Aesthetic Value or Appreciation Potential: Measuring Spillover Effects of House Alterations on Neighbouring Properties in the UK

Yangfanqi Liu, Helen X.H. Bao*

Abstract

Spillover effects have long been a central issue in housing and urban studies, yet few studies have explored positive spillovers and their underlying mechanisms at the micro-neighbourhood level. This study examines the extent to which four types of physical alterations to a house (rear extension, dormer extension, front extension, and front renovation) influence the value of neighbouring properties in Cambridge, UK. Staggered difference-in-differences (DID) models are employed to estimate the temporal duration and spatial extent of these spillover effects. Different types of alterations are identified using local planning application data, and property transaction data from Rightmove between 2006 and 2024 are used to capture changes in property prices. The results show that rear extensions and dormer extensions significantly increase neighbouring property values by 4.39% and 4.64%, respectively, in the third year post-alteration, whereas front extensions and front renovations have no statistically significant impact. Positive effects are observed among immediate neighbours (4.18% and 3.45%) and second-tier neighbours (3.38% and 3.10%) following rear extensions and dormer extensions. These findings support the hypothesis that an approved extension to one house increases the likelihood that similar extensions to neighbouring properties will be approved by the local planning authority, thereby enhancing their appreciation potential and their property values. In contrast, renovations to a property's frontage, which improve the neighbourhood physical environment, have limited spillover effects.

Keywords: spillover effect; micro-neighbourhood; staggered DID

1. Introduction

Understanding the spillover effects within residential neighbourhoods has long been a central issue for policymakers, planners, developers, and local residents. For policymakers, changes to neighbourhood regulations often lead to widespread house alterations and demographic changes. Decisions regarding such regulations, such as permitted development rights[1], are not only technical but also political, especially in areas where housing affordability and social equity have become pressing concerns. For planners, understanding how specific changes ripple across surrounding properties in a neighbourhood is crucial for balancing individual property rights with broader community interests. For property developers, neighbourhood spillovers directly influence strategic decisions about investment and design. Existing studies (Seo, 2018, Seo and von Rabenau, 2011) have shown that overlooking certain negative spillovers from neighbours can lead to systematic

---

[1] In the UK, permitted development rights allow householders to improve or extend their homes without the need to apply for planning permission when such a requirement would be disproportionate to the impact of the proposed works.

overvaluation of property prices. For local residents, house alterations in a neighbourhood are experienced most immediately and tangibly. Any alterations that influece the visual coherence, aesthetic appeal, and perceived safety of the local environment, will shape people's everyday quality of life and attachment to place. Moreover, homeowners often view their property not only as a dwelling but also as their largest financial asset. If nearby house alterations have spillover effects, they will carry direct implications for other residents' family wealth. Taken together, these perspectives highlight the multifaceted significance of neighbourhood spillovers. Physical alterations to one property are not isolated events but can significantly influence nearby houses.

Among studies exploring such spatial spillover effects, most explored the influence of nearby external urban amenities and disamenities at the neighbourhood level. They capture average spillover effects for neighbourhoods as a whole, leaving interactions between individual properties at the micro-neighbourhood level underexplored. Even within the small set of studies focusing on individual properties, the emphasis has largely been on negative spillovers: abandoned, foreclosed, or deteriorated houses have been shown to depress nearby property values through mechanisms consistent with the broken windows theory (Wilson and Kelling, 2011, Johansen et al., 2015, Seo and von Rabenau, 2011, Gerardi et al., 2015). By contrast, far fewer studies have investigated positive spillovers arising from extensions, renovations, or other improvements.

This study therefore addresses a straightforward question: when one property goes through alteration, how does that affect neighbouring properties, and through which mechanisms do these effects occur? The study contributes to the literature in two ways. First, it shifts attention from negative to positive spillovers by examining if and how property-level alterations benefit neighbouring houses. Second, it explores not only the existence but also the mechanisms of these effects, with a particular focus on two channels: an *appreciation potential* channel related to the planning system, and an *aesthetic value* channel associated with visible improvements to the physical environment.

The study employs staggered difference-in-differences (DID) models to estimate spillover effects of different property alterations. Four types of alterations – rear extensions, dormer extensions, front extensions, and front renovations – are identified and analysed. Transaction data for properties around altered houses are used to measure price differences before and after alterations. The study examines not only the spatial reach of the spillover effects but also their temporal changes within a six-year period. Possible spillover mechanisms are also discussed based on the statistical findings.

The remainder of the paper is organised as follows. Section 2 reviews the relevant literature and lays out the general analytical framework as well as key hypotheses of this study. Section 3 describes the local context, data processing procedures, and descriptive statistics. Section 4 presents the results of parallel trends tests and staggered DID estimations. Section 5 reports robustness checks. Section 6 discusses potential spillover channels, broader implications, and limitations based on the estimation results. Section 7 concludes the paper.

2. Analytical Framework

This section first reviews the literature on spatial spillover effects, and then outlines two distinct mechanisms that are examined in this paper. The section concludes by presenting the empirical models and key hypotheses tested in the subsequent analysis.

2.1 Neighbourhood and Micro-neighbourhood spillover effects

Since the introduction of hedonic pricing models, spatial spillover effects have been widely explored. Green and blue spaces (Crompton and Nicholls, 2020, Chen and Li, 2017, Krusky et al., 2015, Yang et al., 2021, Holt and Borsuk, 2020), urban infrastructure projects (Hearne and Yerushalmi, 2025, Tang and Wong, 2020, Elmallah et al., 2023), and other amenities (Beracha and Hardin, 2021, Fleming et al., 2018) are among the most frequently examined sources of spillover effects. In recent years, facilitated by the rise of big data and AI tools, studies have increasingly adopted more granular and precise analyses, such as measuring the spillover effects of building styles (Lindenthal, 2020, Klika et al., 2025) or street trees. Although individual studies differ in the exact measurement of spillover effects, the evidence consistently shows that physical changes improving the environment or accessibility to amenities tend to generate a price premium for surrounding properties, whereas less favorable changes are associated with a discount.

One limitation of the existing literature is that most studies focus on factors external to the neighbourhood, such as a new subway line or park, while relatively few examine spillover effects at the micro-neighbourhood level. The term *micro-neighbourhood*, although used in several previous studies, is loosely defined in the literature and requires clarification. In some studies, a micro-neighbourhood is defined as a radius of a certain distance around a property[2]. This study adopts a similar approach but measures the area in terms of the number of houses. In the following analysis, a micro-neighbourhood refers to an area within a radius of ten houses around a property. Research at this micro-neighbourhood scale is limited and generally addresses only a narrow set of specific issues. The rest of this section first summarises these studies according to the issues they examine and then highlights the main gaps that motivate this study.

The most frequently investigated issue at the micro-neighbourhood level is the negative spillover effects of abandoned or foreclosed houses. Research in this area generally follows and supports the broken windows theory proposed by Kelling and Wilson (1982), which proposes that visible signs of minor disorder can increase fear and crime, thereby reducing nearby property values. For example, Johansen et al. (2015) used interviews with community members in Michigan to illustrate how physical disorder can lead to negative perceptions and lower life satisfaction. Seo and von Rabenau (2011) measured the adverse impact of physical disorder between neighbouring properties, while Seo (2018) found that neighbourhood disorder reduces property sales prices – an effect often overlooked by real estate agencies due to data limitations. Suzuki et al. (2022) reported a 3%

---

[2] The City Council of Santa Barbara uses a radius of 100-450 ft around a property to define a micro-neighbourhood; Seo and von Rabenau (2011) only includes properties sharing a common lot line with or facing a front side of a house into its micro-neighbourhood. Other studies have also included two closest neighbours or a certain radius.

negative spillover effect of vacant houses on properties within 50 metres in Tokyo. Overall, the literature consistently concludes that physical disorder in one property generates negative spillover effects on the values of neighbouring houses. Research focusing specifically on foreclosures reveals a similar pattern: Gerardi et al. (2015) showed that bank-owned foreclosed properties in poor condition reduce nearby transaction prices within 0.1 miles by an average of 2.6%, with comparable negative spillovers reported in related studies (Lin et al., 2009, Turnbull and van der Vlist, 2023).

Apart from the negative spillovers associated with abandoned or foreclosed properties, several studies have examined the positive spillovers of house improvements. Irwin (2019) found that a neighbouring renovation increases the likelihood of further renovations by at least 1.8%, potentially raising property values. Dubé et al. (2023) reported that, although local residents often perceive residential reconversions negatively, empirical evidence indicates a positive spillover of approximately 2.48%. Similarly, Ganduri and Maturana (2024) showed that house prices around rehabilitated properties increase by 2.3% following rehabilitation. Regarding demolitions and greening initiatives, Lin et al. (2009) found that greening vacant lots leads to an average 4% increase in the value of houses located within 1,000 feet. Heckert and Mennis (2012) analysed the economic benefits of greening urban vacant land in the US.

The existing literature demonstrates that spillover effects between neighbouring properties do exist. Improvements to a property generate positive spillovers for nearby houses, whereas neglect or physical disorder produces negative spillovers. This conclusion aligns with studies suggesting that more active investment by community members, which is regarded as a sign of commitment, increases neighbourhood property values (O'Brien and Montgomery, 2015).

Nevertheless, the topic can be further refined in two respects. First, positive spillovers remain considerably less explored than negative spillovers. The emphasis on abandoned or foreclosed properties is understandable, as such negative spillovers demand intervention, but research on positive spillovers is equally important. Second, the mechanisms of spillover effects remain underexplored. Most studies focus on the magnitude of impact, with few examining underlying channels. While physical deterioration is widely cited as the source of negative spillovers (Gerardi et al., 2015, Seo and von Rabenau, 2011), it may not be the only mechanism. Planning and zoning systems – largely overlooked in previous research – may also play a significant role. Just as rezoning a piece of land can affect surrounding property values, planning changes for one house may plausibly influence the potential values of nearby properties.

2.2 Two Spillover Channels: Appreciation Potential and Aesthetic Value

Building on the existing literature, the study proposes two channels through which house alterations may create a value premium for neighbouring houses.

The first channel, referred as the *appreciation potential* channel, relates to the British planning system. In the UK, house alterations involving structural or facade changes require planning permissions from the local authority, and approval for one property can serve as a precedent for neighbouring properties seeking similar alterations. This practice is common enough that real estate agencies often advise prospective buyers to check what changes neighbouring houses have undergone to assess the alternations they may get permitted. In other words, the *appreciation potential* channel describes a mechanism whereby alterations to one property increase the likelihood that neighbouring properties can obtain similar approvals. If such alterations add more space to the property, higher approval potential generates a value premium.

The second channel, the *aesthetic value* channel, focuses on improvements to the local physical environment. As the literature demonstrates, a better physical environment leads to higher property values. If alterations improve the neighbourhood's appearance, this may generate a value premium for neighbouring properties through multiple mechanisms. A pleasant environment is itself a source of premium, and may also signal neighbourhood quality, community spirit, and residents' investment in their surroundings.

To test whether either channel operates, alterations must first be identified and grouped. Logically, alterations adding floor area relate to the *appreciation potential* channel, while those changing the frontage relate to the *aesthetic value* channel. Planning application data provides a suitable basis for this classification, as the UK planning system covers all alterations involving additional space or significant frontage changes. This study focuses on four common alteration types: rear extension, dormer extension, front extension, and front renovation. Table 1 lists them alongside their links to the two proposed channels.

[Table 1]

2.3 Hypotheses and general models

To test the existence of *appreciation potential* and *aesthetic value* channels, this study focuses on two key hypotheses:

> **H1**: Physical alterations adding more floor area of a house generate price premium for nearby houses. (Appreciation potential channel)
> **H2**: Physical alterations improving frontage of a house generate price premium for nearby houses. (Aesthetic value channel)

If either of the two is true, the spillover effect should at least reach a certain distance for a certain period of time. The following of this section first reviews methods used in existing literature and then introduces two similar staggered DID models to check these hypotheses.

The existing literature has employed both qualitative and quantitative methods. Early studies relied on case studies and surveys to identify patterns and explore mechanisms, such as how residents perceive neighbourhood disorder (Johansen et al., 2015, Pendola and Gen, 2008). Later quantitative analyses normally build on the hedonic price model (Rosen, 1974) to link property attributes, surrounding amenities, and neighbourhood characteristics to house prices. Further methodological improvements include incorporating spatial dependence, addressing sample selection bias, employing difference-in-differences (DID) for causal inference, using repeat sales to mitigate unobserved heterogeneity, and leveraging novel datasets and machine learning techniques to enhance variable measurement (Chen and Li, 2017, Lindenthal, 2020, Hearne and Yerushalmi, 2025, Bottero et al., 2022, Yang et al., 2021, Holt and Borsuk, 2020, Dubé et al., 2023).

This study employs two similar time- and distance-staggered Difference-in-Differences (DID) models to estimate spillover effects both temporally and spatially. To account for temporal variation, a time-staggered DID model incorporating time dummies, denoted as $Period_t$, is used. The model is specified as follows:

$$\ln(price) = \sum_{t \neq -1} \beta_t (\text{Treat} \times \text{Period}_t) + \beta \text{Treat} + \alpha X + \gamma \text{Year} + \delta \text{Area} + \varepsilon \qquad (1)$$

where $\ln(price)$ is the natural logarithm of property sale prices; $Treat$ is a dummy variable indicating treatment and control groups (1 for treatment, 0 for control); $Period_t$ is a set of dummy variables identifying specific years before or after the treatment, and $Period_{-1}$ denotes the year immediately preceding the intervention; X represents control variables, including housing characteristics and nearby amenities; $Year$ denotes year fixed effects; $Area$ denotes neighbourhood fixed effects; ε is the error term; β_t denotes the parameters to be estimated for the DID interaction terms $Treat \times Period_t$; β captures the average price difference between treatment and control groups; α denotes the coefficients of the control variables X; γ and δ represent the effects of year and neighbourhood fixed effects, respectively. $Period_{-1}$ is used as the baseline for comparison with other DID terms.

To investigate the spatial reach of spillover effects, a similar distance-staggered DID model is employed to estimate the impact of physical changes to houses on neighbouring properties at varying distances:

$$\ln(price) = \sum_{k \neq 5} \beta'_k (\text{Post} \times \text{Distance}_k) + \beta' \text{Period} + \gamma' \text{Year} + \alpha' X + \delta' \text{Area} + \varepsilon' \qquad (2)$$

where most variables and coefficients retain the same interpretations as in Eq. (1), except for $Post$, $Distance_k$, and their corresponding coefficients β' and β'_k. $Post$ in Eq. (2) is a dummy variable indicating whether an observation falls in the pre- or post-intervention period (0 for pre-intervention, 1 for post-intervention). $Distance_k$ represents a set of dummy variables identifying the distance of each property from the nearest improvement, with $Distance_1$ denoting immediate neighbours and $Distance_5$ indicating properties located between five and ten houses away. The coefficient β' captures the average difference between the pre- and post-intervention periods, while β'_k measures the intervention's impact on properties within different distance groups. $Distance_5$, representing the properties located between five and ten houses away from improvements, serves as the reference category for the DID estimation[3].

---

[3] As is shown in the later section, the data indicates there is no spillover effect at this distance, therefore this threshold is chosen.

[Figure 1]

The key idea of the two DID models is to categorise data samples into before/after groups and treatment/control groups so as to quantify the influence of house alterations. Figure 1 shows a simplified case where one house has undergone alteration and several nearby houses are sold at different times. Each house transaction has a relative time compared to the time when the alteration happens, and every house has a specific distance from the altered house. For Eq. (1), the relative time difference can be used to define different time periods $Period_t$, and a distance threshold need to be implemented to separate the samples into treatment and control groups. For Eq. (2), distances can be classified into several different categories $Distance_k$, and the relative time differences should be converted into binary variable indicating before or after the alteration. Figure 1 only shows one alteration and its surrounding transactions. For each type of alteration, there are hundreds of altered houses and thousands of transactions surrounding them. With more samples, DID models can capture the influence of the specific type of alteration. If **H1** or **H2** is true, then at least some of the DID models for rear extension, dormer extension, and front extension should have significant β_t or β'_k.

3. Empirical Implementation

3.1 Study area

This study selects Cambridge, UK, as the study area. The ‘Cambridge’ in this study refers to the area within the administrative boundary of Cambridge City Council (Figure 2). This area covers 40.7 km^2 and had an estimated population of 145,000 in 2021. It comprises the historic city centre as well as surrounding residential neighbourhoods. As of 2023, the median house price in Cambridge was £492,750 – substantially higher than the UK average of £285,000, but slightly below the London median of £515,000. These figures indicate that Cambridge is a relatively expensive location within the UK. Figure 2 shows the distribution of transaction records within Cambridge between 2006 and 2024.

[Figure 2]

3.2 Preparing the data

3.2.1 Data sources

This study uses two datasets: a property sales dataset to track price changes and a planning application dataset to identify house alterations. Appendices A and B provide detailed variable lists, sample records, and data sources.

The property sales dataset comprises all properties listed in Cambridge on Rightmove between 2006 and 2024. It includes key housing characteristics and transaction prices from HM Land Registry[4], with the transaction price serving as the primary dependent variable and housing characteristics as control variables. Supplementary amenity and community variables are derived from the Ordnance Survey dataset[5] to account for additional determinants of house prices, and a neighbourhood variable, $Area$, is constructed from local community boundaries to capture location fixed effects. After cleaning to ensure accuracy and completeness, 12,812 transaction records remain in the dataset.

The planning application dataset identifies different types of house improvements. Under the *Town and Country Planning Act 1990*, alterations that increase floor area or modify a building's frontage require planning permission[6], making applications a reliable proxy for substantial physical alterations. All planning applications submitted in Cambridge between 2006 and 2023 were extracted from the local government planning portal, and application titles are used to classify alteration types through keyword matching. Appendix B lists the variables included for each application.

Physical alterations are classified into four categories: rear extension, dormer extension, and front extension (all involving additional floor area) and front renovation (facade or front garden modifications that alter external appearance without adding floor area). Keywords were developed for each category to match relevant planning applications (Appendix C).

The four categories can be used to test the two spillover channels. Front renovations affect only the frontage without adding floor area, therefore providing direct evidence for the *aesthetic value* channel. Rear and dormer extensions add floor area without altering the streetscape, so they provide direct evidence for the *appreciation potential* channel. The front extension group, which adds floor area and alters the frontage, enables examination of the combined effects of both channels.

3.2.2 Defining treatment and control groups

This study allocates samples to treatment or control groups according to their distance from the nearest altered property. The basic assumption is that properties located farther away experience weaker or no spillover effects, whereas those in closer proximity are more strongly affected. The classification involves three steps.

First, the network distance between each house and its nearest altered house is calculated using ArcGIS. Instead of relying on Euclidean or planar distance, this study uses local road network data from Ordnance Survey to calculate road distance between houses.

Second, houses are assigned to groups $Distance_k$, where k ranges from 1 to 5, based on both

---

[4] In the UK, the Land Registration Act 2002 requires all property and land transactions to be registered with HM Land Registry, with each registration recording the transaction date and price.

[5] The Ordnance Survey geodatabase provides the physical and socio-economic variables required for this study, integrated with the Rightmove dataset via geographic coordinates. All Ordnance Survey data are licensed.

[6] Stricter regulations apply in designated areas and listed buildings, while certain exceptions under the *Town and Country Planning (General Permitted Development) Order 2015* allow specific alterations without formal planning permission.

property type and network distance to the nearest altered house. A quasi-topological distance – measured in house units – is calculated by dividing the network distance by the average inter-house spacing: 5 metres for terraced houses, 10 metres for semi-detached houses, and 15 metres for detached houses[7]. The resulting value is then rounded up to the nearest integer to assign each house to a specific $Distance_k$ group. Accordingly, the variable $Distance_k$ represents an estimated distance of k houses between a given house and the altered property. To simplify the analysis, all observations with $5 \leq k \leq 10$ are grouped into $Distance_5$, while those with $k > 10$ are excluded from the sample.

Third, a dummy variable $Treat$ is constructed for use in Eq. (1). Houses with $k \leq 2$ are categorised as the treatment group ($Treat = 1$), while houses with $k = 5$ are assigned to the control group ($Treat = 0$). This reflects the assumption that spillover effects occur within a limited spatial range, consistent with local planning authority practice of notifying nearby residents – typically those directly opposite, directly behind, and immediate and next-door neighbours – when an application is submitted. This assumption is further supported by empirical results from Eq. (2), which confirm significant spillover effects within this range.

3.2.3 Defining time periods

This study uses the time difference t between the HM Land Registry transaction date of a house and the validation date of the nearest planning application to assign each house to a specific time group. A negative value represents the number of years before the validation date, and a positive value indicates the number of years after. In the dataset, time differences range from -17.57 to 17.59 years, with a mean of -3.82 years. To focus on short- to medium-term before-and-after effects, transactions with time differences less than -6 or greater than 7 are excluded. The remaining values are then rounded down to the nearest integer. Consequently, the final time difference variable, t, used in the analysis ranges from -6 to 6.

Before proceeding with the analysis, it is important to clarify the interpretation of the time variable t. While it may seem straightforward to assume that a positive value of t indicates that the house transaction occurred after a nearby alteration, the reality is more nuanced. Technically, a positive value of t means that the *registration date* of the transaction took place after the *validation date* of the nearest planning application. Although this represents the most precise timing information available, it does not necessarily imply that the transaction occurred after the nearby house alteration was completed, for the following three reasons.

First, the validation date indicates that the planning authority has received the application; it does not equate to granting planning permission. Most decisions are made approximately eight weeks after the validation date[8]. Second, the exact completion date of the alteration is not available, and

---

[7] To estimate average inter-house distances, the authors randomly selected five streets for each housing type and calculated the average spacing between properties. The results indicate that, on average, terraced houses are spaced 5 metres apart, while the corresponding distances for semi-detached and detached houses are 10 metres and 15 metres, respectively.

[8] Under current law, local planning authorities must decide on applications within eight weeks. To verify that most individual house renovation applications meet this timeline, the authors randomly sampled 50 applications, finding that 46 received a decision within seven to eight weeks.

the only feasible approach is to infer it based on the planning permission date. According to the *Town and Country Planning Act 1990*, the default duration of planning permission is three years from the date it is granted. This study assumes that most applicants complete renovations approximately one year after receiving permission, as the three-year period is intended for all types of developments, whereas private house alterations generally require less time than larger or new-build projects. Third, although the HM Land Registry provides the precise registration date of property transactions, this date is often several months after the transaction is agreed due to the conveyancing process, which typically takes 12 to 16 weeks[9]. Therefore, while the registration date is accurate, the actual transaction date must often be inferred.

These constraints make it difficult to categorise transactions recorded short after alterations. However, it is unlikely to significantly affect the analysis. Transactions with $t = 0$ or $t = 1$ may suffer the identification issue, later transactions with larger t values are unlikely to be affected, as a two-year time lag is typically sufficient for completing all proposed changes and finalising a property transaction. The primary concern is that the DID coefficients for $t = 0$ or $t = 1$ may be attenuated towards zero, as they include some transactions that effectively belong to the pre-treatment period.

3.2.4 Parallel trends assumption test

For the time-staggered DID model, Eq. (1) is used to test the parallel trends assumption by restricting the sample to transaction records preceding nearby house alterations. To satisfy the parallel trends assumption, the coefficients β_t should be statistically insignificant for all $t \leq -1$. For the distance-staggered DID model, Eq. (2) is employed to test the parallel trends assumption using only transaction records in the $Treat_5$ group. The parallel trends assumption requires that β'_k be statistically insignificant for transactions between five and ten houses away from the altered house.

3.3 Descriptive statistics

A total of 12,812 transactions are included in the Cambridge dataset between 2006 and 2024. Table 2 presents the descriptive statistics of the housing variables. The dependent variable, house price, has a mean value of £385,608, which is lower than the median house price of £492,750 recorded in 2023. Given that the dataset includes transactions dating back to 2006, it is reasonable that the mean price is below the 2023 average. Other variables reflecting housing characteristics and amenities are also included to reflect the local housing condition.

[Table 2]

4. Empirical Evidence

4.1 Time-staggered DID analysis

---

[9] Data source: https://hoa.org.uk/advice/guides-for-homeowners/i-am-buying/how-long-does-conveyancing-take/

4.1.1 Parallel trends assumption test

The results of the parallel trends test for the time-staggered DID model are reported in Table 3. Coefficents for the first three groups are statistically insignificant, confirming the absence of divergent pre-treatment trends between the treatment and control groups. However, the front renovation group shows a significant coefficient for $Treat \times Period_{-4}$, indicating that unobserved factors may be influencing the model. Furthermore, although the front extension and front renovation groups have a similar number of observations, the standard errors for the front renovation group are on average 50% larger, suggesting greater model instability for this group. Consequently, only the first three alteration groups are included in the subsequent staggered DID analyses.

[Table 3]

4.1.2 DID results

All models begin with the same set of control variables. To address multicollinearity, stepwise regressions are conducted to select the most appropriate regressors, and any variable with a VIF greater than 10 is excluded. Appendix D presents the regression results. All models exhibit a high degree of fit, with R^2 values exceeding 0.8.

Figure 3 presents the coefficients of the time-staggered DID terms for all three extension categories. The figure reveals a consistent pattern: prior to the intervention, the coefficients for the treatment and control groups are similar across all categories. After the intervention, the rear and dormer extension groups exhibit statistically significant coefficients between years four and six, suggesting positive spillover on nearby properties. All else being equal, rear and dormer extensions are associated with premiums of 4.39% and 4.64% in year four, 3.11% and 6.56% in year five, and 4.67% and 4.27% in year six, respectively. Since both rear and dormer extensions increase floor space without altering the building facade, results from these two groups prove that the *appreciation potential* hypotheses **H1** is true: the successful extension of one property increases the likelihood of similar extensions nearby, which in turn is capitalised into transaction prices as a premium.

[Figure 3]

In contrast, the front extension group shows no statistically significant coefficients. If both the *appreciation potential* and *aesthetic value* channels were simultaneously at work, one would expect the front extension group to exhibit significant post-intervention effects. The absence of such effects suggests that the combined influence of the two channels does not produce a meaningful impact on neighbouring property values.

Apart from the significant results for the rear and dormer extension groups beginning in year four, the overall trend during the first three post-intervention years reveals a more nuanced pattern of neighbour interactions. As shown in Figure 3, the coefficients for all three extension types display an early decline during the initial three post-intervention years before turning positive. This pattern suggests an initial negative influence from neighbouring construction activities followed by a subsequent recovery phase. Given that construction work typically commences shortly after planning approval, it is reasonable to infer that this negative spillover arises from the material construction activities themselves. Consequently, the data for the first three post-intervention periods reflect a combination of positive and negative spillover effects. The positive spillover gradually strengthens as the negative effects caused by construction-related disruptions diminish over time, ultimately resulting in statistically significant positive coefficients.

The coefficients for property attributes in all regression models are consistent with the findings of existing literature (Appendix D). All else being equal, terraced houses are significantly less expensive than semi-detached or detached houses. Larger properties, as well as those with more bedrooms or living rooms, command higher prices. Newly built houses also tend to sell at a premium. In addition, higher council tax bands and better EPC (Energy Performance Certificate) ratings are both positively and significantly associated with property prices.

For other amenity and neighbourhood attributes, all factors included in the regressions yield significant coefficients consistent with existing literature (Appendix D). Houses located near amenities command significant price premiums relative to those situated farther away. The only exception is proximity to retail centres, which is associated with a price discount, likely due to increased noise levels and higher foot traffic in these areas.

4.2 Distance-staggered DID analysis

4.2.1 Parallel trends assumption test

For the distance-staggered DID model, the parallel trends assumption test includes only samples located at least five houses away from the nearest planning application (k ranges from 6 to 10). To assess the general trends, transactions in $Distance_5$ are separated according to their exact distance to the nearest altered house. A five-house distance is selected because existing literature suggests that similar spillover effects typically dissipate within three to four houses.

The results of the parallel trends test for the distance-staggered DID model are presented in Table 4. All coefficients of the interaction terms are statistically insignificant, indicating no divergent trends among properties located five to ten houses away from the nearest house improvement. Consequently, all four groups are retained for the subsequent staggered DID analyses.

[Table 4]

4.2.2 DID results

Similar to the time-staggered DID models, all regressions in this section begin with the same set of control variables. A stepwise selection process is employed to remove unnecessary variables, and those with variance inflation factor (VIF) values greater than 10 are excluded to mitigate multicollinearity. This model switches focus from time to space: Instead of comparing time periods before and after the intervention, it analysis properties based on their distance from the nearest altered house. Appendix E presents the regression results. All models demonstrate high explanatory power, with R^2 values exceeding 0.8.

[Figure 4]

Regarding the distance of spillover effects, Figure 4 presents the coefficients of the staggered DID terms for all four types of alterations. For the rear extension group, houses within a house distance of two – that is, the immediate neighbour and the next adjacent house – experience significant positive spillovers of 4.18% and 3.38%, respectively. Other nearby houses, however, do not exhibit statistically significant premiums. The dormer extension group displays a similar pattern, with the immediate and next adjacent neighbours receiving 3.45% and 3.10% premiums, respectively. The significant results in both cases provide evidence supporting the *appreciation potential* channel. In contrast, the front extension and front renovation groups do not exhibit any significant coefficients for the DID interaction terms. The immediate neighbours and next adjacent houses even show negative coefficients, though these are not statistically significant. Consistent with earlier findings, these negative coefficients may reflect temporary adverse spillovers associated with the construction process. While front extensions increase floor area and may enhance the local streetscape, construction activities also introduce disruptions such as noise and dust. A negative coefficient suggests that the short-term disamenities of construction outweigh any potential benefits for nearby properties. These findings further reinforce the conclusion that the *aesthetic value* channel exerts limited influence on surrounding property values, if any.

Regarding other control variables, including property attributes, nearby amenities, and neighbourhood characteristics, the regression results reported in Appendix E are broadly consistent with those presented in Appendix D. Across both sets of models, the estimated effects align with existing literature, further supporting the robustness and credibility of the findings.

5. Robustness checks

To assess the robustness of the previous results, this study modifies two measurements in the analyses to check whether the conclusions remain consistent.

First, Euclidean distance was used as a substitute for road distance in the analyses. Euclidean distance measures the straight-line distance between two points on a flat plane and does not account for the actual road network, so it is less reliable than the network distance employed in the previous analyses. For this reason, road distance was used in the main analysis. Nevertheless, switching to Euclidean distance does not substantially alter the general trends observed in Figure 3 and Figure 4. The results reported in Table 9 and 11 (Appendices F and G) are consistent with the previous findings.

Second, the study adjusted the thresholds used to measure house-distance. In the main analysis, 5, 10, and 15 meters are used as thresholds to calculate the house-distance between any two properties. In this robustness check, alternative thresholds (6, 12, and 18m) were used for the same regressions.

Table 10 and 12 (Appendices F and G) reports the regression results for all interaction terms. Although the coefficients vary slightly, the general trend and significance level are consistent with the main regression results.

In both checks, steps similar to the main analysis are conducted. The front renovation group is not included in the time-staggered DID model results because it did not pass the parallel trends test. A full table of regression results is also available. Since the results for other variables did not change significantly, Appendix F and G only reported the coefficients for interaction terms.

6. Discussion

6.1 Two hypothetical channels

The results from previous section show that rear and dormer extensions generate significant premiums for immediate neighbours and second-tier neighbours, whereas front extensions and front renovations do not significantly affect neighbouring properties. Since rear and dormer extensions increase floor space without altering the micro-neighbourhood environment, these findings provide evidence that the *appreciation potential* channel operates at the micro-neighbourhood level. In contrast, the front extension group, which adds limited floor space while improving the frontage and micro-neighbourhood environment, shows no significant spillover effect. Given that additional space should positively influence property values, this result indicates that the *aesthetic value* channel has a limited impact. Findings from the front renovation group further support this conclusion. Overall, the results suggest that increasing floor area has a larger spillover effect on neighbouring properties than improvements to the physical environment.

The finding that frontage physical improvements do not generate significant spillover effects for neighbouring properties may seem to contradict some existing literature, so several explanations are necessary. First, while many studies have demonstrated that physical deterioration leads to negative spillovers for nearby properties, few have investigated whether physical improvements generate positive spillovers. Residents are more sensitive to negative changes than positive ones, so the existence of negative spillovers from deterioration does not automatically imply the opposite. In neighbourhoods already considered acceptable, physical improvements can be regarded as a luxury rather than a necessity.

Second, aesthetic value may still matter, but primarily for upper-middle-class households and above. Although Cambridge residents are wealthier on average than those in other UK towns, most houses are occupied by middle-class households and college students. Well-maintained and affluent neighbourhoods exist but represent only a small fraction of the city.

Third, the measurement used to identify frontage improvements may be imprecise. This study assumes that front extensions and renovations enhance the community environment, which is generally reasonable, but in some cases the aesthetic value may not change substantially. Moreover, aesthetic value is inherently difficult to quantify and is influenced by factors such as maintenance, which are not always captured in planning applications.

The significant spillover effects observed for rear and dormer extension groups provide strong evidence that the *appreciation potential* channel exists in micro-neighbourhoods. This finding aligns with common real estate practice to highlight a property's alteration potential in online listings. Theoretically, the premium captured by neighbouring properties should reflect a portion of the difference between the potential value of the additional space and the associated costs, including construction and planning application fees.

6.2 Other implications

Since interactions among neighbours play a fundamental role in shaping communities, the results of this study also carry implications for various stakeholder groups.

For the local planning system, the analysis demonstrates that the houses most influenced by a neighbouring alteration are the immediate neighbours and second-tier neighbours. Currently, local authorities normally notify at least the second-tier neighbours when a planning application is submitted. Our findings support this practice, as these are the households most affected by the application. Furthermore, the results indicate that certain types of improvements can generate spillover effects on neighbouring properties, and the resulting price premium should be taken into account during the planning application process. For the real estate industry, the analyses indicate that neighbours influence each other's property values. To improve the accuracy of house price predictions, information of immediate and second-tier neighbours should be incorporated into pricing models. For the general public, the study reinforces the practice of observing neighbouring properties to gauge what improvements are feasible for one's own house. Additionally, timing plays an important role when buying or selling a property: a nearby construction site can negatively affect prices, whereas a recently approved or completed extension on a neighbouring house can have a positive impact.

6.3 Future Improvements

This study has several limitations. First, it focuses solely on Cambridge, and analyses in other cities may yield similar but slightly different results. Even within the UK, Cambridge is somewhat unique due to its higher average income and large student population.

Second, the method used in this study to identify and measure physical changes, particularly renovations, does not fully capture the exact extent of aesthetic changes. Existing literature has shown that even with rich datasets, measuring the aesthetic value of the built environment is inherently challenging. This study could not obtain such comprehensive data, so the planning application system was used as the most feasible proxy. Furthermore, other unobservable factors, such as the exact maintenance level, the identity of residents, passersby, and even seasonal or weather variations, also affect the physical appearance of a micro-environment. Future research could address these limitations by incorporating more detailed measurements of aesthetic changes.

Third, the dynamics and interactions among households in a neighbourhood may vary depending on the physical environment, country, and cultural context. This study focuses on typical British houses. Spillover effects in other settings, such as high-rise apartment buildings or gated communities, could manifest very differently depending on local conditions.

7. Conclusion

This study explores a straightforward question: when a homeowner undertakes improvements to their property, how does this affect neighbouring properties, and through which mechanisms do these effects occur? Two possible channels in the UK context are identified: the *appreciation potential* channel and the *aesthetic value* channel. The *appreciation potential* channel relates to the planning system and indicates that alterations to one property increase the likelihood of neighbouring properties obtaining similar approvals; this increased approval potential carries a premium and leads to property value appreciation. The *aesthetic value* channel pertains to improvements in the local physical environment, which in turn leads to higher property values. Using house transaction and planning application data from 2006 to 2024, this study adopts staggered DID approaches to measure the spillover effects of different house improvements: rear extension, dormer extension, front extension, and front renovation. Rear and dormer extensions involve only the *appreciation potential* channel, the front renovation group involves only the *aesthetic value* channel, and the front extension group involves both channels.

The results reveal that the rear and dormer extension groups generate significant positive spillover effects on immediate neighbours and second-tier neighbours, persisting even five years after the extension. In contrast, the front extension group does not have any significant impact on neighbouring properties. This evidence indicates that the *appreciation potential* channel is effective, whereas the *aesthetic value* channel is not. In other words, a successful planning application that adds additional floor space to one house can increase the likelihood that neighbouring properties undertake similar extensions, thereby producing a positive spillover effect. Physical improvements to the micro-environment, however, do not exert a significant influence on nearby properties.

The findings of this study contribute to the existing literature by measuring the positive spillover effects of house improvements at the micro-neighbourhood level. While prior studies have largely focused on negative spillovers, this study investigates the mechanisms through which positive spillover effects occur. For local planners, the results support the current practice of notifying immediate and second-tier neighbours during the planning application process, while also highlighting the potential influence of granting planning permission on nearby properties. For real estate companies, the findings suggest that incorporating more information about the neighbourhood – especially the attributes of immediate neighbours – can improve the accuracy of price predictions. For the general public, this study provides greater insight into how their own actions, as well as those of their neighbours, can affect property values.

Tables

Table 1. Categories of House Alterations

Category	Definition	More floor area	Frontage change	Related spillover effects
Rear extension	Expanding a house by building outwards from the rear, such as additional ground-floor living room or kitchen.	Yes	No	Appreciation potential
Dormer extension	Adding a structure that projects vertically from a sloping roof but is invisible from the front, such as an additional dormer bedroom with roof windows.	Yes	No	Appreciation potential
Front extension	Expanding the living space toward the front of a property, such as an additional study room or garage.	Yes	Yes	Appreciation potential; aesthetic value
Front renovation	Improving the physical appearance of the frontage without adding floor area, such as an additional porch, bay window, or front-garden renovation.	No	Yes	Aesthetic value

Table 2: Descriptive Statistics

	Count	Mean	SD	Min	Max
Price (£)	12,812	385,608	255,869	41,250	3,400,000
House type					
detached	1,614	1	0	1	1
semi-detached	3,994	1	0	1	1
terraced	7,204	1	0	1	1
Floor area (m2)	12,812	112	46	17	372
Parcel size (m2)	12,812	256	208	28	1,999
Number of living rooms	12,812	2	1	0	3
Number of bedrooms	12,812	3	1	0	9
Number of bathrooms					
1	6,759	1	0	1	1
2	2,668	1	0	1	1
3 or more	3,385	1	0	1	1
Built year					
before 1899	2,413	1	0	1	1
1900–29	2,457	1	0	1	1
1930–49	1,844	1	0	1	1
1950–75	3,304	1	0	1	1
1976–2000	1,495	1	0	1	1
after 2001	1,299	1	0	1	1
Council Tax Band					

	Count	**Mean**	**SD**	**Min**	**Max**
A/B	967	1	0	1	1
C	5,673	1	0	1	1
D	2,853	1	0	1	1
E/F/G/H	3,319	1	0	1	1
EPC					
A/B	688	1	0	1	1
C	3,993	1	0	1	1
D	5,970	1	0	1	1
E/F/G	2,161	1	0	1	1
Distance to nearest (m)					
bus stop	12,812	157	90	0	471
kindergarten	12,812	858	529	9	2,637
primary school	12,812	442	209	23	1,428
secondary school	12,812	923	525	41	3,089
retail centre	12,812	503	305	24	1,893
health centre	12,812	487	250	14	1,549
chemist	12,812	465	252	21	1,827
dentist	12,812	639	416	8	2,488
fire station	12,812	2,155	968	95	4,485
Observations	12,812				

Table 3: Parallel trends test results for time-staggered DID

	Rear extensions	**Dormer extensions**	**Front extensions**	**Front renovations**
Treat × Period−6	0.00158	0.0307	−0.0150	0.0423
	(0.0226)	(0.0288)	(0.0335)	(0.0483)
Treat × Period−5	0.0252	−0.0233	−0.0243	0.0332
	(0.0203)	(0.0282)	(0.0281)	(0.0536)
Treat × Period−4	0.0156	0.00650	−0.00571	0.0680*
	(0.0201)	(0.0264)	(0.0267)	(0.0365)
Treat × Period−3	0.0106	−0.00872	0.0160	0.0301
	(0.0202)	(0.0256)	(0.0287)	(0.0406)
Treat × Period−2	0.0189	−0.0141	0.00963	0.0497
	(0.0194)	(0.0246)	(0.0276)	(0.0437)
Time fixed effect	Yes	Yes	Yes	Yes
Place fixed effect	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes
R-squared	0.876	0.872	0.902	0.890
Observations	1,297	952	582	599

Standard errors in parentheses; $*p<0.10$, $**p<0.05$, $***p<0.01$

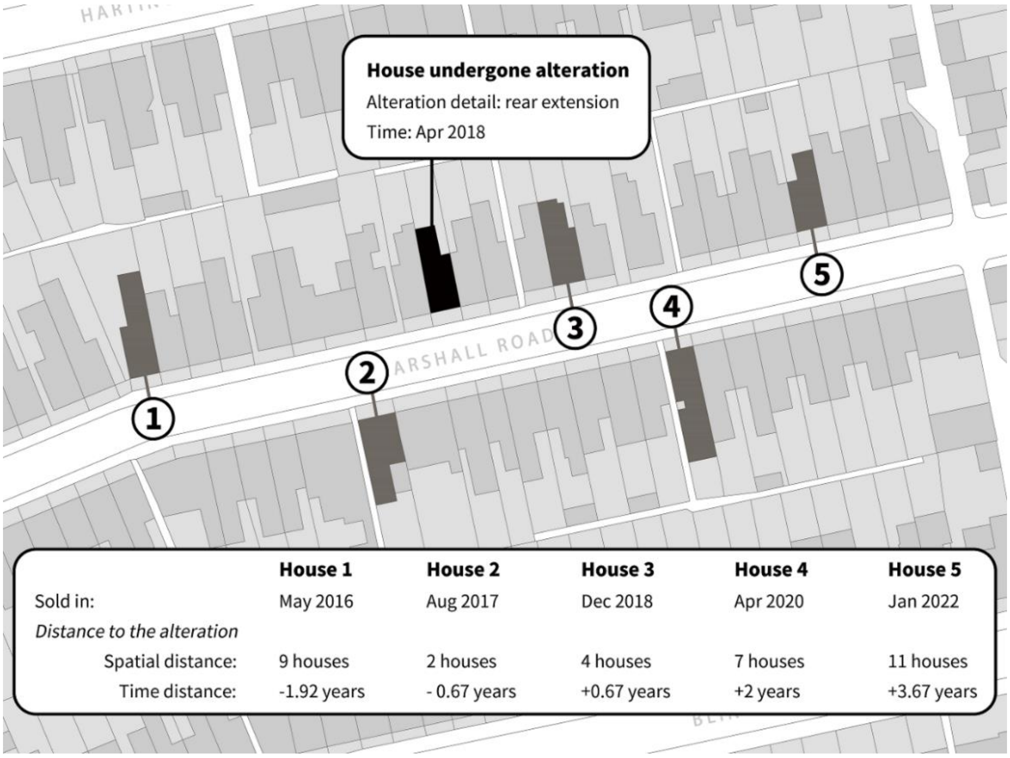
Table 4: Parallel trends test results for distance-staggered DID

	Rear extensions	**Dormer extensions**	**Front extensions**	**Front renovations**
Post × Distance5	0.0171	0.0195	−0.0127	0.00935
	(0.0266)	(0.0252)	(0.0287)	(0.0194)
Post× Distance6	0.0134	−0.00143	0.0114	−0.0186
	(0.0263)	(0.0226)	(0.0290)	(0.0184)

	Rear extensions	**Dormer extensions**	**Front extensions**	**Front renovations**
Post× Distance7	0.0425	−0.00232	−0.0167	0.00155
	(0.0263)	(0.0219)	(0.0287)	(0.0177)
Post× Distance8	0.0138	−0.00521	0.0148	−0.0203
	(0.0271)	(0.0259)	(0.0305)	(0.0186)
Post× Distance9	0.0300	−0.00703	0.0345	−0.0132
	(0.0266)	(0.0226)	(0.0269)	(0.0194)
Time fixed effect	Yes	Yes	Yes	Yes
Place fixed effect	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes
R-squared	0.869	0.862	0.889	0.905
Observations	1,111	1,275	904	1,451

Standard errors in parentheses; * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Figures



	House 1	House 2	House 3	House 4	House 5
Sold in:	May 2016	Aug 2017	Dec 2018	Apr 2020	Jan 2022
Distance to the alteration					
Spatial distance:	9 houses	2 houses	4 houses	7 houses	11 houses
Time distance:	-1.92 years	- 0.67 years	+0.67 years	+2 years	+3.67 years

Figure 1: Example of an alteration and transactions in a micro-neighbourhood

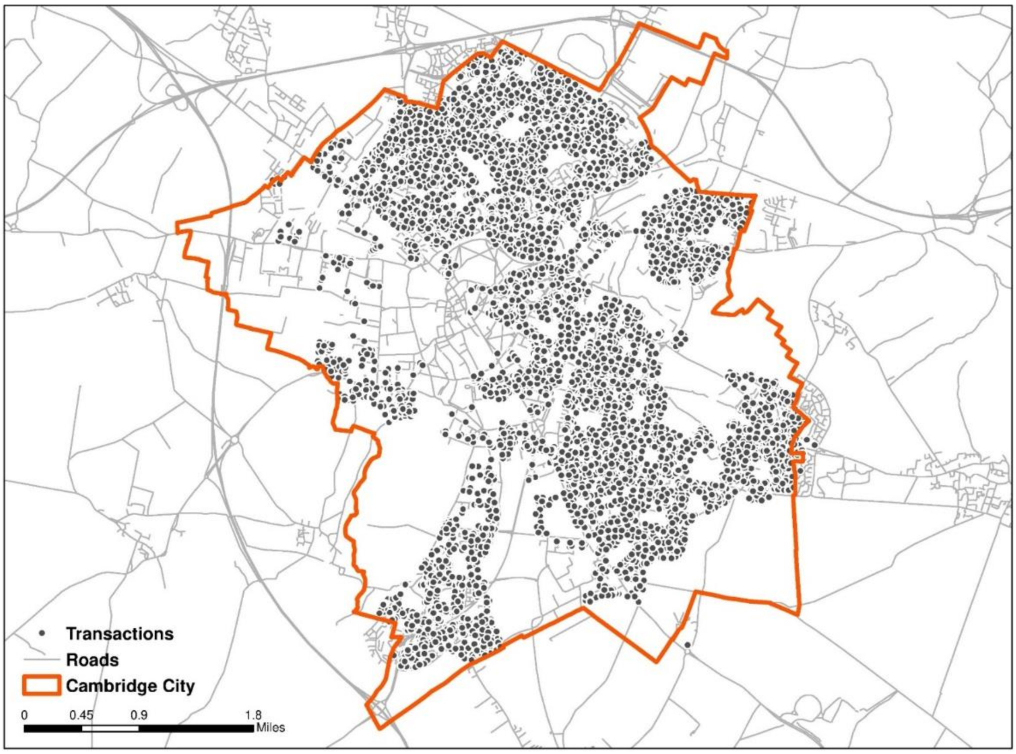


Figure 2: Transaction records in Cambridge City between 2006 and 2024

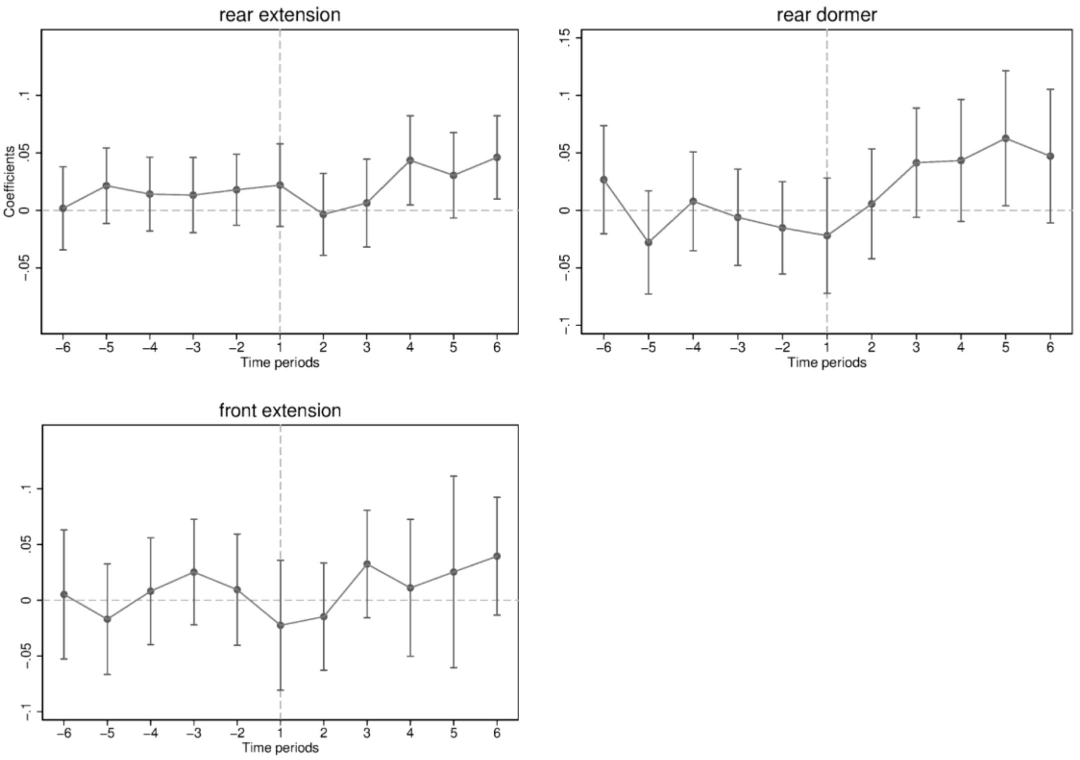


Figure 3: Time-staggered DID interaction term coefficients

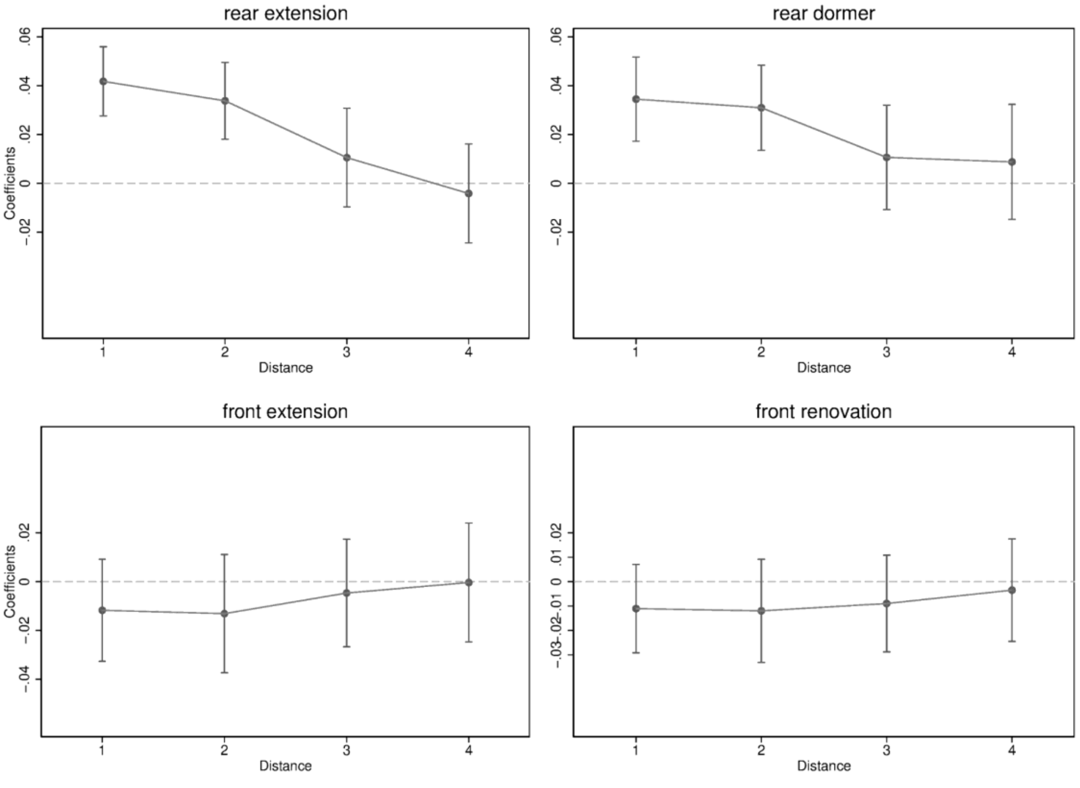


Figure 4: Distance-staggered DID interaction term coefficients

REFERENCES

BERACHA, E. & HARDIN, W. 2021. The housing price premium associated with charter schools. *Real Estate Economics,* 49, 1267-1289.

BOTTERO, M., CAPRIOLI, C., FOTH, M., MITCHELL, P., RITTENBRUCH, M. & SANTANGELO, M. 2022. Urban parks, value uplift and green gentrification: An application of the spatial hedonic model in the city of Brisbane. *Urban Forestry & Urban Greening,* 74.

CHEN, W. Y. & LI, X. 2017. Cumulative impacts of polluted urban streams on property values: A 3-D spatial hedonic model at the micro-neighborhood level. *Landscape and Urban Planning,* 162, 1-12.

CROMPTON, J. L. & NICHOLLS, S. 2020. Impact on property values of distance to parks and open spaces: An update of US studies in the new millennium. *Journal of Leisure Research,* 51, 127-146.

DUBÉ, J., ABDELHALIM, M., DES ROSIERS, F. & DEVAUX, N. 2023. Do residential reconversions affect residential property values? An investigation based on Quebec city (Canada). *Journal of Housing and the Built Environment,* 38, 2373-2397.

ELMALLAH, S., HOEN, B., FUJITA, K. S., ROBSON, D. & BRUNNER, E. 2023. Shedding light on large-scale solar impacts: An analysis of property values and proximity to photovoltaics across six US states. *Energy Policy,* 175.

FLEMING, D., GRIMES, A., LEBRETON, L., MARÉ, D. & NUNNS, P. 2018. Valuing sunshine. *Regional Science and Urban Economics,* 68, 268-276.

GANDURI, R. & MATURANA, G. 2024. Do property rehabs affect neighboring property prices? *Journal of Urban Economics,* 143.

GERARDI, K., ROSENBLATT, E., WILLEN, P. S. & YAO, V. 2015. Foreclosure externalities: New evidence. *Journal of Urban Economics,* 87, 42-56.

HEARNE, D. & YERUSHALMI, E. 2025. The Amenity Value of Bicycle Infrastructure: A Hedonic Application to Greater Manchester, UK. *Environmental & Resource Economics,* 88, 425-457.

HECKERT, M. & MENNIS, J. 2012. The economic impact of greening urban vacant land: a spatial difference-in-differences analysis. *Environment and Planning a-Economy and Space,* 44, 3010-3027.

HOLT, J. R. & BORSUK, M. E. 2020. Using Zillow data to value green space amenities at the neighborhood scale. *Urban Forestry & Urban Greening,* 56, 10.

IRWIN, N. B. 2019. Keeping up appearances: Spatial spillovers and housing renovations. *Papers in Regional Science,* 98, 2115-+.

JOHANSEN, R., NEAL, Z. & GASTEYER, S. 2015. The view from a broken window: How residents make sense of neighbourhood disorder in Flint. *Urban Studies,* 52, 3054-3069.

KLIKA, P., BRANDEJS, D., HÁVA, K., POKORNÁ, S., DOLEZALOVÁ, M. & HLAVINKOVÁ, V. 2025. Relationship Between Architectural Style and Property Value in the Czech Republic. *Civil and Environmental Engineering,* 21, 825-839.

KRUSKY, A. M., HEINZE, J. E., REISCHL, T. M., AIYER, S. M., FRANZEN, S. P. & ZIMMERMAN, M. A. 2015. The effects of produce gardens on neighborhoods: A test of the greening hypothesis in a post-industrial city. *Landscape and Urban Planning,* 136, 68-75.

LIN, Z. G., ROSENBLATT, E. & YAO, V. W. 2009. Spillover Effects of Foreclosures on Neighborhood Property Values. *Journal of Real Estate Finance and Economics,* 38, 387-407.

LINDENTHAL, T. 2020. Beauty in the Eye of the Home-Owner: Aesthetic Zoning and Residential Property Values. *Real Estate Economics,* 48, 530-555.

O'BRIEN, D. T. & MONTGOMERY, B. W. 2015. The Other Side of the Broken Window: A Methodology that Translates Building Permits into an Ecometric of Investment by Community Members. *American Journal of Community Psychology,* 55, 25-36.

PENDOLA, R. & GEN, S. 2008. Does "Main Street" promote sense of community? A comparison of San Francisco neighborhoods. *Environment and Behavior,* 40, 545-574.

ROSEN, S. 1974. HEDONIC PRICES AND IMPLICIT MARKETS - PRODUCT DIFFERENTIATION IN PURE COMPETITION. *Journal of Political Economy,* 82, 34-55.

SEO, W. 2018. Does Neighborhood Condition Create a Discount Effect on House List Prices? Evidence from Physical Disorder. *Journal of Real Estate Research,* 40, 69-87.

SEO, W. & VON RABENAU, B. 2011. Spatial Impacts of Microneighborhood Physical Disorder on Property Resale Values in Columbus, Ohio. *Journal of Urban Planning and Development,* 137, 337-345.

SUZUKI, M., HINO, K. & MUTO, S. 2022. Negative externalities of long-term vacant homes: Evidence from Japan. *Journal of Housing Economics,* 57, 25.

TANG, B. S. & WONG, K. T. 2020. Assessing externality: Successive event studies on market impacts of new housing development on an old residential neighbourhood. *Environment and Planning B-Urban Analytics and City Science,* 47, 156-173.

TURNBULL, G. K. & VAN DER VLIST, A. J. 2023. After the Boom: Transitory and Legacy Effects of Foreclosures. *Journal of Real Estate Finance and Economics,* 66, 422-442.

WILSON, J. Q. & KELLING, G. L. 2011. *"Broken Windows" Atlantic Monthly (1982),* London, Routledge.

YANG, J. C., RONG, H., KANG, Y. H., ZHANG, F. & CHEGUT, A. 2021. The financial impact of street-level greenery on New York commercial buildings. *Landscape and Urban Planning,* 214, 12.