NIMBYs for the rich and YIMBYs for the poor: analyzing the property price effects of infill development

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Abstract

Purpose – This paper aims to analyze how nearby property prices are affected by new construction projects in Stockholm. If there is an impact on property prices, the authors endeavor to investigate whether the effects vary among different areas within the municipality, for different groups of inhabitants and for different types of housing (i.e. public versus private housing).

Design/methodology/approach – The authors use a difference-in-difference specification in a hedonic model, and the sample consists of more than 90,000 observations over the period 2005-2013.

Findings – The results are robust and indicate that house prices in nearby areas increase following the completion of infill development. The results also indicate that infill development has a positive spillover effect on nearby dwelling prices only in areas with lower incomes, more public housing units and more inhabitants born abroad.

Originality/value – It provides an analysis on how nearby property prices are affected by new construction projects by creating a restricted control area, so as to make the treatment group and the control group more homogeneous. Thus, it mitigates any potential problems with spatial dependency, which can cause biased standard errors.

Keywords Difference-in-difference, NIMBY, Infill development, Residential construction, YIMBY

Paper type Research paper

1. Introduction

A combination of strong urbanization and incentives to use land more efficiently in many European and US city areas has led to arguments for infill development[1] (Duany *et al.*, 2010; Farris, 2001; McConnell and Wiley, 2010; Steinacker, 2003). However, current residents often raise concerns that infill development lowers nearby property prices. The Swedish capital of Stockholm is no exception. Research evidence thus far is mixed, with some studies showing that infill development projects lead to a positive impact on property prices (Ding *et al.*, 2000; Ellen and Voicu, 2006; Kurvinen and Vihola, 2016; Ooi and Le, 2013;

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Simons *et al.*, 1998); others find a negative impact (Du Preez and Sale, 2013; Funderburg and MacDonald, 2010; Wiley, 2009).

A housing shortage exists in many western European cities. If it is considered more profitable to develop land through the construction of taller and newer buildings, why are these buildings not being constructed? Perhaps, the most well-known problem is the opposition from current residents against development, often referred to as Nimbyism (not in my backyard) as opposed to the less well-known, contrarian view of Yimbyism (yes in my backyard). Community residents frequently argue that infill development will have negative effects, owing to, among other things, more traffic and lost open space (Burningham, 2012; Esaiasson, 2014; Evans, 2004; Green and Malpezzi, 2003; Malpezzi, 1996; Wolsink, 1994).

The aim of this paper is to analyze how nearby dwelling prices are affected by new multi-family construction projects in Stockholm. If there is an impact on dwelling prices, we endeavor to investigate whether the effects vary among different areas within the municipality, for different groups of inhabitants and for different types of housing (i.e. public versus private housing).

This paper contributes to research on the effects of infill development in several ways. First, it provides an analysis of how nearby property prices are affected by new construction projects by creating a restricted control area, to make the treatment group and the control group more homogeneous. Thus, it mitigates any potential problems with spatial dependency, which can cause biased standard errors[2]. This procedure was not used in earlier research using similar methodologies, such as studies by Ooi and Le (2013) and Zahirovich-Herbert and Gibler (2014).

In their study of the Singapore area, Ooi and Le (2013) use a hedonic model with a difference-in-difference specification, allowing for spatial time trends in house prices. Their contributions, in addition to determining the spillover effects of infill development, involve tracking the spillover effects over critical phases of the development process. They also analyze the heterogeneity of the spillover effects in terms of different attributes of the infill, such as scale and height of the new developments, and whether they are built on teardown sites. Although we can develop further their analysis on heterogeneity in terms of income, type of housing (public and private) and ethnicity, we are not able to test the hypothesis that the effects vary over time in the same detailed manner as carried out by Ooi and Le (2013). However, we estimate the effect per year and find that the effect occurs in the treatment year and is stable in subsequent years.

Second, this paper contributes by using quantile regression to examine whether house prices exhibit an asymmetric behavior across the price distribution, owing to infill development. As for the overall analysis, the effects across price distribution also differentiate between large and small construction projects. Although Zahirovich-Herbert and Gibler (2014) perform a quantile regression, they do not use a difference-in-difference specification of the hedonic price equation or the spatial effects model.

Third, this paper makes use of a spatial drift model, thereby enabling a thorough understanding of the socioeconomic context. Similar to Ding *et al.* (2000), we analyze the differences between low-income and high-income areas. In contrast to that study, however, our hedonic price model is combined with a difference-in-difference approach and a cluster design, to identify the new development projects geographically. The data available in this study is extensive, with approximately 40,000 observations between 2005 and 2013. By including the aspects of income and ethnic background, we are in a position to compare the effects on property prices from new housing projects in areas with ethnic and economic variations. In contrast to earlier studies, the differences between public and private housing structures are also explored here. Thus, the results of this study can provide a foundation for policymakers in their decisions on urban planning.

Fourth, this paper provides an analysis of how nearby property prices are affected by new construction projects in Stockholm, which is segregated in economic and ethnic terms and experiences high levels of in-migration from other parts of Sweden. However, available land is limited, which leads to a demand for infill construction. Despite an ongoing debate about the pros and cons of infill development, there is no available research that systematically studies the spillover effects of infill development within the context of Stockholm. Earlier literature is based heavily on studies carried out in countries characterized as more liberal market economies. A city such as Stockholm is better characterized as a coordinated market economy and is, therefore, a more appropriate case study than earlier studies (Ceccato and Wilhelmsson, 2011). It could be argued that infill developments should be compared among countries, as institutional settings can generate different results (Rafiqui, 2010).

The remainder of this paper is organized as follows: Section 2 provides a theoretical framework and a literature review. Section 3 presents the arguments for choosing the municipality of Stockholm as our area of study. Section 4 discusses the hedonic pricing methodology, the difference-in-difference approach and the method of constructing clusters to identify new development projects geographically, and Section 5 presents the data. The empirical results are presented in Section 6, and Section 7 concludes the paper.

2. Theory and literature review

In this section, we begin by identifying the most common definitions of the terms *infill development*, and by clarifying the definition used in this paper. In the theoretical framework, we then provide arguments for and against infill. Furthermore, we review the literature on the empirical evidence regarding the types of impact (i.e. negative impact, positive impact and no evidence of impact) of infill on property values.

2.1 Definitions of infill development

The broadest definition of infill, according to McConnell and Wiley (2010), is "development that occurs in underused parcels in already developed, urbanized areas" (Maryland Department of Planning (MDP), 2001; Municipal Research and Services Center of Washington, 1997; Northeast-Midwest Institute, 2001). Infill development is mostly associated with city centers, where the focus is often on carrying out revitalization projects and/or increasing density (Farris, 2001; Steinacker, 2003). However, infill can also occur in suburbs where there are underused parcels of land (McConnell and Wiley, 2010). Some definitions also include redevelopment, wherein existing buildings are replaced by higher structures at higher density (Wheeler, 2002). Other aspects to consider are the size of the infill development (Ding *et al.*, 2000; Zahirovich-Herbert and Gibler, 2014), the type of family home – that is, single-family homes (Galster *et al.*, 2004) or multifamily homes – and the condition or state of the area (Ooi and Le, 2013).

In this paper, we define infill development as new construction of multifamily cooperative apartment buildings in urban areas with existing houses and/or existing multifamily cooperative apartment buildings. Hence, the new construction of small houses is not included in our definition. We also make a distinction between small and large building projects. We do not include the rehabilitation of existing housing. Thus, following our definition, infill development projects consist of new apartment buildings only.

2.2 Theoretical framework

The focus of this paper is the impact of infill development projects on property values. Economic, sociological and ecological aspects can create positive spillover effects (i.e. higher property prices) and negative spillover effects (negative property prices owing to, e.g. increased supply or higher traffic). In the remaining paragraphs of this subsection, we will elaborate on these theoretical aspects concerning both positive and negative spillover effects.

From an economic perspective, undeveloped areas within primarily developed urban areas represent an economic opportunity for denser development in later periods (McConnell and Wiley, 2010). Higher land prices will cause developers to substitute structural capital for land, resulting in higher density (Ottensmann, 1977). The creation of denser urban environments means that efficiency can be improved through reduced sprawl and increased use of mass transit (Burchell and Mukherji, 2003; Danielsen *et al.*, 1999). There is a positive correlation between access to public transport and house prices (Debrezion *et al.*, 2007; Dubé *et al.*, 2014). As infill opens up homeownership to more residents, the community's tax base increases, resulting in the provision of more and better public services (Malpezzi, 1996); this has a positive effect on property prices (Thompson, 2017; Larsen and Blair, 2010). Besides, an increase in the number of residents increases retail and commercial opportunities, with potential positive spillover effects. The amenity effect of infill relates to the overall appeal of the neighborhood; for example, the construction of new buildings on vacant lots that used to attract dumping, vandalism and crime improves the esthetics of the area (Ellen *et al.*, 2001; Ooi and Le, 2013), which could create positive spillover effects (Ceccato and Wilhelmsson, 2011).

The amenity effect, which proponents argue is positive, can be negative if, among other things, open space is lost, traffic increases locally and new construction leads to overcrowding and decreased services (McConnell and Wiley, 2010). Existing homeowners may not favor increased density, and, according to Flint (2005), density has a bad reputation. Dye and McMillen (2007) mention increased pollution and traffic noise, disruption to local traffic patterns and loss of neighborhood character as reasons why existing property owners fear infill. One aspect of neighborhood character can include the desire of people with certain interests and lifestyles to live with people who share these interests and lifestyles, and this, together with race- and income-based discrimination, can also explain opposition to new development (McConnell and Wiley, 2010). Furthermore, there can be a supply effect if the construction of new houses reduces the property values of nearby existing houses by increasing supply, while demand remains constant (Simons *et al.*, 1998). The supply effect can be either directly if the market segment is the same or indirectly if filtering through submarkets occurs. Together, the supply effect and the amenity effect can reduce property values, thus resulting in a loss for the existing homeowners (Ooi and Le, 2013; Zahirovich-Herbert and Gibler, 2014).

Glaeser (2011) denounces the Nimbyism (rather than Yimbyism, the contrarian view formed in opposition to Nimbyism) that accompanies infill because it can hinder the construction of new houses, increase house prices and create cities that are available only to rich people. Nimbyism is the idea that citizens would oppose the establishment of facilities in their neighborhood, but would raise no opposition to similar developments elsewhere (Burningham, 2012; Esaiasson, 2014; Evans, 2004; Green and Malpezzi, 2003; Hermansson, 2007; Malpezzi, 1996; Wolsink, 1994). Glaeser (2011) discusses two powerful and interacting psychological tendencies behind the popularity of Nimbyism, the status quo *tendency* and the *effect tendency*. The status quo tendency is illustrated in an experiment by Kahneman *et al.* (1990) in which subjects are given coffee mugs and then presented with the option of either paying more to keep their coffee mugs or paying less to buy exactly the same coffee mugs. Kahneman *et al.* find that the subjects, preferring to maintain the status quo, are prepared to pay more to keep their coffee mugs. The effect tendency is illustrated in a study by Gilbert *et al.* (1998) in which people tend to overestimate how their happiness is affected by a negative shock. For example, the construction of a new building may make some people unhappy, but, in reality, they will adjust quickly to this new situation. From these theoretical aspects of positive and negative spillover effects that form either proponents or opponents of new construction, we will now review the empirical evidence on price effects from infill development.

2.3 Literature review of empirical evidence on price effects

There is a substantial amount of research on Nimbyism (Burningham, 2012; Esaiasson, 2014; Wolsink, 1994), as well as on the impact of a new construction or a rehabilitation project on nearby property prices. In the following subsections (Sections 2.3.1-2.3.3), we will review these impact studies based on the type and design of infill and the methodologies used. As we will show, the empirical evidence on price effects is mixed.

2.3.1 Negative impact on house prices. Studies that show negative effects mainly refer to social housing or other types of infill (e.g. the construction or the announced construction of office buildings, shopping centers and stadiums) rather than residential infill. Only one study involving classic residential infill (Wiley, 2009) shows negative price effects.

Studies on the infill development of social housing (also referred to as public housing, affordable housing, supportive housing and low-income housing tax credit projects) have yielded mixed results. Funderburg and MacDonald (2010) show that the siting of new low-income housing projects is associated with a 2-4 per cent slower rate of appreciation in nearby single-family home valuation. The effect is persisting for five or more years after project approval. However, with improved site planning and design and the development of projects targeted at mixed-income groups, Funderburg and MacDonald find that it is possible to avoid the negative effects. According to Nguyen (2005), most first-wave studies show positive effects, whereas second-wave studies, in which hedonic price models are used, show mixed results. She concludes that the likelihood of a decline in property values increases when the design quality of affordable housing is poor, affordable housing is located in dilapidated neighborhoods that contain disadvantaged populations, and affordable housing residents are clustered. There appear to be no price effects when affordable housing is located in vibrant neighborhoods, the structure of the housing does not change the character of the neighborhood, the housing management is responsive to problems, and affordable housing is dispersed. When negative price do effects exist, they are found to be small.

An exception to the presence of small effects is reported in a study by Du Preez and Sale (2013). Using a hedonic price model, they find that the establishment of social housing development in Walmer Township in South Africa produces large negative effects on nearby property prices. This township had earlier been designated to be in a "whites only" area. A typical house in the neighborhood under investigation (located 500 m from the project site) would experience a 49 per cent rise in value if it were located 3,200 m away.

In his study on the impact of infill on property values, Wiley (2009) reports negative – albeit small (less than a 0.5 per cent decline) – effects on property values for higher-income areas. However, Wiley also finds that infill development tends to benefit lower-income areas. Wiley uses a hedonic price model with a difference-in-difference analysis, thus attempting to account for other factors in the local area that affect house prices but were unrelated to the infill.

2.3.2 No evidence of impact. Pollakowski *et al.* (2005) find no significant effects on single-family house prices related to the introduction in the Boston area of a large-scale, high-density, mixed-income and multifamily rental development. Using a case study approach, they identify seven development projects and select corresponding impact areas. They then use a hedonic model to construct an index for the impact area and the control area. Similarly, Blanchard *et al.* (2008) also use a case study approach (as well as postal survey methodology) in their analysis of residential areas in Idaho. They find no evidence of a decline in property prices accompanying infill construction; however, without the hedonic price model and difference-in-difference specification, it is not possible to isolate the effects on prices from the infill.

2.3.3 Positive impact. Most studies using hedonic price models and difference-in-difference analyses have found that residential infill development produces a positive impact. Ding *et al.* (2000) and Simons *et al.* (1998) investigate residential development in cities based on the hypothesis that developments can have positive spillover effects on certain neighborhoods. Analyzing new and rehabilitation projects and their effects on single-family residential property values in Cleveland, OH, in two periods during the 1990s, both studies find a positive impact on nearby values. Ding *et al.* (2000) note that the effects diminish beyond 300 ft (91.5 m) from the construction site and are the greatest for low-income areas and for large-scale projects. Simons *et al.* (1998) also find housing prices increase with proximity, but, in contrast to Ding *et al.*, they find that the effects diminish for large-scale projects.

In addition to using a hedonic model, Galster *et al.* (2004) use a difference-in-difference approach to control for factors other than those generated by the supportive housing development project. They find a positive impact on single-family homes in the area between 1,000 and 2,000 ft (305 and 610 m) from the project site. Similarly, Ellen *et al.* (2001) use a difference-in-difference design in their hedonic price model and find that properties near the construction site increase in value. Ellen and Voicu (2006) find that the impact remains stable over time for nonprofit organizations but declines for-profit organizations. For large projects, the impact from nonprofit and profit organizations is the same, but for small projects, the impact from profit organizations is larger.

A recent article by Ooi and Le (2013) analyzes the price effect of mixed infill development in neighboring areas. They use a data set from Singapore consisting of more than 55,000 sales transactions of dwellings and 275 new developments between 1997 and 2011. They estimate a hedonic model with a difference-in-difference specification to capture the causal effect better but they (like most others) do not control for spatial dependence. Their findings indicate that infill development has a positive and persistent impact on housing prices in neighboring areas, with this impact greater if the infill is built-in teardown areas. The scale does not seem to be significant, but height has a negative impact.

In another recent article, Zahirovich-Herbert and Gibler (2014) show that new construction in the form of classic infill creates positive externalities. The strongest effects are found within one-fourth of a mile (about 400 m), and for new houses that are larger than average-sized houses and for houses with values lower than others. The construction of average-sized houses has little effect on existing house prices. Zahirovich-Herbert and Gibler do not use a difference-in-difference specification of the hedonic price equation or the spatial effects model. Instead, they use fixed neighboring effects to capture spatial dependency, and they perform a quantile regression to capture the distribution of house prices. Their sample comes from Baton Rouge, Louisiana, and consists of single-family transaction data between 1984 and 2005.

Using a research design with matched samples and hedonic-based difference-in-difference regressions, Kurvinen and Vihola (2016) examine multistory apartment building proposals to determine the value impact on apartment units in the Helsinki area built in the era of industrialized mass production in the 1960s and 1970s. The building developments exist in city blocks with a declining housing price trend relative to nearby blocks outside the development impact radius but within the same zip code area. The authors find that the completion of an apartment building has a positive and statistically significant immediate impact on surrounding apartment values (2.3-2.6 per cent) but no significant impact on the price trend. They conclude that, even if the study suggests a positive value impact from residential infill, this in itself will not turn a declining neighborhood into the most wanted district of the city. A more comprehensive revitalization requires a mix of development measures.

3. The study setting: Stockholm

We chose the municipality of Stockholm as the setting of the present study for four reasons. First, choosing a setting with the same political governance throughout helps minimize differences in land policy that might affect observations. Second, the municipality of Stockholm experiences high levels of in-migration from other parts of Sweden but has limited land available, which leads to a demand for infill construction. By investigating this type of situation and presenting a debate on new construction in developed areas, this article may produce findings of relevance to policymakers in Stockholm and elsewhere. Third, the municipality of Stockholm is segregated in both economic and ethnic terms (Musterd, 2005), which is one of the independent variables in our model. Fourth, our local knowledge of Stockholm helps us in choosing independent variables and clusters (size and number).

Stockholm's design follows that of many old Swedish cities. It is built around the core of a town dating from the middle ages, which was complemented with trees and stone buildings in a grid plan during the period 1600-1850. In the late 1800s, the grid plan was complemented with large boulevards as a way to limit the potential devastation caused by fires. From 1930 to 1970, the development of the city was based on modernist ideas and was largely influenced by the use of cars, which created the possibility of long-distance traveling, thereby lowering the density of Stockholm.

The population of the municipality of Stockholm is just over 900,000 inhabitants. The land area is 188 km^2, of which 40 per cent constitutes park areas and green spaces. The population density is 4,786 inhabitants per square kilometer. The density of Stockholm is higher than the densities of the 50 largest cities in the Nordic countries and is a great deal higher than the densities of average-sized cities in the USA. Compared with the densities of the 100 largest cities in the world, the density of Stockholm is above the median value.

Stockholm is not homogeneous based on population income, the proportion of the population born abroad or homogeneous in the distribution of public housing. In Table I, descriptive statistics of some socio-economic variables are presented for the entire Stockholm metropolitan area. As Table I shows, the variation between parishes in household incomes is highly evident. On average, about 35 per cent of the population has an income that is in the range SEK 160,000-320,000. The parish with the lowest percentage in this range is as low as 27 per cent with a maximum of 42 per cent. The spread in the proportion of born abroad is greater. About 25 per cent of the population has a foreign background. The lowest percentage that can be found in one parish is 12 per cent and the highest is as high as 67 per cent. This gives an indication that segregation is high. Even when it comes to the distribution of public housing, it can be seen that the spread is large, from 2 to 52 per cent.

We have no statistics on completed infill development projects regarding the type of land they use. In the most central locations, it is mainly about not only replacing existing housing but also using land that has been used for recreation such as parks. In the suburb, infill development projects are more about using land that has been used for light industry and, in some cases, more heavy industry, and virgin land in the vicinity of existing residential areas. Housing development projects in Sweden generally follow a similar process. What follows is a very simplified explanation of the process:

- A prospective investor(s) calculates the land's highest value and best use to estimate whether development is profitable;
- Because the municipality generally decides what should be constructed within the municipality's borders, the investor has to obtain approval for the project from the municipality. Several issues must be addressed before an approval is granted, and one issue of particular interest to the present study is that new development should be socially sustainable; that is, new construction should potentially prevent segregation from occurring within the city (Musterd and Andersson, 2005). From a societal view, new construction should also be economically beneficial in that it creates conditions for economic growth; and
- The third stage is the project stage, which entails choosing the final design and constructing the building(s).

The period required to perform this process for an infill project – from the initial idea to its final construction – is difficult to estimate. If the second stage is carried out without any problems, then this stage takes approximately one year. However, owing to the lack of resources within many municipalities, it might take several years. The third construction stage takes approximately two to three years.

The process in Sweden is similar to what occurs in many other European countries but with one key difference: municipalities in Sweden have more independence. In other European countries, municipalities have to adhere to compulsory national and regional regulations and guidelines to a greater extent.

4. Methodology

Our results are based on a difference-in-difference model using repeated cross-sectional data. The first cross-sectional data set contains transactions made before the new infill developments, and the second data set contains transactions made after the developments.

Variable	Mean	Min	Max
Income 0	7.56	4.78	16.31
Income 0.1-159.9	27.84	23.50	37.84
Income 160-319.9	34.75	26.28	42.10
Income 320-499.9	18.97	9.77	23.98
Income 500 and more	10.89	2.38	19.53
Immigrants all	24.74	12.24	66.80
Immigrants born abroad	19.17	10.25	47.05
Immigrants born in Sweden	5.58	1.99	19.75
Municipal rental	21.67	2.28	52.42
Private (other) rental	30.65	12.31	49.25
Cooperative	47.69	16.95	71.01

Table I.
Descriptive statistics of socio-economic variables for Stockholm. For each variable, the percentage (yearly average) is presented

The implicit assumption is that the transactions are randomly drawn from the same population, which means that the transactions from the first cross-sectional data set can be used as proxies for the transactions in the treatment and the control groups in the second cross-sectional data set (Stock and Watson, 2012, p. 535). Hence, we do not make any distribution assumptions about the infill developments, only about the transactions used to estimate the treatment effect.

Our estimating process is based on the following five steps:

(1) traditional hedonic model;

(2) difference-in-difference (DiD) model;

(3) quantile regression;

(4) socioeconomic drift (SD) model; and

(5) spatial regression model (as a robustness check).

4.1 Default model

The main objective is to estimate the effect of infill development on property values. The basic framework is to estimate a hedonic price equation, where the price of the property HP is a function of property P and apartment A characteristics and neighborhood N characteristics. The hedonic price equation can be described as:

$$HP_{i,t} = b_0 + b_1 P_{i,t} + b_2 A_{i,t} + b_3 IF_{i,t} + b_4 N_{i,t} + b_5 T_{i,t} + e_{i,t}, \quad (1)$$

where T is a matrix of (monthly) time binary variables and IF is a dummy that equals 1 if the house or apartment is near an existing infill development and 0 otherwise. For example, a house that was sold in the year 2008 and is near an infill development that was constructed that year will be given the value 1. However, a house that was sold in the year 2008 and is near an infill development that was constructed later (e.g. the year 2010) will have the value 0. Construction date refers to the completion of the house. In the transaction data, we have information about when the buyer signed the contract and when the transaction was completed, i.e. when the buyer moved into his home (occupancy year). For new homes, this means that contract signing dates may refer to pre-sale. However, it is not this date that has been used in the identification of new projects. The majority of apartments in a new property will have the same occupancy year and this occupancy year will be the same as the construction year on the property. This is how the identification of apartments in infill developments has been made possible.

For larger projects, we cannot assume that development projects start of construction and completion will take place within a year. It takes several years from decision to production and to finished house. As we do not have information when there have been changes in plans, when the project has been granted building permits and how long it took to build the house, there is a risk of bias in our results using data based on the completion date. We discuss this issue as we present our results.

In equation (1), subscript i is the transaction, t represents the time and N is a vector of neighborhood fixed effects. We are mainly interested in b_3; that is, we are interested in the effect of infill developments.

The main problem with a traditional hedonic model is that it suffers from omitted variable bias and selection bias (Machin, 2011). By using pooled cross-sectional data (i.e. data before and after the infill construction), we can determine an infill development's effect on nearby house prices and reduce the selection bias (Wooldridge, 2006). In the literature, this method is called a natural experiment or a quasi-experiment.

To estimate a difference-in-difference hedonic model, we need to create two new variables measuring infill development (i.e. the previous variable *IF* cannot be used in a difference-in-difference estimation). The first variable that we create is *Near*, which indicates a closeness to a new residential development regardless of whether the infill development is produced at the time of the transaction of an apartment. This means that *Near* measures the effect of the specific site where it will either be built or already have been built. The interpretation of its effect refers to the price effect of the site before and after construction. It is a dummy variable, equal to 1 if the transaction is within 200 m from the infill development (otherwise 0). Zahirovich-Herbert and Gibler (2014) define the rings around the new construction to be 90 and 150 m, while Ooi and Le (2013) use a ring of 500 m. To test the robustness of the estimates, we also test 100 and 300 m from new infill development. If a house is close to several infill developments, only the closest infill development is regarded as a treatment (i.e. we do not model multiple treatments within a single year). However, if a house or an apartment is close to infill developments that occur in separate years, then that house or apartment can have several treatments.

Creating *Near* in the treatment period allows us to estimate a so-called difference-in-difference hedonic equation model (Galster *et al.*, 2004; Kiel and McClain, 1995; Wooldridge, 2006; as well as Dehring *et al.*, 2007; Dhar and Ross, 2012; Ooi and Le, 2013; Voicu and Been, 2008; Wiley, 2009).

The second variable that we create is *Treatment*, which is a dummy variable that equals 1 for transactions and periods subject to infill developments. In other words, *Treatment* equals 1 for transactions that are close to new residential development during the treatment period. An implicit assumption is that the treatment effect is equal for each year.

As a consequence, our model is now specified as follows:

$$HP_{i,t} = b_0 + b_1 P_{i,t} + b_2 A_{i,t} + b_3 Near_{i,t} + \gamma_1 Treatment_{i,t} + b_4 N_{i,t} + b_5 T_{i,t} + e_{i,t}. \tag{2}$$

For our purposes, the difference-in-difference estimator of γ_1, the coefficient of the interaction variable *Treatment*, is of special interest. It measures the causal treatment effect, which is the change in house and apartment prices attributed to being close to new development following an infill development. The estimated treatment effect is valid as long as the assumption is correct that the prices of apartments located both close to and far from new developments do not change at different rates for other reasons (Wooldridge, 2006). That is, contrary to Diamond and McQuade (2019), we are not estimating the DiD estimator in a non-parametric setting where treatment is a smooth function of distance to the specific infill development site and time, as the project was completed.

The data set used for the estimation of the difference-in-difference model does not include infill developments constructed during the period 2005-2007 because these data are used to identify infill developments (and consequently, transactions) that are near an infill development project.

The b_3 coefficient is interesting, as it measures whether the infill development was built in an area with higher or lower house or apartment prices. The model will be estimated for cooperative apartments.

The estimations are based on a full sample and a so-called restricted sample. The restricted sample is defined as a radius of 500 m around an infill development (Figure 1). The treatment group consists of houses or apartments within 200 m of the infill development, and the control group consists of houses or apartments 200-500 m from the infill

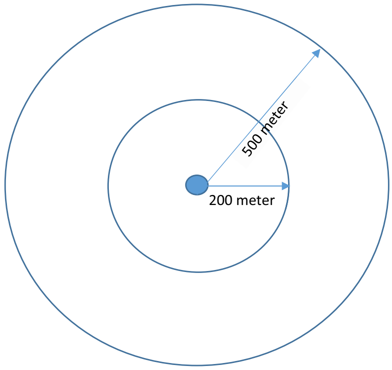

Figure 1. Control group (restricted sample) and treatment group

development. The purpose of calculating a restricted sample, where we only include transactions within a radius of 500 m from infill development, is to test how robust our estimates are. However, the choice of 500 m is arbitrary, but we vary distance in our sensitivity analysis.

In the full sample, all transactions that are not in a treatment area are considered to be in the control group. For obvious reasons, some of them are close to the treatment area, and some are far away. The main reason for creating a restricted sample is to mitigate any potential problems with spatial dependency, which can cause biased standard errors. The restricted sample will likely make the treatment and control groups more homogenous. This method is not used in studies by, for example, Ooi and Le (2013) or Zahirovich-Herbert and Gibler (2014).

In addition to using the aggregated measure of total infill development, we test the hypothesis that large and small projects have potentially different effects on nearby properties. This hypothesis was previously tested by Ellen and Voicu (2006). We define a large project as a project that is larger than the average-sized infill development[3]. Our main hypothesis is that, while large projects have larger price effects on nearby properties, smaller development projects have smaller effects. It is also reasonable to suggest that the spillover effects of smaller development projects are more geographically limited.

Similar to the hypothesis testing carried out by Ooi and Le (2013), we test the hypothesis that the treatment effect varies over time. Because our data are limited, we estimate the effect per year. This is not explicitly shown in equation (2). The treatment time effect has been accomplished by interacting with the time dummies with the treatment variable.

4.2 Quantile regression

A quantile model allows the estimation of the effect of the infill development on the conditional distribution of house prices. That is, the estimation of quantile regression models aims to examine whether house prices, in the presence of infill development, exhibit an asymmetric behavior across the price distribution (various quantiles). The quantile regression model is, in this respect, more flexible than ordinary least squares (OLS). For a description of the method, see an earlier work by Koenker and Bassett (1978); for examples of recent applications of quantile regression models, see McMillen (2008), Ceccato and Wilhelmsson (2011), Liao and Wang (2012), Zahirovich-Herbert and Gibler (2014), Zhang and Wang (2016), Zhang (2016), Amédée-Manesme *et al.* (2016) and Waltl (2016), as well as two recent papers by Rajapaksa *et al.* (2017) and Yoo and Frederick (2017). All these articles indicate that quantile regression analysis is suitable for a segmented housing market. An article by Zietz *et al.* (2008) was one of the first to use quantile regression in a hedonic modeling framework. The authors conclude that some of the variations in estimated hedonic implicit prices derives from the fact that housing attributes are not priced the same across the price distribution. Hence, it is of interest to analyze whether the infill development effect is equal across the price distribution. Other reasons to use quantile regression are that quantile regression estimates are more robust against outliers, compared with OLS regressions (Koenker, 2005; McMillen and Thorsnes, 2006), and that they reduce the effect of heterogeneity (Koenker, 2005). The quantile regression model can be written as follows:

$$HP_{i,t} = b_0 + b_1(\tau)P_{i,t} + b_2(\tau)A_{i,t} + b_3(\tau)Near_{i,t} + \gamma_1(\tau)Treatment_{i,t+4} + b_4(\tau)N_{i,t} + b_5(\tau)T_{i,t} + e_{i,t}, \quad (3)$$

where τ is the quantile of the dependent variable (Kostov, 2009). Quantile regression is based on the minimization of weighted absolute deviations (Zietz *et al.*, 2008).

4.3 Socioeconomic drift model

In general, if a housing market is hypothesized to be uniform or homogenous, the size and statistical significance of the estimated coefficients of the included explanatory variables on house prices are based on the assumption that there exists only a uniform competitive market. However, many housing markets are not uniform. Instead, several submarkets might exist within a large housing market, and each submarket might have its own demand and supply characteristics, thereby implying submarket heterogeneity in the coefficients of the hedonic attributes. Indeed, if submarket heterogeneity results in different coefficient estimations, this will reflect the existence of a segmented housing market, for example, owing to varying local neighborhood characteristics in terms of socio-economic factors, physical features and accessibility to and size of urban amenities and public services (Can, 1992).

Can (1992) discusses different econometric approaches to model neighborhood effects and how to incorporate coefficient heterogeneity into hedonic models based on the assumption that there exist several geographic submarkets and, thus, different coefficients for different submarkets. One of these approaches involves the estimation of the switching regression models where the housing market is divided into several homogenous geographic segments and the application of Chow tests to find evidence of the existence of varying coefficients between submarkets and the entire market.

In this paper, instead of dividing the entire housing market into different segments based on geographic delineations, we divide the Stockholm housing market into different subsamples based on three dimensions that reflect socioeconomic heterogeneity as follows: differences in income, the number of public housing units and the ethnic background of inhabitants (Ding *et al.*, 2000). The starting point in the segmentation is parishes, where we have data on population income, the proportion of public housing and the proportion of the population with a foreign background. Each parish has been classified if they have an income level that exceeds a standard deviation above average income or a standard deviation below average income. We have done in a similar way concerning public housing and country of birth. It has enabled us to classify each parish and to create housing segments into three different dimensions. Using this approach allows us to compare the effects of infill developments across socioeconomically diverse areas.

4.4 Robustness check

As a sensitivity test, we relax the assumption of no spatial dependency that is concerning the influence of space in our hedonic model. Spatial effects can be classified as *spatial dependence* and *spatial heterogeneity*. Spatial dependence, on the one hand, is a consequence of the existence of spillover effects, the omission of spatially correlated variables, measurement error and misspecification of the functional form. Spatial dependence means that observation at one location depends on observations at many other locations (Wilhelmsson, 2002). Spatial heterogeneity, on the other hand, concerns the uneven distribution of transactions (Anselin, 2010).

We adopt the estimation approach formulated by Elhorst (2010). We begin by estimating an OLS model. Next, we perform diagnostic tests on the residuals, to compare different spatial models, such as the spatial autoregressive (SAR) model, the spatial error model (SEM) and the spatial Durbin model (SDM). We then perform the Lagrange multiplier (LM) test, the robust LM test and the likelihood ratio test (Anselin, 1988; Anselin *et al.*, 1996). The selection of a spatial weights matrix involves using a goodness-of-fit measure, such as the log-likelihood value, to distinguish different weight matrices (Stakhovych and Bijmolt, 2009).

Furthermore, as a sensitivity test, we test whether the treatment area and the control area have significant effects on the results. In addition to the default radius of 500 m, we examine the control area at radii of 1,000 and 1,500 m. For the treatment area, we examine radii of 100 and 300 m in addition to the default radius of 200 m. Both the spatial econometric models and the variation in the radii of the treatment and control areas are presented in the Appendix.

5. Data

The data (provided by Valueguard AB) are based on arm's-length transactions of cooperative apartments (94,000 sales observations) over the period 2005-2013. By co-operative apartments, we mean condominiums where the owner jointly owns the property together with other tenants in the property. The respective owners are entitled to the use of a specific apartment. In Table II, descriptive statistics are presented for both the full period (2005-2013) and the treatment period (2008-2013).

The estimation of the hedonic price equation uses six attributes to explain the price variation. We find that the average prices are slightly lower in the restricted sample than in the full sample. Besides, we find the average transaction price to be higher in the treatment group than in the control group, indicating that infill development has a positive effect. The first attribute measures the fee to the management of the cooperative housing company, expressed on a monthly basis. The fee for each apartment is normally based on the apartment's area in relation to the total area of the property. This fee is higher in the treatment group than in the control group, suggesting that the monthly fee cannot explain the higher average transaction price in the treatment group. The second and third attributes measure the size of the apartment (measured as the number of rooms and square meters of living area, respectively). There is no difference in size between the treatment group and the control group. We also include, as the fourth and fifth attributes, the age of the property and the distance to the central business district (CBD) in the price equation. There is no difference between the groups in terms of the distance to the CBD, but there is a rather big difference in the average building year. The apartments in the treatment group are, on average, 10 years younger than those in the control group, which may potentially explain the price difference between the two groups. Finally, as the sixth attribute, we use distance

Table II.
Mean descriptive statistics for property and location attributes

Variables	Full sample	Restricted sample	Treatment group	Control group
Transaction price (SEK)	2,404,731 (1,429,721)	2,194,814 (1,202,450)	2,380,949 (1,220,196)	2,160,787 (1,196,067)
Fee (SEK)	2,991 (1,304)	3,109 (1,319)	3,341 (1,322)	3,066 (1,314)
Number of rooms	2.25 (1.93)	2.27 (1.02)	2.30 (1.00)	2.27 (1.02)
Square meters, living area	60.64 (25.92)	60.74 (24.41)	61.79 (23.81)	60.55 (24.51)
Building year	1945 (34)	1952 (31)	1960 (34)	1951 (31)
Distance to CBD (meter)	4,079 (2,888)	4,441 (2,906)	4,592 (2,714)	4,414 (2,940)
Observations	94,351	42,283	6,535	35,748

Notes: Standard deviation values within parentheses; CBD = Central business district to infill as a treatment variable. In addition to the above variables, there are also fixed effects regarding time and space.

We identify infill developments by using the data set consisting of all transacted cooperative apartments in the Stockholm area from 2005 to 2013. Because we want to estimate the causal effect of proximity to new developments on house and apartment prices, it is important to define what is meant by an infill development. In this paper, an infill development is defined as the new construction of multifamily cooperative apartment buildings in urban areas with existing houses and/or other multifamily cooperative apartment buildings. Any new construction of small houses is not considered to be an infill development.

As we use only transaction data and not data regarding, for example, building permits for infill development projects in Stockholm, we have had to identify the infill developments differently. The basic principle has been to identify new construction projects by analyzing transactions with a building age of zero years and how they cluster in space.

The data are divided into two separate cross-sectional data sets, 2005-2007 and 2008-2013. We use the second data set to identify the location of the infill developments. Sales with the building year of 2008 and sales in the year 2008 are identified as infill developments. We do the same for each year from 2009 to 2013. Consequently, we construct six new data sets of infill developments, one for each year. For each data set, the x and y coordinates of the infill developments are included.

Because infill developments involve the new construction of multifamily apartment buildings, there will naturally be several transactions that can be regarded as belonging to the same infill development. By applying the clustering technique, we create boundaries around the individual transactions that belong to the same infill development. The next step is, therefore, to use cluster analysis to group all transactions of newly constructed houses and apartments into clusters (infill developments). We apply a partitional clustering method to construct 50 clusters[4] for each year from 2008 to 2013. Clusters in 2008 are remained in the model, with 2009-2013 clusters adding up. Transactions can belong to only one of the clusters. The clusters can, of course, contain different numbers of transactions.

Table III shows the average housing prices in the treatment group and in the control group, together with the standard deviation in different segments of the housing market. In almost all segments, average housing prices are higher in the treatment group than in the control group, which indicates that infill development has a potentially positive effect. Here it is important to analyze for differences in the characteristics of the dwellings before drawing any conclusions.

Socioeconomic area	Treatment group	Control group
Low income (SEK)	1,477,707 (604,191)	1,484,414 (715,040
High income (SEK)	3,128,585 (1,497,001)	2,746,750 (1,416,171)
More public housing (SEK)	1,844,631 (790,940)	1,631,972 (741,940)
Less public housing (SEK)	3,003,639 (1,330,336)	2,631,764 (1,320,449)
More born abroad (SEK)	1,899,327 (825,974)	1,676,955 (776,219)
Less born abroad (SEK)	3,116,874 (1,347,151)	2,778,320 (1,352,680)

Note: Standard deviation values within parentheses

Table III. Mean and standard deviation of transaction prices in different socioeconomic areas

6. Econometric analysis

6.1 Default model

First, we present in this section the estimates concerning the hedonic model with the difference-in-difference specification. In the second section, we present the results from the SDM. In the final section, we show the results of the quantile regression model. The results from the cooperative condominium market and the results from the full sample and the restricted sample are presented in Table IV. All estimates are based on OLS, and only the treatment effect variables (*Near* and *Treatment*) are presented in the table. The dependent variable is expressed as the natural logarithm of price. The independent variables living area, and monthly fee are natural logarithm transformed. All coefficients concerning the housing characteristics are presented in Table AI in the Appendix. Each cluster is classified as either a large or a small infill development project. We do this by counting the number of transactions in each cluster. If the number is above average, we define it as a large project; if it is below average, we define it as a small project. Thus, for each of the 50 clusters, we have classified these based on whether they are likely to be a small or large project. Clusters containing many observations are classified as larger projects.

The model uses 94,337 observations in the full sample and 41,763 in the restricted sample, and the model's goodness of fit is high (adjusted R^2). Around 85 per cent of the price variation can be explained by the explanatory variables. The estimates concerning infill developments are robust (full sample versus restricted sample) and statistically significant. All estimated parameters are significant (except one) and positive, indicating that:

- areas with infill developments already had a positive effect on nearby apartments; and
- the effect after the completion of the infill was even larger.

The variation of this price effect is around 2 per cent, depending on the specification of the rings around the development and the number of clusters. The effect is almost the same as those reported in studies by Ooi and Le (2013) and Zahirovich-Herbert and

Table IV. The effect of infill development (new multifamily projects) on multifamily unit prices (DiD models) coefficients and *t*-values (within parenthesis)

Models	Variables	Multifamily Full sample	Restricted sample
All projects	Near	0.0135 (4.52)	0.0161 (4.71)
	Treatment	*0.0233* (6.02)	*0.0192* (4.61)
Adj. R^2		0.8556	0.8403
No. of obs		94,337	41,763
Large projects	Near	0.0138 (3.04)	0.0065 (1.36)
	Treatment	*0.0182* (2.94)	*0.0215* (3.53)
Adj. R^2		0.8554	0.8497
No. of obs		94,337	22,090
Small projects	Near	0.0079 (1.84)	0.0188 (3.62)
	Treatment	*0.0289* (4.79)	*0.0131* (1.97)
Adj. R^2		0.8554	0.8323
No. of obs		94,337	20,858

Notes: Restricted sample maximum = 1,000 m from the new project. *Near* and *Treatment* maximum = 200 m from the new project. The dependent variables are transaction price in its log-form

Gibler (2014). The treatment effect seems to be of the same magnitude regardless of the size of the project, thereby contradicting our hypothesis when we are analyzing the full sample, but the results are reverse in the restricted sample. Hence, our results are not conclusive.

6.2 Quantile regression

Similar to a previous study by Zahirovich-Herbert and Gibler (2014), we estimate a quantile regression to determine whether the effect is different in different portions of the price distribution. The results from the quantile regression model are presented in Table V.

In comparison to the OLS model, a quantile regression model has the potential to offer more information on the relationship between house prices and the effect of infill development. Our results indicate that the infill effect is rather robust across the price distribution. The variation of this price effect is around 1.5-2.0 per cent in the quantile interval of 0.2-0.8 for all projects. In the lower quantile and in the higher quantile, the effect of infill development is smaller. Moreover, it seems that the effect is marginally smaller in the higher portion of the price distribution, especially for large projects. The coefficients concerning small projects vary across quantiles, but only one of them is statistically significant. The results consistently show that infill development effects are not negative and are not significantly different from zero. Hence, only large projects exert a positive, significant impact on prices, from 1.5 to 3 per cent, across most of the price distribution (quantile interval of 0.2-9.7).

6.3 Socioeconomic drift model

For the SDMs, we estimate the models in different subsamples of the data. The subsamples are based on differences in income, the number of public housing units, and the ethnic background of the inhabitants. The results are presented in Table VI.

The category *low income* refer areas where the income level is less than the average income level in the region, the category *more public housing* refers to areas with more public housing than the average, and the category more born abroad refers to areas where the population to a higher degree are born abroad than in the rest of the region. The results that emerge are very interesting. The results are robust in the market for cooperative dwellings. Infill developments have a positive price effect on nearby properties/dwellings but not in all submarkets. Infill developments have a positive effect only in low-income areas with more

Percentile	All Coefficient	*t*-value	Large projects Coefficient	*t*-value	Small projects Coefficient	*t*-value
0.1	0.0117	1.49	0.0109	0.93	0.0190	1.63
0.2	*0.0148*	2.61	*0.0231*	2.78	0.0127	1.30
0.3	*0.0207*	4.42	*0.0307*	4.34	0.0143	1.83
0.4	*0.0197*	4.24	*0.0217*	3.22	*0.0189*	2.64
0.5	*0.0201*	4.42	*0.0197*	3.01	0.0075	1.16
0.6	*0.0205*	4.65	*0.0168*	2.61	0.0060	0.77
0.7	*0.0204*	4.69	*0.0148*	2.12	0.0060	0.83
0.8	*0.0166*	3.67	0.0064	0.92	0.0078	1.06
0.9	0.0064	1.25	0.0142	1.62	−0.0007	−0.09

Note: The dependent variables are transaction price in its log-form

Table V. Results quantile regression model. Effects across price distribution. Treatment effect. Restricted sample public housing units and more people born abroad. In high-income areas, infill developments have no effect at all (i.e. the effect is neither negative nor positive).

6.4 Treatment effect over time

We also estimate the infill effect per year – that is, three years before the treatment year and five years after the treatment year. The results concerning the full sample and the restricted sample are presented in Figure 2. The effect is shown as the difference in price index between the treatment group and the control group. This effect is detected in both the full sample and the restricted sample. However, all individual estimates are not statistically different from zero. Nevertheless, it seems that the effect occurs in the treatment year and is stable in the following years.

The treatment effects over time from the spatial drift model are presented in Figure 3. These results confirm the results in Table V: infill development has a significant impact on nearby properties in low-income areas, in areas with more public housing and in areas where more inhabitants are born abroad. Overall, the treatment effect is a lump-sum effect: there is a shift in the price index in the treatment year, and, over the years that follow, the price indices are parallel.

6.5 Sensitivity analysis

We perform two different sensitivity analyses in this study. The first analysis takes into account the assumption regarding the size of the treatment and control areas. A radius of

Table VI. Results SDM. Treatment effect and restricted sample

Socioeconomic area	All Coefficient	*t*-value	Large projects Coefficient	*t*-value	Small projects Coefficient	*t*-value
Low income	*0.0992*	*7.26*	0.0270	0.10	*0.1398*	*5.35*
High income	0.0068	1.17	−0.0191	−1.56	0.0115	1.51
More public housing	*0.0263*	*4.23*	*0.0233*	*3.09*	*0.0313*	*2.67*
Less public housing	−0.0035	−0.81	*−0.0164*	*−2.16*	0.0040	0.66
More born abroad	*0.0298*	*4.86*	*0.0262*	*3.20*	*0.0315*	*2.84*
Fewer born abroad	−0.0057	−1.25	−0.0014	−0.17	0.0082	1.31

Notes: Italic values are statistically significant at a 95% significance level. In the 18 models presented in the table, the adjusted R^2 varies from 0.74-0.91. The dependent variables are transaction price in its log-form

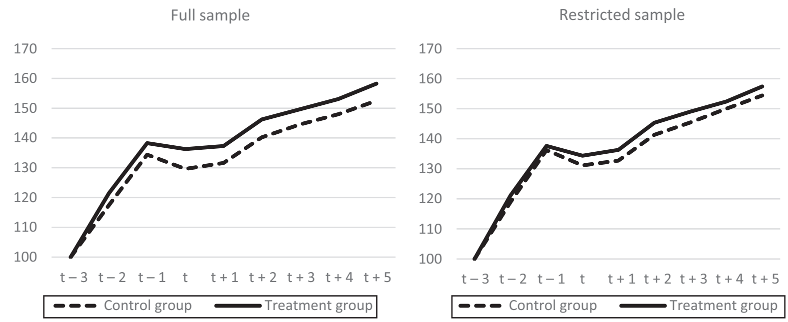

Figure 2. Price index for control and treatment group

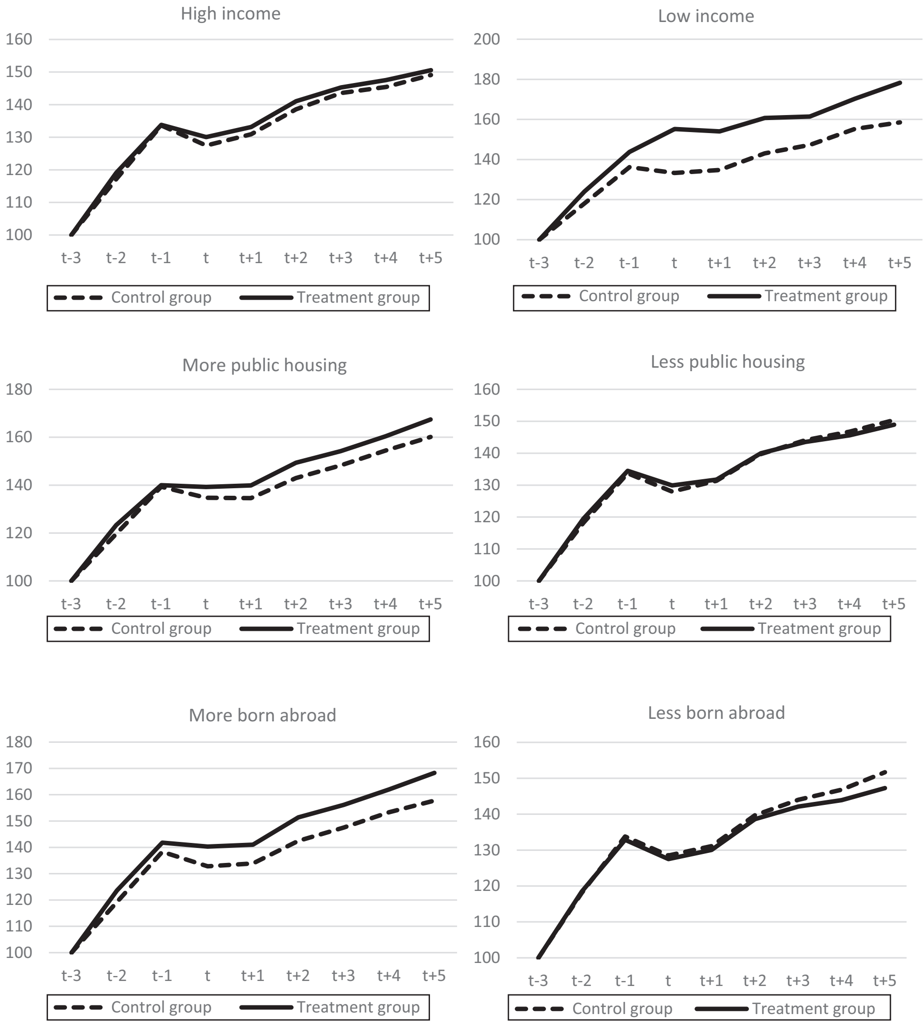

Figure 3.
Price index for control and treatment group (spatial drift models)

200 m for the treatment area and a radius of 500 m for the control area represent the default ratio. We vary these ratios to analyze whether the treatment effect is dependent on this assumption. The second assumption we test is the assumption of no spatial dependence. By estimating the SAR model, the SEM and the SDM with different spatial weight matrixes, we can analyze the impact on the estimates.

The size of the control areas seems to have a minor impact on the results (see Table AII in the Appendix). Overall, our results seem to suggest that the larger the control area, the smaller the estimated treatment effect. However, the difference in effect is not conclusive. The size of the treatment area does seem to have a major impact on the estimates. Smaller treatment areas seem to indicate a larger treatment effect. One conclusion that can be drawn from this is that the spillover effect is local. Interestingly, the magnitude of the spillover effect is not smaller for smaller development projects than for large ones.

The results concerning the spatial regression models are presented in Table AIII in the Appendix. As our results show, the OLS estimates are of the same magnitude as the results from the SAR model, the SEM and the SDM. The OLS results might be considered a little higher than the results from the spatial models. This suggests that OLS estimates tend to overestimate the positive impact of infill development. However, most of our results from the spatial regression models are statistically significant. The effect seems to vary from 1 to 2 per cent.

7. Conclusion and policy implications

A combination of strong urbanization and shortage of land in many European city areas prompts an impetus of infill development, with current residents often raising concerns that lower nearby property prices. The aim of this paper is to analyze how nearby property prices are affected by new construction projects in Stockholm, Sweden.

We use a difference-in-difference specification in a hedonic model, and our sample comprises approximately 40,000 observations over the period 2005-2013. We test for spatial dependency by estimating the following spatial models: the SAR model, SEM, SDM and SDM. We also estimate quantile regression models to analyze whether the treatment effect varies across the price distribution.

Our results are robust and indicate that housing prices in nearby areas increase following the completion of infill developments. Our results are thus in line with those of other studies finding positive spillover effects (Ding *et al.*, 2000; Ellen *et al.*, 2001; Ooi and Le, 2013; Simons *et al.*, 1998; Zahirovich-Herbert and Gibler, 2014). Our results also indicate that infill development has a positive spillover effect on nearby housing prices only in areas with lower incomes, more public housing units, and more inhabitants born abroad. We estimate the effect to be around 1 per cent of the apartment price. The effect does vary with the size of the infill development depending on how we define the control area, and it varies by housing segments.

Our findings highlight several policy implications. Residents opposed to new multifamily construction projects owing to their perceived risk of lowering nearby property prices lack scientific evidence for their concerns – a situation that policymakers need to be aware of. By contrast, there is support for Yimbyism in areas where incomes are low, more public housing units are available, and more inhabitants are born abroad. At the same time, there is no support for Nimbyism in areas where incomes are high and fewer inhabitants are born abroad, and there is only limited support where there are fewer publicly owned housing units. Policymakers' understanding of Nimbyism may thus be inaccurate, which can slow planning processes and reduce the supply of housing.

In Sweden, many inhabitants with low incomes and foreign backgrounds live in the Million Program residential areas – that is, areas where about 1 million dwellings were built between 1965 and 1974 but have not undergone modernization in recent years. According to our findings, infill developments in these areas will increase the property values of the existing multifamily buildings. This is line with findings from previous studies, for example, by Farris (2001), Steinacker (2003) and Kurvinen and Vihola (2016). New construction projects tend, among other things, to revitalize teardown areas, expand the tax base and increase the inhabitants' purchasing power, thereby improving private and public services, as well as the aesthetics of the area (Ellen *et al.*, 2001; Malpezzi, 1996; Ooi and Le, 2013).

The findings of this paper support the existence of positive price effects from increased infill development in certain areas. Therefore, policymakers need to expend greater efforts to understand better the nature of the neighborhood changes derived from infill development (Kim, 2015).

Notes

1. Throughout the paper, we will use the terms infill or infill development interchangeably.
2. See Wilhelmsson (2002) and Anselin (1988). The problem arises because we cannot assume constant variance across space.
3. Theoretically, a large project should be defined not by the average size throughout the city, but by what is near the infill development. However, in this study we are using the same definition across space because of lack of data.
4. The choice of 50 clusters is arbitrary. However, we also perform a cluster analysis with 500 clusters; however, changing the number of clusters does not yield different estimation results.

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Appendix

Variables	All projects Coefficients	t-value	Large projects Coefficients	t-value	Small projects Coefficients	t-value
Treatment	0.0192	4.76	0.0215	3.60	0.0131	2.03
Near	0.0161	5.11	0.0065	1.45	0.0187	4.03
Living area	0.8047	133.48	0.7794	98.58	0.8471	92.95
Rooms	0.1313	29.07	0.1401	23.47	0.1142	17.96
Fee	−0.1793	−43.46	−0.1676	−31.09	−0.2138	−31.26
Floor	0.0131	27.80	0.0139	23.15	0.0147	22.02
Building year	−3.0703	−36.93	−2.0631	−18.83	−2.2796	−19.57
Distance to CBD	−0.1239	−48.63	−0.1938	−48.92	−0.0993	−33.84
Constant	36.54	58.41	29.3358	0.01	29.5411	32.98
Observations	41,763		22,090		20,858	
R^2	0.8403		0.8497		0.8323	

Notes: Coefficients concerning parish and time are not shown in the table. CBD = central business district

Table AI. Results OLS-model. The difference-in-difference hedonic model (multifamily with restricted sample)

Table AII.
Sensitivity analysis. Different sizes of treatment and control groups

Control area		500 m		1,000 m		1,500 m	
Treatment area	Variables	100 m	300 m	100 m	300 m	100 m	300 m
All projects	Near	0.0064 (1.15)	0.0061 (2.06)	0.0040 (0.73)	0.0033 (1.25)	0.0013 (0.24)	0.0008 (0.30)
	Treatment	0.0443 (6.26)	0.0165 (4.87)	0.0517 (7.43)	0.0177 (5.76)	0.0143 (1.85)	0.0192 (6.23)
Large projects	Near	0.0093 (1.20)	0.0019 (−0.52)	0.0096 (1.23)	−0.0016 (−0.50)	0.0543 (7.71)	0.0044 (1.41)
	Treatment	0.0546 (5.20)	0.0096 (2.18)	0.0643 (6.08)	0.0119 (2.93)	0.0581 (5.51)	0.0093 (2.33)
Small projects	Near	−0.0018 (−0.17)	0.0126 (2.96)	0.0035 (0.35)	0.0153 (2.05)	−0.0157 (−1.59)	−0.0007 (−0.20)
	Treatment	0.0503 (3.77)	0.0072 (1.38)	0.0553 (4.28)	0.0116 (2.44)	0.0700 (5.50)	0.0220 (4.74)

Table AIII. Results spatial regression model. Effects across price distribution. Treatment effect. Restricted sample. All projects

Variables	SEM n2	SEM n20	SAR n2	SAR n20	SDM n2	SDM n20
Near	0.0133 (3.64)	0.0110 (3.16)	0.0135 (3.52)	0.0186 (4.56)	0.0121 (4.19)	0.0099 (1.24)
Treatment	0.0233 (6.02)	0.0053 (1.30)	0.0172 (5.78)	0.0186 (5.90)	0.0085 (3.92)	0.0019 (0.63)

Notes: SAR = spatial autoregressive model; SDM = spatial Durbin model; and SEM = spatial error model; The notation n2 and n20 means two neighbors and 20 neighbors, respectively