

Nordic Journal of Surveying and Real Estate Research Special Series, Vol. 5 (2020) 29–48

submitted 3 June 2020

revised 13 July 2020

revised 2 September

accepted 8 September 2020

Impact of Shopping Malls on Apartment Prices: the Case of Stockholm

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***Abstract.** The number of shopping malls, as an important type of commercial facility, is growing dramatically. They have gradually become one of the most dominant factors that can influence people's daily lives as well as a city's economic development. The willingness to pay for dwellings is also primarily associated with the surrounding commercial layout. Hence, it is of interest to apply a quantitative perspective to further investigate the relationship between shopping malls and housing prices. This study aims to analyse how the prices of condominiums are affected by proximity to shopping malls. Two aspects are considered and examined in the empirical research, namely proximity to a shopping mall and the number of shopping malls within a one-kilometre radius. We try to determine if there is any price premium for those apartments near a shopping mall or with more shopping malls in the neighbourhood. In this empirical study, 39 shopping malls in different locations in the county of Stockholm, Sweden, are utilised. The sample of transactions consists of more than 300,000 apartments. By using the traditional hedonic expansion model, the results show that there is an inverse relationship between apartment prices and distance to a shopping mall. Moreover, the number of shopping malls is positively correlated with apartment prices. However, the impact has declined over time. The results also suggest that the impact is highly localised and is larger for small apartments.*

JEL-code: R21, R23, R31

Keywords: hedonic, shopping mall, spillover effect

1 Introduction

The term shopping mall refers to one or more buildings composed of a complex of shops or other facilities. Shopping malls can exist as the hub of urban structure and the foundation of retail economies. The concept originated in the U.S. and has now become a widespread modern retail format. In recent years, there has been a quite rapid increase in the development of shopping malls worldwide, as is demonstrated in the number and size of shopping malls.

However, shopping malls have been challenged by the rise in online shopping in recent years. The form and content of shopping malls are also expected to change in the future. Hence, global trends have caused malls to change the role they play in people's daily lives. In order to adapt to all of these changes and meet the needs of consumers, shopping malls are no longer focused solely on shopping. The idea of shopping has gradually evolved from being purely represented by unavoidable errands to becoming the main segment of the urban recreational lifestyle (Fasli et al., 2016). When people choose to pay a visit to shopping malls today, they are expecting experiences that go way beyond simply buying the goods they need and going back home. Thus, developers behind shopping malls are seeking ways to make shopping and purchasing more of a leisure pursuit (Howard, 2007). Accordingly, recently developed shopping centres try to meet these new demands using a variety of methods. These new shopping complexes are viewed as facilities that can provide the general public with both convenience and amusement. Therefore, it is reasonable to assume that living closer to a shopping mall provides people with better consumption flexibility as well as enjoyment. Thus, proximity to a shopping mall would theoretically have a positive effect on housing prices.

Seago (2013) argues that when it comes to the effects of commercial amenities, such as shopping malls, the relationship can still be unclear. Some previous studies have been done to investigate this topic. However, most of the earlier findings focus mainly on other aspects. For example, Carter (2009) discussed rents and location, while other studies primarily examined the role that the shopping mall plays in society as a whole as well as its role in urban development (Ozuduru, 2013; Fasli et al., 2016). Moreover, studies also investigate how the mall has become the catalyst of the urban lifestyle (Erkip, 2005).

There is no question that shopping malls have the potential to generate externalities. However, there are only limited studies on how the externalities of a shopping mall would influence the nearby housing market. Researchers have found both positive and negative effects of proximity to a shopping mall (see, e.g. Colwell et al., 1985; Sirpar, 1994; Des Rosiers et al., 1996; Pope and Pope, 2015; Zhang et al., 2018; Kurvinen and Wiley, 2019).

The impact of shopping malls on surrounding property values was examined by Des Rosiers et al. (1996), which mainly focused on proximity and the secondary effects. This study analysed the impact of 87 shopping malls of different sizes on the prices of approximately 4,000 residential properties. The results indicated a positive relationship between the size of a shopping mall and residential housing prices. Pope and Pope (2015) analysed the effect on property values after a Walmart location opens in the immediate area. They note that resistance to establishing a Walmart is usually high, but their study shows that the impact on property values is positive and relatively significant.

Two more recent articles include Zhang et al. (2019) and Kurvinen and Wiley (2019). Zhang et al. (2019) analyse the capitalisation rate of shopping malls in property values in Hangzhou, China, between the period 2011–2015. They investigated the effect before construction, during construction and after the mall had opened. They find that there is a substantial effect after a shopping mall

opens, but the effect is minimal before opening. In a recently published article by Kurvinen and Wiley (2019), they analyse the impact of a newly established retail development on housing values. By analysing 130,000 observations over 15 years in Helsinki, Finland, they find that the establishment has a relatively local effect within a radius of 500 metres and that the effect decreases at a radius of 500–1,000 metres.

This study aims to investigate how the prices of condominiums will be affected by the proximity of shopping malls. Two aspects are considered and examined in the empirical research, namely proximity to a shopping mall and the number of shopping malls. We attempt to determine whether there is a price premium for apartments near a shopping mall or with more shopping malls in the neighbourhood within a 400-metre radius. Other studies have revealed an inverse relationship between housing prices and distance to a shopping mall. We will compare our results and contribute with further discussion.

This study contributes to the body of research in the field. Determining the precise effect of shopping malls on apartment values will assist authorities and developers in making better decisions. Schulz (2004) asserted that this type of housing information could be significantly beneficial for real estate developers, banks and policymakers. For instance, this would provide policymakers with clear insight when they are designing the urban structure. It would also be highly beneficial for real estate developers so they may examine their development strategies as they seek financial gain in the volatile commercial real estate market. Both private and institutional investors may also be interested in the potential findings of this study since these purchasers could use this information to compare their potential targets better.

As discussed above, the impact of shopping malls on property prices has not yet been thoroughly examined. The purpose of this paper is to fill the gap in this knowledge by conducting various kinds of regression analysis to examine the relationship between shopping malls and property prices.

The structure of the remainder of the paper is as follows. Section 2 elaborates on the methodology and the model used in this study. Section 3 presents the data and the study area. Sections 4 and 5 present the empirical analysis and test for parameter heterogeneity. Finally, Section 6 presents our conclusions.

2 The hedonic price method

Hedonic price theory

An individual's residence is one of the most important parts of human life. Thus, the housing sector is essential for the stability of our society as well as for economic development. Therefore, it is of interest to analyse the dominant factors that can affect the housing market. One method used to analyse the relationship between housing values and amenities is the hedonic price method. The hedonic price model is widely used in the housing market to analyse property values (see, e.g., Brunet et al., 2020; Walsh et al., 2011; Zhang et al., 2019; Bayer et al., 2009; Palmquist, 2006; Deaton and Hoehn, 2004).

The idea behind this paper is to investigate the relationship between housing prices and housing characteristics on a micro-level. Monson (2009) states that buildings are comparable to a collection of goods sold on the market, where each building characteristic is considered equally when the overall transaction price is determined. Regression analysis and hedonic modelling are valuable tools that allow real estate professionals to determine that correlation and to predict future transaction prices. Hence, the hedonic price model is the method we apply in our empirical analysis to understand the differences in housing prices caused by proximity to shopping malls.

According to Rosen (1974), the principle is that goods differ in their attributes, which can be confirmed by the observed differences in their prices. The expected value is investigated by the use of structural, locational, and macro characteristics (Wilhelmsson, 2002; Chau & Chin, 2003). Structural characteristics are, for example, size of the dwelling and number of rooms; locational characteristics are, for example, distance to CBD, and proximity to public transportation; and macro characteristics control for aggregate price movement over time.

In a simplified form, the hedonic price equation is as follows:

$$Price = f(\text{structural attributes, proximity to shopping mall, other locational attributes, macro characteristics})$$

where proximity to a shopping mall is of primary interest in this study. Rosen (1974) showed that the coefficient of the hedonic price equation can be interpreted as the implicit price of the attribute and that this implicit price is equal to the marginal willingness to pay for the attribute.

Specification of the price equation

The hedonic price model regresses housing price (Y) to a set of observable characteristics (X s), which can be expressed as $Y = \beta X + \alpha$, where Y is a vector of observations on the apartment price, X is a matrix on the property attributes. β is a vector of parameters concerning the explanatory variables (coefficients, the implicit marginal price of each attribute), and α represents random error terms, which reflects unobserved changes in housing prices.

There are different forms of the hedonic model, such as linear models, semi-log models and double-log models (Morancho, 2003). There is nothing, in theory, to suggest which form of the hedonic price equation is preferable. The functional form you choose is usually an empirical question. We have chosen to use the Box-Cox transformation of all continuous variables that are strictly positive. For the dependent variable, we test whether we need to transform the variable with a natural logarithm transformation. We do the same for the independent variables. This means that we test four different functional forms, namely a linear relation, log-linear, inverted log-linear and a log-log relation.

It is not only the functional form that is important when specifying the hedonic price equation. The choice of dependent and explanatory variables is, of course, at least as important. The transaction price will be used as the dependent variable; that is, we use prices set on the market, not valuations.

The central research question is does proximity to a shopping mall affect housing values and to what extent. To be able to isolate this effect, all relevant variables must be included in the hedonic price equation. Of course, the question of causality, or the absence of causality, is always an issue that is important to consider and discuss. If we omit important variables in the hedonic price equation, it can create omitted variable bias that makes the model not exogenously given (see Wooldridge, 2006). We have solved this issue by including the most important explanatory variables both in terms of characteristics in the property and the apartment but also in the geographical location by including distance to CBD, proximity to public transportation, dummy variables for the municipality and including the coordinates as explanatory variables. We assess that this has reduced the risk of omitted variable bias and spatial dependency in the form of spatial autocorrelation and spatial heterogeneity (see Wilhelmsson, 2002). For the latter, we have also tried to control by including different forms of interaction variables. That is, we test if there exists parameter heterogeneity. We analyse whether the estimates are constant north and south of the CBD and if the degree of impact is affected by different segments of the housing market, such as the size and value of the apartment. We have also tested whether proximity to a shopping mall has greater significance closer to the shopping mall and whether this value has changed over time.

Both the inclusion of coordinates and the interaction variables can be seen as a variant of the expansion model developed by Casetti (1972) in general terms and by Jackson (1979) in an intraurban context. This model has been implemented in many articles since it was developed, for example, Can (1992) and Bitter et al. (2006). Bitter et al. (2006) analyse the expansion model and compare it with the geographically weighted regression model. They conclude that the latter is better than the former. Clapp (2004) includes latitude and longitude directly in the hedonic price equation in his benchmark model. This is also done in Walsh et al. (2011), Shimizu (2014) and Hill and Scholz (2018). Clapp et al. (2004), on the other hand, include both latitude, longitude and their product in the price equation. Owusu-Ansah (2018) uses the expansion method in the construction of the property price index. Similar to his analysis, coordinates, square coordinates and the product of the coordinates are also included in our model. Of course, it can be difficult to interpret the different parameter estimates regarding the coordinates individually. Since the main purpose of the analysis is to estimate the impact of proximity to shopping malls on housing prices, this is considered a minor issue.

Rather than including the coordinates directly in the hedonic price equation, Fot et al. (2003) created an interaction variable where the coordinates interact with all included continuous independent variables. A similar analysis can be found in Pavlov (2000). Zhang et al. (2019) do not use the coordinates directly in the hedonic price equation but instead use the coordinates as variables to explain the variation in the residuals. Non-significant estimates are interpreted as lacking spatial dependence. We will use the corresponding method to test for spatial dependence in the residuals.

The lack of good measures of access to public transportation and accessibility can, of course, hamper interpretation or our estimates. Many shopping malls are co-located with public transportation, so the effect we observe may depend more on access to public transportation than access to the shopping mall. Jackson (1979) aimed to find a better, more general way to account for accessibility in housing prices. Since we explicitly lack information on accessibility in our study area, we include coordinates together with distance to the CBD, and proximity to subway stations to capture accessibility in the region. As in Cavailhès et al. (2009), we also include fixed municipal effects to control for missing variables that are fixed between municipalities and constant over time. Ross et al. (2011) also show in their Monte-Carlo simulations that including coordinates and square of the coordinates is recommended over the inclusion of distance variables if there is uncertainty in these variables. However, in addition to the above variables, we have also included a variable that measures whether the apartment is adjacent to a subway station.

There may also be a simultaneity problem. One must consider whether a shopping mall location was chosen where the home values are higher, and thus high potential consumer demand, or are the high housing values a consequence of the proximity to the shopping mall? Here we argue for the latter as most of the shopping malls have been established for many years. Some of the more newly established shopping malls also have a non-central location, which would contradict the hypothesis of reverse causality.

3 Data and the study area

We use Stockholm as a case study to estimate the relationship between housing values and proximity to shopping malls. Stockholm County (Swedish: Stockholms län) is a county (or län in Swedish) on the coast of the Baltic Sea in Sweden, which has 26 municipalities (kommun). Their location is shown in Figure 1 below. In this study, all the data is limited to this specific area, which has a total population of 2,377,081 (SCB, 2019). The population density is 360/km², which makes it the densest county in Sweden.

In the estimation of the hedonic price equation, it is important to have a large number of the historical cross-sectional transactions of dwellings with actual transactional prices. The data in this study comes from Svensk Mäklarstatistik AB and covers a period from 2006 to 2019. Mäklarstatistik AB is a private unit that organises real estate agents and collects data on real estate transactions. The data consists of over 95% of the housing transactions that take place via brokers. All nationwide brokerage chains and the absolute majority of others report all housing transactions to Svensk Mäklarstatistik. This transactional database contains information on apartments, including size, monthly fees paid to the co-operative association, floor level, height of the property, number of rooms, municipality codes and latitude as well longitude (coordinates). In total, there are 336,914 observations.

In terms of the shopping malls, we have included 39 shopping malls from across the county to get a reliable and convincing result. All of these malls are



Figure 1. The county of Stockholm comprises 26 political municipalities.

scattered across different zones or regions in our target area. Shopping mall data comes from the Swedish Shopping Center Directory provided by the company Datscha. We have included shopping malls they classify as a city mall, outlet mall, regional mall, regional retail park, super-regional mall and theme centre. We exclude locations the directory classifies as a community centre or neighbourhood centre as our focus is on shopping malls. Table 1 below is a summary table of the malls included with location information, such as longitude and latitude, and opening year. The latter is important since shopping malls that have only recently been opened or sold should not be included when calculating as the crow flies distances between residences and shopping malls.

Descriptive statistics

The final database consists of 325,973 apartment transactions and ten independent variables. Among these ten variables, distance to a shopping mall, the number of shopping malls within a 400-metre radius and binary buffer zone will be our key variables of interest. The variables living space, floor level, height, number of rooms, proximity to a subway station, and distance CBD will be our control variables.

Before presenting the descriptive statistics, we have created two new variables, namely proximity to a shopping mall and the number of shopping malls

Table 1. *Included shopping malls in the county of Stockholm.*

Region	Mall name	Latitude	Longitude	Opening year
1	Barkaby Handelsplats	59.4236	17.8320	1999–2001
2	Bredden	59.4994	17.9275	1985
3	Bromma Blocks	59.3556	17.9531	2010
4	Centralstation	59.3307	18.0579	N/A
5	Farsta Shopping Centre	59.2431	18.0884	1960
6	Fältöversten	59.3396	18.0892	1973
7	Gallerian	59.3308	18.0654	1976
8	Haninge Centrum, Handen	59.2005	17.9839	1964
9	Heron City	59.2671	17.9081	2001
10	Hornstullgallerian	59.1856	18.0202	2013
11	Huddinge Centrum	59.2358	17.9795	1960
12	Jakobsberg centrum	59.4232	17.8367	1959
13	Kista Galleria	59.4023	17.9435	1977
14	Kungens kurva handelsområde	59.1623	17.5456	1965
15	Kungens kurva shoppingcentere	59.2689	17.9171	2014
16	Liljeholmstorget	59.3098	18.0195	2009
17	Lindhagenshuset	59.3372	18.0101	2009
18	MOOD Stockholm	59.3343	18.0671	1978
19	Mörby Centrum, Danderyd	59.3989	18.0333	1961
20	Nacka Forum, Nacka	59.3100	18.1626	1989
21	Nordiska Kompaniet	59.3332	18.0670	1915
22	PK-huset	53.3333	18.0711	1974
23	Ringen Centrum	59.3083	18.0732	1982
24	Sickla Köp kvarter, Nacka	59.3040	18.1228	1994–1995
25	Skrapan	59.3124	18.0717	2007
26	Skärholmen Centrum (SKHLM)	59.2757	17.9057	1968
27	Sollentuna centrum	59.4986	17.7859	1975
28	Solna Centrum, Solna	59.3610	17.9971	1965
29	Stinsen Shopping center	59.4371	17.9349	1989–1991
30	Stockholm Quality Outlet	59.4167	17.8571	1998
31	Sturegallerian	59.3361	18.0712	1989
32	Tyresö Centrum, Tyresö	59.2438	18.2247	1965
33	Täby Centrum, Täby	59.4451	18.0588	1968
34	Westfield Mall of Scandinavia	59.3692	18.0032	2015
35	Vällingby Centrum	59.3463	17.8644	1954
36	Väsby centrum	59.5185	17.9139	1972
37	Västermalmsgallerian	59.3346	18.0301	2002
38	Åhléns City	59.3323	18.0614	1964
39	Åkersberga centrum	59.2720	18.1810	1976

within a one-kilometre radius. These variables are the main variables we analyse here. The proximity to a shopping mall is constructed using Euclidean distance, which can be used to calculate the distance between any two points using their coordinates. The formula is

$$d(q,p) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2},$$

where q_1, q_2 are the coordinates for the shopping malls, and p_1, p_2 are the coordinates for all the individual properties. Hence, the distance from each apartment to all the shopping malls can be calculated. The shortest distance to any of those gives us the closest proximity to a shopping mall from that specific dwelling. In terms of the variable number of shopping malls, it is the number of shopping malls around the apartment within a certain proximity. A 400-metre radius is chosen in this case. Here, we assume that this distance is considered to be close proximity.

Several other factors can influence housing prices. As mentioned above, we need to include those variables to get a more accurate analysis. Here, we divide the housing characteristics into three groups: structural characteristics, location characteristics, and macro characteristics. Structural characteristics are the intrinsic characteristics the property itself possesses, such as the size of the dwelling. Location characteristics measure the accessibility of the property relative to its location, such as accessibility to public transportation. Neighbourhood characteristics are equally important in terms of the determination of housing prices. A good neighbourhood can be a price catalyst. For example, the view of the housing or surrounding facilities can be important.

Structural characteristics are essential since the condition of the properties can have direct effects on how people perceive the property and how much they are willing to pay for, for example, size, floor level and the number of rooms. All of these attributes must be controlled for in the model. Locational characteristics refer to the different locations of housing within a city or a municipality. Different locations can differ significantly in housing prices because of their degrees of accessibility to the most frequently visited places. Stockholm has a relatively distinct geographical pattern. The distance to central locations, i.e., the Central Business District (CBD), refers to Sergels Torg here, which represents the most central public space in Stockholm. Accessibility is also an essential variable that can add value to an apartment. In addition to distance to CBD, we have also included proximity to a subway station (measured as a buffer zone of a 400-metre radius around the subway station). In Table 2, we present descriptive statistics regarding the variables we use in the analysis.

The number of observations that will be used in the analysis is 325,973. Some observations have been dropped due to lack of information and sometimes because the observations are outliers. The total housing price ranges from SEK 595,000 to 9,400,000 with a mean of SEK 2,729,766. The average housing price per square metre is from SEK 8,666 to SEK 110,000 with a mean of 43,890 SEK. Thus, the variation is relatively high in the dependent variable. The size and monthly fee of the properties also show a relatively high variation. The average size of the dwelling is 65 square metres, with a standard deviation of 24 square metres. The average number of rooms is around 2.5 rooms, but not surprisingly, the variable is highly correlated to the size of the apartment (see the correlation matrix in the appendix). The average monthly fee is almost SEK 3,500 with a variation

Table 2. Descriptive statistics (mean and standard deviation).

Variable	Abbreviation	Average	Standard deviation
Price	Price	2,729,766	1,644,259
Size	Size	64.56	23.77
No. of rooms	Room	2.45	0.99
Monthly fee	Fee	3444.90	2490.01
Height	Height	4.16	2.74
Floor level	Floor	2.58	1.97
Distance to CBD	CBD	9.15	8.09
Within 400 metres from Subway	Subway	0.39	0.49
Distance to a Shopping mall	Shop	2.49	3.96
No. of shopping malls	#Shop	0.08	0.29
Within 400 metres from a shopping mall	Bshop	0.0696	0.25
No. of observations		325,973	

of SEK 2,500. The average distance to the CBD is 10 kilometres, which is also the standard deviation. Around 40% of the dwellings are located in the 400-metre buffer zone around a subway station. That is, a large portion of the dwellings are located within walking distance to a subway station. Yang and Diez-Roux (2012) have shown that 400 metres is considered an acceptable walking distance.

The distance to the nearest shopping mall amounts to about 2.5 kilometres, but the variation is substantial. The standard deviation is almost 4 kilometres. The number of shopping malls within a 400-metre radius amounts to just under 0.8. Around 7% are located in the buffer zone of 400 metres from a shopping mall. The correlation between the distance to a shopping mall and the number of shopping malls within 400 metres is relatively low (-0.14). The same is true when it comes to the correlation between distance to a shopping mall and the variable buffer zone around the shopping mall. However, the correlation between the buffer zone and the number of shopping malls is very high (0.9). The correlation between proximity to a subway station and distance to a shopping mall is small (-0.2).

More problematic is the fact that the correlation between distance to the CBD and distance to a shopping mall is high (0.7). The high correlation may make it difficult to separate the economic effect between these variables. Hence, we use Variance-of-Influence (VIF) to detect severe problems of multicollinearity.

4 Regression results

The estimation of the hedonic price equation has been carried out using Stata version 15.1. The results from Box-Cox transformation show that a log-log (double log) relationship is preferred, i.e., we have taken the natural logarithm of the dependent variable as well as the strictly positive and continuous variables. In this case, this means that the size of the apartment, the number of rooms, the monthly fee, the distance to the CBD and the distance to a shopping mall are all transformed. The interpretation of the implicit prices will then be in the form of price elasticity.

Three models have been estimated where we assume that all estimated parameters are constant in space and over time. In addition to apartment attributes such as size, monthly fee, and floor plan, Model A1 also includes property attributes such as the number of floors in the property. Included locational attributes are the distance to the CBD and the coordinates as well as dummy variables regarding the municipalities in Stockholm County. The intention here is, of course, to capture the spatial dimension. Since we analyse transactions over time, we have also included annual effects. We have also included seasonal effects through the fixed monthly effect. Both the fixed time effect and the seasonal effect are included to control for macro-economic changes over time. The distance to a shopping mall measures the proximity to the nearest of the 39 included shopping malls.

In model A2, the same variables are included as in model A1. However, instead of the distance to the nearest shopping mall, we have included a variable that indicates how many shopping malls the dwelling has access to within a radius of 400 metres. In model A3, we use buffer zones around the shopping malls. Here, we use 400 metres as the buffer zone. The reason we do not estimate a model where all variables are included is that there is a relatively high correlation between the variables as they are both approximations for proximity to a shopping mall. The results are presented in Table 3. All estimated models take into account outliers using the same method as in Wilhelmsson (2019).¹

Parameter estimates regarding the fixed municipality effects and the fixed year effects are not presented in the table, nor are the estimates regarding the coordinates. We can see that explanatory power is high in both models. The explanatory variables can explain about 85% of the variation in price. This can be considered a high degree of explanation and is comparable to other studies. It may also indicate that omitting variables is smaller. The maximum VIF value for the variable distance to the CBD is 14 in Model A1 and 7 in Model A2, which is not surprising. The VIF value for distance to a shopping mall is 2.8 and for the number of shopping malls, the value is 1. None of these numbers can be considered excessive, and the risk for multicollinearity should be considered low.

In model A1, we have included proximity to a shopping mall as a distance variable to the nearest shopping mall. Estimates of the size and number of rooms are as expected both in terms of the sign and magnitude of the coefficients. The interpretation is that if the size of the apartment increases by 1%, then the value of the apartment is expected to increase by 0.78%. If the monthly fee increases by 1%, the price is expected to fall by 0.14%. Furthermore, we can see that the height of the property has a negative price effect and that the floor level where the apartment is located has a positive impact. The distance to the CBD has an expected negative sign, and the interpretation of the estimate implies that if the distance from the

¹ The impact of outliers on estimated parameters is a complex issue. We follow the process laid out in Rousseeuw (1987) concerning detecting outliers. We estimate a hedonic price equation and detect outliers with Cook's D and then analyse the absolute residuals. The most influential observations are excluded, and observations with large absolute residuals are weighted down by an iterative process where observation weights are recalculated until convergence. Berk (1990) provides a full description of the methodology.

Table 3. Empirical results (default model).

Variable	Model A1 Coefficients	Model A2 Coefficients	Model A3 Coefficients
Ln(Size)	0.7301 (297.15)	0.7322 (297.25)	0.7317 (296.99)
Ln(Room)	0.0751 (40.51)	0.0746 (40.15)	0.0747 (40.20)
Ln(Fee)	-0.1368 (-87.40)	-0.1386 (-88.33)	-0.1380 (87.90)
Height	-0.0045 (-26.90)	-0.0040 (-23.73)	-0.040 (-23.96)
Floor	0.0146 (63.27)	0.0148 (64.31)	0.0148 (64.22)
Ln(CBD)	-0.4217 (-382.29)	-0.4328 (-411.80)	-0.4326 (-412.06)
Subway	-0.0042 (-4.58)	-0.0006 (-0.65)	-0.0012 (-1.35)
Ln(Shop)	-0.0204 (-33.72)	-	-
#shop	-	0.0032 (2.59)	-
Bshop	-	-	0.0114 (7.77)
R²_{adj}	0.8539	0.8534	0.8535

Note. The fixed municipality, year effects and seasonal effects are included in the model as well as coordinates – *t*-values within brackets.

CBD increases by 1%, the apartment’s value is expected to fall by 0.43%. The impact of proximity to a subway station is negative. There are several reasons why this may be the case. First, being close to a metro station increases accessibility in the region but being too close means that the negative effects outweigh the positives. These can be effects in the form of vibrations in nearby buildings or that the presence of a subway station makes the environment noisy. Secondly, it may be the case that this variable correlates with other variables that aim to pick up the effects of accessibility, such as the municipal effect, distance to the CBD and the coordinates.

The variable of primary interest is, of course, the distance to the nearest shopping mall. The effect is in line with expectations, i.e., negative. The farther away from a shopping mall a property is located, the lower the expected property value, all other things being equal. The interpretation is that if the distance increases by 1%, the price is expected to decrease by 0.02%, which corresponds to a decrease of approximately SEK 600. This can be considered a relatively low implicit price. For example, Zhang et al. (2018) results indicate that if the distance increased by 1%, the value of the dwelling will decrease by 0.11%. Interpretation of these results should be made in light of the fact that we have included the distance to the CBD

in the model together with fixed municipal effects as well as the coordinates. For all estimates, we can reject the null hypothesis that the variable does not affect the price, i.e., all t-values are higher than the critical value of 1.96.

Model A2 includes the same variables as in the previous model. However, instead of the closest distance to a shopping mall, the variable number of shopping malls within one kilometre from the apartment is included. The explanation rate is as high as in the earlier model, and all parameter estimates have the same sign, magnitude and statistical significance. As expected, the coefficient on the number of shopping malls has a positive sign. The variable is not in the logarithmic form as the variable is not strictly positive. The interpretation of the coefficient is, therefore, if the number of shopping malls increases by one, then the expected price of the property will rise by 1.8%. Since the average price is SEK 2.6 million, this corresponds to an increase in value of about SEK 50,000. Here, we have assumed that the increase is the same whether we go from 0 to 1 shopping malls or from 10 to 11. Here, one should expect a diminishing marginal benefit of access to a shopping mall.

Instead, model A3 includes a binary variable equal to 1 if the residence is within a radius of 400 metres from a shopping mall; otherwise, it is equal to zero. As before, the degree of explanation is high, and all coefficient estimates are at the same level as previous models. The results presented in model A3 can be compared relatively easily with the results of Kurvinen and Wiley (2019). Within 400 metres of a shopping mall, the capitalisation effect is estimated at 1.6%, which can be compared to 1.5% within a 500-metre radius in Helsinki. Pope and Pope (2015) estimated the effect of the establishment of a Walmart location to be about 2–3% within a distance of 800 metres and then to decrease to about 1–2% in the interval 800–1,600 metres. This means that their results are slightly higher than both our results and Kurvinen and Wiley's (2019) results.

5 Parameter heterogeneity

This study aims to determine how the distance to a shopping mall as well as the number of shopping malls would affect surrounding property prices. Based on the regression analysis, the results show that there is a negative relationship between distance and housing prices while there is a positive relationship between quantity and housing prices. These findings are consistent with the existing body of knowledge.

Apart from the above observations, some interesting discoveries can be discussed further to provide a more in-depth perspective on this topic. Thus far, we have estimated a model that covers the entire Stockholm housing market and assumed that all parameters are constant in, for example, space. Of course, this is not the case. In this section, our intention is to investigate whether the estimates vary across different dimensions, i.e., we investigate whether there is any parameter heterogeneity. We will utilise several interaction variables to test whether the effect of proximity to shopping malls varies in four different dimensions, namely, space, size of the dwelling, year over year, and whether the effect is localised or not. The results of these tests can be found in Table 4 of model B1-4.

Table 4. Parameter heterogeneity.

Variable	Model B1	Model B2	Model B3	Model B4
Ln(Size)	0.7300 (297.08)	0.7299 (298.52)	0.7326 (299.79)	0.7304 (297.36)
Ln(Room)	0.0751 (40.51)	0.0764 (41.41)	0.0885 (47.76)	0.0748 (40.41)
Ln(Fee)	-0.1366 (-87.29)	-0.1384 (-88.91)	-0.1377 (-88.56)	-0.1368 (-87.43)
Height	-0.0045 (-26.84)	-0.0044 (-26.42)	-0.0047 (-28.31)	-0.0045 (-26.81)
Floor	0.0146 (63.25)	0.0147 (63.94)	0.0146 (63.56)	0.0146 (63.30)
Ln(CBD)	-0.4213 (-381.91)	-0.4183 (-381.03)	-0.4238 (386.43)	-0.4202 (-379.90)
Subway	-0.0041 (-4.51)	-0.0050 (-5.48)	-0.0037 (-4.11)	-0.0037 (-4.13)
Ln(Shop)	-0.0658 (-7.74)	-0.0491 (-66.88)	-0.0452 (-65.93)	-0.0270 (-33.72)
I_shop_dist	0.0450 (5.35)	-	-	-
I_year	-	0.0467 (64.69)	-	-
I_size	-	-	0.0455 (67.23)	-
I_north	-	-	-	0.0128 (12.30)
Constant	-9734 (-3.49)	5.7579 (6.98)	-10023 (-3.62)	-9974 (-3.58)
R²_{adj}	0.8539	0.8554	0.8557	0.8539

Note. The fixed municipality, year effects and seasonal effects are included in the model as well as coordinates – *t*-values within brackets.

We have also tested whether the relationship between property value and proximity to a shopping mall is constant throughout the price distribution. We do this by estimating quantile regression. The results from these models can be found in Table 5.

The effect of proximity to a shopping mall as measured by distance (Model B1)

In model B1, we have tested the hypothesis that the value of being close to a shopping mall is more local than global. We have created an interaction variable between the distance to the nearest shopping mall and a binary variable indicating if the apartment is within a radius of 6 kilometres from the shopping mall (variable name *I_shop_dist*). If the estimate is significant and negative, it gives a signal that the effect is more localised than global.

The results indicate that the estimated parameter for the interaction variable is statistically significant and positive. It is smaller in size than the shopping mall

parameter estimate, which indicates that the effect is to a large extent, completely local.

The effect of proximity to a shopping mall over time (Model B2)

In Model B2, we have tested the hypothesis that the value of being close to a shopping mall has diminished over time. Increased online shopping has reduced the importance of being physically close to a shopping mall. (variable name I_{year}) The interaction variable is defined as the distance to the shopping mall for the period 2013–2019, otherwise zero. A positive coefficient indicates that the impact has diminished over time.

The results are clear. With high statistical significance, the parameter estimate is different from zero and positive. This means that the effect of being close to a shopping mall has diminished over time. The parameter estimate is less for the interaction variable than for the variable distance to a shopping mall, which indicates that there is an effect even after 2012 but that it is significantly lower.

The effect of proximity to a shopping mall depending on apartment size (Model B3)

The next discussion is about the effects of different sizes. To test the hypothesis that the effects are the same across different sizes of housing, we divide all the apartments into two different size groups and create an interaction variable (variable name I_{size}). It is equal to 1 if it is the distance to a shopping mall for apartments larger than 62 square metres (the median size), otherwise it is zero.

The results for Model B3 are also clear. Parameter estimates of interaction variables are positive, which indicates that the effect of being close to a shopping mall is capitalised primarily on smaller apartments. It is reasonable to assume that younger people live in these apartments and that proximity to a shopping mall is more important for these households. However, this can be an effect of the fact that smaller apartments are mainly located in central locations within Stockholm, and the results can, therefore, be an effect of this characteristic.

The effect of proximity to a shopping mall based on orientation to the CBD (Model B4)

The third discussion is about the orientation to the CBD. Is there any difference in the effect of an 'apartment's location north of the CBD or south of the CBD? Such an effect can be motivated by socio-economic differences in the Stockholm area. We divide apartments into south (0) and north (1) using Sergels Torg as the reference point. Interaction variables are thus between the apartment located north of Stockholm multiplied by the distance to a shopping mall. If the apartment is south of Stockholm centre, the value of the interaction variable will be zero (variable name I_{north}).

Again, the results are clear. The estimate has a positive sign and is statistically significant. This indicates that the value of being close to a shopping mall is greater south of Stockholm centre than north of Stockholm centre. However, the size of the parameter estimate is smaller than the coefficient regarding the distance to a

shopping mall, which indicates that there is a positive effect of being close to a shopping mall even north of the city but that this effect is lower than it is south of the CBD.

The effect of proximity to a shopping mall across price distribution

Finally, we have also tested whether the parameter regarding proximity to a shopping mall varies with the price of the apartment when we keep all other attributes constant. This means that we estimate a so-called quantile regression model. This model has been used, for example, in Brunet et al. (2020) to measure the effect of infill developments. The results from these estimates are shown in Table 5. We have estimated the model for the 25th, 50th, and 75th percentiles.

Table 5. *Quantile regression – coefficient concerning distance to a shopping mall.*

Percentile	Coefficient	t-value
0.25	-0.0317	-36.97
0.50	-0.0195	-27.07
0.75	-0.0092	-11.87

Note. Fixed municipality and year effects are included in the model as well as coordinates and all other variables included earlier.

The results here are interesting. What we see is that the price effect is especially evident in the lower price ranges. The coefficient decreases from -0.04 to -0.01 from the 25th to the 75th percentile. These results are consistent with the results we see, for example, regarding the interaction variable for housing size. It seems plausible that the lower priced apartments are occupied by younger households for which shopping malls are important.

What may be worth noting concerning other independent variables is the effect regarding proximity to a subway station (see Table 2 in the appendix). In the lower price range, proximity to the metro station has a significant price effect. However, the more expensive the apartment is, the less proximity to the metro station has an effect. In the higher price ranges, the effect even becomes negative. Otherwise, it can be noted that the effect of additional housing space increases with the price of housing and that the significance of the monthly fee decreases. Proximity to the CBD is equally capitalised throughout the distribution of prices.

6 Conclusions

This paper aims to examine the effects of shopping malls on residential property values, given samples in the county of Stockholm. By using the hedonic price model, this study analysed the influence of shopping malls on surrounding housing prices from the perspective of both distance and quantity of shopping malls.

The results of the regression show that the explanatory variables have significant effects on the dependent variables. Moreover, the results also reveal an inverse relationship between housing prices and distance to a shopping mall. The increase in proximity to a shopping mall is expected to lead to an increase in the housing price, while the number of shopping malls is positively correlated to housing prices. This is consistent with previous studies. The effects the distance has

on housing prices are more significant for smaller apartments and less significant for larger apartments. Also, the effects are stronger for the apartments north of the CBD. Moreover, the impact over time is declining.

There are several policy implications based on the empirical results we present here. Amenities and disamenities have an impact on housing values. Knowledge about, for example, the impact of shopping malls on housing values is important when determining the value of an apartment. This may apply, for example, to the taxation of housing, to loan applications and, of course, to the sale of housing. Compared to previous studies, this study broadens the investigation of the different aspects of shopping malls that affect housing prices.

Many questions are appropriate for future research. For example, if more traditional spatial models can clarify how the spatial dependence looks, one could estimate the capitalisation effect continuously over time, and it would be possible to use methods similar to difference-in-difference. Of course, it would also be interesting to measure the quality of the specific shopping malls when it comes to, for example, the type of stores.

Acknowledgements. The authors wish to thank the research project Housing 2.0 (Bostad 2.0) for financial support and Mäklarstatistik AB for transaction data.

References

- Bayer, P., Keohane, N. and Timmins, C., (2009), Migration and hedonic valuation: The case of air quality, *Journal of Environmental Economics and Management*, 58, (1), 1–14. <https://doi.org/10.1016/j.jeem.2008.08.004>
- Berk, R. A. (1990). A primer on robust regression. In *Modern Methods of Data Analysis*, ed. J. Fox and J. S. Long, 292–324. Newbury Park, CA: Sage. 1990.
- Bitter, C., Mulligan, G.F., Dall’erba, S. (2007), Incorporating spatial variation in housing attribute prices: a comparison of geographically weighted regression and the spatial expansion method. *Journal of Geographical System*, 9, 7–27. <https://doi.org/10.1007/s10109-006-0028-7>
- Brunes, F., Hermansson, C., Song, H. S., & Wilhelmsson, M. (2020). NIMBYs for the rich and YIMBYs for the poor: analyzing the property price effects of infill development. *Journal of European Real Estate Research*. 13(1), 55–81. <https://doi.org/10.1108/JERER-11-2019-0042>
- Can, A., 1992. Specification and estimation of hedonic housing price models, *Regional Science and Urban Economics*, 22 (3), 453–474. [https://doi.org/10.1016/0166-0462\(92\)90039-4](https://doi.org/10.1016/0166-0462(92)90039-4)
- Carter, C. (2009). What We Know About Shopping Centers. *Journal of Real Estate Literature*, 17(2), 165–180.
- Cavaillès, J., Brossard, T., Foltête, J.-C., Hilal, M., Joly, D., Tourneux, F.-P., Tritz, C., Wavresky, P. (2009). GIS-Based Hedonic Pricing of Landscape. *Environmental Resource Economics*, 44:571–590. <https://doi.org/10.1007/s10640-009-9302-8>

- Chau, K. W., Chin, T. L. (2003). A critical review of literature on the hedonic price model. *International Journal for Housing Science and Its Applications*, 27(2), 145–165.
- Clapp, J.M. (2004). A Semiparametric Method for Estimating Local House Price Indices, *Real Estate Economics*, 32(1), 127–160. <https://doi.org/10.1111/j.1080-8620.2004.00086.x>
- Clapp, J.M., Rodriguez, M., Pace, K.R. (2001). Residential Land Values and the Decentralisation of Jobs, *Journal of Real Estate Finance and Economics*, 22:1, 43–61. <https://doi.org/10.1023/A:1007827309934>
- Colwell, P. F., Gujral, S. S., Coley, C. (1985). The impact of a shopping center on the value of surrounding properties. *Real Estate Issues*, 10(1), 35–39.
- Deaton, B. Hoehn, J. (2004). Hedonic analysis of hazardous waste sites in the presence of other urban disamenities. *Environmental Science & Policy*. 7. 499–508. <https://doi.org/10.1016/j.envsci.2004.08.003>
- Des Rosiers, F., Lagana, A., Thériault, M., Beaudoin, M. (1996), “Shopping centres and house values: an empirical investigation”, *Journal of Property Valuation and Investment*, Vol. 14 No. 4, pp. 41–62. <https://doi.org/10.1108/14635789610153461>
- Erkip, F. (2005). The rise of the shopping mall in Turkey: The use and appeal of a mall in Ankara. *Cities*, 22(2), 89–108. <https://doi.org/10.1016/j.cities.2004.10.001>
- Fasli, M., Riza, M., Erbilin, M. (2016). The assessment and impact of shopping centers: case study Lemar. *Open House International*, 41(4), 98–103.
- Fik, T. J., Ling, D. C., & Mulligan, G. F. (2003). Modeling spatial variation in housing prices: a variable interaction approach. *Real Estate Economics*, 31(4), 623–646. <https://doi.org/10.1046/j.1080-8620.2003.00079.x>
- Gareth, J., Witten, D., Hastie, T., Tibshirani, R. (2017). *An Introduction to Statistical Learning* (8th ed.). Springer Science Business Media New York. ISBN 978-1-4614-7138-7.
- Hill, R.J., Scholz, M. (2018). Can geospatial data improve house price indexes? A hedonic imputation approach with splines, *Review of Income and Wealth*, 64(4), 737–756. <https://doi.org/10.1111/roiw.12303>
- Howard, E. (2007), New shopping centres: is leisure the answer?, *International Journal of Retail & Distribution Management*, Vol. 35 No. 8, pp. 661–672. <https://doi.org/10.1108/09590550710758649>
- Jackson, J.R. (1979). Intraurban Variation in the Price of Housing, *Journal of Urban Economics*, 6, 464–479. [https://doi.org/10.1016/0094-1190\(79\)90025-1](https://doi.org/10.1016/0094-1190(79)90025-1)
- Kurvinen, A. & Wiley, J. (2019). Retail development externalities for housing values. *Journal of Housing Research*, 28(1), 109–128. <https://doi.org/10.1080/10835547.2019.12092155>
- Mok, H., Chan, M., & Cho, K. (1995). A hedonic price model for private properties in Hong Kong. *The Journal of Real Estate Finance and Economics*, 10(1), 37–48. <https://doi.org/10.1007/BF01099610>
- Monson, M. (2009). Valuation using hedonic pricing models. *Cornell Real Estate Review*, 7, 62–73. Morancho, A. (2003). A hedonic valuation of urban green areas. *Landscape and Urban Planning*, 66(1), 35–41. [https://doi.org/10.1016/S0169-2046\(03\)00093-8](https://doi.org/10.1016/S0169-2046(03)00093-8)

- Pavlov, A.D. (2000), Space-varying regression coefficients: A semi-parametric approach applied to real estate markets, *Real Estate Economics*, 28(2), 249–283. <https://doi.org/10.1111/1540-6229.00801>
- Pope, D. G. & Pope, J. C. (2015). When Walmart comes to town: Always low housing prices? Always? *Journal of Urban Economics*, 87, 1–13. <https://doi.org/10.1016/j.jue.2014.10.004>
- Owusu-Ansah, A. (2018). *Construction and Application of Property Price Indices*. Routledge, New York, USA, ISBN: 978-1-138-10470-9. <https://doi.org/10.1201/9781315102085>
- Ozuduru, B. (2013). Assessment of Spatial Dependence Using Spatial Autoregression Models: Empirical Analysis of Shopping Center Space Supply in Ohio. *Journal of Urban Planning and Development*, 139(1), 12–21. [https://doi.org/10.1061/\(ASCE\)UP.1943-5444.0000129](https://doi.org/10.1061/(ASCE)UP.1943-5444.0000129)
- Palmquist, R.B., (2006), Property Value Models in Raymond B. Palmquist (eds.), *Handbook of Environmental Economics*, vol 2, Elsevier.
- Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, 82(1), 34–55. <https://doi.org/10.1086/260169>
- Ross, J.M., Farmer, M.C., Lipscomb, C.A. (2011). Inconsistency in welfare inferences from distance variables in hedonic regressions. *Journal of Real Estate Finance and Economics*, 43, 385–400. <https://doi.org/10.1007/s11146-009-9221-z>
- Rousseeuw, P., & Leroy, A. (1987). *Robust regression and outlier detection* (Wiley series in probability and mathematical statistics). New York: Wiley. <https://doi.org/10.1002/0471725382>
- Schulz, R., Werwatz, A. A (2004). State Space Model for Berlin House Prices: Estimation and Economic Interpretation. *The Journal of Real Estate Finance and Economics* 28, 37–57. <https://doi.org/10.1023/A:1026373523075>
- Seago, J. (2013). Northgate Mall’s effect on surrounding property values. *Economics 355 – Urban Economics*. Durham Paper. Duke University. North Carolina, USA.
- Shimizu, C. (2014). Estimation of hedonic single-family house price function considering neighborhood effect variables, *Sustainability*, 6, 2946–2960. <https://doi.org/10.3390/su6052946>
- Sirpal, R. (1994). Empirical Modeling of the Relative Impacts of Various Sizes of Shopping Centers on the Values of Surrounding Residential Properties, *Journal of Real Estate Research*, vol. 9(4), pages 487–506.
- Statistics Sweden. (2019). Population. Retrieved from <https://www.scb.se/en/finding-statistics/statistics-by-subject-area/population>
- Walsh, P.J., Milon, J.W., Scrogin, D.O. (2011). The Spatial Extent of Water Quality Benefits in Urban Housing Markets. *Land Economics* 87(4), 628–644. <https://doi.org/10.3368/le.87.4.628>
- Wang, R., Li Ye, Liwen Chen. (2019). The Impact of High-Speed Rail on Housing Prices: Evidence from China’s Prefecture-Level Cities. *Sustainability*, 11(13), 3681. <https://doi.org/10.3390/su11133681>

Wilhelmsson, M. (2002). Spatial models in real estate economics, *Housing, Theory and Society*, 19 (2), 92–101. <https://doi.org/10.1080/140360902760385646>

Wilhelmsson, Mats (2019). Energy performance certificates and its capitalization in housing values in Sweden, *Sustainability*, 11, 6101; doi:10.3390/su11216101. <https://doi.org/10.3390/su11216101>

Wooldridge, J.M. (2006). *Introductory Econometrics: A Modern Approach*, 3rd ed. Thomson South-Western, Mason, OH.

Zhang, L., Zhou, J., Hui, E. C. M., Wen, H. (2019). The effects of a shopping mall on housing prices: A case study in Hangzhou. *International Journal of Strategic Property Management*, 23(1), 65–80. <https://doi.org/10.3846/ijspm.2019.6360>

Yang, Y. Diez.Roux, A.V. (2012). Walking distance by trip purpose and population sunrgroups. *American Journal of preventive Medicine*, 43(1), 11–19. <https://doi.org/10.1016/j.amepre.2012.03.015>

Appendix A

Table 1. Correlation matrix (key variables).

	Price	Size	Room	Fee	CBD	Subway	Shop	#shop	Bshop
Price	1								
Size	0.47	1							
Room	0.42	0.91	1						
Fee	0.12	0.43	0.40	1					
CBD	-0.43	0.11	0.09	0.11	1				
Subway	0.21	-0.13	-0.11	-0.42	-0.42	1			
Shop	-0.22	0.04	0.04	0.05	0.72	-0.23	1		
NoShop	0.11	-0.01	-0.02	-0.03	-0.11	0.15	-0.14	1	
Bshop	0.11	-0.01	-0.02	-0.03	-0.12	0.16	-0.15	0.95	1

Table 2. Quantile regression.

	0.25 percentile	0.50 percentile	0.75 percentile
Ln(Size)	0.6621 (187.84)	0.7143 (241.08)	0.7609 (237.87)
Ln(Room)	0.0804 (30.18)	0.0759 (33.87)	0.0676 (27.97)
Ln(Fee)	-0.1552 (-69.15)	-0.1242 (-65.83)	-0.1022 (-50.17)
Height	-0.0044 (-18.17)	-0.0042 (-20.46)	-0.0044 (-19.88)
Floor	0.0124 (37.52)	0.0141 (50.67)	0.0167 (55.63)
Ln(CBD)	-0.4109 (-296.63)	-0.4215 (-362.04)	-0.4421 (-351.67)
Subway	0.0032 (2.47)	0.0003 (0.26)	-0.0067 (-5.66)
Ln(shop)	-0.0317 (-36.97)	-0.0195 (-27.07)	-0.0092 (-11.87)