Public Space and Value of Real Estate: An Analysis of the Case of the Dona Lindu Park in the City of Recife, Brazil

Área de Interesse: Área 2– Economia Pernambucana

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Resumo

Em 2011 foi inaugurado o parque Dona Lindu no bairro de Boa Viagem em Recife. O presente artigo investiga o impacto no preço dos imóveis na região no entorno do parque. Para isso, foi utilizado o método de preços hedônicos com a estratégia de identificação via diferenças-em-diferenças e encontramos um valor aproximado de 7.7% de valorização dos imóveis em um raio de 600 metros do D. Lindu e na região entre 600 e 1000 metros houve um impacto negativo no preço dos imóveis de 11.9%.

Palavra-Chaves: Dona Lindu, Métodos Hedônicos, Diferenças-em-Diferenças, Economia Urbana, Áreas Verdes, Parques Públicos e Valoração dos Imóveis.

Abstract

In 2011 the Park Dona Lindu Park was opened in Boa Viagem neighborhood at Recife. This article investigates the impact on real estate price in the region around the Park. For this, we used the hedonic price method with the identification strategy via differences-in-differences and find an approximate value of 7.7% appreciation of the properties within a radius of 600 meters of D. Lindu and in the region between 600 and 1000 meters away from the Park there was a negative impact on the real estate prices of 11.9%.

Palavra-Chaves: Dona Lindu, Hedonic Metod, Differences-in-Differences, Urban Economics, Green Areas, Public Parks e Valoration of Real Estate.

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1. Introduction

Green areas such as squares, parklands, bodies of water and a pleasant environment provide amenities and services that fundamentally contribute to the quality of life in cities (Van Herzele and Wiedemann, 2003). However, it is difficult to measure the value of nature and the benefits these amenities bring to the urban environment and the impact that these benefits have on the value of the property prices due to a lack of market for them (Freeman III, Herriges and Kling, 2014).

Recently an increased concern has risen regarding the urban green space and environmental quality due to the rapid urbanization and the spread of the cities (Jim and Chen, 2006a). Green areas, sited near residential urban areas in the developing world cities are closely related to the amenities and the health of residents. There are constant concerns about the vulnerability to damage and the improper utilization of these areas, as shown by Jim and Chen (2006b).

In fact, urban green spaces have several functions in cities and may include provision of leisure and amusement opportunity to the local population. Thus, such spaces have value to society that is difficult to measure, given the absence of market to set the price of these amenities. And, as a consequence, they are generally ignored or underestimated by urban planners, which results in the diminishing of the green places in cities and these remaining areas are being gradually overrun by the urban sprawl. So from that perspective, the impact of parks and green areas has been understudied in the Brazilian cities.

Vacant lots are problems in many cities and are not exclusivity to Recife or Brazil. Thus, some cities have recently begun to explore these areas to reverse them into green fields as a management strategy to reduce the negative influence of the vacant space. This is important, as waste land, usually, does not bring positive amenities and it decreases the potential provision of real estate in the region, in addition, there exists a market to negotiate these lands (Freeman III, Herriges and Kling, 2014). In contrast, green spaces and parks generate positive amenities on the properties in the its surrounding range to incorporate the amenities offered by this area, nevertheless, there is no market to measure the value of this space in the city (Freeman III, Herriges and Kling, 2014). Given this difficulty in the measurement, this article proposes to quantity the impact of Dona Lindu Park, until then a vacant area turned into a park, in the value of real estate in the district of Boa Viagem, Recife, Brazil. That is mainly due to the potential outcome of this new green area and its positive or negative amenities in the value of properties in the region.

Recife is one of the most important Brazilian cities, with an estimated population of 1,608 million people, with an area of 218,435 km² and the headquarters of the largest metropolitan region in the Northeast of Brazil (IBGE, 2014). Recife is a metropolis with a very uneven spatial distribution; the richest group of the city lives in the best locations of the municipality, that is, the wealthy people reside in locations with adequate urban infrastructure and closer to the local amenities offered in the city: parks, squares, beaches and the Rio Capibaribe (Seabra, Silveira Neto and Menezes, 2015). The district of Boa Viagem is a very good example of this reality, their inhabitants live in buildings equipped with security services, to protect them from the city violence, near shopping malls and they have access to a high standard of services (de Oliveira and Silveira Neto, 2016).

A mapping done in 2012 by Oliveira et al. (2012) shows that green spaces exist in the metropolis, though it is extremely uneven in distribution. The survey is scoured with aerial images, including all 94 districts of the city. Situated in the North Zone, the Guabiraba district appears as the greatest lung of the city, with almost 75% of all its area covered by trees (Oliveira et al., 2012). It is the greatest and the most wooded district of the metropolis. On the opposite ranking, Brasilia Teimosa, in the South Zone, stands out as the least green space with scarcely 1.89% of its territory occupied by vegetation.

The picture drawn from the study is encouraging. Almost 45% of 222.93 km² of Recife is made up of green fields. There are, more precisely, 99.61 km² of trees, grasses, shrubs and all kinds of vegetation (Oliveira et al., 2012). Thus, the green density per inhabitant of Recife is high and it is near to the 65 thousand m² of greenery per inhabitant. There are, however, important differences between the regions of the city. Nearly, half of all the green cover of the capital is reduced in a single region, the North Zone, formed by neighborhoods of Casa Forte, Apipucos, Dois Irmãos, Sítio dos Pintos, Casa Amarela, Guabiraba and its neighbor Pau-Ferro, primarily the latter two are responsible for the high rate of afforestation (Oliveira et al., 2012).

Due to its rapid urbanization and the large urban densification, the fourth largest in the country (IBGE, 2010), Recife still lacks infrastructure of green areas, particularly parks, in the neighborhoods with high urban density and little green density, e.g., the district of Boa Viagem. Before the installation and construction of the Dona Lindu Park, the main public parks of the city were the Jaqueira Park, Treze de Maio and the Horto de Dois Irmãos, all of them located in the North Zone of the city.

The Park Dona Lindu was officially inaugurated on 30 of December 2008, although incomplete and with the initial budget of R$ 18 million, it reached a cost of more than twice as much, attaining an estimated value of R$ 37 million (Agência de Notícias UFPE, 2012). It was constructed in an area of 27 thousand m², it began to be built on a land of Aeronautics, which had been vacant for several decades, and was transferred to the municipality by the Federal Government, but was engulfed with lawsuits filed by homeowners' associations and it took almost 1000 days to be completed (Agência de Notícias UFPE, 2012).

Cheshire and Sheppard (1995) argue that a property represents not just a set of specific structural features of the building, but also a set of characteristics related to their location. When adding to location the coordinates and the area, along with the other characteristics of the real estate, it is possible to estimate the value of a given attribute via the hedonic pricing method. Thus, it is possible to calculate the value of specific features of the real estate prices, as, for example, the value of the amenities. The hedonic pricing method has been widely applied to estimate the value of nature and, consequently, of the amenities (Price, 2003), for example, the impact of green spaces and housing prices.

In developed nations, there are a series of surveys displaying a positive impact on green areas and parks with housing prices. For US cities, for example, Espey and Owusu-Edusei (2001); Crompton (2001); Lutzenhiser and Netusil (2001); Geoghegan (2002); Anderson and West (2006); Cho, Bowker and Park (2006) and Heckert and Mennis (2012), present evidence of the positive effect on real estate properties located near parks. In others developed nations, especially in Europe, there is also a vast literature showing positive externalities of parks with housing properties, for example, Luttik (2000) for Netherlands, Aalborg, Panduro and Vein (2013) for Denmark, and Schläpfer et al. (2015) for Switzerland, found a positive impact of parks on the real estate properties.

More precisely, Kolbe and Wüstemann (2014) analyze the effect of urban green areas on the price of the real estate in the region of Cologne, Germany. The results presented that there is a capitalization of urban green areas in the real estate prices, but the effect of the structural variables is more outstanding. Their survey implied that there is a positive effect on the cost of housing in regions located near parks, forests and bodies of water, and a negative impact on the residences near farmland and deforested areas.

For Australia, Pearson, Tisdell and Lisle (2002) examine the valuation of the Noosa National Park in an urban area in Queensland. Hence, they used the hedonic pricing model to set the value of the impact of this green area in the price of the real estate. The study found a 7% increment in the price of the properties near the Park. However, this value changes according to the location of the buildings. Properties located south of the park have 85% greater value than real estate just north of the Park. The authors also found that the variables with the greatest effect on the monetary value of the real estate are the distance to the ocean and sea views.

Therefore, the literature has long recognized that green areas tend to raise the value of the properties, since they seem to have a positive effect on the welfare of the population. Research on green spaces shows many other positive impacts on surrounding communities of this area, including the improvement of environmental conditions (Nowak et al, 2006) increases the satisfaction of parks (Ellis et al, 2006) and has a positive impact on mental and physical health (Maas et al, 2009).

Nevertheless, it is well documented in the literature, the negative indirect effects of open areas (Lim and Missios, 2007 and Smith et al., 2002). Thus, the construction of parkland also can face typical problems of the urban environment, i.e., the increase in the crime rate (Linden and Rockoff, 2008 and Troy and Grove, 2008), excessive trash (Lim and Missios, 2007) and noise (Smith et al, 2002).

More specially, for example, Smith et al. (2002) examined the effect of noise in open areas in the United States and used the hedonic pricing model to estimate the impact of disturbance on the value of the properties. The authors establish that people valued negatively noise in relation to real estate prices. And this is noteworthy, because the park attracts people, plays host to concerts, and events can generate a heavy amount of noise and waste, which reduces the welfare of nearby residences, negatively impacting the value of real estate. Lim and Missios (2007), in a survey in Canada, show how landfills negatively affect the perception of welfare of the individuals, because, the parks might attract hundreds of masses in a single day and the waste produced by them can also negatively affect the value of the immovable property.

Linden and Rockoff (2008) study the relationship between property value of the real estate and the risk of crime, in the United States, and show that people who live in violent regions have two options: choose politicians who fight against violence or move away. Both negatively affect the value of properties. Thus, the building of a park can lead to greater attractiveness of the region, with more people moving through the region, in that respect, the likelihood of crime is greater (Becker, 1974), which can generate a negative effect, given the possible increase in the violence. More specifically, Troy and Grove (2008) examine the relationship between the value of the real estate located around parks and regions with a high criminality rate, in the city of Baltimore, USA. The author's results indicate that the proximity of a park is evaluated positively by the real estate market, but the results indicate a negative influence of parks when they were surrounding by a high rate of theft and rape.

Pope and Pope (2015) demonstrated the effect of urban density in the construction of new units of supermarkets and the possible negative effect of the congestion and how this affects the price of buildings nearby this location. Thus, the densification process in this region of a park might, as well, generate possible negative effects in the real estate price.

In developing nations, the literature on the impact of the green areas on real estate prices is much smaller compared to developed countries. Jim and Chen (2006a), in a study in Guangzhou, China, found different characteristics of the impact of amenities than those found in Western States. The sight of a green area and proximity to bodies of water positively impact the monetary value of residential housing. However, the proximity of a wooded area, which cannot be used by residents, did not contribute to residential price, which implies that the usability of green space could be more attractive than just proximity. Moreover, exposure to traffic noise has little impact on the real estate price, suggesting high local tolerability.

Kong and Nakagoshi (2007), for example, found a positive effect of the amenities in the urban green space on housing prices in the city of Jinan, China. Jim and Chen (2009) in a study in Hong Kong evaluated the price of the amenities for the two primary types of natural landscape in the country: harbor and mountain views. Just overlooking the harbor was valued positively among individuals and can increase up to 2.97% of the value of the property. Furthermore, the view of a mountain can have a negative effect of roughly 6.7% on the real estate price.

According to ours best knowledge, there is no study of impact of a building of a park on the real estate price in Brazil. But, there are a few studies that use the hedonic pricing model to estimate the effect of a several facilities in the properties price. For example, Hermann and Haddad (2005) through the POF (Family Budget Survey) data in the year 1999, displayed that proximity to the train stations, the presence of the green fields and the strictly residential urban zoning increased the value of property, while criminality reduces its price for the city of São Paulo, Brazil. In the same city, Fávero, Belfiore and Lima (2008) indicated that there is a positive effect on the price of the real estate located in the district of lower and middle socio-demographic profiles in the variables related to the proximity of private schools and subway stations. And the same goes for the proximity of the private hospitals, the shopping mall and the green areas in the districts with medium and high income profiles.

In Recife, Brazil, Dantas et al. (2007) used data granted by the Caixa Econômica Federal, for apartments sold between the years 2000 and 2002, with the aim to evaluate some attributes to the urban center of Recife. They concluded that the properties are depreciated between 6% and 8% as one moves away from the Jaqueira Park and the beach. Emerenciano and Magalhães (2008) evidence that individuals are willing to pay up to 13% more for buildings located close to green areas and 9% for properties near the bodies of water. Following the hedonic pricing model, just with a much larger set of amenities and observations of the city, in addition to more appropriate interpretation of the results, Seabra, Silveira Neto and Menezes (2015) show that one kilometer of distance from parks decreases by 1.2% the value of the property. And, the influence of the parks on the property value is negligible for greater distance than 1.5 kilometers.

In this research, we use a Difference-in-Difference identification strategy to simulate an experiment to find a causal relationship between the construction of the Dona Lindu Park and the real estate price. Brazil has relegated the presence of the green areas in the urban centers for a long period of time, because of the fast urbanization that occurred in the country. Thus, using an appropriate method, and a database with information about property characteristics for a long period of time (ITBI database), we found that the real estate that is 600 meters

away from the park had an increment in the price of 7.7%. In contrast, the housing properties located 600 meters to 1000 meters distant from the park had a reduction in their value of 11.9%. The results are robust to the consideration of different control groups and forms of the model misspecification.

The paper is organized as follow: section 2 presents the institutional background of the Dona Lindu Park; section 3 describes the data and the empirical strategy; section 4 describes the results; section 5 describes the robustness tests and the falsification tests and section 6 presents the discussion and final considerations.

2. The Institutional Background

The district of Boa Viagem is one of the largest of Recife, around 123 thousand inhabitants (IBGE, 2010) and it is a region with high building standards and it has a population with high purchasing power. Due to the rapid urbanization and extremely important positive amenity, its proximity to the ocean, there was a great demand for this region in recent years, and therefore, the neighborhood went through a very strong verticalization process where most buildings located in the area are skyscrapers (Franklin, 2014).

Dona Lindu Park is located along the seafront in the Boa Viagem district. This land was vacant for over 60 years and only manages to remain resistant to pressure of the real estate, because it belonged to the Air Force. The site operated as an operation base during World War II and its main function was to observe German ships, which, perchance, moved ahead into Brazilian waters. With the conclusion of the War, the land lost its use and remained vacant for several years.

In 2004, residents of the Boa Viagem district delivered a petition with 17 thousand signatures to the then President Luiz Inácio Lula da Silva, requesting the transfer of the land to the city from it was ownership of the Air Force. In the same year, the then mayor of Recife, João Paulo, met for the first time with Air Force representatives to talk about the construction of the Park (Franklin, 2014). Intense negotiations followed and the provision of the site was achieved with the signing of the concession contract in September 2006. Then, it was announced by the City Hall that the architect Oscar Niemeyer was the author of the park project, which caused a big commotion in the city (Franklin, 2014) due to its relevance[1]. The only project of the architect in Recife, a residential building on the same street of the park, was demolished years ago, giving room for another skyscraper (Franklin, 2014).

The initial idea of the project was a park with a large green area, something rare in Boa Viagem with intent of providing a refuge in the hottest neighborhood in Recife (Barros and Lombardo, 2012), and a community leisure area. However, the municipality demanded the architect a metropolitan center of culture and leisure, a cultural park, different from the initial idea of the residents, which led to a discussion between civil society and the state government.

It is important to highlight that the Dona Lindu Park was "opened" several times, the first in December 2008, by the then Mayor, João Paulo, and in 2010 it was again "handed over" to the public. However, the park was only fully operational in March 2011.

[1] Oscar Niemeyer was one of the most important Brazilian architects, considered one of the key figures in the development of modern architecture (Deckker, 2001).

Since the kickoff of the park project, there have always been several controversies. One, for instance, is the value of the work, which increased the final value in over 100%, totaling over R$ 37 million (UFPE News Agency, 2012), compared to R$ 18 million of the initial project. And even the park's name was a cause of polemic, with the purpose to honor the northeastern migrants; the park was named after Dona Lindu, the mother of then President Luiz Inácio Lula da Silva, who was an immigrant.

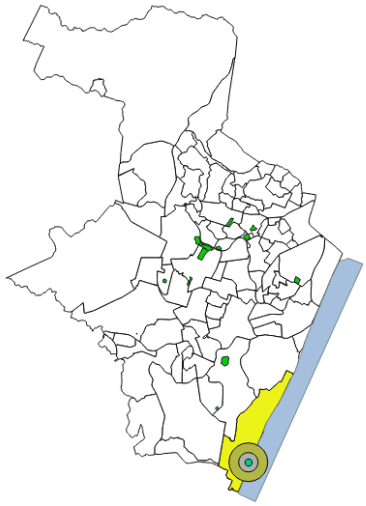
Currently, the Dona Lindu covers an area of 27166.68 m², with 60% covered by a green area (Agência de Notícias UFPE, 2012), much more than the initial prediction. For comparison, the Jaqueira Park, another big park of the city, has approximately 70 thousand m² and Santana Park with 63 thousand m². The D. Lindu Park includes bicycle paths, running trails, skateboard and sports courts, playgrounds, areas for relaxation and fitness, restaurant, toilets, baby changers and also a technical center.

3. Data and Empirical Strategy

The aim of this research is the study of the impact on the value of the properties due to a building of a new green area in the city of Recife, Brazil, in particular the Dona Lindu Park. With this goal in mind, this research utilizes the database provided by the City Hall of the Recife, specifically derived from the ITBI database (Tax on Goods and Property Transfer). And, as we shown below, we will use the basic idea of the hedonic pricing model, which the price of real estate reflects the its own characteristics, along with an identification strategy based on the difference-in difference estimator (DiD) to estimate the impact on the price of the real estate near to the park.

The Figure 1 shows the location of Dona Lindu Park and the map of the city of Recife. In the figure, the district of Boa Viagem is in yellow and the parks are green (we do not consider green areas, just parks). The green dot, in the referred district, corresponds to the location of the Dona Lindu Park and we also made two radiuses of 500 and 1000 meters from the Park, this is the treatment area. Before the installation and construction of Dona Lindu Park, the main public parks of the city were the Jaqueira Park, Treze de Maio and the Horto de Dois Irmãos, all of them located in the North Zone of the city.

Figure 1- Recife and its Parks



Note: Based on information the Municipal Administration of Recife.

To estimate the effect of the construction of the Dona Lindu Park in the housing prices, we will consider the different physical characteristics of real estate in different periods of time, since it provides information on the features of the property for the period prior to the construction[2] of the park (January 2000 to September 2006) and later the park was finally delivered, but now 100% complete, (March 2011 to December 2012). More formally, we will estimate parameters of several versions of the following model:

$$y_{idt} = \beta_0 + \beta_1 DL_{it} + \Phi X_{it} + \theta_t + \eta_d + \varepsilon_{idt} \qquad (2.1)$$

The DL coefficient is equal to 1 if the property is within the treatment area in the period when the park was already handed over to the public and zero, otherwise. That will be considered the treated group and spreads over the period from March 2011 until December 2012. The y_{idt} variable is the logarithm of the price of a given property *i*, located in the district *d*, in period *t*; β_1 the coefficient of interest and it is linked to the fact that if the property is a distance from the park, for example, a radius of 500m or 1000m. Thus a series of regressions will be estimated to measure sensitivity in the housing prices given the distance to the park. The X_{it} vector consists of structural features of buildings and represents a control for these attributes.

The θ_t coefficient denotes the fixed effect of time (year, month, and their interactions) and the η_d is the fixed effect of district. The district fixed effects included in the model control for time-invariant unobservable district characteristics while the time fixed effects control for yearly differences between property prices. The ε_{idt} is the error term that will be organized by cluster at the district level in all the estimates to take into account the heteroscedasticity and serial correlation of the characteristics observed between the attributes belonging to the same neighborhood (Bertrand et al., 2002). Thus, we can interpret the parameter of interest, β_1 as the causal effect of the construction of the park in the real estate prices. In other words, this coefficient represents the difference in the average real estate price before the advent of the park minus the difference of the average price of the real estate after the park.

In the specific case of the D. Lindu Park, we obtain an estimative of the impact of the Park building on the properties values. In this way, we have at least four major obstacles. The first one is the need for information for periods before and after the foundation of the park and this is provided by the ITBI database. We also have to set the pre and post-treatment period, the aim of this point is to eliminate the contamination of the announcement of the park in the housing market prices, due to the delay between the announcement of the park, the first hand over and finally the 100% finalized delivery. The third point is the definition of the treatment region and the fourth point is the definition of the control group region.

It is important to highlight, in the Brazilian case, that the ITBI database has an advantage over other databases with real estate information. As these transactions are recorded in the registry office, the amount and the quality of data are usually much more complete because there is coverage in all regions of the city. Yet, there was another really important advantage in this database. Individuals have incentives to report the values more believable as possible; the undervaluation of the descriptive value is not advantageous to the buyer, because in case of a future sale of the property, there is a tax on the gain from appreciation. On the other hand, the overvaluation brings losses to the buyer, because it brings a higher value of IPTU (Urban

[2] This period of time was used to eliminate the effect of the park announcement in the housing prices. During this section we will make this choice clear.

Building and Land Tax). This information also tends to have a higher quality to those found on offer (ads), since they also reflect the demand side. However, this database information is associated with taxes; inevitably, its scope is restricted to the formal market, which tends to represent improperly the situation for the population with the lowest income (Silveira Neto, Duarte and Sampaio, 2014).

Thus, we will use the municipal data ITBI for the years 2000 to 2012, provided by the city of Recife, with more than 97 thousand observations in the period. This data gathers information on the characteristics of the properties, such as the number of floors, the number of apartments in the building, the building area, the standard of construction and the real estate transaction value in the city, this data is shown in table 1.

Table 1 -Description of the variables

Variables	**Description**
Price-BRL[3]	Logarithm of the property price
Area (m2)	Private built area of the property
Floors	Number of floors of the property
Apartament	Number of apartaments of the property
House	Assumes value equal to 1 for house
Low standard	Low construction standard (dummy)
Medium standard	Medium construction standard (dummy)
High standard	High construction standard (dummy)
Year of construction	Year property was built
Regular	Property considered to have fair conservation conditions (dummy)
Good	Property considered to have good conservation conditions (dummy)
Excellent	Property considered to have excellent conservation conditions (dummy)
Dona Lindu500	Assumes value equal to 1, if the property stays 500 meters of distance of the park
Dona Lindu500-1000	Assumes value equal to 1, if the property stays 500-1000 meters of distance of the park
Dona Lindu1000	Assumes value equal to 1, if the property stays 1000 meters of distance of the park

Note: Based on information the Municipal Administration of Recife.

When there is the announcement of a specific project that can appreciate the price of real estate, various agents might build or leave the region even before the launch in the expectation that there is an appreciation or depreciation (Pope and Pope, 2015). In the year of 2010, approximately 10% of all real estate properties launched in Recife were located 500 meters from the park – according to our database – which can cause some effects on ours results. To eliminate this problem, we use a similar strategy proposed by Pope and Pope (2015) to estimate the impact on the price of real estate due to a new Walmart store in the United States.

[3] Brazil's currency is the Real (R$). Over the study period of this paper, the exchange rate with the dollar fluctuated in an interval between approximately R$ 1.57 and R$ 3.86 US$, with a rough average of R$ 2.22 US$.

Specially, as the park had several opening dates, we have chosen as the reference the first time it was delivered to the public, December 2008, but the Dona Lindu was not 100% operational, so it could not generate any positive amenities. So, from this time we have removed from the sample the period of the assignment and construction of the park in September 2006 until the date of the first opening, December 2008, and the same amount of time forward, December 2008 to March 2011. The last date coincides with the definitive delivery of the park to the population, but now the park is finally done and can generate positive or negative amenities to the population. In other words, we had eliminated two years and four months before and after the park was first delivered in December 2008, with the aim to eliminate any effect of the Dona Lindu announcement in the real estate prices. Later in the robustness tests, were we taken different times of periods, and the result remained quite closed.

There is, however, the possibility that after the construction of the park, part of the demand for real estate might be changed in the region, which it makes difficult to define the treatment region. Even when we utilize the strategy proposed by Pope and Pope (2015), which withdrew two years and four months before and after the first hand over of the park, the advent of D. Lindu might has changed the dynamics of the real estate market in the region. With this concern in mind, we will follow an approach proposed by Linden and Rockoff (2008), which the authors study the relationship between the property value in Mecklenburg, North Carolina, with the risk perception of crime (represented by the number of sexual assault records in the region). Specifically, the main idea is to verify if there is any effect on the treated area (1000 meters from the park) in the housing prices around the treated area, and if so, identify the geographical range of the area of its influence.

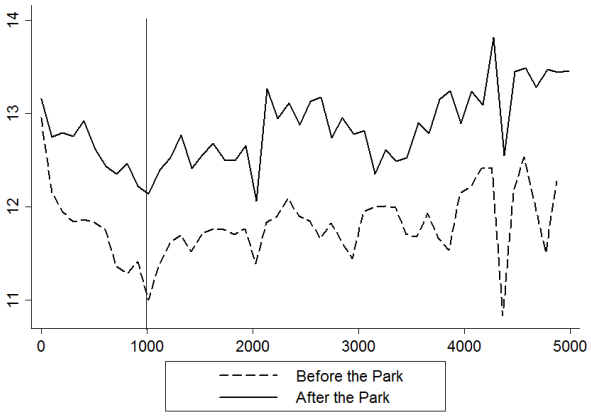
To follow this strategy, it is necessary to compute the distance between the untreated properties (distance greater than 1000 meters from the park) and the boundary of the Dona Lindu. The addresses of the properties are available in our database, and for each property, we obtain the distance via georeferencing using *ArcGIS* software. Then, for the set of untreated properties, we estimated by local polynomial regressions the gradient for the relationship between the property values and the distance to the boundary of the Dona Lindu Park. This gradient allows us to observe possible differences regarding the property value and the distance to the treatment region after the park, and thus to identify as of what distance that possible the contamination stops being relevant[4]. The figure 2 shows the gradient.

In Figure 2, we present the gradient estimated for the relation between the property values and the distance from the boundary of the Dona Lindu Park for the period after the construction of it, represented by the straight line. And, as it is clear, there is a tendency for property prices to decrease as they move away from the boundary of the Park. This can happen due to a possible contamination effect, caused by the emigration of potential property buyers in the treated area. To investigate this effect, this figure also shows the gradient estimate the relationship between prices and distance to the boundary of the park for the

[4] With data on the property values and distances from the boundary of the area subject to the Park, the idea is to estimate the following gradient: $m(d_i)$: $Y_i = m(D_i) + e_i$, where Y_i is the value of propriety and i and Di is the distance of that property from the boundary. At a specific distance d_0, note that $E(Y_i|D_i) = E(d_0) = m(d_o)$. For various distances from the boundary, different values of this gradient are obtained by minimizing the expression $\sum_{i=1}^{n}\{(Y_i - \sum_{j=0}^{p}\beta_j(D_i - d_0)^j\}^2 . h^{-1}K(\frac{D_i - d_0}{h})$ with respect to β_j, where p is the exponent of the polynomial, *K* is a kernel function that forces local minimization and *h* is its window. For each specific distance from the boundary, d_o, a value of de $\beta_0 = m(d_0)$ is obtained. We use the Epanechnikov kernel with optimal window and $p = 3$. For more details, see Gutierrez, Linhart and Pitblado (2003).

period before the construction of the park, the dashed line. Both lines have a different behavior, especially until 1000 meters from the Park, represented by the vertical line. The results begin to be quite closer after this distance. Then, it showed that the behavior pattern of the prices in relation to the distance did not differ before and after the building of the D. Lindu, which suggests that the effect of the treatment is restricted to only 1000 meters away from the park.

Figure 2: Property value gradients: distance and price of the properties before and after the building of the Dona Lindu Park



Note: Based on information the Municipal Administration of Recife.

Rossi-Hansberg, Sarte and Owens III (2008) estimated that housing externalities decreased by half around every 1000 feet or, approximately, 300 meters. In that way, after 4000 feet, or, approximately, 1200 meters, the housing externalities should be very small, around 6.25% in the price properties, which reinforced the treatment area we found in the gradient. In a study of the city of Recife, Seabra, Silveira Neto and Menezes (2015) showed that one more kilometer away from the parks decreases by 1.2% the property value. Thus, this result shows that the influence of the parks on the property value is negligible for a distance greater than 1.5 kilometers. This gives an additional support for the selection of the one kilometer limit on the impact of the real estate price due to the building of the D. Lindu Park.

A survey conducted worldwide by the company TomTom[5], specializing in GPS (Global Positioning System), in March 2015, brought worrying issues about mobility in Recife. According to the document, the capital is the slowest city in the country in the evening peak time of days, from 17h to 19h. In a year, an average individual loses up to 94 hours behind the wheel only returning home after work. Recife also ranked sixth in the world ranking and third in the Brazil. The survey assessed the traffic in 200 cities through information gathered in GPS's produced by the company. According to the data, the congestion charge in Recife is as high as 82% in the evening rush, ahead of cities like Los Angeles and Rio de Janeiro, where it loses 93 hours a year on average, and the congestion charge is 81%.

Due to the limited mobility, the high population density in Recife, the gradient, the decrease of the housing externalities (Rossi-Hansberg, Sarte and Owens III, 2008) and the previous study of Seabra, Silveira Neto and Menezes (2015), we believe that the effect of the park in the housing prices is strictly local. So we do not expect that there is an impact for

[5] Data available in: https://www.tomtom.com/pt_br/trafficindex/#/.

regions with more than one kilometer away from the park, because people hardly shift far away to enjoy the complex. Thus, we have initially created two radiuses leaving the park's boundary, an arbitrary radius of 500 meters, in gray, and another at 1000 meters, in brown – figure 1. Note that this allows heterogeneous effects in the housing marker, a positive effect on the proximity of the park and a negative effect, as the distance increases from the Park. These radiuses will be our treatment groups, because this area is impacted in the real estate prices due to the building of the Dona Lindu Park.

Finally, there is a question associated with definition of the control region. At first, we could only use the Boa Viagem district or region with similar amenities, for example, the proximity to the ocean. However, we cannot simply eliminate the other districts of the city and not take into account the dynamics of other districts in the model. So, we will use all the city's districts as a control group region. At this point, it is important to note that all these considerations are important and will be tested in the robustness section, with different periods and control groups.

To sum up, regarding the first issue, the gradient, Figure 2, and a survey conducted by Seabra, Silveira Neto and Menezes (2015), shows the influence of parks on the property value is negligible for a greater distance than 1.5 kilometers for the city of Recife, helps to explain the reason of the treatment area of 1000 meters away from the D. Lindu, although at first seem an ad hoc choice, the gradient ratified this decision, suggesting that the greatest effect is concentrated to a distance of 1000 meters from the Park. After this distance the curves begin to follow similar patterns, suggesting that the effect of treatment is restricted within this region. Afterwards, we will make smaller radius, of 100 meters, to the distance limit of 1000 meters, to explain better the dynamics of property prices.

Table 2 contains information of the variables for the treatment group (within 1000 meters from the park) as for the control group (all other residences with more than 1000 meters away) and for both the pre-treatment period as the post-treatment period (effective hand over of the park). For both periods, the property prices in the region subject to the treatment were on average larger than the area untreated. However, this difference can be both linked with higher properties and most recently built (year of construction) and with a higher percentage of high standard properties. Treated properties also tend to have a larger number of floors than the region that is more than 1000 meters away from the park. Despite the change in the housing prices between the period before and after treatment, a simple average of the comparison shows that there was a small increase in the monetary value of the treated properties (247%) when compared to the value of control region (352%).

Table 2 - Descriptive statistics of property characteristics

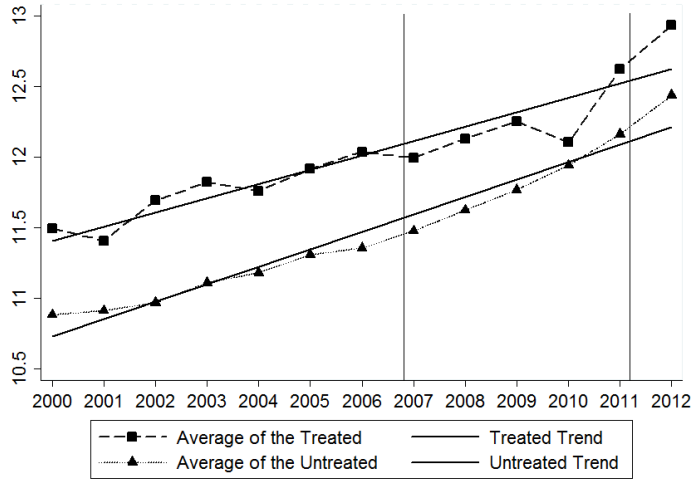
	Pre-treatment Period (Before September 2006)			Post-Treatment Period (After March 2011)		
Variable	Not Treated	Treated	Mean Difference	Not Treated	Treated	Mean Difference
Price-BRL	90,081	146,974	-56,893***	316,698	362,994	-46,296***
	(96,229)	(210,340)		(314,276)	(239,365)	
Area (m2)	124.1	143.6	-19.5***	105.6	122.3	-16.7***
	(84.22)	(100.3)		(76.36)	(75.46)	
Year of construction	1,986	1,991	-0.005***	1,997	1,998	-0.001*
	(15.81)	(10.73)		(16.58)	(12.90)	

House	0.207	0.0246	0.1824***	0.114	0.0245	0.0895***
	(0.405)	(0.155)		(0.317)	(0.155)	
Low standard	0.417	0.125	0.292***	0.219	0.0821	0.1369***
	(0.493)	(0.330)		(0.413)	(0.275)	
Medium standard	0.409	0.571	-0.162***	0.383	0.494	-0.111***
	(0.492)	(0.495)		(0.486)	(0.500)	
High standard	0.174	0.305	-0.131***	0.398	0.424	-0.026*
	(0.379)	(0.460)		(0.490)	(0.494)	
Regular	0.00508	0	0.00508***	0.00246	0.000790	0.00167
	(0.0711)	(0)		(0.0495)	(0.0281)	
Good	0.0325	0.0339	-0.0014***	0.0144	0.0134	0.001
	(0.177)	(0.181)		(0.119)	(0.115)	
Excellent	0.962	0.966	-0.004	0.983	0.986	-0.003
	(0.190)	(0.181)		(0.129)	(0.118)	
Floors	9.558	13.91	-4.352	16.91	17.82	-0.91***
	(8.766)	(8.796)		(10.02)	(8.559)	
Apartments	33.91	43.04	-9.13***	57.35	49.04	8.31***
	(45.10)	(45.04)		(47.26)	(37.91)	
Observations	36,826	3,653		15,458	1,235	

Note: Authors' calculations based on information the Municipal Administration of Recife.

The estimation via difference-in-difference requires that the trend in the pre-treatment period, in this case January 2000 to September 2006, is the same for both sets of the treated and the untreated group (Angrist and Pischke, 2009). And in the post-treatment period, March 2011 to December 2012, the trend has to be different from the same data set. The Figure 3 indicates the distribution of the yearly average price of real estate and the trend in the pre and post-treatment of the treated and untreated group. The two vertical lines show the period that has been removed from the sample to eliminate the effect of the announcement of the park in the housing prices. As noted, the trend in the period prior to the advent of the park is very similar for both sets of sample and different when we consider the post-treatment period. So we can understand that our estimation via DiD fits the model assumptions and, in fact, imply causality of the effect of the park in the property price at a distance of 1000 meters from the park.

Figure 3: Evolution of the Treated and Untreated Group (1000ms) and their Trend



Note: Based on information the Municipal Administration of Recife.

4. Results

4.1 Initial Evidences

The aim of this research is to evaluate the impact on the value of the properties due to a building of a new park, the Dona Lindu Park, in the city of Recife, Brazil. For this, we will use the basic idea of the hedonic pricing model, which the price of the real estate reflects the its own characteristics (Cheshire and Sheppard, 1995), along with the identification strategy based on the difference-in-difference estimator (DiD) to estimate the impact on the price of the real estate nearby the park.

Thus, the first stage of this essay is to work with the treatment area of 1000 meters, as established in the last section. The objective at this point is to test the sensitivity of the outcome of treatment area. We consider three different types of specification (columns (1) to (3)); indicating different subsets of the control variables included in our basic model and different treatment areas. The Table 3, columns (1) to (3), displays the results for the estimation, considering treated all properties within a radius of 1000 meters from the park.

Table 3 – The Impact of the Park Dona Lindu in Prices of Real Estate Properties: the Benchmark Estimation for the 500 and 1000 meters Radius

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
D. Lindu 1000	0.813***	-0.108***	0.005				
	(0.000)	(0.021)	(0.014)				
D. Lindu 500				0.962***	0.084***	0.087***	0.081***
				(0.000)	(0.018)	(0.014)	(0.016)
D. Lindu 500_1000							-0.095***
							(0.014)
Area (m2)			0.004***			0.004***	0.004***
			(0.000)			(0.000)	(0.000)
House			0.271***			0.271***	0.271***
			(0.046)			(0.046)	(0.046)
Medium Standard			0.194***			0.195***	0.194***
			(0.036)			(0.036)	(0.036)
High Standard			0.536***			0.537***	0.535***
			(0.052)			(0.052)	(0.052)
Year of Construction			0.005**			0.005**	0.005**
			(0.002)			(0.002)	(0.002)
Regular			-0.120			-0.120	-0.120
			(0.083)			(0.083)	(0.082)
Good			0.039			0.039	0.039
			(0.062)			(0.062)	(0.062)
District FE	No	Yes	No	No	Yes	No	No
Year FE	No	Yes	No	No	Yes	No	No
Month FE	No	Yes	No	No	Yes	No	No
Year-Month FE	No	No	Yes	No	No	Yes	Yes
District-Year FE	No	No	Yes	No	No	Yes	Yes
Observations	57,182	57,182	57,182	57,182	57,182	57,182	57,182

Adjusted R^2	0.0271	0.5496	0.7562	0,0201	0,5495	0,7563	0,7562

Note: Clustered standard errors are presented in parentheses, *indicates a significance of 10%, ** indicates a significance of 5%, *** indicates a significance of 1%; all specifications include a constant not reported.

In column (1) of Table 3, we estimate the regression with only the variable of interest with the price of real estate (in logarithm), without considering neither structural feature of the property and any fixed effect and it shows a positive and statistically significant effect of the building of the park in the real estate prices. But, the column (2), by including the fixed effects of year, month and district, these effects become negative and statistically significant, indicating a possible negative effect of the price of the properties and the positive initial effect was associated to the characteristics of the district.

However, when we introduced the controls with the characteristics of properties, the fixed effects of district-year and month-year, column (3), the impact of the Park on the real estate was not statistically significant. This indicates that the negative signal was associated to the physical features of the properties. The year of construction also has a positive outcome, indicating that when younger the property higher its value. There is, furthermore, a positive effect if it is a house, which is to be expected, because in the Boa Viagem district most of the buildings consists of apartments and the few houses that remain are highly valued. And the zero-effect possibly occurs due to the probable negative influence such as congestion and noise that cancel out the prior positive effects associate to the direct amenity of the proximity of the Park.

In the last section, we showed that the influence of the park D. Lindu on the value of the properties stands until 1000 meters of the Park´s boundary. As there are potentially different kinds of effects (positive and negative) of the parks in the value of the real estate, we begin by exploring the existence of a positive effect associate to the amenities being located near to a green area (the Dona Lindu Park) and, thus, considering the impact on the properties located until 500 meters from the boundary of the Park. The objective at this point is to test the sensitivity of the outcome of treatment with different distances. The Table 3, columns (4) to (6), presented the results.

In column (4) of the Table 3, we estimate the regression with only the variable of interest with the price of real estate (in logarithm), without considering neither structural feature of the property nor any fixed effect. The estimation of this parameter indicates that there is a positive relationship between the advent of the park with the value of the property and shows a statistically significant at 1% and impact of 96.2%. In column (5), it was added the fixed effects of month, year and district, intended to capture the effect of seasonality in the real estate market. And the impact of the D. Lindu Park for properties situated 500 meters away from it was 8.4%

In column (6), besides the controls with features of the property and with fixed effects control of month-year, we added specific controls to capture the effect of the district and month together. And it is important, because it takes into account the price variation between month-year and district-month combinations not parametrically. In this specification, the impact of the building of the Dona Lindu park on the residential prices in March 2011 until 2012 (treatment group) was 8.7%, when compared to the prices of the control group. Specifically, the area, the medium and high construction standards have positive influences in the property values, while other characteristics are unchanged. Nevertheless, it is important to observe that the estimates presented in Table 3 show the impact on the price of real estate in the post-treatment period.

Now we will work with two radiuses of treatment, up to 500 meters and 500 to 1000 meters from the park and the results are also presented in Table 3, column (7). The motivation behind this point is to verify different kinds of effects depending on the distance of the Park. Thus, in Table 3, in column (7) there was a positive impact in the real estate prices of 8.1% for properties within 500 meters from the Park and a reduction in the housing prices of 9.5% for real estates located within 500 and 1000 meters from the D. Lindu. The result suggests that the properties located up to 500 meters from the park are those that the value of the real estate has increased in the post-treatment period, between March 2011 and December 2012 compared to the pre-treatment period, from December 2000 to September 2006. On the other hand, the statistically significant outcome with a negative signal found in the radiuses of 500 to 1000 meters from the park is consistent with the strong performance of the negative effects associated with the presence of the park, such as congestion, noise, garbage and crime (Lim and Missios, (2007); Smith et al., (2002); Linden and Rockoff, (2008); Troy and Grove (2008)).

There are some others studies that had found negative effects due to a green area. For example, Lim and Missios (2007) and Smith et al. (2002) found negative indirect effects of garbage and noise in the real estate values, respectively. Linden and Rockoff (2008) and Troy and Grove (2008) argued that the construction of a park may increase the crime rate. And some others work that found different effects of the impact of the park, for example Pearson, Tisdell and Lisle (2002) found a 7% increment in the price of the properties near the Noosa Park, Australia. However, this value changes according to the location of the buildings. Properties located south of the park have 85% greater value than real estate just at north of the Park.

Note that our results are analogues to the ones obtain by Nelson (2004), Kolbe and Wüstemann (2014) and Pope and Pope (2015). Nelson (2004), for example, studied the issue of aircraft noise on the property value and he showed that an airport has different impact on the real estate depending on where the property is located. This way, a certain household located in the region of 55 decibels would be sold for about 10-12 percent less if it was placed in a region with 75 decibel noise. This is explained by the fact that these properties located near to the airport, but do not suffer from loud noise, have a clear benefit, easy access to the airport, but without great inconvenience caused by excessive noise. Pope and Pope (2015) demonstrated a possible negative effect of the congestion due to the new Walmart store. Thus, the densification process in this region of a park might, as well, generate possible negative effects in the real estate price. Kolbe and Wüstemann (2014) analyze the effect of urban green areas in the price of the real estate in the region of Cologne, Germany. Their survey implied that there is a positive effect on the cost of housing in regions located near parks, forests and water bodies; and a negative impact on the residences near farmland or deforested areas.

By choosing 500 meters radius from the Park, solely based on the half distance between the boundary of the Park and the treatment area might generate results that could potentially be only a product of this choice. Here, we show that the positive and the negative effects of the Park on properties value effectively occurs much closed to the ones we assume. In Table 4, we present new estimations of the impact of the D. Lindu on the properties' value, but now, we are considering different regions of treatment; according to 100 meters distance to each other, being the more near radius is up to 100 meters from the park and the more distance radius from the park is up to 900 to 1000 meters.

This way, the real estate properties distance up to 100 meters away from Dona Lindu has presented an increase of 13.4% in their prices. For properties located between 100 and 200

meters from the Park the impact of the D. Lindu is not statistically significant. On the other hand, for real estate sited in the radius of 200 and 300 meters away from the park, the outcome is statistically significant, with an appreciation of the real estate of 13.6%. And the positive effect of the Park on the real estate holds until 600 meters from the Park. However, there is a positive, but declining, effect of 4% for the households located in the radius of 500 to 600 meters. From this point on, the effects on the real estate become negative and statistically significant at 1%. And, for example, in the radius of 600 to 700 meters from the park, house prices decrease by 21.1%.

These sets of evidence reinforces the idea that up to 500 meters of the park, the impact of this is positive and, after this distance, the value of the enterprise in the housing prices becomes negative. Within the radius of 500 to 600 from the park, the impact decreases and loses its statistical significance – now it is 5% – and the effect it is only 4% on the value of the properties. Probably, from this point on, homeowners face a reduction in the impact and start to present negative effect on the price.

Table 4 – The Impact of the Park Dona Lindu in Prices of Real Estate Properties: Benchmark Estimation for a 100 meters Radius until 1000 meters

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D. Lindu 100	1.300***	0.354***	0.347***	0.353***	0.142***	0.134***
	(0.000)	(0.023)	(0.025)	(0.030)	(0.031)	(0.027)
D. Lindu 100_200	0.868***	-0.046**	-0.045**	-0.040*	-0.023	-0.024
	(0.000)	(0.022)	(0.021)	(0.023)	(0.016)	(0.016)
D. Lindu 200_300	1.052***	0.135***	0.137***	0.137***	0.135***	0.136***
	(0.000)	(0.022)	(0.021)	(0.020)	(0.016)	(0.016)
D. Lindu 300_400	0.884***	-0.040*	-0.043**	-0.044**	0.076***	0.073***
	(0.000)	(0.022)	(0.022)	(0.022)	(0.015)	(0.014)
D. Lindu 400_500	0.946***	0.034	0.032	0.031	0.085***	0.083***
	(0.000)	(0.022)	(0.021)	(0.021)	(0.016)	(0.015)
D. Lindu 500_600	1.026***	0.097***	0.099***	0.093***	0.040**	0.040**
	(0.000)	(0.022)	(0.021)	(0.019)	(0.019)	(0.019)
D. Lindu 600_700	0.467***	-0.482***	-0.491***	-0.484***	-0.208***	-0.211***
	(0.000)	(0.023)	(0.023)	(0.027)	(0.023)	(0.021)
D. Lindu 700_800	0.722***	-0.226***	-0.227***	-0.240***	-0.144***	-0.147***
	(0.000)	(0.023)	(0.023)	(0.022)	(0.011)	(0.010)
D. Lindu 800_900	0.666***	-0.226***	-0.219***	-0.218***	-0.116***	-0.113***
	(0.000)	(0.021)	(0.021)	(0.021)	(0.019)	(0.018)
D. Lindu 900_1000	0.346***	-0.542***	-0.539***	-0.533***	-0.159***	-0.155***
	(0.000)	(0.021)	(0.020)	(0.020)	(0.018)	(0.017)
Property Features	No	No	No	No	Yes	Yes
District FE	No	Yes	Yes	Yes	Yes	No
Year FE	No	Yes	Yes	No	No	No
Month FE	No	No	Yes	No	No	No
Year-Month FE	No	No	No	Yes	Yes	Yes
District-Year FE	No	No	No	No	No	Yes
Observations	57,182	57,182	57,182	57,182	57,182	57,182
Adjusted R^2	0.0283	0.5499	0.5510	0.5523	0.7432	0.7566

Note: Clustered standard errors are presented in parentheses, *indicates a significance of 10%, ** indicates a significance of 5%, *** indicates a significance of 1%; all specifications include a constant not reported.

4.2 Baseline Estimation

Therefore, the positive effect of the building of the D. Lindu Park still holds for a greater distance than the arbitrary radius of 500 meters away from it. As the last column of table 4 makes clear, the positive effect of the Park in the real estate properties hold until 600 meters from the Park. In the light of the set of evidence, from now on, we considered two treated regions, up to the 600 meters from the Park and the region between 600 and 1000 meters from it. In Table 5, we present evidence considering these two treated regions.

Table 5 – The Impact of the Park Dona Lindu in Prices of Real Estate Properties: Benchmark Estimation for the 600 and 600-1000 meters Radius

Variables	(1)	(2)	(3)	(4)	(5)	(6)
D. Lindu 600	0.987***	0.067***	0.066***	0.067***	0.078***	0.077***
	(0.000)	(0.022)	(0.021)	(0.021)	(0.016)	(0.016)
D. Lindu 600_1000	0.516***	-0.404***	-0.404***	-0.402***	-0.118***	-0.119***
	(0.000)	(0.022)	(0.021)	(0.022)	(0.016)	(0.015)
Area (m^2)					0.004***	0.004***
					(0.000)	(0.000)
House					0.262***	0.271***
					(0.044)	(0.046)
Medium Standard					0.202***	0.194***
					(0.038)	(0.036)
High Standard					0.542***	0.535***
					(0.054)	(0.052)
Year of Construction					0.004**	0.005**
					(0.002)	(0.002)
Regular					-0.128	-0.120
					(0.079)	(0.083)
Good					0.031	0.039
					(0.060)	(0.062)
District FE	No	Yes	Yes	Yes	Yes	No
Year FE	No	Yes	Yes	No	No	No
Month FE	No	No	Yes	No	No	No
Year-Month FE	No	No	No	Yes	Yes	Yes
District-Year FE	No	No	No	No	No	Yes
Observations	57,182	57,182	57,182	57,182	57,182	57,182
Adjusted R^2	0,0291	0,5488	0,5491	0,5515	0,7436	0,7564

Note: Clustered standard errors are presented in parentheses, *indicates a significance of 10%, ** indicates a significance of 5%, *** indicates a significance of 1%; all specifications include a constant not reported.

Hence, in Table 5, in column (1) the properties located in the radiuses of 600 and 600 to 1000 away from the Park are statistically significant and positive, which, in principle, indicate

a positive impact of the construction of the park in the housing prices for the both radiuses. Nevertheless, after introducing the fixed effects of district, month and year, in the columns (2), (3) and (4); the signal of the properties until 600 meters remains positive, but the treated properties that were within 600 to 1000 meters still are statistically significant, but now with a negative effect, similar to what happened in the Table 4.

In the column (5), the effects remained statistically significant and with the same opposite signs found in the former columns and the positive impact of the building of the Park in the real estate market was 7.8% for properties situated until 600 meters from the D. Lindu and a negative effect of 11.9% for properties located up to 600 meters and less than 1000 meters way from the Park. Column (6) introduces, in addition to the controls of the characteristics of the properties, the fixed effects of the month-year and the month-district in order to get these specific effects and it sustained no main changes from the previous column.

Clearly, the estimations found in the previous Tables showed the impact of the Dona Lindu Park in the housing prices in the post-treatment. Depending on the evolution of demand for real estate in the area near to the park and the offer of real estate in the substitute's districts, it is expected that the effect of observed treatment may vary over time. To capture these temporal heterogeneities, we estimated the model exhibited in the equation 2.2, which allow non-linear effects of the park's advent in the average price of the treated properties and the estimation also checks if the common trend assumption is valid. Also, as emphasized in section three, this model informs the effect before the construction of D. Lindu (anticipatory effects) and these should be equal to zero to ensure causal interpretation of the observed effect. It follows the following equation, similar to equation (2.1):

$$y_{idt} = \beta_0 + \sum_{2004}^{2006} \beta_{-\tau} DL600_{it} + \sum_{2011}^{2012} \beta_{+\tau} DL600_{it} + \sum_{2004}^{2006} \delta_{-\tau} DL600\_1000_{it} + \sum_{2011}^{2012} \delta_{+\tau} DL600\_1000_{\_it} + \theta_t + \Phi X_{idt} + \gamma \eta_{id} + \varepsilon_{idt} \quad (2.2)$$

The DL coefficient is equal to 1 if the property is within the treatment area in the period when the Park was already handed over to the public and zero, otherwise. This way, we have two treatment regions, so we have to create two different coefficients for both regions. The sums on the left-hand side allow three leads (β_{2004}, β_{2005} and β_{2006}) or anticipatory effects and the sums on the right-hand side allow for two lags ($\beta_{2011}, \beta_{2012}$) or post-treatment effects for the radius of 600 meters away from the D. Lindu Park. On the other hand, the sums on the left-hand side allow three leads (δ_{2004}, δ_{2005} and δ_{2006}) or anticipatory effects and the sums on the right-hand side allow for two lags ($\delta_{2011}, \delta_{2012}$) or post-treatment effects for the region of 600 to 1000 meters from the Park.

Table 6 – The Impact of the Park Dona Lindu in Prices of Real Estate Properties: The Yearly Estimation – The Lead and Lags Estimation

Variables	(1)
2004* D. Lindu 600meters	0.007
	(0.011)
2005* D. Lindu 600meters	0.025
	(0.033)
2006* D. Lindu 600meters	0.142
	(0.048)
2011* D. Lindu 600meters	0.044**
	(0.018)
2012* D. Lindu 600meters	0.003**

	(0.002)
2004* D. Lindu 600_1000meters	0.053
	(0.055)
2005* D. Lindu 600_1000meters	-0.023
	(0.022)
2006* D. Lindu 600_1000meters	-0.014
	(0.023)
2011* D. Lindu 600_1000meters	-0.018*
	(0.017)
2012* D. Lindu 600_1000meters	-0.188***
	(0.027)
Property Features	Yes
District FE	No
Year FE	No
Month FE	No
Year-Month FE	Yes
District-Year FE	Yes
Observations	55,483
Adjusted R^2	79.81

Note: Clustered standard errors are presented in parentheses, *indicates a significance of 10%, ** indicates a significance of 5%, *** indicates a significance of 1%; all specifications include a constant not reported.

First, note for both groups of residences, the outcomes are statistically insignificant at the pre-treatment period. This strengthens the argument that both the treatment group and the control group had the same dynamic pricing. Second, the estimations for the region up to 600 meters of the park had the highest effect in the first year, 4.4%, and a reduction in the second year after the shock, with 0.3% of appreciation. While the region of 600-1000 meters has a negative effect 1.8% in the first year and 18.8% in the second year indicated a considerable decline in the real estate price due to the building of the Dona Lindu Park. Note that these specifications included controls for the characteristics of real estate, fixed effect of year-month and district-month.

5. The Robustness Tests

In this section we present a series of robustness tests based on both alternative control groups and periods of treatment, once the results we have gotten come from a non-experimental evaluation. We also performed a falsification test by assuming a false period of building of the Dona Lindu Park. In the Table 7, the column (1) is the benchmark model, column (6) of the Table 5. In this section, will made eight robustness tests and the first four will be displayed in the Table 7. The first set of robustness test considers the possibility of the influence of non-observable characteristics associate with the potentially imperfect control group.

Initially, it is important to highlight that in the 2000s, the Suape harbor has been enhanced and revitalized, which drew many workers from other cities to RMR (Metropolitan Region of Recife), in particular to the Boa Viagem district, closest neighborhood to the Harbor. The column (2) displays the results. The effect of the Park in the real estate properties remained robust and statistically significant at 1%, with an impact of 3.7% on properties in the region

within 600 meters and a negative effect of 13.3% on real estates in the region between 600 and 1000 meters away from the park.

The column (3) has as control only the Boa Viagem district, but has also introduced a limit of 500 meters away from the ocean. The importance of this point is to maintain a close comparison between the properties. This came from the fact that the Boa Viagem district, despite being one of the wealthiest neighborhoods of Recife, slums essentially surrounds the neighborhood. So we eliminate households located more than 500 meters away from the beach, and we will be comparing more similar properties. Now, there was a positive impact of 12.6% on properties located 600 meters from the Park and the outcome was statistically significant at 1%. The effect of the building of the D. Lindu Park on the properties within 600 and 1000 meters away from the Park had a negative impact of 34.2% and it was also statistically significant at 1%. Thus, for this control group we got stronger effect of the Park on the property's value.

Table 7 –The Robustness Check I: Different Control Groups According to the Distance from the Park

Variables	(1)	(2)	(3)	(4)	(4)
	Benchmark Equation	Only the District of Boa Viagem as a Control	Until 500 meters from The Sea	Eliminating the distance between 1000 and 1500 meters from the Park	Propensity Score Matching
D. Lindu 600	0.077***	0.037***	0.126***	0.064***	0.095***
	(0.016)	(0.023)	(0.023)	(0.018)	(0.020)
D. Lindu 600_1000	-0.119***	-0.133***	-0.342***	-0.134***	-0.429***
	(0.015)	(0.019)	(0.042)	(0.017)	(0.038)
Property Features	Yes	Yes	Yes	Yes	Yes
District FE	No	No	No	No	No
Year FE	No	No	No	No	No
Month FE	No	No	No	No	No
Year-Month FE	Yes	Yes	Yes	Yes	Yes
District-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	57,182	16,072	7,670	54,766	8,536
Adjusted R^2	0.7581	0.812	0.793	0.754	0.8417

Note: Clustered standard errors are presented in parentheses, *indicates a significance of 10%, ** indicates a significance of 5%, *** indicates a significance of 1%; all specifications include a constant not reported.

Thus far, as defined in section 3, the area of influence of the Park in the value of the real estate is restricted to 1000 meters from the D. Lindu. However, it may occur that the distance somewhat larger than 1000 meters from the Park could also be contaminated by the building of it. Thus, we will proceed with a robustness test, column (4), which we eliminated the region that sited between 1000 and 1500 meters away from the Park. One more time, the results are aligned with the previous columns, there was a positive impact of 6.4% for properties located 600 meters from the Park and it was statistically significant at 1%. For the region situated between 600 and 1000 meters away from the D. Lindu there was a negative effect on the real estate prices by 13.4% and it was also significant at 1%.

Thus, trying to improve the balance between the treated and untreated units, we also use a matching strategy for the properties before the estimation of equation (2), which is implemented through the method of the two nearest neighbors[6]. This form of matching involves a trade-off between variance and bias. It trades reduced variance, resulting from using more information to construct the counter-factual for each participant, with increased bias that results from on average poorer matches (Smith, 1997).

For this, we first estimate a Probit model for each property in the sample with the same complete regression used in the benchmark model, the Table 5. Then we apply the method commonly used by second nearest neighbors and then, after the matching, we estimate the model the difference-in-difference strategy. The column (5), table 7, shows the results. When comparing a subset with more similar dwellings, the impact of the Park on the real estate had intensified, in the region up to 600 meters from the D. Lindu and it had an impact on the value of real estate of 9.5% and the for properties on the region between 600 and 1000 meters had a strong negative impact of 42.9%. Hence, when we compare properties with similar characteristics the effect of the Park in the real estate value has intensified.

The following Table demonstrates the robustness tests when we change the treatment periods. In the first column of the Table 8, we reinclude each year of the sample and keep the shock of the building of the park at the time it was actually the delivered of the Park 100% operational to the population, in March 2011. The intention of this test is whether, even at reintroducing the years that were removed from the sample, with the intention of eliminating the effect of the announcement, the result keeps the same. This result is shown in column (1) of the Table 8. Even when we consider the years we removed from the sample, the result did not change significantly. For the treated area, within 600 meters from the park, the appreciation of the properties was 9.1%, as in the region of 600 to 1000 meters the devaluation was 9.7%, close to what was found in the benchmark model.

In the next column of the Table 8, we consider the period of the original sample, which we had removed the period of 2 years and 4 months backwards and afterwards the first opening of the park, in December 2008. And, we dropped from the sample the six months before the announcement of the construction of the park in September 2006. The goal is to test if the announcement has any consequence on the price of the real estate. Column (2) shows the result and they were very close to that found in the main equation, with an appreciation of 7.8% for properties up to 600 meters from Dona Lindu and depreciation of 11.7% for real estates placed between 600 and 1000 meters from the park.

[6] We also implemented through the method of Kernel estimation and the outcome was closer to the results found in this section. The results are available upon request.

Table 8 – The Robustness Check II: Control Groups According to the Periods of analysis

Variables	(1)	(2)	(3)	(4)
	The Whole Sample	Without the 6 Months Prior to the Announcement	Without the Year of 2006	Without the Year of 2009 and 2010
D. Lindu 600	0.091***	0.078***	0.078***	0.081***
	(0.018)	(0.016)	(0.016)	(0.017)
D. Lindu 600_1000	-0.097***	-0.117***	-0.118***	-0.103***
	(0.015)	(0.015)	(0.014)	(0.014)
Property Features	Yes	Yes	Yes	Yes
District FE	No	No	No	No
Year FE	No	No	No	No
Month FE	No	No	No	No
Year-Month FE	Yes	Yes	Yes	Yes
District-Year FE	Yes	Yes	Yes	Yes
Observations	97,433	53,649	52,542	78,281
Adjusted R^2	0.7229	0,7569	0,7545	0,7628

Note: Clustered standard errors are presented in parentheses, *indicates a significance of 10%, ** indicates a significance of 5%, *** indicates a significance of 1%; all specifications include a constant not reported.

In the column (3) of Table 8, we eliminate the entire year of 2006 and the goal is the same as the previous column, reinforce that there is no contamination by the announcement in the pre-treatment period. And, indeed, the results are very close to the previous column, indicating that there is no contamination in the pre-treatment period.

One more time, in the final robustness test, the idea is to check if there was a contamination of the outcome by the announcement of the Park. Remember that we had eliminated the period of 2 years and 4 months backwards and afterwards the first opening of the park in December 2008. Now we use the introduced the whole sample, but without the years 2009 and 2010 and we verify whether, even when we considered this period of time, the results were aligned with the others outcomes found before. The result is displayed at column (4) of Table 8. The effect of the Park on the real estate stays on and it was robust to the test proposed and the building of the D. Lindu Park impacted on the real estate properties was 8.1% in the region within 600 meters away from the park and a there was an effect of -10.3% on properties within 600 to 1000 meters.

As a final falsification exercise, we investigate the existence of differences in time trend of the pre-treatment in the prices of real estate subjected to the effect of the park. In this practice, we will falsely assume that the announcement of the park was made a year before, in September 2005, and we will compare the average price of the properties of the control group and the treatment group using only the years of 2000 to 2005. The estimations for these coefficients will be displayed in the table 9. These results suggest that the effect of the false release of the Dona Lindu Park is not statistically significant. In summary, the results indicate that there is no difference in the change in the price of real estate between the treated and untreated area. Then, as the exercise of leads and lags also suggests, the falsification check

provides sufficient evidence for different trends before of the construction of the park, validating our empirical results found in the previous section.

Table 9 – The Falsification Test: Treatment period

Variables	(1)
D. Lindu 600	0.025
	(0.016)
D. Lindu 600_1000	-0.022
	(0.014)
Property Features	Yes
District FE	No
Year FE	No
Month FE	No
Year-Month FE	Yes
District-Year FE	Yes
Observations	57,182
R^2	0.8092

Note: Clustered standard errors are presented in parentheses, *indicates a significance of 10%,** indicates a significance of 5%, *** indicates a significance of 1%; all specifications include a constant not reported.

6. The Discussion and Final Considerations

Recife is one of the densest cities in Brazil (IBGE, 2010) and with a very poorly distributed green area (Oliveira et al., 2012), most of this green space is located on the districts in the North Zone of the city, away from the district of Boa Viagem, where Dona Lindu Park is situated. Moreover, it is one of the oldest capital cities of Brazil and suffers from a number of similar urban problems of other cities. Its advanced age and the lack of the urban planning incorporating a modern transportation system, for example, makes the city extremely sensitive to the population and the political changes that might affect the price of the real estate. In this regard, the construction of an urban park in one of the wealthiest and densest districts of the city (de Oliveira and Silveira Neto, 2016) can clearly impact the price of the properties around the park. Thus, the aim of this paper is to estimate the causal impact on the price of real estate properties nearby the Dona Lindu Park.

One of the most significant contributions of this paper is to estimate the impact of a park on the property values for a city of a developing country with few green areas available. And, giving our best knowledge, there was no study in such area for Brazil. The database used in this paper is from the municipal government and holds information about the property features and values from the year of 2000 to 2012. The identification strategy via difference-in-difference allowed us to estimate the value of the impact of the park in the housing prices between the region treated (the radius less than 1000 meters away) with the area not subject to treatment (greater than 1000m). The estimates obtained indicate that the properties are located up to 600 meters of the D. Lindu have an average increase of 7.7% in the real estate price. On the other hand, the properties situated between 600 and 1000 meters from the Dona Lindu Park had a decrease in the price of approximately 11.9%. The results suggest that the positive effect to properties nearby the park probably has a positive effect on the real estate properties and for the properties located more distant from the D. Lindu there was a strong negative impact. This is probably because the high density of the district of Boa Viagem and the

adverse effects on this area, such as congestion, noise or excessive garbage, are greater that the positive effect on this region.

Nevertheless, ours estimates are non-uniform in relation to the building of the D. Lindu Park, it depends on the development of demand for real estate in the region because the effect of the building of the Park on the real estate may vary over time and may also be different for each property (Panduro and Vein, 2013). We also point out how a single building may have very different impacts, positive and negative effects, in such a restricted area – 1000 meters from the Park (Pearson, Tisdell and Lisle, 2002). However, ours results are important because they indicate how work conducted by the public sector is able to affect the prices of the individual properties.

REFERENCE

Agência de notícias UFPE. Parque Dona Lindu, legado de Niemeyer no Recife.

Available in: <https://www.ufpe.br/agencia/clipping/index.php?option=com_content&view=article&id=9467:parque-dona-lindu-legado-de-niemeyer-no-recife&catid=373&Itemid=243>. Access in: 12/05/2015.

Anderson, S. T., & West, S. E. (2006). Open space, residential property values, and spatial context. *Regional Science and Urban Economics*, 36(6), 773-789.

Angrist, J., and J.S. Pischke. (2009) Mostly Harmless Econometrics: An Empiricist's Companion. *Princeton University Press*.

Barros, H. R., & Lombardo, M. A. (2012). A relação entre ilhas de calor urbana, ocupação do solo e Morfologia urbana na cidade do recife. *REVISTA GEONORTE*, Edição Especial, 2, 65-76.

Becker, G. S. (1974). Crime and punishment: An economic approach. In Essays in the Economics of Crime and Punishment (pp. 1-54). *NBER*.

Bertrand, M., Duflo, E., & Mullainathan, S. (2002). How much should we trust differences-in-differences estimates? (No. w8841). *National Bureau of Economic Research.*

Cheshire, P., & Sheppard, S. (1995). On the price of land and the value of amenities. Economica, 247-267.

Cho, S. H., Bowker, J. M., & Park, W. M. (2006). Measuring the contribution of water and green space amenities to housing values: an application and comparison of spatially weighted hedonic models. *Journal of Agricultural and Resource Economics*, 485-507.

Crompton, J. L. (2001). The impact of parks on property values: A review of the empirical evidence. *Journal of Leisure Research*, 33(1), 1-31.

Crompton, J. L. (2005). The impact of parks on property values: empirical evidence from the past two decades in the United States. *Managing Leisure*, 10(4), 203-218.

Dantas, R. A., Magalhães, A. M. e Vergolino, J. R. O. (2007). Avaliação de imóveis: a importância dos vizinhos no caso de Recife. *Revista de Economia Aplicada* 11(2):231–251.

Deckker, Z. Q. (2001). Brazil built: the architecture of the modern movement in Brazil. Taylor & Francis.

Ellis, C. D., Lee, S. W., & Kweon, B. S. (2006). Retail land use, neighborhood satisfaction and the urban forest: an investigation into the moderating and mediating effects of trees and shrubs. *Landscape and Urban Planning*, 74(1), 70-78.

Emerenciano Albuquerque, E., & Matos Magalhaes, A. O. (2008). Ativo ambiental e preço de imóvel na cidade do Recife: um estudo exploratório a partir da utilização do método dos preços hedônicos.

Espey, M., & Owusu-Edusei, K. (2001). Neighborhood parks and residential property values in Greenville, South Carolina. *Journal of Agricultural and Applied Economics*, 33(3), 487-492.

Fávero, L. P. L., Belfiore, P. P., & Lima, G. A. (2008). Modelos de precificação hedônica de imóveis residenciais na região metropolitana de São Paulo: uma abordagem sob as perspectivas da demanda e da oferta. *Estudos Econômicos (São Paulo)*, 38(1), 73-96.

Franklin, A. (2014). Parque Dona Lindu: A marca de Oscar Niemeyer no Recife. Available in: < http://wsimag.com/pt/arquitetura-e-design/10287-parque-dona-lindu>. Access in: 13/05/2015.

Freeman III, A. M., Herriges, J. A., & Kling, C. L. (2014). *The measurement of environmental and resource values: theory and methods*. Routledge.

Geoghegan, J. (2002). The value of open spaces in residential land use. *Land use policy*, 19(1), 91-98.

Gutierrez, R. G., Linhart, J. M., and Pitblado, J. S. (2003) From the help desk: Local polynomial regression and Stata plugins, *The Stata Journal*, 3 (4), 412-419.

Heckert, M., & Mennis, J. (2012). The economic impact of greening urban vacant land: a spatial difference-in-differences analysis. *Environment and Planning-Part A*, 44(12), 3010.

Hermann, B. M. e Haddad, E. A. (2005). Mercado imobiliário e amenidades urbanas: a view through the window. *Estudos econômicos*, 35(2):237–269.

Irwin, E. G. (2002). The effects of open space on residential property values. *Land economics*, 78(4), 465-480.

Jim, C. Y., & Chen, W. Y. (2006a). Impacts of urban environmental elements on residential housing prices in Guangzhou (China). *Landscape and Urban Planning*, 78(4), 422-434.

Jim, C. Y., & Chen, W. Y. (2006b). Recreation–amenity use and contingent valuation of urban greenspaces in Guangzhou, China. *Landscape and urban planning*, 75(1), 81-96.

Jim, C. Y., & Chen, W. Y. (2009). Value of scenic views: Hedonic assessment of private housing in Hong Kong. *Landscape and urban planning*, 91(4), 226-234.

Kolbe, J., & Wüstemann, H. (2014). Estimating the value of Urban Green Space: A hedonic pricing analysis of the housing market in Cologne, Germany (No. 2015-002). *SFB 649 Discussion Paper*.

Kong, F., Yin, H., & Nakagoshi, N. (2007). Using GIS and landscape metrics in the hedonic price modeling of the amenity value of urban green space: A case study in Jinan City, China. *Landscape and Urban Planning*, 79(3), 240-252.

Linden, L., & Rockoff, J. E. (2008). Estimates of the impact of crime risk on property values from Megan's laws. *The American Economic Review*, 1103-1127.

Luttik, J. (2000). The value of trees, water and open space as reflected by house prices in the Netherlands. *Landscape and urban planning*, 48(3), 161-167.

Lutzenhiser, M., & Netusil, N. R. (2001). The effect of open spaces on a home's sale price. *Contemporary Economic Policy*, 19(3), 291-298.

Maas, J., Verheij, R. A., Groenewegen, P. P., De Vries, S., & Spreeuwenberg, P. (2006). Green space, urbanity, and health: how strong is the relation?. *Journal of epidemiology and community health*, 60(7), 587-592.

Nelson, J. P. (2004). Meta-analysis of airport noise and hedonic property values. *Journal of Transport Economics and Policy (JTEP)*, 38(1), 1-27.

Silveira Neto, R. D. M. S.,Duarte, L. & Sampaio, B. (2014). Restrição sobre Uso do Solo Urbano e Valor dos Imóveis: uma Avaliação do Impacto da Lei dos Doze Bairros da Cidade do Recife.

Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. *Urban forestry & urban greening*, 4(3), 115-123.

Oliveira, T. H., Dantas, J. G., Botler, M., da Silva, R. R. V., da Silva, J. P. F., & da Fonte Neves, T. (2012). Mensuração e distribuição do verde urbano no município do Recife–PE: bases para a gestão ambiental urbana.

de Oliveira, T. G., & Silveira Neto, R. D. M. (2016). SEGREGAÇÃO RESIDENCIAL NA CIDADE DO RECIFE: UM ESTUDO DA SUA CONFIGURAÇÃO. *Revista Brasileira de Estudos Regionais e Urbanos*, 9(1), 71-92.

Panduro, T. E., & Veie, K. L. (2013). Classification and valuation of urban green spaces—A hedonic house price valuation. *Landscape and Urban planning*, 120, 119-128.

Pearson, L. J., Tisdell, C., & Lisle, A. T. (2002). The impact of Noosa National Park on surrounding property values: An application of the hedonic price method. *Economic Analysis and Policy*, 32(2), 155-171.

Pope, D. G., & Pope, J. C. (2015). When Walmart comes to town: Always low housing prices? Always?. *Journal of Urban Economics*, 87, 1-13.

Price, C. (2003). Quantifying the aesthetic benefits of urban forestry. *Urban Forestry & Urban Greening*, 1(3), 123-133.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1), 41-55.

Rossi-Hansberg, E., Sarte, P. D., & Owens III, R. (2008). Housing externalities (No. w14369). National Bureau of Economic Research.

Seabra, D. M. Silveira Neto, R. D. M. & Menezes, T.A.O. (2015). Mercado Imobiliário e Amenidades: Evidências para a Cidade do Recife.

Seok Lim, J., & Missios, P. (2007). Does size really matter? Landfill scale impacts on property values. *Applied Economics Letters*, 14(10), 719-723.

Schläpfer, F., Waltert, F., Segura, L., & Kienast, F. (2015). Valuation of landscape amenities: A hedonic pricing analysis of housing rents in urban, suburban and periurban Switzerland. *Landscape and Urban Planning*, 141, 24-40.

Smith, H. (1997). Matching with Multiple Controls to Estimate Treatment Effects in Observational Studies, *Sociological Methodology*, 27, 325–353.

Smith, V. K., Poulos, C., & Kim, H. (2002). Treating open space as an urban amenity. Resource and energy economics, 24(1), 107-129.

Troy, A., & Grove, J. M. (2008). Property values, parks, and crime: A hedonic analysis in Baltimore, MD. *Landscape and urban planning*, 87(3), 233-245.

Van Herzele, A., Wiedemann, T. (2003). 'A monitoring tool for the provision of accessible and attractive urban green spaces'. *Landscape Urban Planning*. 63.