Evaluating the price effects of multifamily and single-family housing construction on surrounding single-family homes in Stockholm: a difference-in-difference analysis

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Abstract

Purpose – This study aims to examine the impact of housing construction on single-family housing values and the implications for urban development.

Design/methodology/approach – To achieve this objective, the author used the difference-in-difference methodology to examine the effect of multifamily and single-family housing construction on surrounding single-family homes in Stockholm, Sweden. The author analysed data from approximately 480 housing construction projects between 2009 and 2014 and 17,000 single-family detached house transactions between 2005 and 2018.

Findings – The research found that multifamily construction projects did not affect the value of surrounding single-family homes, while single-family home construction had a negative impact. The author attributes this result to single-family housing projects typically located in areas with initially positive externalities, while multifamily housing projects are often located on the edge of areas with negative externalities before construction.

Research limitations/implications – The research is limited by its focus on a specific geographic area and time frame, and future research could expand the scope to include other cities and regions and different periods. Additionally, further research could examine the impact of housing construction on other economic factors beyond housing values.

Practical implications – The research has practical implications for urban planners and policymakers. They should consider the potential negative impact of new single-family home construction on existing single-family housing areas while balancing the need for new housing in urban areas. By carefully evaluating construction locations, policymakers can create more sustainable, livable and equitable urban environments that benefit all members of society.

Originality/value – This research paper contributes to the field of housing economics by examining the impact of housing construction on single-family housing values in the context of urban development and climate change mitigation. Using a difference-in-difference methodology, the study provides evidence of the price effect of multifamily and single-family housing construction on surrounding single-family homes, which has important policy implications for urban planners and policymakers. By identifying the negative impact of single-family home construction on surrounding areas and highlighting the need for careful evaluation of

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construction locations, the research provides valuable insights for creating sustainable, livable and equitable urban environments that benefit all members of society.

Keywords Housing construction, Single-family housing values, Difference-in-difference methodology, Urban development

Paper type Research paper

1. Introduction

In this study, our objective was to estimate the effect of price on surrounding buildings resulting from the construction of multifamily and single-family homes using an event study approach. Our analysis focuses on single-family houses, as much of the available land for development is adjacent to or near existing single-family housing areas in the suburbs.

Cities are experiencing rapid urbanisation, leading to increased development demands. Failure to meet the need for new housing can result in a housing shortage that affects economic growth and affordability (Voith and Wachter, 2009). Consequently, urban development plans aim to balance building closer to the city centre and existing public transportation while preserving and enhancing green areas. This goal becomes challenging due to the inherent conflict arising from limited space, as densification efforts can threaten urban green spaces (Haaland and van den Bosch, 2015). Thus, constructing new buildings in established cities becomes a challenge of conflicting goals but also one of justice (Mohorčich, 2023) and localism (Manville and Monkkonen, 2021).

One of the conflicts arises from the price effects on surrounding buildings caused by the supply of new housing in existing residential areas. Increasing the housing supply should reduce overall housing prices in a housing supply-demand framework. However, this effect can be influenced by changes in demand. Positive price effects may arise from increased demand for private and public services (amenities), leading to higher prices. In contrast, adverse effects can result from the environmental impact of new development and changes in the area's character (disamenities). The latter is particularly significant if the new supply differs in style and density from the existing housing stock (Zahirovich-Herbert and Gibler, 2014). Disentangling the effects of changes in housing supply and demand on surrounding property prices is a complex task.

Several previously published articles have explored the price and rent effects of new housing construction in nearby residential areas. Some studies (Brunes *et al.*, 2020; Deng, 2011; Ding and Knaap, 2002; Ellen *et al.*, 2001; González-Pampillón, 2022; Ki and Jayantha, 2010; Kurvinen and Vihola, 2016; Lee *et al.*, 2017; Ooi and Le, 2013; Peng and Tian, 2022; Simons *et al.*, 1998; Zahirovich-Herbert and Gibler, 2014) have shown positive price or rent effects, while others (Ahvenniemi *et al.*, 2018; Asquith *et al.*, 2023; Li, 2022; Newell, 2010; Song and Knaap, 2004) have found negative effects. Mixed results can be attributed to differences in methodology, institutional conditions and impact scale (local vs regional). However, it should be noted that most studies have estimated a positive impact on nearby housing. This suggests that the positive externalities of new housing construction, such as increased demand, tend to outweigh any negative price impacts caused by increased supply.

Previous studies have used various types of hedonic price models (Davison *et al.*, 2017; Simons *et al.*, 1998; Song and Knaap, 2004; Zahirovich-Herbert and Gibler, 2014) and different variants of hedonic difference-in-difference (DID) models (Asquith *et al.*, 2023; Brunes *et al.*, 2020; González-Pampillón, 2022; Li, 2022) to analyse the effects of new housing construction. Most studies explore the impact of new multifamily home construction

(Ahvenniemi *et al.*, 2018; Brunes *et al.*, 2020; Deng, 2011; Ooi and Le, 2013) on apartment prices. However, some studies have examined the effects on apartment values in multifamily houses or prices of single-family homes (Davison *et al.*, 2017; Ellen *et al.*, 2001). Notably, there is a literature gap in analysing and comparing the impact of new multifamily and single-family housing construction on single-family houses. Based on the literature, we might expect that new buildings positively impact neighbouring properties.

We estimate the price effect using the DID methodology, and our case study is the capital of Sweden, Stockholm. We analysed approximately 300 housing construction projects between 2009 and 2014 and approximately 17,000 detached house transactions between 2005 and 2017. Our DID models, referring to the Stockholm case, indicate that the new housing supply in multifamily houses near single-family housing areas has no or limited positive effect on housing prices. On the other hand, the new supply of single-family homes in existing single-family housing areas has a statistically significant negative price impact on surrounding single-family properties. This can probably be explained by the new single-family homes directly adjacent to or in the single-family housing area.

A policy implication of the findings of this study is that urban planners and policymakers should prioritise the construction of multifamily housing projects in areas where the demand for housing is high and adjacent to single-family housing areas. This could positively or at least not impact the value of surrounding single-family homes. However, the construction of single-family homes close to existing single-family housing areas should be thoroughly evaluated, as it negatively impacts the value of surrounding houses. Therefore, policymakers must consider possible trade-offs and goal conflicts when deciding on new housing development in urban areas.

We add to the previous literature in several ways. Firstly, we analyse the effect of infill developments in or near single-family housing areas. We do this because it is missing in the research, and we want to analyse the importance of the size/type of new houses in the old city. The availability of buildable land in locations with good accessibility and public and private services is often found in single-family housing areas. However, this land is also sensitive because it infringes on current property owners in the area. We also contribute to the application of the DID methodology in a case with multiple constructions over time. We also contribute an analysis of parameter heterogeneity to better understand how new construction can affect the value of nearby detached houses depending on their size, age and centrality. Finally, we contribute by performing a comprehensive sensitivity analysis of the robustness of the parameter estimates.

The disposition of the article is as follows: Section 2 presents the chosen method, namely, a multievent DID approach. Section 3 presents our case study with data, and Section 4 follows with the empirical results. The section will also give a detailed analysis of parameter heterogeneity and test the parameter estimates' robustness. The article ends with Section 5, where our results are discussed, and Section 6, where we conclude our study and present some policy implications.

2. Methodology

In this section, we will present the model approach that we have used in the empirical analysis to test the hypothesis of whether new construction projects in the urban environment have a price impact on surrounding properties and thus increase or decrease the attractiveness of the area. The method we use is the staggered dynamic DID (SDDID) method. The method is presented briefly in the section, together with the assumptions made. Finally, we also present how we have tested the robustness of our estimates.

2.1 Staggered dynamic difference-in-difference

The DID estimator is often used in empirical economic research to assess the impact of public interventions and other treatments without purely experimental data (Abadie, 2010; Angrist and Pischke, 2009; Wooldridge, 2013). The DID equation can be stated as follows.

$$Y_{i,t} = \alpha_{k,t} + \lambda_1 Treat_{i,j} + \lambda_2 Post_{i,t} + \lambda_3 (Treat * Post)_{i,j,t} + \beta X_{i,t} + \varepsilon_{i,t} \tag{1}$$

The subscript i equals the individual transaction, j equals the treatment area, k equals the postal code and t equals the year. The outcome variable is Y, and *Treat* equals the treatment area. The treatment area is defined as a 500 m ring around new construction. The variable *Post* equals the years after construction, and (*Treat* * *Post*) is the interaction variable between the treatment area and the period after construction. X is a vector of other covariates. Properties within the treatment area will be compared with those in the control area (500–2,000 m from the nearest new construction).

We use SDDID to analyse multiple events (new construction) over time (Callaway and Sant'Anna, 2021). It is an extension of the traditional DID method in equation (1), which compares the change in outcomes between a treatment group and a control group before and after a policy intervention. In SDDID, the treatment and control groups are staggered over time, which means that the treatment is implemented at different times for different groups. It allows the estimation of the dynamic effects of the policy intervention, which may vary over time and between groups. SDDID incorporates a dynamic component by including the lags of the treatment variables in the regression model and helps capture the gradual effects of the policy intervention over time and any delayed effects. The model we have used is equal to the following equation; see, e.g. (Callaway and Sant'Anna, 2021; Li, 2022):

$$Y_{i,t} = \alpha_{k,t} + \beta X_{i,t} + \sum_{j=-9}^{8} \gamma_j YSC(j) + \varepsilon_{i,t} \tag{2}$$

It is a two-way fixed effect specification (Imai and Kim, 2021). The subscript i equals the transaction, j equals the treatment area, k equals the postal code and t equals the year. The variable *YSC* measures the number of years since completion. The binary variables of the *YSC* are the variables of interest. In this case, from nine years before to eight years after. X is a vector of other covariates. It is a two-way fixed effect model where α varies with k and t. As (Bertrand *et al.*, 2004) show, conventional standard errors often understate the standard deviation of the estimators. A possible solution could be to cluster standard errors at the group level, such as postal code (Liang and Zeger, 1986). We have also used White's heteroskedastic adjusted standard errors (White, 1980) for comparison.

2.2 Assumptions

The parallel trend assumption is essential in causal inference in DID approaches (Abadie, 2005; Angrist and Pischke, 2009). It refers to the idea that the treatment and control groups would have followed the same trend over time without treatment. In other words, the assumption is that any differences between the treatment and control groups before the treatment was implemented are due to chance or other factors unrelated to the treatment itself. If this assumption holds, any difference in results between treatment and control groups after treatment can be attributed to the treatment itself. The parallel trends assumption is often tested using pretreatment data to determine if the treatment and control groups' trends were similar before implementation. If there are significant differences in the trends of the treatment and control groups before treatment, it can be challenging to determine whether any differences in outcomes after treatment are due to treatment or other factors.

However, there is a criticism that the tests used to analyse whether pretrends exist have relatively low power. There is a risk that the tests cause us to exaggerate the bias in the point estimate and underestimate the importance of confidence intervals (Rambachan and Roth, 2023; Roth, 2022). There is also a risk that the assumption of parallel trends is not fulfilled, as there may be an imbalance in the treated and untreated groups. One way to remedy the problem is to include covariates associated with the dynamics of housing prices, such as the property's value-affecting characteristics (Abadie, 2005). An alternative or complement is to use the propensity score to probability inversely weigh the observations to balance the differences between the treated and untreated groups, such as the propensity score methods (Abadie, 2005; Callaway and Sant'Anna, 2021; Rosenbaum and Rubin, 1983).

2.3 Robustness tests

We have carried out several tests to ensure that we have partly estimated causal relationships and partly have estimates that do not depend on the assumptions we have made. The first test aims to test whether we have a corresponding effect on important housing characteristics, such as property size. Therefore, we have estimated the models with living space and the number of rooms as outcome variables rather than housing price, and we assume that we do not observe any effect on these variables.

The second test aims to vary the size of the treatment and control area. We estimate SDDID with treatment areas of 300 and 700 m, respectively. The corresponding control area will then be up to 1 km and 4 km, respectively, from the construction project. Here, too, we expect robustness in the estimates, but there may be a slightly more substantial effect the narrower we limit the treatment area. The third test aims to estimate a placebo DDID by randomly assigning a property to be treated. The proportion of people who have been randomly treated is equal to those who are actually in the treatment area. Here, the expectation is that we will not see a corresponding price effect as in the basic model.

The fourth test involves the order of the events concerning observations with multiple treatments. In equation (2), we computed YSC by subtracting the year of treatment from the transaction year. We used the YSC from the most recent treatment for observations with multiple events. To test the reliability of our results, we also calculated the YSC based on the property's first treatment.

3. The case study of Stockholm

This section presents the case study, the data used in the study, and how we handled the data to estimate SDDID.

3.1 Stockholm, Sweden, as a case study

Our case study is Stockholm, the capital of Sweden, which has around one million inhabitants and when including surrounding municipalities (Stockholm County), has a total of approximately 2.3 million inhabitants. Since 1990, the population has grown by 0.7 million, reaching 1.6 million. The current housing construction plans for Stockholm County from 2019 to 2030 aim to construct around 280,000 dwellings, with 85% of these plans referring to multifamily apartment buildings. This expansion means that the total number of homes will increase by roughly 25% in the next decade, nearly double the number of homes built in the previous decade. These ambitious plans will demand significant attention on where and how to build, with around one-third of the construction occurring within Stockholm's municipality, which is relatively densely populated but has space for new projects in existing residential areas.

Engerstam *et al.* (2023) present the planning process in Sweden. The relationship between land use policies and building permits in Sweden can be summarised as a system of regulation and compliance. Land use policies provide guidelines for responsible land use and development, while building permits ensure adherence to these policies. The process involves the creation of municipal plans, including general and detailed development plans, which outline long-term goals and directions for land use. These plans consider various factors such as environmental quality, housing needs and sustainable development. Zoning codes and regulations govern the types of land use allowed in different areas, promoting controlled growth and preserving the character of the community. The detailed development plan, a legally binding document, governs the building permit process by specifying land use designations, building restrictions and construction guidelines. After a thorough review, the municipality issues building permits to ensure compliance with land use policies. They serve as a mechanism for enforcing these policies and promoting responsible development. The number of building permits per capita reflects a municipality's land use policy. Hence, where and what is built in the city results from the municipality's plans and the construction companies' assessment of where it is economically possible to build. The effects on surrounding properties can be included in the assessment when planning permission is granted to construct single-family homes and apartment buildings. Thus, where one builds might not be exogenously determined, which can affect its possible price impact on surrounding existing housing.

3.2 The data

The data we use comes from two sources. The first concern is the data on completed housing construction projects during the period 2009–2014 in the city of Stockholm. The data contain information about construction projects, such as who the developer is, the type of building, the type of lease, the start of construction and when it is completed, as well as the number of apartments and addresses. Based on the street addresses, we have geocoded all construction projects. The type of building refers to multifamily or single-family houses; the type of lease refers to rental apartments, condominium apartments and ownership of single-family dwellings. The data source is the city of Stockholm.

We have analysed all 488 housing construction projects from 2009 to 2014. Of these, 336 are apartment building projects and 152 are single-family housing projects. Most projects have ownership rights, but 131 multi-apartment projects have the tenure form of rental housing. Apartment building projects comprise approximately 20,000 apartments, with the most significant project consisting of 320 apartments. The different construction locations are depicted in Figure 1.

On average, 1.5 years have passed between the start date and the end date of the construction. Furthermore, there was a period before the project received a building permit, in which plans were drawn up and, after consultation with the stakeholders involved, decisions were made. Some so-called "fill-in projects" refer to constructing new buildings or infrastructure in previously developed areas with gaps or empty spaces. These projects aim to "fill in" gaps and densify urban areas by efficiently using existing infrastructure and services. However, it might come with a cost: negative capitalisation on existing surrounding houses.

The second data refers to information on detached house sales in Stockholm. The data contain information about the transaction date, the transaction price and various properties, such as the size and year of construction. The transactions are related to the years 2005–2017. All transactions have been geocoded, allowing us to calculate the distance to new

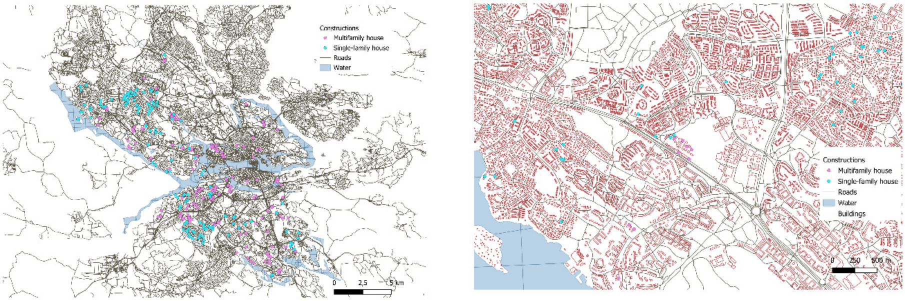


Figure 1. Constructions of new multifamily and single-family houses in Stockholm

Notes: The figure has been constructed by using QGIS. The map on the left shows all construction in Stockholm, and the map to the right is a close-up of an area northwest of Stockholm (Hässelby) – data source and maps: the city of Stockholm and author's creation

construction projects, the nearest subway station and the central business district (CBD). The data source is Svensk Mäklarstatistik AB.

3.3 Data preparation

As said, we have estimated a SDDID model. Before we could estimate the model, we prepared the data by calculating the Euclidian distance from all single-family transactions to all construction projects carried out during 2009–2014 in the study area. We calculated the distance to the multifamily and single-family projects separately, and the shortest distance to a construction project per year was used in the analysis. Around each new construction project, the treatment and control area is defined on two rings around the new constructions. The ring that makes up the treatment area is, as in Ooi and Le (2013) and Zahirovich-Herbert and Gibler (2014), equal to 500 m (one-third of a mile). It is larger than, for example, Asquith *et al.* (2023) who used 250 m; Deng (2011) who used a distance of 100 feet (around 300 m); Ellen *et al.* (2001) who used 150, 300 and 600 m; and Davison *et al.* (2017) who uses 100–500 m. However, we have also used 300 and 700 m as a robustness test. We have calculated the control area as four times the treatment area, 2 km from the construction project. For each transaction, the number of years from the implementation of the construction project in the treatment area has been calculated from up to nine years before to up to eight years after the performance of the project. Year zero indicates when the project was completed, and the properties of a control group have the default value of 0. The year before and after the construction project will consist of 19 binary variables, where all except year zero have been included in the SDDID.

3.4 Descriptive statistics

Table 1 presents the variables included in the empirical analysis and descriptive statistics. In addition to variables about real estate transactions (price, living area, number of rooms and plot size), distance to the nearest subway station (subway) and distance to the CBD are also presented. The distance to the nearest construction project is presented yearly, whether a multifamily residential building or a single-family house.

In total, we have 15,043 transactions, but due to missing construction years for approximately 100 transactions, we have 14,900 observations for the empirical analysis. The average price is just over SEK 5m, with a standard deviation of approximately SEK 2.5m. During the survey period, housing prices have increased significantly and, together with a significant intraregional variation in prices, the standard deviation is relatively high in

Variable	Definition	Obs	Mean	Std. dev.
Price	Contract price (SEK)	15,043	5,077,251.5	2,432,466.5
LA	Living area (sq. m)	15,043	128.616	37.372
PA	Plot area (sq. m)	15,043	561.841	286.754
NR	Number of rooms	15,043	5.574	1.291
BY	Building year	14,900	1,955.376	22.807
DS	Distance to subway station (km)	15,043	1.209	0.637
DCBD	Distance to CBD (km)	15,043	9.564	3.063
DMF09	Distance to multifamily constructions in 2009 (km)	15,043	6.092	3.87
DMF10	Distance to multifamily constructions in 2010 (km)	15,043	2.35	1.426
DMF11	Distance to multifamily constructions in 2011 (km)	15,043	2.163	1.439
DMF12	Distance to multifamily constructions in 2012 (km)	15,043	1.456	0.834
DMF13	Distance to multifamily constructions in 2013 (km)	15,043	1.636	0.979
DMF14	Distance to multifamily constructions in 2014 (km)	15,043	1.606	0.861
DSF09	Distance to single-family constructions in 2009 (km)	15,043	1.816	1.225
DSF10	Distance to single-family constructions in 2010 (km)	15,043	1.993	2.059
DSF11	Distance to single-family constructions in 2011 (km)	15,043	1.728	1.963
DSF12	Distance to single-family constructions in 2012 (km)	15,043	1.438	1.046
DSF13	Distance to single-family constructions in 2013 (km)	15,043	1.685	1.169
DSF14	Distance to single-family constructions in 2014 (km)	15,043	1.551	1.406

Notes: The table presents data on single-family house transactions. The dependent variable is the transaction price (Price), and the value that influences the independent variables is the living area (LA), the number of rooms (NR), the plot area (PA) and the year of construction (BY). LA and PS are measured in square metres, NR in numbers and BY in years. The variables are also the distance to the subway station (DS) and the central business district (CBD), both measured in kilometres (km). The distance to the nearest distance to a completed construction is measured in 3 km per year and the type of building, that is, apartment building project (DMF09-14) and single-house project (DSF09-14). The descriptive statistics in the table are mean and standard deviation. The data have been cleaned of observations that are potential outliers. We excluded all observations that fall below 1% or exceed 99% in price, living space, plot area and the number of rooms. Regarding the variables' distance from the metro station and CBD, we have excluded observations further away than the 99th percentile
Source: Data from the city of Stockholm and Svensk Mäklarstatistik. Calculation and table: Author's work

Table 1.
Variable definition and descriptive statistics

relation to the average price. The size of the home is about 128 sq. m, with a variation around the average value of 37 sq. m. The plot area varies significantly due to the properties built in different periods. Older houses are more often built on larger plots. The average plot area is 561 sq. m; the plot area is barely five times larger than the living area. The average building was built in 1955 with a standard deviation of just over 20 years. Most properties have good access to the metro, with an average distance of only 1.2 km. The average distance from the CBD is just under 10 km. The shortest distance between existing properties and new construction projects is 1.45–2.35 km with an exception: the distance to the new construction projects of multifamily houses in 2009, which have a distance of 6 km. This means that none of the transactions will be included in the treatment or control area for the construction projects of multifamily houses built in 2009. Table 2 presents descriptive statistics on transactions in the treatment area, defined as transactions within 500 m of the construction project (treated) in multifamily residential buildings and single-family homes and transactions included in the control area (untreated).

The number of observations in the treatment group is equal to 3,691 in the multifamily case and 7,310 in the single-family case. The corresponding figures in the control group are 11,352 and 7,733, respectively. In the multifamily case, most treated observations are treated

Variables	Multifamily Treated	Untreated	Single-family Treated	Untreated
Price	5,693,648	4,876,836	4,980,810	5,168,417
Living area	126.3665	129.348	134.5946	122.9653
Plot area	551.0149	565.3616	644.4104	483.7891
Number of rooms	5.5834	5.5705	5.6790	5.4741
Building year	1949	1957	1958	1953
Distance subway	0.8543	1.3237	1.40597	1.02194
Distance CBD	7.9772	10.0801	9.9393	9.209559
No. of observations	3,691	11,352	7,310	7,733

Notes: The table illustrates the mean values for the price and the independent variables. Columns 2 and 3 refer to multifamily residential buildings, and Column 4 refers to single-family housing projects. The table compares single-family house transactions in the treatment area 0–500 m (treated) with transactions outside 500 m up to 2 km (untreated)
Source: Data from the city of Stockholm and Svensk Mäklarstatistik. Calculation and table: Author's work

Table 2. Descriptive statistics of the treated and untreated groups (mean values)

only once (2,601 transactions), close to one new construction project. In the case of a single-family home, this is not the situation. Only 35% of the treated transactions are treated only once, and almost 65% are treated twice or more. As we have calculated the YSC variable, it will record the year to the last treatment. To ensure that this does not affect the parameter estimates and their interpretation, we have estimated the models with only the observations that either have one treatment or are found in the control group every year.

Furthermore, we can state that there are differences between those close to new construction projects (treated) and those farther away (untreated). Generally, the average price is higher for those closest to new construction, and the difference is relatively significant. This applies to the new construction project being a multifamily house. In terms of value-influenced attributes, they are relatively equivalent. Single-family homes near new multifamily buildings are smaller in terms of square metres of living space and plot area. They still have a higher average price because they have better access to public transportation and are closer to the CBD. In Figure A1 in the Appendix, we plot the price trend for the transactions that have received treatment for multifamily house construction and those that have not received treatment over time. The trends are parallel before 2009, 2009–2014 and after 2014.

Regarding single-family house new construction projects, treated properties have a lower average price, even if the difference is not statistically significant. However, we can observe that the treated houses are larger indoors and outdoors than the untreated ones. However, those treated are further away from a metro station and the CBD. In the DID model, we will consider differences by including value-affecting characteristics and using propensity modelling to balance the distribution of covariates in treated and untreated subjects. In Figure A2 in the Appendix, we plot the price trend for the transactions that have received treatment for single-family house construction and those that have not received treatment over time. Trends are parallel before 2009 and after 2014. However, during 2009–2014, when the projects were completed, house prices in the treated group began to decline compared to those in the untreated group.

4. The result of staggered dynamic difference-in-difference

We will present two results from our estimates of the SDDID models. The first results refer to the spillover effect of building multifamily houses on single-family house prices, and the

Table 3. Staggered dynamic difference-in-difference, multifamily and single-family houses

Variables	(1) MFRobust	(2) MFCluster	(3) SFRobust	(4) SFCluster
lnLA	0.335*** (49.08)	0.328*** (15.10)	0.331*** (48.14)	0.331*** (17.62)
lnPA	0.173*** (51.74)	0.179*** (16.89)	0.177*** (55.51)	0.177*** (19.41)
lnNR	0.185*** (23.19)	0.189*** (13.57)	0.184*** (23.07)	0.184*** (14.75)
lnBY	−0.994*** (−5.03)	−1.113 (−1.89)	−0.382* (−1.96)	−0.382 (−0.68)
lnDS	−0.0218*** (−5.94)	−0.0230 (−1.58)	−0.00572 (−1.59)	−0.00572 (−0.43)
lnDCBD	−0.386*** (−19.45)	−0.354*** (−4.37)	−0.458*** (−22.65)	−0.458*** (−6.22)
−9	−0.0581** (−2.82)	−0.0849** (−3.18)	0.0490*** (3.55)	0.0490 (1.82)
−8	−0.0482*** (−3.75)	−0.0555** (−3.03)	0.00613 (0.58)	0.00613 (0.28)
−7	−0.0376** (−3.00)	−0.0453** (−2.61)	−0.00654 (−0.71)	−0.00654 (−0.43)
−6	−0.0408*** (−3.77)	−0.0344 (−1.90)	−0.0134 (−1.69)	−0.0134 (−0.97)
−5	−0.0304** (−2.86)	−0.0391* (−2.16)	−0.00334 (−0.43)	−0.00334 (−0.24)
−4	−0.0206* (−2.03)	−0.0230 (−1.28)	−0.0136 (−1.66)	−0.0136 (−0.97)
−3	−0.0137 (−1.31)	−0.0191 (−1.05)	−0.0158* (−2.03)	−0.0158 (−1.24)
−2	−0.00448 (−0.43)	−0.00857 (−0.50)	−0.0127 (−1.55)	−0.0127 (−0.90)
−1	0.00974 (0.94)	−0.0112 (−0.58)	−0.0112 (−1.50)	−0.0112 (−0.87)
1	−0.00795 (−0.70)	−0.0107 (−0.52)	−0.00183 (−0.26)	−0.00183 (−0.15)
2	0.00684 (0.67)	0.00495 (0.28)	−0.0354*** (−4.83)	−0.0354** (−2.65)
3	−0.0162 (−1.44)	−0.0220 (−1.27)	−0.0259*** (−3.30)	−0.0259 (−1.91)
4	0.0155 (1.19)	0.00186 (0.09)	−0.0408*** (−4.81)	−0.0408** (−2.64)
5	0.0148 (1.13)	0.0121 (0.55)	−0.0355*** (−3.57)	−0.0355* (−2.14)
6	0.0403* (2.56)	0.0368 (1.50)	−0.0859*** (−6.99)	−0.0859*** (−4.13)
7	0.0452* (2.05)	0.0381 (1.40)	−0.0753*** (−4.52)	−0.0753** (−3.18)
8	0.108* (2.38)	0.113* (2.59)	−0.130*** (−4.19)	−0.130** (−3.32)
R^2	0.871	0.874	0.875	0.875
Adjusted R^2	0.869	0.872	0.874	0.874
AIC	−11,366.9	−10,652.7	−11,577.3	−11,641.3
Observations	13,803	12,728	13,560	13,560

Notes: The table presents the staggered dynamic difference-in-difference model with multiple events. The outcome variable is the natural logarithm of the transaction price. The independent variables are the living area (lnLA), the plot area (lnPL), the number of rooms (lnNR), the year of the building (lnBY), the distance from the metro station (lnDS) and the distance to the central business district (lnDCBD). All of them are in the natural logarithm. In addition to housing characteristics, 17 binary variables were included in the models. They represent the years before (−9 to −1) and after (1 to 8) the construction of houses. The models in Columns 1 and 2 show the estimates of the impact of new multifamily construction, and Columns 3 and 4 show the impact of new single-family construction. The model in Columns 1 and 3 (*MFRobust* and *SFRobust*) uses propensity score weights to control for potentially unbalanced data between treated and untreated groups (Rosenbaum and Rubin, 1983). Properties within the treatment group were assigned a weight of (1/propensity score), while properties in the control group were assigned a weight of [1/(1–propensity score)], as follows (Cole and Hernán, 2008). The model uses White's heteroskedasticity-adjusted standard errors (White, 1980), and the models in Columns 2 and 4 (*MFCluster* and *SFCluster*) adjust the stand errors for clustering (Liang and Zeger, 1986). The statistics for the *t-values* are in parentheses $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$. R^2 and adjusted R^2 are presented with the Aiken information criterion (AIC) and the number of observations
Source: Data from the city of Stockholm and Svensk Mäklarstatistik. Calculation and table: Author's work

second aims to estimate the same spillover effects from the new construction of single-family dwellings. The section will conclude by testing the robustness of the estimates when we change critical assumptions.

Table 3 reports the differences in the different estimates of multifamily and single-family construction in single-family homes. The first two models analyse the impact of multifamily housing construction, and the last two analyse the impact of single-family housing construction.

All estimated models use propensity score weights to balance properties that are part of the treated and untreated groups (Rosenbaum and Rubin, 1983). Models 1 and 3 (*MFRobust* and *SFRobust*) have White's heteroskedasticity-adjusted standard errors (White, 1980). In Models 2 and 4 (*MFCluster* and *SFCluster*), we adjust the standard errors for clustering based on correlation within zip code areas (Abadie *et al.*, 2023; Liang and Zeger, 1986).

4.1 Multifamily houses results

The degree of explanation (R^2) is approximately 87% in all models, and all housing characteristics have the expected sign. If the size increases, the expected price will be higher regardless of whether we measure the indoor or outdoor size. If the living area increases by 1 sq. m, the price is expected to increase by 0.3% (given all other variables), and if the plot area increases by 1%, the price is expected to increase by 0.17%. Older properties have a lower price due to wear and tear on the house and become outdated over time. Depreciation is estimated to be approximately 1% per year. Distance to the subway station, that is, poorer accessibility, reduces the value of the home, and the same applies to the distance to the CBD. The farther away from the CBD, the lower the price. If the distance from the CBD increases by 1%, the price is expected to drop by 0.37%. We note that the parameter estimates are generally robust regardless of the model. The most significant difference in Model 2 is that we have higher cluster-adjusted standard errors. The first model has significantly lower standard errors, which means that the *t*-values in parentheses are somewhat higher than in Model 2. However, the coefficients regarding the value-affecting variables (except building years) in Model 2 are all statistically significantly different from zero.

The coefficients for the years before and after the completion of the new apartment buildings are of primary interest to the study. We can observe several things. Firstly, the parameter estimates are robust regardless of the model, although Model 2 shows higher standard errors than the other models. Secondly, estimates of seven to three years before construction completion are negative and statistically significant, indicating that multifamily houses have been built in areas that, before construction, were not as attractive as in the control group; that is, the price level was lower for the places where they had later built. Thirdly, the negative capitalisation then disappears two years before completion. A cautious interpretation could be that there is a positive influence, even if no statistically significant parameter estimates can be observed. Finally, the years after the residential buildings are completed show no statistically significant effects except for a few sporadic years, such as years six and eight.

To illustrate the effect, we plotted the coefficient estimates and confidence intervals in Figure 2. The figure shows the estimates of Models 1 and 2 in Table 3. The confidence intervals are becoming more extensive as we are farther away from the completion, especially for the estimates after the completion.

The areas where building permits have been granted have had a lower price than those in the control areas before completion. However, this lower value has decreased in the years before the completion of multifamily housing projects. An interpretation could be that construction projects have benefitted the surrounding single-family housing areas. However, the parameter estimates do not show a statistically significant effect in the years after completion. The difference between the model with White's heatskedasticity-adjusted standard error naturally indicates the same point estimates as the model with cluster-adjusted standard error (only the standard errors differ in the models). However, as expected, the confidence intervals are wider in the cluster-adjusted model.

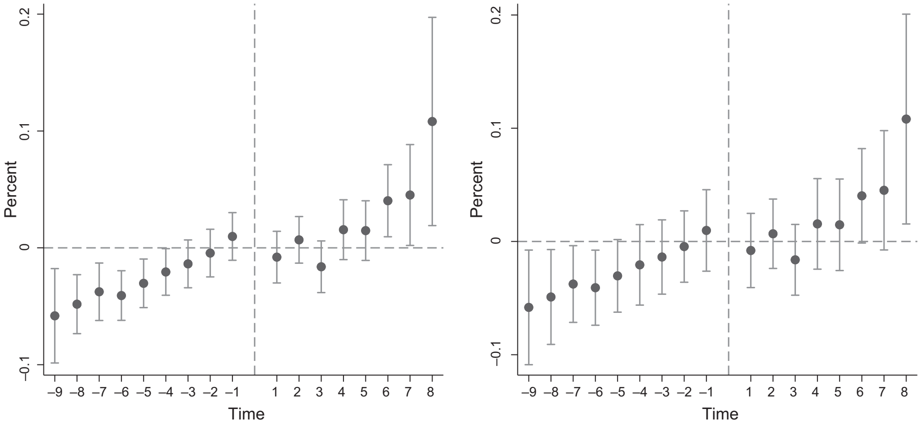


Figure 2.
New multifamily housing coefficients over time (Robust and Cluster)

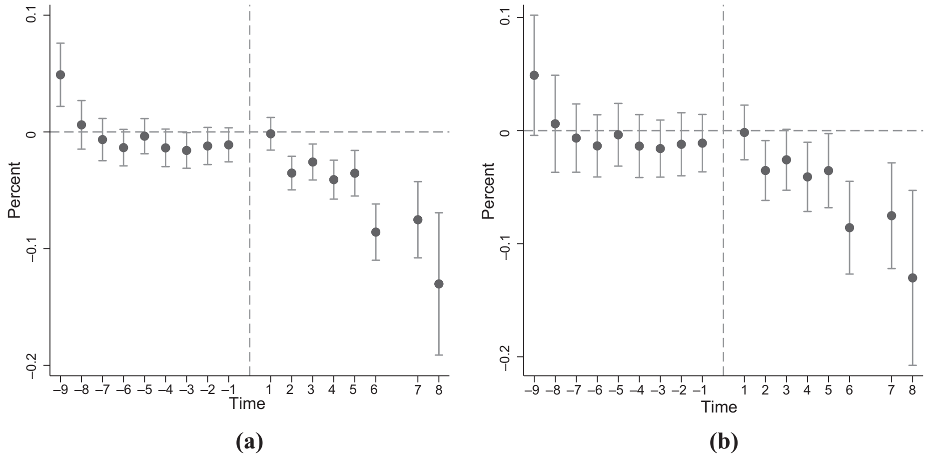
Notes: The plot shows the coefficients of Table 3, models 4 [left plot (a)] and 5 [right plot (b)]. We have time from −9 to +8 on the horizontal axis. The zero in the timeline is when the event occurs and is indicated with a red vertical line. The percentage impact on the housing price of the outcome variable is on the vertical line. The results are the point estimate and the 95% confidence interval.
Source: Data from the city of Stockholm and Svensk Mäklarstatistik. Calculation and figure: Author's work based on Jann (2016)

4.2 Single-family homes results

Table 3 also reports the differences in the estimates of single-family construction in single-family houses (Columns 3 and 4). The table presents two models concerning single-family house construction (SFRobust and *SFCluster*).

The models have a high degree of explanation at around 87%. The risk of omitted variable bias appears to be relatively limited. All value-affecting characteristics have the expected signs and order of magnitude. Based on the *SFRobust* model, we note that the cluster-adjusted standard error model deviates considerably since its standard error in the *SFCluster* model is significantly higher than in *SFRobust*. This means that the parameter estimates for years of construction, which was statistically significant before, are no longer.

However, many parameter estimates of the value-influencing characteristics remain statistically significant in the cluster model. The findings on the impact of the number of years until the completion of single-family house projects in the vicinity of existing single-family houses remain unchanged across all models. The construction of detached houses has occurred in areas with the same price level as other properties in the control group, and the city has not granted building permits on plots or areas considered problematic or significantly more or less attractive. However, the effect of price has been negative in the years following the completion of the detached houses. The effect is statistically significant and ranges from 2% to 13%, depending on the time elapsed since the completion. The capitalisation effect increases with time, but we must interpret this effect with caution since other events may have influenced property values over time. The estimated capitalisation effect is between 2% and 4% within two to four years after completion. Although this may seem like a small effect, the fact that many neighbouring properties are affected by new construction implies that the total economic cost to society may be substantial.



Notes: The plot shows the coefficients of Table 2, models 4 [left plot Robust estimation (a)] and 5 [right plot Cluster estimation (b)]. We have time from−9 to +8 on the horizontal axis. The zero in the timeline is when the event occurs and is indicated with a red vertical line. The percentage impact of the housing price variable on the outcome is on the vertical line. The results are the point estimate and the 95% confidence interval
Source: Data from the city of Stockholm and Svensk Mäklarstatistik. Calculation and figure: Author's work based on Jann (2016)

Figure 3. New single-family housing coefficients over time

Figure 3 illustrates the results of Columns 3 (*SFRobust*) and 4 (*SFCluster*) in Table 3. As before, the point estimates are the same in the two models, but the higher standard error in the cluster model means the confidence intervals are wider. Still, the results are relatively straightforward; the effect before completion is not statistically significant, and the period after shows a negative capitalisation.

4.3 Parameter heterogeneity

Callaway and Sant'Anna (2021) address the problem of treatment effects that vary between different groups. They conclude that it is relatively unusual for this type of heterogeneity to be analysed in applied research even if it has been done in the applied work, e.g. Brunes *et al.* (2020). Here, we attempt to examine the question of parameter heterogeneity by splitting the material on the size of the single-family houses, their age and their distance to the CBD. The division has taken place on the mean value of the distribution. The result is presented in Figure 4.

The result indicates that in the case of new apartment building construction, single-family house prices are not significantly affected if the single-family houses are large indoors or outdoors or if the property was built after 1959. All estimates are around 0 both before and after construction. As for new single-family housing, it has a negative effect as before, but it is not statistically significant because the estimated parameters are based on fewer observations. Estimates are lower than in the previous model, where all observations are used. This suggests that the impact is more significant for smaller and older detached houses. An interpretation could be that the new developments differ more in shape and volume than older and smaller detached houses.

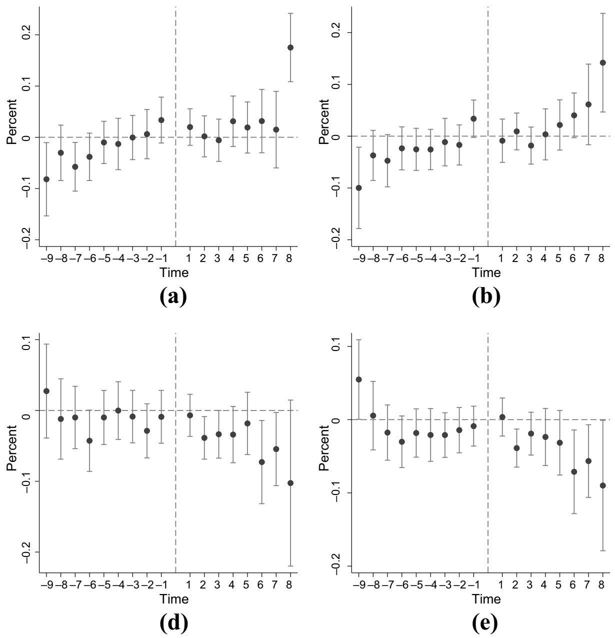


Figure 4.
Parameter heterogeneity – living area, plot area and building year

Notes: The plot shows the test of parameter heterogeneity concerning living areas (a) and (d), plot areas (b) and (e) and building years (c) and (f). Plot (a)–(c) is the new multifamily construction, and (d)–(f) is the new single-family construction. All estimated coefficients refer to the plot area of the living area and building year above the median value. We have time from−9 to +8 on the horizontal axis. The zero in the timeline is when the event occurs and is indicated with a red vertical line. The percentage impact of the housing price variable on the outcome is on the vertical line. The results are the point estimate and the 95% confidence interval using cluster-adjusted standard errors
Source: Data from the city of Stockholm and Svensk Mäklarstatistik. Calculation and figure: Author's work based on Jann (2016)

4.4 Robustness tests

There are many assumptions built into the model that we estimate. As a sensitivity analysis, we have relaxed some assumptions to examine the robustness of the results. All tests are presented in Appendix Figures A3 and A4. Overall, the robustness tests on the effect of the price of constructing new houses show that the parameter estimates are relatively robust.

5. Discussion

How should we then interpret the result? We analyse two types of housing construction in the city and measure their price effect on single-family houses in existing residential areas. Existing single-family housing areas generally have relatively good locations in the city, as many homes were built in the 1940s and 1950s, and they have good access to public transport and the most central parts of the city. The land is attractive, and naturally, the city investigates the possibility of densification in and near the areas. It would allow the city to become denser with its benefits (Combes and Gobillon, 2015; Duranton and Puga, 2020), but concerns are also raised about the risks of a denser city (Adlakha and Sallis, 2021; Carozzi and Roth, 2023). A new supply of housing can increase house prices, which has been demonstrated by several studies such as Brunes *et al.* (2020), Deng (2011), Ding and Knaap (2002), González-Pampillón (2022), Ki and Jayantha (2010), Kurvinen and Vihola (2016), Lee *et al.* (2017), Ooi and Le (2013), Peng and Tian (2022), Simons *et al.* (1998) and Zahirovich-Herbert and Gibler (2014). In the long run, it can also increase housing affordability.

However, densification means a negative externality for existing residents in the areas and, in the long run, can cause increased or decreased gentrification and segregation in the city. Building new in existing single-family housing areas also means that what is built deviates from the existing buildings in form and volume, which can largely explain the negative capitalisation we can observe, which is in line with Zahirovich-Herbert and Gibler (2014) referring to Hinshaw (2002):

> constructing large houses in an established neighbourhood of small houses is the epitome of public rudeness, that incompatible size development benefits only the new house owners, not the surrounding property owners.

Our results indicate that different types of new buildings do not have the same impact on single-family house prices. New multifamily housing seems to have no effect on house prices in the surrounding area, and new single-family houses seem to impact surrounding house prices negatively. However, we must be careful about the comparison. Large multifamily apartment buildings built near single-family housing areas are usually not built inside the single-family housing area but instead in areas surrounding the single-family housing area. For example, our data show that the distance and number of affected property owners are fewer in multifamily housing projects than in single-family housing projects. With that in mind, it is perhaps understandable that single-family housing negatively impacts single-family home prices. It is a more significant intrusion for existing property owners than a multifamily housing project located on the edge of the area.

One type of exploitation in existing single-family housing areas is that properties with larger plot areas are bought by private housing developers, who then build several single-family houses with smaller plot areas. In some cases, the existing building is demolished. Much of that exploitation occurs outside the city's control and operational planning. It is often not seen as something positive by existing nearby property owners, which results in many appeals for demolition and building permits.

On the other hand, it may also be the case that there is a negative externality even when we build multifamily housing but that there are more positive externalities that come with multifamily housing, such as an increased level of private and public service, that is, the net effect is positive.

Unlike Cho *et al.* (2020) and Liang *et al.* (2020), we cannot observe an impact already before completion, which would speak against an announcement effect during the planning process. Our result also follows, e.g. Asquith *et al.* (2023).

We also note that the results show that the land used for multifamily houses is less attractive than the land used for single-family homes. Therefore, another reason the capitalisation is greater for single-family house construction may be that the land used for construction in the single-family house area is land that today is parks or other green areas appreciated by residents. Literature shows a positive effect of parks and green areas on health and residential attractiveness (Iqbal and Wilhelmsson, 2018; Poudyal *et al.*, 2009; Tyrväinen, 1997). Increasing the construction of single-family homes in existing residential areas could make these green areas irretrievably disappear.

There is also an alternative explanation. One channel to the result we observe is that an increase in supply causes the prices of nearby properties to fall in value. Nearby single-family properties will be substitutes for the new single-family houses but not for the dwellings in the multifamily buildings. Therefore, prices will decrease if new single-family homes are built in single-family areas, but not if we build single-family homes around single-family areas. Li (2022) analysed, among other things, the effect of price on nearby residential buildings of building multifamily buildings nearby. They argue that their results indicate that the supply effect dominates over the amenity effect; hence, the net effect is that nearby housing prices fall. However, it is not clear from their research whether their negative impact comes from an increase in supply or a negative externality.

The result can also be analysed on the commonly occurring problem of endogeneity or reverse causality. Here, the argument has been that housing developers have expectations about where there will be price appreciation in the future, and that is where they choose to build. The question then is whether the positive price effects observed in the literature result from causality between building, demand change and higher prices or whether causality goes the other way. The same problem cannot burden our results. We do not assume that housing developers have chosen locations that will be expected to have a price depreciation in the future. Therefore, the observed negative price impact will result from either a supply effect or negative externalities that affect demand or a combination. If anything, our results should have an upward bias.

Moreover, we argue that the observed price decrease is not due to a supply effect but rather a result of a negative externality caused by local demand. The number of new homes being built is relatively small compared to the overall housing supply of single-family homes in Stockholm, which means that it should not significantly impact the supply-driven price effect in the local market. The number of new single-family as a ratio to the number of transactions within the treatment area during the same period is only 2% (=152/7,310).

Hence, the study analyses the impact of two types of housing construction, single-family and multifamily, on the prices of single-family homes in the city's residential areas. The results show that the construction of single-family homes in these areas has a negative impact on the price of the surrounding houses, while multifamily housing has no effect. This could be due to the fact that single-family homes are built in areas that are currently parks or green spaces, which have a positive impact on residential attractiveness.

6. Conclusions and policy implications

This paper presents two results from estimates of DID models. The first result is related to the spillover effect of building multifamily houses on single-family house prices, and the second is to estimate the same spillover effects from the new construction of single-family dwellings.

The case study focuses on Stockholm, the capital of Sweden, which plans to build around 280,000 homes between 2019 and 2030. The data used in the study are from completed housing construction projects in Stockholm from 2009 to 2014, including information on developers, building types, tenure and addresses. The study analysed 488 projects, most of which were apartment buildings and 131 were rental housing. The second data source includes information on the sales of detached houses in Stockholm from 2005 to 2017, allowing for the calculation of distances to new construction projects, the nearest subway station and the CBD.

For multifamily houses, the models have a high degree of explanation, and all housing characteristics have the expected sign. Estimates are generally robust regardless of the model, although the model with cluster-adjusted standard errors has higher standard errors. The coefficients for the years before and after the completion of the new apartment buildings are of primary interest. Estimates of seven to three years before construction completion are negative and statistically significant, indicating that multifamily houses have been built in less attractive areas before construction. The years after the residential buildings are completed show no statistically significant effects except for a few sporadic years.

For single-family houses, the models have a high degree of explanation, and the risk of omitted variable bias appears relatively limited. All value-affecting characteristics have the expected signs and order of magnitude. The cluster-adjusted standard error model deviates considerably since its standard errors are much higher than the other model. The effect of the price on neighbouring properties after the completion of the detached houses is negative and ranges from 2% to 13%, depending on the time elapsed since the completion. The estimated capitalisation effect is between 2% and 4% within two to four years after completion.

The policy implication of this study is that policymakers should consider the spillover effects of new construction projects on surrounding areas. This can be done by carefully evaluating the potential impact on property values and using targeted policies to mitigate any adverse effects of new construction in surrounding single-family housing areas. Additionally, policymakers can invest in infrastructure, such as public transportation and community facilities, to increase the area's desirability and property values. Overall, the study highlights the importance of carefully considering the potential spillover effects of new construction projects and implementing policies to mitigate any negative impacts on surrounding areas. Hence, new detached house developments are less suitable to build in existing detached house areas. Instead, city planners should exploit new land for single-family housing.

Reducing the city's climate impact and making the housing market more socially, economically and environmentally sustainable is essential. Still, it should not be done with means that negatively affect existing citizens/property owners. It would be desirable for the city to analyse all the socio-economic consequences of the residential development plans and not only on, for example, revenues in land sales.

When we analyse living space and plot area, we can state that new multifamily houses tend to have been out of proportion with slightly larger single-family houses in indoor and outdoor space, even if the parameter estimates are insignificant. Regarding indoor space, we note that after treatment, the properties sold have been smaller due to the construction of new apartment buildings.

In the tests, when we reduce or increase the treatment area to 300 and 700 m, the interpretation remains that we cannot statistically significantly increase the prices. We also see no price effect when we expand the control area. The placebo test, in which we randomly vary where we have built new, shows no effect, which confirms our estimates that it is causality that we are analysing. In the last two tests, we see no difference if we only analyse the properties that have a treatment or if we start from the past year when treatment has occurred (if it has occurred multiple times).

Concerning the construction of detached houses and its effect on detached homes, we can state that it is statistically significant that the building has taken place in areas where we have larger properties, which is not surprising, as this is where there is an opportunity to densify in the detached house area. The conclusion is that it is important to include property attributes in the model and that it may be necessary to, for example, use propensity score weighting.

We can also note that the causal price effect is not statistically significant if we reduce the treatment area to 300 m but remains if we expand the treatment area to 700 m. This may be because there are too few properties within 300 m, which means that the number of degrees of freedom decreases or that the effect is not so local that it only occurs within 300 m. However, the spreading impact is more significant than that. When we expand the control area, the parameter estimates are not statistically significant, which can be explained by the fact that including more properties in the control group reduces its ability to be good comparison properties with those in the treatment group.

The placebo model shows no effect. If we analyse only single-family houses affected by treatment, there is still a statistically significant negative price impact, but the standard errors and associated confidence intervals become larger. The negative effect is unclear when we reverse the order and assume that the last treatment affects the property when we estimate the time to treatment. However, estimates are statistically significant up to 3–4 years after treatment.

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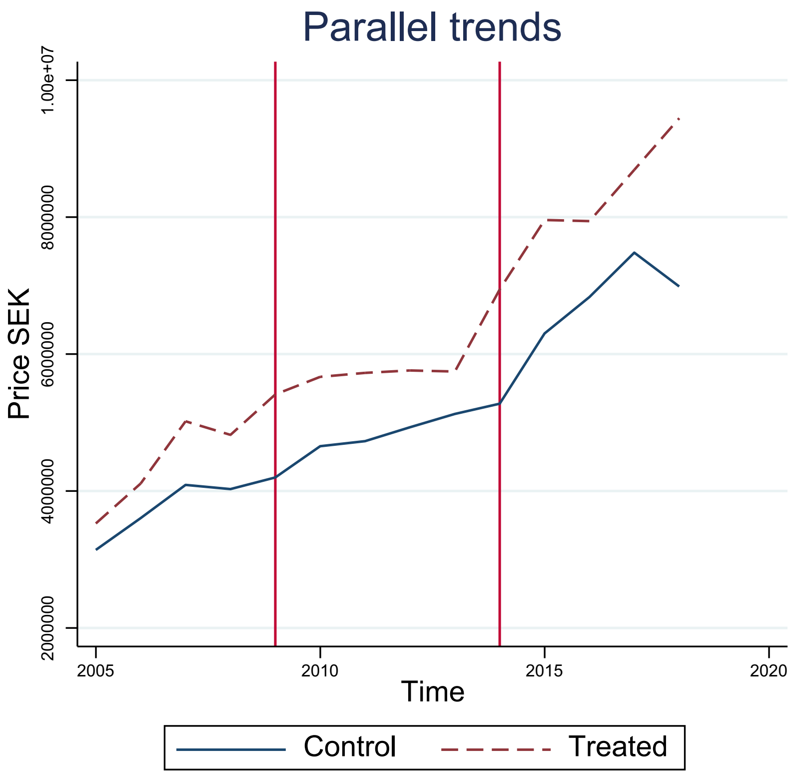


Figure A1.
Parallel Trends - Multifamily Homes

Source: Data from the City of Stockholm and Svensk Mäklarstatistik. Calculation and figure: Author's work

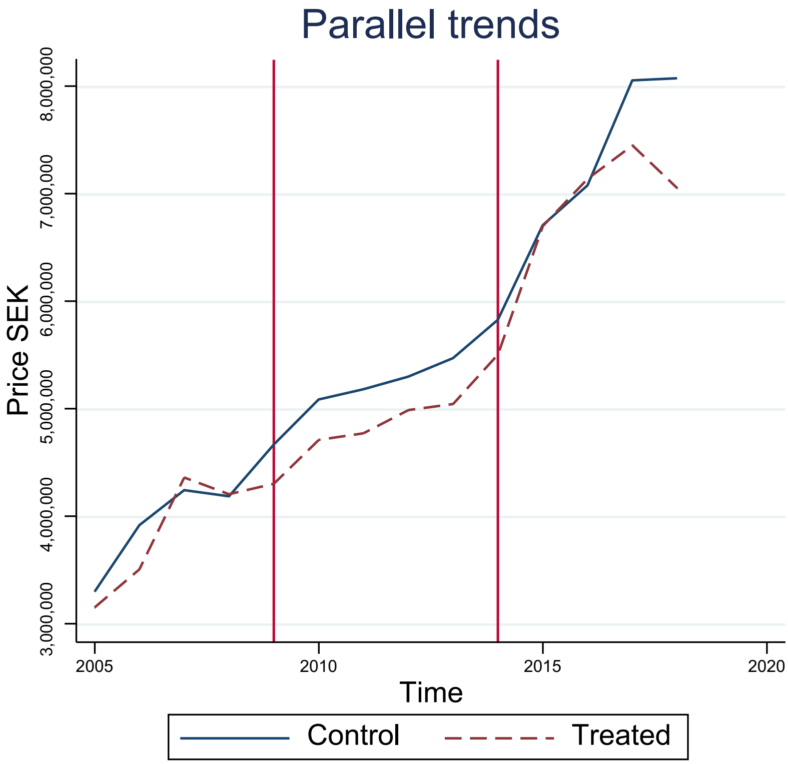
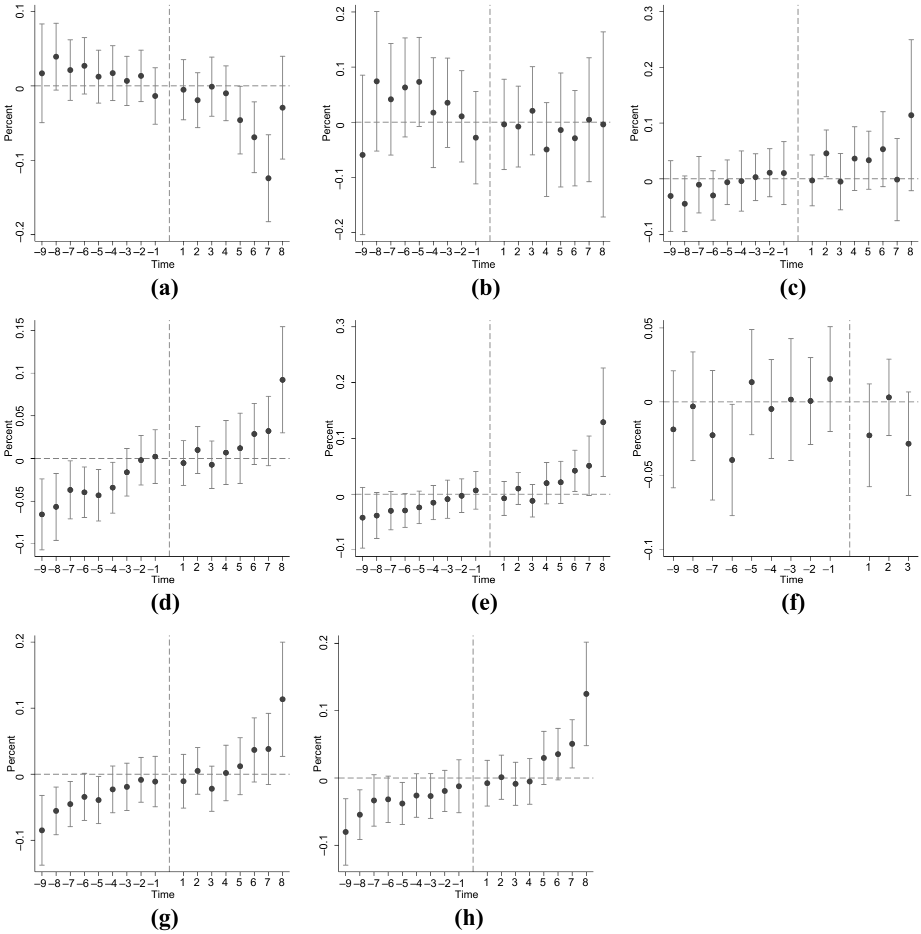


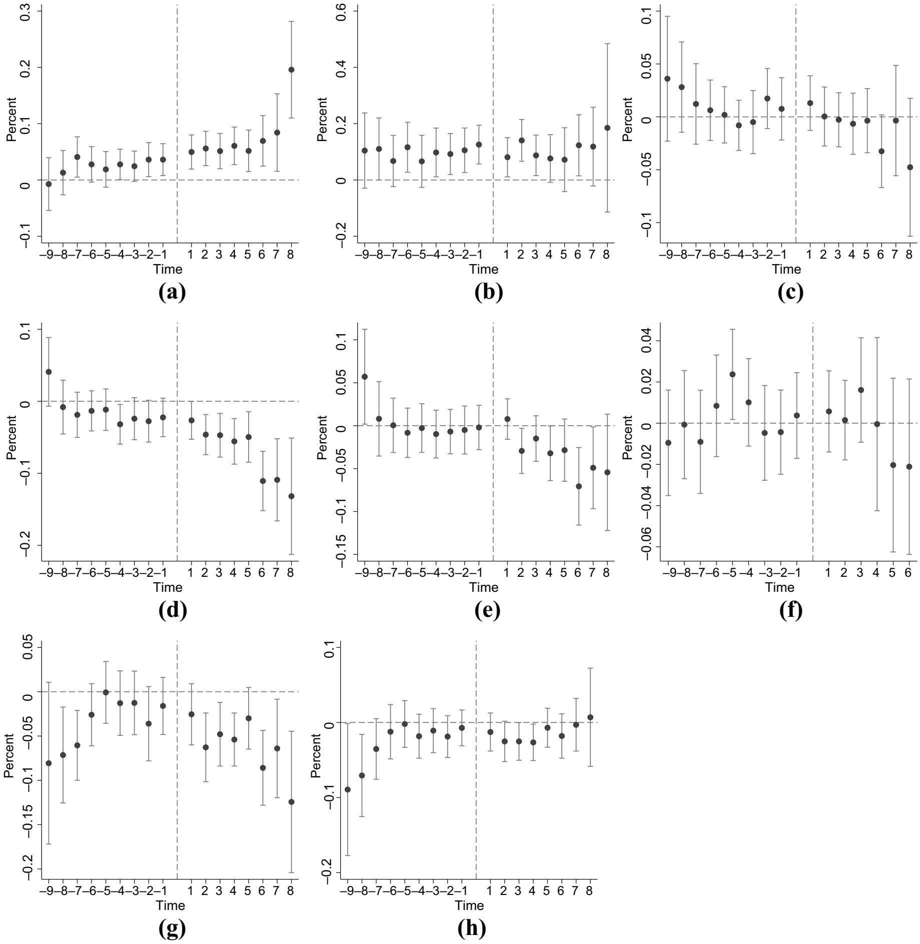
Figure A2.
Parallel Trends:
Single-family homes

Source: Data from the City of Stockholm and Svensk Mäklarstatistik. Calculation and figure: Author's work



Notes: The plot shows the robustness test for new multifamily housing construction. Eight different tests: living area as the outcome variable (a), plot area as the outcome variable (b), treatment area 300 metre (c), treatment area 700 metre (d), control area 2000 metre (e), placebo test (f), one treatment (g) and reverse treatment order (h). We have time from minus 9 to plus 8 on the horizontal axis. The zero in the timeline is where the event occurs and is indicated with a red vertical line. The percentage impact of the housing price variable on the outcome is on the vertical line. The results are the point estimate and the 95% confidence interval. Cluster-robust standard errors.
Source: Data from the City of Stockholm and Svensk Mäklarstatistik. Calculation and figure: Author's work based on (Jann, 2016)

Figure A3.
Robustness test - New multifamily houses



Notes: The plot shows the robustness test for new single-family housing construction. Eight different tests: living area as the outcome variable (a), plot area as the outcome variable (b), treatment area 300 metre (c), treatment area 700 metre (d), control area 2000 metre (e), placebo test (f), one treatment (g) and reverse treatment order (h). We have time from minus 9 to plus 8 on the horizontal axis. The zero in the timeline is where the event occurs and is indicated with a red vertical line. The percentage impact of the housing price variable on the outcome is on the vertical line. The results are the point estimate and the 95% confidence interval. Cluster-robust standard errors.
Source: Data from the City of Stockholm and Svensk Mäklarstatistik. Calculation and figure: Author's work based on (Jann, 2016)

Figure A4.
Robustness test: New single-family houses