Valuing the Micropublic Space: A Perspective from Beijing Housing Prices

Wanting Hsu[1]; Yuyang Zhang[2]; and Ying Long[3]

Abstract: Research on public space has long been a primary focus in urban studies. Most previous studies have measured public space from the macroscale perspective, such as the distance to the city center, and therefore cannot specify the social significance and economic benefits related to its quality or details. Hence, we fill this gap by evaluating the impact of quality and the presence of specific public space elements on housing prices after dividing public space into two parts: public space surrounding the gated community (PSSG) and public space inside the gated community (PSIG). We measure the visible and touchable features of PSSG and PSIG and estimate the effects and the monetization value of PSSG and PSIG on housing prices. Our empirical analyses focused on the area within the Beijing 5th Ring Road and revealed the following: For the PSSG, wider streets, higher buildings along the streets, higher street greenery levels, higher proportions of street wall continuity, and lower street spatial disorder can contribute to higher housing prices. For PSIG, the presence of most gated community facilities can raise housing prices. We infer that the economic value of PSSG and PSIG, including housing prices will increase by 546 yuan/m^2 as the gated community gains a sport field. **DOI:** 10.1061/(ASCE)UP.1943-5444.0000794.

Author keywords: Public space quality; Gated community; Hedonic pricing model; Marginal price; Beijing.

Introduction

Public space, as one of the most important spatial elements that undergird citizens' lives in urban areas, has always been a primary interest in urban studies. Most existing studies have been limited to assessing the value of public space from the macroscale perspective, such as the distance to urban centers or visibility with indispensable landscapes. At the microscale or human-scale perspective, public space refers to the space that involves residents' daily life and affects residents' perception most directly (Long and Ye 2016; Miller and Tolle 2016; Shen et al. 2017). Therefore, the micropublic space is considered to be highly related to urban life quality, such as livability and comfort level. High-quality public space can both frame a good built environment network (Francis et al. 2012), improve the quality of residents' leisure life and foster community awareness, creating a more sustainable living space (Talen 2000). Thus, from this perspective, the areas of focus should be the elements and characteristics with which humans physically engage and interact (Long and Ye 2019), such as the form, greening, and facilities of the space; the ability to measure such elements remains relatively undeveloped, resulting in the ineffective measurement of the value of such spaces' quality or presence.

Fortunately, the evaluation and measurement of the urban built environment have benefited from highly diverse and accurate data generated by the Internet of Things and a set of information and communication technologies (ICT) that are in the process of rapid development and cover nearly every corner of each city (Batty 2013). Consequently, various scholars have begun to employ this emerging data, such as street-view image data and social media data, to conduct research on different types of public spaces, including street spaces and historical conservation areas (Rundle et al. 2011; Griew et al. 2013; Li et al. 2015, 2018b; Dubey et al. 2016; Hamstead et al. 2018; Lu et al. 2018; Tang and Long 2019; Zhang et al. 2019). These empirical studies have proven that the new data environment can support the microscale measurement of public spaces.

Moreover, existing evidence has shown associations between high-quality public space and positive housing sales since early time (Norcross 1976; Hammer et al. 1974; McMillan 1974; Jim and Chen 2006; Duncan 2011; Wu et al. 2017; Law et al. 2020). Housing prices have globally become an appropriate criterion for measuring the value of urban spatial elements, offering us the chance to understand more deeply the value of public space from the microscale perspective. The design, construction, and renovation of urban public space is presenting a pattern of meeting the various needs of different population groups rather than following the traditional monocentric rule that the quality of public space declines as the location moves away from the city center. Such patterns clearly fall within the microscale dimension.

In summary, we focus on one particularly important question: Can the quality and presence of specific public space impact housing prices? We conducted a three-step study to answer this question comprehensively. First, we build a framework for evaluating public space from the microscale perspective. Second, we specify the impact effects of public space surrounding the gated community (PSSG) and public space inside the gated community (PSIG) by examining the associations between the quantitative measurement results of public spaces and housing prices. Third, we calculate the actual impact on housing prices to speculate on the monetization value of different public spaces. As our reference is housing price and most residential areas in Beijing are gated communities, PSIG is defined as the space surrounding housing and within the gated community boundaries, including streets, landscapes, trees, and

[1]Master's Student, School of Architecture, Tsinghua Univ., Beijing 100084, China. Email: wantinghsu10@gmail.com

[2]School of Architecture, Tsinghua Univ., Beijing 100084, China. Email: 33848350@qq.com

[3]Associate Professor, School of Architecture and Hang Lung Center for Real Estate, Key Laboratory of Eco Planning & Green Building, Ministry of Education, Tsinghua Univ., Beijing 100084, China (corresponding author). Email: ylong@tsinghua.edu.cn

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facilities for physical activities. PSSG is defined as the streets within the 200-m buffer surrounding the gated community boundary.

Literature Review

Value of the Quality of Public Space

The quality of public space directly relates to citizens' quality of life (Tankel 1986; Mehta 2014). For urban residents, public space is a place to perform daily activities that not only serves as a physical place but also serves the social function of affecting social cognition and psychological experience (Madanipour 1996). Existing studies have shown that high-quality public spaces in cities can effectively promote residents' social interaction and thereby forming community awareness and identity (Low 2020; Kearney 2006; Lofland 2017).

If such public spaces are surrounded by greenery, and the street has corresponding supporting measures, the sense of security provided by the space will be enhanced (Craig et al. 2002; Harvey et al. 2015).

Associations between Public Space and Housing Prices from the Macro and Micro Perspectives

The 5D theory (Ewing and Cervero 2010), frequently applied in public transportation-oriented development (TOD) planning, proposed a protocol that measures the urban built environment through five categories: density, diversity, design, distance to transit, and destination accessibility. From a macro perspective, location and accessibility to public transportation have been commonly considered as the determinants of housing price (Adair et al. 2000; Li et al. 2019). Thus, most researchers have measured the value of public spaces from the macroscale perspective, such as the specific facility density and accessibility (Osland and Thorsen 2008; Richardson et al. 1990; Zhang et al. 2012; Efthymiou and Antoniou 2013; Irwin et al. 2014; Albouy 2016; Li et al. 2019).

The measurement of public space from the microscale perspective belongs more to the design dimension and involves the spatial elements of buildings, streets, trees, and so on, which are most directly related to the patterns and experiences of human behavior, including urban livability, comfort, and other related aspects of urban quality of life (Ewing et al. 2013; Harvey et al. 2015). From the microscale perspective, Pandit et al. (2013) evaluated the impact of street trees on housing prices in Western Australia by adding the type and location of trees (within the property/on the street/adjacent property) to the hedonic pricing model. Other study results have shown that higher greenery levels (extracted from street view images) in the gated community promoted housing prices within the Beijing 5th Ring Road (Zhang and Dong 2018); the effects of street greenery and sky proportions are the same within the Beijing 6th Ring Road as those in Shanghai's central urban area. The quality of spatial facilities has been significantly positively correlated with housing prices by estimating the vitality and service quality of the space or facility (Wu et al. 2016; Li et al. 2019). Conversely, a higher proportion of buildings in street-view images decreased gated community housing prices (Fu et al. 2019). Ye et al. (2019) evaluated the importance of street greenery and accessibility to housing prices in 1,395 gated communities in central Shanghai. Recently, the study of the environmental design on housing prices are also emerged (Cui et al. 2018; Kim and Kim 2020) but not sufficient.

In summary, although ICT technology and a new data environment enable us to measure the public space precisely and exhaustively, some studies have examined the associations from a microscale perspective. Most studies regard the microscale as comprising facility quality and space greenery and overlook the additional features of street width, street wall continuity, street elements, and so on. These features are generally decisive in the design of urban public spaces and should be considered in the measurement and evaluation of public space quality. Finally, the hedonic pricing model is used to monetize public space features based on housing prices to quantify the benefits and specific values of different public space features (Liisa 1997; Brent et al. 2000; Poudyal et al. 2008; Geng et al. 2015).

Micropublic Space within and Surrounding the Gated Community

For better quantifying the value of micropublic space that affected residents' daily activities and perceptions directly, we consider the main residential types in China, gated community, as our basic spatial units. The gated community has been developing in Chinese cities for a long time. During the period of China's planned economy, in order to effectively organize production units in the city, the gated community was formed as one of the main neighborhood types containing multiple urban functions (Wu 2005; Yang et al. 2021). Since the 1978 China's reform and opening up, the middle and upper class began to increase, and the real estate market also began to thrive. Real estate developers began to follow the principles of building gated communities from Western society and increase the housing prices by providing good public space quality and facilities, such as sport field, yard, great green space, and so on, in the community (Miao 2003; Xu and Yang 2009). As the main residential types, the biggest difference between gated communities and those common ones in western countries is that there is a clear physical boundary around the community to demarcate the public space that only for the residents living in the community (PSIG) and the public space surrounding the community (PSSG) (Grant and Mittelsteadt 2004). Most previous studies have mainly focused on the characteristics of PSSG, which could also be considered as microscale spaces, such as the street patterns (Ukkusuri et al. 2012; Liu et al. 2017), greenery (Hillsdon et al. 2006; De Vries et al. 2013; Jennings and Bamkole 2019), and other elements that might affect the spatial quality (Ewing and Handy 2009; Forsyth 2015; Tang and Long 2019). Another important area, gated communities, are where Chinese residents access and interact more frequently and directly than the external one. Because the gate and physical boundary could provide more sense of security and the gated communities are highly characterized by the same social positions, the residents often prefer to perform various activities in the gated communities, including physical activities and social interaction, indicating that the public space, where residents could walk, play balls and chat, inside the gated communities would more determine the housing price. However, the current discussions on the PSIG are rare and should be further developed.

Methods

Study Area

To effectively measure the characteristics of PSSG and PSIG and examine their associations with housing prices, we consider only the area within the Beijing 5th Ring Road, which comprises the central Beijing area and has a total area of 667 km^2. We extract the boundary of gated communities to delineate the PSSG and PSIG with precision (Fig. 1). We first identify the location and

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preliminary boundaries of the Beijing gated communities by using the urban basic spatial dataset and then revise the boundaries by overlapping this data with the satellite images. Ultimately, 3,857 gated communities with a total area of 154 km^2 are obtained (Fig. 2). The PSIG is then defined as the area within the boundaries of each gated community, whereas the PSSG is defined as the streets within the 200-m buffer surrounding the gated community boundary, which could be considered as the spaces that most encountered outside the gated community. The 200-m buffer radius is chosen mainly for avoiding an excessive overlap of each buffer area of gated community, as well as the distance also commonly used in the existing studies to predict residents' daily activities (Villanueva et al. 2014; Lin 2018).

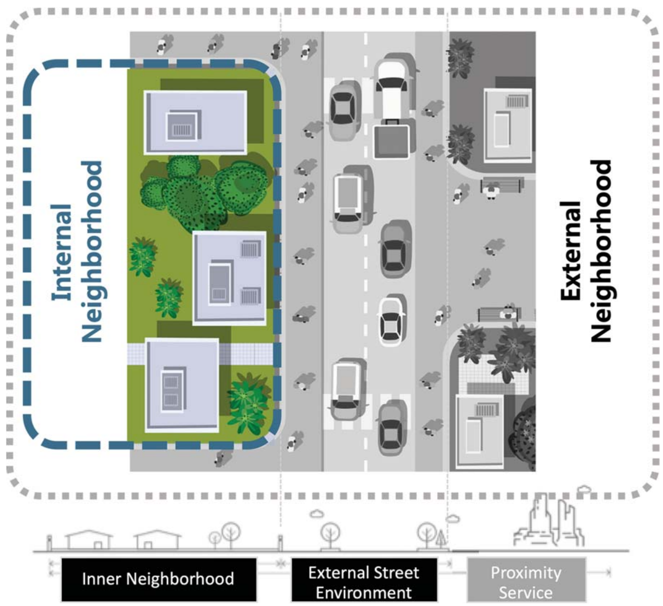

Fig. 1. Internal and external spaces of a Chinese gated community.

Data

The basic urban spatial dataset includes the basic datasets of streets, buildings, blocks, and other physical spaces, which are used to describe the attributes of street form. A total of 127,453 transaction records for secondhand housing within the Beijing 5th Ring Road from March 2016 to March 2017 were crawled from one of the most important housing websites in China (www.lianjia.com), including the attributes of housing price and housing structure related-information. A total of 281,745 street-view images (70,436 collection points and four directions) within the Beijing 5th Ring Road in 2016 were obtained through the Tencent map API. The size of each picture is 480 × 360 pixels, and the view angle is 180°. The Google Earth remote sensing images within the Beijing 5th Ring Road in 2016 were downloaded with the highest spatial resolution of 0.3 m. The images were clipped by using the specific gated community boundaries, which were used to manually interpret the elements of public space in these gated communities.

Dependent and Independent Variables

The natural logarithm of housing price (yuan/m^2) is considered as the dependent variable. For the independent variables, environmental (E) attributes are primarily considered in our research.

For assessing the environmental condition of PSIG, we aim to assess the condition of the certain public facilities and sidewalks based on the daily activities types and movement paths of general community residents. For assessing the environmental condition of PSSG, we choose surrounding streets that could directly affect residents' daily behaviors as the main interest area. Based on the literature review and data accessibility, the street environment is then divided into three categories: street form, street-view greenery, and spatial disorder. We summarized the following microscale characteristics for PSIG and PSSG as the focal points in this paper, including the internal gated community layout (E_i), street form (E_f), greenery (E_g), and spatial disorder (E_d) of 28 variables

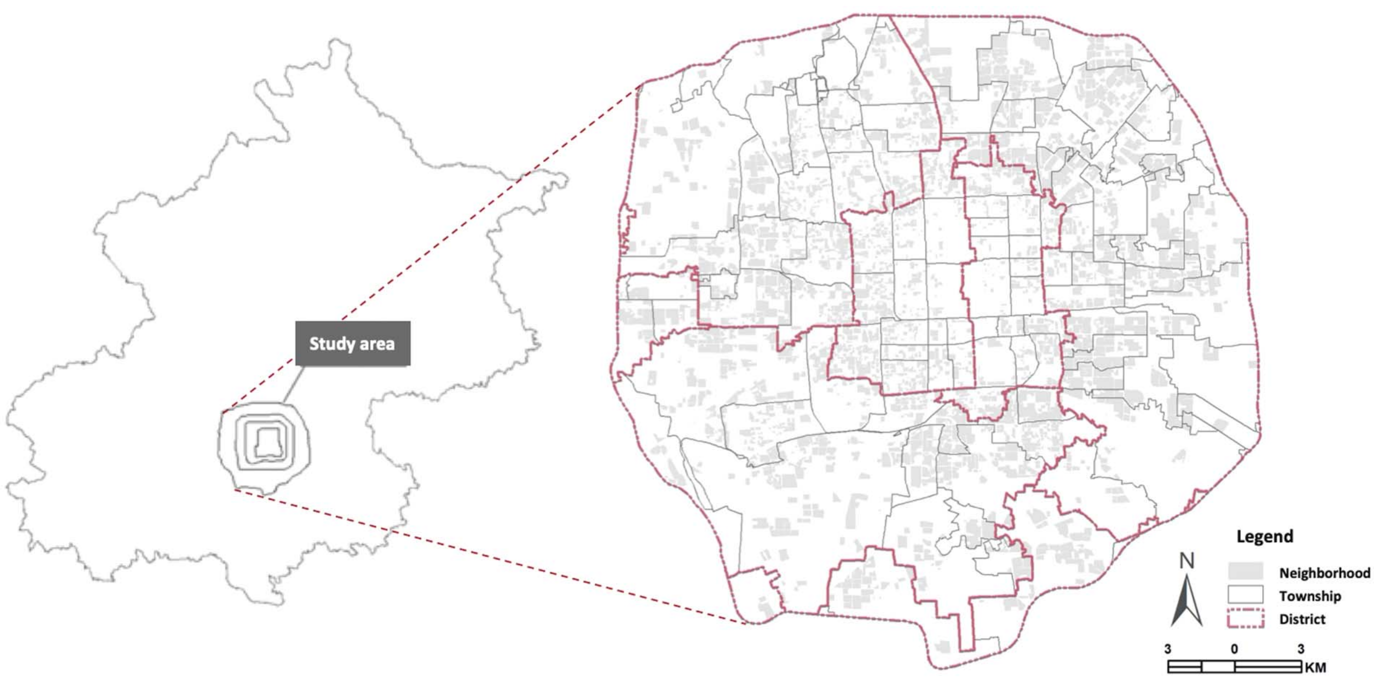

Fig. 2. Study area and gated community boundaries.

(Table 1). Additionally, we control for confounding factors, including housing structure (S), housing location (L), and the surrounding facilities of each gated community (G).

All the variables above are measured objectively. For the PSIG variables, the facilities inside the community (E_i), such as yard (YARD) and sport field (SPORT), are identified manually through high-resolution remote sensing images (Fig. 3), whereas the tree density (*DEN_TREE*) is identified by using deep learning technique and satellite images to recognize the tree inside the community. For the PSSG variable, the street form (E_f) is calculated geometrically through the urban street and building data. The street view greenery (E_g) is extracted from the street view image. The spatial disorder (E_d) is evaluated by examining the presence of visible street elements which are commonly presented spatial quality decline, such as, abandoned building, overgrown plant, unpaved road, and so on, appears in the street view images, rather than measured by analysts' personal subjective perception (Figs. 4 and 5). This measurement work is conducted by four trained analysts, and the result is verified through interrater reliability test, ensuring that the subjectivity and misjudgment of the results are eliminated as much as possible (Chen and Long 2021).

Model

In this study, the ordinary least squares regression method (OLS) is used to estimate and test the parameters of each variable initially. Among all the variables, the continuous variables, such as unit price, area, and distance, require logarithmic transformation for subsequent marginal price analysis, which is indicated by *ln* before the variable names.

The hedonic pricing model is applied to estimate the mechanism of influence between PSSG and PSIG and the housing price. The hedonic pricing model is shown as follows:

$$\ln P = \beta_0 + \Sigma\beta_i X_i + \Sigma\beta_j \ln X_j + \varepsilon \quad (1)$$

where P = housing price; X_i = discontinuous characteristic variables, such as direction and architectural form; and X_j = continuous characteristic variables, such as area and distance. In the model, the variable needs ln logarithmic conversion; β_i and β_j are variable coefficients, β_0 is a constant, and ε is an error.

To effectively measure the actual impact of different housing characteristics on housing prices, the regression results obtained through the hedonic pricing model need to be further monetized. Before the marginal price of each variable is calculated, the price elasticity of each characteristic variable (price elasticity) should be determined.

Based on the regression results of the hedonic pricing model in logarithmic form, the unstandardized regression coefficients obtained are equivalent to the price elasticity coefficient or semielasticity coefficient of each variable. The regression coefficient of the continuous variable reflects the price elasticity coefficient of the feature, whereas the dummy variable and the grade variable are not continuous. The unstandardized coefficient of the regression cannot be used directly as the price elasticity coefficient. It needs to be derived from the antilog of the regression coefficient. The semielastic coefficient is obtained, and the specific calculation formula is shown in the following equation:

$$\beta_j' = \exp(\beta_j) - 1 \quad (2)$$

After the elasticity coefficient (or semielasticity coefficient) of each variable is determined, the average value in the sample can be studied as a benchmark, and the marginal price of each variable characteristic can be estimated. The marginal price estimated by the elasticity coefficient reflects the control. In the case of other variables, a 1% change in this variable will cause a percentage change in housing price, and the marginal price estimated by the semielasticity coefficient reflects the currency price increase that the variable causes in housing price for each additional unit change. According to the descriptive statistics, the average housing price of the data sample is 60,378 yuan/m^2, whereas the marginal price of logarithmic variables and the marginal price of nonlogarithmic variables are calculated by the following equations:

$$\text{MIP}_i = (\beta_i * \mu_P)/\mu_i \quad (3)$$

$$\text{MIP}_j = (\beta_j{}' * \mu_P) \quad (4)$$

In the equations, MIP represents the marginal price, β_i and β_j represent, respectively, the logarithmic elasticity coefficient and the nonlogarithmic semielasticity coefficient, μ_P is the average housing price, and μ_i is the original data average of logarithmic variables.

Results

Hedonic Pricing Model Analysis

Before applying the hedonic pricing model, we conduct a correlation analysis to check whether there are any highly correlated variables (greater than 0.8 or less than −0.8) between the variables to avoid multiple collinearities in the OLS regression analysis. The results demonstrate that no correlation coefficients are greater than 0.8 or less than −0.8.

The results of the multicollinearity test showed that the variance inflation factor (VIF) values of all variables were less than 4, indicating that the linear relationship between the independent variables was extremely small. In the significance test of the independent variables, the significance level (Sig.) of most variables passed the test, indicating that these residential characteristics have a close linear relationship with housing price (ln UNIT_P). The R^2 indicates that the model can ultimately explain 40.9% of the influence mechanism (Table 2).

For PSSG, the coefficients of street form variables indicate higher housing prices if the streets surrounding the gated community are wider, the buildings along the streets are higher, and the proportion of street wall continuity is higher. A wide road not only reflects that the gated community may be located around the main road, indicating convenient transportation but also associates with wider *setback space* in Chinese urban planning, meaning longer distance from building to the street, which retains more space for pedestrian and greenery to reduce the direct negative impact of the main road on the residents, including road noise and air pollution; a high level of street wall continuity implies that the buildings along the streets within the gated community have a certain sense of organization and order, which is consistent with Kevin Lynch's idea of enhancing street wall continuity to ensure gated community identification (Lynch 1960). The coefficients of street greenery and the degree of the street spatial disorder are also consistent with the expected directions; higher street greenery and lower spatial disorder contribute to higher housing prices.

For PSIG, except for the presence of a road parking lot (PARKA), the coefficients of all the gated community facilities and the gated community layout variables are essentially consistent with expectations. For example, the presence of a courtyard (YARD) and sport facilities such as playgrounds and swimming pools (SPORT) are two variables that are positively related to housing

Table 1. Dependent and independent variables

Variable	Description (unit)	Expected direction	Average	Std.	Min.	Max.	Data sources
Dependents							
UNIT_P	Average housing price (yuan/m^2)	—	60,378.14	21,964.06	3.00	150,000.00	Lianjia.com
Structure (*S*)							
ROOM	Number of rooms	+	3.01	1.12	1.00	10.00	Lianjia.com
AREA	Housing area (m^2)	+	88.12	992.49	5.00	147,052.00	Lianjia.com
DIRECTION	Whether the housing faces north or south (assigned 1 if existed, otherwise 0)	+	0.33	0.47	0.00	1.00	Lianjia.com
DECO	Housing decoration degree (3 for hardcover, 2 for simple, and 1 for rough)	+	2.35	0.71	1.00	3.00	Lianjia.com
ELEVATOR	Whether there is an elevator in the building (assigned 1 if yes, otherwise 0)	+	0.60	0.49	0.00	1.00	Lianjia.com
FLOOR	Floor height (3 for high floors, 2 for medium floors, 1 for low floors)	Unknown	2.04	0.81	0.00	3.00	Lianjia.com
YEAR	House age	+	19.78	8.63	1.00	68.00	Lianjia.com
TYPE	Architectural form (3 for plate building, 2 for combination building of plate and tower, 1 for tower building)	+	2.12	0.90	0.00	3.00	Lianjia.com
Location (*L*)							
DIST_TAM	Euclidean distance to Tiananmen Square (km)	−	8.13	0.31	0.94	17.39	Amap
DIST_SUBCENTER	Euclidean distance to the nearest center (km). The city subcenters are calculated with the method from Li et al. (2018a), including Zhongguancun (known as Beijing Silicon Valley); Xidan, Wangfujing, and Chongwenmen, which represent the city-level commercial centers; and Guomao as well as Dawang Road (representing the CBD).	−	5.51	0.03	0.07	15.73	Amap
Gated community (*G*)							
DIST_SUBWAY	Euclidean distance to the nearest metro station (km)	−	2.53	0.13	0.02	4.73	Amap
NOR_BJ	Whether it is located north of Chang'an Street (north marked 1, otherwise 0)	+	0.56	0.50	0.00	1.00	Amap
ENTERTAIN	The nearest distances of various facilities within the scope of the *15-min Living Circle* (500-m buffer surrounding the gated community) are compared with the distances of other gated communities in the city. Scores are then normalized to comprehensively evaluate the four types of service in the gated community.	+	96.71	1.64	87.33	99.66	Amap
LIFECONV		+	96.62	1.58	81.99	99.66	Amap
HEALTH		+	57.11	1.70	45.10	60.09	Amap
EDUCATE		+	94.3	2.73	79.17	99.23	Amap
PSIG-Inner Facilities (E_i)							
PLOTAREA	Plot ratio (%)	+	2.34	1.42	0.00	10.00	Lianjia.com
NEIAREA	Residential area (km^2)	+	0.10	0.10	0.00	0.65	Lianjia.com
YARD	An online system has been established for the spatial evaluation of Beijing gated communities (Fig. 3); the system also measures the following three variables. Whether there is a square in the gated community (assigned 1 if yes, otherwise 0)	+	0.71	0.46	0.00	1.00	Google Earth
SPORT	Whether there is a sport field in the gated community (assigned 1 if yes, otherwise 0)	+	0.21	0.40	0.00	1.00	Google Earth
PARKA	Whether there is a ground parking lot in the gated community (assigned 1 if yes, otherwise 0)	+	0.62	0.48	0.00	1.00	Google Earth
PARKR	Whether there are vehicles on the sidewalk in the gated community (assigned 1 if yes, otherwise 0)	−	0.54	0.50	0.00	1.00	Google Earth
DEN_TREE	Tree density in the gated community (number of trees/km^2). The calculation method of the tree density index within the gated community mainly refers to the research of Jin and Yang (2020). Due to data limitations, this paper currently only focuses on the tree density of the gated communities in the 4th Ring Road of Beijing (a total of 2,812).	+	7,530.18	3,022.44	0.00	21,287.70	(Jin and Yang 2020)
PSSG-Street Form (E_f)							
WIDTH	Average street width (m) (Harvey et al. 2017)	+	39.38	6.73	12.00	67.00	Amap
HEIGHT	Average height along both sides of the street (m) (Harvey et al. 2017)	Unknown	16.63	6.36	2.00	46.00	Amap
CONTINUE	Street wall continuity (%) (Harvey et al. 2017)	+	0.37	0.09	0.03	0.70	Amap

Table 1. (*Continued.*)

Variable	Description (unit)	Expected direction	Average	Std.	Min.	Max.	Data sources
PSSG-Greening (E_g)							
GREENERY	Street average greening ratio (%) (Long and Liu 2017)	+	19.27	0.06	2.29	44.83	Tencent Map
PSSG-Spatial Disorder (E_d)							
DISORDER	Spatial disorder (DISORDER) refers to the observable spatial elements that interfere with residents' daily lives in and the appropriate use of public spaces (Skogan 1992). Concrete manifestations of spatial disorder, such as poorly maintained building facades and abandoned buildings, are directly or indirectly harmful for human health. The evaluation system is based on the existing theoretical research and the current problems of Chinese cities and divides spatial disorder into five dimensions (building, street business, environmental greening, roads, and infrastructure) and 19 elements (Fig. 4). Through the online audit platform (Fig. 5), four analysts who have been systematically trained beforehand will manually interpret the nineteen categories of the five dimensions of the street-view picture. If one of the above 19 elements appear in the street-view image, then it is counted as one point, and the spatial measurement analysis is performed after accumulation to obtain the total *disorder score* of each street.	−	1.92	1.41	0.00	11.00	Tencent Map

Table 2. Regression results of the hedonic pricing model within the 5th Ring Road

N: 58,540		Model		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7	
Categories	Variables	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.
S	ln ROOM	0.225	***	0.280	***	0.277	***	0.289	***	0.292	***	0.292	***	0.278	***
	ln AREA	−0.285	***	−0.313	***	−0.308	***	−0.326	***	−0.329	***	−0.330	***	−0.304	***
	DIRECTION	−0.026	***	0.022	***	0.021	***	0.024	***	0.025	***	0.025	***	0.019	***
	DECO	0.146	***	0.113	***	0.114	***	0.112	***	0.110	***	0.110	***	0.108	***
	ELEVATOR	0.197	***	0.140	***	0.143	***	0.126	***	0.114	***	0.112	***	0.119	***
	FLOOR	0.002	**	0.018	***	0.017	***	0.020	***	0.020	***	0.020	***	0.018	***
	ln YEAR	0.149	***	−0.072	***	−0.077	***	−0.053	***	−0.049	***	−0.061	***	−0.068	***
	TYPE	0.119	***	0.126	***	0.128	***	0.127	***	0.128	***	0.129	***	0.144	***
L	ln DIST_TAM	—	—	−0.378	***	−0.375	***	−0.368	***	−0.397	***	−0.388	***	−0.354	***
	Ln DIST_SUBCENTER	—	—	−0.062	***	−0.069	***	−0.073	***	−0.065	***	−0.074	***	−0.096	***
	ln DIST_SUBWAY	—	—	−0.019	***	−0.036	***	−0.028	***	−0.021	***	−0.021	***	−0.024	***
	NOR_BJ	—	—	0.356	***	0.360	***	0.353	***	0.356	***	0.348	***	0.313	***
G	ln ENTERTAIN	—	—	—	—	−0.032	***	−0.031	***	−0.397	***	−0.034	***	−0.035	***
	ln LIFECONV	—	—	—	—	−0.036	***	−0.035	***	−0.065	***	−0.039	***	−0.036	***
	ln HEALTH	—	—	—	—	0.012	**	0.006		−0.021	*	0.014	*	0.002	
	ln EDUCATE	—	—	—	—	0.050	***	0.071	***	0.356	***	0.079	***	0.087	***
PSIG E_i	ln PLOTAREA	—	—	—	—	—	—	−0.016	***	−0.024	***	−0.023	***	−0.023	***
	ln NEIAREA	—	—	—	—	—	—	−0.046	***	−0.054	***	−0.054	***	−0.052	***
	YARD	—	—	—	—	—	—	0.080	***	0.078	***	0.080	***	0.064	***
	SPORT	—	—	—	—	—	—	0.018	***	0.022	***	0.022	***	0.023	***
	PARKA	—	—	—	—	—	—	0.004	*	0.002	*	0.001		0.000	
	PARKR	—	—	—	—	—	—	−0.061	***	−0.062	***	−0.063	***	−0.061	***
PSSG E_f	ln WIDTH	—	—	—	—	—	—	—	—	0.063	***	0.064	***	0.022	***
	ln HEIGHT	—	—	—	—	—	—	—	—	0.001		0.001		0.026	***
	ln CONTINUE	—	—	—	—	—	—	—	—	0.060	***	0.058	***	0.019	***
PSSG E_g	ln GREENERY	—	—	—	—	—	—	—	—	—	—	0.038	***	0.025	***
PSSG E_d	ln DISORDER	—	—	—	—	—	—	—	—	—	—	—	—	−0.103	***
R^2		0.088		0.379		0.382		0.394		0.399		0.400		0.406	

Note: All coefficients have been standardized for cross comparison, and Sig.: *** < 0.001; ** < 0.01; * < 0.05. These notes also apply to the following tables. The results of covariates are not reported in the following tables.

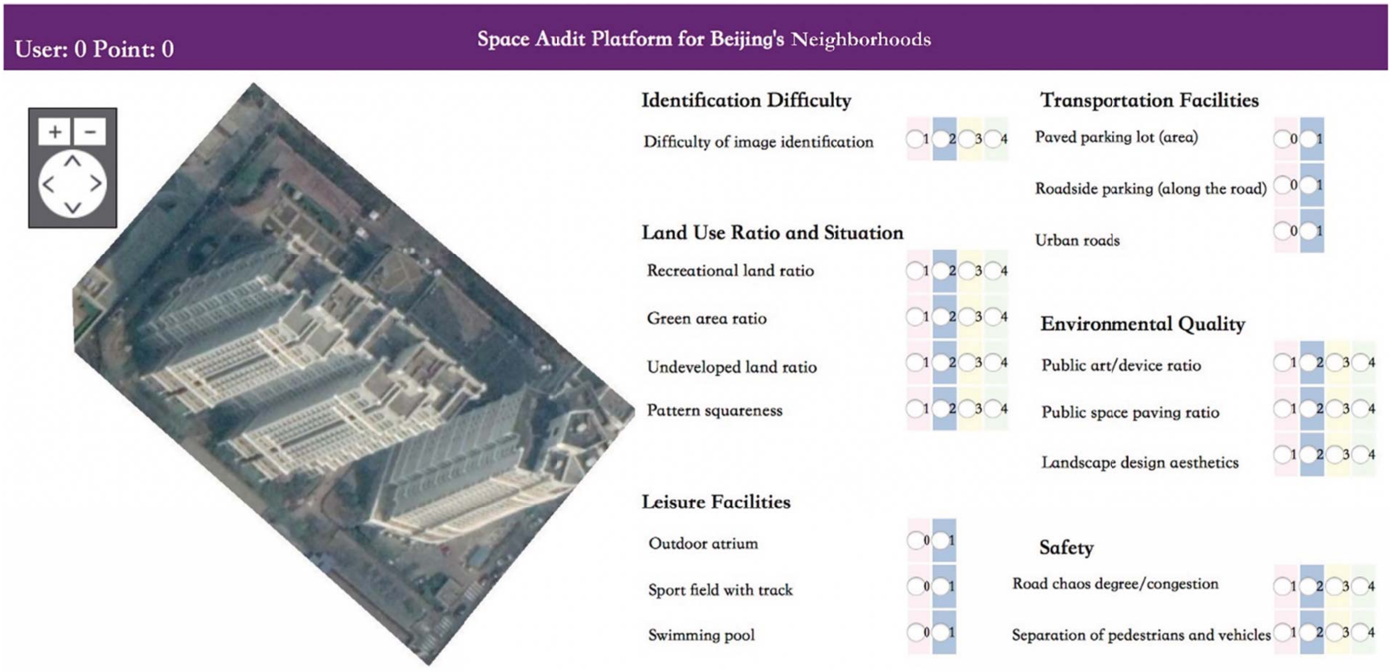

Fig. 3. Online audit platform for high-resolution remote sensing images of the gated communities within the Beijing 5th Ring Road. (Map data © 2016 Google.)

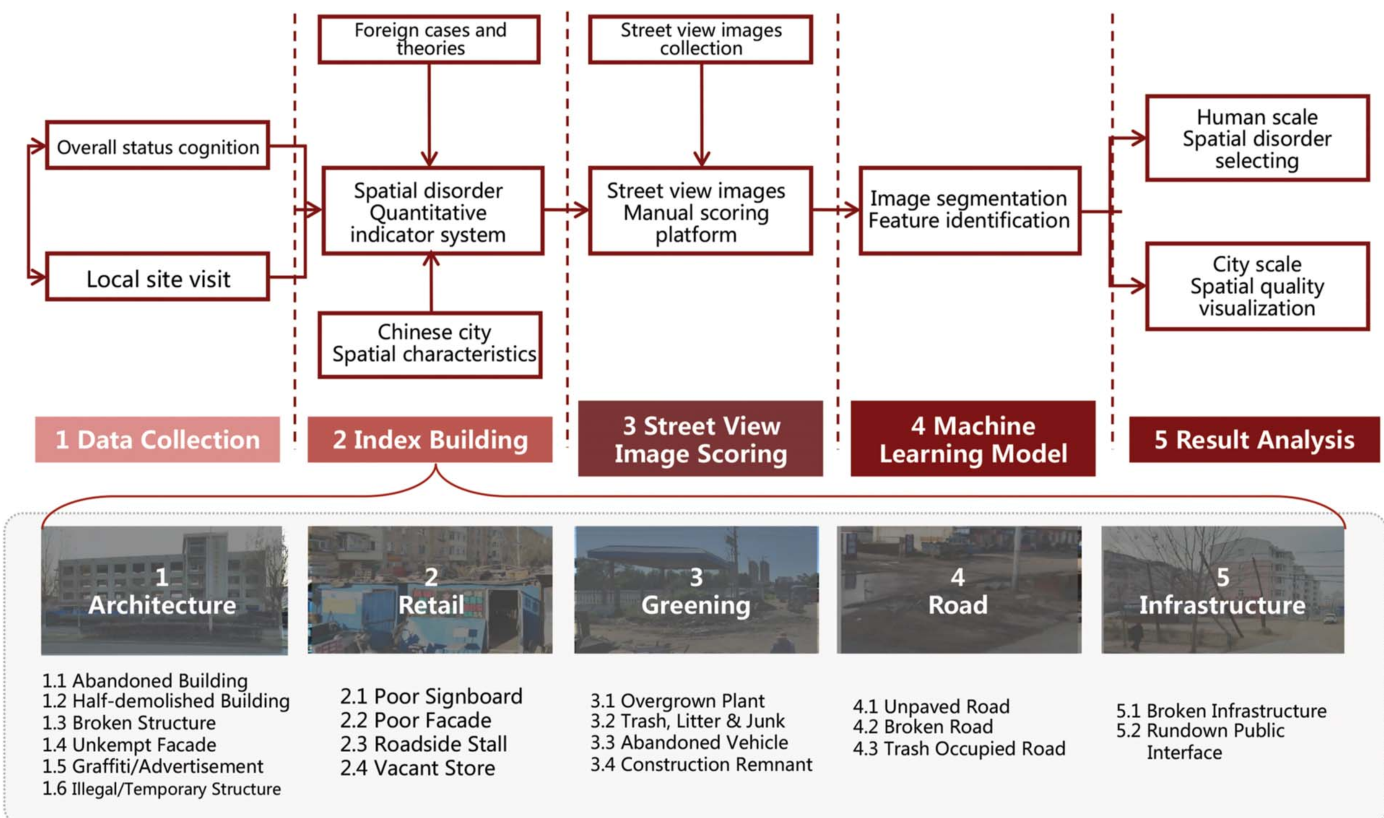

Fig. 4. Evaluation framework for street spatial disorder. (Street View Image Data: © 2015 Tencent.)

prices, indicating that these two spatial facilities can increase housing prices. In addition, a disorderly parking situation (PARKR) on the sidewalk exerts a negative impact on housing prices.

Additionally, we compare the difference between greenery (within and surrounding the gated communities) and housing prices for the area within the 4th Ring Road. The results indicate that greenery within gated communities is more crucial than that surrounding gated communities (0.068 $P < 0.001$ versus 0.018 $P < 0.01$), which means that higher greenery levels within gated communities can raise housing prices to a greater degree.

Fig. 5. Online audit platform for spatial disorder within the Beijing 5th Ring Road area. (Street View Image Data: © 2015 Tencent.)

Table 3. SAR results of the hedonic pricing model within the 5th Ring Road

N: 58,540			Model 1		Model 2		Model 3		Model 4	
Types	Categories	Variables	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.
PSIG	E_i	ln PLOTAREA	−0.003		−0.006	*	−0.006	*	−0.006	*
		ln NEIAREA	0.015	**	0.011	**	0.011	**	0.012	**
		YARD	0.044	***	0.046	***	0.045	***	0.045	***
		SPORT	0.002		0.004		0.004		0.004	
		PARKA	0.005	*	0.004	*	0.004	*	0.004	*
		PARKR	−0.006	*	−0.006	*	−0.006	*	−0.006	*
PSSG	E_f	ln WIDTH	—	—	0.001		0.001		0.000	
		ln HEIGHT	—	—	0.002	*	0.003	*	0.002	*
		ln CONTINUE	—	—	0.008	*	0.008	*	0.006	*
	E_g	ln GREENERY	—	—	—	—	0.005	*	0.006	*
	E_d	ln DISORDER	—	—	—	—	—	—	−0.008	*
		Spatial Lag	0.688	***	0.674	***	0.675	***	0.673	***
	R^2		0.556		0.556		0.556		0.557	

Note: The covariates have been controlled, but the results are not reported in the tables. The notes also apply to the following tables. *, **, and *** refer to significance levels for the two-tailed tests at $P < 0.1$, $P < 0.05$, and $P < 0.01$, respectively.

Robustness Analysis

To eliminate the spatial autocorrelation effect on the hedonic pricing model, as the spatial correlation coefficient is very high (ranging up to 0.835), we add a spatial lag coefficient to the model, which is the spatial autoregression regression model (SAR) proposed by Anselin (2001). We select the 500-m buffer of each gated community's center as the basic spatial unit and calculate the average housing price in the buffer as the spatial lag indicator. The results show that the R^2 of all models is improved, indicating that the SAR improved their determinant ability. SPORT and WIDTH fail to pass the significance test, whereas the directions of the coefficients are consistent with the results presented previously, confirming the reliability of the results calculated by the original least squares regression method (Table 3).

Further, we conduct another robust test by dividing the samples into different geographical categories, including Beijing's inner city (within the 2nd Ring Road) and suburbs (outside the 2nd Ring Road), as the 2nd Ring Road used to be the historical city wall. The results show that although the R^2 decreases slightly, the coefficients and significances of most variables remain the same as in the original results (Table 4), indicating the high robustness of the main analysis.

Marginal Price Analysis

For PSIG, Table 5 shows that the average housing price of those gated communities with yards is 1,467 yuan/m^2 higher than those without a yard. If the gated communities have sport fields, the housing price is 546 yuan/m^2 higher than those without sport fields. However, if the gated communities have roads where pedestrians and vehicles must share space, the average housing price is 1,255 yuan/m^2 lower than those without such conditions.

For the PSSG, the average housing price increases by 78 yuan/m^2 and 90 yuan/m^2, respectively, with each 1m increase in the average street width and the average street height. The average housing price increases by RMB 4,269 for every 1% increase in street wall continuity. Except for the street form variable, the average housing price increases by 85 yuan/m^2 for every 1% increase in street greenery. However, the average housing price decreases by 1,539 yuan/m^2 for every 1-point increase in the average score of street spatial disorder.

We further compared the difference in greenery between the PSSG and PSIG within the 4th Ring Road in Beijing (Table 6). The results show that the marginal price of trees in the gated community is 0.44 yuan/m^2, which means that housing prices increase by 0.44 yuan for each additional tree present in the area, whereas the greenery surrounding the gated community requires an increase

Table 4. Robust test results

			Geographical division			
			Suburbs		Inner city (within 2nd Ring Road)	
Types	Categories	Variables	Beta	Sig.	Beta	Sig.
PSIG	E_i	ln PLOTAREA	−0.022	***	0.008	—
		ln NEIAREA	−0.050	***	0.108	***
		YARD	0.018	***	0.069	***
		SPORT	0.063	***	0.061	**
		PARKA	0.029	***	−0.044	—
		PARKR	−0.066	***	−0.015	***
		ln DEN_TREE	—	—	0.073	***
PSSG	E_f	ln WIDTH	0.036	***	0.061	**
		ln HEIGHT	−0.002	—	0.125	***
		ln CONTINUE	−0.029	***	−0.072	**
	E_g	ln GREENERY	0.028	***	0.111	***
	E_d	ln DISORDER	−0.099	***	−0.066	**
	R^2		0.318		0.322	

Note: Number of samples in Suburbs 54,793, Inner City (within 2nd Ring Road), 3,753. *, **, and *** refer to significance levels for the two-tailed tests at $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.

Table 5. Results of marginal price analysis within the 5th Ring Road

Types	Categories	Variables	Mean[a]	Standardized beta	Unstandardizedized beta	Coefficient of elasticity (%)	Coefficient of semielasticity (%)	MIP[b] (yuan/m^2)
PSIG	E_i	ln PLOTAREA	2.34	−0.02	−0.02	−0.02	—	−463.97
		ln NEIAREA	0.10	−0.05	−0.02	−0.02	—	−11,907.38
		YARD	0.71	0.06	0.02	—	2.43	1,466.60
		SPORT	0.21	0.02	0.01	—	0.90	545.85
		PARKR	0.54	−0.06	−0.02	—	−2.08	−1,254.72
PSSG	E_f	ln WIDTH	39.38	0.02	0.05	0.05	—	78.19
		ln HEIGHT	16.62	0.03	0.03	0.03	—	90.82
		ln CONTINUE	0.37	0.02	0.03	0.03	—	4,268.91
	E_g	ln GREENERY	19.27	0.03	0.03	0.03	—	84.60
	E_d	ln DISORDER	1.92	−0.10	−0.05	−0.05	—	−1,538.96

[a]The average, minimum, and maximum values are calculated using raw data rather than logarithmic data.
[b]The average housing price of the data sample within the 5th Ring Road is 60,378 yuan/m^2.

Table 6. Results of marginal price analysis of greenery

Variables	Mean[a]	Minimum	Maximum	Standardized beta	Unstandardized beta	Coefficient of elasticity (%)	MIP[b] (Yuan/m^2)
ln GREENERY (%)	20.24	2.54	44.83	0.02	0.02	0.02	58.31
ln DEN_TREE (number/km^2)	7,530.31	0.00	21,287.70	0.07	0.05	0.05	0.44

[a]The average, minimum, and maximum values are calculated using raw data rather than logarithmic data.
[b]The average housing price of the data sample within the 4th Ring Road is 65,570 yuan/m^2.

in the overall greening ratio of the street by 1% to increase housing prices by 58 yuan/m^2. The public space value of the trees within the gated community is relatively higher than that of the street greenery surrounding the gated community.

Conclusion and Discussion

Conclusion

Although the study of public space has long been a primary area of interest in urban studies, its social significance and economic benefits remain unclear for immeasurable public space from the microscale perspective. Hence, we conduct a three-step research study to evaluate the impact of the presence and quality of specific public space on housing prices within Beijing's 5th Ring Road. First, from the microscale perspective, we measure PSSG and PSIG, which are related to the features that can be seen or touched. Second, we specify the effects of PSSG and PSIG on housing prices. Third, we speculate regarding the monetization value of different PSSG and PSIG features. The results are as follows:

(1) A new data environment supports the measurement of PSSG and PSIG from the microscale perspective. For PSIG, the measurement content includes the presence of major facilities, such as squares or courtyards, sport fields, parking lots, and the situation of vehicles occupying the road. The tree density within the Beijing 4th Ring Road is used to represent PSIG greenery, which can be used for comparison with PSSG greenery. For PSSGs, the form, greenery, and spatial disorder of the street are selected as the main features to depict the quality of the public space.

(2) For PSIG, after controlling for confounding factors, except for the presence of a road parking lot (PARKA) and a disorderly parking situation (PARKR) on the sidewalk, which decreases housing prices, the presence of all gated community facilities raises housing prices, clarifying that the inner facilities are indispensable for residents and even could determine the housing prices. Housing prices are 1,467 yuan/m^2 higher for gated communities with yards. Housing prices are 546 yuan/m^2 higher for gated communities with sport fields. If the gated communities have roads where pedestrians and vehicles must share the road, the housing price is 1,255 yuan/m^2 lower. For the PSSG, wider streets, higher buildings along the streets, higher levels of street greenery, higher proportions of street wall continuity, and lower street spatial disorder contribute to higher housing prices, which all could be considered as expensive housing prices preferred the gated communities that located at the high spatial quality area. Housing prices increase by 78 yuan/m^2 and 90 yuan/m^2, respectively, as the average width and building height of streets increase in 1-m increments. Housing prices rise by 4,269 yuan/m^2 with each 1% increase in higher street wall continuity. Housing prices rise by 85 yuan/m^2 for each 1% increase in street greenery. However, housing prices decrease by 1,539 yuan/m^2 for each 1-point increase in the average score of street spatial disorder. Besides, the greenery inside the gated community is more important as higher greenery levels within gated communities raise housing prices to a greater degree compared to that of the PSSG.

Academic Contributions

We categorize the following three main innovations by comparing them with existing research:

(1) Our study proposes a relatively comprehensive description framework for future microscale studies. We select various features to represent PSIG and PSSG from the microscale perspective. These features largely determine citizens' quality of life, as citizens frequently interact and engage with such features in daily life.

(2) By introducing the emerging advanced tools, we clarify that the image data of street-view images and remote sensing images can effectively depict microscale public space features. These tools offer the following advantages: first, the features extracted from street-view image data are similar to those seen from the human visual perspective; and second, remote sensing image data can identify small to medium-sized facilities that other data types cannot capture.

(3) We specifically measure the marginal price of different public space elements and facilities, quantifying the value in a more intuitive and scientific way. The results could help urban planning designers, developers, and property managers understand the economic benefits of the construction and renovation of PSIGs and PSSGs. In addition, the results can also be used to determine which public space features should be prioritized to adjust housing prices.

Potential Bias and Next Steps

We propose a preliminary method to examine the value of public space from the microscale perspective. However, there remains some limitations, including the spatial heterogeneity of different urban regions that were not considered. The limitations should be addressed in future research.

Data Availability Statement

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

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