Gentrification effects on housing prices in neighbouring areas

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Abstract

Purpose – This study aims to measure the occurrence of gentrification and to relate gentrification with housing values.

Design/methodology/approach – The authors have used Getis-Ord statistics to identify and quantify gentrification in different residential areas in a case study of Stockholm, Sweden. Gentrification will be measured in two dimensions, namely, income and population. In step two, this measure is included in a traditional hedonic pricing model where the intention is to explain future housing prices.

Findings – The results indicate that the parameter estimate is statistically significant, suggesting that gentrification contributes to higher housing values in gentrified areas and near gentrified neighbourhoods. This latter possible spillover effect of house prices due to gentrification by income and population was similar in both the hedonic price and treatment effect models. According to the hedonic price model, proximity to the gentrified area increases housing value by around 6%–8%. The spillover effect on price distribution seems to be consistent and stable in gentrified areas.

Originality/value – A few studies estimate the effect of gentrification on property values. Those studies focussed on analysing the impacts of gentrification in higher rents and increasing house prices within the gentrifying areas, not gentrification on property prices in neighbouring areas. Hence, one of the paper's contributions is to bridge the gap in previous studies by measuring gentrification's impact on neighbouring housing prices.

Keywords Sweden, Housing prices, Housing market analysis, spillover effects, gentrification, Getis-Ord statistics

Paper type Research paper

1. Introduction

Academic literature cites social/cultural factors, economic factors or some combination of both as the primary causes or drivers of gentrification. Rapid job growth, the key driver of gentrification in the inner-city during the gentrification wave from the late 1970s through the 1980s, is crucial for gentrification (Kennedy and Leonard, 2001). Housing market dynamics and tight housing markets, with short housing supply compared to job growth, are critical in generating gentrification and a contributing factor to increasing house prices in urban areas. Moreover, the preferences of certain demographic groups for easy access to city amenities create higher demand-side housing pressures (Kennedy and Leonard, 2001).

In many European cities, gentrification concerns were linked to public policy interventions (Atkinson, 2004). Demographic changes caused an increase in demand following the post-war "baby boom", where the segment of the population age 25–30 increased. In the 1970s, Britain's demand from this age group contributed to a rapid rise in housing market prices, accompanied by a sharp decline in family size due to several factors. More women joined the workforce due to increasing rates of divorce and unmarried persons. These factors contributed to a significant increase in the number of small families, consisting of one or two children and contributed to increased demand pressures in central city neighbourhoods (Ley, 1986). The durable racial hierarchy dominates residential selection and leads to gentrifying neighbourhoods (Hwang and Sampson, 2014).

Debates related to gentrification's impacts have always been distinguished as highly polarised (Easton *et al.*, 2020). Gentrification contributes to revitalising the city's neighbourhoods and urban development, which increases property values in the gentrifying area. However, few studies tried to explain the increased property values due to gentrification. Atkinson (2004) and Shaw (2010) suggest that having more wealthy householders and the physical rehabilitation of housing in neighbourhoods increases tax revenues and local services associated with further investment. Hence, this will lead to improvement of social mixing and less segregation. Simultaneously, gentrification can impose tremendous pressures and exorbitant costs (rent, taxes and other maintenance costs) on low-income families and elderly residents living on fixed incomes, as well as a loss of affordable housing. That contributes to increasing the "exclusionary displacement" caused by the displacement of low-income residents and changing of the neighbourhood's cultural fabric and flavour (Chum, 2015; Atkinson, 2004; Kennedy and Leonard, 2001; López-Morales, 2016; Walks *et al.*, 2021).

Although gentrification has been studied for over 50 years, significant complexity and confusion remain in gentrification studies due to differences in the methodology and strategy used to define the gentrified neighbourhoods (Barton, 2016). However, concentrating on demographics in terms of socioeconomic status changes represents gentrification's best measure (Braswell, 2018). Emphasising demographic changes was the focus of quantitative studies (Barton, 2016), where gentrification is accompanied by increases in the number of households and changes in residential demographic structure. In addition to growing housing stock (Kolko, 2007), income represents the most precise and coherent measure of socioeconomic change (Hedin *et al.*, 2012; Ellen and O'Regan, 2008, 2011; Ding *et al.*, 2016; McKinnish *et al.*, 2010). Therefore, we have used population changes and income as measures of gentrification in our study.

This study's primary purpose is about *how* to measure the occurrence of gentrification, *estimate* the concentration of gentrified areas between 2007 and 2013 and *relate* gentrification with housing values two years later in Stockholm, Sweden.

The major research questions we seek to answer are:

RQ1. Where are the gentrified areas in metropolitan Stockholm during the study period?

RQ2. Is there a relationship between housing gentrification and neighbouring housing prices?

RQ3. Does proximity to gentrified areas have a positive effect on nearby housing prices? In other words, do the gentrified areas have a positive impact on housing values not only in gentrifying areas but also on housing values in nearby neighbourhoods?

Here, gentrification is defined as the process whereby new high-income households displace low-income households. This process contributes to change the basic features and flavours of that neighbourhood and its residents (Marcuse, 1985; Kennedy and Leonard, 2001; Smith, 1996). The research questions will be addressed using Getis-Ord statistics to identify and quantify gentrification in different residential areas in Stockholm. Gentrification will be measured in two dimensions, change in income and population, between 2007 and 2013. The hedonic price model will be used to explain cross-sectional housing prices (2014–2015). Finally, we will examine the relationship between housing gentrification and neighbouring housing prices; that is, we will include a spatial spillover component in the hedonic price model.

A few studies estimate the effect of gentrification on property values (Guerrieri *et al.*, 2013; Ley, 2002). Those studies focussed on analysing the impacts of gentrification in higher rents and increasing house prices within the gentrifying areas, not gentrification on property prices in neighbouring areas. Hence, one of our paper's contributions is to bridge the gap in previous studies by measuring gentrification's impact on neighbouring housing prices. Our study seeks to examine the measurable impacts of gentrification on property values in neighbouring areas for gentrifying areas, not only within gentrification neighbourhoods in Stockholm.

The remainder of the paper is divided into six major sections. Section 2 presents the concept of gentrification. It opens with a review of previous studies on gentrification and its effects. Section 3 explains our research methodology and the different model approaches used. Section 4 describes the different data sets used. Section 5 presents the empirical analysis by analysing gentrification estimated by income and the total population of the city of Stockholm between 2007 and 2013. We examine the causal effect of gentrification on housing prices. Finally, the paper concludes with a discussion of the study's results and implications in Section 6.

2. Concept of gentrification
The term gentrification was coined by Glass (1964) and was first identified in London during the 1960s. The term was used to describe the "invasion" of traditionally working-class neighbourhoods by middle- and upper-class residents (Ilic *et al.*, 2019; He, 2007; Barton, 2016). It resulted in the displacement of the indigenous low-income residents and changes in the neighbourhood's socioeconomic character (Barton, 2016). The first definition concentrated on the rehabilitation of existing buildings. The gentrification concept expanded to include new units' redevelopment as a part of broad urban redevelopment (Rérat *et al.*, 2010).

Hackworth and Smith (2001) have identified three waves of gentrification, the first wave beginning in the 1950s and continuing until the economic recession of 1973. This wave was irregular and state-led, where reinvestment (funded by the public and private sectors) targeted inner-city districts in US, Western Europe and Australia. The state's intervention was often justified by urban degradation, but it negatively affected the urban low-income class. The second wave from the late 1970s continued almost until the end of the 1980s. This wave was characterised by expansion gentrification and it often materialised during the recovery of real estate markets. Gentrification was integrated into a broader range of economic and cultural processes on the national and global levels (Hackworth and Smith, 2001; Podagrosi *et al.*, 2011). Scott (2019) indicates that widespread and significant gentrification began in the late 1950s and early 1960s in large US cities such as New York.

Since the 1990s, the third wave of gentrification has expanded into inner-city neighbourhoods and the more distant neighbourhoods outside the immediate city centres.

With the continuous displacement of the working class from the inner city, effective resistance to gentrification has decreased. The state contributed to the gentrification process more than in the other two waves, fuelling the third wave (Hackworth and Smith, 2001). Immergluck (2009) indicates researchers' agreement that the third wave saw more state leadership of gentrification (Lees *et al.*, 2008; Smith, 2002).

Atkinson (2004) discusses the possible effects of the gentrified neighbourhood in price-shadowing, such as increased rents and price and policy impacts on adjacent neighbourhoods. Atkinson (2004) also cited studies done by Wyly and Hammel (1999) and Shaw (2000) that aimed to examine the resurgence of gentrification in eight American cities between 1992 and 1997. Wyly and Hammel's (1999) study showed that gentrified neighbourhoods obtained two and a half times more mortgage loans than homebuyers in the suburbs. This had an impact on neighbouring areas. In some cities, gentrified neighbourhoods surrounded islands of poverty and increased gentrification pressures. Shaw (2000) indicates the impact of the neighbourhoods undergoing gentrification on a deprived area of Sydney's Aboriginal population, created in the early 1970s and known as "the block". The transformation of the surrounding areas made The Block appear out of place, and worsened the Block's economic and social problems, which gentrification was purported to solve.

Hedin *et al.* (2012) examine the social, geographic change in Sweden's three largest cities, Stockholm, Gothenburg and Malmö, between 1986 and 2001. The study displays the Swedish housing policies, governed by the market with limited state engagement. In addition to relating the gentrification mappings and low-income filtering to neoliberal housing policies, the study indicated the growth of super gentrification and low-income filtering and that social, geographic polarisation intensified during the study period.

Guerrieri *et al.* (2013)'s study investigated the extent and nature of urban housing price movements during citywide real estate boom periods. They developed a spatial model that links house prices' movements in urban neighbourhoods and the gentrification of those neighbourhoods in response to a city-wide housing demand shock. The model is based on the concept of "endogenous gentrification", the tendency of high-income individuals to move to poor neighbourhoods located directly on the border of affluent neighbourhoods, where people prefer to live next to more affluent neighbours. This in-migration process contributes to increasing house prices in more impoverished neighbourhoods and leads to poorer residents leaving their original neighbourhoods; the proximity to affluent neighbourhoods represents neighbourhood gentrification. The study found that gentrification is higher by 64% for neighbourhoods located within 0.5 miles of affluent neighbourhoods, consistent with Kolko's (2007) results showing that neighbouring tract income contributes to gentrification and indicated positive inter-neighbourhood spillovers. Gentrification probability was greater in neighbourhoods closer to wealthier neighbourhoods.

Ley *et al.* (2002) compare the effects of immigration, social polarisation and gentrification upon housing prices in Canada's principal cities, Toronto and Vancouver. They estimated the three factors' relative contributions to the changing maps of house values between 1971 and 1996 in both cities. The study showed that house prices between the two cities were consistent in terms of spatial patterns, with a difference in the three factors' importance at different times and places. In terms of the gentrification effect, their results vary between the two cities. In Toronto, gentrification was not too evident as an effect and showed a weaker positive correlation to house values changes. In Vancouver, all three factors showed modest positive relationships with inflating house values, followed by a weaker gentrification factor.

Although scholars recognise the dangers of displacement as a consequence of gentrification, there is no agreement on the magnitude of influence, which remains a controversial issue. Chum (2015) aimed to examine displacement geography in the city of Toronto from 1999 to 2001. The study indicates a significant relationship between gentrification and evictions. The early gentrification may lead to increased demand for houses and rent increases, which increases the vulnerability of low-income residents to evictions. The study results correspond with Murdie and Teixeira (2011), who uncover the effects of gentrification in west-central Toronto. The results indicated an increase in property values in gentrifying areas, rent increases and loss of affordable housing. Low-income people and immigrants are the most affected in gentrifying areas.

What drives house prices and why can we expect gentrification to affect price levels in a gentrified area and its surroundings? The most obvious factors are population and income changes. More people with higher incomes demand housing in the area in question, which drives up prices. A certain momentum continues to gentrify areas that have begun the gentrification process. In addition to the population and income effect on demand and price, it is conceivable that there will also be a change in preferences, which increases demand further than justified by the population and income impact. Here one can, perhaps, also imagine a certain speculative element. A third reason may be that new housing production triggers the gentrification process in the area. New homes mean that a premium generally increases the price level in the residential area. The increased supply of housing also means a larger basis for private and municipal services of different types. This, in itself, entails price level increases.

3. Methodology
Our primary purpose is to estimate the relationship between housing values and proximity to gentrified housing areas, within and without gentrified neighbourhoods – i.e. any spillover effect. This section will illustrate our research methodology and the different model approaches and regression techniques used to estimate this relationship.

3.1 The gentrification variable
We use Getis-Ord statistics G_i* as a measure of a gentrified residential area to estimate the concentration of gentrified areas (hot spots) in Stockholm in the study period 2007–2013 on two variables, income and population changes.

Getis-Ord statistics G_i^* is used to study evidence of identifiable spatial patterns, specified a set of weighted features and distinguish statistically significant so-called "hot spots" and "cold spots". Besides, it determines and recognises cluster structures of hot and cold spots, concentrations of local observations. Other indices, such as Moran's I indices, do not distinguish between hot and cold spots. Therefore, we have used a G_i^* index. The standard definition of the Getis-Ord G_i^* statistic is:

$$G_i^* = \frac{\sum_{j=1}^n W_{i,j} X_j}{\sum_{j=1}^n X_j} \tag{1}$$

The sum of the weights (W_i) and the expectation (E) of G_i^* are:

$$W_i = \sum_{j=1}^n W_{i,j} \quad \text{and} \quad E\left(G_i^*\right) = \frac{W_i}{n} \tag{2}$$

G_i^* is usually standardised based on its sample mean and variance. The standardised G_i^* statistic for each feature is a Z score and attached to the statistical significance:

$$Z\left(G_i^*\right) = \frac{\sum\limits_{j=1}^{n} W_{i,j}X_j - \overline{X}\sum_{j=1}^{n} W_{i,j}}{S\sqrt{\frac{n\Sigma_{j=1}^{n} w_{i,j}^2 - \left(\Sigma_{j=1}^{n} w_{i,j}\right)^2}{n-1}}} \qquad (3)$$

where n = the total number of features, X_j = attribute value for feature j, the magnitude of variable X at incident location j over all n (j may equal i), W_{ij} = weight value between feature i and j that refers to their spatial interrelationship. A high positive Z score for a feature indicates a spatial clustering of hot spots, whilst a low negative Z score indicates a spatial clustering of cold spots and a Z score near zero indicates no apparent spatial clustering (Ord and Getis, 1995; Songchitruksa and Zeng, 2010).

3.2 The transaction data and the hedonic price model

The hedonic price model was developed and presented in a seminal article by Rosen (1974). The hedonic method will estimate the impact of area characteristics and proximity to other positive and negative externalities where housing values are related to several characteristics of the home and the residential area. Variables included in the price equation are living area, number of rooms and monthly fees in the apartment model. The distance to the shopping mall and central business district (CBD) will also be included, as well as the distance to different sub-centres of Stockholm. In addition, the distance to hot spots (gentrification) will be included in the model. The model that will be estimated can be illustrated with the below equation:

$$P_{i,t} = \alpha + \beta_1 X_{i,t} + \beta_2 S_{i,t-1} + \beta_3 D_{i,t} + \varepsilon_i \qquad (4)$$

where P is equal to price and X is a vector of housing and neighbourhood characteristics. S is the distance or proximity to the gentrified residential area and D is a vector of binary fixed effects. All letters in Greek are parameters to be estimated and subscript i indicates the number of observations and t indicates the time. Note that the variable S is lagged in time by $t-1$ to reduce the problem of endogeneity. The distance between transactions and hot and cold spots has been calculated using ArcGIS, a geographic information system for working with maps and geographic information. It calculates the distance and additional proximity information between the input features and the closest feature in another layer or feature class.

In addition to the traditional hedonic model, we have also estimated a so-called treatment effect (TE) model with and without propensity score (PS) as weights in the regression. The transactions that are considered treatment are within the gentrified area and right on the border. The control area consists of the closest area around the gentrified area. The intention is only to compare those within the gentrified area (treatment) with approximately comparable properties outside the control area using the PS approach. The purpose is to reduce the endogeneity and spatial dependency problems.

3.3 Quantile regression

Quantile regression is used to test the hypothesis that the capitalisation effect of proximity to a gentrified residential area varies in the price distribution. The estimation of quantile regression models explores whether house prices, in the presence of treatment, display an asymmetric behaviour across the price distribution. The quantile regression model is more flexible and more robust to outliers than ordinary least square regression (Koenker and Bassett, 1978) with

richer characterisation and description of the data. The quantile regression model can be written as follows:

$$P_i = \alpha + \beta_1(\tau)X_i + \beta_2(\tau)Treat_i + \beta_3(\tau)D_i + \varepsilon_i \qquad (5)$$

where τ is the quantile of the dependent variable (Kostov, 2009). Quantile regression is based on the minimisation of weighted absolute deviations (Zietz *et al.*, 2008). Recent applications of quantile regression models are, for example, McMillen (2008), Liao and Wang (2012), Zhang and Wang (2016), Zhang (2016), Amédée-Manesme *et al.* (2016), Waltl (2016) and Yoo and Frederick (2017).

4. Data and descriptive statistics

4.1 Disaggregated data and descriptive statistics

To achieve the study's purpose, we must integrate information on gentrification and property values within the case study area. Therefore, we have used data on income, population and housing values. The data we have used is spatial and provides information on the population at a disaggregated level for squares measuring $250 \, m^2$, where the total number of squares is 2,421. The following sections present the descriptive statistics and explain how we have estimated the concentration of gentrified areas.

To analyse housing gentrification, we have used the information about population income and the total populations of Stockholm presented in Tables 1 and 2.

As Table 1 shows, the average total number of people with income has increased by 9% from 2007 to 2013. The highest increase was for people with upper-middle income and high

	2007		2013	
Population income categories	Mean	SD	Mean	SD
Total number of people with income	288.337	346.53	315.57	369.48
Number of people with low income in the included area	73.7791	101.308	77.9654	105.152
Number of people with lower middle income in the included area	56.2398	67.5937	60.9717	71.502
Number of people with upper middle income in the included area	59.378	69.3397	66.3452	75.5665
Number of people with high income in the included area	98.9399	141.137	110.287	155.319
N	2,421		2,421	

Table 1.
Population income in the municipality of Stockholm in 2007 and 2013

Notes: Different income levels measured in 1,000 Swedish kronor are low income (<150), lower-middle (150–250), upper-middle (250–360) and high income (>360). Only income of persons aged 20 and older are considered

	2007		2013	
Population age categories	Mean	SD	Mean	SD
Total population in the included area	365.882	418.236	401.884	449.505
Age 0–6	30.8507	35.6897	37.5301	44.1648
Age 7–15	30.9552	35.5469	33.8321	35.6653
Age 16–19	15.7306	17.9877	14.9556	17.0603
Age 20–24	22.9672	33.3003	26.4618	33.8161
Age 25–44	125.359	168.56	137.154	177.045
Age 45–64	88.0541	103.344	94.2352	107.204
Age 65–W	51.9658	68.1541	57.7159	76.2803
N	2,421		2,421	

Table 2.
The total population of the municipality of Stockholm, 2007 and 2013

income in the area from 2007 to 2013 (12% and 11%), whilst the growth of people with lower-middle income and low income in the included area was 8% and 6%, respectively. This indicates an increase in the proportion of high-income people in Stockholm during the study period.

As Table 2 demonstrates, the average total population living in the included area has increased by 10% between 2007 and 2013. Similarly, the average for most population age groups increased, except for the age group 16–19, which decreased by 5%. The rate of increase for age group 20–44 was 24%, accompanied by a 22% increase in the proportion of the population age 0–6, a possible indication of an increase in the proportion of young families in Stockholm between 2007 and 2013. The lowest increase, 7%, was in the age group 45–64.

4.2 The measurement of gentrification

To measure gentrification in Stockholm during 2007–2013, we used the median income and population variables. The following section illustrates how we will estimate the gentrification areas. The first step was to create a dummy variable for income and the total population in 2007 and 2013, as shown in Table 3.

The table presents a dummy variable (0, 1) created for income. The value is equal to zero (0) when income is equal or greater than the income means and value one (1) when income is less than the income mean, where the income mean was for 2007 and 2013 (256.162 and 298.297, respectively). Similarly, a dummy variable was created for the population. The value is equal to zero (0) when the population is greater or equal the population mean and value one (1) when the population is less than the population means, where the population means was for 2007 and 2013 (365.8822 and 401.8842, respectively). The second step to measure gentrification was creating a dummy variable for measuring the change in income and total population during 2007–2013.

Table 4 shows gentrification by income, and a dummy variable (0, 1), that measures the change in income during 2007–2013. The value 1 (gentrification) indicates that median income in 2007 was less than average and in 2013 median income was higher than the average. At the same time, the value 0 (no gentrification) represents two cases. In the first, median income in 2007 and 2013 is higher than the average. In the second case, median

Dummy variable for income_2007	Frequency	(%)	Mean = 256,162
0	1,353	55.89	Income_2007 >= 256,162
1	1,068	44.11	Income_2007 < 256,162
Total	2,421	100.00	
Dummy variable for income_2013	Frequency	(%)	Mean = 298,297
0	1,391	57.46	Income_2013 >= 298,297
1	1,030	42.54	Income_2013 < 298,297
Total	2,421	100.00	
Dummy variable for population_2007	Frequency	(%)	Mean = 365.8822
0	967	39.94	Population_2007 >= 365.8822
1	1,454	60.06	Population_2007 < 365.8822
Total	2,421	100.00	
Dummy variable for population_2013	Frequency	(%)	Mean = 401.8842
0	939	38.79	Population_2013 >= 401.8842
1	1,482	61.21	Population_2013 < 401.8842
Total	2,421	100.00	

Table 3.
Dummy variable for income and the total population in 2007 and 2013

income in 2007 is higher than the average and in 2013 less than the average. Similarly, to measure the total population's gentrification, a dummy variable (0, 1) was created to measure the total population change during 2007–2013, as illustrated in Table 5.

As Table 5 presents, the value 1 (gentrification) indicates that the total population living in the included area in 2007 was less than the average, and in 2013 the total population was higher than the average. In contrast, the value 0 (no gentrification) represents two cases. In the first one, the total population in 2007 and 2013 is higher than the average. In the second case, the total population in 2007 is higher than the average and in 2013 is less than the average.

In the third step, we used Getis-Ord statistics G_i^* to estimate the concentration of gentrified areas (hot spots) and non-gentrified areas (cold spots) in Stockholm for the study period 2007–2013. As illustrated in Figures 1 and 2, changes of income and population are measured.

Figure 1 illustrates the results of Getis-Ord statistics (hot and cold spots) analysis for gentrification based on income. The hot spots (Gentrification) are concentrated in Stockholm's centre, in the Hägersten-Liljeholmen area. In the east of Stockholm, gentrified areas are concentrated in Skarpnäck and Farsta. The cold spots (no gentrification) are concentrated in the west of Stockholm, in Rinkeby-Kista, Spånga-Tensta and Hässelby-Vällingby, as well as cold spots distributed to the north of Stockholm and in parts of Norrmalm and Skärholmen, south of Stockholm.

Figure 2 presents Getis-Ord statistics (hot and cold spots) analysis for gentrification based on population. The hot spots (gentrification) are concentrated in Stockholm's centre, in the Hägersten-Liljeholmen area. East of Stockholm, hot spots are concentrated in Skarpnäck, Farsta and Enskede.

The gentrified areas (hot spots) with high-income people, especially in the centre and east of Stockholm, are the same spots where the population increased during the study period of 2007–2013. It is notable that the increase in income was accompanied by an increase in the population of the gentrified area. Furthermore, the increase in the market segment of high-income people was also associated with the construction of new buildings of higher quality and price. The cold spots (no gentrification) are concentrated in the west of Stockholm, in Rinkeby-Kista, Spånga-Tensta and Hässelby-Vällingby, the same areas in Figure 1. In the north of Stockholm, the cold spots are parts of Östermalm and, south of Stockholm, Älvsjö.

Gentrification _ income	Freq.	(%)	Method	Description
0	2,112	87.24	If income_2007 == 0 and income_2013 == 0 If income_2007 == 0 and income_2013 == 1	No gentrification
1	309	12.76	If income_2007 == 1 and income_2013 == 0	Gentrification
Total	2,421	100.00		

Table 4.
Gentrification based on income in the city of Stockholm 2007–2013

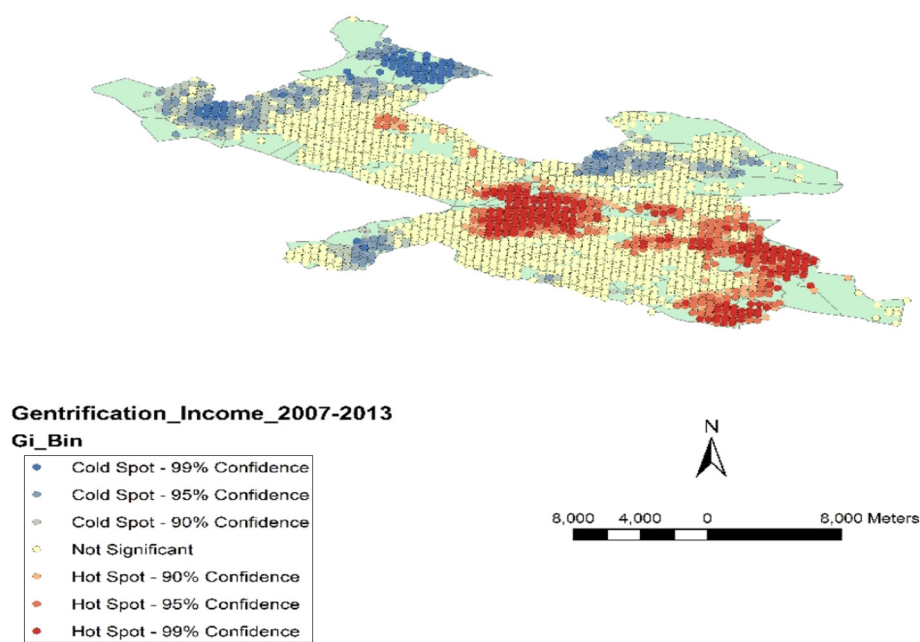| Gentrification _ population	Freq.	(%)	Method	Description
0	2,200	90.87	If population_2007 == 0 and population_2013 == 0 If population_2007 == 0 and population_2013 == 1	No gentrification
1	221	9.13	If population _2007 == 1 and population_2013 == 0	Gentrification
Total	2,421	100.00		

Table 5.
Gentrification based on population in the city of Stockholm 2007–2013

Gentrification_Income_2007-2013
Gi_Bin

- Cold Spot - 99% Confidence
- Cold Spot - 95% Confidence
- Cold Spot - 90% Confidence
- Not Significant
- Hot Spot - 90% Confidence
- Hot Spot - 95% Confidence
- Hot Spot - 99% Confidence

N

8,000   4,000   0   8,000 Meters

Figure 1.
Gentrification _income
hot and cold spots
analysis in the city of
Stockholm 2007–2013

Gentrification_Population_2007-2013
Gi_Bin

- Cold Spot - 99% Confidence
- Cold Spot - 95% Confidence
- Cold Spot - 90% Confidence
- Not Significant
- Hot Spot - 90% Confidence
- Hot Spot - 95% Confidence
- Hot Spot - 99% Confidence
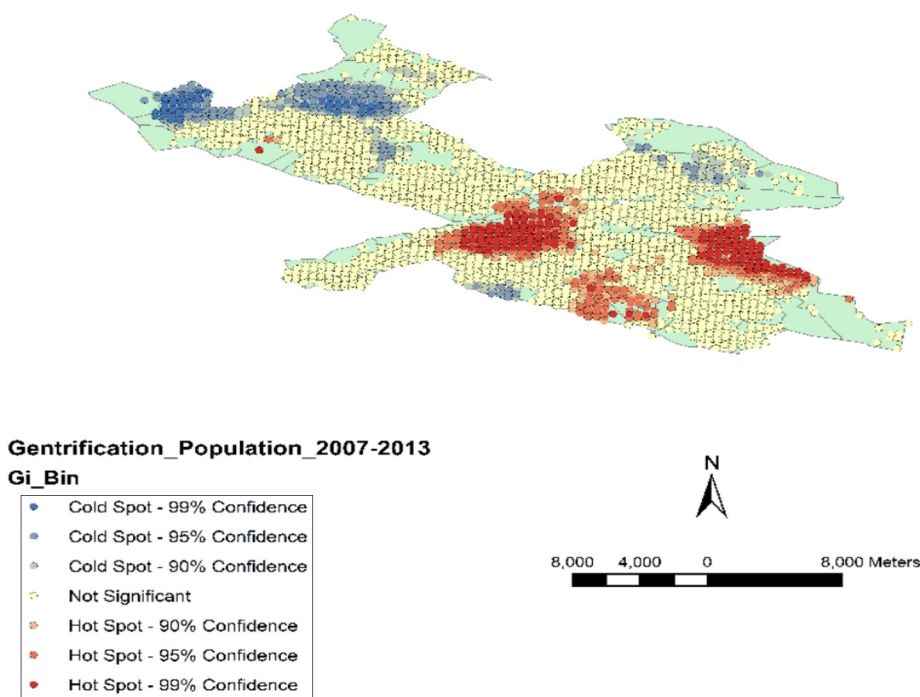
N

8,000   4,000   0   8,000 Meters

Figure 2.
Gentrification _
population hot and
cold spots analysis in
the city of Stockholm
2007–2013

4.3 The hedonic price model data

The traditional hedonic pricing model will be estimated for the condominium market. Data refer to the period 2014–2015 in the City of Stockholm. The source of the data is Mäklarstatistik AB [1] (Swedish Brokerage Statistics). Since 2005, Mäklarstatistik has been collecting data from home sales that take place via brokers. Almost all brokers in Sweden report their contract data to Mäklarstatistik, enabling them to provide up-to-date and comprehensive price statistics for homes throughout Sweden, and an overall picture of price development in the Swedish housing market. Descriptive statistics regarding the variables included in the hedonic model are illustrated in Table 6.

The table presents descriptive statistics regarding the data on condominium sales. The observed number of apartments amounts to 25,898. The average price is just under SEK3.5m, with a standard deviation of as much as SEK1.6m. The average size of rental apartments is 60 square metres, with a standard deviation of 22 square metres. Condominium owners pay a monthly fee to the building association for maintenance and upkeep. On average, this fee amounts to SEK3,200 with a standard deviation of SEK1,200. The average number of rooms is equal to 2, and the average number of building floors is equal to 4. The vast majority of observations have a city-close location, an average of 48 metres from the CBD, and 42 metres from the closest subway station. The average distance to a gentrified residential area, whether income or population gentrification, amounts to about 1,500 metres.

5. The econometric analysis

The econometric analysis aims to estimate the hedonic equation. We use multi-level analyses to find the empirically best form of the hedonic function. The proximity to income-gentrification and population-gentrification areas will be included as a continuous variable in a hedonic price model, and a binary variable in a so-called TE model.

5.1 The hedonic price equation

Here, we will estimate the hedonic price model. Table 7 shows the results of the multi-level regression models analysis.

Variables	Mean	SD	Minimum	Maximum
Price	3,456,579	1,650,389	780,000	103,000,000
Living area	60.367	22.229	23	203
No. of rooms	2.336	0.925	1	7
Monthly fees	3,234.237	1,198.525	932	8,011
Distance to CBD	47.761	536.312	0.314	6,765.676
Distance to subway	42.411	524.241	0.002	6,609.22
No. of building floors	3.953	2.337	0	14
Elevator	0.653	0.476	0	1
New	0.019	0.137	0	1
Age	60.006	38.005	−2	1,000
Gentrification income	0.184	0.388	0	1
Gentrification population	0.169	0.375	0	1
Distance to gentrification income	1,326.452	1,359.982	0	4,999.634
Distance to gentrification population	1,485.097	1,509.16	0	7,142.767

Notes: The number of observations is 25,898; prices are in Swedish Krona (SEK) and distance is in metres

Table 6.
Descriptive statistics (2014–2015)

Variables	(1) M1	(2) M2	(3) M3	(4) M4
Gentrification income	0.0597*** (18.48)		0.0231*** (5.64)	
Gentrification population		0.0792*** (22.83)	0.0638*** (14.46)	
Gentrification income and population				0.0779*** (20.60)
New	0.134*** (15.85)	0.133*** (15.86)	0.135*** (16.03)	0.130*** (15.46)
Age	0.000560*** (14.62)	0.000556*** (14.61)	0.000569*** (14.93)	0.000529*** (13.88)
Elevator	0.0318*** (10.37)	0.0320*** (10.48)	0.0324*** (10.63)	0.0325*** (10.62)
Floor level	0.0196*** (25.11)	0.0193*** (24.91)	0.0195*** (25.09)	0.0194*** (24.98)
Building stories	0.000962 (1.58)	0.000745 (1.23)	0.000909 (1.50)	0.000921 (1.51)
Living area	0.0132*** (104.04)	0.0133*** (104.65)	0.0133*** (104.77)	0.0132*** (104.24)
Distance to CBD	−0.0754*** (−116.74)	−0.0725*** (−112.38)	−0.0733*** (−111.16)	−0.0735*** (−114.38)
Distance subway station	0.0771*** (116.72)	0.0742*** (112.34)	0.0750*** (111.13)	0.0752*** (114.34)
Rooms	0.0383*** (13.98)	0.0378*** (13.87)	0.0380*** (13.92)	0.0377*** (13.80)
Monthly fee	−0.0000689*** (−39.54)	−0.0000682*** (−39.36)	−0.0000686*** (−39.58)	−0.0000675*** (−38.88)
Constant	14.47*** (2255.28)	14.47*** (2261.91)	14.46*** (2259.32)	14.47*** (2261.97)
Observations	23,017	23,017	23,017	23,017
R^2	0.843	0.844	0.844	0.843
AIC	−16,115.3	−16,291.7	−16,321.5	−16,196.8

Notes: t statistics in parentheses. ***$p < 0.001$

Table 7.
Regression results
(default models
2014–2015)

In the models presented in Table 7, we can note that the goodness-of-fit models are high at around 84%. All estimated parameters have expected signs and reasonable magnitude. For example, increasing the living area by one square metre increases the price by about 1.3%. The newer the building by a year, the greater the price, by 13%. The same positive effect, when a building has an elevator, increases the price by about 3% and an additional room increases the price by about 4%. The further away from the CBD, the apartment is located, the lower the price, whilst distance from the subway station increases the price.

Table 7 shows an income- and population-gentrified area's direct effect on house prices. The parameter estimate is statistically significant in all models. It can be observed that location within income gentrified areas has a price level that is 6% higher compared to outside gentrified areas (Model M1) and in Model M3 the estimate is 2%, where the location in population-gentrified areas is also included. Locations within population-gentrified areas, as in Model M2, increase the price by around 8% and in the Model M3 by 6%. Simultaneously, the proximity to income- and population-gentrified areas, illustrated in Figures 1 and 2, increases the price by around 8% (Model M4). What emerges from the results is that housing value in an income- or population-gentrified area affects housing prices. What is also clear is that gentrification based on population movement to a residential area has a more significant impact on future prices than the gentrification of a higher income level in the area. Furthermore, we can note that the joint effect is greater than the individual effects. A contributing reason for this result is that the gentrified areas of the population are probably also connected to increased housing supply, i.e. new buildings have been built in the area. We have certainly underestimated the premium for a newly built housing price model, resulting in the higher estimated price impact. New construction is also certainly associated with the expansion of services in the residential area. It may also have generated higher housing prices in the population-gentrified areas compared to income-gentrified areas.

Table 8 presents the spillover effect models of gentrification measured by income and population on house values within and outside the gentrified area. As above, we can observe a positive and significant direct effect from both income- and population-gentrified areas on house values within the gentrified area. The houses located in the income-gentrified areas M5 and M7 increase in price by around 6% and 3%, respectively. The population-gentrified areas have a positive and significant direct effect on house prices in the gentrified area, where house values increase by 7% in model M6 and by 5% in model M7. The direct effect from both income- and population-gentrified areas (Model M8) increases the price by around 7%. The spillover effect from income-gentrified areas on values outside the gentrified area is not significant in model M5 and has a too small positive effect in Models M7 and M8. The spillover effect from population-gentrified areas on values outside the gentrified area is significant and negative in both models.

The effect of gentrification on nearby residential areas is a bit surprising. When it comes to gentrification because of a change in income, we can state that this effect is only seen within the gentrified area. The effect outside the area is weakly positive, which indicates that housing prices rise further away from the gentrified area. On the other hand, the results suggest that the effect of gentrified areas based on population change is negative, i.e. the further away from the gentrified area the apartment is located, the lower the prices; that is, we can, to a certain extent, observe a spillover effect. As stated above, this may be because of nearby housing construction, which triggered the expansion of local services. New housing construction can bring investments in public transportation, which also increase the value of homes in and around gentrified areas. That the same effect cannot be observed concerning income-gentrified areas is, perhaps, obvious, as gentrification based on income alone does

Variables	(1) M5	(2) M6	(3) M7	(4) M8
Gentrification income	0.0618*** (17.87)		0.0333*** (7.65)	
Distance gentrification income	0.00000179 (1.70)		0.0000126*** (8.66)	0.0000102*** (7.41)
Gentrification population		0.0724*** (20.24)	0.0521*** (11.53)	
Distance gentrification population		−0.00000740*** (−7.58)	−0.0000151*** (−11.15)	−0.0000156*** (−11.77)
Gentrification income and population				0.0736*** (19.07)
New	0.133*** (15.82)	0.134*** (15.94)	0.134*** (15.97)	0.129*** (15.43)
Age	0.000553*** (14.34)	0.000575*** (15.10)	0.000554*** (14.47)	0.000524*** (13.67)
Elevator	0.0314*** (10.23)	0.0349*** (11.36)	0.0358*** (11.67)	0.0364*** (11.85)
Floor level	0.0196*** (25.13)	0.0194*** (25.00)	0.0196*** (25.35)	0.0195*** (25.18)
Building stories	0.000897 (1.47)	0.000864 (1.42)	0.000660 (1.09)	0.000719 (1.18)
Living area	0.0132*** (103.61)	0.0133*** (105.01)	0.0132*** (104.50)	0.0132*** (104.22)
Distance to CBD	−0.0757*** (−113.56)	−0.0726*** (−112.60)	−0.0752*** (−108.14)	−0.0747*** (−112.75)
Distance subway station	0.0774*** (113.54)	0.0742*** (112.55)	0.0769*** (108.11)	0.0764*** (112.71)
Rooms	0.0383*** (13.99)	0.0380*** (13.95)	0.0385*** (14.15)	0.0382*** (14.01)
Monthly fee	−0.0000686*** (−39.21)	−0.0000691*** (−39.82)	−0.0000684*** (−39.37)	−0.0000677*** (−38.86)
Constant	14.47*** (2226.80)	14.47*** (2234.03)	14.47*** (2229.51)	14.48*** (2241.20)
Observations	23,017	23,017	23,017	23,017
R^2	0.843	0.844	0.845	0.844
AIC	−16,116.2	−16,347.2	−16,443.4	−16,331.7

Notes: t statistics in parentheses. *** $p < 0.001$

Table 8.
Spillover effect
models

not necessarily entail local service and public transportation investments that spill over into nearby areas.

5.2 An alternative approach: propensity score and treatment effect model
The presented models' goal is to minimise the endogeneity problem. To achieve this, we have also estimated so-called TE models by creating a binary treatment variable to analyse the relationship between gentrification and housing values. The value of one (1) signifies that the house is within a gentrified area and zero (0) that the house is outside of the gentrified area. To measure the gentrified area's impact on house value, we have included a buffer zone around the gentrified area. Any housing located within 125 metres of the gentrified area may be considered within the area, and beyond 125 metres considered outside the gentrified area.

As shown in Table 9, two models use the PS methodology and two use the TE model approach. Compared to the earlier models, the control area is reduced to 500 metres from the gentrified area in the two TE models TE1 and TE2. In the two PS models PS1 and PS2, we have included PSs as sample weights, where we first estimate a logistic regression model to calculate the probability of being in the treatment area. Models (1) and (2) refer to gentrified areas by income and Models (3) and (4) refer to the gentrified area by population.

In the TE model presented in Table 9, we can see that the degree of explanation is high. About 80% of price variation can be explained by the variables used. Compared to hedonic models, significantly fewer observations are used in the calculation. Instead of over 23,000 observations, we are here using only around 7–8,000 observations. In these models, we will only include housing located within 500 metres of the gentrified area. We have separated the estimates of proximity into one income-gentrified area and one population-gentrified area.

We can observe that there is a positive effect on housing values within income-gentrified housing areas. House values in the model TE1 increased by 3% and in the model PS1 increased by 2.5%. As well, there is a positive effect on housing values within population-gentrified housing areas, where house values in the model TE2 increased by 3%, whilst the lowest increase in price was 1%, in the model PS2. In the models with TE approach and PS approach, the effect on housing values is the same regardless of whether the area is gentrified in terms of income or population. The results can be compared with models M1 and M2 in Table 7, both reporting a greater effect of gentrification on housing values. However, the results cannot be compared with spillover effects estimated in the M5–M8 models in Table 8.

5.3 Parameter heterogeneity
We also test whether the parameters are constant in the price distribution by estimating a quantile regression model, which is used to describe the distribution of the dependent variable and gives a more comprehensive picture of the effect of the independent variables on the dependent variable. Table 10 shows the results of the quantile regression models analysis.

The quantile regression results show the effect on the housing value from gentrification income and gentrification, where the price effect is generally higher in the lower price levels and stable over the rest of the price distribution. The lowest statistically significant effect for the gentrification population ($p < 0.05$) in the percentiles is 0.9.

6. Conclusion and policy implications
Demographic and other socioeconomic factors such as household income can lead to different types of gentrification. A better understanding of the gentrification

Variables	(1) TE1	(2) PS1	(3) TE2	(4) PS2
Gentrification income	0.0329*** (8.41)	0.0252*** (6.13)	0.0306*** (7.43)	0.0105* (2.30)
Gentrification population			0.0708*** (4.26)	0.0891*** (5.16)
New	0.111*** (7.11)	0.115*** (6.53)		
Age	0.000133 (1.79)	-0.0000729*** (-7.83)	0.0000325 (0.39)	-0.0000596*** (-5.16)
Elevator	0.0407*** (7.82)	0.0248*** (4.63)	0.0360*** (6.52)	0.0233*** (4.09)
Floor level	0.0225*** (16.66)	0.0238*** (16.32)	0.0212*** (14.00)	0.0227*** (13.09)
Building stories	-0.000677 (-0.65)	-0.00122 (-1.12)	-0.00422** (-3.51)	-0.00639*** (-4.70)
Living area	0.0116*** (48.53)	0.0122*** (35.96)	0.0119*** (47.31)	0.0125*** (28.58)
Distance to CBD	-0.0779*** (-63.81)	-0.0810*** (-60.81)	-0.103*** (-67.81)	-0.111*** (-65.16)
Distance subway station	0.0797*** (63.80)	0.0828*** (60.81)	0.105*** (67.80)	0.113*** (65.15)
Rooms	0.0514*** (10.99)	0.0382*** (6.44)	0.0502*** (10.31)	0.0278*** (3.80)
Monthly fee	-0.000573*** (-18.55)	-0.000573*** (-13.85)	-0.000555*** (-17.10)	-0.000529*** (-12.50)
Constant	14.49*** (1,270.52)	14.53*** (1,839.65)	14.56*** (1,117.27)	14.61*** (1,384.68)
Observations	8,023	8,023	7,018	7,018
R^2	0.786	0.818	0.792	0.830
AIC	-6,041.2	-9,774.9	-5,652.6	-17,453.8

Notes: t statistics in parentheses. $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

Table 9.
Treatment effect model (reduced sample and propensity score weights)

phenomenon is vital in attaining reliable estimates of gentrification's social impact and its multi-dimensional impact on various neighbourhoods, and for formulating proper strategies and policies essential for sustainable urban development. This study's primary objective was to establish a plausible relationship between gentrification and property values in certain neighbourhoods in Stockholm municipality.

Using population and income data between 2007 and 2013, we estimated gentrification stemming from population and income increases. In addition to building characteristics, we also considered other control variables such as distance to CBD and subway stations in our hedonic price model. Our results indicate that demographic and income increases potentially contribute to the observed gentrification in certain neighbourhoods in Stockholm municipality. Gentrification because of population increase was slightly higher than gentrification by income during the study period.

Regarding proximity to gentrified areas, our hedonic price model results confirm a potential spillover effect from income- and population-gentrified areas. As other previous studies suggest, our study found that the parameter estimate is statistically significant, indicating that gentrification contributes to housing values near gentrified neighbourhoods. The estimated spillover parameter slightly varied between different models. The hedonic price models have the highest estimated figures (around 6%–8% for gentrification both by income and population), whilst TE models indicate lower estimated figures. Our quantile regression results show that the estimated spillover parameters are constant in the price distribution. In other words, the price effect is generally higher and stable over the entire price distribution.

Gentrification has many consequences, such as increased housing and neighbourhood values, which require sound policies that are beneficial to local municipalities, through tax revenues and homeowners, through rent and price increases. A better understanding of the gentrification spillover effect will enable local municipalities to raise more tax revenue and combat and reduce adverse associated effects of gentrification, such as displacement. Furthermore, it provides insights useful for various neighbourhoods related to housing stock quality and proximity to other desirable neighbourhoods, as well as amenities such as subway stations and commercial centres.

Further studies, exploring whether gentrification by income is because of income increases of pre-gentrification indigenous households or newly arrived households, are needed to address any potential displacement effect.

Quantiles	Gentrification income	Gentrification population
0.1	0.0471***	0.0463***
0.2	0.0314***	0.0400***
0.3	0.0260***	0.0365***
0.4	0.0213***	0.0275***
0.5	0.0277***	0.0348***
0.6	0.0276***	0.0347***
0.7	0.0284***	0.0308***
0.8	0.0248***	0.0268***
0.9	0.0235***	0.0153*
Notes: *$p < 0.05$, ***$p < 0.001$		

Table 10.
Quantile regression results, treatment effect model

Note

1. www.maklarstatistik.se

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