Aalto University
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Housing externalities

The impact of exterior renovations on housing prices in Helsinki

Master's Thesis
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Abstract of master's thesis

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Abstract

This paper aims to quantify the spillover effect from exterior renovations in Helsinki, to investigate whether a positive spillover effect exists from renovating the exterior of houses and whether they should be subsidized. The empirical assessment uses permit data from The city Helsinki between the years 2002 to 2020 to determine which houses have been renovated. The empirical research utilizes the difference in differences method to determine whether the renovation has resulted in a price increase. The houses that have sold within a 250-meter radius from the renovated house are considered the treatment group. In contrast, the houses that have been sold within a radius over 250 meters up to 500 meters from the renovated house are considered the control group.

An exterior renovation appears to increase house prices by approximately three percent for the houses within 250-meter proximity from a renovated house. Moreover, the spillover effect seems to be the most prominent in Helsinki's West and Southeastern parts. Several assumptions need to be met in order to trust this result. Firstly, the parallel trends assumption needs to hold. This assumption has been controlled for through a descriptive analysis which suggests that the parallel trends assumption holds. Secondly, since the study relies on permit data, it is hard to estimate when exactly the renovations have commenced and completed. Since permits that have been granted need to commence within three years in Helsinki, the assumption is that most renovations have begun and are completed within three years. However, through a robustness check that changed the time interval, there are some worrying results. The estimate for the spillover effect stays approximately the same when expanding the time interval from one to five years. This might suggest that the exterior renovations have been completed at different times. On the contrary, another robustness analysis, testing the spillover effect changes with distance, supports the positive spillover effect.

Given that the two assumptions hold, there does indeed seem to be a positive spillover effect that is the most prominent in the Southern and Southeastern parts of Helsinki. This is also supported by the literature on neighborhood improvement, which has found a positive spillover effect that is approximately the same size. Thereby there is evidence that could support that exterior renovations should be subsidized. Moreover, the literature on foreclosures has found that neglecting the exterior in some cases can lead to a negative externality, meaning that with the looming threat of environmental crisis, exterior renovations could maintain the value of houses.

Keywords Exterior renovation, spillover effect, Difference in Differences, Neighborhood improvement

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Abstrakt

Syftet med denna avhandling är att undersöka externaliteten av fasadrenoveringar i Helsingfors. Vidare ämnar jag fastställa huruvida det finns en positiv externalitet och om fasadrenoveringar därför bör subventioneras. För att empiriskt avgöra vilka hus som blivit renoverade använder jag data för bygglov i Helsingfors stad mellan åren 2002 och 2020. För att estimera externaliteten används *difference in differences* estimat. Indelningen i försöks- och jämförelsegrupper har gjorts utgående från avståndet till det renoverade huset. Försöksgruppen är de sålda husen som befinner sig inom en 250 meters radie från ett renoverat hus medan jämförelsegruppen befinner sig inom en radie som är större än 250 meter men mindre än 500 meter.

Resultatet tyder på att en fasadrenovering ökar priset på försöksgruppen med omkring tre procent. Denna externalitet verkar vara mest signifikant i de västra och sydöstra delarna av Helsingfors. För att dessa resultat ska kunna antas vara kausala bör flera antaganden uppfyllas. Det första antagandet som bör uppfyllas är parallella trender. Detta har undersökts genom deskriptiva analyser. Resultatet från dessa tyder på att detta antagande uppfylls då prisutvecklingen och attributen är liknande för bägge grupper. Det andra antagandet gäller svårigheterna som uppstår av att använda bygglov. Eftersom renoveringarna baseras på bygglov är det omöjligt att veta när renoveringen de facto har påbörjats och avlutas. Antagandet är att renoveringen har påbörjats och avslutats inom tre år efter att bygglovet beviljats. Detta i enlighet med att en renovering måste påbörja tre år efter att ett bygglov beviljats. Dessvärre visar robusthetsanalysen att estimatet för externaliteten är ungefär lika stor för ett intervall på ett år som ett femårigt intervall. Detta kan bero på att renoveringarna slutförts vid olika tillfällen inom fem år efter att bygglovet beviljat. Den andra robusthetsanalysen för distans understöder dock en positiv externalitet.

Givet att de två antaganden håller finns det bevis för en positiv externalitet i Helsingfors. Det här resultatet understöds även av tidigare studier över olika stadsförnyelse projekt, som även funnit en positiv effekt i samma storlek. Detta innebär att det kan finnas orsak till att subventionera fasadrenoveringar i Helsingfors. Speciellt eftersom studier om utmätningar på hus visat att förfallna fasader kan minska på husets värde. Förfallande fasader kan bli ett större hot på grund av den globala uppvärmningen och därför kommer fasad renoveringar ha en större betydelse i framtiden.

Keywords Fasadrenovering, Externalitet, Difference in Differences, Stadsförnyelse projekt,

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1. Introduction

In economics, the pricing of houses has been studied extensively from many different perspectives. There is a myriad of factors that contribute to the prices of homes. One exciting and relatively unstudied variable is the spillover effect from the exterior condition of houses. A non-market interaction such as neighborhood aesthetics is harder to estimate but nonetheless important (Ahlfeldt et al. 2016). Infrastructure investment is a vast market. In 2015 approximately 2.3 trillion dollars was spent on infrastructure (Oxford Economics, n.d). Governments invest in different types of neighborhood improvement projects that aim to improve the quality of houses and neighborhoods to make them more attractive (McIntosh et al., 2018). Raising the attractiveness of an area should consequently lead to a rise in demand for apartments and, thereby, prices. The effect of infrastructure investments is hard to estimate due to the endogenous nature of the projects (McIntosh et al., 2018). Since house renovations tend to be expensive, it is relevant to quantify the spillover effect to understand how neglecting or maintaining the exterior of houses affects neighborhood prices (Rossi-Hansberg et al., 2010). Particularly to know whether it is beneficial for governments to subsidize or fund neighborhood improvements. Several studies have looked at how improving the aesthetics of houses and neighborhoods has affected prices. These studies are primarily conducted in the U.S (e.g., Ganduri & Maturana, 2021; Rossi-Hansberg et al., 2010). This spillover effect has not been assessed to the same extent in Finland. With this paper I hope to add to the literature on housing externalities by studying this effect in Helsinki.

This paper aims to quantify the spillover effects of a building's physical condition on neighborhood housing prices in Helsinki. The research question, therefore, is: what is the impact of exterior renovations on neighborhood prices? In this paper, an exterior renovation is defined as any improvements executed to the exterior of a building by replacing or fixing a visible surface. This paper aims to assess the spillover effect through permit data on exterior renovations. If there is a positive spillover effect, there may be cause for policy intervention since the allocation of exterior renovations at equilibrium is inefficient. The sub-questions that are being explored are how the estimated effect changes with distance and time.

Previous studies have assessed the effect of neighborhood improvements and foreclosures on neighborhood prices. Many studies have argued that improving the visual appeal of a neighborhood has raised its prices (see, e.g., Ganduri & Mutarana, 2021; Rossi-Hansberg et al., 2010). However, it is hard to argue any of these effects are causal due to the endogenous nature of the renovations. Renovations tend to cluster in areas with increased interest which might increase prices. On the contrary, studies on foreclosures have argued that the consequent visual blight has caused neighborhood prices to drop (see, e.g., Campbell et al. 2011; Harding et al. 2009). These studies also have challenges since it is hard to identify which effect drives the price decreases.

The City of Helsinki is continuously investing money in neighborhood improvement programs. Many are targeted towards the more disadvantaged parts of Helsinki e.g, Suburb Programme, through the years 2020 to 2022 (City of Helsinki, n.d). Another significant example is Lähiöprojekti, a long-running neighborhood improvement project in Helsinki, which was discontinued in 2017 (Helander & Ruotsalainen, 2017). Research should assess the spillovers in detail before suggesting new policies regarding interventions or subsidies of exterior renovations to improve neighborhoods. While most governments have had programs that target funds to enhance communities, the effects of such interventions are relatively unknown. It is essential to understand the returns of these projects to know whether they benefit society in monetary terms.

Helsinki is one of Finland's fastest-growing cities, attracting more residents yearly (Kaasila & Vuori, 2020). In the last couple of years, the prices of apartments in Finland have grown in certain areas tremendously. Between 2015 and 2020, the price for a square meter grew by 20-25 percent (Kauppalehti, 13.08.2021). However, this trend is only common in specific growth areas in the south of Finland. When one moves outside these growth areas, the prices may either decrease, stay the same, or increase by small amounts (Kauppalehti, 13.08.2021). A decrease in house prices might lead to negative consequences for homeowners, as many have put all their life savings into one apartment. Hence homeowners are reluctant to move if they do not get their invested money back for their apartment when selling it (Kauppalehti, 13.08.2021). Even though there has been a significant price increase in centers of growth, there is no proof of a price bubble (Nieminen, 2021). It is in the interest of particular areas in Helsinki to attract more residents to ensure economic growth in the form of more investments and services (Kaasila & Vuori, 2020). Existing residential areas want to stay competitive with the new dwellings. Through renovations, the existing neighborhoods can become more attractive and increase the demand for apartments. The higher the demand, the higher the price, given that supply is stationary

This study is only considering the monetary returns from renovations,While it is true that everyone might not desire high prices on apartments, it is in the seller's interest to get the best possible price for their apartment. In a city such as Helsinki, there is a fair amount of gentrification, which specific neighborhoods might be privy to, e.g. Punavuori and Kallio (Hudson, 2015). Even with the risk of gentrification, the prices of houses should be getting the price tag that equals their value. Low-valued houses mean that the homeowner will not get back the money they have invested in the house. It is in the interest of homeowners to maintain the value of their homes to the greatest extent. The higher price is also a bi-product of an increase in the quality of the underlying product. It can be explained by the hedonic regression, when two identical products are priced differently, consumers will only consider the cheaper one (Rosen, 1974). If prices in a neighborhood start to drop, it will lead to a chain reaction where similar apartments in the same area will have to lower their prices. This is an undesired situation for the sellers and homeowners since the value of their house goes down.

Consequently, a hedonic price regression is utilized to assess the spillover effect in Helsinki. A difference in difference strategy is used to decrease the possibility for confounding factors. The ring method is used to divide houses into treatment and control groups. Houses within 250 meters of a renovated house are considered the treatment group, while houses within a 250–500-meter radius from a house are considered the control group in the primary analysis. The difference and difference method aims to minimize confounding factors by having treatment and control groups follow parallel trends and obtain an unbiased estimate of the spillover effect. Furthermore, distance and time analyses have been used as robustness checks. Lastly, Helsinki has been divided into eight districts to assess the heterogeneity of the Helsinki areas. Permit data on renovations between 2000-2020 has been utilized to determine which houses have been renovated. And the transaction data has been provided by Kiinteistönvälitysalan Keskusliitto ry, KVKL Hintaseurantapalvelu for houses sold between 2002 to 2020.

There does seem to be a positive spillover effect following an exterior renovation. The prices have increased by approximately three percent closer to the renovated house compared to far away between 2000 and 2020. This result relies on the assumption that the parallel trends hold, that no other time-varying factors would affect the price, and that the renovation has taken place within three years following a granted permit.

The main result is supported by the distance model, which finds that each ten meters away from the treated house decreases the price after the treatment compared to before the treatment. On the other hand, when challenging the time interval of three years, I find that all the time intervals between one to five years yield approximately the same spillover effect and are all significant. This is worrying because the spillover effect does not seem to be time-sensitive, as indicated in previous studies. It also suggests that the renovations may have taken place at significantly different times, which would mean that the main result is not the result of a renovation but rather the result of other variables.

The last and perhaps most significant result is dividing Helsinki into eight major districts. Through this analysis, it becomes clear that the spillover effect differs significantly depending on the area of Helsinki. The largest and most significant impact is found in the West and Southeast districts, supported by previous studies. (Ganduri & Maturana, 2021). These areas of Helsinki have intermediate prices compared to the other districts. The renovations have had the most considerable monetary impact in these areas.

All separate analyses support that there is indeed a small albeit positive spillover effect following renovations. However, there are fundamental problems with the regressions. The first and most prominent is that the permit data does not mean that the renovation has commenced within the same year. A permit that has been accepted has to commence within three years and needs to be finished within five years (City of Helsinki, 2019B), meaning that it is hard to assess when precisely the renovation has begun and ended. However, the assumption is that, on average most renovations have finished within three years after a permit has been accepted. Secondly, there is a myriad of factors that affect the prices of apartments. Given that the assumption about parallel trends holds, most of these biased factors are controlled for. It does seem like the treatment and control groups, on average, fulfill the assumptions of parallel trends. Given that all of these assumptions hold, it does seem like there is a positive spillover effect

The paper is presented as follows; I will give a background to the Helsinki real estate market and introduce some underlying mechanisms. Then I will present literature on the subject, focusing on the strategy and outcome. I will give an introduction to literature, both urban renewal literature and foreclosure literature. As for the actual analysis, I will present some descriptive statistics in Helsinki and the results from the empirical strategy. Lastly, I will present the final conclusions and a discussion

2. Background

2.1 Threats to the real estate market

The topic of exterior renovations is of particular interest since they may execute too seldom to ensure that the quality of houses is maintained in the future with the looming threat of climate change. If climate change cannot be halted or reversed, Finland can expect increased rain, which will strain building materials (Laatikainen, 2021). Buildings' exteriors are likely to be damaged by the increased dampness caused by the extreme rain if they are not continuously maintained (Laatikainen, 2021). Increased moisture may consequently cause rust, mold, or cracks due to water expanding as it freezes (Laatikainen, 2021). If the exteriors show visible signs of destruction, the damage might already be too far gone, and the whole building will need a complete exterior renovation with new concrete (Laatikainen, 2021).

There has been an increase in the number of executed exterior renovations in Finland over the last couple of years. However, they are still executed too seldom (Perttula, 2021). The low frequency of renovations leads to possible dangerous building structures and buildings that are not aesthetically pleasing. The spokesperson for the Finnish exterior renovation association Toni Pakkala (as cited in Perttula, 2021), estimates that today's exterior renovations should double to sufficiently maintain a building's integrity. Usually, the exterior renovations are executed when there are already significant problems in the structure. By this point, the damage often needs tremendous remedies with substantial costs (TM Rakennusmaailma, 2021). Due to the potentially extreme weather conditions caused by climate change, maintaining the exterior continuously is even more critical (Laatikainen, 2021).

At the same time, there are some real challenges when it comes to exterior renovations on houses, they are traditionally costly, and it can be challenging to acquire funds (Perttula, 2021). The CEO for the Raksystems Inspections & Surveys division Jari Mattinen (as cited in TM Rakennusmaailma, 2021), expressed that over 80 percent of the inspection done to assess the state of the exterior concluded that more invasive renovations are needed to fix the exterior. These renovations come with a hefty price tag, tens of thousands of euros. This predicament is worsened by increasing construction costs in Europe due to inflated labor and material costs (PWC, 2019).

Since it is one can argue that the allocation of exterior renovations at equilibrium is inefficient in Finland, there could be an incentive for government intervention. The market equilibrium is inefficient since it has not considered the positive spillover effects on surrounding houses. The neglect of exterior renovations could mean a reduction in neighborhood prices, and the decrease in prices could amplify due to extreme weather conditions. Given a positive externality, the government would need to subsidize exterior renovations to achieve an efficient number of renovations. Quantifying the spillover effect is necessary to know whether such a subsidy is economically beneficial.

2.2 Housing prices

Hedonic pricing estimates a commodity's value based on its utility-bearing attributes (Rosen, 1974). By using Hedonic pricing, the price of an apartment can be broken down to the apartment's characteristics. Several different elements influence an apartment's price size, location, neighborhood, number of bedrooms, etc. Each of these characteristics has a value that they attribute to the cost of an apartment (Rosen, 1974). Through Hedonic pricing, one can assess how significant the effect of these characteristics is on the prices of houses.

The different attributes of an apartment have a specific demand (Rosen, 1974). For the spillover effect to be positive, the assumption is that households are prepared to pay more for a house near the renovated house. I will use the Hedonic model to estimate households' desire to live close to a renovated house. In this paper, the underlying assumption is that neighborhoods are open markets. This means that there are no restraints on residents' movements within the city which will lead to equal utility for residents in every part of the city (Rossi-Hansberg et al., 2010). People choose to reside based on their optimal consumption of amenities that maximizes their utility given their income (Autor et al., 2014). This implies that high-income households will decide to reside in areas with increased amenities and more attractive neighborhoods.

2.3 The amenities and removal of disamenity effect

To truly understand what is driving the spillover effect, one needs to understand the underlying mechanisms. Many of these have been extensively explored in the previous literature. Essentially, I will be focusing on one main mechanism: the amenity effect. Muchof the previous literature has estimated the spillover effect through the demand or supply effect mechanisms.

In a traditional setting, these are studied through the change in the supply of apartments. However, in this study, the supply will stay the same only the character of a neighborhood will change. Therefore, they are not directly applicable to this study.

As there is an increase in demand in the neighborhood due to them being more aesthetically pleasing one can argue that the rise in prices is due to the increase in demand (Bratu, 2021). An increase in prices is a sign of higher demand. An aesthetically pleasing neighborhood gives the impression that the neighborhood is thriving, which might attract more high-income households (Autor et al., 2014). When amenities increase through renovations, this will lead to the more high-income household being interested in the neighborhood. This effect is also known as the amenities effect. The amenities, high-income households, and neighborhood maintenance can be considered a positive loop. A well-maintained neighborhood will increase amenities, attract more high-income residents to the area, and raise prices (Autor et al., 2014). The amenities effect thereby also leads to gentrifications of neighborhoods (Asquith et al., 2021). This amenity effect is expected to be more significant, close to visual improvements, and decrease with distance (Asquith et al., 2021).

The amenity effect can also be explained through the removal of disamenities, which means that the increase in prices due to an exterior renovation happens because visual blight is removed (Schwartz et al. 2006). There is a large disutility from living near a visually distraught building (Ganduri & Maturana, 2021). Eliminating an eye soar of a building from the environment and replacing it with a newer, more pristine-looking building makes the neighborhood more desirable, leading to a price increase. If this were the underlying mechanism, prices would increase immediately after the property has been resold and not after the renovation is completed. Since then, the spillover would be the result of a reduction in the supply of unattractive houses (Ganduri & Maturana, 2021). Unfortunately, I am unable to assess this effect with the given data set. I do not have access to the date when the renovation was executed but rather when the decision to renovate was made.

Salience could also explain part of the effect, and this means that the more noticeable the renovation is the more extensive the spillover effect would be. If this mechanism were the underlying fact the price increase would be the most significant during the renovation (Ganduri & Mutarana, 2021). Salience also implies that the effect of a renovation is expected to be more prominent when the renovation is more extensive (Ganduri & Maturana, 2021). This would be intuitive; the more extensive the change to a house is, the more significant the spillover effect would be.

Since spillover effects can work through many channels, these underlying mechanisms must be understood to interpret the result correctly. If there is an insignificant result, it would mean that none of these mechanisms work effectively in practice.

3. Literature

This section will present relevant literature to understand how the spillover effects are estimated in previous literature. When it comes to the literature on housing externalities, it approaches the spillover from many angles. Some have focused on crime or environmental factors, while others have looked at the spillover effects following new development. In this section, literature on different improvements in the neighborhood is of specific interest. These studies have utilized various urban renewal programs to estimate the effect and minimize selection bias.

I have added a section on literature that has looked at the spillover effects following foreclosures since these are important to understand when assessing the need for exterior renovations. Foreclosures have the opposite effect on the building's exterior. Following foreclosures, buildings tend to be left to decay, which is interesting because these studies provide a cautionary tale of the negative consequences of not renovating buildings. Foreclosures are therefore likely to have an adverse price effect on surrounding houses compared to neighborhood improvement programs.

Most of the literature has used the difference-in-difference strategy to quantify spillover effects. Several studies implemented the ring model to divide the sample into treatment and control groups. The model is an easy first step toward estimating the spillover effects. Other strategies have been combined with the difference in differences approach to understand the externality better. Studies have mainly been carried out in the US at different times. Below I will first present the literature on urban renewal and then move on to studies on foreclosures. After which, a discussion of the literature will be carried out.

3.1 Spillover effects of neighborhood improvements

Neighborhood improvements are, in this context, used to explain different measures taken to improve neighborhoods aesthetically. In many cities, so-called urban renewal programs have been implemented to increase the attractiveness of specific areas. Urban renewal aims to enhance an area through, e.g., prevention of decline and incentives to renew communities (Ahlfeldt et al. 2016). Therefore, they are the perfect setting for a quasi-experimental study. Hence most studies referenced have used some urban renewal programs to estimate the spillover. Different vocabulary for urban renewal has been used depending on the study, e.g., urban revitalization in Rossi-Hansberg et al. (2010).

One of the few papers contributing to the literature on urban renewal and foreclosures is by Ganduri and Maturana (2021). They study how property rehabilitation following foreclosures affects neighborhood property prices in the U.S. They use the national community stabilization trust NCST to estimate the result. NCST took form following the Great Recession. The program aims to prevent blight in neighborhoods by making REO[1] available to local housing providers before selling it to traditional market participants. Ganduri and Maturana (2021) estimate the spillover effect through the ring method as a first step. This difference in differences estimate method is used as a benchmark. The treatment group is the neighborhood within 0.1 miles of a rehabilitated house, while the control group is housed within a 0.33-mile radius. The treatment radius is negligible since the spillover effect tends to be local. The time interval is one year before and one year after the rehabilitation. However, a nonparametric method is used to get an unbiased estimate since it considers very local house price trends. This method uses house prices as a function of time and distance relative to the rehabilitation of houses. A rehabilitated house increased the price of surrounding homes by 2.3 to 4.0, and this impact is very local. Ganduri and Maturana (2021) also include a robustness analysis. The robustness analyses assess how the estimated impact changes with the amount spent on rehabilitation, the length of the repair, the housing market liquidity, and the degree of distress in the neighborhood? Ganduri and Maturana (2021) find that the spillover effect is more significant when more money is spent on rehabilitation, and restoration time is prolonged, and when the market is more liquid and less distressed. Lastly, they also find the impact more significant for houses in regions more prone to extreme weather conditions, specifically storms. Here Ganduri and Maturana (2021) used weather conditions as an instrument.

Ganduri and Maturana (2021) argue that the estimated effect arises through salience[2] as the spillover effect is prevalent even during the renovation. They also find that this effect is more

[1] REO is short for real estate owned, this is when a property owner repeatedly defaults on the mortgage and the property consequently is owned by bank or other institution. Then the bank is responsible for selling the home (Bond & Witkowski, 2021).
[2] Salience refers to the spillover effect being more prevalent with a higher degree of external improvements (Ganduri &Mutarana, 2021)

prominent in less distressed neighborhoods. The distress is based on the number of foreclosures in an area. Usually, more distressed areas are low-income areas. The results from the study indicate how rehabilitation can be used to stabilize distressed housing markets and that government should incentivize the restoration of run-down houses.

Another important paper from the U.S that has focused on urban renewal programs is by Rossi-Hansberg et al. (2010). They have studied the direct effects of the urban revitalization program, Neighborhood-in-Bloom, on neighborhood land prices. The urban revitalization program was a federally funded project in Richmond, Virginia, from 1999 to 2004 that invested funds into disadvantaged neighborhoods to visibly raise the prices of neighboring homes (Rossi-Hansberg et al., 2010). The investments included home demolitions, rehabilitation, and new constructions to improve the overall well-being. The study contributes to the literature on housing externalities from the view of residents with a novel dataset on individual data transactions from the Neighborhood-in-Bloom project. The urban revitalization program provides an exogenous source of beatification to a neighborhood which helps reduce the circular causation. Rossi-Hansberg et al. (2010) found a positive impact between the program and land prices, a two to five percent increase in the neighborhood land prices following the revitalization program. For each dollar invested, there is a return of 2 to 6 dollars. This result is relatively local since it decreased by half every 1000 feet. The empirical strategy used to obtain the results is a semiparametric hedonic price equation. They compared neighborhoods selected for the Neighborhood-in-Bloom program to those almost chosen for the program. The almost chosen areas provide an excellent counterfactual since they are physically and demographically similar. The final estimate was obtained by comparing the change in prices between the treated and the non-treated areas. The impact is argued to be caused by the services, and amenities created by the rehabilitation

Another paper that studies the impact of an urban renewal program in the U.S is by Schwartz et al. (2006). They explore whether subsidizing housing investments in New York leads to neighborhood benefits on property prices. Since it is hard to obtain a genuinely unbiased effect of spillovers, they utilized a project in New York City that poured funds into creating new apartments. This project took place between 1987 and 2000, and lead to many new subsidized apartments being built. Subsidized housing reduces visual blight in a neighborhood by replacing, e.g., littered vacant lots or abandoned buildings. They find a significant positive impact on prices from investments in subsidized housing. The estimate is obtained through the difference in differences model with a hedonic regression. The 10-treatment group is the houses close to the housing investment, within 200 feet, and the control group is a comparable neighborhood further away, in other words, the ring method. The estimate is positively correlated with the project size and decreases with distance. The relationship is argued to be causal since including prior trends in neighborhood values to the model did not significantly impact the estimate. Moreover, the result does not support other alternative explanations, e.g., that the new developments are more likely to be built in distressed areas. The spillover effect is found to decrease with distance. Schwartz et al. (2006) find that this effect is driven by disamenity, the removal of a visually unpleasing building Schwartz et al. (2006). The lack of amenity effect is proven by the price increase being the strongest immediately when the construction starts and a lack of increase when the rehabilitation is completed. Moreover, Schwartz et al. (2006) additionally find that the spillover effect is less extensive in low-income areas, similar to what Ganduri and Mutarana (2021) reported. One small change in exterior renovation is unlikely to have a significant impact on a disadvantaged neighborhood

While the previous studies have, for the most part, found a positive impact following different urban renewal programs, Ahlfeldt et al. (2016) find no evidence of a positive externality on property prices following a renewal policy in Berlin after the cold war. They study the how a targeted renewal policy in Berlin, Germany affected the house prices. After the fall of the Berlin wall in 1990, there were tremendous differences in the quality of house stock, with deplorable housing stock conditions. Therefore, the East was privy to an urban renewal program; 39 areas were proposed for the program; however, only 22 were targeted for the program. Ahlfeldt et al. (2016) utilize the division into areas and compares the price trends in the 22 sites targeted to those proposed but not chosen. The aim is to find proof that supports spatial policies through quasi-experimental methods since the spillover effects are hard to estimate without bias. They implemented a difference in differences strategy between 1990 to 2912. The physical condition of housing stock increased because of the policy. They found that the program increased housing prices between 0.1 to 2 percent per year following the breakdown of the Berlin wall. However, these results were insignificant at the lower bound, which weakens the estimate's causality.

The Ahlfeldt et al (2016) paper differs in many respects from the previously mentioned papers regarding where the study took place and the setting. Using a significant historical event such as the Berlin wall breakdown will likely not have the same impact as policy implemented in the U.S. in the modern world. In Berlin, the state of housing stock targeted for the policy is likely worse compared to the U.S. And since Ganduri & Maturana (2021) and Schwartz et al. (2006)

find that spillover has a more negligible impact in low-income neighborhoods, the result of Ahlfeldt et al. (2016) is not surprising. Ahlfeldt et al. (2016) show how the setting can change the result even if the empirical method is the same.

Table 1: Summary of literature on neighborhood improvements and their results

Author	Empirical method	Control group	Outcome measure	Main findings
Ganduri & Maturana (2021)	Diff-in-Diff and non-parametric regression	A neighborhood within 0.11- 0.33 miles from the rehabilitated house	Property price	Price increase of 2.3 to 4.0 percent surrounding the rehabilitated house. A larger impact in high income areas and in areas with storms. The salience effect is the underlying mechanism
Rossi-Hansberg et al. (2010)	Diff-in-Diff with semiparametric equation	Neighborhoods that were not chosen into the neighborhood revitalization program	Land prices	Land prices increased 2-5 percent in the neighborhood following the revitalization program. For each dollar spent, there is a return of 2 to 6 dollars. The impact decreased by half every 1000 feet. The amenities effect the underlying factor
Schwartz et al. (2006)	Diff-in-Diff	Comparable neighborhood further away from a house that received investment	Property prices	An increase in neighborhood prices following the investment. Larger impact in high income neighborhoods. The disamenity effect the underlying factor.
Ahlfeldt et al (2016)	Diff-in-Diff	The 17 areas that were not chosen for the renewal policy	Property prices	An increase in the physical condition of houses. An increase in prices between 0.1 to 2 percent per year. However, the result was insignificant.

3.2 The spillover effect of foreclosures

While the studies presented in this section do not directly look at the spillover effects following housing improvements, these studies bear a resemblance. One could argue that foreclosures estimate the opposite effect of the studies in the previous section. While urban renewal studies focus on the positive impact following neighborhood improvements, studies on foreclosures study the negative impact following the neglect of houses. Understanding the effects of foreclosures is integral to understanding the consequences of neglecting homes.

Several possible mechanisms could explain why the negative spillover arises. The reduction in prices following foreclosures can be attributed to an increase in the supply of apartments. Another explanation follows the fire sales of foreclosed homes. If sales are established through comparison, fire sales will harm neighborhood prices (Campbell et al., 2011). And lastly and most interestingly, the spillover can be explained through the physical damage following a foreclosure, the disamenity effect (Anenberg and Kung, 2014). Since there are many possible underlying mechanisms, most studies on foreclosures have tried to establish which causes the negative spillover.

Campbell et al. (2011) studied data from the Financial crisis of 2008 to 2009, when an unprecedented amount of houses went into foreclosure in Massachusetts. Through a hedonic regression with neighborhood fixed effects, Campbell et al. (2011) estimate that foreclosures cause a house's value to decrease by 28 percent on average. This decrease was calculated by comparing houses that were not subjected to foreclosure to those that were foreclosed. Campbell et al. (2011) implemented a difference-in-differences method to estimate the spillover effect of foreclosures. The treated neighborhood lies within a 0.1 miles radius of a foreclosed house, while the control group is within a radius of 0.25 miles. The time interval is a year before and a year following the foreclosure. Furthermore, the analysis included a control for price trends in the neighborhood before the foreclosure. Campbell et al. (2011) found that houses within a radius of 0.05 miles from a foreclosed home had a one percent decrease in their price. The estimated impact is substantial in low-income neighborhoods. Campbell et al. (2011) argue that the negative impact is caused by visual blight due to vandalism and neglect and due to the urgency of the sale.

Another excellent paper on foreclosures and their spillover effect is by Anenberg and Kung (2014). Anenberg and Kung (2014) studied the foreclosures that arose due to the financial crisis, which is similar to Campbell et al. (2011) paper. In contrast to Campbell et al. (2011), Anenberg and Kung (2014) studied the spillover in San Francisco and found that the negative impact on house prices on housing prices is due to the increase in the supply of houses rather than the visual blight caused by foreclosures. For the most part, the empirical approach follows the difference in differences set up in Campbell et al. (2011). The treatment group is housed within a radius of 0.1 miles from a foreclosed home, while the control group is within 0.33 miles. They exploit the exogeneity in listing a home to obtain the result, rather than using the foreclosure date like Campbell et al. (2011). An additional difference is that Anenberg and Kung (2014) assess REOs. The increased supply of houses caused homes within a 0.1-mile radius of a foreclosed home to have a one percent decrease in price. The impact is local and time-sensitive. The prices of houses tend to return to pre-listing prices six weeks after the listing.

Anenberg and Kung (2014) argue the result to be caused by the fire sale of houses. They further find proof of the supply effect since the prices on the local market tend to react the same to a new REO listing as to a non-REO listing. But they do not entirely neglect the possibility of the disamenity effect from their analysis. Anenberg and Kung (2014) assess the prices before and after the foreclosure to test for the disamenity effect. The after period is before the actual listing date. The argument is that it is most likely that the house's condition will deteriorate during this time, and the disamenity effect would be prevalent. Anenberg and Kung (2014) do not find any impact on prices in this time frame.

The last study in this section is by Harding et al. (2009). They also study the impact of foreclosures on neighborhood prices in several large cities in the U.S between 1989 to 2007. The most significant estimated decrease in value of surrounding houses following a foreclosure is one percent. The impact is local, within 300 feet of a foreclosed home. The contagion effect, the risk that decreasing prices might spread in the neighborhood following a foreclosure, is argued to be caused by the visual blight after foreclosures. In other words, the spillover is mainly explained by the neglect, vandalism, and abandonment of foreclosed homes. The disamenity effect is found to cause the spillover since the impact of the foreclosure is most substantial between the time a house goes into foreclosure and before the REO sale. This means that the impact of supply has yet to come into effect, but the visual appeal and the possibility of vandalism have changed. To estimate the result, Harding et al. (2009) use a repeat sales approach instead of using a hedonic function to avoid omitted variable bias. The model also accounts for time-varying factors between the sales the most important being foreclosures. The model takes into consideration the attributes that are likely to change between sales, one of them being foreclosures. The model controls for any 14 foreclosed properties near the sale for each sale and divides properties into buckets. Foreclosures are estimated to cause a one percent decrease in value within 300 meters from a foreclosed house.

Table 2: Summary of literature on foreclosures and their results

Author	Empirical method	Control group	Outcome measure	Main findings
Campbell et al. (2011)	Diff-in-Diff, and controlling for preexisting price trends	A neighborhood within a radius of 0.25 miles.	House price	One percent decrease in house prices within a radius of 0.5 miles from a foreclosed house. Most likely due to the disamenity and urgency of sale.
Anenberg and Kung (2014)	Diff-in-Diff	A neighborhood within a radius of 0.33 miles.	House price	Within a 0.1-mile radius prices decreased by one percent. This is attributed to the supply effect
Harding et al. (2009)	Repeat sale model estimated through OLS	Neighborhoods with different degrees of foreclosed homes in their vicinity	House price	A one percent decrease in house prices following a foreclosure within 300 feet of a sold house. Caused by the disamenity effect

3.3 Discussion of the literature

Much of the neighborhood improvement literature has focused on the U.S market. Most of these studies have found a positive and local spillover effect (see, e.g., Rossi-Hansberg et al., 2010; Ganduri & Maturana, 2021). Many studies have used a quasi-experimental strategy and utilized different urban renewal programs or historical events to assess the impact. Moreover, most of them have used the difference in differences approach to estimate the spillover effect. The percentage increase, generally, is not particularly significant, a couple of percent on average. However, there is nonetheless a positive effect on prices that some have managed to argue as causal (see, e.g., Schwartz et al. 2006). On the other hand, there are studies that have found an insignificant positive effect, meaning they cannot argue that there is a positive spillover effect (Ahlfeldt et al., 2016).

Interestingly, the effect appears to be more prominent in high-income neighborhoods that are less distressed (Ganduri & Maturana, 2021; Schwartz et al. 2006). This is an intuitive result as one renovation will likely not change the neighborhood's structure when the neighborhood is deplorable (Ganduri & Maturana, 2021). Another interesting finding is that weather conditions seem to impact the spillover's significance. The spillover effect was more extensive in areas more prone to storms (Ganduri & Maturana, 18 2021). This could indicate that when extreme weather increase, more funds will be targeted towards infrastructure to maintain the value of houses.

To assess the spillover effect further, I have included literature on foreclosures. The foreclosure literature estimates the opposite effect of urban renewal, namely what happens to neighborhood prices when the condition of a house deteriorates. Many studies have looked at the financial crisis since there were an unprecedented number of foreclosures (Campbell et al., 2011; Anenberg & Kung, 2014). The dominant strategy when assessing this spillover effect seems to be the difference in differences. The consensus appears to be that disclosures reduce neighborhood prices; although this effect is not large, around one percent. However, one of the most central questions when assessing the foreclosures spillover effect is whether this is due to the visual blight caused by vandalism and neglect or an increase in the supply of houses. The cause of the spillover seems to be hard to separate. Some studies have found the visual blight to be the culprit, e.g., Campbell et al. (2011) and Harding (2009). While others have argued that it is due to the supply effect or the comparison to neighboring houses when setting a price on a home (Anenberg & Kung, 2014). This makes it hard to draw any accurate conclusions just from the literature.

Another interesting find from Campbell et al. (2011) paper is that the spillover effect seems to be more prominent in low-income neighborhoods. While renovations seem to affect moderate to high-income neighborhoods more, low-income communities appear to be more affected by foreclosures. Even though it appears that the benefits from subsidizing renovations might not increase the value of houses following in low-income neighborhoods, they might prevent the value of homes from decreasing further.

In conclusion, the literature review indicates a positive effect of neighborhood improvements. The effect changes depending on the weather, how much is spent on the renovation, and where the house is located. The analysis on foreclosure has provided a breakdown of whether there is expected to be an effect if the exterior is neglected. Foreclosures are harder to analyze compared to neighborhood improvement since the underlying mechanisms are hard to separate. To some extent, the literature supports the notion that visual blight causes a decrease in price following the neglect of houses, especially in low-income neighborhoods.

4. Study outline

This section describes the setting for exterior renovations in the Finish case. To understand the spillover effect being assessed in this study, it is important to know how decisions regarding renovations are made in Finland. In this study, all the treated houses are terraced houses or apartment buildings, which will be discussed in this section. Specifically, how construction is made is a deciding factor in the endogeneity of renovations.

In Finland, there are two primary forms of real estate one can purchase either a housing share or a property. If you are buying an apartment, you are purchasing a stake in a Limited Liability Housing Company (Suomi.fi, 2021). A Limited Liability Housing Company is a limited company where every apartment owner owns shares in the housing company. According to the Limited Liability Housing Companies Act/Asunto-osakeyhtiölaki (Finlex. 1599/2009) section 1 paragraph 2, each shareholder in the Limited Liability Housing Company has the right to possess an apartment. Moreover, according to the Limited Liability Housing Companies Act/Asunto-osakeyhtiölaki (Finlex. 1599/2009), section 4, paragraph 2 and 3 states that each apartment owner is responsible for the upkeep of their apartment while it is the housing company's responsibility to care for the rest of the building. This means that, e.g., renovating pipes or the exterior is the housing companies' responsibility while renovations on individual apartments are the apartment owners' responsibility. The Housing Company has a board of members that gets chosen by the shareholders, the apartment owners (Sipilä, 2019). The board of members is responsible for the housing company’s economy and building common facilities (Sipilä, 2019). The common renovations are financed through company remuneration that the stock owners pay and loans. The amount of shares each apartment owner holds depends on the size of the apartment in relation to the total size of the apartment building. Terraced houses are also Limited Liability Housing Companies meaning they have the same practicalities as an apartment building.

In Finland, renovations are not regulated by law; instead, it is up to the board for the limited liability company to decide on construction (Orava & Turunen, 2020). The process is more complicated for limited liability companies than for privately owned property. The process firstly requires voting to decide whether construction should take place or not. According to Limited Liability Housing Companies Act (Ministry of Justice, Finland. 1599/2009) section 9, all shareholders have the right to vote on these questions, and a majority rule generally makes the final decision. The renovations that concern all residents aim to maintain the value and the integrity of the building's common areas (Orava & Turunen, 2020). These common renovations differ from renovations carried out by individual owners of an apartment, they aim to maintain the value of their apartments (Orava & Turunen, 2020). It generally is the case that the renovations done by the apartment owner themselves add the most considerable monetary value to the individual apartment. At the same time, the extensive renovations affecting all residents might not directly add value to the owners of the apartments (Orava & Turunen, 2020). Hence, the spillover effect should be considered when deciding whether to renovate. The extensive renovations are costly not only in monetary terms but also in terms of comfort for the resident (Norontaus, 2014). Construction affecting all residents in an apartment building usually entails that the owners of the apartments need to chip in to pay for the renovations. At the same time, the construction may also cause dust, noise, and scaffolds (Norontaus, 2014).

What an individual apartment owner pays for a renovation of common areas can be based on the size of the apartment or the number of shares one shareholder holds. If it is based on the size of the apartment, the apartment owner pays based on how many square meters the apartment is (Orava & Turunen, 2020). And since the residents are also deciding whether to renovate or not, the high price tag might cause them to postpone renovations for as long as possible. However, the scales might tip the other way if the potential positive externality was considered. According to Orava & Turunen (2020), the Limited Liability Housing Companies Act law states that it is up to the shareholders to decide how to divide the payments. Nonetheless, most common renovations are costly, exterior renovations being no exception. Moreover, all renovations that affect the remuneration are by law bound to be reported five years in advance in Finland (Orava & Turunen, 2020). This means that apartment owners have time to acquire funds.

When discussing exterior renovations, the price differs depending on what type of renovation is being executed, e.g., the renewal of a plaster facade is between 160 to 200 euros per square meter, while replacing and implementing thermal insulation is between 280 to 300 euros per square meter (Orava & Turunen, 2020). How often these renovations need to be executed depends on the material of the building. There are essentially six different building materials; concrete, element-washed concrete, brick, plaster, plated, and tiled exterior walls (Orava & Turunen, 2020). Typically, a plate exterior needs to be changed every 30 years, while a plastered surface needs to be renewed every 50 years and maintained every 20 years (Orava & Turunen, 2020). On the other hand, a red brick exterior needs little to no upkeep and generally does not need to be replaced (Orava & Turunen, 2020). These time estimates for exterior renovations are for changing the entire exterior, while there may be measures taken between these intervals to maintain the exterior. Besides the durability of materials, these renovations also differ in renovation time. In this paper, we are mainly concerned about the larger project that requires permits.

Most renovations and constructions require a building permit, and these are granted by the municipality (Suomi.fi.20.05.2021). The necessary permits differ depending on the municipality, but requiring a permit for changes on the facade is common. These permits are the focus of this study. To obtain a valid permit, there is a process that each housing company needs to follow; first, a permit needs to be constructed, after which it needs to be granted by the municipality only then the construction can take place (City of Helsinki, 2019A). Usually, rigorous planning is required before submitting the permit application to the construction committee. E.g., meetings with permitting authorities, hiring a project designer, Building control meetings, and technical meetings (City of Helsinki, 2019B). After the permit application has been sent, it will become public and subject to appeals. Anyone can appeal a permit to the administrative court within 30 days of the decision being made public (City of Helsinki, 2019A). Only a legal permit can be executed. However, a legal permit does not mean that the housing company is obligated to complete the renovation (City of Helsinki, 2019A). In this study, it is assumed that most permits are executed since it would be pointless to go through the rigorous planning for the renovation not to take place. An approved permit needs to commence with renovation within three years, and the construction needs to be completed within five years (City of Helsinki, 2019A). If the construction does not follow these guidelines, the permit will expire, and an expired permit can at most be extended by two years after the construction has started (City of Helsinki, 2019).

This study focuses on the permits regarding exterior and balcony renovations, there is a sizeable exogenous factor with these renovations. The renovations have not been made objectively and are decided by the owners of the apartments. There is a tradeoff for owners in these cases. The renovations cause costs in terms of an increase in rents that need to be paid to the housing association since loans are necessary to fund the renovations. They are also expensive because the apartment can become hard to live in for a while due to the noise and pollution. Therefore, many apartment owners may delay the renovations as long as possible to avoid the costs. On the other hand, these renovations also tend to raise the value of the apartment since a more clean-looking house is more desirable.

Furthermore, many assumptions need to be made about the execution of renovations since there is no clear time frame for how long it takes to execute the renovations. There is no strict time frame for the renovation to commence or be completed. This means that most of the renovations will take place within three years, but there could be an additional two years before the renovations are completed. This makes it harder to know precisely how long after the permit has been excepted that the renovations have taken place. A general estimate is that these exterior renovations can last anywhere from months to weeks (Talofakta.fi, 2019)

There are naturally exceptions to these rules of renovation. Neighborhood improvement programs may be implemented that try to raise the value of neighborhoods through renovations. These, of course, are not financed by the housing association and tend to be targeted at disadvantaged neighborhoods. These provide a more exogenous source of exterior renovations; however, they are only targeted to specific neighborhoods, usually the most disadvantaged. In the grand scheme of things, most housing associations need to apply for renovations through permits granted by the city before renovations start. While the results from such projects may be hard to generalize to other neighborhoods studying permits may be able to assess the effect of the most common renovations.

5. Empirical strategy and data

This section presents the empirical strategy and the data. Firstly, the relevant data will be presented followed by a walkthrough of the empirical approach. The empirical strategy is based on the most common strategies used in the referenced literature: the difference in differences setting. The paper that will have the most influence on my strategy is Ganduri and Maturana (2021).

5.1 Data

Three different data sources have been utilized. The two most important ones are permit data from the City of Helsinki and transaction data from Kiinteistönvälitysalan Keskusliitto ry, KVKL Hintaseurantapalvelu. I will also be using a third data set from the City of Helsinki, which contains the coordinates for addresses in Helsinki.

The Permit data from the city of Helsinki contains permits that have been granted for different kinds of renovation in Helsinki between 2000-2020. The included permits are those that have had an impact on the visual appearance of a building. These are all permits that contain the word exterior e.g., paint renewal or renewal of old material. I have also included renovations that have added class to balconies. Renovations granted through permits are usually implemented in packages e.g., putting glass on the balconies and painting the exterior may have been approved simultaneously. This means that I cannot differentiate the effect of different kinds of renovation. Hence this study estimates the effects of a general exterior update on neighborhood prices. One slight drawback is that the data does not contain the date when the renovation was executed but rather only the date when the decision to do the renovation was made. This means that the analysis will rely on certain assumptions regarding when renovations have been executed.

The second important data set for this study is the transaction data, the prices of houses sold through real estate agencies in Finland. This data comes from the Central Federation of Finnish Real Estate Agencies, in Finnish *Kiinteistönvälitysalan Keskusliitto ry*, they are more commonly referred to as KVKL. More specifically, the transaction data has been acquired from the KVKL service Hintaseurantapalvelu. I have included transaction data between 2002 and 2020 as the dependent variable. This data set does not include the entirety of Finnish real estate transactions that have taken place, but it should be sufficient to execute the study in question. Besides the transactions, the data set also contains attributes of the apartments, e.g., the size and number of rooms that are used as control variables. Only residential apartments are included in the data set.

The final data set comes from Kartta.hel.fi and contains the addresses' coordinates. This data set is merged with the transaction data set to obtain the coordinates and calculate the distances. The coordinates that are used in this data set are ETRS-GK25. This data set is only used to help make the analysis possible.

All different data sets have been merged to make the analysis possible. Following this thorough explanation of the underlying data sets, there needs to be a good understanding of what the data contains. Before diving into the data sets in detail, there first needs to be an explanation of the empirical strategy, which will be addressed in the following section.

5.2 Empirical strategy

The empirical strategy aims to find an unbiased estimate for the spillover effect. In this section, I will present the different techniques that are being used. The primary analysis is based on a difference in differences model (here after referred to as DID). Much like in Gaduri and

Mutarana (2021) paper, the ring method is utilized to divide houses into treatment and control groups.

This division is based on distance from the renovated house. The radius for the treatment group will be 250 meters from a renovated house, while the control group will have a radius of over 250 meters up to 500 meters from the treated house. The radius has been kept small to ensure that one observation, in this case, sold apartment, is included in only one treatment or control group. Moreover, a small radius is supported by previous studies that have found the spillover effect to be local (see, e.g., Rossi-Hansberg et al., 2010; Ganduri & Maturana, 2021). There is a tradeoff with having a small enough radius but a large enough sample. A small radius ensures that the control and treatment groups have the same attributes and that the house is only in one treatment or control group. However, a smaller radius means fewer observations in the treatment and control groups. By having large treatment and control groups in terms of observations, the mean values for the group's attributes will be more alike (Angrist & Pischke, 2015).On the other hand the further one moves from the treated house the more bias may be introduced since the treatment and control groups are likely to differ more. And the likelihood of one observation being in two treatment or control groups is higher. Therefore, it is crucial to have the right size of the treatment and control group. Because we are assessing such a densely populated area, 250 and 500 meters respectively is a large enough radius not to introduce bias while having enough apartments in both the treatment and control group.

The time frame that is used is three years before and three years after the permit has been approved. The difficulty is to know when the renovation has been executed after the permit has been approved. How long a renovation takes depends on the completed construction type. Exterior renovations are usually implemented in bundles with other changes, e.g., windows and roof (Ilveskoski, 2014). Therefore, it isn't easy to estimate how long the renovation generally takes, and renovation lengths depend on what renovations are executed, e.g., painting is significantly faster compared to a complete update of the exterior material. Renovations may take anywhere from days to years (Norontaus, 2014). A rough estimate is that facade upgrades and renovations take weeks or months, meaning no longer than one year (Talofakta.fi, 2019). Therefore, most renovations are assumed to have commenced before the three-year deadline for a renovation permit (City of Helsinki, 2019A). Hence, a time frame of three years should be sufficient for the renovation to be executed, scaffolds to be removed, and for one to see the effect of the renovation.

Similarly, increasing the time frame can also have a vital tradeoff. A larger timeframe means more observations which make for more precise estimates. On the other hand, the further from the time of renovation, the more bias is likely to be introduced. There are more factors besides the exterior renovation that could influence house prices. A three years time interval should be sufficient; however, a robustness check is needed to look closer.

The main hedonic regression for the logarithmic sales price of apartment i in time t is specified as:

$$Ln(P)_{nit} = \alpha + \beta_1 Near_{ni} + \beta_2 Post_t * Near_{ni} + \beta_3 X_{nit} + \varepsilon_{nit} \quad (1)$$

The dependent variable is the logarithmic sales price for an apartment i when sold at time t in neighborhood n. The dependent variable is the sales price, meaning the actual price the buyer paid to the seller. The neighborhood fixed effect is represented by the subscript n and the time fixed effect by the subscript t. A neighborhood is a 500-meter radius from a renovated house. In equation (1), the logarithmic price reflects the percentage change in price rather than the absolute value. The percentage change gives a better understanding of the effect than the absolute value since there are significant price variations. This means that all independent variables are interpreted in percent. The explanatory variable of interest is the interaction term β_3 since it captures the percentage change in price for the treated houses after the renovation compared to the control group. Including the control variables are also integral since they might capture the time-varying differences between treatment and control apartments that may cause bias. Additionally, the control variables will give more precise estimates since the standard error will be minimized. Equation (1) has been implemented with and without control variables to assess the robustness of the spillover effect. Moreover, the standard error will be clustered on a neighborhood level, to account for possible heteroscedasticity (Ahlfeldt et al. 2016).

To assess the locality of the effect an additional DID regression is used.

$$Ln(P)_{nit} = \alpha + \beta_1 Distance_{ni} + \beta_2 Distance_{ni} * Post_t + \beta_3 X_{nit} + \varepsilon_{nit} \quad (2)$$

Looking at the interaction term in equation (2), β_2 captures how much the price changes per ten meters after the renovation, while β_1 captures how much the price changes when moving ten meters away from the renovated house before renovation. The same control variables have been used in equation (2) as in equation (1). The treatment and control groups have been assigned with the same method as in equation (1). This means that the neighborhood fixed effects are defined in the same way in both equations.

Moreover, it is essential to assess the effect of time. As expressed earlier, the time estimate is based on assumptions. To determine how long it takes to finalize the renovation and at what point the spillover effect becomes visible, it is also essential to assess how the result changes depending on the timeframe. I will use equation (1) to estimate this result with different time intervals.

Besides just the assumptions made regarding the time frame, the DID strategy relies on several assumptions that have to be fulfilled to interpret the results as causal. The most fundamental assumption is the parallel trends assumption. The intuition behind the use of DID is to compare the price difference between the treated and the non-treated group before the treatment and then again after the treatment to estimate the effect of the treatment. To detect an unbiased treatment estimate, the treatment and control groups must have the same price trends. This means that the price development would have been the same for the treatment and the control group if it was not for the treatment (Angrist & Pischke, 2015). For this assumption to hold, there cannot be any time-varying differences between the treatment and control group (Angrist & Pischke, 2015). It is impossible to know how the price would have developed for the treated group without the renovation. Hence no test can formally state whether this assumption holds. However, the likelihood of this assumption holding for the treatment and control group can be tested by looking at the historical price trend to see whether it has developed similarly. To understand how likely it is for all of the named assumptions to hold, one needs to have a good understanding of the underlying data

5.3 Descriptive analysis

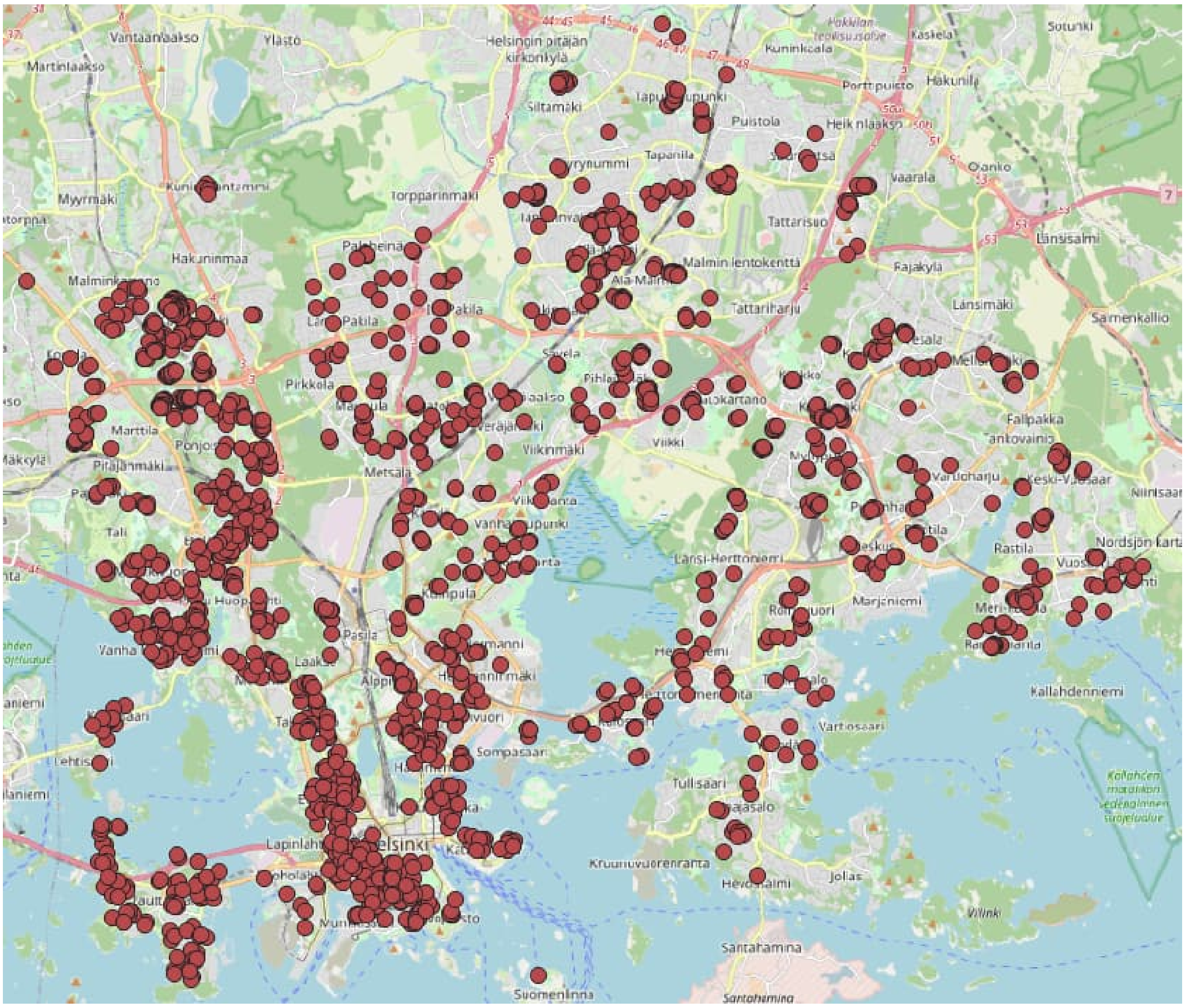
In this section, I will present the distribution of the treated house through time and geography. In the analysis, in the main result due to the time interval permits between 2005 and 2017 have been used. During this time frame, 1 235 permits have been granted for renovations that have significantly impacted the exterior of houses (permits that have changed the exterior of a house by adding glass or renovating). The distribution of treated houses through the years can be seen in Table 3. Through the years, there seems to have been an increase in exterior renovations, with the largest jump between 2008 and 2009.

Table 3: distributions of renovations between years 2005-2017

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
12	26	10	31	188	148	116	85	124	106	138	128	122

In most of the mentioned literature, there is an extensive discussion on obtaining unbiased estimates. Most previous studies used a quasi-experimental research design (e.g., Rossi-Hansberg et al. 2010; Ahlfeldt et al. 2016) since exterior renovations are not distributed exogenously by nature. The best option for getting an unbiased estimate without a randomized experiment would be to utilize some quasi-experimental studies (Ahlfeldt et al. 2016). It is integral to look at the distribution of renovations in Helsinki to assess the endogeneity of the distribution of renovations. This way, one could notice if there are areas that are more targeted than others. In Figure 1, the distribution of exterior renovations between the years 2005 to 2017 been distributed.

Figure 1: geographical distribution of granted permits for exterior renovations between 2005 and 2017



The permit data from the City of Helsinki. The geographic distribution of granted permits for renewing class balconies and most exterior renovations between 2005 to 2017

The observations are distributed throughout Helsinki. There are areas with more renovations than others, specifically the southern area of Helsinki. But I would argue that this is due to the density of houses. Since the renovations are spread throughout the Helsinki area, it allows for a broader analysis where on average, one could argue that most renovations have taken place because there is a need to renovate, e.g., poor building structures, rather than an opportunity like increase of funds.

The largest source of bias is that renovations might not take place due to a decrease in the quality of the exterior but rather due to an increase in investment into the neighborhood. The renovation might then occur because there is an inflow of new interest and money targeted to the neighborhood (Rossi-Hansberg et al. 2010). Then the rise in prices would consequently not be the result of the renovation but rather some other factor. In Figure 1, one can see that there seems to be wide distribution of houses. The assumption to execute the study would need to be that the price would have followed the same trend if it was not for the treatment.

The biased nature of renovation can somewhat be explained if the treatment and control of neighborhoods follow parallel trends. To achieve this, the groups should, on average, have the same attributes, e.g., the same demand and similar demographic of people moving into the neighborhood. Many of these characteristics are so-called unobservable variables; hence they cannot be captured in the regression. However, if the treatment and control groups are equal on average in their characteristics, these unobservable variables would be controlled for and would not bias the result. It is necessary to perform a descriptive analysis to assess the similarity between the treatment and control groups, this has been done in table 4.

Table 4: Descriptive statistics for houses sold between 2002-2020

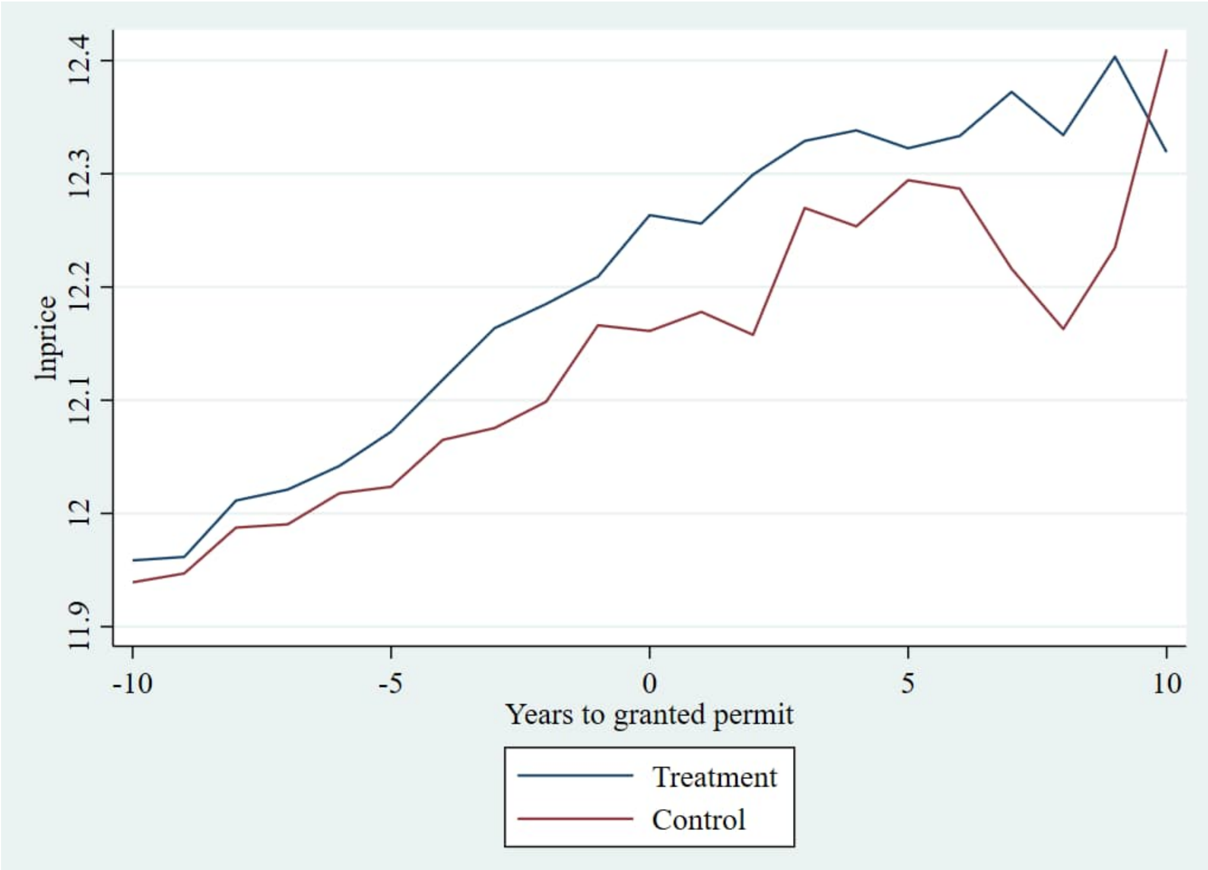
VARIABLES	All Nr. observations	All Mean	Treatment Nr. observations	Treatment mean	Control Nr. observations	Control Mean
Square meter	31,901	64.91	26,235	62.55	5,666	75.85
Year built	31,410	1,968	25,879	1,964	5,531	1,988
Nr. Of rooms	31,788	2.493	26,136	2.410	5,652	2.878
Square meter price (Euro)	32,029	4,407	26,298	4,522	5,731	3,882
New construction (dummy)	32,068	0.136	26,320	0.105	5,748	0.277
Coast (dummy)	32,068	6.24e-05	26,320	0	5,748	0.000348
Elevator (dummy)	32,068	0.434	26,320	0.450	5,748	0.363
Price (ln)	32,068	12.22	26,320	12.24	5,748	12.16

Notes: This table displays the mean values for apartment attributes and the number of observations. They are split between the treatment and control groups to see the similarities between the group's attributes. These characteristics are for houses sold between 2002-2020 within a 500-meter radius from a renovated house

While looking at Table 4, it becomes clear that the treatment and control groups, on average, have the same attributes. There are some small differences between the two groups. The treatment group seems to have smaller apartments with fewer rooms. The square meter price is somewhat higher for the treatment group, and the sales price of apartments is the same for the groups on average. The apartments are smaller, but the prices are a little higher, indicating a higher demand for apartments in the treatment neighborhoods; however, since the difference is so tiny in this case, this effect is obsolete. The treatment group is, on average 620 euros more expensive compared to the control group. Additionally, the square meter price is essential since this study does not have direct access to data on the demographics of buyers. The square meter price could serve as an indicator, and high square meter prices mean that high-income households live in the area. Therefore, the fact that, on average, the square meter price between treatment and control groups is similar is an important sign that the demographics are likely similar between treatment and control groups. Even if the fixed effects and the small radius ensures that the demographic is similar between groups, Table 4 supports this assumption. Interestingly the control groups have somewhat newer built houses on average. Judging by the mean values for the attributes between the control group is an excellent counterfactual to the treatment group. It is also important to note that the treatment group has many more observations than the treatment group. However, since the mean values are comparable this is not a concern.

While comparing attributes between treatment and control groups indicates that the groups are equal in the expectation, it does not rule out all the possibilities for differences. The treatment and control groups' price trends are compared to further validate the parallel trends assumption. In Figure 2, the logarithmic price development for the treatment and control groups has been plotted. In the figure year, zero is the year a permit has been approved. The treatment group is the houses within a 250-meter radius from a house that has been approved for an exterior renovation. I have plotted the logarithmic price for the treated houses ten years before the permit was approved and ten years after the permit was approved. The same goes for the control group. The control group is the houses with a radius that is larger than 250 meters but smaller than 500 meters from a house that has gotten an approved permit. For this group, I have plotted the logarithmic price for houses sold ten years before and ten years after a permit has been granted. So we are comparing how much the price on average was for a house sold e.g., ten years before the renovation, for the control group and the treatment group on average. Looking at the historical differences in price trends can help indicate how the costs would have developed in the future without the renovation.

Figure 2: Mean Price development of Helsinki house 10 years before and after granted permit



Data: Kiinteistönvälitysalan Keskusliitto ry, KVKL Hintaseurantapalvelu. The figure presents the logarithmic house prices for houses sold between 2002 to 2020. The house prices have been plotted ten years prior and ten years after a permit has been granted. For control and treatment groups, respectively

On average, the treatment and control group price trends followed a similar price pattern before the permit was granted. After the license has been granted at year 0, there is a deviation in the price patterns as the treatment group's price has a more considerable increase compared to the control group. However, what is important to note is that, on average, there seems to have been an increase in the prices overall even before the renovation took place, indicating that there has been a positive price trend for apartments in the metropolitan area of Helsinki. Moreover, a slight deviation between the price trends occurred even before the permit was granted. There is a slight deviation in prices one year before the permit has been approved. Furthermore, the trends seem to deviate significantly from each other after five years from the renovation. Here the lines separated the furthest from each other. The similarity in prices before the permit has been approved at year 0 indicates that the parallel trends assumption may hold.

The analyses from Table 3 and Figure 2 reassure that the parallel trends assumption seems to hold and that the control group is a good counterfactual to the treatment group. As stated, there is not any way to fully conclude that the groups fulfill the parallel trends assumption. However, the descriptive statistics indicate a good chance that the assumption is fulfilled. With these indications, the next step is to present the results from the regression.

6 Results

Following the descriptive analysis, the results from the empirical models are represented. Firstly, the results from the DID analysis. Next, I will be presenting an analysis of how the results change with distance. Lastly, I present an analysis of how the effect changes when dividing Helsinki into different districts. The aim is to give a broad understanding of the spillover effect.

6.1 Main results

I start by presenting the result from the DID model in regression and using these as a benchmark for different robustness analyses. In line with the findings from previous studies, the results from Table 5 indicate that there indeed seems to be a small positive spillover effect.

Firstly, column (1) in Table 5 represents equation 1 without fixed effects or an interaction term. This naïve regression shows that the treatment group has had a price increase and that this increase is significant at the one percent level. However, this result cannot be trusted since no fixed effects exist. Without the fixed effect, we are comparing all treatment groups to all control groups, which is not feasible since a treatment neighborhood in the East of Helsinki cannot be compared to a control neighborhood in the center of Helsinki. There are many differences in terms of price, demographics, and amenities, among other things. This model is merely a representation of a standard regression used as a benchmark to compare the models with fixed effects.

When applying the fixed effects and the interaction term In Column 2, the spillover effect is positive but relatively small and significant at the five percent level. The renovation increases the price of apartments by 2.46 percent for the houses within a 250-meter radius of a treated house compared to the control group. Control variables have been applied to Column 3 to decrease confounding factors. The spillover effect remains positive and even increases, which is in agreement with findings from most previous studies. The estimated spillover effect of 0.0267 means that the treatment group had a price increase of 2.67 percentage points after the renovation compared to the control group. This effect is not particularly large; however, the effect is significant at the one percent level. This means that the estimate's precision is adequate to conclude that there indeed seems to be a positive spillover effect within three years from a granted permit.

The r squared for Column 2 is inadequately small only 0.522, indicating that the model only captures 52.2 percent of the price variation. When adding the control variable for Column 3 the R squared does increase significantly but is still not a satisfactory rate, rising from 0.522 to 0.789. This indicates that the model is only able to capture approximately 78.9 percent of the price variation. This low value means that there still are some variables that have not been included in the regression, which may bias the estimates.

Table 5: Price analysis of permits granted between 2005 to 2017

VARIABLES	(1)	(2)	(3)
Treatment (dummy)	0.128***	-0.105***	-0.0791***
	(0.0419)	(0.0307)	(0.0213)
Treatment*after		0.0246**	0.0267***
		(0.0118)	(0.00770)
Constant	11.57***	11.87***	6.111***
	(0.0514)	(0.109)	(0.897)
Neighborhood fixed effect	No	Yes	Yes
Year fixed effects	No	Yes	Yes
Control variables	Yes	No	Yes
Observations	31,751	32,023	31,155
R-squared	0.370	0.522	0.789

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Standard errors have been clustered on neighborhood level. The dependent variable for all regression is the natural logarithm of sales price. For a complete representation of regressions, see Appendix 1. Model 1 uses all control variables except for the interaction term and has no fixed effects. Model 2 is equation (1) without the control variable, while model 3 is equation (1) with all fixed effects and control variables. The treatment group is the houses within a 250-meter radius from a renovated house, while the control group lies within a radius of 250-500 meters from a renovated house.

Looking closer at the control variables, they seem to differ in their significance on the price of apartments (see appendix 2). There are three attributes that are significant on the one percent level. These are the number of rooms, the year when the house was built, and whether the house is new construction. However, the apartment size is only significant on the ten percent level. At the same time, the location in terms of proximity to the water and amenities in terms of elevator does not seem to matter for the price much since these attributes are insignificant.Moreover, there does seem to be a clear positive time trend when looking at the price change per year. The price for each year (see appendix 2) confirms that every year after 2004 compared to 2002 have had an increase in price. This means that there indeed seems to have been a positive time trend for apartments on average in Helsinki between 2002 to 2020.

Given the results from the DID in Column 3 it is easy to assume that there indeed exists a positive spillover effect. The standard errors are relatively small compared to the estimate. If one were to take the estimate minus two standard errors, the estimate would remain positive. Meaning that the confidence interval is positive There seems to be a positive correlation between granted permits and the price of apartments, but there may still be some confounding factors that are not included in the regression.

The parallel trends assumption is not the only assumption that needs to hold in order to interpret the result as the actual effect. A myriad of time-varying attributes contribute to the value of an apartment, and it is hard to argue that all of these differences between control and treatment groups have been included. The element of confounding factors has been minimized thanks to DID method, where we are only comparing apartments within the same neighborhoods. However, there may still be time-varying differences between apartment buildings that affect the price of a house. In other words, the error term may be correlated to any of the independent variables leading to inconsistencies and biased results (Wooldridge, 2013). It is impossible to know the size and the direction of the inconsistency of the correlation, meaning that this issue cannot be ignored (Wooldridge, 2013). It is essential to test the robustness of the estimates to explore the effect further.

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6.2 Robustness analysis

To better understand the estimated spillover effect, I will present a result from a model that tries to capture how the effect changes with distance. The objective is to find how much the price has changed per ten meters away from the treated house within the 500-meter radius. The aim is to strengthen the results presented in the previous section. For this to be the case, the interaction term should be negative. Indicating that after the renovation, the price decreases for every ten meters when moving away from the renovated building. Furthermore, this means that the price is the highest closest to the treated house. Which indeed would give some validation to the positive spillover effect hypothesis. The results from equation (2) are presented in Table 6.

The distance is given for each 10-meter radius from the renovated house within the 500-meter neighborhood. This is because looking at the price change per meter when the price is logarithmic is not particularly informative due to the small values, which is why I have rounded the distance variable and looked at the changes per ten meters away from the renovated house. The distance has been rounded to the closest tenth meter. A larger distance span gives a better understanding of the price gradient, since most houses are meters or more apart.

In the analysis, two modifications of equation (2) have been used, which are represented in Table 6. Column (1) presents equation (2) without control variables. In contrast, column (2) is the complete equation (2) with all control variables. This modification is used to better understand the estimates robustness and the effect of an apartment's attributes on the spillover effect.

In Table 6 column (1) the interaction term indicates that the prices decrease by 0.0160 percent for each ten meters when moving away from the treated house after the a permit has been granted compared to before the treatment. This is in line with what we could expect if there is a positive spillover effect since it means that prices do decrease when moving away from the renovated house, which supports the hypothesis of a positive spillover effect. However, the estimate is not significant, and the R2 is small. The estimate changes when we apply the control variables in column (2). The interaction term takes a value of -0.000159 percent. This means that the price of an apartment decreases by 0.0159 percent for every ten meters when moving away from the treated house compared to before the treatment. This estimate is still in line with what can be expected for a positive spillover effect, even if the estimate is small. Furthermore, the estimate is significant at the five percent level giving further validation to the previous section's result.

The peculiar thing is that when applying the control variables, the decrease in prices after the renovation is smaller, even if the change is negligible. However, the estimate is more precipice meaning that more can be said about column (2) compared to column (1). This means that the result from column (2) is better at explaining the price variation than column (1).

Table 6: Distance analysis of permits granted between 2005 to 2017

VARIABLES	(1)	(2)
Distance (Meter)	0.000503***	0.000312***
	(0.000126)	(9.19e-05)
Distance*after_10	-0.000160	-0.000159**
	(0.000107)	(7.57e-05)
Constant	11.59***	5.996***
	(0.0989)	(0.897)
Control variables	No	Yes
Neighborhood fixed effect	Yes	Yes
Year fixed effects	Yes	Yes
Observations	32,023	31,155
R-squared	0.523	0.789

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered on neighborhood level. The dependent variable for all regression is the natural logarithm of price. For a complete representation of regressions, see Appendix 2. The treatment group is the houses within a 250-meter radius from a renovated house, while the control group lies within a radius of 500 meters from a renovated house.

The results from Table 6 support the findings in table 5 that there indeed seems to be a small albeit positive spillover effect. However, this analysis faces the same problems as the previous one. Even if the effect appears to be significant at the five percent level, it is hard to argue that this is the causal effect. And even if it would be causal, the effect is minimal and almost invisible. Some possible confounding time-varying factors may impact variables, e.g., renewal of green areas or if a rehab has moved into the area that may value disturbances for the residents.

Following the discussion on the time interval, it is important to understand how the estimate for equation (1) changes with time. This is of particular interest since there is no clear time frame of how long it takes to finalize these renovations. As already stated, three years has been predicted to be enough time to show the results however, to gain insights as to whether this is the case, I have studied the year intervals from one to five. The latest deadline for completing a permit is five years. Furthermore, after five years, other factors may likely have influenced the price rather than just a renovation. Previous studies also found the spillover effect to be time sensitive because the most considerable impact can be found directly after a renovation (see e.g. Rossi-Hansberg et.al. 2010; Ganduri & Maturana, 2021).

Looking at Table 5, it becomes evident that the estimate is not sensitive to the time interval. All five intervals have approximately the same value for the interaction term, around 2 percent. Moreover, all of these effects are significant on the one percent level. Within a one-year interval from the granted permit, the spillover effect is the largest, with a price increase of 3.66 percent for the treated houses compared to the control group. On the other hand, the time interval of five years has the most negligible effect, with a price increase of 2.4 percent. This means that the spillover effect seems to decrease with time. Given that most of the renovations are completed within one year of the permit being granted, this would be intuitive, and the effect is the most prominent closest to the renovation. The result from Table 5 indicates that the spillover effect does not seem to be time sensitive.

This result contradicts what has been discussed in previous studies. Previous studies had examined that the spillover effect is both local and time-sensitive in the sense that the most noticeable impact is found close to when the renovation took place (Rossi-Hansberg et al. 2010; Ganduri & Maturana, 2021). However, this can also be the result of the completion of the renovation being completed at different times. It may be the case that the completion of the renovations that have been granted a permit at year zero has been evenly distributed within a 5-year time interval. In that case, the three-year time interval used in the benchmark regression may only capture a part of the permits that were granted at year zero. The underlying assumption is that the renovations have commenced and been completed within three years after the permit has been granted.

To further argue for a smaller time interval, the larger interval introduced more observations, making the estimate more precise (Wooldridge, 2013). The larger the number of observations, the more extensive the variation in the independent variables, which leads to a smaller variance (Wooldridge, 2013). In other words, as the sample size grows, the estimates increase precision. Hence, there might be a chance that the results from the five-year interval are more significant simply because of a large number of observations. This is also why the three-year time interval is argued to be the most optimal.

In Table 5, the R2 remains at approximately 60 percent for all columns. The most precise estimate appears within the first year of the renovation. The renovations that have had time to be executed within a year are most likely the easiest and small renovations. However, the effect remains approximately the same for all intervals between one to five years. This is interesting since this result would indicate that the estimate is not time sensitive. However, there are also other possible explanations for this. Since there is no way of knowing when precisely the renovation has been executed, it may be the case they have been evenly spread out in the five years after the permit has been granted. Meaning that the estimate is picking up only part of the renovations.

Given this discussion, it is hard to say what factor may be driving the positive spillover effect. Nonetheless, the estimations for all observations are positive and significant on the one percent level, meaning that there is still proof of a positive impact no matter how large or small this effect might be is hard to conclude. The three-year time interval can be argued to be the best

Table 5: Price analysis for different time intervals for permits granted between 2002 to 2020

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Interval 5 y	Interval 4 y	Interval 3 y	Interval 2 y	Interval 1 y
Treatment (dummy)	-0.0596***	-0.0659***	-0.0791***	-0.0869***	-0.0656***
	(0.0197)	(0.0223)	(0.0213)	(0.0240)	(0.0251)
Treatment*after	0.0240***	0.0257***	0.0267***	0.0286***	0.0366***
	(0.00903)	(0.00930)	(0.00770)	(0.00972)	(0.0102)
Constant	6.521***	6.111***	6.111***	6.274***	7.926***
	(0.819)	(0.828)	(0.897)	(1.003)	(0.995)
Neighborhood fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes
Observations	48,980	40,369	31,155	21,375	11,169
R-squared	0.781	0.786	0.789	0.780	0.820

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The dependent variable for all regression is the natural logarithm of price. For a complete representation of regressions, see Appendix 1. Model 1 uses all control variables except for the interaction term and has no fixed effects. Model 2 is equation (1) without the control variable, while model 3 is equation (1) with all fixed effects and control variables. The treatment group is the houses within a 250-meter radius from a renovated house, while the control group lies within a radius of 250-500 meters from a renovated house

The distance and the time robustness analyses support the findings in the previous section that there seems to be a small but positive spillover effect following the renovation. These robustness analyses have tried to assess some assumptions regarding the optimal time frame and distance division into treatment and control groups. Even if there may be some confounding factors that affect the result in general, the time and distance tables support a positive spillover effect.

6.3 Major districts

Another problem that the analysis faces is that the metropolitan area of Helsinki is quite large and heterogeneous in many aspects, e.g., the price of apartments and the demographic of residents. This means that there is a possibility that the effect is different depending on the area of Helsinki. It may be hard to generalize the spillover effect for all areas of Helsinki. To assess the issue, equation (1) has been implemented in different areas to see how the spillover effect differs between Helsinki's seven major districts.

Previous studies also indicate that there seems to be some difference in the spillover effect depending on the area's demographics which also could be the case in Helsinki (Ganduri & Maturana, 2021; Schwartz et al. 2006). Depending on the Area in Helsinki, neighborhoods differ. In the South of Helsinki, there are more affluent areas with some of the highest per square meter prices in the country, while the East of Helsinki has a more disadvantaged neighborhood with cheaper apartments. To better understand the effect, it would make sense to study these areas separately to see how the effect changes.

To divide Helsinki into smaller areas, I have used subdivisions of the metropolitan area of Helsinki. Helsinki officially has eight major districts, but since none of the treated houses were in the Östersundom district, it has been excluded. Most of the major districts are named after points on the compass in Finnish; these have been directly translated to English from Service Map (n.d). In this analysis, houses have been assigned to areas based on their postal code. Figure 3 presents these eight different areas East, North, Central, South, Northeast, East, and Southeast.

Figure 3: Eight major districts of Helsinki

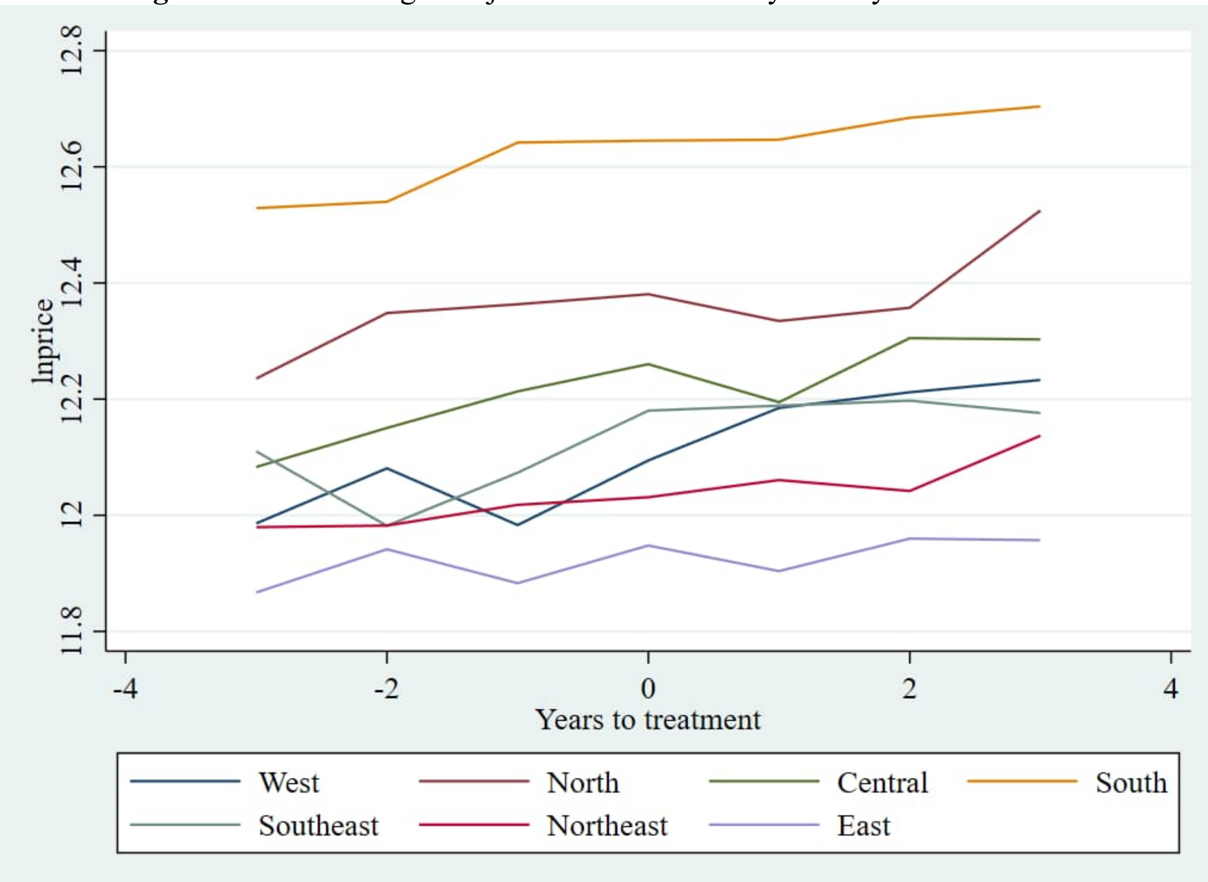
Source: Service Map (n.d). The names have been translated directly from Finish to English

The average house price differs depending on the Helsinki district. This becomes evident when looking at Figure 4. In Figure 4, treatment neighborhoods have been plotted three years before and three years after the permit has been accepted at year zero. The South of Helsinki has a remarkably higher price level for houses compared to the other areas. In contrast, the East and the Northeast of Helsinki have the lowest price level for houses. Based on the prices of houses, one can conclude that people with lower income generally live in East and Northeast Helsinki.

It has been noted that the Eastern and Northern part of Helsinki has suffered from terrible segregation. In 2015, Johannes Kaananen raised concerns about the large polarization between different parts of Helsinki (as cited in Wall, 2015). The Eastern and the Northern areas have a tremendously lower socioeconomic status compared to those living in the South of Helsinki. Consequently, it is only the high-income households that can afford to live in the South district. In comparison, low-income households reside in more affordable neighborhoods e.g., East and the Northeastern areas. Consequently, the South would have more access to funds compared to the East and Southeast, which will impact the neighborhoods' state.

The state of the neighborhood is critical as previous studies have found that the spillover effect may differ depending on the neighborhood's state. It could be argued that renovating one house in an already neglected neighborhood may not lead to any real increase in price since the neighborhood is in a badly depleted state (Ganduri & Maturana, 2021). On the other hand, in the most affluent areas, the areas may already be in their best possible condition. And these affluent neighborhoods usually have high demand, even if one house has some minor cracks and old paint. The state of the exterior will not affect the prices since the overall demand is high. The renovation may not even be noticed. Based on the average prices of houses in Figure 4, the most significant effect can, therefore, most likely be detected in the West, Southeast, or Central areas. Since here, the demand will very well depend on the slightest inconvenience.

Figure 4: Price for eight major districts Price analysis for years 2002-2020



Source: : Kiinteistönvälitysalan Keskusliitto ry, KVKL Hintaseurantapalvelu, Year zero is the date when the permit has been accepted. The figure plots the mean price for a house sold in relation to when a permit has been granted. The year with negative values are the prices before

There indeed seems to be different spillover effects depending on the district. Looking at Table 7, there are significant differences in the spillover effect between districts. There is even a district that has negative spillover effects e.g. North, South, and East. On the contrary, West, Southeast, Northeast, and Central have positive effects. The only areas that have significant interaction terms are the West and Southeast. Southeast has a significant spillover effect on the ten percent level while West is significant on the one percent level.

Both West and Southeast have the most considerable positive spillover effect, which is expected since these areas are in the middle in terms of apartment prices. On the other hand, the most disadvantaged neighborhoods are likely to have a quite small spillover effect. These are the neighborhoods with the lowest-priced apartments. The areas in question are East and Northeast. If the overall state of the neighborhood is depleted, one renovation is not likely to have a significant effect since most houses are still in a terrible state. At the same time, in the high-price neighborhoods, the demand is high regardless of the state of the building, meaning that one renovation will not have a huge effect on the price since the demand will not change.

Therefore, South and North naturally have the most negligible spillover effect. However, the precision of the estimates from these neighborhoods is quite small. The insignificance makes it hard to make any conclusions about these neighborhoods. What is also notable is that East seems to have had a negative time trend, see appendix 4, where prices, in general, have decreased following the treatment, which may be further proof that these neighborhoods are disadvantaged and have been polarized.

The West district is of specific interest since the effect is positive, large, and significant. The spillover effect indicates that the prices of treated houses increased by 3.94 percent compared to the control group. This is not the most considerable spillover effect but the most significant. The R2 is 84.3 percent which is more extensive compared to Table 5 Model 2. The confidence interval for the estimate is positive, indicating that there indeed seems to be a positive spillover effect for West. Looking at the Southeast, here, the spillover effect is the highest. However, the significance is lower compared to the West. The estimate is only significant at the five percent level, but the spillover effect is 13.4 percent which is relatively high. The conclusion that can be drawn from this table is that there indeed seems to be differences In the spillover effect depending on where the apartment is in Helsinki.

Table 7: Price analysis for eight major districts of permits granted between 2005 to 2017

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	West	North	Central	South	Southeast	Northeast	East
Treatment	-0.146**	-0.0356	0.0240	-0.0627	-0.152**	-0.0347*	-0.0520**
	(0.0694)	(0.0257)	(0.0903)	(0.0657)	(0.0626)	(0.0205)	(0.0245)
Treatment*after	0.0394**	-0.00671	0.00844	-0.00732	0.134**	0.0122	-0.0139
	(0.0196)	(0.0215)	(0.0113)	(0.0137)	(0.0561)	(0.0148)	(0.0183)
Constant	7.603**	4.447**	7.837***	11.38***	2.602	0.585	-8.092***
	(3.686)	(2.116)	(1.099)	(1.241)	(3.591)	(2.094)	(2.382)
Neighborhood fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,489	1,730	5,678	6,815	2,301	3,671	5,444
R-squared	0.843	0.782	0.779	0.801	0.787	0.789	0.745

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The dependent variable for all regression is the natural logarithm of price. For a complete representation of regressions, see Appendix 1. Model 1 uses all control variables except for the interaction term and has no fixed effects. Model 2 is equation (1) without the control variable, while model 3 is equation (1) with all fixed effects and control variables. The treatment group is the houses within a 250-meter radius from a renovated house, while the control group lies within a radius of 250-500 meters from a renovated house

One of the most critical results from Table 7 is that Helsinki's most neglected and affluent areas seem to be the least affected by the renovations. The East, South, and Northeast. This means that minor neighborhood improvements will not give any value to the neighborhoods. Instead the effect is the most prominent in the most middle-priced neighborhoods. Therefore, large neighborhood improvement programs should target the most middle-grounded neighborhoods in order for the improvements to have any economic effect. These funds should be targeted to the West and Southeast to get the most rerun on the investments. This result only considers the monetary returns, and this is not to say that neighborhood improvement programs do not have any value to the neglected neighborhood in terms of the well-being of residents in these areas.

6.4 Discussion

There have been many different empirical models presented in this chapter, hence it is essential to tie these results together with the result from the literature. The consensus from all models is that there appears to be a positive spillover effect following a façade renovation on average.

The main results did yield a positive spillover and significant spillover effect. On average, the neighborhood close to the renovated house had a three percent higher price increase compared to the neighborhood further from the renovated house. This result was obtained by comparing the price three years before and three years after the permit for a renovation has been granted. This estimate seems to align with the effect that has been captured in the literature for neighborhood improvement programs (e.g. Ganduri & Maturana, 2021; Rossi-Hansberg et al. 2010). This estimate can be trusted given that the parallel trends assumption is fulfilled, and the renovation was executed within three years after the permit was granted. This result is similar to Ahlfeldt et al. (2016) study, who find a positive spillover effect but have a hard time arguing that the result is causal. There are indications of a positive spillover effect, That can be trusted only if the two assumptions are fulfilled.

Since several assumptions need to be fulfilled in order to trust the estimates, two robustness analyses have been applied. The distance model does support a positive spillover effect even if the effect is relatively small. The most important thing is that it is significant. As extensively discussed, the second robustness analysis addresses one of the largest sources of bias: the time interval. The most prominent effect appears within one year of the permit being granted. However, all five intervals have approximately the same spillover effect ranging from 2.40 to 3.66 percent. All five spillover effects are significant on the one percent level. This is quite worrying since many previous studies have discussed that the spillover effect tends to be time-sensitive (e.g. Rossi-Hansberg et.al. 2010; Ganduri & Maturana, 2021). There is a risk that many renovations have taken place after three years, meaning that the main results cannot be trusted. If this is the case, then the main results do not capture the effect of the renovation but rather, the increase in price may be due to other factors. On the other hand, the estimate does decrease with time which is expected if the estimate captures the spillover effect.

The argument for choosing the three-year time interval is that since the condition for the granted permit is that the renovations need to start within three years from the granted permit (City of Helsinki, 2019B) most will keep to this time frame and complete the renovation within this time interval. Since the process of getting a permit granted is extensive, the assumption is that the renovations will take place as soon as possible after the renovation has been granted. Or at least before the three-year deadline to start the renovation.

The last analysis divides Helsinki, into eight different districts, due to the heterogeneity of areas in Helsinki in terms of socio-economic status and prices. This analysis did yield significant and interesting results. In accordance with previous studies, the intermediate neighborhoods in terms of prices yielded the most important results. These districts are West and Southeast. This type of analysis was assessed in Schwartz et al. (2006) and Ganduri and Maturanas (2021) paper that found evidence that suggested that low-income neighborhoods would have the smallest spillover effect. Unlike Ganduri and Maturana (2021), the areas that are put under the most strain from the environment, South, Southeast, and East, which are the closest to the coast, do not seem to have any more significant effects compared to areas that are not on the cost. Moreover, the result that it is the moderately priced neighborhoods that have the most significant spillover effect is supported by the findings in Schwartz et al. (2006) and Ganduri and Maturanas (2021) papers

Due to the limitations of this study, it is hard to give any advice to policymakers. If the assumptions are met, the neighborhood improvement programs should be targeted to the West and Southeast of Helsinki. Given that the aim is to get the highest monetary return from the investments. These areas will most likely be affected if neglected, especially with the future's looming threat of extreme weather. Since there seems to be a positive spillover effect, neighborhood improvement programs can have a real purpose. Primarily, since some of the literature focused on foreclosures found evidence that neglecting houses decreases their values due to visual blight (see e.g. Campbell et al. 2011 & Harding, 2009). Therefore, I argue that façade renovations should be subsidized to maintain the housing stock's value. Not only because of the risk of visual blight but also because there indeed seems to be monetary return for the investments primarily in the West and Southeast of Helsinki, given that the two assumptions hold.

Since I cannot derive when exactly a renovation has been completed, it is not feasible to state which of the underlying mechanisms are driving this positive spillover effect. It is likely a combination of all three; salience, amenity and disaemity effect. To be able to derive which is the underlying fact, more detailed data on renovations are needed. Exactly when the spillover effect is the most prominent is a condition for deriving the underlying mechanism.

7. Conclusion

This paper has analyzed the spillover effect following façade renovations in Helsinki. There has been a deep analysis of the previous literature on neighborhood improvement programs as well as foreclosures. The analysis for the spillover effect in Helsinki has used two main data sets: Kiinteistönvälitysalan Keskusliitto ry, KVKL Hintaseurantapalvelu and the City of Helsinki. The main analysis is based on the DID method, where price trends after a renovation have been compared between the treated and control area.

Following the discussion of the results, there indeed seems to be a positive spillover effect from renovation, around three percent. Several robustness analyses also support this. There are several problems with the model itself. Even if the descriptive statistics suggest that the parallel assumption is fulfilled, it is hard to argue that the price change arises from the renovation itself. There may be other time-varying factors that affect the prices. Moreover, since the renovations are usually implemented in packages, it is hard to pinpoint precisely what has affected the price increase. The assumption that the renovations were completed within a three-year interval after the permit was granted needs to be fulfilled.

Given that these assumptions are fulfilled, there indeed seems to be a positive spillover effect that is the most prominent in the West and southeast of Helsinki. Thereby it appears that neighborhood improvement programs should, on average, yield a positive spillover effect and should be used to ensure that the quality of housing stock remains at a sufficient level.

References

Ahlfeldt, G. M., Maennig, W., & Richter, F. J. (2016). Urban renewal after the Berlin Wall: a place-based policy evaluation. *Journal of Economic Geography, 17*(1), 129-156.

Anenberg, E, & Kung E. (2014). Estimates of the size and source of price declines due to nearby foreclosures, *American Economic Review 104,* 2527–51.

Angrist, J & Pischke, J-S. (2015) Mastering 'Metrics The Path from Cause to Effect. *Princeton University Press*

Bratu, C. (2021). The effects of increasing housing supply through market-rate construction. *URBARIA Summaries Series.*

Campbell, John Y., Stefano Giglio & Parag Pathak. (2011). Forced sales and house prices. *American Economic Review* 101, 2108–31.

City of Helsinki. (06.12.2019A). Approved permit. *Helsinki.* Retrieved 24.04.2022 from: https://www.hel.fi/helsinki/en/housing/construction/info-builders/permit/granted/

City of Helsinki. (06.12.2019B). Applying for a permit. *Helsinki.* Retrieved 25.04.2022 from: https://www.hel.fi/helsinki/en/housing/construction/info-builders/permit/

City of Helsinki. (n.d). Suburban regeneration. *Helsinki.* Retrieved 06.07.2022 from: https://www.uuttahelsinkia.fi/en/sustainable-urban-development/suburban-regeneration/suburb-programme

Service Map.(n.d). Service Map; Major district. Retrieved 24.04.2022 from: https://palvelukartta.hel.fi/en/area?p=1&t=1

Finlex. 1599/2009. *Asunto-osakeyhtiölaki.* https://www.finlex.fi/fi/laki/ajantasa/2009/20091599?search%5Btype%5D=pika&search%5Bpika%5D=asunto-osakeyhti%C3%B6

Ganduri, R., & Maturana, G. (2021). Do Property Rehabs Affect Neighboring Property Prices?. *Available at SSRN*.

Harding, J. P., Rosenblatt, E., & Yao, V. W. (2009). The contagion effect of foreclosed properties. *Journal of Urban Economics, 66*(3), 164-178.

Helander, A. & Ruotsalainen, P.(2017). Lähiöprojektin toimintaraportti 2017. Kaupunkiympäristön esitteitä 2017:1. *City of Helsinki.* Retreived 04.10.2021 from: https://www.hel.fi/static/liitteet/lahioprojekti/Tekstit/Lahioprojektintoimintaraportti2017.pdf

Hudson, S.(13.07.2015). Helsinki's changing streetscape: Progress or a one way street to Boringville?. *Yle.* Retrieved 19.07.2022 from: https://yle.fi/news/3-8152377

Ilveskoski, O. (2014). Kerrostalon peruskorjauksen hankesuunnitelma. *Hämeen ammattikorkeakoulu ja kirjoittajat*

Kaasila, M. & Vuori, P. (2020). Helsingin ja Helsingin seudun väestöennuste 2019–2060 - Ennuste alueittain 2019–2035. *City of Helsinki*. retrieved 04.10.2021 from: https://www.hel.fi/hel2/tietokeskus/julkaisut/pdf/20_11_04_Tilastoja_11_Vuori_Kaasila.pdf

Kauppalehti (13.08.2021). Oma asunto voikin olla ongelma talouskasvulle. *Kauppalehti.* retrieved 04.10.2021 from: https://www-kauppalehti-fi.libproxy.aalto.fi/uutiset/oma-asunto-voikin-olla-ongelma-talouskasvulle/282b3748-d3a2-419d-95ec-8971b6d8d4d9

Laatikainen, T. (2021, September 15). Jopa kaksi kolmannesta Suomen asuinkerrostaloista uhattuna – Ilmastonmuutos runtelee julkisivut, vanhaa rakennuskantaa pitää purkaa. *Kauppalehti*. Retrieved 15.09.2021 from: https://www-kauppalehti-fi.libproxy.aalto.fi/uutiset/jopa-kaksi-kolmannesta-suomen-asuinkerrostaloista-uhattuna-ilmastonmuutos-runtelee-julkisivut-vanhaa-rakennuskantaa-pitaa-purkaa/7718c348-9506-4c8c-a99c-34b5d74c6ba4

Norontaus, K. 5.10.2014. Siedettävä julkisivuremontti syntyy yhteistyöllä. T*urun Sanomat.* Retrieved 10.04.2022 from: https://www.ts.fi/koti/1279275494

Nieminen, S. (13.08.2021). Asuntomarkkinoilla ei sittenkään ylikuumenemista – Hintojen kehitys suhteessa tuloihin vielä maltillista. *Kauppalehti.* Retrieved 04.10.2021 from: https://www-kauppalehti-fi.libproxy.aalto.fi/uutiset/asuntomarkkinoilla-ei-sittenkaan-ylikuumenemista-hintojen-kehitys-suhteessa-tuloihin-viela-maltillista/b1e4af6c-3fbb-402b-a439-83b8903de447

Orava, J., & Turunen, O. (2020). Osta, vuokraa, vaurastu. Alma Talent

PWC. (2019). Emerging Trends in Real Estate®: Europe 2020. Retrieved 159.2021 from: https://www.pwc.com/gx/en/asset-management/real-estate-insights/assets/pwc-emerging-trends-real-estate-europe-2020.pdf

Rossi-Hansberg, E., Sarte, P. D., & Owens III, R. (2010). Housing externalities. *Journal of political Economy,* 118(3), 485-535.

Service Map. (n.d). Major district. Retrieved 23.04.2022 from: https://palvelukartta.hel.fi/en/area?p=1&t=1

Schwartz, A.E., Gould Ellen, I., Voicu, I., Schill, M.H. (2006). The External Effects of Place-Based Subsidized Housing. *Regional Science and Urban Economics 36: 679-707*

Sipilä, M. (19.06.2019). I bostadsbolagets styrelse. *Kiinteistöliitto uusimaa.* Retrieved 28.04.2022 from: https://www.ukl.fi/i-bostadsbolagets-styrelse/?u_source=ukl#187847f9

Suomi.fi. (20.05.2021). Construction and renovation. *Suomi.fi.* Retrieved 24.04.2022 from:

https://www.suomi.fi/citizen/housing-and-construction/construction-and-properties/guide/construction-and-waste-management/construction-and-renovation

Suomi.fi.(16.09.2021). Buying a home or property. *Suomi.fi.* Retrieved 24.04.2022 from: https://www.suomi.fi/citizen/housing-and-construction/purchasing-a-home/guide/renting-and-selling-a-home/buying-a-house-or-a-flat

Talofakta.fi.(2019). *JULKISIVUREMONTIN KESTO.* Retrieved 02.05.2022 from : https://talofakta.fi/taloyhtion-remontit/julkisivuremontti/julkisivuremontin-kesto/

TM Rakennusmaailma.(2021). Julkisivuremontin kallis hintalappu voidaan välttää. *TM Rakennusmaailma.* Retrieved 04.10.2021from: https://rakennusmaailma.fi/julkisivuremontin-kallis-hintalappu-voidaan-valttaa/

Wall, E .(2016). *Helsinki 2050 - diverse and tolerant or isolated and segregated?*. Yle. Retrieved 01.04.2022 from: https://yle.fi/news/3-8935308

Wooldridge, J. M. (2006). Introductory econometrics: A modern approach (fifth edition). *Mason, OH: Thomson South-Western.*

Appendices

Appendix 1

A. **Table 5:** Price Analysis of permits granted between 2005 to 2017

This appendix contains the complete result from the main analysis with all the attributes and the year fixed effects, respectively. Column 1 is the naïve equation (1) without any fixed effects or control variables. Column 2 has equation (1) with fixed effects but without control variables. Lastly Column 3 contains equation (1) with both fixed effects and control variables. The Robust standard errors are in parentheses represented by: *** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1)	(2)	(3)
Treatment (dummy)	0.128***	-0.105***	-0.0791***
	(0.0419)	(0.0307)	(0.0213)
Treatment*after		0.0246**	0.0267***
		(0.0118)	(0.00770)
Square meter	0.00385*		0.00263*
	(0.00223)		(0.00150)
Nr. Of rooms	0.146***		0.191***
	(0.0537)		(0.0392)
New construction (dummy)	-0.436***		-0.403***
	(0.0639)		(0.0533)
Year built			0.00269***
			(0.000457)
Coast			-0.449
			(0.602)
Elevator			-0.0161
			(0.0126)
Yearsale = 2003		-0.0388	-0.111
		(0.172)	(0.127)
Yearsale = 2004		0.0411	-0.0682
		(0.107)	(0.0756)
Yearsale = 2005		0.0908	0.0166
		(0.0906)	(0.0820)
Yearsale = 2006		0.148	0.0473
		(0.104)	(0.0894)
Yearsale = 2007		0.250**	0.143
		(0.106)	(0.0943)
Yearsale = 2008		0.255**	0.137
		(0.102)	(0.0906)
Yearsale = 2009		0.264**	0.129
		(0.103)	(0.0915)
Yearsale = 2010		0.366***	0.231**
		(0.104)	(0.0916)
Yearsale = 2011		0.393***	0.276***
		(0.104)	(0.0919)
Yearsale = 2012		0.441***	0.297***
		(0.104)	(0.0918)
Yearsale = 2013		0.439***	0.308***
		(0.105)	(0.0924)
Yearsale = 2014		0.436***	0.298***
		(0.106)	(0.0927)
Yearsale = 2015		0.451***	0.300***
		(0.107)	(0.0931)
Yearsale = 2016		0.468***	0.315***
		(0.107)	(0.0936)
Yearsale = 2017		0.519***	0.354***
		(0.107)	(0.0937)

Yearsale = 2018		0.512***	0.373***
		(0.109)	(0.0958)
Yearsale = 2019		0.577***	0.415***
		(0.111)	(0.0952)
Yearsale = 2020		0.645***	0.480***
		(0.114)	(0.0959)
Constant	11.57***	11.87***	6.111***
	(0.0514)	(0.109)	(0.897)
Observations	31,751	32,023	31,155
R-squared	0.370	0.522	0.789

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 2

B.Table 6: Distance analysis of permits granted between 2005 to 2017

This appendix contains the complete result from the distance analysis with all the attributes and the year fixed effects, respectively. Column 1 is the equation (2) without any control variables. Column 2 has equation (2) with fixed effects and with control variables. The Robust standard errors are in parentheses represented by: *** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1)	(2)
Distance_10	0.000503***	0.000312***
	(0.000126)	(9.19e-05)
Distance_after_10	-0.000160	-0.000159**
	(0.000107)	(7.57e-05)
Square meter		0.00263*
		(0.00150)
Nr. Of rooms		0.191***
		(0.0391)
New construction (dummy)		-0.402***
		(0.0543)
Year built		0.00264***
		(0.000455)
Coast		-0.461
		(0.597)
Elevator		-0.0161
		(0.0121)
Yearsale = 2003	-0.0139	-0.0909
	(0.159)	(0.120)
Yearsale = 2004	0.0684	-0.0468
	(0.0970)	(0.0704)
Yearsale = 2005	0.131	0.0518
	(0.0818)	(0.0770)
Yearsale = 2006	0.197**	0.0920
	(0.0964)	(0.0853)
Yearsale = 2007	0.310***	0.198**
	(0.0969)	(0.0893)
Yearsale = 2008	0.320***	0.198**
	(0.0928)	(0.0858)
Yearsale = 2009	0.343***	0.205**
	(0.0953)	(0.0876)
Yearsale = 2010	0.460***	0.322***

	(0.0975)	(0.0886)
Yearsale = 2011	0.495***	0.376***
	(0.0984)	(0.0897)
Yearsale = 2012	0.552***	0.406***
	(0.1000)	(0.0901)
Yearsale = 2013	0.561***	0.429***
	(0.102)	(0.0910)
Yearsale = 2014	0.570***	0.431***
	(0.104)	(0.0918)
Yearsale = 2015	0.595***	0.443***
	(0.105)	(0.0927)
Yearsale = 2016	0.623***	0.468***
	(0.107)	(0.0933)
Yearsale = 2017	0.683***	0.518***
	(0.109)	(0.0953)
Yearsale = 2018	0.687***	0.548***
	(0.110)	(0.0943)
Yearsale = 2019	0.762***	0.600***
	(0.111)	(0.0964)
Yearsale = 2020	0.843***	0.679***
	(0.117)	(0.100)
Constant	11.59***	5.996***
	(0.0989)	(0.897)
Observations	32,023	31,155
R-squared	0.523	0.789

Appendix 3

C. Figure 4: Price for eight major districts Price analysis for years 2002-2020

This appendix contains the complete result from the time analysis with all the attributes and the year fixed effects, respectively. Each column represents equation (1) with different time intervals between one to five years before and after a granted permit. The Robust standard errors are in parentheses represented by: *** p<0.01, ** p<0.05, * p<0.1

VARIABLES	Interval 5 y	Interval 4 y	Interval 3 y	Interval 2 y	Interval 1 y
Treatment (dummy)	-0.0596***	-0.0659***	-0.0791***	-0.0869***	-0.0656***
	(0.0197)	(0.0223)	(0.0213)	(0.0240)	(0.0251)
Treatment*after	0.0240***	0.0257***	0.0267***	0.0286***	0.0366***
	(0.00903)	(0.00930)	(0.00770)	(0.00972)	(0.0102)
Square meter	0.00319**	0.00307**	0.00263*	0.00220*	0.00688***
	(0.00144)	(0.00155)	(0.00150)	(0.00132)	(0.000733)
Nr. Of rooms	0.177***	0.179***	0.191***	0.192***	0.109***
	(0.0343)	(0.0374)	(0.0392)	(0.0402)	(0.0171)
New construction (dummy)	-0.396***	-0.403***	-0.403***	-0.386***	-0.340***
	(0.0404)	(0.0455)	(0.0533)	(0.0582)	(0.0759)
Year built	0.00244***	0.00268***	0.00269***	0.00268***	0.00229***
	(0.000415)	(0.000422)	(0.000457)	(0.000509)	(0.000495)
Coast	0.0768	-0.0327	-0.449	-0.430	-0.223
	(0.172)	(0.308)	(0.602)	(0.640)	(0.623)

Elevator	-0.0150	-0.0199	-0.0161	-0.0173	-0.0257
	(0.0111)	(0.0123)	(0.0126)	(0.0165)	(0.0241)
renoid = o,	-	-	-	-	-
Yearsale = 2003	-0.0619	-0.0785	-0.111	-0.207	-0.575***
	(0.109)	(0.108)	(0.127)	(0.193)	(0.0637)
Yearsale = 2004	-0.0290	-0.0596	-0.0682	-0.148	-0.644***
	(0.0906)	(0.0667)	(0.0756)	(0.120)	(0.0639)
Yearsale = 2005	0.0440	0.0120	0.0166	0.0287	-0.527***
	(0.0911)	(0.0675)	(0.0820)	(0.158)	(0.0798)
Yearsale = 2006	0.0961	0.0566	0.0473	0.0247	-0.885***
	(0.0905)	(0.0663)	(0.0894)	(0.151)	(0.160)
Yearsale = 2007	0.181*	0.148**	0.143	0.0643	-0.816***
	(0.0960)	(0.0688)	(0.0943)	(0.162)	(0.183)
Yearsale = 2008	0.176*	0.142**	0.137	0.0438	-0.875***
	(0.0918)	(0.0671)	(0.0906)	(0.158)	(0.187)
Yearsale = 2009	0.186**	0.142**	0.129	0.0401	-0.874***
	(0.0928)	(0.0679)	(0.0915)	(0.161)	(0.190)
Yearsale = 2010	0.292***	0.242***	0.231**	0.135	-0.806***
	(0.0930)	(0.0676)	(0.0916)	(0.161)	(0.191)
Yearsale = 2011	0.339***	0.289***	0.276***	0.173	-0.789***
	(0.0933)	(0.0681)	(0.0919)	(0.161)	(0.192)
Yearsale = 2012	0.364***	0.314***	0.297***	0.182	-0.784***
	(0.0930)	(0.0677)	(0.0918)	(0.162)	(0.194)
Yearsale = 2013	0.374***	0.323***	0.308***	0.186	-0.792***
	(0.0931)	(0.0678)	(0.0924)	(0.163)	(0.196)
Yearsale = 2014	0.372***	0.322***	0.298***	0.171	-0.823***
	(0.0931)	(0.0679)	(0.0927)	(0.164)	(0.198)
Yearsale = 2015	0.368***	0.322***	0.300***	0.185	-0.814***
	(0.0933)	(0.0685)	(0.0931)	(0.165)	(0.201)
Yearsale = 2016	0.404***	0.347***	0.315***	0.189	-0.824***
	(0.0934)	(0.0686)	(0.0936)	(0.166)	(0.203)
Yearsale = 2017	0.441***	0.383***	0.354***	0.222	-0.798***
	(0.0936)	(0.0689)	(0.0937)	(0.166)	(0.205)
Yearsale = 2018	0.468***	0.407***	0.373***	0.232	-0.829***
	(0.0952)	(0.0716)	(0.0958)	(0.169)	(0.214)
Yearsale = 2019	0.508***	0.447***	0.415***	0.262	-0.815***
	(0.0947)	(0.0705)	(0.0952)	(0.170)	(0.215)
Yearsale = 2020	0.572***	0.514***	0.480***	0.325*	-0.760***
	(0.0957)	(0.0718)	(0.0959)	(0.171)	(0.217)
Constant	6.521***	6.111***	6.111***	6.274***	7.926***
	(0.819)	(0.828)	(0.897)	(1.003)	(0.995)
Observations	48,980	40,369	31,155	21,375	11,169
R-squared	0.781	0.786	0.789	0.780	0.820

Appendix 4

D. Table 7: Price analysis for eight major districts of permits granted between 2005 to 2017

This appendix contains the complete result from the analysis of the eight different districts of Helsinki with all the attributes and the year fixed effects, respectively. Each column represents equation (1) for each of the seven districts. The Robust standard errors are in parentheses represented by: *** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) West	(2) North	(3) Central	(4) South	(5) South East	(6) North East	(7) East
treatment	-0.146**	-0.0356	0.0240	-0.0627	-0.152**	-0.0347*	-0.0520**
	(0.0694)	(0.0257)	(0.0903)	(0.0657)	(0.0626)	(0.0205)	(0.0245)
treat_after	0.0394**	-0.00671	0.00844	-0.00732	0.134**	0.0122	-0.0139
	(0.0196)	(0.0215)	(0.0113)	(0.0137)	(0.0561)	(0.0148)	(0.0183)
Asuinala	0.000786***	0.00614***	0.0117***	0.00645***	0.00574***	0.00566***	0.00449***
	(0.000249)	(0.000938)	(0.00116)	(0.00143)	(0.000635)	(0.000716)	(0.00102)
Huoneita	0.248***	0.0289	0.0592***	0.169***	0.134***	0.0838***	0.108***
	(0.00959)	(0.0223)	(0.0208)	(0.0403)	(0.0123)	(0.0152)	(0.0236)
Uudiskohde	-0.338***	-0.309*	-0.510***	-0.216***	-0.513***	-0.707***	-0.455***
	(0.0769)	(0.157)	(0.150)	(0.0582)	(0.148)	(0.0683)	(0.0899)
Rakennusvuosi	0.00184	0.00350***	0.00151**	-4.69e-05	0.00452**	0.00526***	0.00976***
	(0.00185)	(0.00107)	(0.000581)	(0.000631)	(0.00180)	(0.00104)	(0.00120)
Ranta = o,	-	-	-		-		-
Hissi	-0.00122	-0.114*	-0.0523	0.00898	-0.0293	-0.0382*	-0.00370
	(0.0197)	(0.0572)	(0.0387)	(0.0101)	(0.0368)	(0.0228)	(0.0203)
renoid = o,	-	-	-	-	-	-	-
yearsale = 2003	0.0275	0.0459		0.164***		0.189***	-0.250
	(0.0236)	(0.0428)		(0.0344)		(0.0228)	(0.192)
yearsale = 2004	0.0702**	0.121*		0.126**		-0.0227	-0.150*
	(0.0338)	(0.0654)		(0.0497)		(0.0752)	(0.0812)
yearsale = 2005	0.0865**	0.266***	0.215***	0.181**	-0.0268	0.279***	-0.00867
	(0.0375)	(0.0575)	(0.0157)	(0.0852)	(0.0625)	(0.0551)	(0.114)
yearsale = 2006	0.0778	0.191***	0.410***	0.261**	-0.0130	0.376***	0.0193
	(0.0612)	(0.0377)	(0.0366)	(0.112)	(0.0545)	(0.0446)	(0.114)
yearsale = 2007	0.269***	0.333***	0.464***	0.355***	-0.0312	0.435***	0.116
	(0.0516)	(0.0515)	(0.0204)	(0.118)	(0.0699)	(0.0459)	(0.137)
yearsale = 2008	0.257***	0.291***	0.419***	0.363***	0.0273	0.400***	0.134
	(0.0541)	(0.0735)	(0.0257)	(0.119)	(0.0409)	(0.0453)	(0.122)
yearsale = 2009	0.282***	0.294***	0.506***	0.339***	0.00133	0.365***	0.0917
	(0.0542)	(0.0660)	(0.0228)	(0.118)	(0.0716)	(0.0502)	(0.131)
yearsale = 2010	0.368***	0.424***	0.598***	0.446***	0.0381	0.481***	0.212*
	(0.0581)	(0.0732)	(0.0331)	(0.119)	(0.0824)	(0.0530)	(0.126)
yearsale = 2011	0.378***	0.447***	0.689***	0.520***	-0.0105	0.505***	0.263**
	(0.0600)	(0.0730)	(0.0245)	(0.119)	(0.0931)	(0.0550)	(0.128)
yearsale = 2012	0.415***	0.476***	0.715***	0.581***	-0.0174	0.514***	0.276**
	(0.0614)	(0.0731)	(0.0279)	(0.120)	(0.0973)	(0.0553)	(0.127)
yearsale = 2013	0.426***	0.455***	0.747***	0.617***	-0.0136	0.544***	0.308**

	(0.0667)	(0.0779)	(0.0337)	(0.121)	(0.105)	(0.0569)	(0.126)
yearsale = 2014	0.412***	0.482***	0.773***	0.594***	0.00602	0.525***	0.307**
	(0.0710)	(0.0763)	(0.0320)	(0.122)	(0.117)	(0.0585)	(0.127)
yearsale = 2015	0.400***	0.503***	0.787***	0.621***	0.00424	0.507***	0.297**
	(0.0748)	(0.0797)	(0.0341)	(0.123)	(0.129)	(0.0606)	(0.132)
yearsale = 2016	0.439***	0.494***	0.824***	0.646***	-0.0302	0.515***	0.275**
	(0.0726)	(0.0831)	(0.0397)	(0.124)	(0.131)	(0.0642)	(0.138)
yearsale = 2017	0.483***	0.527***	0.893***	0.715***	0.00896	0.519***	0.300**
	(0.0829)	(0.0843)	(0.0357)	(0.127)	(0.139)	(0.0682)	(0.136)
yearsale = 2018	0.504***	0.528***	0.880***	0.764***	0.0264	0.547***	0.291**
	(0.0942)	(0.0890)	(0.0588)	(0.131)	(0.147)	(0.0743)	(0.139)
yearsale = 2019	0.528***	0.505***	0.950***	0.813***	0.0911	0.527***	0.316**
	(0.0968)	(0.0971)	(0.0501)	(0.129)	(0.156)	(0.0753)	(0.139)
yearsale = 2020	0.603***	0.552***	1.049***	0.900***	0.139	0.550***	0.347**
	(0.102)	(0.0944)	(0.0411)	(0.131)	(0.176)	(0.0728)	(0.137)
Ranta				-1.060***		0.299***	
				(0.0674)		(0.0614)	
Constant	7.603**	4.447**	7.837***	11.38***	2.602	0.585	-8.092***
	(3.686)	(2.116)	(1.099)	(1.241)	(3.591)	(2.094)	(2.382)
Observations	5,489	1,730	5,678	6,815	2,301	3,671	5,444
R-squared	0.843	0.782	0.779	0.801	0.787	0.789	0.745