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The influence of urban green and recreational areas on the price of housing in Zagreb

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Abstract

Urban green and recreational spaces are important for residents and one of the foundations for the functioning of cities. They offer numerous benefits, including the influence on the price of real estate as an economic benefit. In this paper, the influence of green and recreational areas in Zagreb on the price of apartments in residential buildings is analysed using the hedonic pricing model. The data for the study was processed and analysed using a geographic information system. A local hedonic price model was developed. The results show that some of the observed green and recreational areas increase the price of housing due to their proximity, while others decrease it. Some areas have no influence on the price of housing. The influence of the observed areas on housing prices was heterogeneous. Spatial differences were also found in the influence of the observed areas on housing prices. The most attractive factors when choosing a place to live are Jarun and the parks in the city centre. The price of apartments that near the Jarun increases by 41 EUR/m^2 if the apartment is 100 m closer to the Jarun. The price of the apartment increases by 91 EUR/m^2 the closer the apartment is to the parks in the city centre (per 100 m). Apartments near Jarun and the parks in the city centre are not available for residents with lower socio-economic status. The forest areas, Maksimir Park and the banks of the Sava river are not favoured when choosing a place to live. Neighbourhoods near these areas are available to the lower socioeconomic status population. Bundek raises the price of one part of the apartments and lowers the price of the other. The results of this study can contribute to the study of green gentrification in Zagreb, but further research is needed on socio-economic indicators and other changes in the region.

Keywords: urban green areas, recreational areas, hedonic model, geographically weighted regression, real estate

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Introduction

A city is a space that is characterized by a compact structure and whose elements are in constant interaction. One of the elements of the functional-spatial structure of the city are recreational areas. Recreational areas are open spaces with built infrastructure intended for recreational activities. Their basic characteristics are the predominant natural environment, which includes vegetation, i.e. greenery (forest, grass, flowers), and often also water areas (river, canal, lake) and a certain number of built objects (paths, roads, buildings, playgrounds, sports halls, sports facilities). These areas are used by users for recreational activities. The largest recreational areas are generally located on the outskirts of the city, as this is where the largest open spaces are available. Green areas in the city consist of parks, gardens, urban forests, promenades and other smaller areas that are covered with vegetation but have fewer or no buildings (they may include walking paths, benches and other rest areas). In addition to other functions, the green areas integrated into the urban structure also serve active and passive recreation.

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Green and recreational areas in the city play an important role in the functioning of the city and its inhabitants. Sustainable urban development has recognized the importance of cultural, historical and natural values that are irreplaceable and therefore non-renewable (Pacione, M. 2009). In addition to historic neighbourhoods, this category includes parks and natural landscapes that provide space for play, recreation and access to nature. In addition to economic vitality, an ideal sustainable urban community is characterized by ecological integrity (clean environment, access to natural areas) and social well-being (equitable access to housing, recreational activities, etc.) (Pacione, M. 2009).

The importance of planning and incorporating green spaces into urban design stems from the benefits they provide to city residents. Tyrväinen, L. and Miettinen, A. (2000) emphasize the aesthetic, ecological and economic benefits of forests, the positive influence on people's mental health and the opportunities for recreation. Swanwick, S. *et al.* (2003) have categorized the benefits of green areas into four groups: social benefits (access for all population groups, educational benefits), health benefits (outdoor exercise, psychological benefits), ecological benefits (preservation of biodiversity and cultural heritage, reduction of air and water pollution, positive impact on urban climate) and economic benefits (employment, attraction for businesses and tourists, value of nearby real estate). Harnik, P. and Crompton, J.I. (2014) distinguish between the direct and indirect economic value of parks.

The direct economic value includes the economic profit from park visitors and the profit from the provision of some services in the park. Visitors give funds to the municipality in the form of taxes by paying gas, groceries, restaurant meals or hotel accommodation. The municipality uses some proportion of this money to reinvest in tourism and the promotion of the parks.

The indirect economic value of parks relates to the impact on property values, reducing flooding, reducing air pollution, improving health and general social benefits. Olbińska, K. (2018) categorizes the benefits of urban green areas into three groups: economic (impact on property value, rent, real estate market activity, jobs, tourism), environmental (increased biodiversity, air temperature balancing, reduced pollution, improved drainage, flood risk reduction, noise reduction), social benefits (they enable sports and recreation, socialization, education, usually have a positive impact on health).

The public interest in the city's green and recreational areas arises from all the benefits mentioned and not mentioned. They are public goods and as such have often been regarded as free of charge. Nevertheless, they contribute to the economy through their existence and use. The economic value of a public good is made up of a market value and a non-market value (Lockwood, M. and Tracy, K. 1995). The greatest economic value of a public good, recreational resources, cannot usually be expressed through a price mechanism. The non-market value consists of a user component and a non-user component. The user component results from the use of the content. The non-user component relates to the legacy for other generations and the awareness of the existence of such a space.

As recreational and green areas are not traded on the market, it is possible to use non-market valuation methods for their valuation (Logar, I. 2019). Non-market valuation methods are based on individual perceptions and include revealed preference and stated preference methods. Revealed preference methods determine utility values and reveal the individual preferences of individuals by observing their actual market behaviour. The hedonic price method belongs to this group of methods. The hedonic price method (hedonic price model) is based on the assumption that goods and services from the environment influence market prices. It follows that the price of a market good (e.g. a property) is related to its characteristics, but also to the characteristics of the environment. It is often used when assessing the impact of public goods on real estate prices.

The aim of this thesis is to investigate the impact of green and recreational areas in the city of Zagreb (settlement) on the prices of apartments in residential buildings. There are two hypotheses of the study are. First, green and recreational areas influence on the higher price of real estate in Zagreb. Second, there are spatial differences in the impact of individual green and recreational areas in the city of Zagreb on real estate prices.

Literature preview

An overview of previous research shows that the topic of the influence of green and recreational areas on the price of real estate has become more frequent in the last thirty years. The papers analysed show studies conducted in cities in Europe, the USA, Turkey, China, Indonesia and Malaysia. The studies differ according to the type of green areas. Some authors included all green areas in the city in the analysis (Jim, C.Y. and Chen, W.Y. 2006; Conway, D. *et al.* 2010; Liebelt, V. *et al.* 2017, 2018, 2019; Nur Syafiqah, A.S. *et al.* 2018; Czembrowski, P. *et al.* 2019; Daamsa, M.N. *et al.* 2019). Other authors differentiated the green areas and analysed them individually according to their type. Green areas predominate in the analyses, while recreational areas are less well represented. Most authors are of the opinion that recreation is one of the functions of green areas.

In terms of property types, apartments predominate over houses. Of all the studies examined, mainly sold or for-sale properties were analysed, only Liebelt, V. *et al.* (2017, 2018, 2019) examined rental properties. Most of the studies analysed the property prices achieved, while only Herath, S. *et al.* (2015), Bonetti, F. *et al.* (2016), and Liebelt, V. *et al.* (2017, 2018) examined advertised prices.

The research also differs in terms of the environmental variables examined. The environmental variables depend on the assumptions of the research, the availability of data and the characteristics of the area studied. The most common is the distance from green and recreational areas.

Some authors used GIS to prepare variables and process data (e.g. Lindsey, G. *et al.* 2004; Kong, F. *et al.* 2007; Poudyal, N.C. *et al.* 2009; Panduro, T.E. and Veie, K.L. 2013; Wu, J. *et al.* 2015; Franco, S.F. and Macdonald, J.L. 2018; Heymana, A.V. and Sommervollb, D.E. 2019). In some studies, the GIS was used to collect data in the form of a survey (Czembrowski, P. *et al.* 2016; Daamsa, M.N. *et al.* 2019).

In most studies, the results showed a positive influence of green areas on real estate prices, i.e. an increase in real estate prices with proximity to green areas. Tyrväinen, L. and Miettinen, A. (2000) report results for the Solo district in Finland, according to which increasing the distance of apartments to a park by 1 km reduces the price of real estate by an average of 5.9 percent and apartments with a view are on average 4.9 percent more expensive. Studies by other authors show that green and recreational areas increase the price of real estate (Tyrväinen, L. 1997; Morancho, A.B. 2003; Conway, D. *et al.* 2010; Bark, R.H. *et al.* 2011; Kolbe, J. and Wüstemann, H. 2014; Norzailawati, M.N. *et al.* 2015; Trojanek, R. 2016; Harnik, P. *et al.* 2017; Trojanek, R. *et al.* 2018; Liebelt, V. *et al.* 2019).

In some studies, the results showed the opposite effect of green areas. Liebelt, V. *et al.* (2019) found that in the vicinity of large green areas, the price of real estate increases with the distance to them, citing overcrowding, noise and a large number of cars as reasons for this. Czembrowski, P. *et al.* (2019) state that not all characteristics of green areas are desired by buyers in Stockholm. There are many high-quality green areas in upscale neighbourhoods, which should be a reason to invest in green areas elsewhere. Bonetti, F. *et al.* (2016) find that proximity to a natural watercourse is a negative factor for the price and lowers it, while proximity to a built canal is a positive factor and increases it. Bark, R.H. *et al.* (2011) state that the value of houses decreases when they are next to or near a park, as parks are large, noisy, crowded and less safe, and also have questionable maintenance that leads to the death and drying out

of vegetation. Hu, S. *et al.* (2016) found that larger lakes in Wuhan lower house prices in their vicinity due to clutter, while smaller lakes increase house prices.

In the context of customer preferences for green areas, research has shown that in addition to distance to green spaces, multi-functionality (Czembrowski, P. *et al.* 2019), a certain type and size of green areas (Melichar, J. and Kaprová, K. 2013) and the extent of overall greening (Franco, S.F. and Macdonald, J.L. 2018) also play a role. The social aspect of this topic includes the impact of real estate values on the local population. The process of green gentrification is explained in the urban literature. Green gentrification is a process in which the removal of pollution or the provision of green amenities increases local property values and attracts more affluent residents to a previously polluted or disenfranchised neighbourhood (Dooling, S. 2009). As a result of policies to improve the characteristics of green and recreational areas in deprived neighbourhoods, the "green space paradox" emerges (Wolch, J.R. *et al.* 2014; Anguelovski, I. *et al.* 2022). Urban strategies to restore degraded urban environments, create green spaces or deploy climate-adapted green infrastructure improve the attractiveness of an area. At the same time, they lead to higher housing prices and the physical displacement of working class residents and racialized groups and cultures. This is the factor behind green gentrification.

Environmental injustice appears when not all city dwellers have equal access to green and recreational areas. Disadvantaged residents living close to green spaces not only have less access to green areas, but are also characterized by a shorter length of stay and may end up being "trapped" far from green areas (Łaszkiewicz, E. *et al.* 2018).

Methodology

The hedonic pricing model is one of the methods used to determine customer preferences. The data is analysed using multiple regression analysis, which measures the influence of individual variables on the price of a property (Logar, I. 2019). The hedonic model contains three groups of variables: structural, neighbourhood and environmental variables. Structural variables show the characteristics of the property. The neighbourhood variables determine the location of the property in relation to other elements in the space. The environmental variables show the location of the property in relation to the green and recreational area. They show how much users are willing to pay for the environmental benefits they receive. Some authors have also included the socio-economic characteristics of the area in the model (Liebelt, V. *et al.* 2018; Panduro, T.E. *et al.* 2018). The variables are selected by the author depending on the research assumptions, data availability and other conditions.

The hedonic model can be global and local. The global hedonic model processes the data using the least squares method and provides unique coefficients for the entire study area, ignoring the specific characteristics of the individual parts of the study area. This is the main disadvantage of this method. The local hedonic model provides the geographical variation of the coefficients for each independent variable. This is a geographically weighted regression (GWR) that uses the coordinates of each sample point and includes the characteristics of neighbouring observations in the analysis. The geographically weighted regression equation is:

$$y_i = \beta_0(u_i, v_i) + \sum_k^p \beta_k(u_i, v_i) x_{ki} + \varepsilon_i,$$

where y_i is the real estate price and represents the dependent variable, β_0 is the independent coefficient that is estimated, k is sumation index, p is the number of independent variables in regression and the highest value of k, u_i and v_i are the geographic coordinates, β_k are the coefficients of the independent variables, x_{ki} is the kth independent variable at location i, and ε_i is the standard error.

Study area

The study covers the area of the city of Zagreb as a settlement with an area of 304 km^2. According to the 2021 census, Zagreb has 663,592 inhabitants. Zagreb is the largest urban centre in Croatia with various attractive factors for migration to the city and change of residence within the city. The city is of great importance for all aspects of life in Croatia, including leisure activities. Zagreb was selected due to the availability and volume of data, as it represents the largest and most dynamic real estate market in Croatia.

Zagreb was established at the foot of Medvednica Hill, where the old city centre is located. With urban development from the 19th century to the present day, the city spread southwards across the Sava river. The development and expansion of the city of Zagreb to the east and west is due to the extension of the Medvednica in a southwest-northeast direction. The expansion to the north was limited by the Medvednica, which is covered by forest and protected by the status of a nature park. In the general city plan, forests occupy the largest area in Zagreb (more than 25%). Forest areas also extend along the foothills of the Medvednica and are used as public green areas (about 7% of the city area). A large area is also occupied by agricultural land, more than 23 percent. They are mainly located on the south-eastern and south-western outskirts of the city and on the foothills of the Medvednica. Residential areas cover about 18 percent of the city of Zagreb. The highest building density and the largest number of residential areas can be observed in the wider centre of the city (districts of Gornji grad-Medveščak, Donji grad, Trnje, Trešnjevka-north) *(Figure 1).*

The subject of interest are the green and recreational areas in Zagreb. The most important recreational areas in the city of Zagreb are the Recreational Sports Center (RSC) Jarun, the Sports Recreational Center (SRC) Bundek and the Sava dam. Green areas in the city of Zagreb are attractive for recreation, such as forests and parks. The planning document of the General Urban Plan of Zagreb distinguishes between urban park forests and park foreststs (Generalni urbanistički plan 2016, Articles 54 and 92). The spatial data on the location of the forests was provided by the City Office for Economy, Environmental Sustainability and Strategic Planning in dwg format. Maksimir Park was included separately in the analysis, as well as other larger parks in the wider centre of Zagreb. The parks were digitized in GIS by the authors.

Data

The information about real estate was provided by the online classifieds Njuškalo.hr. The advertisements refer to 15 March 2023. The data were collected for apartments in a residential building for which precise location information is available (geographical coordinates available). The dependent variable in the hedonic model is the asking price of the property per square metre.

The independent variables are divided into three groups: structural variables (S), neighbourhood (N), and environmental variables (E). Due to the lack of data, the following characteristics were included: the area of the apartment in square metres, the number of rooms in the apartment and the floor on which the apartment is located. These are structural independent variables. A total of 2314 apartments were included in the analysis.

The neighbourhood variables were determined with the help of GIS tools *(Table 1).* For this purpose, spatial data were collected on the locations of public sports fields (e.g. children's playground, basketball courts, sports fields), sports facilities (e.g. swimming pool, stadium, tennis court), cultural facilities (e.g. museums, cinemas, libraries), kindergartens, elementary school, secondary schools, higher education facilities, health centers, hospitals, public garages, bus, streetcar and train stops (GeoHub ZaGreb 2023). The locations of shopping centers and streetcar hubs were digitized by the author on the basis of location data and a cartographic background.

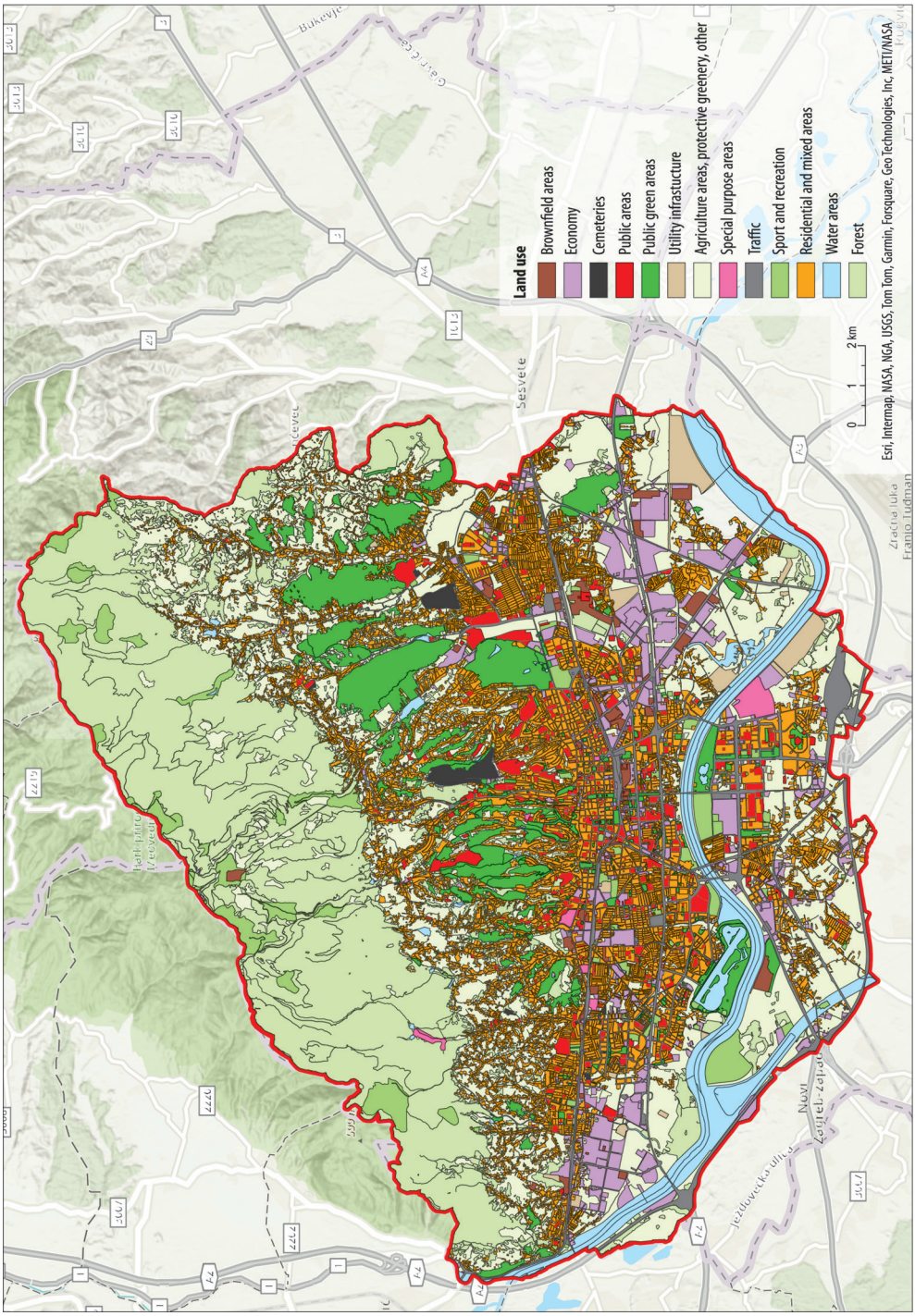

Fig. 1. Land use map of Zagreb. *Source:* Compiled by the authors, data from https://geoportal.zagreb.hr/Karta

Table 1. Variables of the hedonic model

Variables	Variable category	Variable explanation	Expected sign
Dependent variable			
price_m2	–	Advertised price of the apartment in m^2	+
Independent variables*			
area	Structural (S)	Apartment area in m^2	-
rooms**		Number of rooms	-
floor		The floor where the apartment is located	+
dist_centar**	Neighbourhood (N)	Distance from the city centre (Bana Josip Jelačić square)	-
dist_public		Distance from the nearest public transport station	-
dist_stat		Distance from the nearest station or tram interchange	-
dist_kinder		Distance from the nearest kindergarten	-
dist_elem		Distance from the nearest primary school	-
num_high**		Number of secondary schools within a radius of 500 m	+
num_fax		Number of higher education institutions within 500 m	+
dist_shop		Distance from the nearest shopping center	-
dist_ind		Distance from the nearest industrial area	+
dist_health		Distance from the nearest health center	-
dist_hosp		Distance from the nearest hospital	-
num_kult		Number of cultural institutions within 500 m	+
num_sportobj		Number of sports facilities within 500m	+
num_sportigr		Number of sports fields within a radius of 500 m	+
dist_gara**		Distance from the nearest public garage	-
dist_otp**		Distance from the landfill	+
dist_zona	Environmental (E)	Distance from the nearest green or recreation area	-
dist_forest		Distance from the forest	-
dist_jarun		Distance from RSC Jarun	-
dist_bundek		Distance from SRC Bundek	-
dist_bank		Distance from the Sava embankment	-
dist_maksimir		Distance from Maksimir Park	-
dist_park		Distance from the nearest park	-

*The unit of measurement for distance is the metre. ** Variables were omitted due to autocorrelation.
Source: Authors' own elaboration.

Spatial data on industrial areas, the boundaries of the urban area of Zagreb and streetcar and railroad lines were downloaded from the Geofabrik service (2023) (Geofabrik.de).

Environmental variables are: distance of apartments from the nearest forest (park forest and urban park forest), distance from RSC Jarun, distance from SRC Bundek, distance from the Sava dam, distance from Maksimir Park and distance from nearest park in the city centre. All distances are in metres. The data was prepared and processed in ArcGIS Pro 3.1.0.

Local hedonic model

Using the defined variables, a local hedonic model was created in the form of a geographically weighted regression. It was assumed that green and recreational areas have an influence on the higher prices of real estate in Zagreb and that there are spatial differences in the influence of individual green and recreational areas in the city of Zagreb on the price of real estate.

The problem of autocorrelation or mutual correlation of two independent variables in the regression was eliminated with the Pearson correlation coefficient (r). If the Pearson-coefficient $r > 0.7$, the variable is removed from the model due to correlation with another independent variable (Oliveira, S. *et al.* 2014) (see *Table 1*). If possible, highly correlated independent variables should be avoided, but in many cases this choice does not exist (Newbold, P. 2010), for

example when mutually correlated variables are of great interest for research. Since the environmental variables are of interest, none of the highly correlated variables were omitted. Due to the use of georeferenced data, only the results of the local hedonic model are presented in this paper.

The geographically weighted regression was performed with 120 neighbours. The Gaussian weighting method was used, according to which the weight decreases exponentially the further the point is from the observed point.

Results

The spatial autocorrelation in the local hedonic model was tested with the Moran I index, which is 0.185698 (p-value = 0.00000, z-score = 12.780390) and shows a statistically significant clustering of the analysis results. The coefficient of determination is R2 = 0.4090 and the adjusted coefficient of determination is adj. R2 = 0.3616 *(Table 2).* There are differences in the coefficient of determination between the apartments *(Figure 2).* The highest coefficients of determination are observed west of Maksimir Park and in the western part of Novi Zagreb (Kajzerica). The lowest coefficient of determination is observed in the wider surroundings of the city centre (Donji grad, Trnje).

The statistical significance of the model was tested at the 10 percent level (p-value < 0.1, t-value > 1.660). Since the attractiveness of certain factors in space is determined by their proximity (distance) to the apartment, a geographically weighted regression was used to account for apartments that are up to

Table 2. Local (GWR) model coefficients

Variables	Coefficients		
	min	mean	max
Intercept	-36,531.74	-1808.923	18,759.15
Structural variables (S)			
area	-7.01288	-3.596185	-0.424051
floor	-7.27306	54.1917	221.9165
Neighbourhood variables (N)			
dist_public	-0.490508	1.27809	4.15467
dist_kinder	-0.91591	0.558948	2.48765
dist_elem	-2.562863	-0.014774	3.054714
num_fax	-1404.26	6.95362	206.193
dist_shop	-1,533588	-0,084314	0,841975
dist_ind	-1.073735	0.209952	2.349503
dist_health	-1.153004	0.250067	2.759074
dist_hosp	-0.606382	0.154938	2.718514
num_kult	-111.232	7.15274	176.7045
num_sportobj	-114.2322	-11.7921	173.7824
num_sportigr	-277.8436	-3.03338	558.92
Environmental variables (E)			
dist_zona	-5.15309	0.079955	3.65268
dist_forest	-3.542074	0.075858	5.27866
dist_jarun	-2.05610	0.972864	8.43639
dist_bundek	-14.39090	0.983093	12.36982
dist_bank	-14.45573	-1.035173	17.62028
dist_maksimir	-2.89827	0.507891	5.95143
dist_park	-4.37027	-0.664219	0.91697
N	2314		
R^2	0.4090		
Adjusted R^2	0.3616		

Source: Authors' own elaboration.

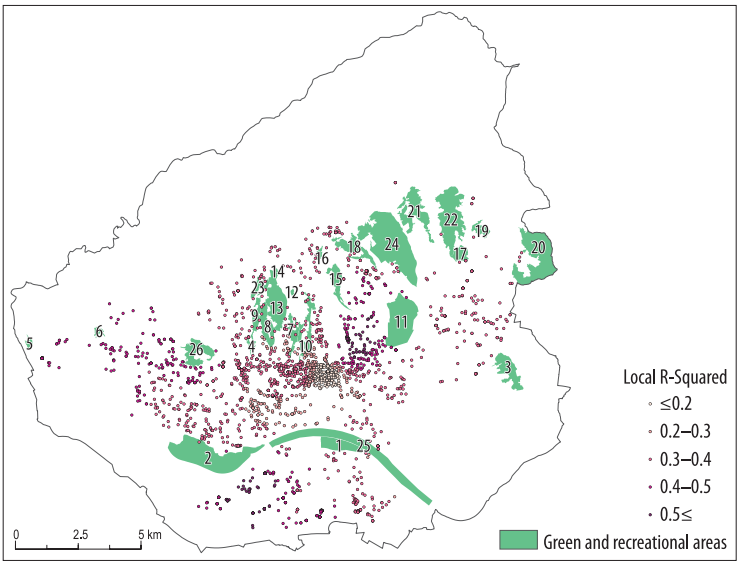

Fig. 2. Coefficient of determination R^2 in the local hedonic model. 1 = SRC Bundek, 2 = RSC Jarun. *Urban park-forests*: 3 = Čulinečina, 4 = Šestinski dol, 5 = Susedgrad, 6 = Lisičina, 15 = Mirogoj, 16 = Remetinski kamenjak, 17 = Granešina (Urban of Youth), 18 = Remete, 19 = Oporovec, 20 = Novoselčina, 21 = Miroševečina, 22 = Dankovečina, 23 = Zamorski Breg, 24 = Dotršćina, 26 = Grmošćica. *Park-forests:* 7 = Zelengaj, 8 = Jelenovac, 9 = Vrhovec, 10 = Tuškanac-Dubravkin put-Cmrok, 12 = Kraljevec, 13 = Pantovčak, 14 = Prekrižje. 11 = *Maksimir Park*, 25 = Sava dam. *Source:* Compiled by the authors.

2000 m away from a green or recreational area *(Table 3).* The distance given is the upper limit for a walk (about 25 minutes). Some studies have shown that the influence of the observed environmental elements on the property price extends up to a maximum distance of 2000 m (Melichar, J. and Kaprová, K. 2013), in some cases also over a shorter distance (Tyrväinen, L. and Miettinen, A. 2000; Biao, Z. *et al.* 2012; Daamsa, M.N. *et al.* 2019).

Although the neighbourhood variables are not the direct object of interest of this research, they should be briefly commented on. According to their mean values of the coefficients, four variables increase the value of real estate with their attractiveness (when all other variables in the regression are constant) (see *Table 2*). These are the distance from the elementary school, the distance from the shopping center, the number of higher education institutions and the number of cultural institutions within 500m of the apartment. The average of the coefficients shows a high value for the variables number of higher education and cultural institutions. The proximity of the shopping center is an attractive factor despite the crowds, noise and large built-up areas (buildings, parking lots, roads).

Other neighbourhood variables show unattractive factors for housing. Increasing the distance from health institutions (health center, hospital) increases the price of real estate, which is contrary to expectations. The same was expected for the variables distance from the nearest public transport station and the nearest kindergarten. The coefficients of the variables number of sports facilities and number of sports fields within 500 m of the property show the opposite of what was expected. Increasing the number of such facilities reduces the price of real estate. Possible causes are crowding and noise.

The results of the local hedonic model (GWR) show that there are large ranges of variation in

Table 3. *Results of the local hedonic model for apartments up to 2000 m away from a green or recreational area*

Variables	Count				Percentage			Statistic for significant properties (coefficients)			Part of the apartment price* in EUR		
	Non sign	Sign**	Sign -	Sign +	Sign	Sign -	Sign +	min	max	mean	min	max	mean
dist_zona	930	1202	609	593	56	51	49	-5.153090	3.652680	0.083059	-515	365	8
dist_forest	852	723	143	580	46	20	80	-3.542070	5.278660	0.337271	-354	528	37
dist_jarun	188	213	212	1	53	100	0	-0.621160	0.296880	-0.406531	-62	30	-41
dist_bundek	66	89	50	39	57	56	44	-1.512264	0.631705	-0.231906	-151	63	-23
dist_bank	486	38	3	35	7	8	92	-0.432529	1.285763	0.705826	-43	129	71
dist_maksimir	180	190	0	190	51	0	100	0.167898	2.580130	0.623056	17	258	62
dist_park	620	487	457	30	44	94	6	-1.945374	0.908357	-0.907034	195	91	-91

*Part of the apartment price for statistically significant apartments by individual variable, the change was estimated for every 100 m of distance from a green or recreational area. The Sign (-) shows a decrease in price with increasing distance from the observed green or recreational area, and the Sign (+) shows the inverse relationship. The unit of measurement is EUR/m². **Statistically significant ($p < 0.1$). *Source:* Authors' own elaboration.

the coefficients of the individual environmental variables (see *Table 2*). These results should be viewed with caution as they include apartments for which a single environmental variable is not statistically significant. For this reason, we will not interpret them here. We will interpret the results for the apartments for which the environmental variables are statistically significant ($p < 0.1$, $t > 1.660$) and which are located at a distance of up to 2000 m from the observed green or recreational area (see *Table 3*).

The variable distance to the nearest green or recreational area (dist_zona) is statistically significant for 56 percent of the apartments. It has a negative sign for 51 percent of the apartments, which means that proximity to this area increases the price of the apartment. Analogous to the coefficients, the value range of the price share associated with this variable ranges from -515 to 365 EUR/m², with an average of 8 EUR/m² (see *Table 3*). The geographical distribution of the coefficients *(Figure 3)* shows that the coefficients with a negative sign are concentrated in the western and south-western part of the city, while the coefficients with a positive sign predominate in the rest of the city, with the exception of the area around the forests of Mirogoj, Remetinski kamenjak and Remete.

Proximity to an urban park-forest or park-forest (dist_forest) has a statistically significant effect on 46 percent of apartments up to 2000 m away. The coefficients of the variables have a positive sign for most apartments (80%). According to the coefficients, the share of housing price attributable to proximity to the nearest forest ranges between -354 and 528 EUR/m², i.e., the extreme values, and the mean value is 37 EUR/m² (see *Table 3*). The coefficients with a negative sign (the variable increases the price of the apartment with decreasing distance from the forest) are located near the seven park-forests in the area of the historic city centre (Park-forests Zelengaj, Jelenovac, Vrhovec, Tuškanac-Dubravkin put-Cmrok, Kraljevec, Pantovčak and Prekrižje) and two urban park-forests (Zamorski Breg, Šestinski dol). It can be seen that other forest areas lower the price of housing the closer they are to the forest (coefficients with a positive sign) *(Figure 4).*

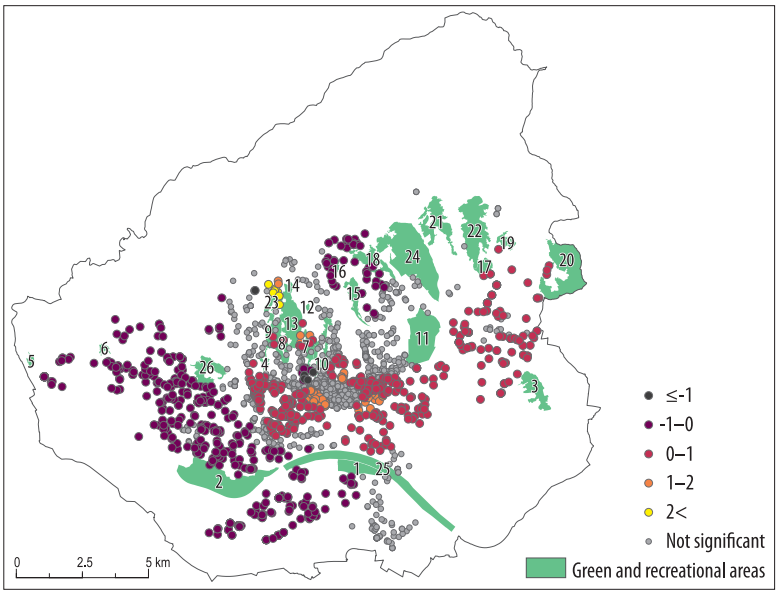

Fig. 3. Coefficients of the variable distance to the nearest green or recreational area. Numbers 1–25: see *Fig. 2. Source:* Compiled by the authors.

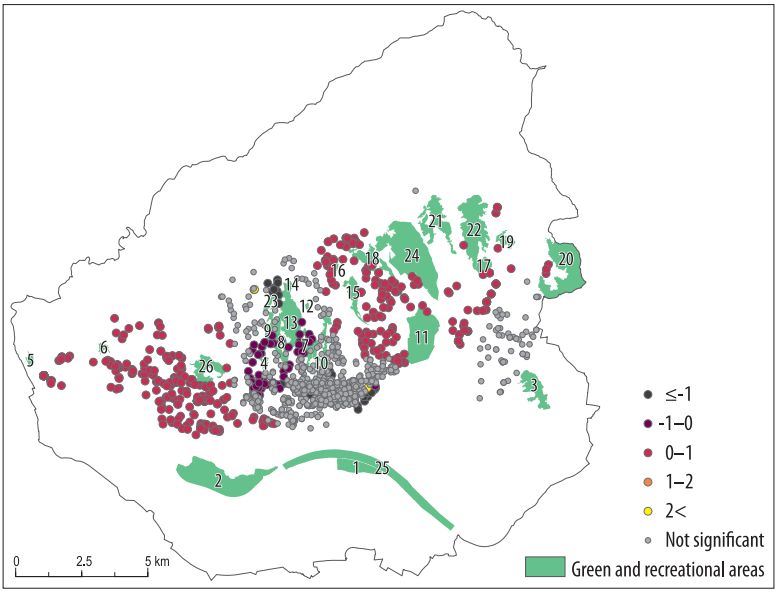

Fig. 4. Coefficients of the variable distance to the nearest urban park-forest or park-forest. Numbers 1–25: see *Fig. 2. Source:* Compiled by the authors.

The variable distance from RSC Jarun (dist_jarun) is statistically significant for 53 percent of the apartments at a distance of up to 2000 m. Almost all dwellings have a negative sign (212 out of 213 apartments), indicating that the price of apartments under the influence of Jarun increases when the apartment is closer to Jarun *(Figure 5).* The part of the apartment price that is close to the Jarun RSC averages 41 EUR/m^2, with values ranging from -62 to 30 EUR/m^2 (see *Table 3*). Given the relatively small range of coefficient values, *Figure 5* shows that all apartments are in the same class. Jarun also affects the price of apartments south of the Sava.

The variable Distance from SRC Bundek has the lowest number of dwellings included in the analysis of all environmental variables, which is due to a lower number of advertisements. The variable is statistically significant for 57 percent of the apartments (it has a positive sign for 44% of the statistically significant apartments, and a negative sign for 56%). The data show that proximity to the SRC Bundek influences the price of an apartment between -151 and 63 EUR/m^2, but on average 23 EUR/m^2 (see *Table 3*). The geographical distribution of the coefficients of the variable distance from Bundek (see *Figure 5*) shows that the variable is not statistically significant for the majority of apartments south of Bundek and is statistically significant for a large proportion of apartments north of Bundek, but also north of the Sava. A grouping of coefficients with a positive sign is observed in the western part of the observation area and with a negative sign in the eastern part of the observation area *(Figure 6).*

The distance variable from the bank of the Sava (dist_bank) has a statistically significant effect on the smallest proportion of apartments in its vicinity, namely only 7 percent of them. In 92 percent of the apartments for which the variable is statistically significant, the coefficient of this variable has a positive sign. The share of the price of an apartment near the Sava embankment ranges from -43 to 129 EUR/m^2, with an average of 71 EUR/m^2 (see *Table 3*). The geographical distribution of apartments *(Figure 7)* observed by this vari-

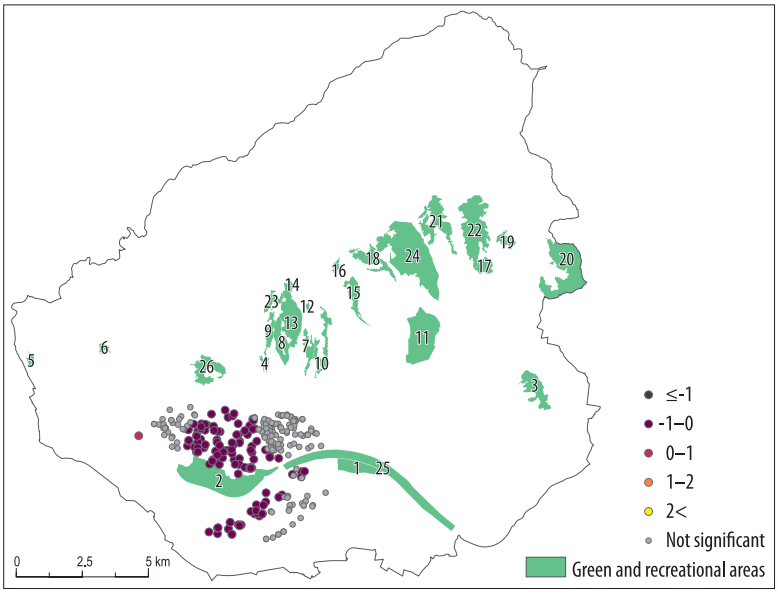

Fig. 5. Coefficients of the distance variables from RSC Jarun. Numbers 1–25: see *Fig. 2. Source:* Compiled by the authors.

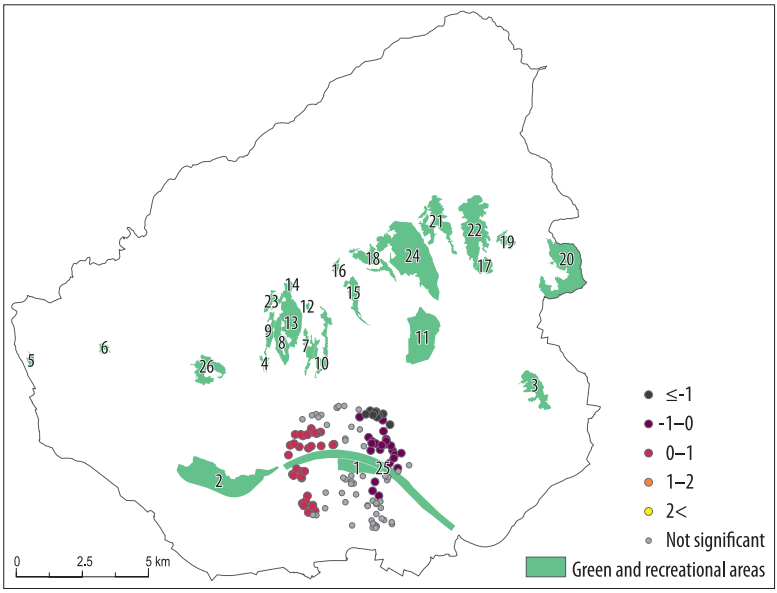

Fig. 6. Coefficients of the distance variables from SRC Bundek. Numbers 1–25: see *Fig. 2.*
Source: Compiled by the authors.

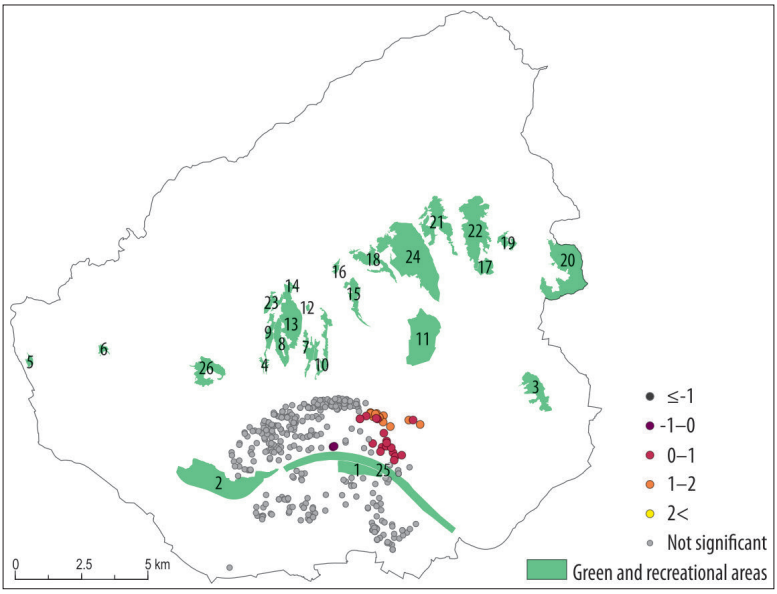

Fig. 7. Coefficients of the variable distance from the Sava dam. Numbers 1–25: see *Fig. 2.*
Source: Compiled by the authors.

able shows that the apartments for which the variable is statistically significant are located only in the Prisavlje area.

The variable distance to Maksimir Park (dist_maksimir) is statistically significant for 51 percent of the apartments at a distance of up to 2000 m. The sign of the coefficients of the variable is positive for all apartments, which shows that Maksimir Park lowers the price of apartments in the immediate vicinity and increases the price the further away the apartments are. On average, the price of an apartment that is 100 m away from Maksimir Park is 62 EUR/m^2 higher (see *Table 3*). The geographical distribution of apartments near Maksimir Park *(Figure 8)* shows that the variable distance to the park is statistically significant for apartments located west of the park. It can be seen that the coefficients of the variables are higher the further west the apartments are from Maksimir Park.

The variable for the distance to the nearest park (dist_park) is statistically significant for 44 percent of the apartments. The sign is negative for most apartments (92% of the apartments for which the variable is statistically significant). The share of the apartment price resulting from the distance to the nearest park is on average 91 EUR/m^2, which shows that the price of the apartment increases the closer the apartment is to the park. The value range of the share of the variable in the apartment price ranges from 195 to 91 EUR/m^2 (see *Table 3*). The geographical distribution of the apartments shows that the parks have the greatest influence on the apartment price for the apartments closest to the parks. The coefficients are somewhat lower (closer to zero) for apartments that are slightly further away from parks *(Figure 9).*

Discussion

The aim of the work is to investigate the influence of green and recreational areas in the city of Zagreb on the price of apartments in residential buildings. The research method is the local hedonic model. The results of the hedonic model show that green and recreational areas influence the price of apartments. They are therefor among the preferences of buyers when choosing a place to live.

The local hedonic model, created by geographically weighted regression, provides regression coefficients for each individual apartment. The model created in this study has a higher coefficient of determination than global models. Similar to the work of Sander, H.A. and Zhao, C. (2015), this study also shows that the global hedonic model provides poorer results because it generalizes. The local hedonic model differentiates the individual parts of the study area and therefore provides spatially clearer data. The coefficients of determination are spatially different, which indicates that a different part of the property price is explained by the variables of the model.

The direction of the influence (sign of the coefficient) of the green or recreational area on the price of the apartment is completely consistent for the variables distance from Jarun and distance from Maksimir Park.

The proximity to Jarun is an attractive factor for an apartment. The residential district of Trešnjevka-South, which was built in the last thirty years, extends north of Jarun. The development of the area near Jarun was mainly stimulated by the development of Jarun into a recreational area for the needs of the Universiade in 1987 and the construction of a streetcar line. The results of this research point to an obvious green gentrification. It is necessary to examine the socio-economic characteristics of the residents of this area in order to speak with certainty about environmental injustice and green gentrification.

For all apartments, the presence of Maksimir Park reduces the price of the apartment the closer the apartment is to it. These results contradict expectations, and it is necessary to find out more about this through further research. It can be assumed that the further one goes away from Maksimir Park, the closer one gets to the historical core, which means that the strict city centre and the main square are more attractive than

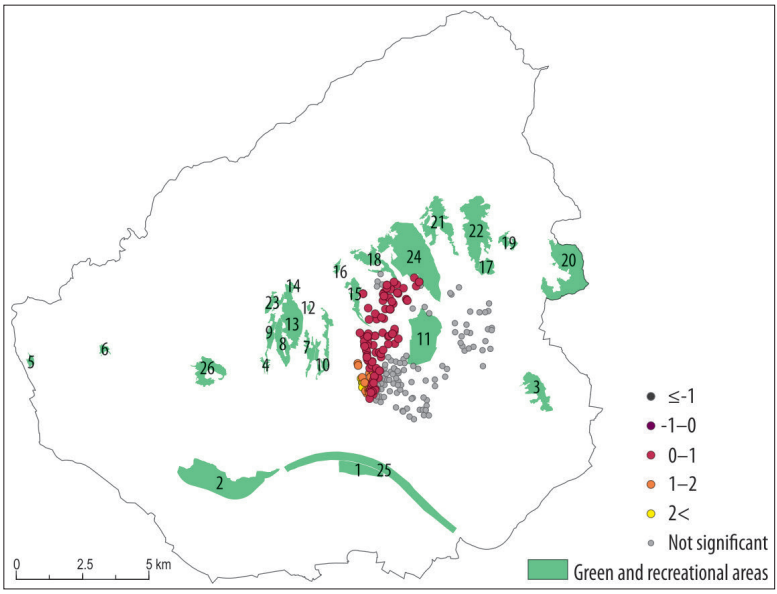

Fig. 8. Coefficients of the variable distance to Maksimir Park. Numbers 1–25: see *Fig. 2.*
Source: Compiled by the authors.

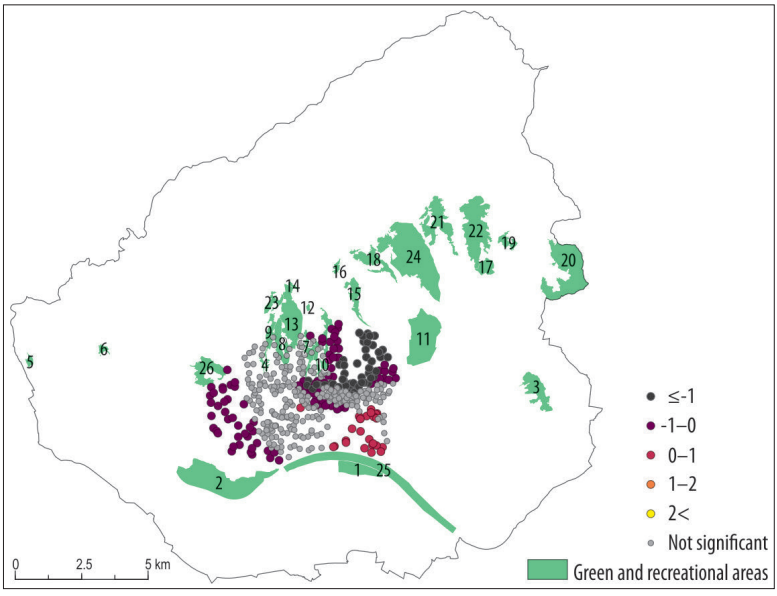

Fig. 9. Coefficients of the variable distance to the nearest park. Numbers 1–25: see *Fig. 2.*
Source: Compiled by the authors.

the large green city park. Maksimir Park is a well-maintained and large park and offers numerous recreational activities and rest.

A greater difference in the proportion of apartments with a positive and a negative coefficient of a statistically significant variable can be observed for the variables distance to the nearest park, distance to the Sava dam and distance to the nearest forest area. The results show the attractiveness of the parks due to their layout and their location in the wider city centre. The parks are well maintained, have recreational facilities (benches, fountains, walkways), landscaped vegetation (trees, lawns suitable for picnics) and occasionally host social events. Some of the parks are important tourist destinations in the city (Zrinjevac and Tomislavac parks). The parks in the city centre are small but important for the population, as they are located in a densely built-up part of the city where there are few green areas. Other green and recreational areas are located further away from the city centre. Regarding the availability of housing around the parks in the city centre, it can be said that it is not available for residents of lower socio-economic status. Due to the high building density, the proximity of parks is highly appreciated by the residents of Zagreb.

The distance to the nearest urban forest lowers the price in 80 percent of the apartments, the closer the apartment is to the urban forest. These results are contrary to expectations. The results of the local hedonic model suggest that forest areas are not an attractive factor for the location of the apartment in the vast majority of cases. The reason for this could be the poor organization of some of the observed forest areas (fewer recreational opportunities, lower diversity of vegetation, poor maintenance, overgrown vegetation), weaker promotion as a place for recreation and the proximity of the Medvednica Nature Park as a large forest area. Some of these reasons are mentioned by Bark, R.H. *et al.* (2011) and Hu, S. *et al.* (2016). Indeed, the proximity of Medvednica forest means a distance from the city centre, a certain peripheral location and a distance from numerous urban facilities, and the forest itself offers recreational opportunities only in two places of the long forest front of over 25 km. Investing in and promoting urban forests as places for recreation can increase their attractiveness, which could lead to the "urban green paradox". For the population with a lower socio-economic status, housing near forests is not available due to the increase in property values.

Looking at the variable of distance from the bank of the Sava river, the least number of apartments is included. Most of the apartments have a positive sign for the coefficient. According to these results, the Sava embankment lowers the price of apartments the closer they are to it. We can only speculate about the cause. Perhaps the cause is the extremely elongated shape of the area or the unattractiveness of the watercourse, as in the work of Bonetti, F. *et al.* (2016). On the embankment along the Sava river from SRC Jarun in the west to the Bridge of Youth and RSC Bundek in the east, there are well-maintained paths for recreation (walking, running, cycling, etc.) and places to rest. Numerous other recreational facilities have been established along the embankment. Our results suggest that the Sava dam is also accessible to residents of lower socio-economic status, as it does not increase the price of housing due to its proximity.

If we look at the nearest green or recreational areas and the Bundek, we can see a double effect on the price of housing in their vicinity. They increase the price of one part of the apartments, while they decrease the price of the other part because they are closer to them.

According to the local hedonic model, the most attractive factors when choosing a place to live are the RSC Jarun and the parks in the city centre. It is important to note that the urban forest parks and the forest parks, the Maksimir Park, and the banks of the Sava are not preferred when choosing a place to live. Bundek is partly a preference and partly not.

The results of this study can contribute to the study of green gentrification in Zagreb, but further research is needed that also takes into account socio-economic indicators and

other changes in the region. It needs to be clarified whether there is green gentrification in Zagreb and what impact other changes in the region have on gentrification in relation to green areas.

Conclusions

This article investigated the influence of green and recreational areas on the price of housing and provides indirect information on preferences in the choice of residential location. The results are largely consistent with previous studies. Green and recreational areas can drive up the price of housing, but also the price of housing in their vicinity. Some areas have no influence on the price of housing.

The first hypothesis can be partially accepted. Green and recreational areas have an influence on the higher price of real estate in some parts of Zagreb. Heterogeneity was found in the type of influence (sign and size of the coefficients of the hedonic model) of the observed green and recreational areas on real estate prices. In addition, spatial differences were found in the way the observed areas influence house prices. Some areas increase the price of some apartments in their neighbourhood, while the price of some other apartments decreases. The second hypothesis can be accepted. There are spatial differences in the impact of individual green and recreational areas in the city of Zagreb on real estate prices.

Some limitations were identified during the preparation and execution of the study. It is necessary to include in the models some other variables describing the characteristics of the area (distance from roads, distance from the Medvednica Nature Park, topography, characteristics of the neighbourhood).

The uniqueness of the study lies in the fact that it is the first study on the influence of green and recreational areas on housing prices in Zagreb, which indicates the importance of the results obtained and the possibility of their application. The results can be used for decision-making in the management of green and recreational areas in Zagreb as well as for real estate brokerage. Another special feature of this work compared to similar works is the use of a geographic information system (GIS) in the preparation and processing of the data.

Further research will focus on the influence of green and recreational areas on real estate prices. It will also include the socio-economic characteristics of the population and their desire to change residence. Future research will contribute to gaining new insights into green gentrification.

REFERENCES

Anguelovski, I., Connolly, J.J.T., Cole, H., Garcia-Lamarca, M., Triguero-Mas, M., Baró, F., Martin, N., Conesa, D., Shokry, G., Pérez del Pulgar, C., Argüelles Ramos, L., Matheney, A., Gallez, E., Oscilowicz, E., López Máñez, J., Sarzo, B., Beltrán, M.A. and Martinez Minaya, J. 2022. Green gentrification in European and North American cities. *Nature Communications* 13. (3816): 1–13. https://doi.org/10.1038/s41467-022-31572-1

Bark, R.H., Osgood, D.E., Colby, B.G. and Halper, E.B. 2011. How do homebuyers value different types of green space? *Journal of Agricultural and Resource Economics* 36. (2): 395–415. https://doi.org/10.22004/ag.econ.117210

Biao, Z., Gaodi, X., Bin, X. and Canqiang, Z. 2012. The effects of public green spaces on residential property value in Beijing. *Journal of Resources and Ecology* 3. (3): 243–252. https://doi.org/10.5814/j.issn.1674-764x.2012.03.007

Bonetti, F., Corsi, S., Orsi, L. and De Noni, I. 2016. Canals vs. streams: To what extent do water quality and proximity affect real estate values? A hedonic approach analysis. *Water* 8. (12): 1–17. https://doi.org/10.3390/w8120577

Conway, D., Li, C.Q., Wolch, J., Kahle, C. and Jerrett, M. 2010. A spatial autocorrelation approach for examining the effects of urban greenspace on residential property values. *The Journal of Real Estate Finance and Economics* 41. 150–169. https://doi.org/10.1007/s11146-008-9159-6

Czembrowski, P., Kronenberg, J. and Czepkiewicz, M. 2016. Integrating non-monetary and monetary valuation methods – SoftGIS and hedonic pricing. *Ecological Economics* 130. 166–175. https://doi.org/10.1016/j.ecolecon.2016.07.004

Czembrowski, P, Łaszkiewicz, E., Kronenberg, J., Engström, G. and Andersson, E. 2019. Valuing individual characteristics and the multifunctionality of urban green spaces: The integration of sociotope

mapping and hedonic pricing. *PLoS ONE* 14. (3): 1–16. https://doi.org/10.1371/journal.pone.0212277

Daamsa, M.N., Sijtsmaa, F.J. and Veneri, P. 2019. Mixed monetary and non-monetary valuation of attractive urban green space: A case study using Amsterdam house prices. *Ecological Economics* 166. 1–12. https://doi.org/10.1016/j.ecolecon.2019.106430

Dooling, S. 2009. Ecological gentrification: A research agenda exploring justice in the city. *International Journal of Urban and Regional Research* 33. (3): 621–639. https://doi.org/10.1111/j.1468-2427.2009.00860.x

Franco, S.F. and Macdonald, J.L. 2018. Measurement and valuation of urban greenness: Remote sensing and hedonic applications to Lisbon, Portugal. *Regional Science and Urban Economics* 72. 15–180. https://doi.org/10.1016/j.regsciurbeco.2017.03.002

Generalni urbanistički plan 2016. *Odluka o donošenju Generalnoga urbanističkog plana grada Zagreba (pročišćeni tekst)* (Decision on the adoption of the General Urban Plan of the City of Zagreb [refined text]). Zagreb, GUP. Available at https://www.zagreb.hr/UserDocsImages/arhiva/prostorni_planovi/GUP%20ZAGREBA_USVOJENI%20plan%206-2016/Odluka%20o%20dono%C5%A1enju%20GUP-a%20grada%20Zagreba_SGGZ%2012-16-procis.pdf (15.2.2023.)

Geofabrik service 2023. Available at http://download.geofabrik.de/europe/croatia.html (2.3.2023.)

GeoHub ZaGreb 2023. Zagreb, GeoHub. Available at https://geohub-zagreb.hub.arcgis.com/ (16.2.2023.)

Harnik, P. and Crompton, J.I. 2014. Measuring the total economic value of a park system to a community. *Managing Leisure* 19. (3): 188–211. https://doi.org/10.1080/13606719.2014.885713

Harnik, P., Sargent, J. and Plowden, J. 2017. *The Economic Benefits of the Public Park and Recreation System in the City of Los Angeles, California*. Los Angeles, The Trust for Public Land.

Herath, S., Choumert, J. and Maier, G. 2015. The value of the greenbelt in Vienna: A spatial hedonic analysis. *The Annals of Regional Science* 54. 349–374. https://doi.org/10.1007/s00168-015-0657-1

Heymana, A.V. and Sommervollb, D.E. 2019. House prices and relative location. *Cities* 95. 1–14. https://doi.org/10.1016/j.cities.2019.06.004

Hu, S., Yang, S., Li, W., Zhang, C. and Xu, F. 2016. Spatially non-stationary relationships between urban residential land price and impact factors in Wuhan City, China. *Applied Geography* 68. 48–56. https://doi.org/10.1016/j.apgeog.2016.01.006

Jim, C.Y. and Chen, W.Y. 2006. Impacts of urban environmental elements on residential housing prices in Guangzhou (China). *Landscape and Urban Planning* 78. 422–434. https://doi.org/10.1016/j.landurbplan.2005.12.003

Kolbe, J. and Wüstemann, H. 2014. Estimating the value of urban green space: A hedonic pricing analysis of the housing market in Cologne, Germany. *Acta Universitatis Lodziensis Folia Oeconomica* 5. (307): 45–61.

Kong, F., Yin, H. and Nakagoshi, N. 2007. Using GIS and landscape metrics in the hedonic price modelling of the amenity value of urban green space: A case study in Jinan City, China. *Landscape and Urban Planning* 79. 240–250. https://doi.org/10.1016/j.landurbplan.2006.02.013

Łaszkiewicz, E., Kronenberg, J. and Marcinczak, S. 2018. Attached to or bound to a place? The impact of green space availability on residential duration: The environmental justice perspective. *Ecosystem Services* 30. (B): 309–317. https://doi.org/10.1016/j.ecoser.2017.10.002

Liebelt, V., Bartke, S. and Schwarz, N. 2017. Hedonic pricing analysis of the influence of urban green spaces onto residential prices: The case of Leipzig, Germany. *European Planning Studies* 26. (1): 133–157. https://doi.org/10.1080/09654313.2017.1376314

Liebelt, V., Bartke, S. and Schwarz, N. 2018. Revealing preferences for urban green spaces: A scale-sensitive hedonic pricing analysis for the city of Leipzig. *Ecological Economics* 146. 536–548. https://doi.org/10.1016/j.ecolecon.2017.12.006

Liebelt, V., Bartke, S. and Schwarz, N. 2019. Urban green spaces and housing prices: An alternative perspective. *Sustainability* 11. (13): 3707. https://doi.org/10.3390/su11133707

Lindsey, G., Man, J., Payton, P. and Dickson, K. 2004. Property values, recreation values, and urban greenways. *Journal of Park and Recreation Administration* 22. (3): 69–90.

Lockwood, M. and Tracy, K. 1995. Nonmarket economic evaluation of an urban recreation park. *Journal of Leisure Research* 27. (2): 155–167. https://doi.org/10.1080/00222216.1995.11949740

Logar, I. 2019. Pregled principa i metoda vrednovanja dobara i usluga iz okoliša (An overview of principles and methods for the valuation of ecosystem goods and services). *Ekonomska misao i praksa* 1. 409–429.

Melichar, J. and Kaprová, K. 2013. Revealing preferences of Prague's homebuyers toward greenery amenities: The empirical evidence of distance-size effect. *Landscape and Urban Planning* 109. 56–66. https://doi.org/10.1016/j.landurbplan.2012.09.003

Morancho, A.B. 2003. A hedonic valuation of urban green areas. *Landscape and Urban Planning* 66. 35–41. https://doi.org/10.1016/S0169-2046(03)00093-8

Newbold, P. 2010. *Statistika za poslovanje i ekonomiju* (Statistics for business and economy). Zagreb, Mate.

Norzailawati, M.N., Zainora Asmawi, M. and Abdullah, A. 2015. Sustainable urban regeneration: GIS and Hedonic Pricing Method in determining the value of green space in housing area. *Procedia – Social and Behavioral Sciences* 170. 669–679. https://doi.org/10.1016/j.sbspro.2015.01.069

Nur Syafiqah, A.S., Abdul-Rahim, A.S., Mohd Yusof, M.J. and Tanaka, K. 2018. An economic valuation

of urban green spaces in Kuala Lumpur City. *Pertanika Journal of Social Sciences & Humanities* 26. (1): 469–490.

Olbińska, K. 2018. The value of urban parks in Lodz. *Real Estate Management and Valuation* 26. (1): 73–88. https://doi.org/10.2478/remav-2018-0007

Oliveira, S., Pereira, J.M.C., San-Miguel-Ayanz, J. and Lourenço, L. 2014. Exploring the spatial patterns of fire density in Southern Europe using Geographically Weighted Regression. *Applied Geography* 51. 143–157. https://doi.org/10.1016/j.apgeog.2014.04.002

Pacione, M. 2009. *Urban Geography. A Global Perspective*. London, Routledge. https://doi.org/10.4324/9780203881927

Panduro, T.E. and Veie, K.L. 2013. Classification and valuation of urban green spaces – A hedonic house price valuation. *Landscape and Urban Planning* 120. 119–128. https://doi.org/10.1016/j.landurbplan.2013.08.009

Panduro, T.E., Jensen, C.U., Lundhede, T.H., von Graevenitz, K. and Thorsen, B.J. 2018. Eliciting preferences for urban parks. *Regional Science and Urban Economics* 73. 127–142. https://doi.org/10.1016/j.regsciurbeco.2018.09.001

Poudyal, N.C., Hodgesa, D.G. and Merrett, C.D. 2009. A hedonic analysis of the demand for and benefits of urban recreation parks. *Land Use Policy* 26. 975–983. https://doi.org/10.1016/j.landusepol.2008.11.008

Sander, H.A. and Zhao, C. 2015. Urban green and blue: Who values what and where? *Land Use Policy* 42. 194–209. https://doi.org/10.1016/j.landusepol.2014.07.021

Swanwick, S., Dunnett, N. and Woolley, H. 2003. Nature, role and value of green space in towns and cities: An overview. *Built Environment* 29. (3): 94–106. https://doi.org/10.2148/benv.29.2.94.54467

Trojanek, R. 2016. The impact of green areas on dwelling prices: The case of Poznań city. *Entrepreneurial Business and Economics Review* 4. (2): 27–35. https://doi.org/10.15678/EBER.2016.040203

Trojanek, R., Gluszak, M. and Tanas, J. 2018. The effect of urban green spaces on house prices in Warsaw. *International Journal of Strategic Property Management* 22. (5): 358–371. https://doi.org/10.3846/ijspm.2018.5220

Tyrväinen, L. 1997. The amenity value of the urban forest: An application of the hedonic pricing method. *Landscape and Urban Planning* 37. (3–4): 211–222. https://doi.org/10.1016/S0169-2046(97)80005-9

Tyrväinen, L. and Miettinen, A. 2000. Property prices and urban forest amenities. *Journal of Environmental Economics and Management* 39. 205–223. https://doi.org/10.1006/jeem.1999.1097

Wolch, J.R., Byrne, J., and Newell, J.P. 2014. Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. *Landscape and Urban Planning* 125. 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017

Wu, J., Wang, M., Li, W., Peng, J. and Huang, L. 2015. Impact of urban green space on residential housing prices: Case study in Shenzhen. *Journal of Urban Planning and Development* 144. (4): 1–8. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000241

ZG Geoportal 2024. *Zagrebačka infrastruktura prostornih podataka* (Zagreb spatial data infrastructure). Zagreb, Gradski ured za gospodarstvo ekološku održivost i strategijsko planiranje. Available at https://geoportal.zagreb.hr/Karta (16.7.2024.)

Appendix - Correlation coefficient matrix (Pearson's correlation coefficient r)