ISSN: 1648-715X / eISSN: 1648-9179

VILNIUS TECH
Vilnius Gediminas Technical University

INTERNATIONAL JOURNAL OF STRATEGIC PROPERTY MANAGEMENT

2025
Volume 29
Issue 5
Pages 316–328

https://doi.org/10.3846/ijspm.2025.24813

DYNAMIC EFFECT OF SPORTS PARKS ON HOUSING PRICES: EVIDENCE FROM HANGZHOU ASIAN GAMES PARK

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Article History:
- received 18 March 2025
- accepted 28 July 2025

Abstract. The construction of sports parks often involves significant investment and extended development timelines, making it crucial to evaluate their economic impacts for informed policymaking and strategic urban planning. While research on the externalities of urban parks has grown, the specific economic effects of sports parks remain underexplored. This study examines the impact of the Hangzhou Asian Games Park on housing prices using 31,329 transaction records from 2018 to 2023. Employing a hedonic pricing model and a difference-in-differences approach, we find that housing prices increase by 1.6% for every 1 km reduction in distance to the park. Spatial heterogeneity is observable, as the effect diminishes with increasing distance. Temporally, the park's planning announcement triggered a 0.7% increase in price-distance elasticity, compared to a 0.2% increase after its opening. These findings suggest that the anticipatory market response was stronger than the realized benefits after the park's completion. This study quantifies the spatial and temporal dynamics of the economic value of sports parks, providing valuable insights for urban planning, public policy, and investment strategies.

Keywords: sports parks, housing prices, hedonic pricing, spatial heterogeneity, temporal dynamics, Hangzhou Asian Games Park.

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1. Introduction

Urban parks play a critical role in enhancing the livability and sustainability of cities. Extensive research has demonstrated the environmental, social, and economic contributions of urban parks. For instance, urban parks help mitigate air pollution (Kim & Coseo, 2018), reduce urban heat island effects (Yan et al., 2018), and provide spaces for recreation, social interaction, and physical activity (Brown et al., 2014; Peters et al., 2010; Chiesura, 2004). These benefits, along with their influence on real estate values, have sparked interest in assessing their impact on housing markets (Jim & Chen, 2010; Mueller et al., 2022). However, most existing studies focus on general green spaces or conventional urban parks, leaving a significant gap in understanding the economic value of sports parks as a distinct category of public infrastructure.

Unlike traditional urban parks, sports parks blend fitness and recreational facilities with natural landscapes, offering sports venues, exercise amenities, and leisure spaces. As multifunctional public goods, they contribute to urban vitality and public health while also serving as venues for organized sports events. Previous research on sports parks has predominantly examined their planning and design (Luo & Wang, 2022), social benefits (Sun et al., 2022), and ecological functions (Li, 2020). For instance, Sun et al. (2022) demonstrated how sports parks promote community interaction, while Wu and Li (2022) emphasized their role in meeting public exercise needs. Access to sports parks has also been linked to improved health outcomes and subjective well-being (Dadvand et al., 2016; Kou et al., 2021; Zhang et al., 2021b). However, their economic externalities, particularly their impact on housing prices, remain underexplored. This gap in the literature limits our understanding of their broader value and constrains evidence-based urban planning and investment decisions.

The Hangzhou Asian Games Park provides a compelling case study to address this gap. Developed to support the 19th Asian Games, this large-scale sports park integrates green space with sports facilities and commercial areas, representing an innovative approach to urban park development. Its phased development process, including the announcement of the project in 2019 and its official opening in 2021, offers a unique opportunity to examine both the spatial heterogeneity and the temporal evolution of its economic effects. By adopting a framework that combines hedonic pricing with difference-in-differences (DID) approach, this study aims to address three key research questions: (1) Does the Asian Games Park significantly impact housing prices? (2) How does this effect vary spatially, particularly across different distance thresholds? (3) How does the effect evolve during key phases, including the park's announcement and opening?

This study makes two primary contributions to the existing literature. First, it offers a novel quantitative assessment of the capitalization effects of sports parks, a topic largely overlooked in prior research. Second, by integrating spatial and temporal dimensions, it provides a comprehensive evaluation of the park's impact, shedding light on the dynamic interplay between policy-driven urban development and housing markets. The findings have significant implications for urban policymakers and planners, particularly in understanding the economic rationale for investing in sports-oriented public spaces.

2. Literature review

2.1. Urban parks, stadiums, and housing prices

The relationship between urban parks and housing prices has garnered considerable academic attention. Early studies from the 1960s and 1970s established that urban parks positively influence housing prices (Kitchen & Hendon, 1967; Correll et al., 1978; Darling, 1973; Weigher & Zerbst, 1973). With the advent of hedonic price theory (Lancaster, 1966; Rosen, 1974), it has become a dominant approach in real estate research (Freeman et al., 2014). Empirical studies from the United States (Mueller et al., 2022), Finland (Tyrväinen & Miettinen, 2000), Sweden (Engström & Gren, 2017), and Norway (Luttik, 2000) consistently demonstrate the positive impact of parks on neighboring housing prices. Similarly, Chinese scholars have examined this relationship in cities like Shanghai (Li et al., 2019), Nanjing (Yuan et al., 2020), and Hangzhou (Wen et al., 2015), confirming that urban parks enhance housing values in the Chinese context.

Key attributes, including distance, size, and type, play a critical role in influencing the impact of parks on housing prices (Liang et al., 2018). For instance, Luttik (2000) found a 6% housing price premium for properties located within 400 meters of a park. Wen et al. (2015) observed that housing prices decrease by 0.052% for every 1% increase in distance from a park, while a 1% increase in park area raises housing prices by 0.008%. Panduro et al. (2018) reported that proximity to parks within 1,000 meters generates an implied price of €53.25 per hectare, with larger parks driving more significant price increases. Larger urban parks tend to generate stronger positive effects on housing prices compared to smaller parks (Czembrowski & Kronenberg, 2016; Piaggio, 2021). For example, Jiao and Liu (2010) demonstrated that city-level parks in Wuhan, China, significantly increase housing prices, whereas district-level parks do not. Similarly, Dell'Anna et al. (2022), using data from Singapore, found that each additional meter of distance to a city-level park decreases housing prices by \$181.67, compared to \$85.97 for district-level parks. The varying effects of different park types on housing prices have also been emphasized (Chen et al., 2022; Crompton, 2001; More et al., 1988). Zhang et al. (2021a) classified parks into comprehensive, community, specialized, and recreational parks, finding distinct differences in their externalities. For instance, housing prices decrease by 0.7%, 4.4%, and 2.3% for every 1 km increase in distance to comprehensive parks, community parks, and specialized parks, respectively, highlighting variations in residents' willingness to pay for different park types.

In contrast to parks, research on the externalities of stadiums remains relatively limited. Tu (2005), using FedEx Field in Washington D.C. as a case study, found that stadium construction positively influences nearby housing prices, countering public concerns about potential negative effects. Feng and Humphreys (2012, 2018) conceptualized sports facilities as urban public goods, demonstrating their positive effects on surrounding property values, though these effects attenuate with distance. Ahlfeldt and Maennig (2010) studied three multipurpose stadiums and found inconsistent effects at varying ring distances, while Kavetsos (2012) discovered that proximity to a stadium increased housing prices by 5% within 3 miles but diminished to 2% by 9 miles. Despite these positive impacts, some studies note potential downsides, such as noise, traffic congestion, and crowding. For instance, Humphreys and Nowak (2017) noted that sports events could lead to localized disamenities, and Hyun (2022) found that new baseball stadiums cause significant housing price reductions within 400 meters, with effects extending up to 1,600 meters.

Sports parks, a hybrid form of urban infrastructure, combine the long-term recreational and aesthetic benefits of parks with the event-hosting functions of sports facilities. This unique combination results in complex externalities, blending the positive amenity effects of parks with the potential disruptions caused by large-scale sports events. Despite their growing importance in urban planning, the economic impacts of sports parks remain underexplored. This study addresses this gap by focusing on the Hangzhou Asian Games Park, a large-scale sports park developed for the 19th Asian Games. By examining its external effects on housing prices, this research provides a nuanced understanding of how sports parks influence real estate values, particularly in light of their dual roles as recreational spaces and event venues.

2.2. Dynamic evolution of externalities

The externalities of large-scale urban projects, such as sports parks, often change over time, reflecting shifts in market expectations and actual usage. These temporal dynamics are typically shaped by key project milestones, including the announcement, construction, and opening phases. During the announcement phase, market expectations of future amenities and urban renewal often generate anticipatory effects reflected in housing prices (Ahlfeldt & Kavetsos, 2014; Keeler et al., 2021). For instance, the announcement of mega-events such as the Olympics or the World Cup frequently triggers immediate reactions in local housing markets, as residents and investors anticipate infrastructure upgrades and increased urban vitality (Kavetsos, 2012; Yamawaki & Duarte, 2014). However, these effects depend on factors such as project credibility and the scale of expected benefits.

To better understand these temporal dynamics, scholars often employ the DID model to analyze key milestones. This model addresses issues of endogeneity by comparing outcomes between a treatment group experiencing an intervention (e.g., policy implementation or project announcement) and an unaffected control group (Bertrand et al., 2004; Wu & Deng, 2024). For example, Kim et al. (2019) analyzed urban parks in Busan, South Korea, across three phases–"comprehensive plan," "implementation plan," and "completion"–finding that different park types had varying impacts during these phases. Ahlfeldt and Kavetsos (2014) demonstrated that the positive externalities of stadium projects emerged as soon as plans were announced, while Propheter (2023) observed significant shifts in housing prices following the announcement of a site change for a sports facility. Similarly, Keeler et al. (2021) found that project announcements increased housing prices by 6%–11%, while venue openings produced additional price increases of 5%–6%.

Sports parks hosting large-scale events can significantly influence local property values through similar temporal dynamics. Kavetsos (2012) found that the announcement of the London Olympics altered the externality of the main Olympic stadium, with housing prices near the stadium decreasing by 0.4% for each additional mile of distance. Likewise, Yamawaki and Duarte (2014) showed that housing prices in Sydney increased immediately after the city was announced as the host for the 2000 Olympics, with the growth rate exceeding that observed during and after the event. Hur and Kim (2023) demonstrated that housing prices near the PyeongChang Winter Olympics venues increased by 27.9%–35% following the successful bid announcement.

Despite the increasing use of the DID framework to analyze such dynamic effects, few studies have applied this approach to sports parks. This study adopts a DID framework, combined with hedonic pricing, to explore the temporal evolution of the externalities associated with the Hangzhou Asian Games Park. By focusing on critical milestones, such as the project announcement and opening, this study captures the spatial and temporal variation in the park's impact on housing prices. In doing so, it contributes to a deeper understanding of how sports parks influence urban housing markets across different phases of their development.

3. Data and model

3.1. Study case

The 19th Asian Games opened on September 23, 2023 in Hangzhou, Zhejiang Province. This event marked the third time that China had hosted Asia's highest-profile international comprehensive sporting event, following the 1990 Beijing Asian Games and the 2010 Guangzhou Asian Games. In preparation for this event, the Hangzhou Municipal Government constructed the Asian Games Park project, the only project to build a new Asian Games stadium within a park. As the first comprehensive urban sports park in Zhejiang Province that integrates the stadium, park green space, sports fields, and commercial facilities, the Asian Games Park has become the largest sports park in Hangzhou. Moreover, it is the first three-star green building project in Zhejiang Province for sports venues, thus highlighting its commitment to sustainability and environmental design.

Located in the Gongshu District, Hangzhou, the Asian Games Park covers a total area of about 701 acres, with a total construction area of 186,000 m^2 and a total investment of approximately 2.9 billion yuan. As a sports park, its greening rate reaches 72.03%. The park consists of "one stadium, one hall, one square, and two centers." According to the layout of "South Hall and North Field," the southern area houses the stadium, which has a total construction area of 58,395 m^2, 6,928 spectator seats, and a national fitness center. The fitness center doubles as a warm-up hall for the Asian Games table tennis tournament and includes three standard basketball courts, 12 badminton courts, a 2,000 m^2 comprehensive sports hall, and professional activity rooms. The northern area contains the field, with a total construction area of 27,121 m^2, 4,870 spectator seats, a training ground, and a visitor service center. The central square connects the northern and southern areas and features underground parking facilities with more than 2,000 social parking spaces. Around the stadium, the southern part of the park also includes a 30,000 m^2 children's playground, a 750 m^2 skateboard park, and an outdoor open-air music performance venue that can accommodate up to 200 people.

The site of the Hangzhou Asian Games Park was initially planned for the construction of the Chengxi Sports Park, which was later changed to the Asian Games Park during the preparatory process. On 5 April 2019, the Hangzhou Municipal Government publicly announced the project planning for the Asian Games Park. Subsequently, the Hangzhou 19th Asian Games Organizing Committee made its first official announcement to determine the time and competition events for the Hangzhou Asian Games. Since then, the Hangzhou Asian Games Park, which hosts three important Asian Games events–table tennis, hockey, and breakdancing (newly added to the Asian Games)–has gradually come into the public's view. In December 2021, the Hangzhou Asian Games Park project was completed and officially opened to the public.

3.2. Data and variables

The secondhand housing transaction data and architectural characteristics, including area and age, used in this study were obtained from real estate intermediary companies and the CRIC database. The housing price is the total transaction price of a single housing unit, which spanned from January 2018 to March 2023 in 1,671 residential communities in Hangzhou. After excluding imperfect and anomalous samples, we obtained valid data for 31,329 housing transaction samples.

The housing price was selected as the dependent variable in this study. The independent variables were categorized into three aspects according to hedonic price theory: architectural characteristics, neighborhood characteristics, and location characteristics. Data related to neighborhood and location characteristics were collected at the residential community level, and relevant latitude and longitude coordinates were obtained through the electronic map. This approach allowed for the direct calculation of distances or the use of map ranging tools, thus quantifying the relevant variables. Drawing on previous empirical studies on the factors influencing housing prices in Hangzhou (Du & Huang, 2018; Wen et al., 2015, 2018, 2022; Xiao et al., 2019), two architectural characteristic variables, two locational characteristic variables, and eight neighborhood characteristic variables were adopted as control variables. The architectural characteristics of housing represent the physical attributes of the buildings. In this study, building age and size were selected to capture these features. Location characteristics reflect the fixed and relative positions of housing, typically quantified through accessibility measures such as straight-line distance, travel time, or path distance. To better represent the spatial structure of Hangzhou, this study includes the distances to West Lake, the traditional cultural and commercial center, and Qianjiang CBD, the emerging central business district, as the primary location characteristic variables. West Lake serves as a key natural and cultural landmark, with its historical and aesthetic value significantly influencing housing prices. In contrast, Qianjiang CBD represents the city's modern economic development and the shift in its commercial core, playing a crucial role in shaping housing price patterns. In addition, neighborhood characteristics focus on the natural environment, social surroundings, and supporting facilities around the housing. This study selected the distances to major hospitals, key schools, bus stops, metro stations, and green spaces as neighborhood characteristic variables. These factors reflect the accessibility to public services, quality of life, and proximity to essential resources, further enriching the explanatory power of the model and ensuring the robustness of the conclusions. Definitions and descriptive statistics for each variable are provided in Table 1.

Table 1. Variable definitions and descriptive statistics

Type	Variable	Definition	Mean	S.D.	Min	Max
Dependent variable	*HP*	Total transaction price of a housing ($)	3,157,000	1,756,000	400,000	17,000,000
Architectural features	*Age*	Building age (years)	17.690	10.110	1	46
	Area	Floor area of a housing (m^2)	82.140	35.830	24	372
Locational features	D_{WL}	Distance from residential community to West Lake (km)	6.308	3.696	0.205	17.950
	D_{QJ}	Distance from residential community to Qianjiang CBD (km)	9.705	5.067	0.299	23.250
Neighborhood features	*Green*	Availability of green spaces within a 1 km radius of the community (1 for availability, 0 otherwise)	0.841	0.366	0	1
	Bus	Number of bus routes within a 1 km radius of the community	62.930	36.450	0	205
	Metro	Availability of metro stations within a 1 km radius of the community (1 for availability, 0 otherwise)	0.729	0.444	0	1
	PriSch	Availability of key primary schools within a 1 km radius of the community (1 for availability, 0 otherwise)	0.412	0.492	0	1
	MidSch	Availability of key middle schools within a 1 km radius of the community (1 for availability, 0 otherwise)	0.364	0.481	0	1
	HighSch	Availability of high schools within a 1 km radius of the community (1 for availability, 0 otherwise)	0.313	0.464	0	1
	Univ	Availability of universities within a 1 km radius of the community (1 for availability, 0 otherwise)	0.249	0.432	0	1
	D_{Hosp}	Distance from community to nearest tertiary hospital (km)	2.617	2.614	0.033	13.440
	D_{AGP}	Distance from community to Asian Games Park (km)	6.083	3.100	0.348	12.000
	D_j	Eight distance buffers between community and the Asian Games Park: j = 1 is within 1 km, j = 2 is 1–2 km, j = 3 is 2–3 km, j = 4 is 3–4 km, j = 5 is 4–5 km, j = 6 is 5–6 km, j = 7 is 6–9 km, j = 8 is 9–12 km				

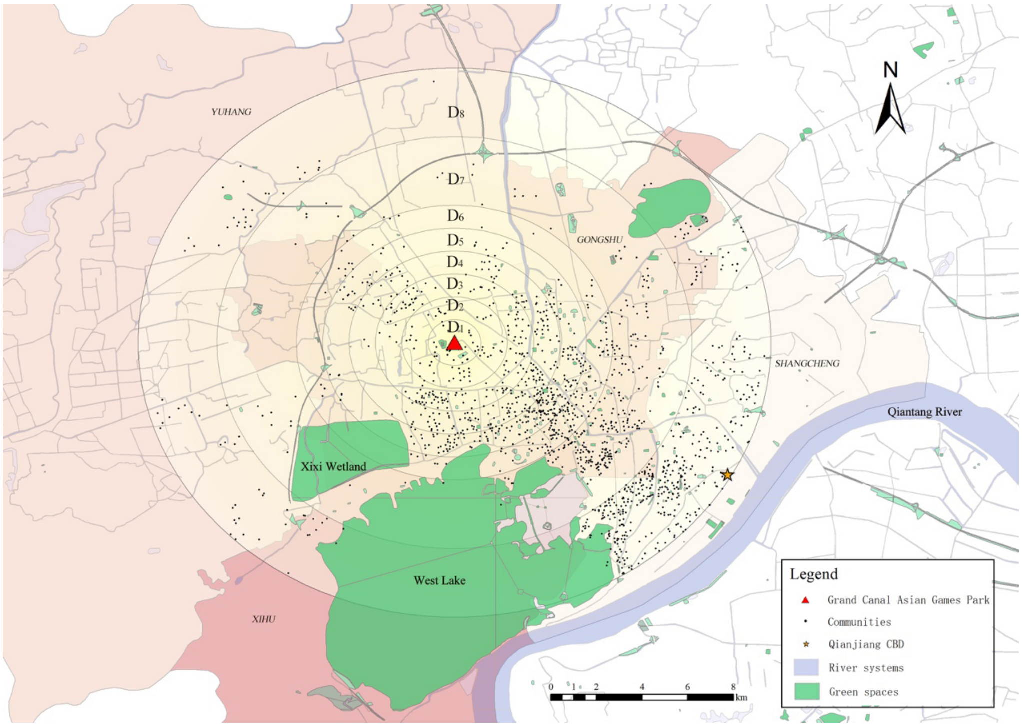

Figure 1. Locations of the Hangzhou Asian Games Park and housing samples

Accessibility to the Asian Games Park is the primary variable examined in this study. Prior research has consistently demonstrated that accessibility can be effectively analyzed using linear distances (Ardeshiri et al., 2016; Jim & Chen, 2006; Vom Hofe et al., 2018). Studies on the effects of sports stadiums and urban parks frequently highlight significant impacts on housing prices within a 3 km radius, with diminishing effects observed beyond this range (Ahlfeldt & Kavetsos, 2014; Mueller et al., 2022). For large-scale cultural and sports facilities constructed for public welfare, previous research suggests that the service radius is typically larger, often extending beyond 5 km (Zhang et al., 2019).

To account for these varying impacts and explore their attenuation across distance, this study categorizes residential communities into eight groups based on their straight-line distance from the Hangzhou Asian Games Park: 0–1 km, 1–2 km, 2–3 km, 3–4 km, 4–5 km, 5–6 km, 6–9 km, and 9–12 km. Communities within the 9–12 km range are used as the control group, as this distance is well beyond the typical impact radius of similar facilities. This categorization allows for a nuanced analysis of how the park's influence on housing prices varies with distance.

It is worth noting that some communities near the boundaries of these distance categories may be subject to overlapping influences, which could lead to a certain degree of spatial correlation or spillover effects. However, existing literature indicates that the effects of policies or facilities tend to attenuate with increasing distance, significantly reducing the likelihood of spillover effects impacting the control group. Additionally, the use of multiple finely defined distance categories, rather than a simple binary classification of treatment and control groups, helps capture subtle variations in impact across distances and mitigates potential concerns about spatial autocorrelation.

Figure 1 illustrates the spatial distribution of the Hangzhou Asian Games Park and the selected residential communities, providing a visual representation of the study area and distance classification.

The date of the public announcement of the planning of the Hangzhou Asian Games Park coincides with the date when the organizing committee first clarified the date and events of the Asian Games. Since then, residents have become aware that professional sports facilities and stadiums would be built on the site for the Asian Games events. We consider this time point, 5 April 2019, as the date of the announcement. The second key time point is the official opening of the sports park to the public on 1 December 2021.

The total time period is represented as T, and all the data were divided into four time periods:

T_1: 1 January 2018 to 4 April 2019 (preannouncement period),

T_2: 5 April 2019 to 31 July 2020 (postannouncement period),

T_3: 1 August 2020 to 30 November 2021 (preopening period),

T_4: 1 December 2021 to 31 March 2023 (late opening period).

In addition, we define the following broader time periods for analysis:

$T_{announced}$: The period between the announcement and the opening, which includes the postannouncement period (T_2) and the preopening period (T_3).

T_{open}: The late opening period, corresponding to T_4.

T_{12}: The two consecutive periods surrounding the announcement, encompassing the preannouncement period (T_1) and the postannouncement period (T_2).

T_{34}: The two consecutive periods surrounding the opening, including the preopening period (T_3) and the late opening period (T_4).

3.3. Model specification

To answer the following questions: (1) As a large-scale comprehensive urban sports park, does the Asian Games Park have a significant external effect on housing prices? (2) If so, does spatial heterogeneity exist in this external effect? (3) How does the external effect change during different periods from the announcement of the plan to the opening of the park? First, we explore whether the Asian Games Park has external effects on housing prices using a hedonic price model as the basic model. Next, we examine whether these external effects exhibit spatial heterogeneity by using ring distance analysis. We employ a framework that combines hedonic pricing with the DID methodology to verify further whether the external effects change before and after the two critical time points of the planning announcement and the public opening. Meanwhile, using OLS regression, we introduce fixed effects for administrative regions and monthly time periods to control for potential differences in regions and time (Gonzalez & Komisarow, 2020).

First, we use the traditional hedonic price model as the baseline model. The logarithmic form of housing prices is used as the dependent variable, while the distance from the residential community to the Asian Games Park is included in a linear form. Models are constructed for the total time period T and the four specific periods T_1, T_2, T_3 and T_4. The relevant functional form is as follows:

$$\ln HP = \alpha_0 + \alpha_1 D + \Sigma\beta_i \ln X_i + \Sigma\eta_i Y_i + \lambda_i + \gamma_t + \varepsilon, \quad (1)$$

where: HP represents the housing price; D is the distance from the residential community to the Asian Games Park; X_i is the continuous control variable; Y_i is the noncontinuous control variable; λ_i represents region fixed effects; γ_t represents monthly fixed effects; $\alpha_0, \alpha_1, \beta_i$, and η_i are the coefficients to be estimated; ε is the error term.

Second, based on the distance from the residential community to the Asian Games Park, the areas are divided into eight distance segments, using 9–12 km as the control group to analyze the spatial heterogeneity of the external effects. The relevant functional form is as follows:

$$\ln HP = \alpha_0 + \alpha_j D_j + \Sigma\beta_i \ln X_i + \Sigma\eta_i Y_i + \lambda_i + \gamma_t + \varepsilon, \quad (2)$$

where D_j are dummy variables for distance segments from the residential community to the Asian Games Park.

To address potential spatial effects and reduce the risk of bias caused by treatment spillovers or spatial autocorrelation, this study incorporates administrative district fixed effects into the regression model. This approach helps control for unobserved heterogeneity across regions that may otherwise confound the results. Furthermore, rather than employing a binary classification of treatment and control groups, the study divides communities into eight distance categories. This design allows for a more nuanced analysis of the gradual changes in the impact of proximity to the park on housing prices, which significantly reduces the risk of boundary bias.

Finally, to analyze the changes in external effects before and after the critical time points of the planning announcement and the public opening, DID models were constructed for the periods T_{12}, T_{34}, and T were constructed. $T_{announced}$ includes T_2 and T_3, which represent the period after the announcement and before the opening, respectively, to verify the impact of the planning announcement on external effects. T_{open} represents the post-opening period, including T_4, which verifies the impact of the opening event on external effects. The relevant functional form is as follows:

$$\ln HP = \alpha_0 + \alpha_1 D + \alpha_m D \times T_m + \Sigma\beta_i \ln X_i + \Sigma\eta_i Y_i + \lambda_i + \gamma_t + \varepsilon. \quad (3)$$

The functional form considering distance segments is similar to the one above.

A regression-based parallel trends test was conducted to validate the model's key assumption. Interaction terms between time-period dummies and the treatment group indicator were constructed, with the quarter immediately preceding the project announcement in April 2019 (pre_1) serving as the baseline.

Figure 2 illustrates the results of the parallel trends test. Prior to April 2019, the treatment and control groups followed similar development trajectories, as indicated by the statistically insignificant coefficients of the interaction terms in the pre-treatment period. This confirms the absence of significant differences between the two groups before the project announcement.

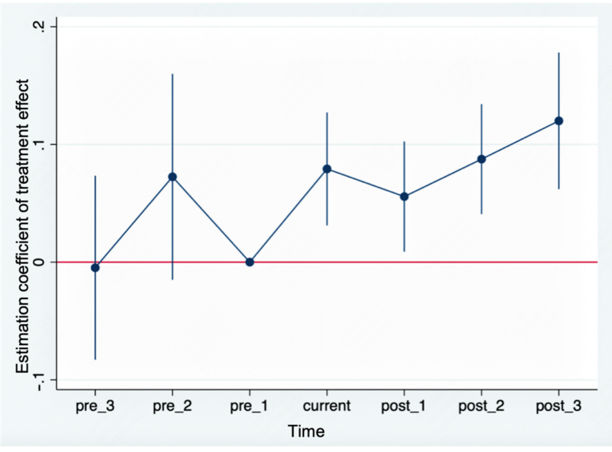

Figure 2. Parallel trend test

In contrast, during the post-treatment periods (post_1, post_2, and post_3), the interaction term coefficients become significant, with confidence intervals that do not cross zero. This demonstrates the emergence of a clear treatment effect following the project announcement. These findings confirm that the parallel trends assumption holds in the pre-treatment period, and the observed differences in the post-treatment period can be attributed to the impact of the Asian Games Park project.

4. Results and analysis

4.1. Baseline impact of sports park on housing prices

The basic model measures the overall impact of the Asian Games Park on housing prices, which is estimated using OLS regression. The results are shown in column (1) of Table 2. The adjusted R^2 is 0.770, thus indicating that the model has a good fit. The coefficient of D_{AGP} is −0.016, thereby suggesting that the park has a positive external effect on housing prices. For every 1 km increase in distance from the park, housing prices decrease by 1.6%.

In terms of architectural characteristics, floor area has a positive impact on housing prices, while newer buildings have higher prices. Variables related to transportation facilities show different results. Bus routes have a slightly negative impact on housing prices possibly because of noise and exhaust emissions. Proximity to metro stations has a positive impact on housing prices. Proximity to key primary schools, middle schools, high schools, and green spaces all have positive impacts, which is consistent with other empirical studies on Hangzhou (Du & Huang, 2018; Wen et al., 2015, 2018). For every 1% decrease in distance to a tertiary hospital, housing prices increase by 0.009%. Regarding location variables, for every 1% decrease in distance to West Lake and Qianjiang New City CBD, housing prices increase by 0.164% and 0.013%, respectively.

Four models were estimated for the time periods T_1, T_2, T_3, and T_4, with results shown in columns (2) to (5) of Table 2. The results show that the coefficient of D_{AGP} is not significant in T_1 before the planning announcement. Nevertheless, the coefficients in the subsequent three periods are −0.019, −0.017, and −0.020, respectively. These values indicate that the impact of distance to the sports park on housing prices becomes significant after the planning announcement. Overall, these coefficients suggest that for every 1 km decrease in distance to the sports park, housing prices increase by 1.9%, 1.7%, and 2.0% in the T_2, T_3, and T_4 periods, respectively.

4.2. Spatial heterogeneity of external effects

To examine the spatial heterogeneity of the impact of the sports park on housing prices, dummy variables for different distance ranges to the Asian Games Park were introduced. These ranges include 0–1 km, 1–2 km, 2–3 km, 3–4 km, 4–5 km, 5–6 km, 6–9 km, and 9–12 km, which correspond to D_1, D_2, D_3, D_4, D_5, D_6, D_7, and D_8 respectively, with D_8 serving as the reference variable.

Column (1) of Table 3 shows the overall regression results for the distance dummy variables. Most variables are statistically significant, thus indicating good explanatory power. The results show that the Asian Games Park has a premium effect on housing prices within a 5 km range. The coefficients of D_1, D_2, D_3, D_4, and D_5 are 0.349, 0.115,

Table 2. Baseline regression results

	(1) T	(2) T_1	(3) T_2	(4) T_3	(5) T_4
D_{AGP}	−0.016***	−0.003	−0.019***	−0.017***	−0.020***
ln*Area*	1.084***	1.082***	1.053***	1.054***	1.177***
ln*Age*	−0.030***	0.030***	−0.030***	−0.037***	−0.044***
Green	0.046***	0.068***	0.042***	0.034***	0.060***
Bus	−0.001***	−0.001***	−0.001***	−0.000*	0.000
Metro	0.054***	0.067***	0.055***	0.042***	0.054***
PriSch	0.009***	0.020**	0.013**	0.003	0.006
MidSch	0.009**	0.001	0.007	0.012**	0.015*
HighSch	0.045***	0.070***	0.063***	0.000	0.061***
Univ	0.002	−0.027***	−0.015**	0.021***	0.010
lnD_{Hosp}	−0.009***	−0.003	−0.009**	−0.013***	−0.006
lnD_{WL}	−0.164***	−0.132***	−0.168***	−0.178***	−0.147***
lnD_{QJ}	−0.013***	−0.029***	−0.065***	0.013**	0.000
Constant	10.562***	10.300***	10.869***	10.716***	10.087***
Month	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES
Obs.	31,329	3,768	9,572	11,054	6,935
R^2	0.770	0.785	0.791	0.769	0.759

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3. Regression results considering spatial heterogeneity

	(1) T	(2) T_1	(3) T_2	(4) T_3	(5) T_4
D_1	0.349***	0.180***	0.345***	0.368***	0.452***
D_2	0.115***	−0.003	0.154***	0.120***	0.160***
D_3	0.054***	−0.025	0.084***	0.069***	0.066***
D_4	0.047***	0.02	0.058***	0.056***	0.062***
D_5	0.028***	−0.018	0.030***	0.017	0.086***
D_6	−0.010	−0.030	0.012	−0.023**	0.022
D_7	−0.018***	0.000	−0.017	−0.008	−0.024*
Controls	YES	YES	YES	YES	YES
Constant	10.486***	10.308***	10.765***	10.641***	9.966***
Month	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES
Obs.	31,329	3,768	9,572	11,054	6,935
R^2	0.777	0.789	0.798	0.778	0.767

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

0.054, 0.047, and 0.028, respectively. These results suggest that housing prices within 1 km of the sports park are approximately 41.7% ($e^{0.349} - 1$, Halvorsen & Palmquist, 1980) higher than those in the outermost distance ring. This effect decreases with increasing distance, with housing premiums within 4–5 km being 2.8%.

Similar to Table 2, columns (2) to (5) of Table 3 correspond to the sample time ranges T_1, T_2, T_3, and T_4, respectively. In the period before the announcement (T_1), only D_1 is significant at the 1% level, whereas other distance variables for the Asian Games Park are not significant. In the period after the announcement (T_2), the coefficients of D_1 to D_5 are significant, with values of 0.345, 0.154, 0.084, 0.058, and 0.030, respectively. However, D_6 and D_7 are not statistically significant. In the period before the opening (T_3), the coefficients of D_1 to D_4 indicate that the corresponding housing price premiums are approximately 44.5%, 12.7%, 7.1%, and 5.8%, respectively. The external effect of the sports park becomes insignificant beyond 4 km. In the post-opening period (T_4), the premium effect results shown in column (5) indicate that the premium rates for D_1 and D_5 have further increased compared with other periods, with coefficients of 0.452 and 0.086, respectively.

These results preliminarily indicate that, before the planning announcement, the Asian Games Park had an external effect only on housing within a 0–1 km range. After the announcement, premium effects appeared within different distance ranges from 1–5 km, which have decreased with increasing distance, thus suggesting an anticipatory effect among homebuyers. Comparing the periods before and after the park's opening, the premium effects of close distance within 1 km and longer distance within 4–5 km have increased significantly. Overall, the results indicate that residents have an additional willingness to pay for housing within a 5 km range of the Asian Games Park, with the premium being higher with closer distance. This outcome demonstrates significant spatial heterogeneity in the external effect on housing prices.

4.3. Dynamic effects around key time periods

The estimation results of Equation (3), shown in Table 4, provide a detailed analysis of how the planning and opening of the Hangzhou Asian Games Park affected nearby housing prices. The model captures the dynamic relationship between housing prices and distance to the park (D_{AGP}) across key time periods, with a focus on the effects of the park's planning announcement and eventual opening.

Column (1) examines the entire period (T), including the pre-announcement (T_1), post-announcement ($T_{announced}$, covering T_2 and T_3), and post-opening (T_{open}, covering T_4) phases. The coefficient of D_{AGP} is −0.009, which is statistically significant at the 1% level. This indicates that, on average, housing prices decreased by 0.9% for every additional kilometer of distance from the park during the overall study period. This result highlights the significant positive externality of the park, as properties closer to it tend to have higher prices.

The interaction term $D_{AGP} * T_{announced}$, with a coefficient of −0.007, also reaches statistical significance at the 1% level. This indicates that, after the planning announcement, the effect of distance on housing prices became stronger. Specifically, for every 1 km closer to the park, housing prices increased by 1.6% (0.9% + 0.7%) during the post-announcement period. This reflects the market's anticipation of the park's future benefits, as expectations of improved amenities and public space began to be incorporated into housing prices. After the park opened, the interaction term $D_{AGP} * T_{open}$ has a coefficient of −0.009, which is also significant at the 1% level. This suggests that the opening of the park further strengthened the effect, with housing prices increasing by 1.8% (0.9% + 0.9%) for every 1 km closer to the park. These results demonstrate that the external effects of the park were significantly enhanced after the planning announcement. However, the increase in external effects after the park opened was relatively marginal (only 0.2%).

Column (2) narrows the analysis to the pre-announcement and post-announcement phases (T_{12}). The coefficient of D_{AGP} is −0.010, implying that during these two periods, housing prices decreased by 1.0% for every additional kilometer of distance from the park. The interaction term $D_{AGP} * T_{announced}$ has a coefficient of −0.005, which is significant at the 1% level. This indicates that immediately after the planning announcement, the negative effect of distance on housing prices increased by 0.5% per kilometer relative to the pre-announcement period. Although this is slightly smaller than the overall effect reported in column (1), it still demonstrates that the announcement of the park created immediate market anticipation.

Column (3) focuses on the pre-opening and post-opening phases (T_{34}), offering a comparison of housing price dynamics immediately before and after the park became operational. The coefficient of D_{AGP} is −0.018, significant at the 1% level, indicating that during these two periods, housing prices decreased by 1.8% for every additional kilometer of distance from the park. This suggests that as the park neared completion and its impact became more tangible, the spatial price premium for properties closer to the park intensified. However, the interaction term $D_{AGP} * T_{open}$ has a coefficient of −0.001 and is not statistically significant. This indicates that the opening of the park did not result in a significant additional change in the relationship between distance and housing prices compared to the pre-opening phase. The lack of significance suggests that much of the park's positive effect on housing prices had already been realized in anticipation of its completion, and the actual opening simply confirmed these expectations without further enhancing the premium.

Table 4. Results of DID model based on baseline regression

	(1) T	(2) T_{12}	(3) T_{34}
D_{AGP}	−0.009***	−0.010***	−0.018***
$D_{AGP} * T_{announced}$	−0.007***	−0.005***	
$D_{AGP} * T_{open}$	−0.009***		−0.001
Controls	YES	YES	YES
Constant	10.559***	10.707***	10.473***
Month	YES	YES	YES
Region	YES	YES	YES
Obs.	31,329	13,340	17,989
R^2	0.770	0.789	0.762

Notes: *** $p < 0.01$.

Table 5 shows how the external effects of the Asian Games Park on housing prices vary spatially and over time. By incorporating interaction terms between ring distance variables and time variables, the table illustrates the price impacts at different distances before and after the park's planning announcement and opening.

The baseline coefficients (D_1 to D_7) indicate a clear spatial gradient in housing prices, with higher premiums observed closer to the park. In column (2) of Table 5, the coefficients of the interaction terms $D_1 * T_{announced}$, $D_2 * T_{announced}$, and $D_3 * T_{announced}$ are 0.113, 0.107, and 0.057, respectively. This outcome indicates that, after the planning announcement, housing prices within 3 km of the Asian Games Park increased by 12.0%, 11.3%, and 5.9%, respectively. The coefficients of the interaction terms $D_4 * T_{announced}$ and $D_5 * T_{announced}$ are not significant, thereby suggesting no significant changes in the park's external effects within the 3–5 km ring distance before and after the planning announcement. Column (3) presents the results for the period T_{34}, which covers the time before and after the park's opening. After the opening, the external effects are only strengthened within 1 km of the park and in the outer 4–5 km ring distance, with premiums of approximately 6.7% and 2.9%, respectively, which are significant at the 5% level.

Column (1) of Table 5 uses sample data from the entire period to examine the impacts of the planning announcement and park opening on the external effects simultaneously. Using the period before the planning

Table 5. Results of DID model considering spatial heterogeneity

	(1) T	(2) T_{12}	(3) T_{34}
D_1	0.195***	0.214***	0.375***
D_2	0.021	0.030	0.124***
D_3	0.005	0.008	0.073***
D_4	0.033***	0.045***	0.061***
D_5	0.009	0.005	0.033***
D_6	−0.038**	−0.030**	−0.006
D_7	−0.006	−0.003	0.011
$D_1 * T_{announced}$	0.153***	0.113***	
$D_2 * T_{announced}$	0.104***	0.107***	
$D_3 * T_{announced}$	0.060***	0.057***	
$D_4 * T_{announced}$	0.015	−0.001	
$D_5 * T_{announced}$	0.014	0.013	
$D_6 * T_{announced}$	0.033**	0.036**	
$D_7 * T_{announced}$	−0.002	−0.019	
$D_1 * T_{open}$	0.252***		0.065**
$D_2 * T_{open}$	0.128***		0.027
$D_3 * T_{open}$	0.047***		−0.018
$D_4 * T_{open}$	0.020		−0.007
$D_5 * T_{open}$	0.047***		0.029**
$D_6 * T_{open}$	0.027		−0.005
$D_7 * T_{open}$	−0.037**		−0.059***
Controls	YES	YES	YES
Constant	10.484***	10.638***	10.377***
Month	YES	YES	YES
Region	YES	YES	YES
Obs.	31,329	13,340	17,989
R^2	0.778	0.795	0.771

Notes: ** $p < 0.05$, *** $p < 0.01$.

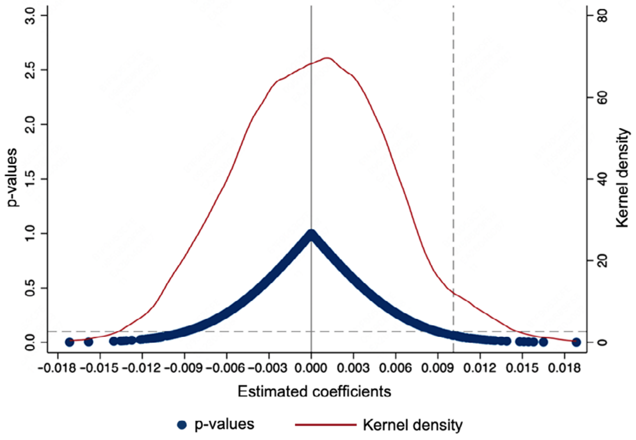

Figure 3. Kernel density distribution of placebo test results

announcement (T_1) as a comparison baseline, the park's external effects within 0–3 km significantly increased after the announcement and the opening. The coefficients of the interaction terms $D_1 * T_{announced}$, $D_2 * T_{announced}$, and $D_3 * T_{announced}$ are 0.153, 0.104, and 0.060, respectively, while the coefficients of $D_1 * T_{open}$, $D_2 * T_{open}$, and $D_3 * T_{open}$ are 0.252, 0.128, and 0.047, respectively. All these values are statistically significant at the 1% level. In addition, the announcement and opening up have also generated significant premiums for 5–6 km and 4–5 km, respectively.

These results are consistent with the previous model, thus further confirming that the planning announcement and park opening have had significant impacts on the external effects of the Asian Games Park. In terms of magnitude and impact range, the anticipatory effect of the planning announcement is evidently greater than the changes in the external effects caused by the park's opening.

To verify the robustness of the results, we conducted additional analyses. First, we performed a robustness check using log-transformed distance as an alternative specification to examine potential non-linear effects of distance on housing prices. The results of this specification are consistent with those from the main analysis, providing further support for the validity of the findings. Second, a placebo test was conducted to validate the robustness and effectiveness of the DID model in estimating the intervention effects. This test aims to confirm that the observed results are not driven by random fluctuations or omitted variables but are instead caused by the actual policy intervention. Following established methods, we randomly assigned treatment groups using computational simulation and repeated the regression analysis 1,000 times.

Figure 3 presents the results of the placebo test. The kernel density of estimated coefficients is centered around zero, and most p-values exceed 0.1, indicating that the observed effects are unlikely to result from random noise or omitted variables. Only a small proportion of p-values fall below 0.1, as highlighted by the vertical line, confirming that outliers are minimal. These results reinforce the robustness of the main findings and the validity of the causal effects identified in the study.

5. Discussion

As cities continue to invest in mega sporting events and their associated infrastructure, understanding the economic impact of such projects becomes increasingly important. The Hangzhou Asian Games Park serves as a compelling case study, demonstrating that well-planned sports parks can yield substantial gains for nearby housing markets. However, these gains vary across locations and over time, highlighting the need for strategic urban planning and investment decisions.

Previous research has documented the positive impact of urban parks on housing prices (Czembrowski & Kronenberg, 2016; Panduro et al., 2018; Piaggio, 2021). Our findings extend this understanding by showing that large urban sports parks, such as the Hangzhou Asian Games Park, also enhance housing prices. Specifically, we found that for every 1 km decrease in distance from the park, housing prices increase by 1.6%. This is consistent with studies by Feng and Humphreys (2012, 2018) and Yang et al. (2018), which reported significant positive externalities of sports spaces on nearby housing prices.

Spatial heterogeneity is another critical aspect of this study. While previous research has noted varying degrees of impact based on proximity to parks and stadiums (e.g., Tu, 2005; Iqbal & Wilhelmsson, 2018; Dell'Anna et al., 2022), our study provides a more granular analysis by introducing dummy variables for different ring distance ranges. This variation in the park's effects further highlights the importance of proximity in shaping the economic impact. Housing prices within 1 km of the park experienced the most significant increases, while the effects diminished with greater distances and became negligible beyond 5 km. This pattern suggests that the perceived value of the park's benefits, such as access to green spaces, recreational amenities, and improved air quality, is highly localized. Residents living closer to the park can enjoy these benefits more conveniently, which enhances the desirability of properties in the immediate vicinity. This spatial gradient also reflects the challenges of ensuring equitable access to urban public goods, as those living further away may not experience comparable benefits.

The DID analysis reveals that the Hangzhou Asian Games Park had a substantial and dynamic impact on housing prices over time. The planning announcement generated strong market anticipation, as evidenced by the increased impact of proximity on housing prices during the post-announcement phase. The park's opening further reinforced these effects, though the short-term dynamics around the opening phase suggest that much of the value had already been capitalized into prices prior to its completion. This phenomenon can be attributed to several factors. First, the announcement of a large-scale urban sports park often generates significant market expectations, as it signals the government's commitment to improving local infrastructure, enhancing environmental quality, and providing recreational amenities. These expectations are rapidly reflected in housing prices as buyers and investors anticipate the future benefits of living near such a park. In contrast, after the park becomes operational, the initial excitement may subside, and the actual benefits, while still significant, may not exceed the heightened expectations already priced into the market. Once completed, the realized benefits are subject to practical constraints such as accessibility, maintenance quality, and public utilization, which may temper initial enthusiasm. These findings are consistent with prior studies by Ahlfeldt and Kavetsos (2014), Yamawaki and Duarte (2014), and Hur and Kim (2023), which highlight the significant anticipatory effects of urban development projects on housing prices.

6. Conclusions and implication

Although scholars have extensively studied the external effects of urban parks and sports venues, quantitative research on large comprehensive urban sports parks remains underexplored. Hence, this study uses the Hangzhou Asian Games Park as a case study, drawing on housing market data from January 2018 to March 2023 in Hangzhou. By adopting a framework that combines hedonic pricing with the DID methodology, this study analyzes the external effects of large comprehensive urban sports parks. The study draws the following conclusions:

First, Hangzhou Asian Games Park significantly impacts housing prices, demonstrating its dual value as a professional sports venue and a multifunctional urban park. On average, housing prices increase by 1.6% for every 1 km reduction in distance to the park. This highlights how the park's ecological landscape, accessibility, and recreational facilities enhance its appeal, making nearby residential properties more desirable.

Second, the park's external effects exhibit clear spatial heterogeneity. The value-added effect is most pronounced within 1 km of the park, where housing prices rise by up to 41.8%. This effect decreases with distance and becomes insignificant beyond 5 km. This finding underscores the importance of proximity in maximizing the economic benefits of large urban sports parks.

Third, the temporal dynamics of the park's external effects are driven by key project milestones, particularly the planning announcement and the official opening. Prior to the announcement, the park's influence on housing prices was limited, with significant premiums only observed within 1 km. After the announcement, the external effects increased notably, with housing prices within a 5 km radius reflecting market anticipation of the park's future benefits. The DID model further quantifies these effects: the planning announcement increased the price semi-elasticity coefficient by 0.7%, whereas the park opening contributed an additional 0.2%. This suggests that market expectations during the planning phase have a greater impact on price premiums than the realized benefits after the park's completion.

From a policy perspective, these findings underscore several important implications for urban planning and public policy. First, the strong anticipatory effects highlight the strategic value of timely and transparent communication during the planning stages of major urban projects. Policymakers and planners can leverage announcements to build public support, stimulate economic activity, attract investments, and boost property values in targeted areas. However, they must also manage expectations carefully to ensure that the eventual delivery of the project aligns with public and market anticipation. For example, ensuring high-quality design, effective management, and accessibility of the completed park can help sustain its long-term benefits.

Second, the pronounced spatial heterogeneity of the park's effects suggests that urban planners should prioritize the location of sports parks in areas where proximity can maximize social and economic benefits. Parks should be integrated into neighborhoods with high population density to ensure that a larger number of residents can enjoy their benefits. Additionally, transport infrastructure and pedestrian accessibility should be enhanced to extend the park's reach and improve access for residents living further away.

Finally, the results provide practical insights for private investors and public-private partnerships. The strong property value increases near the park suggest opportunities for residential and mixed-use developments that integrate green spaces, recreational facilities, and modern amenities. Such developments can create vibrant urban environments that attract residents and businesses while further enhancing the economic impact of the park. Policymakers can also consider incentivizing private investment in park construction and management, thereby alleviating fiscal pressure on the government while ensuring high-quality outcomes.

Despite the significant contributions of this study, some limitations remain. For instance, this study did not account for potential long-term adjustments in housing markets beyond the observed period, which may further refine the understanding of the park's external effects. Despite measures to address spatial effects, spatial autocorrelation may still be a limitation of this study. More advanced spatial econometric techniques, such as spatial error models or spatial lag models, could be used in future research to address these dependencies. Additionally, the use of detailed geospatial data could provide further insights into the spatial dynamics of housing price changes, enhancing the precision and credibility of future findings.

Funding

This work was supported by the Major Humanities and Social Sciences Research Projects in Zhejiang higher education institutions [number 2024GH038], China Postdoctoral Science Foundation under Grant [number 2024M762785], Ministry of Science and Technology of the People's Republic of China, National Natural Science Foundation of China under Grant [number 72174178].

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