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KEEP ONE'S EYES ON THE BALL: THE IMPACT OF SPORT ARENA ON HOUSING PRICE

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Abstract

Urban planning regulates cultural and sports mega-projects in cities and requires detailed planification for their surroundings. However, regulation is not enough to mitigate negative externalities or maximize positive ones arising from these projects. Using hedonic prices approach and difference-in-difference method, I investigate the impact of net effect of externalities on housing price surrounding sport stadium following its inauguration. The estimates suggest apartment prices decreasing by 8% and 45%, depending on the econometric specification used and on distance from source of the externalities. These findings contribute to the literature on the impact of mega-projects on housing prices literature and inform discussion about urban planning and regulation.

Resumo

O planejamento urbano regula a construção de megaprojetos nas cidades e exige um planejamento específico para suas áreas ao redor. No entanto, apenas a regulação não é suficiente para mitigar as externalidades negativas ou maximizar as positivas decorrentes desses projetos. A partir da abordagem de preços hedônicos e método de diferenças em diferenças, avaliei o impacto das externalidades líquidas (positiva *menos* negativa) nos preços de imóveis ao redor de um estádio esportivo após sua inauguração. As estimativas indicam uma diminuição os preços dos apartamentos variando de 8% a 45%, dependendo das especificações econométricas utilizadas e da distância da fonte da externalidade. Este artigo contribui para a literatura sobre o impacto de megaprojetos nos preços de imóveis e para a discussão sobre planejamento e regulação urbanos.

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1. Introduction

Urbanization planning is a very complex theme and involves many issues in Economics, Urbanism, Finance, Politics etc. Many players in a municipality have different interest for land use that is subject to their utility or profit maximization functions. Urban Master Plan (PDE - *Plano de Diretor Estratégico*) and zoning rules (LPOUS – Lei de Parcelamento Uso e Ocupação do Solo) are urban instruments to regulate land use and balance several interests inside the urban area.

The zoning system of São Paulo city is complex, comprising 42 territorial divisions (36 zones and 6 public areas), 87 land use types, and various occupation and subdivision parameters. Amongst all zones, I focus on the Special Land Use Zones (ZOE – *Zonas de Ocupação Especiais*) due to its characteristics and the objective of this paper. ZOE are areas designed for activities like airports, convention centers, and large sports or recreation facilities and are outlined in an Urban Intervention Project (PIU – *Plano de Intervenção Urbana*), which must be approved by decree and must follow the rules set for each macro area in the PDE (Igliori et al, 2002).

Sports stadiums are one of prominent mega projects that often attract substantial attention in urban development discussion about cost and benefits. These large-scale structures demand services and urban infrastructure from the public sector and change the usual organization in the neighborhood.

Stadiums serve as focal points for sports events, cultural gatherings, and economic activities, contributing to the overall vibrancy and identity of a city. It also generates revenue not only from ticket sales but also from merchandise, concessions, and ancillary services like hospitality and transportation. Additionally, stadiums can attract tourists and visitors, leading to increased spending in local businesses such as restaurants, hotels, and shops. The construction and ongoing operation of stadiums also create jobs, further stimulating economic growth. These effects are more pronounced when sports stadiums also host concerts, festivals, and other cultural activities. Hereafter, I use arena and sport stadiums as synonyms.

Building entrepreneurs may undertake mixed-use projects such as hotels, retail spaces, and residential complexes nearby, leading to the transformation of formerly underutilized or blighted areas into vibrant districts. This phenomenon, known as the "stadium effect," can help rejuvenate urban cores and enhance the overall quality of life for residents.

However, the residents that lives surrounding stadiums may face negative externalities that are not internalized by residents far from stadiums. Recently, stadiums have attracted journalist, entrepreneurs, homeowners and public agents' attention due to the Draft Bill (PL 239/2018) in the city of São Paulo, the biggest city of Brazil. The Draft Bill proposed in São Paulo Chamber seeks to change noise limit from 55 to 85 decibels (between 12 am and 11 pm) until the approval of a specific PIU. Exposure to noise levels exceeding 85 decibels is considered unhealthy if it occurs for more than 8 hours daily. However, sound pollution is one of many other negative externalities faced by residents close to arenas, crowds, crime, traffic jam, trash etc. are also observed around those places. Such negative externalities are limited over space and affect differently the population of cities.

The impact of externalities on housing market close to the sport stadiums has been studied, but not focusing on cities of developing country. The relationship between proximity to sports stadiums and housing prices is a topic of considerable interest in Urban Economics and real estate studies, because it generates positive and negative externalities. Although disentangle each one of those effects is challengeable/impossible, I focus on evaluate the net effect on housing market by considering apartments sold nearby Allianz Park stadium. It is one of the most important stadiums of Brazil and is located at the most important municipality in terms of economics and population in the country.

The central question addressed in this study is: What is the premium price surrounding Allianz Park Arena after its opening? To answer this question, I investigate changes in apartments' prices before and after the stadium renovation using Difference-in-Difference approach. Positive net effects indicate that higher apartment prices near the stadium reflect a greater willingness to pay for improved amenities. Conversely, negative net effects suggest that lower transaction prices imply a reduced willingness to pay for proximity to the stadium. Estimates permit to test for positive or negative net effects of externalities.

The findings suggest evidence in favor of negative net effects. Apartments surrounding the stadium were sold by smaller price than to those sold far from. The effects ranges by -27% and – 8% depending on distance from stadium and econometric specification. My

findings have implications for policymakers and urban planners involved in mega projects development and may contribute for PIU elaboration.

The remainder of this paper is organized as follows. In Section 2, I review the related literature. In Section 3, I set out the empirical strategy. In Section 4, I present background information on the Allianz Park and descriptive statistics of the database. Section 5 provides the empirical results, and Section 6 concludes.

2. Literature review

Many academic articles have extensively discussed the multifaceted implications of megaprojects on surrounding communities. While sports stadiums bring forth a myriad of opportunities and challenges, understanding their net effect on housing prices remains a critical area of investigation in the Brazilian academic context.

The presence of sports stadiums generates a spectrum of externalities that intricately shape the socio-economic fabric of neighborhoods. On one hand, they offer positive externalities including enhanced access to entertainment, an aesthetically pleasing urban landscape, and a sense of community pride (Brueckner et al., 1999). Conversely, negative externalities such as noise and light pollutions, increased crowds, traffic congestion, and potential upticks in crime pose challenges to nearby residents (Ahlfeldt and Kavetsos, 2012).

The interplay between amenities and space significantly influences housing prices (Brueckner et al., 1999; Ahlfeldt and Kavetsos, 2012; Campos and Almeida, 2018; Campos and Chagas, 2021). Mega projects, with their amenities, play a pivotal role in altering the perceived value of residential areas. Sport stadiums may be seen as facilities provision and then as amenity, maximizing owners and renters' utility (Ahlfeldt and Kavetsos, 2012). However, it may not true if the negative externalities overcome the positive effect of sport stadium and its facilities (Johnson, 2011; Hyun, 2021). In this scenario, sport arenas are seen as disamenities by the residents surround this building.

Net positive externality (*positive minus negative externalities*) on property prices or mortgage have been documented according to several studies focused on impact evaluation (Tu, 2005; Dehring et al., 2007; Feng and Humphreys, 2012, 2018; Kavetsos, 2012; Ahlfeldt and Kavetsos, 2014; Huang and Humphreys, 2014). Recent findings

suggest that the net effect of externalities generated by sports stadiums may also be negative (Humphreys and Nowak, 2017; Hyun, 2021).

Understanding the net benefits derived from mega projects construction, often termed as land use externalities, is crucial in assessing their impact on urban economics, especially housing prices (Dehring et al., 2007). Empirical studies provide valuable insights into this phenomenon. For instance, Tu (2005) observed a decrease in housing prices following the opening of the FedEX Field in Maryland, USA, while Dehring et al. (2007) noted a price appreciation of +2.1% in Dallas upon the announcement of a new stadium for the NFL team, the Dallas Cowboys.

Furthermore, the hosting of major events such as the Olympics also influences housing prices. Kavetsos (2012) found a price appreciation of +3.3% in the host neighborhood and +5.2% in adjacent areas following the 2012 Olympics in London. Feng and Humphreys (2012) estimated the effect of various sports facilities in different sports arenas (NFL, NBA, MLB and NHL) in the USA, revealing a significant increase in housing prices with proximity to such amenities. Each additional mile closer to a sports facility increases the house price by $793. Ahlfeldt and Kavetsos (2014) assessed the impact of the New Wembley and Emirates Stadiums in London, finding a price appreciation of 17%. Huang and Humphreys (2014) analyzed 56 professional sports facilities opened between 1995 and 2008, reporting a price increase of 9.94% within 3 miles and 7.42% within 2 miles.

However, to my knowledge, few researchers have found negative effects when assessing sport arenas in the US and in South Korea. Humphreys and Nowak (2017) studied the impact of the NBA's departure from arenas in Seattle and Charlotte, observing a price increase of up to 20.3% within a 1-mile radius and 9.5% within a 2-mile radius surround the arena. Hyun (2021) examined the effect of a sport stadium impact on housing prices in Gwangju Metropolitan City, South Korea, and found a price decrease of up to 7%.

The specialized literature has found negative and positive impacts, ranging by +2.1 and +17% and -20.3% and -7%, respectively. This diffuse finding is remarkably interesting because it brings to the debate several factors such as the role of urban fabric, the effectiveness of institutions in enforcing laws, the household utilities, and the characteristics of properties in different cities worldwide. Therefore, the effects derived

by mega projects (sport arena, for example) must be evaluated considering neighborhood specificities and households preferences.

3. Allianz Park Arena Background

Allianz Park Arena is located in São Paulo city, Brazil, and emerges as a significant transformation from its predecessor, the Palestra Italia Stadium, which was established on May 5th, 1902. Initially boasting a capacity of 28,000 attendees, the stadium underwent expansion in 1976, increasing its capacity to accommodate 32,000 people. Recognizing the need for modernization and expansion to meet contemporary demands, the project for the construction of Allianz Park Arena was approved on June 30th, 2008. This marked a pivotal moment in the evolution of the stadium's infrastructure, signaling a departure from its traditional roots towards a state-of-the-art facility.

Following extensive development efforts, the final match at the Palestra Italia Stadium was held on July 19th, 2010, paving the way for the grand opening of Allianz Park on November 19th, 2014. With a total capacity of 44,000 for soccer matches and 55,000 for concerts and shows, Allianz Park stands as a testament to modernity and innovation in the realm of sports and entertainment venues, ushering in a new era of spectator experiences in the municipality of São Paulo.

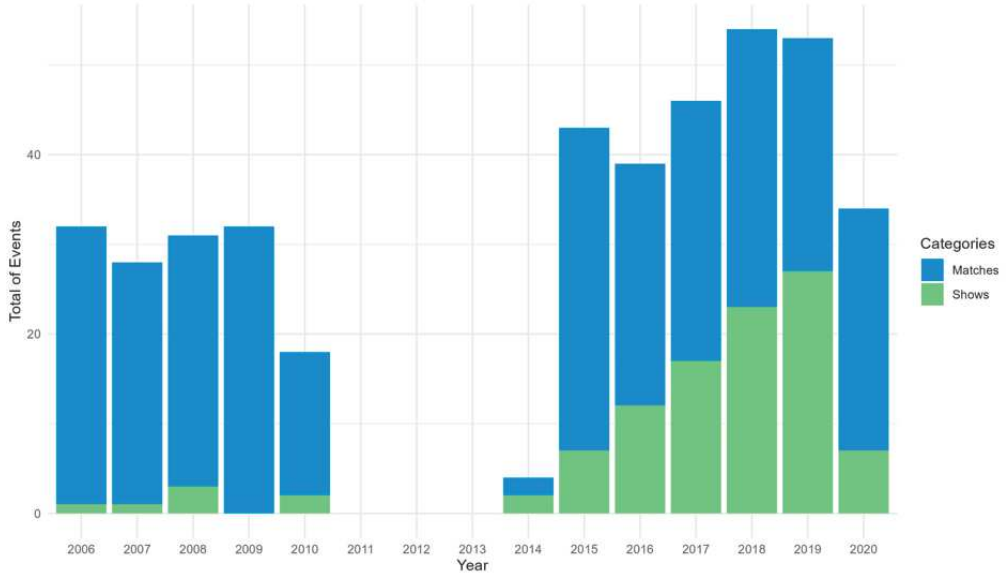
Figure 1: From Palestra Italia Stadium to Allianz Park Arena

Source: elaborated by author.

The utilization of Allianz Park Arena has seen a notable shift over time, as outlined previously. Particularly significant is the decrease in the proportion of soccer matches

held at the venue. Prior to renovations, soccer matches dominated the schedule, constituting nearly 100% of the total events. However, following the reform, there has been a remarkable increase in the hosting of shows and concerts, resulting in a significant decline in the share of soccer matches.

Figure 2: Matches and shows over year



Source: elaborated by author.

Allianz Park is not only host major sporting events but also function as multipurpose spaces for concerts, festivals, and corporate gatherings. The strategic location of this sports stadium within ZOE reflects careful urban planning considerations, seeking to harness the potential of these iconic structures to foster inclusive growth and enhance the city's overall livability, which demand suitable urban infrastructure around the stadium. However, residents close to this mega project may not evaluate stadiums in the same way of those living far from it.

One of the primary grievances voiced by residents pertains to the noise pollution generated during shows that disrupts the peace and tranquility of the surrounding neighborhoods and affect the quality of life for residents. The flow of visitors and vehicles on event days exacerbates traffic congestion, leading to delays and inconvenience for commuters. Additionally, large-scale shows require almost two or three days of preparation beforehand to set up all the necessary structures for the presentation, followed by additional time for dismantling afterward. This implies that logistical challenges begin days before the shows and persist for a couple of days after.

The stadium operator WTorre recently received a notification for the third time, for violating the permitted noise limit in the region. To prevent the stadium's closure, in May 2022, the Draft Bill (PL 239/2018) was reintroduced in the City Chamber of São Paulo with the proposal to increase in the acceptable noise threshold from 55 to 85 decibels in the ZOE. This legislative proposal has sparked debate regarding the externalities associated with stadium activities, bringing attention to the balance between economic development and community well-being. Additionally, WTorre installed acoustic windows in some apartments surrounding the stadium with the aim of mitigating the noise impact. However, it is a palliative measure since such a solution have deprived of external air and impose additional cost for air conditioner using for the household, for example.

These issues highlight the complexities of managing urban development and quality of life within ZOE. The impact of mega project in cities must be analyzed by evaluating how the positive and negative effects affect household well-being and wealth, such as properties prices surround the stadiums.

4. Empirical Strategy and Database

4.1. Empirical Strategy

To comprehensively examine the impact of sports stadiums on housing prices, I employ a two-fold empirical strategy. Firstly, the Hedonic Price Approach (HPA) is widely used to estimate implicit prices (Lancaster, 1966; Rosen, 1973; and Ekeland, Heckman, and Nesheim, 2002, 2005), including housing proximity to amenities like sports stadiums (Tu, 2005; Ahlfeldt and Kavetsos, 2012, 2014; Feng and Humphreys, 2018; Hyun, 2021). This approach involves regressing housing prices on a set of property characteristics, including distance to the stadium, neighborhood amenities, structural features, and other relevant factors.

By employing the HPA, I consider difference-in-difference (DiD) quasi experimental approach to reduce the risk of attributing impact evaluation due to omitted variable (Galster, Tatian, and Smith, 1999; Ellen et al. 2001; Galster, Tatian, and Petiti, 2004). This empirical strategy tracks price transactions of apartments (units) both before and after a treatment. DiD methodology leverages temporal and spatial variation in treatment group to estimate causal effects (Ahlfeldt and Kavetsos, 2014; Pope and Pope, 2015; Hyun, 2021).

Let D_i be an indicator equal to one if unit i is treated and treatment status is defined as $D_{it} = D_i * \mathbf{1}_{t=1}$, where $t \in \{0,1\}$ for simplicity. Following Vazquez-Bare (2022) and Butts (2023), $Y_{it}(D_i, h_i(\vec{D}))$ is potential outcome having unit i's own treatment-status D_i and exposure mapping $h_i(\vec{D})$ as arguments. $h_i(\vec{D})$ is a vector of treatment assignments where $\vec{D} \in \{0,1\}^n$ represents the n-dimensional vector of all units' treatments and identifies spillover effects.

In the absence of exposure mapping $h_i(\vec{D}) = \vec{0}$, the change in potential outcomes (τ_i) from period 0 to 1 is similar to the classic DiD $\tau_i = Y_{i1}(1) - Y_{i0}(0)$ if holds classic parallel counterfactual trends under stable-unit treatment value assumption (SUTVA) (Butts, 2023; Wooldridge, 2010). However, research using hedonic prices applied to housing market points to spatial spillover effects of externalities (Bourassa, Cantoni and Hoesli, 2010; Campos and Almeida, 2018; Campos and Chagas, 2021). It means units experience spillover effects as treated and as control. Then, exposure mapping is a valid argument and classic DiD is biased. Then, the impact in the presence of exposure mapping the switching effect is like $\tau_{i,\text{switching}} = Y_{i1}(1, \vec{h}) - Y_{i0}(0, \vec{h})$.

According to Butts (2023), switching effect may be decomposed as following identity

$$\overbrace{Y_{i1}\left(1, h_i(\vec{D})\right) - Y_{i0}(0, h_i(\vec{D}))}^{switching\ effect} = \underbrace{Y_{i1}(1,0) - Y_{i0}(0,0)}_{Direct\ Effect} + \underbrace{Y_{i1}\left(1, h_i(\vec{D})\right) - Y_{i0}(1,0)}_{Spillover\ on\ Treated} - \underbrace{Y_{i1}\left(0, h_i(\vec{D})\right) - Y_{i0}(0,0)}_{Spillover\ on\ Control} \quad (1)$$

From Equation (1), switching effect is decomposed into *total effect* on treated (direct effect plus spillover on treated) and spillover on control. It imposes some challenges to identify each component of (1).

The assumption that spillovers are local is necessary for *total effect* identification. This hypothesis is well stablished in spatial econometrics, necessary to hold function convergence (Arbia, 2006; Anselin, 2006) and means there exist a distance cutoff (d_c) separating exposed and nonexposed units. In practice, identifying treatment and control groups depended on total of units exposed (Ahlfedt and Kavetsos, 2014) and distance d_c knowledge.

Consider sport stadium is located at $\theta\ (x, y)$, where x and y are longitude and latitude, respectively, I initially created rings (r) with distance d from $\theta(.)$ (**Figure 3**) where apartments unit i are located at $\theta_i(x_i, y_i)$ and nested within rings with distance $d_i \leq d$. Under assumption of cutoff knowledge, treatment group is located between $0 < d_i < d_c$ (inner ring) and control group is at $d_c < d_i < d$ (outer ring). In outer ring, units are no longer exposed to spillovers after d_c.

If spillovers are local, then units located after d_c are no longer exposed to spillover. Therefore, switching effect is decomposed into direct effect and spillover on treated. The spillover identification depends on parallel trends assumption that the untreated units in each ring are on the same trend as the untreated units in outer ring. Regarding to stadium spillover, the empirical studies show that this effect extends up to 2 and 5 km from the stadium location and to spillover identification uses to slice treatment group by using ranges between 0.5 and 1 km (Ahlfedt and Maenning, 2009; Coates and Humphreys, 2006; Kavetsos, 2012; Tu, 2005; Ahlfedt and Kavetsos, 2014; Hyun, 2021).

To identify the total effect, we need to use control units that are not affected by spillover effects to determine the counterfactual trend for treatment (total effect) and spillover on treatment (spillover effect). Since we are looking at subgroups of these control units, each subgroup must follow a parallel trend (Butts, 2023). Shortly, the rings closer to Allianz Park (inner rings) are designated as the treatment and exposure groups, as these properties are expected to be directly impacted by their proximity to the new sports arena. Conversely, the area farther from the stadium (outer ring) serve as the control group, representing properties that are less likely to be influenced by the stadium's presence.

The DiD econometric specification takes the form of

$$ln(P_{it}) = \beta Z_i + \tau D_{it} + \rho Ring_{ij} + \gamma_j \sum_{j=1}^{n} D_{it} Ring_{ij} + \mu_N + \mu_Q + \mu_Y + \epsilon_{it} \quad (2)$$

Where, P_{it} is a vector of apartment's price per square meter in period *t* for unit i; Z_i is a matrix of apartment's intrinsic and extrinsic characteristics; $Ring_{ij}$ is an indicator for unit i within ring j; μ_N , μ_Q, μ_Y are neighborhood, quarter period and year fixed effects. β, τ, ρ, and γ_j are coefficients associated with its respective variables and ϵ is the error term. For $j = 1$ is associated with treatment group and $j > 1$ is associated with exposure mapping group.

Since I do not know the effective cutoff distance, defining the appropriate control group also poses a significant challenge. Then, I use a rolling control group strategy to test various control groups by setting different d_c ranges (Tu, 2005; Casey et al., 2018; Di Tella and Schargrodsky, 2004; Alexander et al., 2019). The control group is defined as fallowing two steps. First, the outermost ring for a given rings set is candidate to control group. In other words, for a set of 2 rings, the second one serves as the control group; for a set of 3 rings, the third one is the control group, while the first one is considered the treatment group, the second one is the exposure group and so forth. If the changing of control group to treatment group does not result in statistically significant differences, it means spillover effect necessarily decay over distance and potentially exists d_c such that the net effect externality is limited (local spillovers) and apartments located at distance $d_i > d_c$ are never treated and not affected by spillover effect (control group spillover free).

For parallel trends hypothesis test I run data-driven strategy. I test run conditional and unconditional event studies, as shown in Equation 3

$$ln(P_{it}) = \beta Z_i + \rho Ring_{ij} + \pi_j \sum_{j=1}^{n} \mu_Q Ring_{ij} + \mu_N + \mu_Q + \mu_Y + \epsilon_{it} \qquad (3)$$

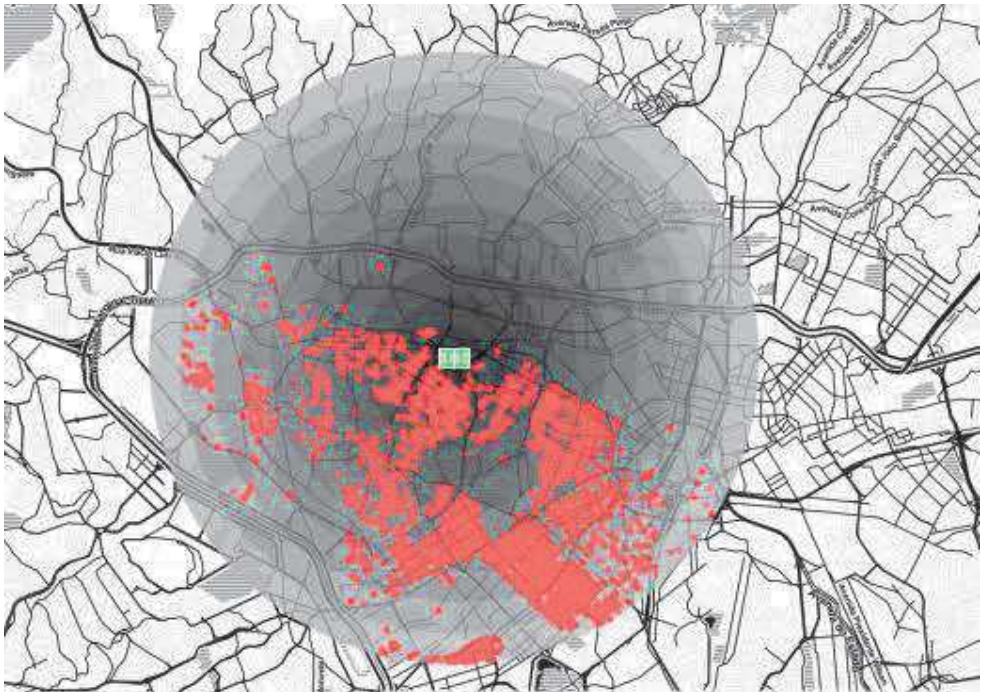
For $\mu_Q Ring_{ij} = 1$ it identifies apartments sold within treated and/or exposure rings compared to those located in outer ring. The vector of estimate coefficient π captures the average price/m² over the quarter-year for each ring. Equation 3 represents conditional econometric model. For the unconditional model, $\beta = \mu_N = \mu_Y = 0$.

Therefore, if econometric tests confirm that the rolling control group strategy and parallel trends hypothesis hold, then this ring will be used as the control group in the two-way fixed effects estimator for equations (2) and (3).

4.2. Database

I rely on a comprehensive dataset sourced from the notaries of São Paulo, spanning from January 2006 to December 2017. This dataset includes detailed information on various housing attributes, such as the number of bedrooms, private area, building age, and address of residential flats. Additionally, the dataset allows for the calculation of latitude and longitude coordinates, facilitating spatial analysis and mapping. **Figure 1** presents the spatial location of each building surrounding the stadium.

Figure 3: Buildings Location around Allianz Park



Source: elaborated by author based on Notaries database.

Given the potential impact of stadiums affect surrounding areas, this study focuses on residential apartments located within up to 6 kilometers from Allianz Park, as suggested by Tu (2005). This scope enables to capture the full extent of the stadium's influence on housing market dynamics in the vicinity.

To enrich the dataset and provide a comprehensive analysis, I calculate additional spatial variables, including the distance to key urban features such as the historic center of São Paulo city (Central Business District - CBD), Subcenter Business District (SBD), subway and train stations, favelas, and green places (public parks). By incorporating these variables, the econometric model control for intrinsic and urban amenities that influences housing prices and may confound the main result.

Table 1 presents the descriptive statistics. Price per square meter (Price/m²) in 2022 constant prices emerges as a crucial metric, with a mean value of R$10,878 and a standard deviation of R$4,606. The range of prices is notable, with the minimum observed price per square meter being R$1,419 and the maximum reaching R$33,222. The mean private area is calculated at 105.3 square meters, with a standard deviation of 65.18 square meters. The number of bedrooms per property exhibits a mean value of 2.44. On average, properties feature 1.6 parking spots, with a standard deviation of 0.92. Additionally, the

dataset provides insights into the age of buildings, with a mean building age of 21 years and a standard deviation of 17.5 years. The range of building ages is extensive, spanning from newly constructed properties to those with a maximum age of 74 years.

Table 1: Descriptive Statistics

Variable	Mean	Std Dev.	Min	Max
Price/m^2 *	6711,03	3046,44	730,85	24128,69
Price/m^2 (2022 price) *	10878,91	4606,5	1419,09	33222,33
Area	105,30	65,18	26,00	404,44
#bedrooms	2,44	0,94	1,00	5,00
#parking spots	1,60	0,92	0,00	9,00
Building age	21,26	17,51	0,00	74,00
Alianz Park distance**	3,58	1,45	0,15	6,00
CBD distance**	5,05	2,19	0,26	10,86
SBD distance**	2,38	1,59	0,21	7,22
Subway station distance**	0,24	1,14	0,03	5,19
Train station distance**	2,21	1,10	0,16	4,5
Favela distance**	2,02	0,76	0,013	3,54
Parks distance**	1,03	0,50	0,02	2,88

Source: elaborated by the author based on notaries database and using Geosampa vectorial maps. Note: * in Brazilian currency; ** measured in kilometers.

The mean distance from buildings to Allianz Parkis calculated at 3.5 kilometers, with a standard deviation of 1.45 kilometers. The mean distances to other key locations include 5 km to the historic center (Central Business District - CBD), 1.24 km to the nearest subway station, 2.21 km to the nearest train station, 2.02 km to the nearest favela, and 1.03 km to the nearest park.

5. Main Results

The control group is an issue in many impacts' evaluation analysis. Since the net externalities spillovers onto nearby areas and the selecting maximum distance too large increase the variance and make incomparable control group in terms of observed characteristics, the choice of the distance bin depend on economic context, the source of the spillover and/or data-driven strategy (Butts, 2021b; Tu, 2005).

The empirical literature on sports externalities points out that stadium effect may spillovers 5 km distance from its location (Tu, 2005). However, I test rings with 1 km distance bins into the econometric specification in Equation 2, applying the labelled rolling control group strategy . Later, I relax the distance bin and test narrower rings for the treatment group.

Since treatment effects decay over distance, then there exists d_c that control group is spillover free if the additional ring is statistically insignificant. In other words, the outer ring is like a spatial barrier for the externality spillover. In **Table 2**, the rolling control group strategy shows that incorporating the control group as a treatment group increases the absolute magnitude of the estimated effect in comparison to the previous regression, and the last ring exhibits statistical significance. However, such a statistical significance is not observed when the control group ring ranges between 5-6 km from the stadium, which supports the findings in the empirical literature.

Table2: Selecting Control Group

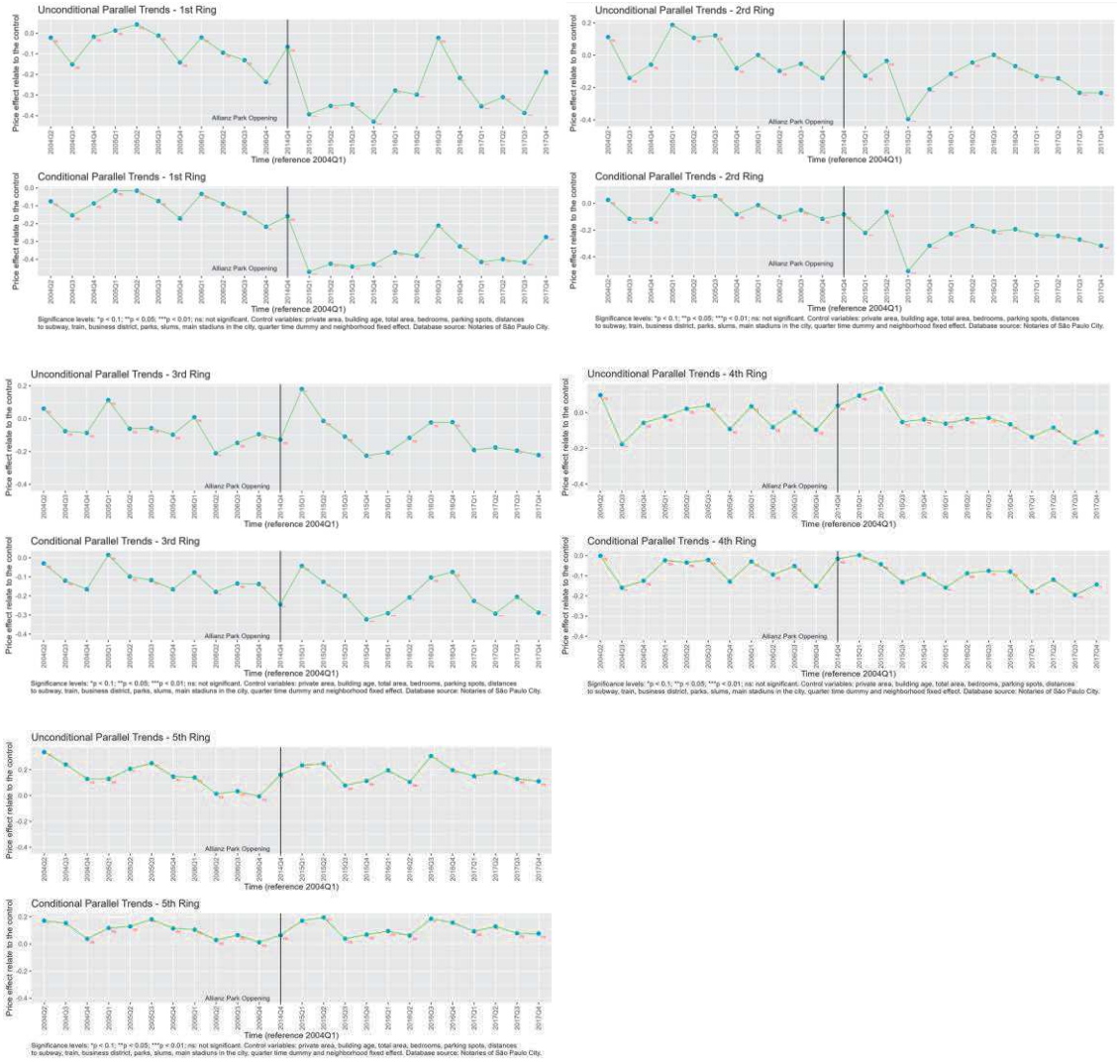
Control Group Distance bin	1st Ring	2nd Ring	3rd Ring	4th Ring	5th Ring	Obs.	R2 Adjusted
1-2 km	-0,071***					4.009	0,532
2-3 km	-0,214***	-0,139***				6.325	0,570
3-4 km	-0,233***	-0,171***	-0,048**			10.746	0,597
4-5 km	-0,332***	-0,270***	-0,146***	-0,080***		14.106	0,590
5-6 km	-0,279***	-0,214***	-0,09***	-0,029	0,020	17.459	0,575

Source: elaborated by the author using Notary database. Significance levels: *10%, **5%, and ***1%. Note: Control variables: private area, building age, total area, bedrooms, parking spots, distances to subway, train, business district, parks, slums, main stadiums in the city, time and neighborhoods fixed effect.

In the next step, I test the parallel hypothesis. **Figure 2** shows event studies under conditional and unconditional parallel trends for each ring and 5-6 km distance bin as control group. The vertical axis corresponds to the π coefficient in Equation 3, capturing the interaction between distance and quarterly time dummies. I plot the apartment prices/m² effects associated with the distance to the arena over the study period.

The parallel trends assumption holds after controlling for covariates for the first three rings (treatment control) since the coefficients for those set of rings are generally statistically significant after Allianz Park opening. However, considering the last two rings the estimates are relatively insignificant, providing not strong evidence for parallel trends assumption. The conditional parallel trends for 4th and 5th rings present statistically significant coefficients for six and five of thirteen estimates at least level 10%, respectively.

Figure 2: Event Study



Source: elaborated by the author.

Taking 1st ring as an example, before the opening of Allianz Park, the price/m² elasticity ranged between 0% and -20. During the period following the opening, the elasticity sharply decreased in the initial quarters, rebounded in the third quarter of 2016, and then decreased again, though not at the same rate as in the initial quarters. For the 2nd ring, the estimated elasticity before the opening ranged between 10% and -10%, but these estimates were not statistically significant. The price effects took relatively more time compared to the 1st ring. The elasticity sharply dropped in the third quarter of 2015, recovered in the subsequent quarter, and then began a downward trend again from the fourth quarter of 2016 onward.

While coefficients estimate before the opening are statistically insignificant, after the Allianz Park opening the estimates are statistically significant, suggesting parallel trends

holds for the three first rings. The last two rings present weak evidence in favor of parallel trends assumption, as showed in Figure 2.

Apartments near Allianz Park experienced a decrease in value compared to the control group. The impact of this depreciation spread over time and varied in different ways. In the immediate quarters following the park's opening, the closest areas experienced noticeable effects, while the more distant areas showed significant impacts only in the later quarters over the rings (**Figure 2**).

Table 3 presents the base-line econometrics specification considering sixth ring (5-6 km distance from the stadium) as control group. Rings up to 5 km distance are taken as treatment/exposed group and added stepwisely. Estimate coefficients suggest a negative net effect on apartment price. The magnitude of impact depends on the level of exposure to net externalities, flats' prices/m² within first ring faces higher negative effect and decay over space with distance increasing.

Table 3: Impact of Allianz Park on flats' price/m²

	(1)	(2)	(3)	(4)	(5)
Treatment 1 x After	-0.260***	0.259***	0.268***	0.266***	0.277***
Treatment 2 x After		0.193***	0.200***	0.204***	0.215***
Treatment 3 x After			0.057**	0.079***	0.088***
Treatment 4 x After				0.038*	0.030
Treatment 5 x After					0.016
Control Variables	Yes	Yes	Yes	Yes	Yes
Observations	4,681	7,273	9,544	13,910	17,199
Adjusted R^2	0.523	0.542	0.558	0.581	0.578

Source: elaborated by the author using Notary database. Significance levels: *10%, **5%, and ***1%. Note: Control variables: private area, building age, total area, bedrooms, parking spots, distances to subway, train, business district, parks, slums, main stadiums in the city, time and neighborhoods fixed effect.

Considering estimates from column 5, the impact on flats' prices located at the first ring is 27,7% lower than those sold in sixth ring (control group). The impact reduces by 6-point percent (p.p.) within the second ring and then reduces by 12 p.p. within the ring 3. The next two rings are not statistically significant. The findings suggest the negative net effect sprawls over the space but in not a linear way, i.e., negative externalities (e.g. light pollution, noise, traffic congestion, and bad smelling) overcome the positive externalities (e.g. access to entertainment, aesthetic urban landscape, pride to the community etc.) derived from stadium.

The estimate provide evidence the global effect by using just one ring from 0-5 km distance does not characterize nonlinearity and overestimates the net effect for treated group located far from stadium while closer rings would be underestimated. The effect is locally heterogeneous, justifying why slicing the treated groups into many rings improve the findings.

Besides the challenge of identifying the extent of treatment effects, the distance bins length may affect the findings. Then, I also test for narrower rings for treated groups while the control group remains the same. By narrowing the ring size, the treated group now consists of transactions closer to the stadium and then the inner rings exposition to the source of externalities are stronger than before.

Considering first ring results, the magnitude of the estimated effect is greater, in absolute terms, within the 0.5 km radius (flats' price fell by -45,3%) compared to the 0.9 km radius (flats' price fell by -32,3%). For the other ring areas, the effect diminishes as the distance from the source of the externality increases, as stated by the first Tobler law. Furthermore, the prices change is larger amongst the smaller distance bin compared to the larger one.

Table 4: Robustness Tests for Treated Group

Treatment Group distance bin	1st Ring	2nd Ring	3rd Ring	4th Ring	5th Ring	Obs.	R2 Adjusted
0,5 Km	-0,453***	-0,172***	-0,138***	-0,058***	0,086*	6.245	0,576
0,6 Km	-0,362***	-0,146***	-0,13***	0,045	-0,017	8.546	0,588
0,7 Km	-0,316***	-0,234***	-0,133***	-0,061***	-0,071***	11.516	0,594
0,8 Km	-0,358***	-0,296***	-0,157***	-0,144***	-0,076***	13.332	0,596
0,9 Km	-0,323***	-0,252***	-0,072***	-0,133***	-0,007	14.412	0,583

Source: elaborated by the author using Notary database. Significance levels: *10%, **5%, and ***1%. Note: Control variables: private area, building age, total area, bedrooms, parking spots, distances to subway, train, business district, parks, slums, main stadiums in the city, time and neighborhoods fixed effect.

To evaluate anticipation effects, I use two different econometric specification. The first one compares transaction prices two years before and after last match in Palestra Italia stadium (July 2010). The second one evaluates apartments sold two years before and after project approval (June 2008). Both specifications provide evidence on anticipation effects on prices of apartments. I also stress control rings size aiming to highlight how the donuts size affect the findings.

I considered transactions of apartments during the construction phase (from the final match at Palestra Italia to the opening of Allianz Park – July 2010 to December 2014) and

compare it with transactions occurring after the opening, up to December 2012. Such evaluation seeks to shed light on housing market anticipation behavior. Since net effect externalities is worse after Allianz Park opening, the estimate result must be negative and statistically significant.

The findings presented in **Table 5** do not provide evidence supporting the anticipation of externalities during construction phase (development) but not during announcement period (anticipation). The estimate effect for the four first rings have negative signals and are statistically significant in column (1). During the announcement period, the apartment sold within treatment rings are sold at a discount (1^{st} – 4^{th} rings) in comparison to those in the control ring, but estimates are statistically significant for 3^{rd} ring only. Considering 5^{th} ring, estimate suggests that there was price appreciation. However, results in Table 3 indicate that this expectation did not materialize. Based on these findings, it can be concluded that the stadium effect observed in this study is more likely attributable to the development effect (construction phase) rather than the anticipation effect (announcement phase).

Table 5: Development Vs Anticipation Assessment

	Construction Phase[1] (1)	Annoucement Phase[2] (2)
Treatment 1 x After	-0.205***	-0.018
Treatment 2 x After	-0.148***	-0.010
Treatment 3 x After	0.095***	-0.072***
Treatment 4 x After	0.058***	-0.019
Treatment 5 x After	0.0004	0.044**
Control Variables	Yes	Yes
Observations	26,999	13,524
Adjusted R^2	0.43	0.36

Source: elaborated by the author using Notary database. Significance levels: *10%, **5%, and ***1%. Control variables: private area, building age, total area, bedrooms, parking spots, distances to subway, train, business district, parks, slums, main stadiums in the city, time and neighborhoods fixed effect. Note: [1] Two years before and after last match in Palestra Italia stadium (July 2010). [2] two years before and after project approval (June 2008).

6. Final remarks

Mega projects located in city involves numerous issues related to institutions and the housing market, as discussed here. The empirical literature has shown different effects on housing prices, since positive and negative externalities may overcome to each other and unevenly sprawl over the urban space. The effects on housing prices depend on how close

houses and apartments are from the mega project and how neighborhoods perceive the externalities.

I assess the impact of prices of apartment surrounding the stadium before and after renovation construction and seats expansion. The findings presented negative net effect of externalities. Homeowners have experienced a decrease in transaction prices fallowing the opening of Allianz Park compared to transaction prices before the renovation. The estimate effects are not linear, which means that resident closer to the stadium face greater negative externalities when compared to those living more than one kilometer away.

Although ZOE and Psiu Law regulate mega-project constructions, it is not working well in Allianz Park neighborhood. Addressing negative externalities associated with Allianz Park requires a multifaceted public policy approach, such as enhanced zoning regulations, noise and environmental controls, compensation and enforcement.

Policymakers should regulate the development of transition area (around mega-projects like stadiums or arenas) or zones (like ZOE) by creating green spaces or commercial zones. Additionally, regulations should mandate noise barriers for these large structures, for example. Furthermore, local justice and political leaders may strengthen enforcement mechanisms to ensure that stadium operators comply with noise regulations.

It is important to say the magnitude of impact and its spillover effects depend on nature of externalities. Therefore, policymakers should evaluate different land use and its externalities and spillover effects before public policy proposes, focusing on mitigate negative externalities and foster positive one. Having it on the top of mind, many other research may be driven focusing on different mega-projects, such as public transportation, clubs, churches etc.

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