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THE EFFECT OF URBAN GREEN SPACES ON HOUSE PRICES IN WARSAW

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Abstract. In the paper, we analysed the impact of proximity to urban green areas on apartment prices in Warsaw. The dataset contained in 43 075 geo-coded apartment transactions for the years 2010 to 2015. In this research, the hedonic method was used in Ordinary Least Squares (OLS), Weighted Least Squares (WLS) and Median Quantile Regression (Median QR) models. We found substantial evidence that proximity to an urban green area is positively linked with apartment prices. On an average presence of a green area within 100 meters from an apartment increases the price of a dwelling by 2,8% to 3,1%. The effect of park/forest proximity on house prices is more significant for newer apartments than those built before 1989. We found that proximity to a park or a forest is particularly important (and has a higher implicit price as a result) in the case of buildings constructed after 1989. The impact of an urban green was particularly high in the case of a post-transformation housing estate. Close vicinity (less than 100 m distance) to an urban green increased the sales prices of apartments in new residential buildings by 8,0–8,6%, depending on a model.

Keywords: hedonic methods, parks, urban green, property prices.

Introduction

The market value of a property depends mainly on its physical characteristics, out of which the most important is location. The location choices depend mostly on individual preferences but generally can be related to the distance from work, schools, and hospitals, an accessibility of public transport, positive or negative neighbourhood effects both about built and natural environment. Among, various factors affecting housing choices, and thus house prices, environmental attributes rank very high in the hierarchy of importance (Źróbek, M. Trojanek, Źróbek-Sokolnik, & R. Trojanek, 2015; Gluszak & Marona, 2017).

Green spaces not only provide a pleasant and natural environment but also improve the quality of life in urban areas and undertake essential environmental functions (B. Zhang, Xie, C. Zhang, & J. Zhang, 2012; Streimikiene, 2014). A considerable range of benefits provided by urban green areas has been studied and reported in the literature. The list includes, but is not limited to (Konijnendijk, Annerstedt, Maruthaveeran, & Nielsen, 2013): human health and wellbeing, social cohesion, tourism, biodiversity, air quality and carbon sequestration, water management and the role of parks in the cooling of urban areas. Moreover, green spaces have a significant economic effect, most notably an impact on neighbouring property values. The latter effect was reported in a great number of research papers (for example Espey & Owusu-Edusei, 2001; Jim & Chen, 2010).

The topic of urban green in CEE (Central and Eastern Europe) cities has been neglected in the discussion on the post-1989 transformation of the major metropolitan areas. Like many cities in the region, Warsaw experienced discontinuity of urban development (Staniszkis, 2012), and as a metropolitan area entity consists of two different systems. First of them is a heritage of a socialist period, and it is key characteristics are relatively low housing quality, but low development densities (building coverage ratios), greenness, and well-planned accessible public infrastructure. The second urban system is an effect of spontaneous, chaotic and dynamic development (Kusiak, 2012), that was not adequately regulated, due to malfunctions in urban planning. The higher quality of housing often comes at a price of high development density, lack of urban green

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areas, and lack of sufficient public infrastructure. From this perspective, Warsaw is, in fact, two cities – planned and spontaneous, each representing contradictory forces shaping its urban form. The problem with the latter is that unregulated new residential development has hampered the existing public green spaces in Warsaw and resulted in urban sprawl (Mantey, 2017). The paper aims to address the implicit value of urban green areas, in case of both for pre and post-1989 housing stock.

In the paper, we analyse the effect of proximity to urban green areas on housing prices in Warsaw. The remaining part of this paper is structured as follows. Section 1 addresses the existing empirical research impact of parks, recreation areas and urban green on real estate prices. Section 2 discusses on data issues and methods used in the study. Section 3 comments on the results and confronts them with previous findings in the relevant literature. The last section assesses the results and suggests directions for future research.

1. Literature review

The urbanisation process, which is accompanied by the growing population in cities, is absorbing green areas in urban and suburban areas (Tanaś & Trojanek, 2014; Źróbek-Różańska & Zadworny, 2016). This situation requires efforts that aim at maintaining or restoring green areas because this space is essential for the quality of life in cities (Zhou & Parves Rana, 2012). Green belts fulfil some functions and generate various benefits for urban dwellers (Robinette, 1972; Grey & Deneke, 1978; Laurie, 1979). Studies on the positive influence of green areas in cities have been conducted in many countries for years. An overview of the existing body of literature helps us single out the following categories of general benefits of urban green areas (Sadeghian & Vardanyan, 2013):

- environmental, including ecological benefits, pollution reduction, cooling urban areas, ensuring biodiversity and wildlife conservation;
- economic, including saving energy, influence on water balance, increasing the tourist attractiveness of urban areas, an increase in the value of properties;
- social and psychological, as a place of entertainment and recreation, improvement of health and physical and mental state, strengthening social bonds, crime reduction;
- planning and designing, including the perception of green areas, aesthetic values, planning and designing green areas.

Some of the benefits listed above can have market effects and can be captured using hedonic models. More in line with hedonic pricing framework Sarkar et al. (2015) identify five reasons why proximity to urban green can increase residential satisfaction, and thus affect housing choices and house prices: (i) creating recreation possibilities, (2) strengthening community bonds and increasing social capital, (3) health and stress relief, (4) natural filtration against pollution, (5) protection of urban heat islands.

The significant impact of urban green areas on real estate prices is confirmed by numerous studies carried out over the last few decades. A valuable overview of literature concerning this issue was provided by Crompton (Crompton, 2001). Among 30 studies he analysed, there were only five not supporting the proximity principle, i.e. that having a park nearby raises property prices. One of the first studies related to this problem was conducted in the USA in 1960. Due to the applied methodology, however, the results were not consistent. The research carried out by Knetsch (Knetsch, 1964) showed that benefits of an attractive location, such as on the shoreline, may contribute to the growth in the value of the property. In another study, no and uniform influence of the neighbourhood of recreational areas on real estate prices was observed (Hendon, 1971).

By the analysis of literature, the studies conducted so far may be arranged by taking into account first of all the applied research method, and then the type and size of green areas and the kind of property.

On account of the applied research method, most studies have been carried out with the application of revealed preference methods and stated preference methods, both based on the theory of consumer choice. The former group, represented mostly by hedonic regression studies, investigates economic value of green spaces. The embedded assumption is that the property is the function of various structural, location and neighbourhood characteristics (urban green being one of them), thus observed prices could be decomposed into implicit prices of attributes. With rare exceptions (Biao, Gaodi, Bin, & Canqiang, 2012) this branch of empirical research relies on individual property information (sales, rentals, offers). The latter approach, applying quasi-experimental, qualitative or survey methods, analyses explicitly preferences, consequences and values households (buyers or renters) attached to various attributes, and links between them (McConnell & Walls, 2005).

In a number of studies, real estate prices have been analysed depending on the kind of green areas, e.g. parks (Weigher & Zerbst, 1973; Espey & Owusu-Edusei, 2001), forests (Tyrväinen & Miettinen, 2000), greenbelts (Lee & Linneman, 1998; Herath, Choumert, & Maier, 2015), golf courses (Do & Grudnitski, 1995), or wetlands (Doss & Taff, 1996; Mahan, Polasky, & Adams, 2000; Earnhart, 2001). Research has shown that the degree of influence depends on the type of green areas that property borders and on the distance from these areas (Bolitzer & Netusil, 2000; Lutzenhiser & Netusil, 2001). It has also been pointed out that the degree to which a park influences its neighbourhood is dependent on its attractiveness, extra facilities and landscape (Millward & Sabir, 2011).

Studies also differ regarding the type of properties for which the influence of green areas on prices was examined. Some studies deal with the impact of green areas on the prices of flats (Morancho, 2003; Hoshino & Kuriyama, 2010; Jim & Chen, 2010; Kolbe & Wüstemann, 2014). The influence of the neighbourhood of parks on land properties was in turn examined by, among others, Hendon (1971) and Zygmunt and Gluszak (2015). Other studies show the impact of green areas on single-family house prices (Anderson & Cordell, 1998; Anderson, 2000; Dombrow, Rodriguez, & Sirmans, 2000; Luttik, 2000; Des Rosiers, Thériault, Kestens, & Villeneuve, 2002; Conway, Li, Wolch, Kahle, & Jerrett, 2010; Bark, Osgood, Colby, & Halper, 2011; Kim, Li, Newman, Kil, & Park, 2016). In the case of single-family houses, when the plot area is large (a garden may be treated as private leisure space), the influence of parks on the price is small. It may also be assumed that the vicinity of a park is more important for multi-family housing than for single-family housing.

Most studies have been conducted in the USA, Western Europe and Asia. In recent years, a few studies on the issues discussed above have also been carried out in Poland (Zygmunt & Gluszak, 2015; Czembrowski & Kronenberg, 2016; Trojanek, 2016; Trojanek, Tanas, Raslanas, & Banaitis, 2017). Table 1 presents the description and results of recent studies (published in 2010 and later) of the influence of urban green areas on real estate prices.

Some general conclusions can be drawn from the empirical research on urban green areas. There is a consensus on the positive influence of the vicinity of parks on the market price of urban residential real estate. It was con-

Table 1. Recent research on Urban Green Areas (UGA) and property prices (source: own research)

Lp.	Place of Research	Authors of research	Type of property	Number of samples	Time of research	Findings
1.	Vermont corridor, Los Angeles (USA)	Conway et al. (2010)	Single-family residences	260 transactions	1999–2000	Significant positive effect of UGA on property prices
2.	Setagaya Ward, Tokyo (Japan)	Hoshino and Kuriyama (2010)	Single room dwellings	2370 apartments for rent	2007	The effect depends on park size. Significant positive effect of UGA on apartment rents for medium-size parks.
3.	Hong Kong (China)	Jim and Chen (2010)	Apartments	1471 transactions	2005–2006	Significant positive effect of UGA on property prices (mostly due to recreational availability, but also to view).
4.	Tucson, Arizona (USA)	Bark et al. (2011)	Single family residence	6676 transactions	1998–2003	Significant positive effect of UGA on property price
5.	Beijing (China)	Biao et al. (2012)	Residential properties	The average house prices in 76 residential areas and 14 parks in Beijing	2009	Significant positive effect of UGA on property price, but the results vary
6.	Aalborg (Denmark)	Panduro and Veie (2013)	Houses, apartments,	12928 transactions	2000–2007	Mixed-effect of UGA on property prices, results depend on UGA type and differ for various types of properties
7.	Belfast (UK)	McCord et al. (2014)	Detached, semi-detached, terrace and apartment	3854 transactions	2011	Significant positive effect of UGA on property prices, the results depend on property type, the strongest impact was observed for apartments.
8.	Cologne (Germany)	Kolbe and Wüstemann (2014)	Apartments	85046 transactions	1995–2012	Significant positive effect of UGA on property prices
9.	Cracow (Poland)	Zygmunt and Gluszak (2015)	Undeveloped land	355 transactions	2002–2011	Significant positive effect of UGA on property prices
10.	Vienna (Austria)	Herath et al. (2015)	Apartments	1651 apartments for sale	2009–2010	Significant positive effect of UGA on property prices
11.	Lodz (Poland)	Czembrowski and Kronenberg (2016)	Apartments	9346 transactions	2011–2013	Significant positive effect of UGA on property prices, the results depend on UGA type
12.	Poznan (Poland)	Trojanek (2016)	Apartments	1438 transactions	2013–2014	Significant positive effect of UGA on property prices
13.	Austin, TX (USA)	Kim et al. (2016)	Single-family houses	11326 transactions	2010–2012	Significant positive effect of UGA on property prices, the results depend on UGA size and structure (the most influential impact for large, non-fragmented UGA
14.	Helsinki (Finland)	Votsis (2017)	Apartments	44300 transactions	2000–2011	Significant positive effect of UGA on property prices, the results depend on UGA type and distance to the city centr
15.	Leipzig (Germany)	Liebelt, Bartke, and Schwarz (2018)	Apartments for rent, sale; houses for rent and sale	290559 asking prices/rents	2007–2013	Significant positive but fairly small impact on housing prices, The results depend on the type of housing.

firmed in different cities all over the world, in different economic and cultural conditions. The positive proximity effect is not linear and tends to disappear with the distance. Moreover, although the literature is consistent on premium price attached to the presence of urban green areas, the effect can vary depending on its type, accessibility, diversity, and extra recreation facilities (Crompton, 2005; Panduro & Veie, 2013; McCord et al., 2014). There is also evidence that scarcity of urban green in the city and density of development can affect the urban green premium (Herath et al., 2015; Votsis, 2017). Nonetheless, the literature reports several cases when proximity to a park causes negative externalities and decreases property values: fire risk exposure or poor management, and vulnerability to crime (Troy, J. M. Grove, & J. M. Grove, 2008). To conclude, although the presence of an urban green seems to be an important factor in housing decisions there are few empirical papers on the impact of urban green areas on property prices in major cities in Central and Eastern Europe. Despite recent efforts to explore the influence of (1) development density and (2) substitution effects between public and private space on urban green premiums some unanswered questions remain. In this paper, we ask whether the implicit price for the proximity to the urban green area is similar in case of pre- and post-transition dwellings.

2. Methods and data

2.1. Study area

Warsaw is the capital of Poland. The housing market in Warsaw is undoubtedly the biggest market in Poland. One reason may be the size of the conurbation, which – being the capital of Poland – is the city of the largest population in Poland. Moreover, not only is Warsaw the heart of political activity, but it is also the centre of economic, cultural and scientific life. Forests in Warsaw occupy an area of about 7258 ha, which accounts for nearly 14% of the city's surface. It makes Warsaw one of the few European capitals with such a large share of forest complexes in the total area of the city. In the existing administrative system, the City of Warsaw is in possession of 76 parks with a total area of about 715 ha.

Szulczewska and Kaliszuk (2003) argue that urban planning in Warsaw faces a dilemma, as planners must choose between the idea of a compact city (thus limiting the urban green space within) or green city (thus allowing further urban sprawl).

2.2. Hypothesis development and variables

Our study seeks to explore how the proximity to park/forest is capitalized in property prices. The theoretical underpinning for the research roots is based on utility theory. There are several benefits of urban green areas which can result in higher residential satisfaction. Most of them were discussed and studied extensively in the relevant literature.

On an efficient market higher residential satisfaction (thus higher housing utility) will result in higher rent (and higher market value) of a housing unit. As a consequence, the proximity to park or forest should, in theory, result in higher property prices. The question arises, however, whether the effect is uniform for all: (1) cities, (2) types of housing units. In the former case, proximity to a park should be particularly attractive in case of cities, with an insufficient share of green areas. In latter case, the

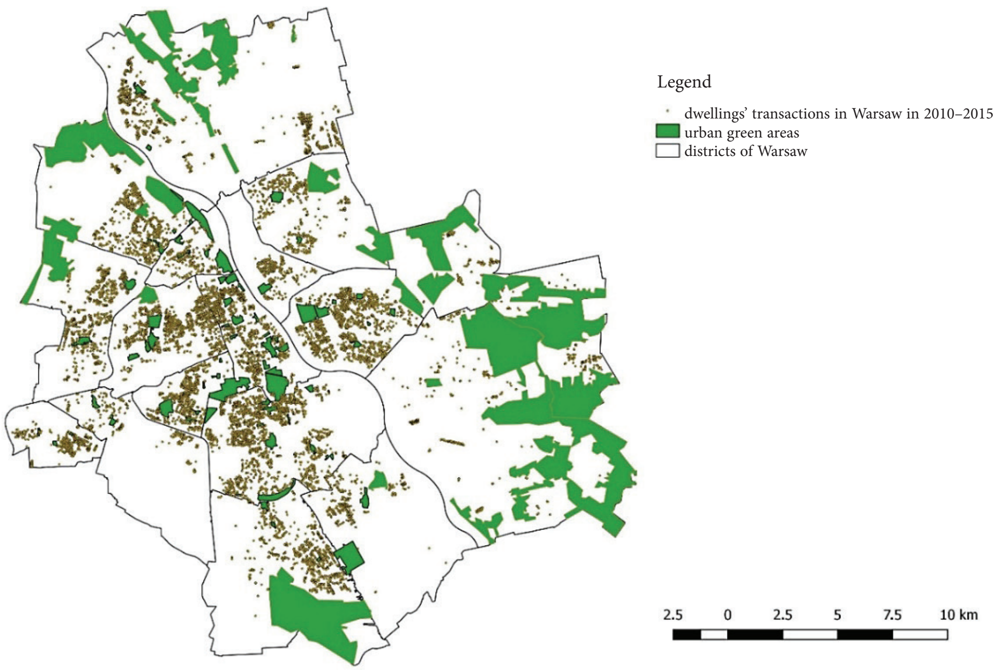

Figure 1. Urban green area and dwelling transactions in Warsaw in years 2010–2015 (source: study based on own research and Board of Geodesy and Municipal Cadastre in Warsaw)

economic reasoning suggests that implicit value of public green areas is linked with availability of substitutes. The example of substitutes include, but are not limited to:

- private gardens in case of single-family houses;
- an enclave of gardens or recreation grounds in case of gated communities;
- promenades, waterfronts, and small green areas between buildings.

While alternatives listed above do not substitute perfectly for a large park, their presence can lower general dissatisfaction resulting from the lack of urban green in the vicinity. One can suspect that although access to public green areas is positive, it will be particularly attractive for residents of densely developed housing estates lacking green areas, and relatively less attractive for estates with an abundance of green areas between buildings. The same logic applies to a willingness to pay for proximity to urban green. Put it differently; we hypothesise that the implicit price of proximity to urban green will differ about the type of housing estate. We suspect that marginal willingness to pay for urban green will be higher in case of post-transformation dwellings.

Warsaw makes a great study area to examine the hypothesis like this. For one, the city has an intriguing urban landscape, resulting from dramatic and turbulent historical events in the 20th century. The residential stock in Warsaw reflects both catastrophic events (the destruction of the majority of buildings in the city after Warsaw Uprising, and subsequent redevelopment of Old Town) and economic system transformation (large scale modernist housing projects typical to a socialist period from 1945 to 1989, followed by a period of spontaneous and chaotic development and urban sprawl after transformation in 1990s and 2000s). The diversity of housing stock allowed us to check how proximity to urban green is capitalized in prices of different types of residential projects.

In the mid-1990s, around 44% of the area of Warsaw was built-up. The average density of the built-up area 7 is 67 peoples per hectare or about 150 square meters of land per person. Bertaud (A. Bertaud & M. A. Bertaud, 2000) claims that development density is comparable with other metropolitan areas in Europe (higher than London and Berlin, and lower than in Moscow). Interestingly, the relation between density and distance from the city centre resembles a negatively sloped exponential curve. This particular density pattern is typical for cities in mature market economies, but in case of Warsaw, it is mainly the product of post-II WW socialist planning process (A. Bertaud & M. A. Bertaud, 2000). In the first decade of Warsaw experienced a dynamic period of suburbanization, that resulted in uncontrolled urban sprawl (Degórska, 2012). The process of erosion of clear urban boundaries was observed in other CEE cities (Nedović-Budić & Tsenkova, 2006; Stanilov & Sýkora, 2014).

Housing stock evolution in Warsaw (Figure 2) resembles a situation in other major cities in Poland – from mass public housing projects that characterized a socialist period (with medium development densities, and relatively accessible green areas around buildings) to small, disconnected private housing projects (with profit-driven high densities and relative lack of green space around). A study conducted in Wroclaw revealed that about 45% developments completed during a transformation period in the 1990s and 2000s had considerably high development density (building coverage ratios around of 0.25–0.35) – a development density considerably higher than

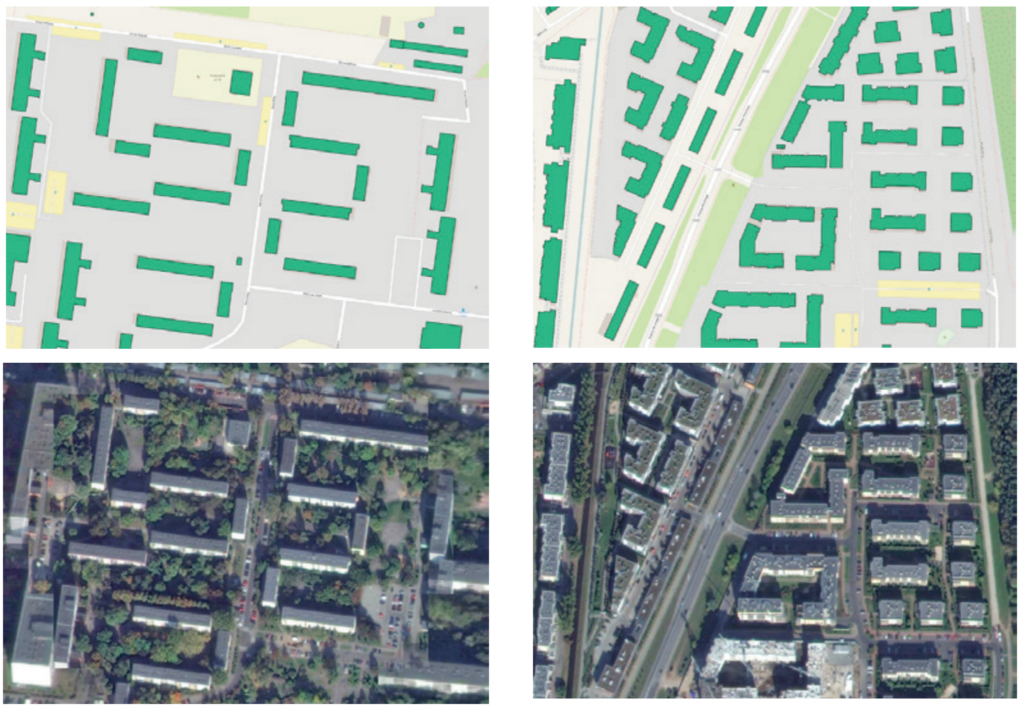

Figure 2. Differences between residential density between old (left panel) and new (right panel) residential projects in Warsaw (source: own elaboration based on openstreetmap.org and maps.google.com)

in case of pre-transformation (socialist) housing estates (Masztalski & Michalski, 2011).

While the literature reports that share of green areas in a neighborhood is positively linked with apartment prices (Czembrowski & Kronenberg, 2016) substitution effect between small recreation green areas around a building and bigger public green areas (park or forests) in its proximity, as well as their joint influence on house prices has not been addressed sufficiently (see Section 1). In order to examine the relationship between residential development density and hedonic value of green urban areas, in addition to the standard hedonic regression model, we estimate separate quantile regression models for different types of housing stock. Szulczewska and Kaliszuk (2003) argue that urban planning in Warsaw faces a dilemma, as planners must choose between the idea of a compact city (thus limiting the urban green space within) or green city (thus allowing further urban sprawl).

2.3. Data collection, variables

This paper aims to determine the scope of the subject, which includes the secondary housing market relating to full ownership rights of private accommodation. This research refers to dwellings located in multi-family buildings (the majority of dwellings are located in multi-family residential apartment blocks and houses are characterized by great differentiation regarding both quantitative and qualitative features, which requires the database to include the appropriate information on each property in order to

Table 2. Qualitative and quantitative variables applied in the models (source: own elaboration)

Variable	Category	Description	Symbol
Area	S	Area of the dwelling	area
Construction technology	S	1 – if the dwelling is located in a building made with a prefabricated technology, 2 – if the dwelling is located in a building made with traditional technology.	technology
Time of construction	S	6 dummy variables. If the dwelling is located in a building built in a given period, it takes the value 1; otherwise it takes 0.	cons1950 – built 1950–1959* cons1960 – built 1960–1969 cons1970 – built 1970–1979 cons1980 – built 1980–1989 cons1990 – built 1990–1999 cons2000 – built after 2000
Floor	S	3 dummy variables. If the dwelling is located on a given floor, it takes the value 1; otherwise it takes 0	floor1 – ground floor* floor2 – other floors floor3 – first and second floor
Height	S	1-buildings up to 4 floors 2-buildings above 5 floors	height
Basement	S	A dummy variable, it takes the value 1 if the apartment has basement or storage room; otherwise it takes 0	basement
Garage	S	It takes the value 2 if the apartment has individual parking space in the garage; it takes value 1 if there is a parking space outside the building. Otherwise it takes 0	garage
Kindergarten	N	Distance to nearest kindergarten (in km)	kindergarten
School	N	Distance to nearest primary school (in km)	school
Subway	N	Distance to nearest subway station (in km)	subway
Duga	N	Distance to the urban green area, 6 dummy variables. If the dwelling is located within given distance band from uga it takes the value 1; otherwise it takes 0	duga100 – distance 0–100 m, duga200 – distance 101–200 m, duga300 – distance 201–300 m, duga400 – distance 301–400 m, duga500 – distance 401–500 m, duga500 distance >500 m*
Dcc	L	Distance to city centre (in km)	dcc
District	L	18 dummy variables. If an apartment is located in a given district, it takes the value 1; otherwise it takes 0.	d1-Bemowo, d2-Białołęka, d3-Bielany, d4-Mokotów, d5-Ochota, d6-Praga Południe, d7-Praga Północ, d8-Rembertów, d9-Śródmieście*, d10-Targówek, d11-Ursus, d12-Ursynów, d13-Wawer, d14-Wesoła, d15-Wilanów, d16-Włochy, d17-Wola, d18-Żoliborz
Year	T	6 time dummy variables used in the global model. If the dwelling was sold in a given year, it takes the value 1; otherwise it takes 0.	y2010*, y2011, y2012, y2013, y2014, y2015

* base category.

construct models that will not be biased because of a low-quality dataset). The research is based on transaction data. The sample is based on residential property sales from the 1st quarter of 2010 to the 4th quarter of 2015. The data was obtained from Board of Geodesy and Municipal Cadastre in Warsaw. All non-market transactions (e.g. debt enforcement sales) were removed from the final dataset. Notarial contracts contain following information: transaction date, sales price, area of a dwelling, the floor on which a dwelling is located, and the area of any auxiliary premises (e.g. a garage/parking spot in an indoor parking lot or a cellar/storage). On the other hand, notarial contracts do not include information on various price determinants such as construction technology, architecture, building quality. Using cadastre data, additional information was gathered on the height of buildings and the year of construction. Finally, using Street View application on maps.google.com, the missing data concerning the height, and most importantly building technology was added. Locations of transactions (exact addresses) were geocoded with google maps API. Based on WMS servers of the Warsaw City Hall, the vector layer of parks was prepared. In this research, we excluded apartments built before 1939. The reason for which was the fact that in the case of such apartments, the technical condition of a building is a significant determinant of their value (our base does not include this factor), which might burden the obtained results. Moreover, during the Second World War Warsaw was almost completely demolished, so the share of such transactions is very small (should not burden the results). The final dataset contained 43 075 geo-coded apartments sold between 1q 2010 and 4q 2015 (Figure 1). Taking into account Dubin (1988) and Malpezzi (2008) suggestions three major categories of characteristics of dwellings may be distinguished: (1) structural attributes *S*, (2) neighbourhood related services and features *N*, (3) location and accessibility *L*. Additionally it is important to control for time (*T*).

The choice of qualitative and quantitative data was limited by the availability of information gathered. Table 2 presents variables used in the study.

To conclude we controlled for various characteristics typically used in hedonic pricing models for residential market: location (administrative district), construction technology, floor, time of construction, area of an apartment, presence of a garage, presence of a basement, height of building, and distance to a city centre, a kindergarten, a primary school, a subway and an urban green areas. The summary statistics of variables are presented in Table 3.

The results of the hedonic models' estimation are presented in Section 3.

Table 3. Summary statistics of variables used in the research (source: own elaboration)

Category	Variable	Mean	Standard deviation	Category	Variable	Mean	Standard deviation
T	2010	0.16	0.37	S	area	52.86	24.23
	2011	0.16	0.37		area2	3381.06	4089.24
	2012	0.14	0.35		basement	0.43	0.50
	2013	0.17	0.38		cons1950	0.18	0.38
	2014	0.17	0.38		cons1960	0.16	0.36
	2015	0.19	0.39		cons1970	0.11	0.31
L	d1	0.06	0.24		cons1980	0.04	0.20
	d2	0.10	0.30		cons1990	0.06	0.23
	d3	0.06	0.23		cons2000	0.40	0.49
	d4	0.15	0.36		cons2010	0.06	0.24
	d5	0.05	0.23		floor1	0.13	0.34
	d6	0.10	0.30		floor2	0.51	0.50
	d7	0.03	0.17		floor3	0.36	0.48
	d8	0.01	0.09		garage	0.42	0.66
	d9	0.09	0.28		height	1.67	0.67
	d10	0.05	0.22		technology	1.73	0.44
	d11	0.04	0.20	N	kindergarten	0.28	0.19
	d12	0.07	0.25		school	0.45	0.29
	d13	0.01	0.11		subway	2.78	2.48
	d14	0.01	0.09		duga100	0.06	0.24
	d15	0.03	0.18		duga200	0.11	0.31
	d16	0.02	0.13		duga300	0.12	0.32
	d17	0.10	0.30		duga400	0.11	0.32
	d18	0.02	0.14		duga500	0.10	0.30
	dcc	6.31	3.37		duga501	0.50	0.50

2.4. Hedonic price models

In a great number of researchers, the aim of which is to estimate the implicit price for each characteristic of a good, the hedonic method is used. Since Lancaster's (1966) and Rosen's (1974) seminal work, the hedonic method is widely employed in housing studies. Hedonic price models focus on the utility derived from individual characteristics of a good. The core of the hedonic methodology is the assumption that the price of any heterogeneous good (apartment in this study) is the function of its attributes (localisation, area, quality of an apartment). As housing is heterogeneous good, it is difficult to even indicate a full list of crucial attributes. In our study, we examine the implicit value of one of neighbourhood related environmental features, namely the proximity to the urban green area (duga). We hypothesise that transaction price is a function of a distance to the urban green area (duga), while controlling for other relevant structural (S), neighbourhood (N), and location attributes (L), as well as time (T). In general, the price is a hedonic function:

$$price = f\ (duga, S, N, L, T)\ . \quad (1)$$

In our research, we use a typical log-linear hedonic model specification, commonly used in the literature (Malpezzi, 2008). Regress apartment's price (natural logarithm of sales price) on a set of independent variables. Our baseline model is given by:

$$\ln price = \beta_0 + \beta_1 duga_{100} + \beta_2 duga_{200} + \beta_3 duga_{300} + \beta_4 duga_{400} + \beta_5 duga_{500} + \sum \theta_k S_k + \sum \omega_m N_m + \sum \gamma_i L_i + \sum \tau_j T_j + \varepsilon. \quad (2)$$

In this research, we used several variants of hedonic regression, namely standard Ordinary Least Squares (OLS), robust Weighted Least Squares (WLS) and Median Quantile Regression (Median QR) models. We use different estimation techniques to ensure the results are robust and reliable. The housing literature is quite consistent on treating housing as heterogeneous in several dimensions. From econometric (or data analysis) perspective, this heterogeneity can create heteroscedasticity in the residuals, while estimating the price function using standard OLS. Therefore, we decided to address the problem using different analytical approaches. Firstly, a robust model, employing OLS with heteroscedasticity-correction (WLS) was estimated. Secondly, we decided to employ median quantile regression. The quantile regression relies on minimisation of weighted absolute deviations, and during the process, conditional quantiles (percentile) functions are estimated (Koenker & Bassett, 1978; Koenker & Hallock, 2001). The quantile regression involves weighing, both symmetric (for the median, quantile = 0.5), and asymmetric (for all other quantiles). In this research we decided to use symmetric weighting (quantile-0.5). Within the quantile regression approach, there is no limitation imposed on explaining the mean of the dependent variable. The quantile regression is more flexible, as it can be employed to explain the implicit prices of housing attributes at any point of the distribution of the dependent variable, thus for low-priced, medium-priced, and high-priced properties (J. Zietz, E. Zietz, & Sirmans, 2008).

The mechanism to perform the quantile regression is similar to ordinary regression. The difference in the mechanism to perform the quantile regression to ordinary regression lies in the way of searching for the margin of sums of squared residuals; the quantile regression looks for the margin of weighted sums of absolute residuals. There are several theoretical advantages of a hedonic quantile regression reported in the literature. The technique can be particularly useful in case of heteroscedasticity, outliers, and unobserved heterogeneity found in the empirical data on housing transactions (Liao & Wang, 2012).

Due to the high number of independent variables available, multicollinearity may be a serious concern. Multicollinearity leads to unstable coefficients and inflated standard errors. The Variance Inflation Factors (VIFs) was used to detect it. The VIF values in models do not exceed 6.8 which is in line with the most conservative rules of thumb that the mean of the VIFs should not be considerably larger than 10.

3. Results

We estimated two groups of regression models. The first group of models, later referred to as a general model, is based on the whole sample of housing transactions conducted in Warsaw (apartments built after 1950). The second group of models was based on the same sample. However, new variables were introduced to track the influence of a construction period (different housing estate) on proximity to the urban green area. The estimation results for the general model is presented in Table 4.

As a robustness check, alongside baseline OLS model we used WLS and quantile regression. The results are relatively similar, albeit we found several differences regarding statistical significance for selected parameters. The estimates discussed below refer to quantile regression model.

In our study nominal prices were used (we did not correct for inflation) and we observed that within the period under study (2010–2015), the time had a significant impact on transaction prices. It is worth mentioning that housing prices in the biggest cities in Poland increased by about 100% between 2006 and 2007 (Trojanek, 2012). At the end of 2007, the subsequent decreasing phase in the house price cycle began resulting from this abnormal price increase and the beginning of the financial crisis.

The regression coefficients of the locational variables (districts) can be interpreted as district values. In this research, the base variable was d9 corresponding to the Downtown district. Statistically significant negative coefficients of regression of other districts confirmed the fact that consumers for apartments in the city centre are willing to pay more (Trojanek, 2015).

In general, the relations between physical characteristics of apartments and sales prices were consistent with expectations. Additionally, we found that the increase

Table 4. Estimation results – general mode (dependent variable is natural logarithm of sale price) (source: own elaboration)

	OLS		WLS		Median QR	
Variable	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
const	11.9593	0.0001	11.8682	0.0001	11.9052	0.0001
Y2011	–0.0071	0.0130	–0.0071	0.0027	–0.0088	0.0011
Y2012	–0.0805	0.0001	–0.0809	0.0001	–0.0788	0.0001
Y2013	–0.1290	0.0001	–0.1282	0.0001	–0.1261	0.0001
Y2014	–0.0987	0.0001	–0.0995	0.0001	–0.0981	0.0001
Y2015	–0.0907	0.0001	–0.0951	0.0001	–0.0922	0.0001
d1	–0.1572	0.0001	–0.1490	0.0001	–0.1358	0.0001
d2	–0.2174	0.0001	–0.2347	0.0001	–0.2115	0.0001
d3	–0.1479	0.0001	–0.1553	0.0001	–0.1393	0.0001
d4	–0.0746	0.0001	–0.0802	0.0001	–0.0687	0.0001
d5	–0.1553	0.0001	–0.1396	0.0001	–0.1291	0.0001
d6	–0.1708	0.0001	–0.1690	0.0001	–0.1578	0.0001
d7	–0.2860	0.0001	–0.2837	0.0001	–0.2705	0.0001
d8	–0.1126	0.0001	–0.1154	0.0001	–0.0987	0.0001
d10	–0.2220	0.0001	–0.2142	0.0001	–0.2046	0.0001
d11	–0.1309	0.0001	–0.1258	0.0001	–0.1021	0.0001
d12	–0.0102	0.2429	–0.0244	0.0018	0.0013	0.8743
d13	–0.1069	0.0001	–0.0993	0.0001	–0.0870	0.0001
d14	0.0177	0.2303	0.0182	0.1767	0.0478	0.0006
d15	–0.1504	0.0001	–0.1186	0.0001	–0.1221	0.0001
d16	–0.2111	0.0001	–0.1911	0.0001	–0.1733	0.0001
d17	–0.1953	0.0001	–0.1859	0.0001	–0.1758	0.0001
d18	–0.0651	0.0001	–0.0797	0.0001	–0.0685	0.0001
area	0.0227	0.0001	0.0256	0.0001	0.0242	0.0001
$area^2$	–0.0001	0.0001	–0.0001	0.0001	–0.0001	0.0001
basement	0.0294	0.0001	0.0204	0.0001	0.0216	0.0001
cons1960	0.0147	0.0001	0.0154	0.0001	0.0180	0.0001
cons1970	0.0341	0.0001	0.0245	0.0001	0.0307	0.0001
cons1980	0.0608	0.0001	0.0371	0.0001	0.0415	0.0001
cons1990	0.1354	0.0001	0.1310	0.0001	0.1366	0.0001
cons2000	0.2273	0.0001	0.2079	0.0001	0.2139	0.0001
cons2010	0.2213	0.0001	0.2210	0.0001	0.2059	0.0001
floor2	0.0269	0.0001	0.0256	0.0001	0.0269	0.0001
floor3	0.0284	0.0001	0.0288	0.0001	0.0302	0.0001
garage	0.0291	0.0001	0.0250	0.0001	0.0267	0.0001
height	–0.0061	0.0001	–0.0037	0.0063	–0.0026	0.0757
technology	0.0497	0.0001	0.0482	0.0001	0.0484	0.0001
dcc	–0.0268	0.0001	–0.0217	0.0001	–0.0233	0.0001
kindergarten	–0.0119	0.0131	–0.0029	0.5049	–0.0081	0.0718
school	–0.0352	0.0001	–0.0288	0.0001	–0.0307	0.0001
subway	–0.0160	0.0001	–0.0188	0.0001	–0.0186	0.0001
duga100	0.0452	0.0001	0.0276	0.0001	0.0304	0.0001
duga200	0.0145	0.0001	0.0138	0.0001	0.0077	0.0042
duga300	0.0120	0.0001	0.0069	0.0044	0.0065	0.0126
duga400	0.0074	0.0074	0.0021	0.3788	0.0028	0.2807
duga500	0.0056	0.0510	0.0015	0.5372	0.0029	0.2778
R-squared	0.8702		0.8495		–	
N	43075		43075		43075	

in distance from the city centre negatively affects the value of the apartment. The negative relation between the distance and a property price was also observed in case of a kindergarten, a primary school and a subway station (Trojanek & Gluszak, 2017). What is important, estimation results confirm the findings from earlier studies in Poland which suggest that the proximity to an urban green area has a positive impact on property values (Zygmunt & Gluszak, 2015; Czembrowski & Kronenberg, 2016; Trojanek, 2016).

The results suggest that proximity to urban green has a significant positive impact on apartments' prices up within 400 metres distance, and the reported price premiums were the highest within 100 meters distance band. The effect is statistically insignificant beyond this distance threshold. These findings are also in line with the existing body of evidence, which suggests that urban green affects property process within 500–600 meters radius, and the values of adjacent properties are affected the most (Lutzenhiser & Netusil, 2001; McCord et al., 2014).

On average the distance to urban green areas has a significant nonlinear impact on residential prices. Direct proximity to a park or an urban forest (up to 100-meter distance) increased apartment sale prices by 2.8%–3.1% (depending on a model) compared with apartments located outside 500 distance band. The premium declined with distance – apartments located in the second distance band (100–200 meters, thus relatively close, but not in direct proximity to the urban green) were still sold for a higher price than comparable apartments situated further from the green area, but the difference was only by about 1.0%. The premium had somewhat steep distance decay function – proximity to the urban green did not affect significantly sales prices of otherwise comparable apartments located outside 400 meters distance band from urban green. The result can be intuitively explained – it is worth to pay for proximity to the park/forest only if it is easily accessible (a short walk from the building entrance, plus sometimes a relaxing view from the apartment). If the trip to the park/forest demands longer walk/drive the direct benefits from urban green will diminish.

To discuss the impact of an urban green on a housing value of different housing estates, we estimated an alternative model with interaction terms. We interacted distance to an urban green (duga) with $period_1$ and $period_2$ dummy variables. Variable $period_1$ takes value 1 if the dwelling was built during the years 1950–1989, otherwise it takes 0. Analogously, $period_2$ is equal to 1 if the dwelling was built after 1989, and 0 otherwise. The models were estimated again, and the results were presented in Table 5.

Table 5. Hedonic regression estimation results (dependent variable is natural logarithm of sale price) (source: own elaboration)

	OLS		WLS		Median QR	
Variable	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
const	11.9685	0.0001	11.8746	0.0001	11.9074	0.0001
Y2011	–0.0068	0.0174	–0.0070	0.0031	–0.0079	0.0024
Y2012	–0.0805	0.0001	–0.0810	0.0001	–0.0796	0.0001
Y2013	–0.1291	0.0001	–0.1283	0.0001	–0.1274	0.0001
Y2014	–0.0989	0.0001	–0.0996	0.0001	–0.0984	0.0001
Y2015	–0.0905	0.0001	–0.0951	0.0001	–0.0913	0.0001
d1	–0.1602	0.0001	–0.1521	0.0001	–0.1387	0.0001
d2	–0.2198	0.0001	–0.2363	0.0001	–0.2118	0.0001
d3	–0.1451	0.0001	–0.1533	0.0001	–0.1354	0.0001
d4	–0.0747	0.0001	–0.0801	0.0001	–0.0673	0.0001
d5	–0.1547	0.0001	–0.1396	0.0001	–0.1284	0.0001
d6	–0.1753	0.0001	–0.1712	0.0001	–0.1599	0.0001
d7	–0.2900	0.0001	–0.2869	0.0001	–0.2738	0.0001
d8	–0.1253	0.0001	–0.1230	0.0001	–0.1083	0.0001
d10	–0.2259	0.0001	–0.2180	0.0001	–0.2056	0.0001
d11	–0.1345	0.0001	–0.1295	0.0001	–0.1051	0.0001
d12	–0.0041	0.6345	–0.0188	0.0161	0.0069	0.3836
d13	–0.1136	0.0001	–0.1062	0.0001	–0.0902	0.0001
d14	0.0008	0.9589	0.0067	0.6314	0.0368	0.0063
d15	–0.1449	0.0001	–0.1153	0.0001	–0.1161	0.0001
d16	–0.2159	0.0001	–0.1961	0.0001	–0.1771	0.0001
d17	–0.1972	0.0001	–0.1881	0.0001	–0.1763	0.0001
d18	–0.0620	0.0001	–0.0749	0.0001	–0.0631	0.0001
area	0.0227	0.0001	0.0257	0.0001	0.0243	0.0001
$area^2$	–0.0001	0.0001	–0.0001	0.0001	–0.0001	0.0001
basement	0.0287	0.0001	0.0198	0.0001	0.0215	0.0001
cons1960	0.0144	0.0002	0.0143	0.0001	0.0181	0.0001

End of Table 5

	OLS		WLS		Median QR	
Variable	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
cons1970	0.0342	0.0001	0.0238	0.0001	0.0297	0.0001
cons1980	0.0564	0.0001	0.0328	0.0001	0.0408	0.0001
cons1990	0.1197	0.0001	0.1190	0.0001	0.1237	0.0001
cons2000	0.2116	0.0001	0.1960	0.0001	0.2026	0.0001
cons2010	0.2074	0.0001	0.2098	0.0001	0.1949	0.0001
floor2	0.0268	0.0001	0.0254	0.0001	0.0267	0.0001
floor3	0.0281	0.0001	0.0288	0.0001	0.0305	0.0001
garage	0.0293	0.0001	0.0256	0.0001	0.0265	0.0001
height	–0.0059	0.0002	–0.0038	0.0046	–0.0023	0.1029
technology	0.0495	0.0001	0.0476	0.0001	0.0492	0.0001
dcc	–0.0270	0.0001	–0.0219	0.0001	–0.0237	0.0001
kindergarten	–0.0117	0.0145	–0.0024	0.5690	–0.0082	0.0596
school	–0.0354	0.0001	–0.0290	0.0001	–0.0294	0.0001
subway	–0.0146	0.0001	–0.0176	0.0001	–0.0175	0.0001
$period_1$ x duga100	–0.0037	0.4587	–0.0057	0.1814	0.0022	0.6303
$period_1$ x duga200	–0.0015	0.6965	0.0020	0.5545	–0.0034	0.3284
$period_1$ x duga300	0.0009	0.8070	–0.0001	0.9685	–0.0017	0.6198
$period_1$ x duga400	–0.0009	0.8015	–0.0046	0.1672	–0.0043	0.1940
$period_1$ x duga500	0.0042	0.2963	0.0015	0.6614	0.0002	0.9484
$period_2$ x duga100	0.0993	0.0001	0.0768	0.0001	0.0826	0.0001
$period_2$ x duga200	0.0310	0.0001	0.0273	0.0001	0.0208	0.0001
$period_2$ x duga300	0.0220	0.0001	0.0136	0.0002	0.0147	0.0001
$period_2$ x duga400	0.0139	0.0008	0.0084	0.0191	0.0111	0.0032
$period_2$ x duga500	0.0040	0.3152	0.0003	0.9339	0.0051	0.1665
R-squared	0.8709		0.8498		–	
N	43075		43075		43075	

The results of the second group models estimation (with variables which should distinguish the influence of proximity to an urban green area on different housing estate) provide interesting results. On an average proximity to an urban green areas did not have a significant impact on sale prices (neither in OLS, not WLS and Median QR model) in case of apartments built in years 1950–1989. Even immediate proximity (an urban green area located within 100 meters from the apartment) did not influence house prices. No significant (at alpha = 0.05) difference was observed for other distance bands.

The results differed significantly in case of building constructed after 1989. The impact of an urban green was particularly strong in case of post-transformation housing stock. Close vicinity (less than 100 m distance) to urban green increased the sales prices of apartments in new residential buildings by 8.0–8.6%, depending on a model. It did not have a significant impact in case of apartments located in socialist housing estates. The empirical results provide arguments in support of the research hypothesis. Apparently, relative lack of green areas around buildings and dense development typical for post-transformation residential development increases the hedonic value of public urban green areas. In the Figure 3 duga's regression coefficients of quantile models are presented.

We believe that this finding can have interesting policy implications. It is easy to dismiss positive effects of urban green areas when the city is relatively green. Increasing demand for residential land and chaotic housing development resulted in a decrease of green areas at the urban fringe, where most of the new housing projects have been located. The relative shortage of green areas has increased the implicit price of proximity to parks and urban forests in

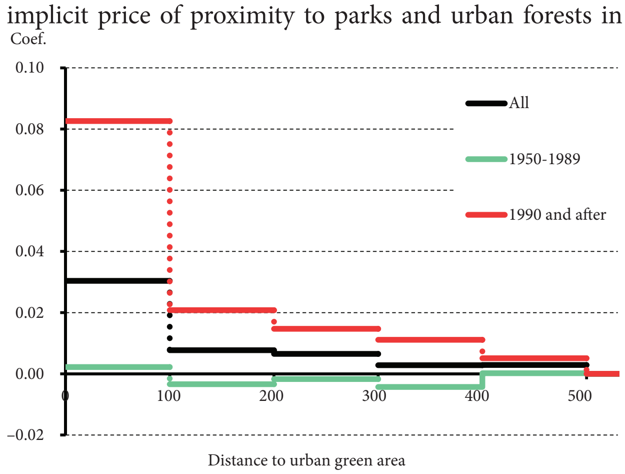

Figure 3. Regression coefficients of distance to urban green areas (quantile models) (source: own elaboration)

Warsaw. The residential value increase around parks and value can be captured in property taxes, but currently, this option is not exploited (in Poland nowadays property taxes are based on the size of a dwelling, not on its value – the location does not influence the tax amount). Currently, the tax system in Poland does not allow to link taxation with property value directly. Although the law allows for tax rate differentiation (based on location and other factors), in practice tax rates in most of the cities in Poland (Warsaw included) are set uniformly at a highest possible level for residential property (thus no differentiation is possible if we want to increase revenues). The increase in revenues from property tax revenues could be used to establish and maintain urban green and recreational areas, that would generate positive externalities and help to mitigate the negative effects of air pollution, typical to major cities in Poland.

Conclusions

We found strong evidence that proximity to a park is positively linked with apartment prices what is in line with previous studies. On the average presence of an urban green area within 100 meters from apartment increases the price of the dwelling by 2.8% to 3.1%. However, the effect of park/forest proximity on house prices is more significant for newer apartments than those built before 1989. We found that proximity to a park is particularly important (and has a higher implicit price as a result) in the case of buildings constructed after 1989. Modern residential buildings are located smaller lots and built accordingly to the density maximisation principle (both regarding floor area ration and building coverage ratio). As a result, green areas within gated communities are often limited and can be treated like a club good, available only to residents. In that context, proximity to a publicly accessible green area outside the gates, only within a short walking distance is highly beneficial and translates into a significantly higher price of subject apartments.

We did not find a significant effect of urban green proximity on prices of apartments located in housing estates built during the years 1950–1989. This somewhat surprising result may stem from the fact that contrary to modern residential buildings there is an abundance of green areas (children playgrounds, recreation facilities, convenient walking paths) within housing estates for public use. Presence of additional public park in proximity may not result in significantly higher residential satisfaction, and as a consequence will not be capitalised in apartment price.

The latter result may shed new light on previous findings, notably Trojanek (2016) and Czembrowski and Kronenberg (2016), that overlooked potential differences in hedonic prices of urban green areas for different types of housing estates. The results may be interesting for (i) housing developers, providing incentives for better location choices regarding residential projects, as well as for (ii) urban planners, providing arguments to protect and maintain existing parks and green belts in the city.

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