immigrants and then matched based on these propensity scores. PSM eliminates the chance of selection bias, as the control group is now selected based on its characteristics instead of only distance to the transformation site (Van Duijn et al., 2016). There is a chance of selection bias because it may be possible that certain neighborhoods received treatment based on certain characteristics. The PSM method was not applied in this thesis, but may be used in further research.

In the empirical analysis, no evidence was found for external effects as a result of construction nuisance or the increase of housing supply. It is possible that these factors negatively impacted the positive external effects for the periods 'during' and 'after' but we were unable to distinguish this from the results.

This study discovered that certain project characteristics are driving forces behind the external effects. In further research on this topic it might be advised to select projects based on these characteristics and expand the total number of cases in order to gain stronger evidence of the existence of external effects for these projects. The addition of qualitative research may add to our understanding of the process that occurs in the area surrounding the transformation leading to the external house price effects. This qualitative research could, for example, include an extensive assessment of the change in visual appearance and interviews with residents about their experience regarding the transformations.

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Appendix A: before and after pictures

Office 1:

Office 2:

Office 3:

Office 4:

Office 5:

Office 6:

Office 7:

Office 8:

Office 9:

Office 10:

Office 11:

Office 12:

Office 13:

Office 14:

Office 15:

Office 16:

Office 17:

Appendix B: Assumptions of linear regression

1 Linearity — Average value of residuals is zero

A constant term is used in the regression, furthermore scatter plots show a pattern.

2 Homoscedasticity — Residuals show constant variance

The use of robust standard errors solves the problem of heteroskedasticity.

3 Autocorrelation — Covariance between errors is zero

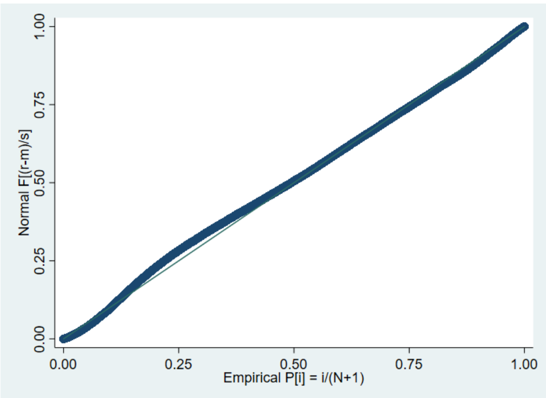
Neighborhood and time FE are used to control for spatial & time autocorrelation

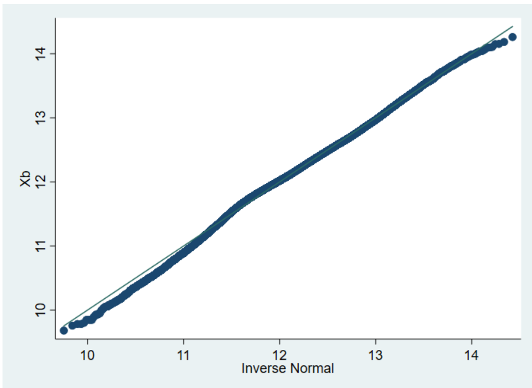
4 Independence — Regressors are not correlated with error term

No multi-collinearity issues arise from the variables used in our regressions.

5 Normality — Residuals are normally distributed

When visually inspecting the distribution of the residuals, we can state that they appear to be normally distributed, with some very slight deviations. The Shapiro Wilk test however rejects H0 (residuals are normally distributed). This may be caused by the large number of observations.





Shapiro Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
r	78,925	0.99509	127.078	13.534	0.00000

Appendix C: Syntax

```
use "C:\Users\bobkr\Documents\RUG\Scriptie\Topic herbestemming\Data\Data Bob Kramers vanaf 1990_nospatie.dta"

merge m:m obj_hid_postcode obj_hid_huisnummer using "C:\Users\bobkr\Documents\RUG\Scriptie\Topic herbestemming\Data\adrestabel_nvm.dta"

drop if _merge==1 | _merge==2

drop _merge

sort obj_id

quietly by obj_id: gen dup = cond(_N==1,0,_n)

drop if dup>0

drop dup

sort obj_hid_woonopp

drop if obj_hid_woonopp<18&obj_hid_m2<18

drop if obj_hid_woonopp>499&obj_hid_m2==0

drop if obj_hid_woonopp==0&obj_hid_m2>499

drop if obj_hid_woonopp>499&obj_hid_m2>499

replace obj_hid_m2=obj_hid_woonopp if obj_hid_m2==0

sort obj_hid_transactieprijs

merge 1:1 obj_id using "C:\Users\bobkr\Documents\RUG\Scriptie\Topic herbestemming\Data\afstand.dta"

drop _merge

drop if near_1 ==0

drop if near_2 ==0

drop if near_3 ==0

drop if near_4 ==0

drop if near_5 ==0

drop if near_6 ==0

drop if near_7 ==0

drop if near_8 ==0

drop if near_9 ==0

drop if near_10 ==0

drop if near_11 ==0

drop if near_12 ==0
```

```
drop if near_13 ==0
drop if near_14 ==0
drop if near_15 ==0
drop if near_16 ==0
drop if near_17 ==0
drop if near_18 ==0
drop if near_19 ==0
drop if near_20 ==0
drop if near_21 ==0
drop if near_22 ==0
drop if near_23 ==0
drop if near_24 ==0
drop if near_25 ==0
drop if near_26 ==0
drop if near_27 ==0
drop if near_28==0
drop if near_29==0
drop if near_30==0
drop if near_31==0
rename obj_buurt_id obj_neighb_id
rename obj_wijk_id obj_district_id
rename obj_gem_id obj_muni_id
rename obj_plaats_id obj_locality_id
rename obj_hid_straatnaam obj_hid_street_name
rename obj_hid_huisnummer obj_hid_house_number
rename obj_hid_huisnummertoevoeging obj_hid_house_number_add
rename obj_hid_postcode obj_hid_postal_code
rename obj_hid_woonplaats obj_hid_residency
rename obj_hid_categorie obj_hid_category
rename obj_hid_nvmcijfers house_type_nvm
rename obj_hid_nkamers n_rooms
rename obj_hid_transactieprijs transaction_price
```

```
rename obj_hid_bwper constr_period
rename obj_hid_perceel lot_size
drop if constr_period==0
drop if n_rooms==0
drop if n_rooms>15
drop if house_type_nvm==1
gen terraced_house = 0
replace terraced_house=1 if inlist(house_type_nvm,2,3)
gen corner_house=0
replace corner_house=1 if house_type_nvm==4
gen semi_detached=0
replace semi_detached=1 if house_type_nvm==5
gen detached_house=0
replace detached_house=1 if house_type_nvm==6
gen appartment=0
replace appartment=1 if inlist(house_type_nvm,7,8,9,10)
gen transaction_year=year(transaction_date)
gen ln_transaction_price=ln(transaction_price)
gen ln_m2=ln(obj_hid_m2)
gen house_condition_good=0
replace house_condition_good=1 if inlist(house_condition,1,2,3)
gen house_condition_med=0
replace house_condition_med=1 if inlist(house_condition,4,5,6)
gen house_condition_bad=0
replace house_condition_bad=1 if inlist(house_condition,7,8,9)

merge 1:1 obj_id using "C:\Users\bobkr\Documents\RUG\Scriptie\Topic
herbestemming\Data\near_174.dta"
drop if _merge==2
drop _merge

gen office_id=0
replace office_id=1 if near_fid==3
```

```
replace office_id=2 if near_fid==6
replace office_id=3 if near_fid==10
replace office_id=4 if near_fid==0
replace office_id=5 if near_fid==11
replace office_id=6 if near_fid==5
replace office_id=7 if near_fid==4
replace office_id=8 if near_fid==2
replace office_id=9 if near_fid==7
replace office_id=10 if near_fid==12
replace office_id=11 if near_fid==1
replace office_id=12 if near_fid==8
replace office_id=13 if near_fid==9
replace office_id=14 if near_fid==16
replace office_id=15 if near_fid==15
replace office_id=16 if near_fid==14
replace office_id=17 if near_fid==13
```

Eliminating overlapping transactions:

```
drop if near_10<1000
drop if near_9<1000
drop if near_7<1000
drop if near_8<1000
drop if near_23<1000
drop if near_24<1000
drop if near_26<1000
drop if near_5<1000
drop if near_3<1000
drop if near_15<1000
drop if near_16<1000
drop if near_13<1000
drop if near_12<2000&near_29<1000
drop if near_12<2000&near_14<1000
```

```
drop if near_29<2000&near_12<1000

drop if near_29<2000&near_14<1000

drop if near_14<2000&near_12<1000

drop if near_14<2000&near_29<1000


replace before=1 if near_dist<1000

replace during=1 if transaction_year>=2004 & transaction_year<=2005 & office_id==1 & near_dist<1000

replace during=1 if transaction_year==2014 & office_id==2 & near_dist<1000

replace during=1 if transaction_year>=1997 & transaction_year<=1999 & office_id==3 & near_dist<1000

replace during=1 if transaction_year>=2001 & transaction_year<=2003 & office_id==4 & near_dist<1000

replace during=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==5 & near_dist<1000

replace during=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==6 & near_dist<1000

replace during=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==7 & near_dist<1000

replace during=1 if transaction_year>=2001 & transaction_year<=2002 & office_id==8 & near_dist<1000

replace during=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==9 & near_dist<1000

replace during=1 if transaction_year>=2004 & transaction_year<=2006 & office_id==10 & near_dist<1000

replace during=1 if transaction_year>=1999 & transaction_year<=2002 & office_id==11 & near_dist<1000

replace during=1 if transaction_year>=2008 & transaction_year<=2010 & office_id==12 & near_dist<1000

replace during=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==13 & near_dist<1000

replace during=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==14 & near_dist<1000

replace during=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==15 & near_dist<1000

replace during=1 if transaction_year>=2012 & transaction_year<=2012 & office_id==16 & near_dist<1000
```

replace during=1 if transaction_year>=2009 & transaction_year<=2010 & office_id==17 & near_dist<1000

replace after=1 if transaction_year>2005 & office_id==1 & near_dist<1000

replace after=1 if transaction_year>2014 & office_id==2 & near_dist<1000

replace after=1 if transaction_year>1999 & office_id==3 & near_dist<1000

replace after=1 if transaction_year>2003 & office_id==4 & near_dist<1000

replace after=1 if transaction_year>2004 & office_id==5 & near_dist<1000

replace after=1 if transaction_year>2014 & office_id==6 & near_dist<1000

replace after=1 if transaction_year>2014 & office_id==7 & near_dist<1000

replace after=1 if transaction_year>2002 & office_id==8 & near_dist<1000

replace after=1 if transaction_year>2004 & office_id==9 & near_dist<1000

replace after=1 if transaction_year>2006 & office_id==10 & near_dist<1000

replace after=1 if transaction_year>2002 & office_id==11 & near_dist<1000

replace after=1 if transaction_year>2010 & office_id==12 & near_dist<1000

replace after=1 if transaction_year>2009 & office_id==13 & near_dist<1000

replace after=1 if transaction_year>2014 & office_id==14 & near_dist<1000

replace after=1 if transaction_year>2009 & office_id==15 & near_dist<1000

replace after=1 if transaction_year>2012 & office_id==16 & near_dist<1000

replace after=1 if transaction_year>2010 & office_id==17 & near_dist<1000

keep if near_dist<2000

Model 1:

xi: reg ln_transaction_price before during after i.transaction_year, robust absorb(obj_neighb_id)

Model 2:

xi: reg ln_transaction_price before during after ln_m2 terraced_house semi_detached corner_house detached_house n_rooms i.obj_hid_onbi i.obj_hid_onbu i.transaction_year i.obj_hid_verw

Model 3:

xi: reg ln_transaction_price before during after ln_m2 terraced_house semi_detached corner_house detached_house n_rooms i.obj_hid_onbi i.obj_hid_onbu i.transaction_year i.obj_hid_verw i.constr_period

Model 4:

xi: areg ln_transaction_price before during after ln_m2 terraced_house semi_detached corner_house detached_house n_rooms i.obj_hid_onbi i.obj_hid_onbu i.transaction_year i.obj_hid_verw i.constr_period, robust absorb(obj_neighb_id)

Model 5:

```
gen before250=0
gen before500=0
gen before750=0
gen before1000=0
gen during250=0
gen during500=0
gen during750=0
gen during1000=0
gen after250=0
gen after500=0
gen after750=0
gen after1000=0
replace before250=1 if near_dist<250
replace before500=1 if near_dist>=250 & near_dist<500
replace before750=1 if near_dist>=500 & near_dist<750
replace before1000=1 if near_dist>=750 & near_dist<1000
replace during250=1 if transaction_year>=2004 & transaction_year<=2005 & office_id==1 & near_dist<250
replace during250=1 if transaction_year==2014 & office_id==2 & near_dist<250
replace during250=1 if transaction_year>=1997 & transaction_year<=1999 & office_id==3 & near_dist<250
replace during250=1 if transaction_year>=2001 & transaction_year<=2003 & office_id==4 & near_dist<250
replace during250=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==5 & near_dist<250
replace during250=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==6 & near_dist<250
replace during250=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==7 & near_dist<250
replace during250=1 if transaction_year>=2001 & transaction_year<=2002 & office_id==8 & near_dist<250
replace during250=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==9 & near_dist<250
```

replace during250=1 if transaction_year>=2004 & transaction_year<=2006 & office_id==10 & near_dist<250

replace during250=1 if transaction_year>=1999 & transaction_year<=2002 & office_id==11 & near_dist<250

replace during250=1 if transaction_year>=2008 & transaction_year<=2010 & office_id==12 & near_dist<250

replace during250=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==13 & near_dist<250

replace during250=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==14 & near_dist<250

replace during250=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==15 & near_dist<250

replace during250=1 if transaction_year>=2012 & transaction_year<=2012 & office_id==16 & near_dist<250

replace during250=1 if transaction_year>=2009 & transaction_year<=2010 & office_id==17 & near_dist<250

replace during500=1 if transaction_year>=2004 & transaction_year<=2005 & office_id==1 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year==2014 & office_id==2 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=1997 & transaction_year<=1999 & office_id==3 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2001 & transaction_year<=2003 & office_id==4 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==5 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==6 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==7 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2001 & transaction_year<=2002 & office_id==8 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==9 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2004 & transaction_year<=2006 & office_id==10 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=1999 & transaction_year<=2002 & office_id==11 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2008 & transaction_year<=2010 & office_id==12 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==13 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==14 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==15 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2012 & transaction_year<=2012 & office_id==16 & near_dist>=250 & near_dist<500

replace during500=1 if transaction_year>=2009 & transaction_year<=2010 & office_id==17 & near_dist>=250 & near_dist<500

replace during750=1 if transaction_year>=2004 & transaction_year<=2005 & office_id==1 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year==2014 & office_id==2 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=1997 & transaction_year<=1999 & office_id==3 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2001 & transaction_year<=2003 & office_id==4 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==5 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==6 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==7 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2001 & transaction_year<=2002 & office_id==8 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==9 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2004 & transaction_year<=2006 & office_id==10 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=1999 & transaction_year<=2002 & office_id==11 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2008 & transaction_year<=2010 & office_id==12 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==13 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==14 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==15 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2012 & transaction_year<=2012 & office_id==16 & near_dist>=500 & near_dist<750

replace during750=1 if transaction_year>=2009 & transaction_year<=2010 & office_id==17 & near_dist>=500 & near_dist<750

replace during1000=1 if transaction_year>=2004 & transaction_year<=2005 & office_id==1 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year==2014 & office_id==2 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=1997 & transaction_year<=1999 & office_id==3 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2001 & transaction_year<=2003 & office_id==4 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==5 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==6 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==7 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2001 & transaction_year<=2002 & office_id==8 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==9 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2004 & transaction_year<=2006 & office_id==10 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=1999 & transaction_year<=2002 & office_id==11 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2008 & transaction_year<=2010 & office_id==12 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==13 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==14 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==15 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2012 & transaction_year<=2012 & office_id==16 & near_dist>=750 & near_dist<1000

replace during1000=1 if transaction_year>=2009 & transaction_year<=2010 & office_id==17 & near_dist>=750 & near_dist<1000

replace after250=1 if transaction_year>2005 & office_id==1 & near_dist<250

```
replace after250=1 if transaction_year>2014 & office_id==2 & near_dist<250
replace after250=1 if transaction_year>1999 & office_id==3 & near_dist<250
replace after250=1 if transaction_year>2003 & office_id==4 & near_dist<250
replace after250=1 if transaction_year>2004 & office_id==5 & near_dist<250
replace after250=1 if transaction_year>2014 & office_id==6 & near_dist<250
replace after250=1 if transaction_year>2014 & office_id==7 & near_dist<250
replace after250=1 if transaction_year>2002 & office_id==8 & near_dist<250
replace after250=1 if transaction_year>2004 & office_id==9 & near_dist<250
replace after250=1 if transaction_year>2006 & office_id==10 & near_dist<250
replace after250=1 if transaction_year>2002 & office_id==11 & near_dist<250
replace after250=1 if transaction_year>2010 & office_id==12 & near_dist<250
replace after250=1 if transaction_year>2009 & office_id==13 & near_dist<250
replace after250=1 if transaction_year>2014 & office_id==14 & near_dist<250
replace after250=1 if transaction_year>2009 & office_id==15 & near_dist<250
replace after250=1 if transaction_year>2012 & office_id==16 & near_dist<250
replace after250=1 if transaction_year>2010 & office_id==17 & near_dist<250
replace after500=1 if transaction_year>2005 & office_id==1 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2014 & office_id==2 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>1999 & office_id==3 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2003 & office_id==4 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2004 & office_id==5 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2014 & office_id==6 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2014 & office_id==7 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2002 & office_id==8 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2004 & office_id==9 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2006 & office_id==10 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2002 & office_id==11 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2010 & office_id==12 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2009 & office_id==13 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2014 & office_id==14 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2009 & office_id==15 & near_dist>=250 & near_dist<500
replace after500=1 if transaction_year>2012 & office_id==16 & near_dist>=250 & near_dist<500
```

```
replace after500=1 if transaction_year>2010 & office_id==17 & near_dist>=250 & near_dist<500
replace after750=1 if transaction_year>2005 & office_id==1 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2014 & office_id==2 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>1999 & office_id==3 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2003 & office_id==4 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2004 & office_id==5 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2014 & office_id==6 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2014 & office_id==7 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2002 & office_id==8 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2004 & office_id==9 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2006 & office_id==10 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2002 & office_id==11 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2010 & office_id==12 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2009 & office_id==13 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2014 & office_id==14 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2009 & office_id==15 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2012 & office_id==16 & near_dist>=500 & near_dist<750
replace after750=1 if transaction_year>2010 & office_id==17 & near_dist>=500 & near_dist<750
replace after1000=1 if transaction_year>2005 & office_id==1 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2014 & office_id==2 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>1999 & office_id==3 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2003 & office_id==4 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2004 & office_id==5 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2014 & office_id==6 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2014 & office_id==7 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2002 & office_id==8 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2004 & office_id==9 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2006 & office_id==10 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2002 & office_id==11 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2010 & office_id==12 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2009 & office_id==13 & near_dist>=750 & near_dist<1000
replace after1000=1 if transaction_year>2014 & office_id==14 & near_dist>=750 & near_dist<1000
```

```
replace after1000=1 if transaction_year>2009 & office_id==15 & near_dist>=750 & near_dist<1000

replace after1000=1 if transaction_year>2012 & office_id==16 & near_dist>=750 & near_dist<1000

replace after1000=1 if transaction_year>2010 & office_id==17 & near_dist>=750 & near_dist<1000

keep if near_dist<2000

xi: areg ln_transaction_price before250 before500 before750 before1000 during250 during500
during750 during1000 after250 after500 after750 after1000 ln_m2 terraced_house semi_detached
corner_house detached_house n_rooms i.obj_hid_onbi i.obj_hid_onbu i.transaction_year
i.obj_hid_verw i.constr_period, robust absorb(obj_neighb_id)
```

Model 6

```
gen near_dist2 = near_dist^2

gen before_dist=before*near_dist

gen before_dist2=before*near_dist2

gen during_dist=during*near_dist

gen during_dist2=during*near_dist2

gen after_dist=after*near_dist

gen after_dist2=after*near_dist2

xi: areg ln_transaction_price before before_dist before_dist2 during during_dist during_dist2 after
after_dist after_dist2 ln_m2 terraced_house semi_detached corner_house detached_house n_rooms
i.obj_hid_onbi i.obj_hid_onbu i.transaction_year i.obj_hid_verw i.constr_period, robust
absorb(obj_neighb_id)
```

Model 7:

```
replace before=1 if near_dist<1000

replace during=1 if transaction_year>=2004 & transaction_year<=2005 & office_id==1 &
near_dist<1000

replace during=1 if transaction_year==2014 & office_id==2 & near_dist<1000

replace during=1 if transaction_year>=1997 & transaction_year<=1999 & office_id==3 &
near_dist<1000

replace during=1 if transaction_year>=2001 & transaction_year<=2003 & office_id==4 &
near_dist<1000

replace during=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==5 &
near_dist<1000

replace during=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==6 &
near_dist<1000

replace during=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==7 &
near_dist<1000
```

```
replace during=1 if transaction_year>=2001 & transaction_year<=2002 & office_id==8 & near_dist<1000

replace during=1 if transaction_year>=2002 & transaction_year<=2004 & office_id==9 & near_dist<1000

replace during=1 if transaction_year>=2004 & transaction_year<=2006 & office_id==10 & near_dist<1000

replace during=1 if transaction_year>=1999 & transaction_year<=2002 & office_id==11 & near_dist<1000

replace during=1 if transaction_year>=2008 & transaction_year<=2010 & office_id==12 & near_dist<1000

replace during=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==13 & near_dist<1000

replace during=1 if transaction_year>=2013 & transaction_year<=2014 & office_id==14 & near_dist<1000

replace during=1 if transaction_year>=2008 & transaction_year<=2009 & office_id==15 & near_dist<1000

replace during=1 if transaction_year>=2012 & transaction_year<=2012 & office_id==16 & near_dist<1000

replace during=1 if transaction_year>=2009 & transaction_year<=2010 & office_id==17 & near_dist<1000

replace after=1 if transaction_year>2005 & office_id==1 & near_dist<1000

replace after=1 if transaction_year>2014 & office_id==2 & near_dist<1000

replace after=1 if transaction_year>1999 & office_id==3 & near_dist<1000

replace after=1 if transaction_year>2003 & office_id==4 & near_dist<1000

replace after=1 if transaction_year>2004 & office_id==5 & near_dist<1000

replace after=1 if transaction_year>2014 & office_id==6 & near_dist<1000

replace after=1 if transaction_year>2014 & office_id==7 & near_dist<1000

replace after=1 if transaction_year>2002 & office_id==8 & near_dist<1000

replace after=1 if transaction_year>2004 & office_id==9 & near_dist<1000

replace after=1 if transaction_year>2006 & office_id==10 & near_dist<1000

replace after=1 if transaction_year>2002 & office_id==11 & near_dist<1000

replace after=1 if transaction_year>2010 & office_id==12 & near_dist<1000

replace after=1 if transaction_year>2009 & office_id==13 & near_dist<1000

replace after=1 if transaction_year>2014 & office_id==14 & near_dist<1000

replace after=1 if transaction_year>2009 & office_id==15 & near_dist<1000

replace after=1 if transaction_year>2012 & office_id==16 & near_dist<1000
```

```
replace after=1 if transaction_year>2010 & office_id==17 & near_dist<1000
drop if near_dist>=1000 & near_dist<1250
keep if near_dist<2250
```

Appendix D: Syntax Chow tests

Chow G5

gen G5_1 = 0

replace G5_1 = 1 if inlist(office_id,2,3,5,6,7,13,14,15,16,17)

gen G5_0 = 0

replace G5_0 = 1 if inlist(office_id,1,4,8,9,10,11,12)

xi: areg ln_transaction_price before during after ln_m2 terraced_house semi_detached corner_house detached_house n_rooms i.obj_hid_onbi i.obj_hid_onbu i.transaction_year i.obj_hid_verw i.constr_period if G5_1==1, robust absorb(obj_neighb_id)

xi: areg ln_transaction_price before during after ln_m2 terraced_house semi_detached corner_house detached_house n_rooms i.obj_hid_onbi i.obj_hid_onbu i.transaction_year i.obj_hid_verw i.constr_period if G5_0==1, robust absorb(obj_neighb_id)

reg ln_transaction_price before during after ln_m2 terraced_house semi_detached corner_house detached_house n_rooms i.obj_hid_onbi i.obj_hid_onbu i.transaction_year i.obj_hid_verw i.constr_period obj_neighb_id G5_1 G5_0, noconstant

test _b[G5_1]=0, notest

test _b[G5_0]=0, accum

Chow vacancy

gen V_1 = 0

replace V_1 = 1 if inlist(office_id,3,6,7,8,10,11,15,16)

gen V_0 = 0

replace V_0 = 1 if inlist(office_id,1,2,4,5,9,12,13,14,17)

reg ln_transaction_price before during after ln_m2 terraced_house semi_detached corner_house detached_house n_rooms i.obj_hid_onbi i.obj_hid_onbu i.transaction_year i.obj_hid_verw i.constr_period obj_neighb_id V_1 V_0, noconstant

test _b[V_1]=0, notest

test _b[V_0]=0, accum

Chow change in appearance

gen CA_3=0

replace CA_3 = 1 if inlist(office_id,1,3,8,15,16)

gen CA_2 = 0

replace CA_2 = 1 if inlist(office_id,6,9,11,12)

gen CA_1 = 0

```
replace CA_1 = 1 if inlist(office_id,2,4,5,7,10,13,14,17)

reg ln_transaction_price before during after ln_m2 terraced_house semi_detached corner_house
detached_house n_rooms i.obj_hid_onbi i.obj_hid_onbu i.transaction_year i.obj_hid_verw
i.constr_period obj_neighb_id CA_3 CA_2 CA_1, noconstant

test _b[CA_3]=0, notest

test _b[CA_2]=0, accum

test _b[CA_1]=0, accum
```