The effects of burying a highway on housing prices: evidence from Parques del Rio in Medellin

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Abstract

The nature and extent of the effects of highways on the quality of life of those living near them remains an open question in economics. Previous research has found both positive and negative effects associated with them, such as amenities, market access, property values, etc. This work will study the *Parques del Río* project, a linear park in the city of Medellín, Colombia, which is located in its downtown; the park united the two shores of the Medellín river and buried a section of the two highways that ran alongside it, this work will focus particularly on the effect this project had over housing prices. We find that for the year 2016, when the first half of the project was completed, there was a significant positive effect on housing prices, which wore down over time.

JEL Codes: H54, O18, R31

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1 Introduction

The nature and extent of the effects of highways on the quality of life of those living near them remains an open question in economics. Previous works have found both positive and negative effects associated with them. On one hand, given the increase in connectivity and access, the nature of the positive effects is both clear and relatively easy to quantify (Levkovich et al., 2015). On the other hand, there are several negative effects, of which the most notorious is the "community severance" effect, which consists of a loss in welfare for the inhabitants of the neighborhoods where the highway was built, who now have a much harder time accessing amenities located on the other side of the highway (Grisolía et al., 2014). There are other negative effects associated with the increase in air and noise pollution due to the higher traffic levels (Levkovich et al., 2015). These effects are much harder to pin down but are extremely relevant given the discussion surrounding urban renewal and the relation between highways and suburbanization (Baum-Snow, 2007). This trade-off and the difficulty of measuring the negative effects of highways have led to an inaccurate appraisal of their social costs.

Linear parks, a staple of urban renewal projects, are defined by the fact that, unlike conventional parks, they are much longer than they are wide (Spacey, 2017). The main sources of their attractiveness for urban renewal projects are varied: they mesh seamlessly with existent infrastructure–such as canals, bike paths, and highways–or natural features, such as rivers and shorelines–boosting alternative means of transportation. These parks also provide various means of recreation in the same manner as conventional parks, in the form of food trucks, green spaces, playgrounds, sports grounds, etc. (Barber, 2018). Finally, they connect previously separated neighborhoods by reclaiming pedestrian space in the downtowns of cities (Madrid Nuevo Norte, 2020).

The *Parques del Río* project in Medellín is a linear park located in the city's downtown with the stated objective of bringing together the river's shores (see Figure A.1). The project was approved in 2014, works started in 2015 (El Tiempo, 2015) and ended in 2019. The *Parques del Río* project connects the two banks of the river and has a size of 72 square kilometers (Alcaldía de Medellín, 2022). It is intended as a space for leisure and various open-air activities, it is filled with green spaces, sports grounds, and bike paths, and it provides an easy means for pedestrians to cross the river, which has historically split the city into two halves and made moving between them somewhat difficult. This project is an interesting case of study for our purposes as it buried a small but important section of the two highways located on both sides of the river (a section of the *Avenida Regional* and a section of the *Autopista Sur*).

The idea of burying a highway has been studied in various theoretical scenarios (Grisolía et al., 2014) but has rarely been seen in practice, with one notable exception being the Cheonggyecheon River linear park in Seoul (see Figure A.2), Wang, 2014. Such a case of a highway being buried in the real world is highly useful as it provides an excellent natural experiment to measure the scale and nature of the negative effects of highways, as it ameliorates them while leaving their positive effects mostly unchanged. Most of the previous works that could be found that studied the *Parques del Río* project focused exclusively on its financial viability, as opposed to its effects on the welfare of the inhabitants of the nearby neighborhoods.

Economic theory suggests that highways have positive effects, in the form of increased connectivity and access to amenities, especially at the regional level, even if not on a purely local one (Brinkman & Lin, 2022). The work of Artigue et al. (2022) suggests that housing in high amenity areas, depending on whether they are located in a small town or a rural area vs a large city, either presents an increase in housing prices for large metropolitan areas or increased demand that instead leads to an increase in population growth for high amenity rural or small metro counties. Asahi et al. (2022) find that increased amenities in urban areas also lead to a significant increase in residential floor space, as long as land use regulations do not put a constraint on housing supply.

Grisolía et al. (2014) performed a binary choice experiment that measured the willingness to pay of various inhabitants of the Canary Island of Las Palmas in exchange for burying the GC-3 highway, along with providing various other additional amenities such as CCTV cameras, a green space and urban furniture that would attract people to the area. The authors find that people were willing to pay a rather high amount of money in exchange for burying the highway: 73 euros per year for those who do not cross the highway as pedestrians and 149 euros for those who do.

Baum-Snow (2007) finds that highways contributed significantly to the suburbanization of cities in the United States, with each highway reducing the population of its respective city center by 18%. The positive effects of highways are more significant for suburbia, as it grants them access to amenities and jobs located in the city center, while those who were living in the city center already had access to those amenities and faced the brunt of the disamenities caused by the highways. Brinkman and Lin (2022) find similar results, attributing a third of the effect of highways on the decline of city centers to a diminishment in the quality of life due to the resultant disamenities. They also find, through a general equilibrium model, that the benefits of burying highways are very large and concentrated in the downtown.

In their work Levkovich et al. (2015) conclude that greater accessibility had a positive effect on the value of properties located near the newly built A30 and A50 highways, while the increase in noise pollution and traffic had a negative effect on the value of such properties. For Highway A50 the combined effect of both externalities was positive, even before the completion of the project. Whereas for Highway A30, the negative effect was predominant. Levkovich et al. (2015) propose that this is because the area in which it was built already had high accessibility levels.

However, building highways also has significant negative effects in the form of the “barrier effect” (Grisolía et al., 2014), which splits communities in half and makes it harder to access amenities that used to be a short walk away but now are on the other side of the highway. Highways also increase traffic levels and noise pollution (Levkovich et al., 2015; Parry et al., 2007) as well as worsening health outcomes for newborns, infants (Currie & Walker, 2011) and adults (Anderson, 2020), negatively affecting those living close to highways in multiple ways. It is important to keep in mind that these negative effects on health outcomes come not only from the highways themselves but also from the community severance effect they cause, which has been found by itself (without taking traffic into account) to have negative effects on the self-reported health of adults in Great Britain as reported by Higgsmith et al. (2022).

Given the nature of the *Parques del Río* Project (connecting two areas on different sides of the Medellín River and burying the highways that are in between them), no community severance was caused by the highway itself. Therefore, rather than ameliorating a barrier effect, the project connects two neighborhoods that were never interconnected in the first place. This new connection can also potentially lead to an increase in crime levels, as there's a stark contrast in the economic affluence of both neighborhoods, which can serve as an incentive for criminals to move from the less wealthy community to the wealthier one.

Taking into account this possibility, it's fitting to conclude by mentioning the work of Khanna et al. (2022), who carried out a study on the effects of a gondola lift system in Medellín (also known as Metro Cable). This gondola facilitated movement in and out of the poor informal neighborhoods on the slopes of the hills surrounding the city. They find that this increased connectivity led to a marginal increase in crime levels in lower crime neighborhoods, but an overall increase of welfare in the city driven by increased employment and economic opportunity in high crime neighborhoods, substantially reducing the crime in said locations. These results suggest that "improving access to jobs in economically segregated parts of the city can substantially lower crime rates in high-crime environments".

This paper estimates the effect of the announcement, construction, and completion of the *Parques del Río* project over the value of nearby properties. For this purpose, we use different data sources pulled from Medellin's Cadaster, Colombia's national census, and the various standing land use regulations as established by the city's zoning ordinance, together with a difference-in-differences methodology with two different strategies. Our main results suggest that the presence of the *Parques del Río* project increased the value of nearby properties for the year 2016, yet said increase was short-lived and wore off over time.

This paper contributes to this debate by focusing on the effects on property prices of burying a highway. When a highway, or a fraction of it, is buried, the connectivity of nearby areas is not affected, but it can positively affect communities by decreasing the severance effect, as well as by decreasing pollution. This question also contributes to the discussion about the effects of urban renewal projects that seek to increase walkability in city centers.

The rest of this work (without counting this introduction) is divided into another four sections. The second section describes the data we use. In the third section, we describe the empirical model used to estimate the effects of Parques del Rio on housing prices. The fourth section presents the results of our models. Finally, the fifth section presents our conclusions and discusses their significance.

2 Data

To study the effects of the *Parques del Río* project on housing prices, we use the following three main data sources. First, the OIME (*Observatorio Inmobiliario de Medellín*), an initiative carried out by Medellin's cadaster sub-secretary, seeks to track the dynamics of the real estate market in the city. These data provide us with information regarding the location, value of the property, type (apartment, home, parking lot, etc.), and area of various real estate that were up for sale (or sold) each year for the 2008-2021 period. The OIME data is meant to provide a representative sample of the dynamics in the Housing market in the city, but it does not track every single transaction that took place.[1]

Due to certain features of the data, among those, the lack of residential properties on the east bank of the River (as shown in Figure 2 below) and the relatively low amount of observations for years 2008 and 2009 in the OIME data, we restrict our sample to those properties on the west bank of the Medellín River and whose transaction was registered in 2011 onwards. From these data, we construct our main measure of property values using only apartments and homes and excluding other kinds of properties, such as storage and commercial real estate.

It is important to mention that the version of the OIME data used for this project is a deprecated version, different from that which is currently available on the OIME webpage (even for the same years), as the newer data presents a very significant reduction in the number of observations compared to the older version, we opted to use the latter to have the largest number of observations possible.

Second, we use the 2018 Colombian Census (*Censo Nacional de Poblacion y Vivienda*), constructed by the National Department of Statistics (DANE), which provides us with individual and house-level data with their respective block identifiers. These data include information on the construction materials of each house, the number of rooms, socioeconomic data of the inhabitants, etc. These data will help us characterize the various city blocks and the properties located within them. Since these data do not contain property level data (our unit of analysis), we calculate the mean of the variables for the various city blocks and then associate said means to the OIME data to make use of the information contained in the census.

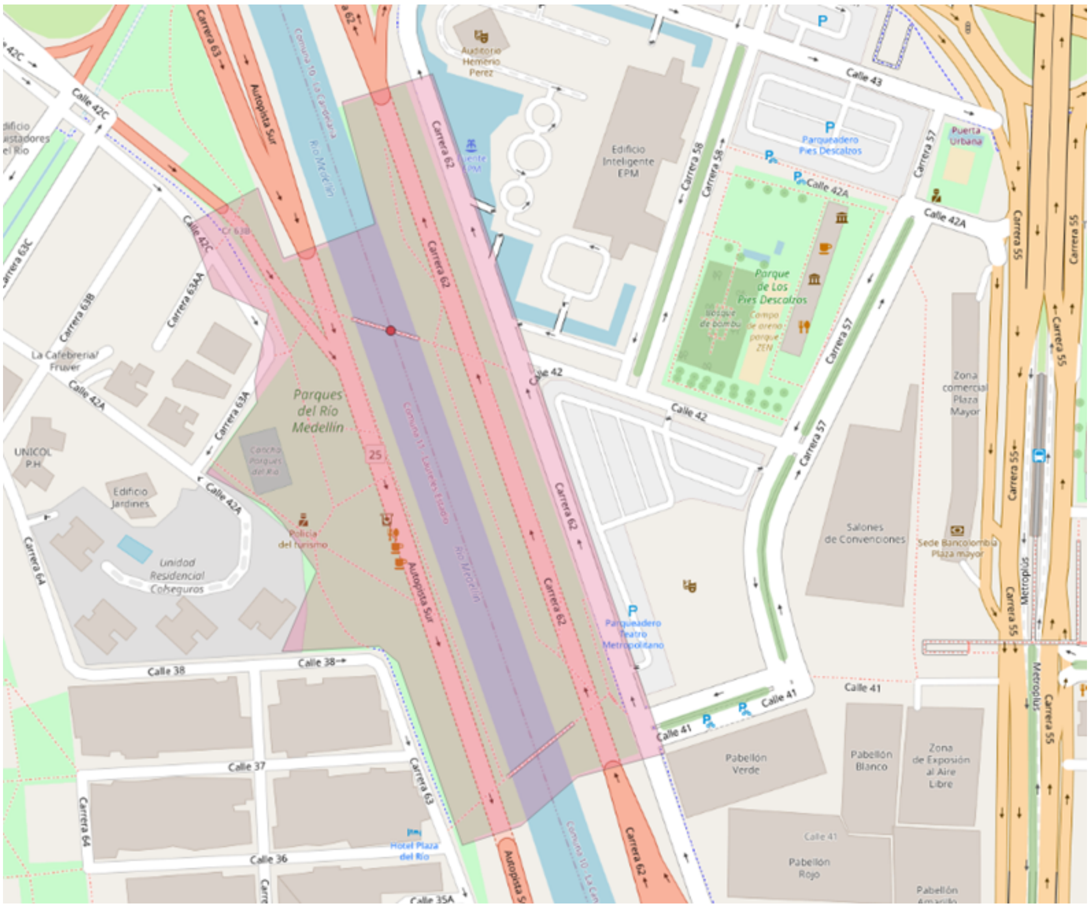
Third, we retrieve several maps containing different characteristics from the land use regulations in the city as established by the building code in the *Plan de Ordenamiento Territorial* (POT), which is equivalent to the city's zoning Ordinance. These data are useful to know whether the area in which a property is located is for residential, business, or mixed usage, as well as the allowed built density in that location. Previous literature has shown that land use regulations could affect housing prices and welfare within cities (Acosta, 2021). All these data are geo-referenced, and the purpose is to have a unified database where all the properties

[1] It is also worth pointing out that the OIME data used in this work also presented several complications which may have concealed the possible effects of the project, as the data presented several changes in variable notation during the period encompassed by the data, as well as sometimes proposing implausible values for variables. It is also worth mentioning that the version of the OIME data used for this project is an older version, different from that which is currently available on the OIME webpage (even for the same years), as the newer data presents a very significant reduction in the number of observations compared to the older version, we opted to use the latter to have the largest number of observations possible.

described in the OIME database are paired with the census characteristics of their respective city block and the land usage attributed to the area by the POT.[2]

Moreover, to measure the effects of the *Parques del Río* project, it is necessary to measure the distance between the various properties of the OIME database and the project. Therefore, using different architectural and financial documents as a starting point (Gómez & Taborda, 2020) (Alcaldía de Medellín, 2022), we build a GIS polygon to represent *Parques del Río*. The shape of the polygon is defined as comprising the whole of the area between the start of the buried highway and its return to the surface. Afterward, the centroid of the polygon is calculated with the intention of estimating the distance between the properties listed in OIME and said centroid. As the centroid of the polygon was in the middle of the Medellín River, the actual point of comparison taken to estimate the distance between the various OIME properties and the *Parques del Río* project was moved slightly north of the centroid, in the middle of a pedestrian bridge connecting the two sides of the Medellín river.

Figure 1: Parques del Rio - Polygon and Central Point



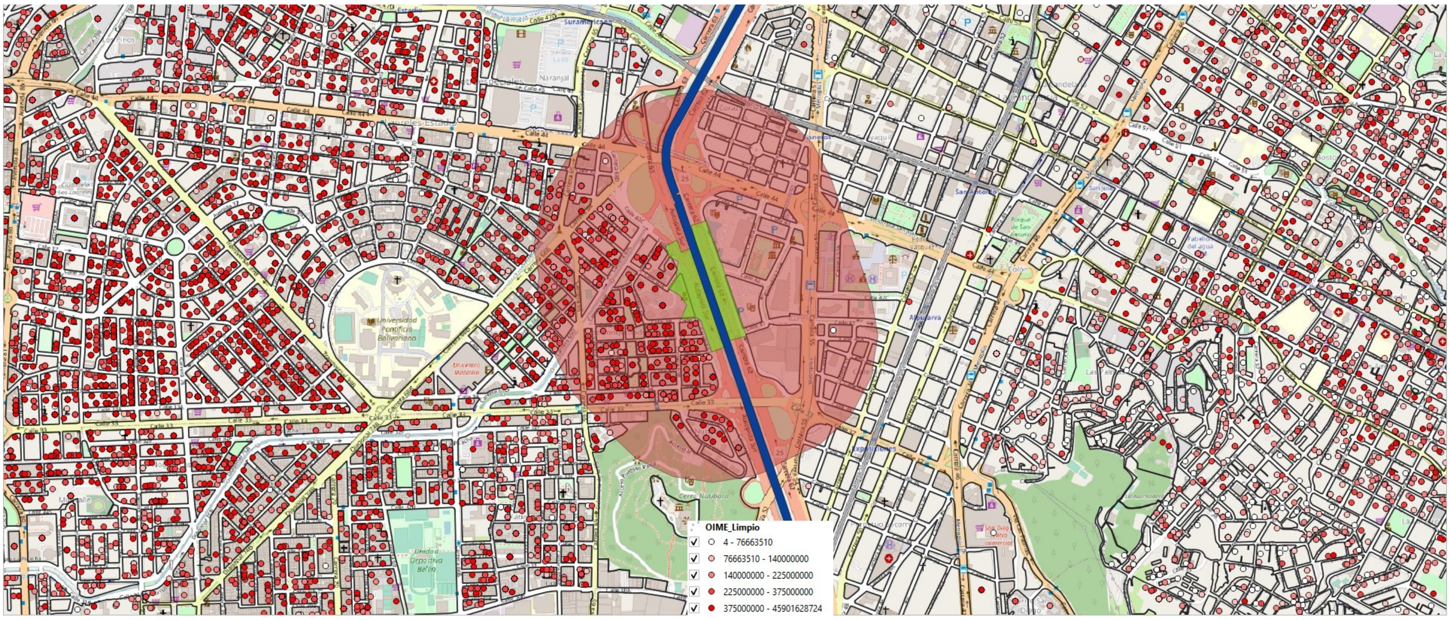
The defined *Parques del Río* polygon and the point taken to measure the distances of the various properties listed on the OIME database, imposed over a map of the city of Medellín.

[2]See Table A.2 for a description of each of the variables we used. On a related note, since the number of observations for Land Usage categories 4, 5, and 6 was rather low, which was to be expected, as we are interested exclusively in residential properties and only included those in the sample, we merged those 3 categories into one.

In Figure 1, we plot the polygon and centroid of Parques del Rio. The two thin lines crossing the River correspond to Pedestrian Bridges that were part of the construction of the Park. On the right side of the River, there are important Points of Interest, such as the convention center and the Metropolitan Theater, among others.

In Figure 2, we plot the same polygon together with the transactions listed in OIME for an area close to the project. In Figure 2, the stark contrast between the western and eastern banks of the Medellín River can be observed, with the western side of the city recording significantly more housing properties for sale as well as much higher prices for said properties. These patterns are explained by the western bank of the river mostly consisting of the *Conquistadores* neighborhood, which is a high-income residential area. The eastern bank is almost exclusively constituted by small businesses with no residential areas to speak of at all–it is especially famous for *El Hueco*, which is a shopping area (an open-air market of sorts) with a reputation for cheap products and haggling. Even though these blocks are relatively safe, it is surrounded by several hotspots for theft. This contrast led us to conclude that the location of the property using the Medellín River as a point of reference (either to the west or to the east of it) was also another variable of interest and that there were very few properties located on the eastern bank of the Medellín river close by to the project whose value could have been affected by it.

Figure 2: Parques del Rio and Housing Transactions with Property Value



The defined *Parques del Río* polygon and properties that are either houses or apartments for sale in the real estate market recorded by the OIME for the 2008-2021 period, color-coded according to their property value, the red circle encompasses all the properties that are within a 500-meter radius of *Parques del Río*, imposed over a map of the city of Medellín.

In Table 1, the means of the most relevant variables are given, separated according to their distance from the *Parques del Río* Project.[3] One can observe that the value[4] of those properties closest to the project is higher, especially in comparison to that of those properties which are close (within 500m) to the river but more than 2km away from *Parques del Río*. While size does not change significantly between those properties close to the project and those farther away from it, those close to the river are, on average, around $30m^2$ smaller.

For social stratum, there is a seeming contrast with property value, where, despite being worth more, properties closer to the *Parques del Río* project tended to be classified as having a lower social stratum than those farther away from it, this is not a contradiction, but a result of the way social stratum is defined in Colombia [5], while those properties close to the river follow the general trend they did in the other variables and likewise have a lower social stratum than the other two groups. Finally, it can be observed that, in general, those properties close to the *Parques del Río* project and those far away share a similar composition in regards to the type of property they are, with the overwhelming majority being gated community houses; while those properties farther away are also for the most part gated community houses, there is a much greater proportion of houses that are not part of a gated community.

Overall, one can see that for the most part, those properties close to the *Parques del Río* are more similar in their characteristics to those in the surrounding area than to those properties that are also far away from the project but alongside the river; which shows that the former (those in the 501-2000m radius) are a better control group than the latter.

Table 1: Means of various variables of interest for various groupings

Variables	**Grouping of sample**			
	All	<500m radius	501-2000m radius	500m from River
Property Value (millions of COP)	263$	389$	344$	238$
Carpet Area (square meters)	119.93	137.69	139.97	109.95
Social Stratum (*estrato social)*	3.19	3.32	3.73	2.73
Type of Property				
House	22.22%	11.66%	18.38%	30.87%
Gated Community House	71.96%	87.97%	79.77%	65.69%
Apartment	5.82%	0.36%	1.85%	3.44%
Observations (N)	49,662	823	6,269	2,556

[3] As for the various groupings of the sample, "all" refers to every single OIME observation, "<500m radius" refers to those observations that were within 500 meters of *Parques del Río*, "501-2000m radius" refers to those properties that were farther away than 500 meters but within 2000 meters of the project, and "500m from River" refers to those properties that were within 500 meters of the Medellín river but more than 500 meters away from *Parques del Río*, this third group was added as a "control group" of sorts to compare with those properties close to Parques del Río.

[4] To contextualize these values, note that the exchange rate of US Dollar to Colombian person went from 2000 COP/USD at January of 2010 (the start of our sample) to 4000 COP/USD by December of 2021 (the end of our sample)

[5] Social Stratum is a variable that is idiosyncratic to Colombia. It is a measure of the socioeconomic status of the inhabitants of a particular property. An interesting particularity of it is that rather than being assigned to a particular household, it is assigned to the property itself.

3 Methodology

To measure the effects of the project on property prices, we estimate the following event study equation:

$$logp_{it} = \alpha_t + \beta_t \star Treatment_i + \gamma \star X_i + \epsilon_{it} \quad (1)$$

where $logp_{it}$ corresponds to the logarithm of the property price, α_t and β_t denotes year fixed effects, where the latter are interacted by $Treatment_t$, which is a dummy variable that equals 1 when a property is “treated” by Parques del Rio. We define our two identification strategies to define which properties we consider to be treated in the following paragraphs. X_i is a vector of time-invariant control variables, which are presented in Table A.2. This vector includes housing characteristics (such as size, whether the property is an apartment, is new, has a storage unit, or has parking space), regulatory controls (maximum allowed density and land use categories), and the social stratum categories from the Census. Subindexes i and t represent the specific property and the year of the observation, respectively. We implemented robust standard errors to estimate the ϵ_{it} error term to account for the potential heteroscedasticity problems in our model associated with the variance of property prices along the river and on both sides of it.

For our first strategy, we take all properties within a certain distance (one implementation used 500 meters and another used 1 kilometer) from the *Parques del Río* project and take said properties as our treatment group and we compare them with other properties that were farther from the project than the specified distance, but within the radius of said distance in comparison to the Medellín river, to avoid including properties that were too far away from the Medellín river and Medellin’s city center.

The second strategy was to establish a set of two rings around *Parques del Río*, one consisting of those properties located within 500 meters of the *Parques del Río* project (the treatment group) and another one for those properties within the 500 meters to 2 kilometers range from *Parques del Río* (the control group). We also experiment by tweaking the distances encompassed by the rings and study a second implementation of this strategy with ranges of 0-300 meters and 300-1500 meters for the treatment and control groups, respectively.

Finally, we also exploit various critical dates of the *Parques del Río* project through an event study methodology. The dates of interest are:

- 2014: The project is officially announced in the POT (we take this as the ”base year” for the event study specifications).
- 2015: Works begin.
- 2016: Phase 1A is completed.
- 2019-2020: Phase 1B (and the project as a whole) is completed.

Therefore, the analysis will encompass three time periods, one before the announcement of the project in 2014, one after the project was announced but before it was completed, and one after it has been completed. The goal of dividing it into these three periods is to separate the different phases of the project that can have a differentiated effect on housing prices, as discussed and done by Levkovich et al. (2015) and Hoyos Barba and Vallejo Hernandez (2021). This analysis will help us estimate the project's effects on housing prices.

4 Results

We present the results for the first identification strategy in Figures 3 and 4. Recall that this strategy consisted of taking all properties within a certain distance from the *Parques del Río* project as our treatment group and comparing them with other properties that were farther from the project but also within the same radius from the Medellín River.

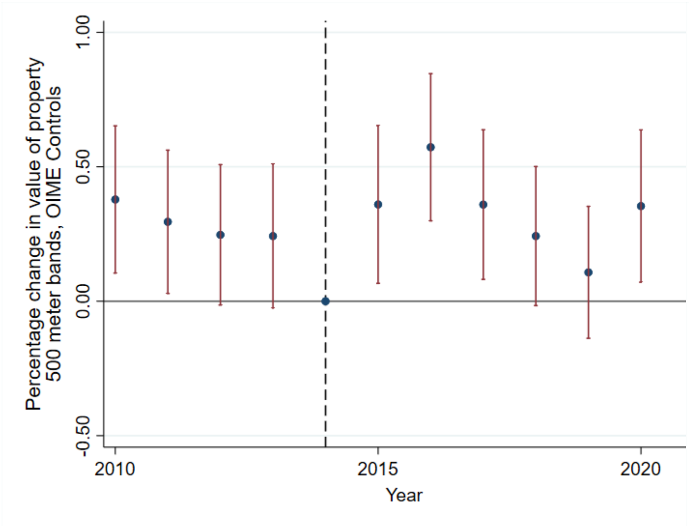
It is interesting to note that the estimates for the first years after the project was announced and the first phase was opened (2015 to 2017) are statistically different from zero in most of the specifications. The specifications differ in the set of control variables used. In particular, the results for the year 2016 consistently remain statistically significant, no matter the specification or set of controls used.

These results could serve as evidence in favor of the idea that the project had a positive effect on property prices, as by 2016, works on the first phase of the project had already concluded, sending a signal to the market that the local government is serious about carrying out the project. However, this increase in property values does not seem to remain for the following years after 2016.

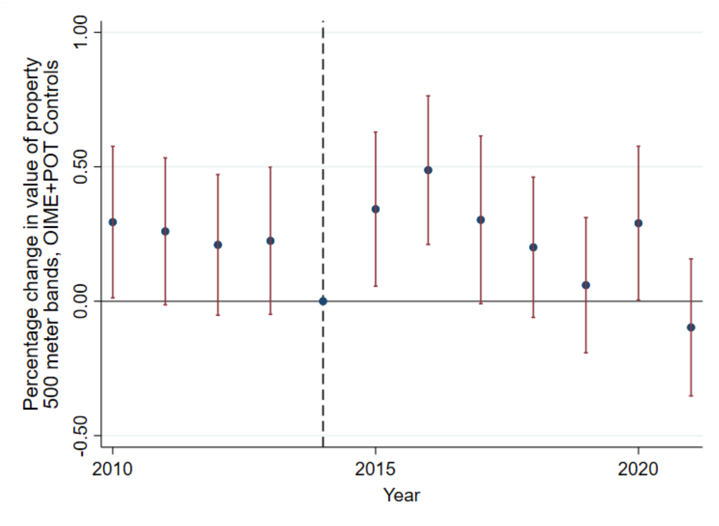
These results are in line with other research. For example, Brinkman and Lin (2022) find that the benefits of burying highways are very large and concentrated in the downtowns of cities. Since the *Parques del Río* project is located in Medellín's downtown, it makes sense that the effects on property prices are always positive and never negative when statistically significant. However, it is still odd that they are only statistically significant in certain years and not for the whole period after the end of the project.

This seems to imply that in the following years, some consequence of the project, such as an increase in crime or at least the perception of it (Khanna et al., 2022); or the disturbances caused by the continuation of the works for the second phase of the project, could have played a role in reducing the initial positive effect.

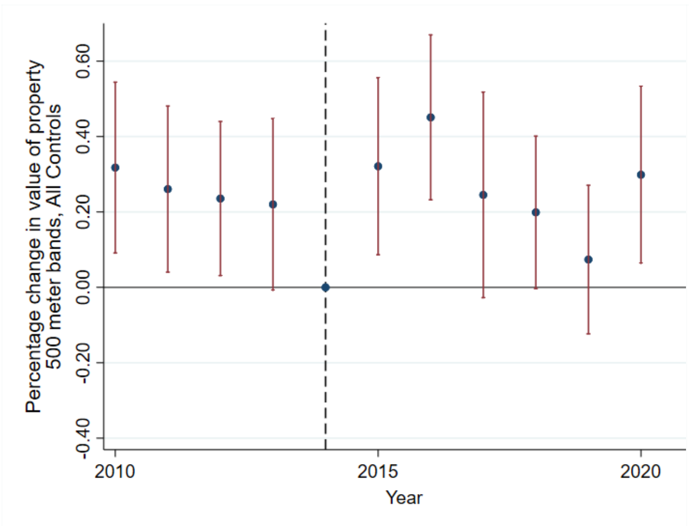
Figure 3: Event Study Plots for the 500-Meter Range Design



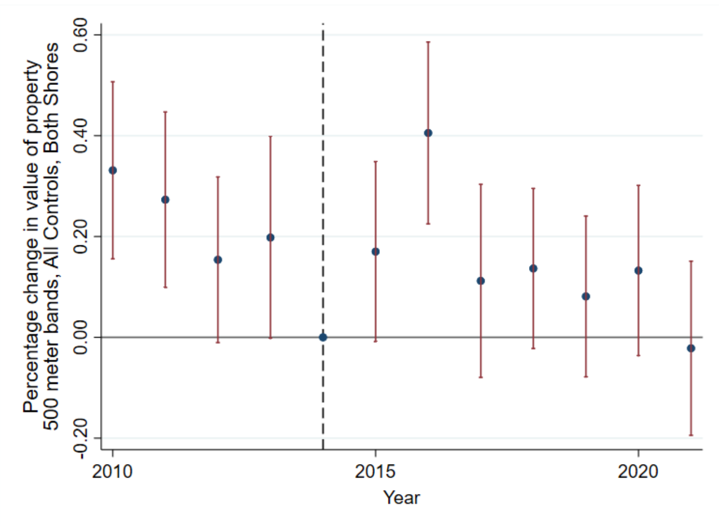
Panel A: OIME Controls



Panel B: OIME+POT Controls

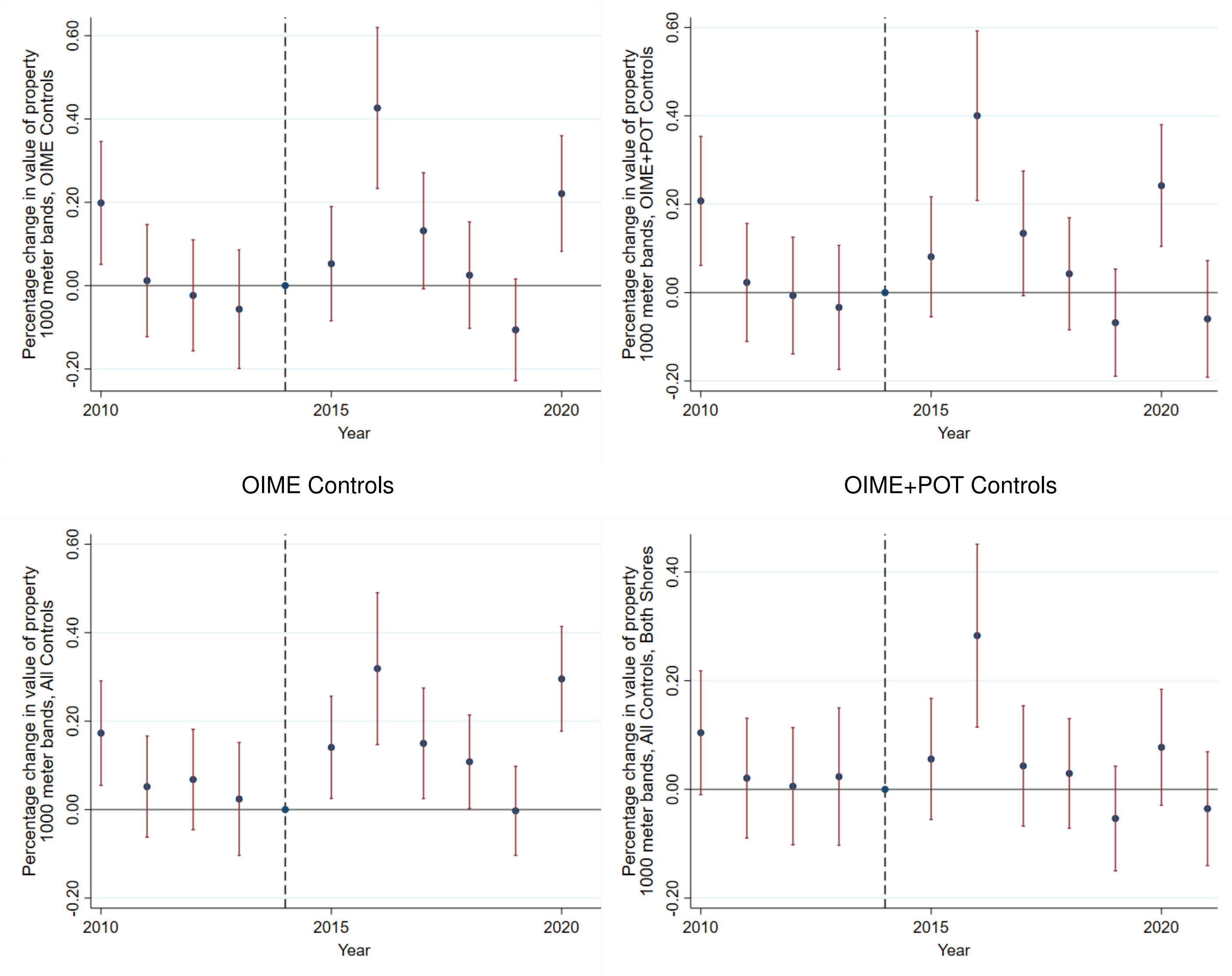


Panel C: All Controls



Panel D: All Controls+Both shores

Figure 4: Event Study Plots for the 1000 Meters Range Design



OIME Controls

OIME+POT Controls

All Controls

All Controls+Both shores

Now, we present the results for the second identification strategy in Figures 5 and 6. Recall that this strategy consisted of establishing a set of two rings around *Parques del Río*, one larger than the other; the treatment group consisting of those properties located within the first, smaller ring, and defining as the control group those properties that are inside the second, larger ring but not inside the first one. While the coefficients estimated for the regressions that used the 0-300m and 300-1500m ring specifications were all statistically insignificant, no matter the set of controls used. This may be the result of the lower number of observations for these specifications, as the specifications with 0-500m and 500-2000m rings obtained results that were all consistently significant for the years 2010, 2016 and 2020, no matter the set of controls used; and when using all controls except for the shore variable, even the coefficient for 2015 shows the project had a statistically significant impact over property prices.

Figure 5: Event Study Plots for the 0-500m and 500-2000m Rings Design

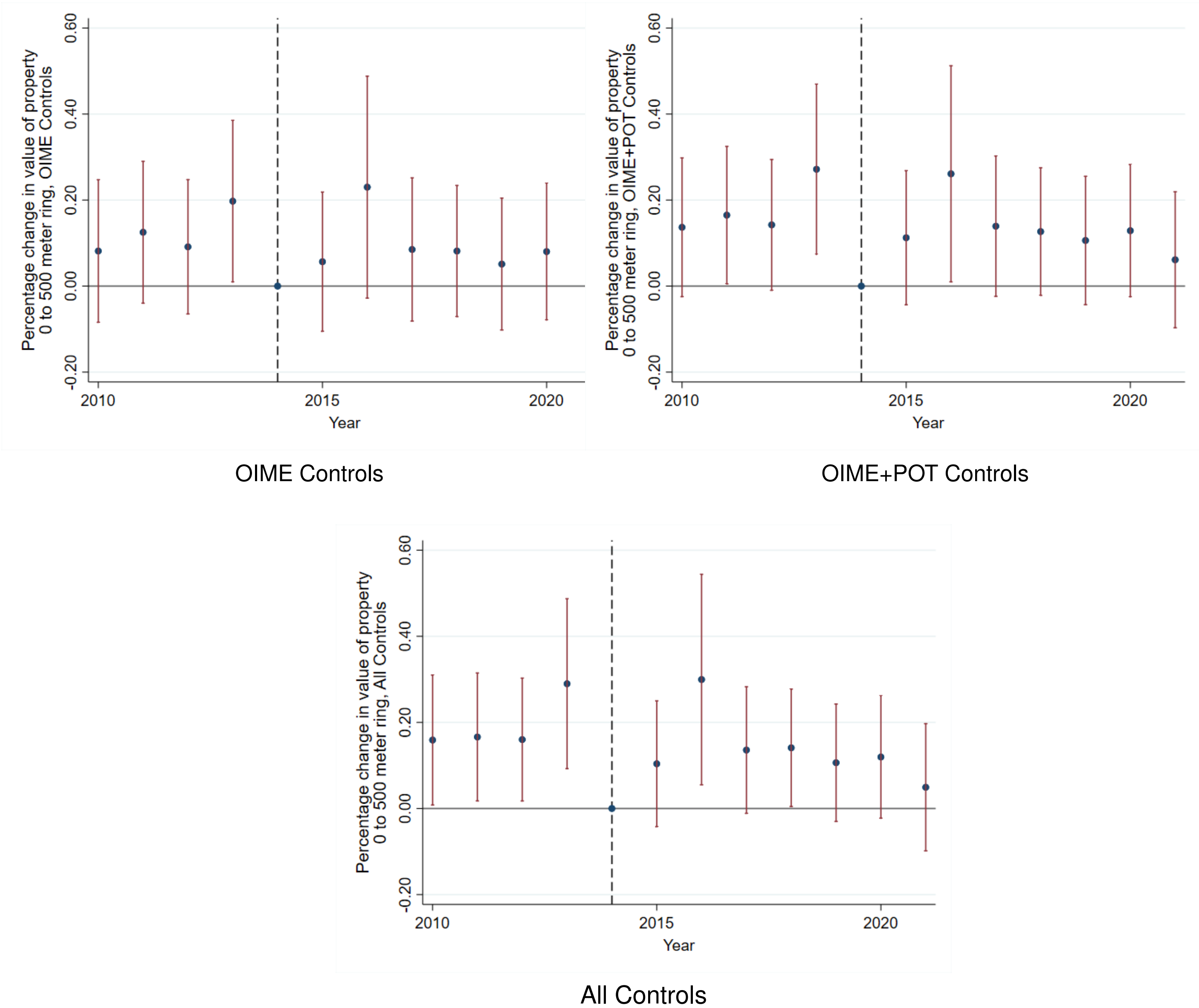
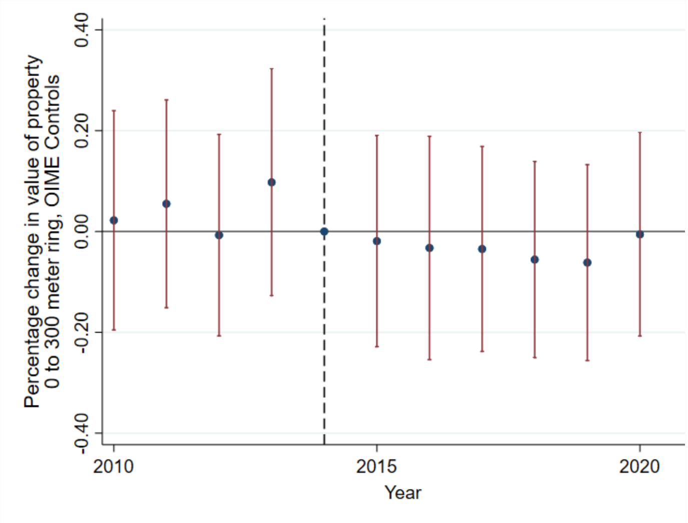
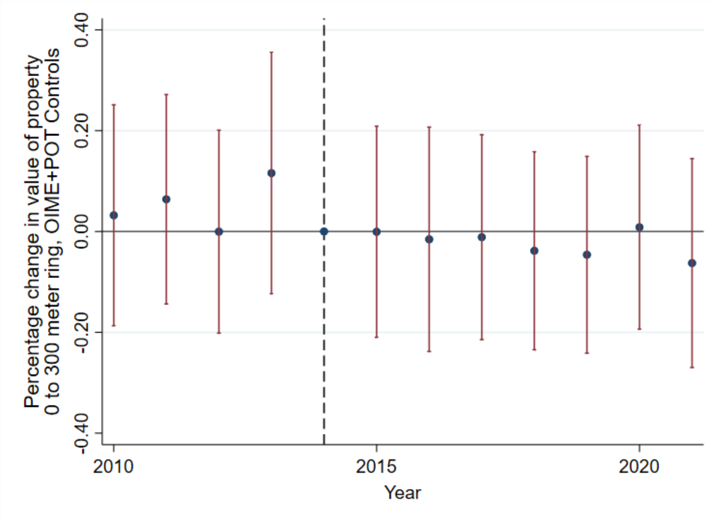


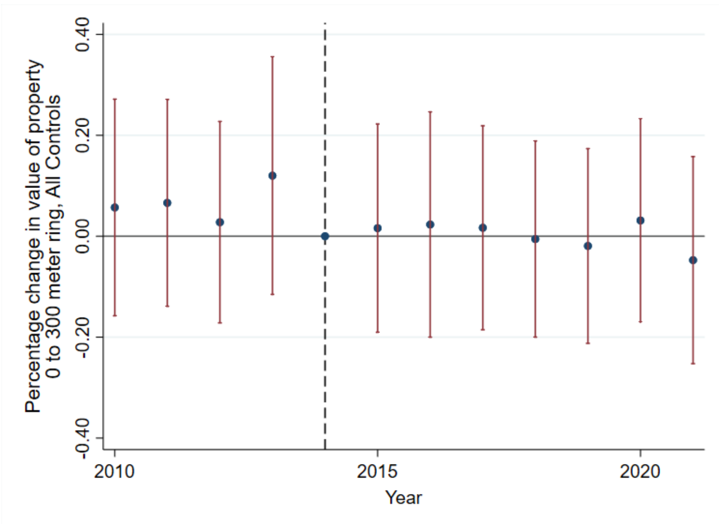
Figure 6: Event Study Plots for the 0-300m and 300-1500m Rings Design



OIME Controls



OIME+POT Controls



All Controls

It is worth noting that even when the first specifications agree with the second ones on the positive of the treatment over housing prices for a certain year. The first specification tend to do so with a much stronger statistical significance (mostly p-values below 1%) in comparison to the second one (their p-values are between 5% and 10%). A possible explanation for the lack of decisive results of this specification in comparison to the first design is that since both the control and the treatment group in this analysis are located in Medellin's crowded downtown, there is a possibility that the housing market there is not dynamic enough to fully assimilate the impact the project had over housing in the period studied; the fact that Phase 1B (and therefore the project as a whole) ended very close to the end of the period encompassed by the cadaster data makes this hypothesis possible but hard to verify.

It is, however, quite encouraging to observe that all the coefficients point towards what we would expect from previous literature (Brinkman & Lin, 2022; Grisolía et al., 2014) and our *a priori* expectations. Specifically, when they are statistically significant, the coefficients that estimate the effect of the project on property prices are always positive. Moreover, the results seem most decisive when a significant milestone of the project is reached (e.g., the conclusion of phase 1A).

5 Conclusion

In this paper, we sought to estimate the effect of the announcement, construction, and conclusion of the *Parques del Río* project on the value of nearby properties. For that purpose, we used different data sources pulled from Medellin's Cadaster, Colombia's national census, and the various standing land use regulations as established by the city's zoning ordinance, and implemented a difference-in-differences methodology with two different strategies: one in which we compared those properties closest to the project with those which were also alongside the Medellin river but farther away from the project and another where we established a set of two rings comparing those properties closest to the *Parques del Río* project with those surrounding them. [6]. Our main results suggest that the presence of the *Parques del Río* project increased the value of nearby properties for 2016, yet said increase wore off over time.

While it seems that the coefficients we obtained with our specifications were, for the most part, not statistically significant, our results indicate that the presence of the *Parques del Río* project seems to have increased the value of nearby properties for 2016, yet said increase wore off in the following years. A possible future work could pursue a similar empirical strategy to test some of the mechanisms driving these changes in prices and, in that way, explain why the increase in property prices was dampened. Various possibilities for these effects include a possible increase in criminality, the discomfort caused by the continued works, or perhaps that the first stage of the project did not bring about the full benefits of the project or that some benefits from the project, such as a reduction in the negative effects associated to traffic never materialized.

The aforementioned possibility could also serve as an explanation, as it may be possible that our data could not fully capture the benefits of the project, as works fully concluded in the early months of 2020, just as the COVID-19 epidemic rocked the world, causing significant economic damage through the ensuing lockdowns and slowing down the housing market, thereby dampening the positive effects of the project over housing prices. Given the fact that the years 2022 and 2023 (when the economy finally started to "return to normalcy") were outside of the period covered by our sample, this remains a plausible explanation.

It is worth pointing out that the OIME data used in this work also presented several complications that may have concealed the possible effects of the project, as the data presented several changes in variable notation during the period encompassed by the study, as well as sometimes proposing implausible values for variables. Therefore, future studies that want to

[6] We initially had plans to study the results of a more complex ring specification with multiple rings to measure the intensity of the effect of the project, but the lack of significant results obtained in the ring specifications studied as seen in Figures 6 and 5, made us conclude that pursuing such a course of action would be unnecessary as it would not lead to any additional insights.

study housing markets and evaluate the effect of urban or transport policies may consider using private sources of information as their sampling procedure is more transparent and consistent over time. Nonetheless, these private databases tend to oversample properties in middle- and high-income neighborhoods with more formal housing markets. Ideally, agencies such as the *Observatorio de Vivienda de Medellin* or the *Agencia de Vivienda de Antioquia* should invest in technologies and data collection procedures that facilitate the proper study of the economics and social dynamics in the city. The evidence from these studies should become the backbone of every intervention in the city.

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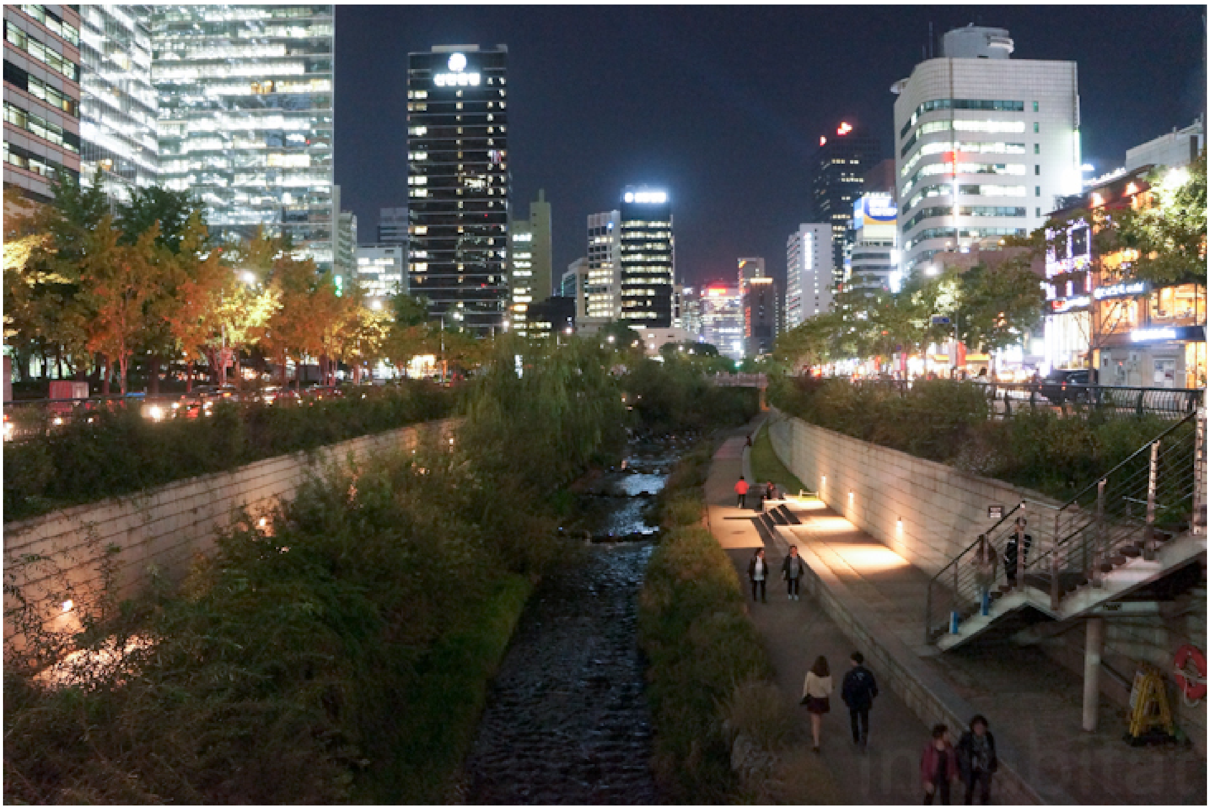
Appendix

5.1 Extra Figures

Figure A.1: *Parques del Río*

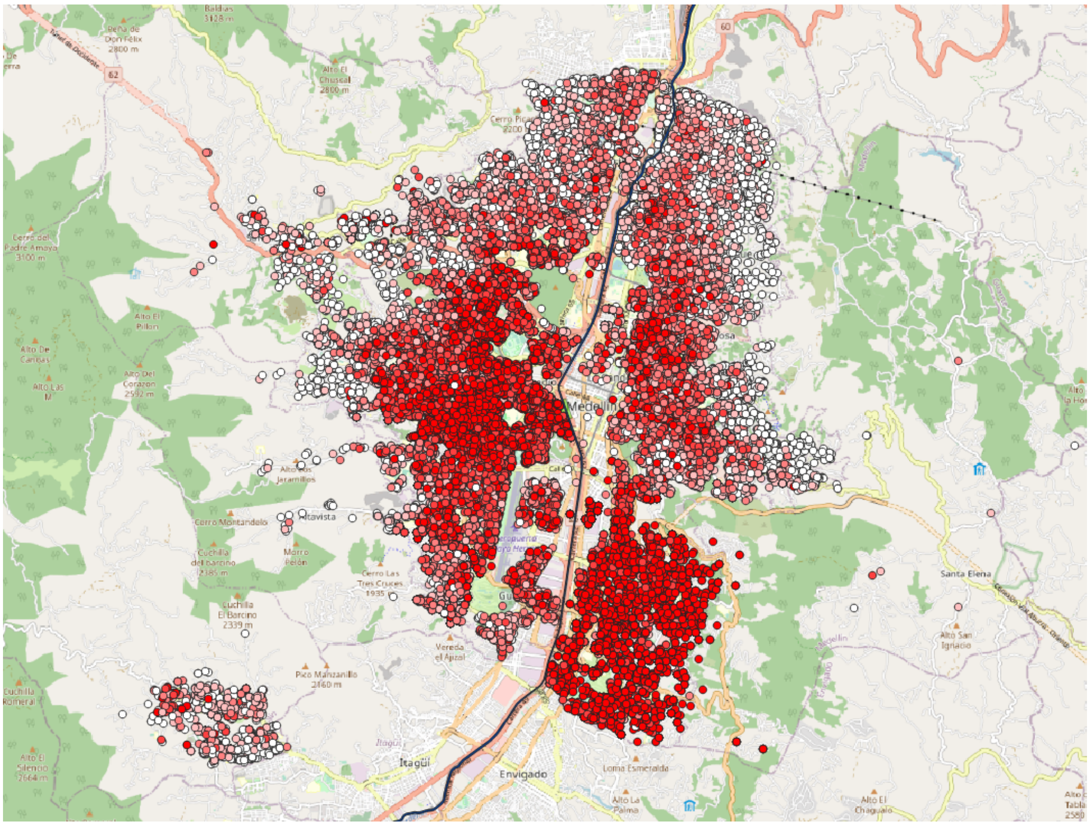
Source: https://www.sainc.co/portfolio-view/obra-parques-del-rio-medellin/

Figure A.2: The Cheonggyecheon River linear park in Seoul, Korea



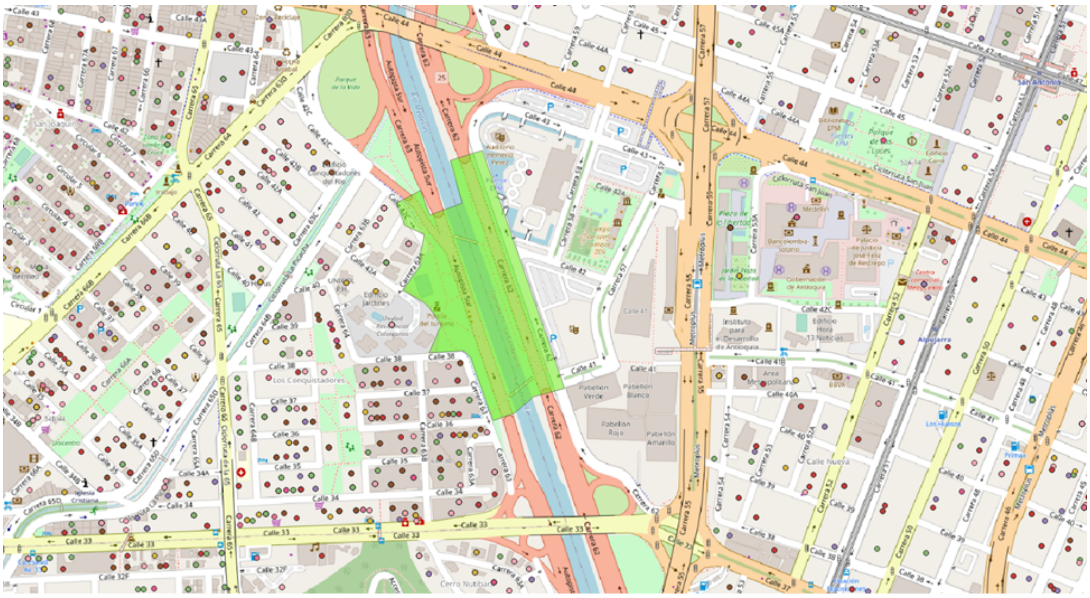
Source: https://inhabitat.com/how-the-cheonggyecheon-river-urban-design-restored-the-green-heart-of-seoul/

Figure A.3: Map of Medellín with the OIME Datapoints



A map showing all the sample OIME data points in Medellín, notice the Medellín river (in blue) splitting the city in half.

Figure A.4: Parques del Rio and Housing Transactions



The defined *Parques del Río* polygon and various properties for sale in the real estate market recorded by the OIME for the 2008-2021 period, imposed over a map of the city of Medellín.

5.2 Extra Tables

Table A.1: Mean property value (millions of COP) for various groupings for the three critical periods of our timeline for the project (Before works begin, during works, and after works end)

	Period of Time		
Grouping of Sample	2010-2014	2015-2019	2020-2021
All	175	288	443
Percentage Change	-	65%	54%
Observations (N)	14029	21553	8295
$<$500m	275	448	546
Percentage Change	-	63%	22%
Observations (N)	163	361	154
501-2000m	222	392	490
Percentage Change	-	77%	25%
Observations (N)	1450	2973	1131
500m from River	174	228	479
Percentage Change	-	31%	110%
Observations (N)	700	1076	432

Table A.2: Control Variables

Variables	**Description**
OIME	
Utility Room	Dummy variable for whether the property has a utility room (1) or not (0).
Apartment	Dummy variable for whether the property is an apartment (1) or a house (0).
Parking	Dummy variable for whether the property has parking (1) or not
New Property	Dummy variable for whether the property is new (1) or has been used (0).
Log of Carpet Area m^2	Natural logarithm of the carpet area of the property in square meters.
POT	
Log of Maximum Density	Natural logarithm of maximum allowed density for the area.
Land Usage Category:	Categorical variable for the zoning class where the property is located.
Land Usage Category 1	Low mixture areas (predominantly residential).
Land Usage Category 2	Medium mixture areas and corridors.
Land Usage Category 3	High mixture areas and corridors.
Land Usage Category 4	Currently used as public space.
Land Usage Category 5	Projected to be used as a public space.
Land Usage Category 6	Public infrastructure.
2018 Census	
Stratum:	Categorical variable for the stratum of the households interviewed in the census.
Stratum 1	Percentage of households in the block with no stratum.
Stratum 2	Percentage of households in the block that belongs to Stratum 1.
Stratum 3	Percentage of households in the block that belongs to Stratum 2.
Stratum 4	Percentage of households in the block that belongs to Stratum 3.
Stratum 5	Percentage of households in the block that belongs to Stratum 4.
Stratum 6	Percentage of households in the block that belongs to Stratum 5.
Stratum 7	Percentage of households in the block that belongs to Stratum 6.

Table A.3: Table of the regression results for the Event Study specifications that used the 500-meter range.[7]

	(1) logpreciovivienda		(2) logpreciovivienda		(3) logpreciovivienda		(4) logpreciovivienda	
Treatment	0.0847	(0.71)	0.135	(1.14)	0.0494	(0.54)	-0.0461	(-0.59)
2010	-0.347**	(-3.00)	-0.432***	(-3.82)	-0.386***	(-4.50)	-0.364***	(-8.52)
2011	-0.315**	(-2.85)	-0.364***	(-3.36)	-0.350***	(-4.25)	-0.350***	(-9.11)
2012	-0.218*	(-2.01)	-0.268*	(-2.47)	-0.248**	(-3.21)	-0.157***	(-4.50)
2013	-0.130	(-1.21)	-0.175	(-1.69)	-0.185*	(-2.35)	-0.136***	(-3.68)
2015	-0.162	(-1.36)	-0.199	(-1.62)	-0.165	(-1.78)	-0.0327	(-0.79)
2016	-0.154	(-1.35)	-0.247*	(-2.21)	-0.132	(-1.57)	-0.0485	(-1.37)
2017	0.0792	(0.56)	0.00502	(0.04)	0.0875	(0.71)	0.228***	(3.87)
2018	0.298**	(2.73)	0.246*	(2.23)	0.284***	(3.61)	0.335***	(8.68)
2019	0.502***	(5.01)	0.443***	(4.44)	0.461***	(6.44)	0.446***	(12.78)
2020	0.322**	(2.63)	0.252*	(2.08)	0.265**	(2.71)	0.422***	(9.92)
2021	0.776***	(7.68)	0.737***	(7.21)	0.705***	(9.23)	0.640***	(18.28)
Treatment⋆2010	0.294*	(2.05)	0.378**	(2.71)	0.318**	(2.75)	0.331***	(3.70)
Treatment⋆2011	0.260	(1.86)	0.295*	(2.17)	0.261*	(2.32)	0.273**	(3.08)
Treatment⋆2012	0.210	(1.57)	0.247	(1.86)	0.236*	(2.26)	0.154	(1.84)
Treatment⋆2013	0.225	(1.61)	0.242	(1.77)	0.220	(1.90)	0.198	(1.94)
Treatment⋆2015	0.342*	(2.34)	0.360*	(2.41)	0.321**	(2.68)	0.170	(1.87)
Treatment⋆2016	0.487***	(3.46)	0.573***	(4.10)	0.451***	(4.04)	0.405***	(4.41)
Treatment⋆2017	0.303	(1.90)	0.359*	(2.53)	0.245	(1.76)	0.112	(1.15)
Treatment⋆2018	0.201	(1.51)	0.242	(1.84)	0.199	(1.93)	0.137	(1.69)
Treatment⋆2019	0.0596	(0.46)	0.107	(0.86)	0.0737	(0.73)	0.0811	(1.00)
Treatment⋆2020	0.290*	(1.99)	0.354*	(2.45)	0.299*	(2.50)	0.132	(1.54)
Treatment⋆2021	-0.0974	(-0.75)	-0.0645	(-0.49)	-0.0891	(-0.84)	-0.0217	(-0.25)
Utility Room	0.117***	(4.71)	0.121***	(4.81)	0.0804***	(3.38)	0.143***	(6.77)
Apartment	0.124***	(3.35)	0.155***	(3.92)	0.00400	(0.12)	0.0836***	(3.89)
Parking	0.0908***	(4.18)	0.0920***	(4.08)	0.0936***	(4.51)	0.116***	(6.42)
New Property	0.239***	(6.70)	0.276***	(8.87)	0.224***	(6.28)	0.286***	(12.36)
Log of Carpet Area m^2	1.019***	(27.09)	1.084***	(32.53)	0.912***	(24.30)	0.982***	(52.18)
Land Usage Category 2	0.148**	(3.15)			0.128**	(2.88)	0.172***	(7.14)
Land Usage Category 3	0.0743	(1.12)			0.0373	(0.58)	0.125***	(4.25)
Land Usage Category 4	0.0460	(0.88)			0.0873*	(2.19)	-0.00717	(-0.17)
Log of Maximum Density	0.101***	(7.47)			0.0469***	(3.54)	-0.0197	(-1.62)
Stratum 1					2.814	(1.87)	0.512	(0.69)
Stratum 2					-0.714***	(-12.02)	-0.808***	(-12.07)
Stratum 3					-0.521***	(-10.29)	-0.833***	(-24.77)
Stratum 5					0.174***	(7.42)	0.186***	(8.36)
Stratum 6					0.182***	(7.56)	0.256***	(10.94)
Stratum 7					0.545	(0.88)	0.246***	(5.08)
Western Bank							-0.272***	(-9.83)
_cons	13.32***	(73.52)	13.66***	(70.48)	14.26***	(86.32)	14.45***	(120.77)
Controls	POT		OIME		All Controls		All+Eastern bank properties	
N	1312		1312		1312		2801	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[7]Treatment indicates whether a certain property received the treatment; followed by the various years of the event study, then by the interaction between the treatment variable and the various years, finally followed by the various controls used. Western Bank is a dummy variable that shows whether a certain property is located on the western bank of the river (1) or not (0)

Table A.4: Table of the regression results for the Event Study specifications that used the 1000-meter range.[8]

	(1)		(2)		(3)		(4)	
	logpreciovivienda		logpreciovivienda		logpreciovivienda		logpreciovivienda	
Treatment	0.297***	(5.18)	0.331***	(5.79)	0.173***	(3.72)	0.143**	(3.16)
2010	-0.341***	(-6.22)	-0.322***	(-5.74)	-0.297***	(-7.74)	-0.258***	(-8.37)
2011	-0.234***	(-5.05)	-0.217***	(-4.59)	-0.260***	(-7.53)	-0.280***	(-11.79)
2012	-0.152***	(-3.40)	-0.127**	(-2.78)	-0.200***	(-5.98)	-0.152***	(-6.48)
2013	-0.0117	(-0.25)	0.00916	(0.20)	-0.0780*	(-2.25)	-0.0836***	(-3.36)
2015	0.0163	(0.36)	0.0530	(1.14)	-0.0273	(-0.80)	0.0325	(1.29)
2016	-0.0729	(-1.39)	-0.0805	(-1.49)	0.0458	(1.28)	0.0729**	(2.90)
2017	0.156**	(2.85)	0.171**	(3.05)	0.146**	(3.08)	0.232***	(6.97)
2018	0.365***	(7.78)	0.397***	(8.40)	0.320***	(9.01)	0.368***	(14.42)
2019	0.507***	(11.79)	0.538***	(12.38)	0.451***	(14.01)	0.479***	(21.07)
2020	0.296***	(5.59)	0.321***	(5.98)	0.250***	(5.73)	0.431***	(14.43)
2021	0.693***	(14.72)	0.730***	(15.20)	0.630***	(17.26)	0.634***	(26.93)
Treatment⋆2010	0.207**	(2.79)	0.198**	(2.64)	0.173**	(2.87)	0.104	(1.79)
Treatment⋆2011	0.0229	(0.34)	0.0120	(0.17)	0.0518	(0.89)	0.0207	(0.37)
Treatment⋆2012	-0.00676	(-0.10)	-0.0234	(-0.34)	0.0679	(1.17)	0.00574	(0.10)
Treatment⋆2013	-0.0336	(-0.47)	-0.0565	(-0.78)	0.0239	(0.37)	0.0234	(0.36)
Treatment⋆2015	0.0811	(1.17)	0.0526	(0.75)	0.141*	(2.38)	0.0558	(0.98)
Treatment⋆2016	0.400***	(4.09)	0.426***	(4.33)	0.319***	(3.64)	0.283***	(3.30)
Treatment⋆2017	0.134	(1.86)	0.132	(1.85)	0.150*	(2.35)	0.0431	(0.76)
Treatment⋆2018	0.0424	(0.66)	0.0251	(0.39)	0.108*	(2.00)	0.0293	(0.57)
Treatment⋆2019	-0.0681	(-1.10)	-0.106	(-1.71)	-0.00283	(-0.06)	-0.0536	(-1.09)
Treatment⋆2020	0.242***	(3.45)	0.221**	(3.12)	0.295***	(4.89)	0.0773	(1.42)
Treatment⋆2021	-0.0595	(-0.88)	-0.0956	(-1.41)	-0.00631	(-0.11)	-0.0356	(-0.67)
Utility Room	0.203***	(13.85)	0.209***	(14.30)	0.156***	(11.68)	0.174***	(14.56)
Apartment	0.0524*	(2.54)	0.0710**	(3.29)	-0.0304	(-1.52)	-0.000639	(-0.04)
Parking	0.0695***	(4.75)	0.0817***	(5.52)	0.0576***	(4.33)	0.118***	(9.61)
New Property	0.207***	(9.22)	0.218***	(9.66)	0.177***	(8.21)	0.265***	(16.52)
Log of Carpet Area m^2	0.959***	(49.86)	0.998***	(51.73)	0.851***	(45.87)	0.898***	(60.79)
Land Usage Category 2	0.0940***	(6.51)			0.0793***	(5.65)	0.108***	(8.97)
Land Usage Category 3	0.0973***	(3.99)			0.0709**	(2.80)	0.101***	(6.43)
Land Usage Category 4	-0.0937	(-1.61)			0.0570	(1.59)	0.00407	(0.10)
Log of Maximum Density	0.0603**	(3.25)			0.0226	(1.46)	-0.0302**	(-2.89)
Stratum 1					-0.294	(-0.39)	-0.339	(-0.81)
Stratum 2					-0.958***	(-16.36)	-0.880***	(-19.68)
Stratum 3					-0.521***	(-10.26)	-0.716***	(-31.35)
Stratum 5					0.216***	(11.44)	0.241***	(15.40)
Stratum 6					0.256***	(16.04)	0.324***	(18.67)
Stratum 7					-0.0721	(-0.24)	0.467***	(17.20)
Western Bank							-0.180***	(-11.98)
_cons	13.79***	(94.66)	13.95***	(132.59)	14.60***	(105.63)	14.78***	(149.72)
Controls	POT		OIME		All Controls		All+Eastern bank properties	
N	4043		4047		4043		7448	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[8]Treatment indicates whether a certain property received the treatment; followed by the various years of the event study, then by the interaction between the treatment variable and the various years, finally followed by the various controls used. Western Bank is a dummy variable that shows whether a certain property is located on the western bank of the river (1) or not (0)

Table A.5: Table of the regression results for the Event Study with ring specifications that used the 0-500m and 500-2000m ranges. [9]

	(1) logpreciovivienda		(2) logpreciovivienda		(3) logpreciovivienda	
0 to 500 Meter Radius	-0.00150	(-0.02)	-0.128	(-1.67)	-0.0931	(-1.39)
2010	-0.160***	(-3.92)	-0.192***	(-5.45)	-0.212***	(-7.28)
2011	-0.210***	(-5.15)	-0.222***	(-6.47)	-0.237***	(-8.16)
2012	-0.130***	(-3.34)	-0.148***	(-4.49)	-0.168***	(-6.05)
2013	-0.0838*	(-2.08)	-0.110**	(-3.19)	-0.135***	(-4.75)
2015	0.109**	(2.73)	0.0814*	(2.40)	0.0694*	(2.41)
2016	0.221***	(4.80)	0.199***	(5.11)	0.176***	(5.42)
2017	0.272***	(5.43)	0.247***	(5.37)	0.232***	(5.89)
2018	0.398***	(9.87)	0.377***	(10.77)	0.355***	(11.89)
2019	0.486***	(13.02)	0.466***	(14.62)	0.450***	(17.44)
2020	0.529***	(12.78)	0.501***	(14.03)	0.481***	(15.90)
2021	0.667***	(16.97)	0.639***	(19.40)	0.618***	(22.65)
0 to 500 Meter Radius*2010	0.0815	(0.96)	0.136	(1.66)	0.159*	(2.06)
0 to 500 Meter Radius*2011	0.125	(1.49)	0.163*	(2.00)	0.165*	(2.17)
0 to 500 Meter Radius*2012	0.0913	(1.15)	0.141	(1.81)	0.159*	(2.19)
0 to 500 Meter Radius*2013	0.197*	(2.06)	0.271**	(2.69)	0.290**	(2.88)
0 to 500 Meter Radius*2015	0.0567	(0.69)	0.112	(1.41)	0.104	(1.40)
0 to 500 Meter Radius*2016	0.230	(1.75)	0.261*	(2.04)	0.300*	(2.40)
0 to 500 Meter Radius*2017	0.0851	(1.00)	0.139	(1.67)	0.136	(1.81)
0 to 500 Meter Radius*2018	0.0815	(1.05)	0.127	(1.68)	0.141*	(2.03)
0 to 500 Meter Radius*2019	0.0512	(0.65)	0.106	(1.39)	0.106	(1.53)
0 to 500 Meter Radius*2020	0.0802	(0.99)	0.128	(1.63)	0.119	(1.65)
0 to 500 Meter Radius*2021	0.00493	(0.06)	0.0606	(0.75)	0.0493	(0.65)
Utility Room	0.148***	(11.87)	0.133***	(11.07)	0.124***	(10.74)
Apartment	-0.00979	(-0.36)	-0.0233	(-0.90)	-0.0652**	(-2.58)
Parking	0.0982***	(10.58)	0.0884***	(9.68)	0.0811***	(8.83)
New Property	0.251***	(18.50)	0.222***	(16.46)	0.216***	(16.22)
Log of Carpet Area m^2	0.875***	(35.15)	0.845***	(34.21)	0.813***	(34.59)
Log of Maximum Density			0.540**	(2.81)	0.276*	(2.03)
Land Usage Category 2			0.0166	(1.14)	0.0228	(1.73)
Land Usage Category 3			-0.0974***	(-6.49)	-0.0796***	(-6.19)
Land Usage Category 4			-0.125*	(-2.09)	-0.0320	(-0.59)
Stratum 1					0.798	(0.96)
Stratum 2					-0.713***	(-4.12)
Stratum 3					-0.541	(-0.67)
Stratum 5					0.0748***	(4.20)
Stratum 6					0.176***	(11.30)
Stratum 7					-0.0939	(-0.36)
_cons	14.94***	(99.17)	12.02***	(11.19)	13.66***	(17.24)
Controls	OIME		OIME+POT		All Controls	
N	4972		4972		4972	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[9]"0 to 500 Meter Radius" is the variable that indicates whether a certain property received the treatment or not; followed by the various years of the event study, then by the interaction between the treatment variable and the various years, and finally followed by the various controls used.

Table A.6: Table of the regression results for the Event Study with ring specifications that used the 0-300m and 300-1500m ranges.[10]

	(1)		(2)		(3)	
	logpreciovivienda		logpreciovivienda		logpreciovivienda	
0 to 300 Meter Radius	0.114	(1.21)	0.0476	(0.50)	0.0259	(0.27)
2010	-0.182***	(-4.88)	-0.179***	(-4.74)	-0.185***	(-4.91)
2011	-0.216***	(-5.70)	-0.208***	(-5.41)	-0.213***	(-5.52)
2012	-0.145***	(-4.06)	-0.134***	(-3.68)	-0.147***	(-3.98)
2013	-0.130**	(-3.16)	-0.122**	(-2.96)	-0.126**	(-3.03)
2015	0.110**	(2.93)	0.108**	(2.84)	0.0965*	(2.52)
2016	0.238***	(4.29)	0.231***	(4.14)	0.219***	(3.91)
2017	0.298***	(7.56)	0.299***	(7.41)	0.290***	(7.07)
2018	0.431***	(12.35)	0.434***	(12.24)	0.419***	(11.65)
2019	0.487***	(14.46)	0.494***	(14.47)	0.481***	(13.91)
2020	0.522***	(12.70)	0.528***	(12.72)	0.513***	(12.10)
2021	0.637***	(18.15)	0.644***	(18.10)	0.632***	(17.59)
0 to 300 Meter Radius*2010	0.0222	(0.20)	0.0320	(0.29)	0.0571	(0.52)
0 to 300 Meter Radius*2011	0.0549	(0.52)	0.0652	(0.62)	0.0676	(0.65)
0 to 300 Meter Radius*2012	-0.00724	(-0.07)	0.000898	(0.01)	0.0295	(0.29)
0 to 300 Meter Radius*2013	0.0976	(0.85)	0.116	(0.95)	0.120	(1.00)
0 to 300 Meter Radius*2015	-0.0191	(-0.18)	-0.000635	(-0.01)	0.0161	(0.15)
0 to 300 Meter Radius*2016	-0.0327	(-0.29)	-0.0160	(-0.14)	0.0229	(0.20)
0 to 300 Meter Radius*2017	-0.0347	(-0.33)	-0.0113	(-0.11)	0.0170	(0.16)
0 to 300 Meter Radius*2018	-0.0557	(-0.56)	-0.0399	(-0.40)	-0.00639	(-0.06)
0 to 300 Meter Radius*2019	-0.0617	(-0.62)	-0.0474	(-0.48)	-0.0198	(-0.20)
0 to 300 Meter Radius*2020	-0.00576	(-0.06)	0.00749	(0.07)	0.0307	(0.30)
0 to 300 Meter Radius*2021	-0.0759	(-0.72)	-0.0641	(-0.61)	-0.0482	(-0.46)
Utility Room	0.117***	(9.24)	0.114***	(9.02)	0.110***	(8.89)
Apartment	-0.163***	(-4.23)	-0.157***	(-4.11)	-0.160***	(-4.13)
Parking	0.0724***	(6.38)	0.0637***	(5.64)	0.0567***	(5.14)
New Property	0.232***	(15.09)	0.223***	(14.11)	0.219***	(13.99)
Log of Carpet Area m^2	0.768***	(20.33)	0.761***	(20.07)	0.753***	(20.06)
Log of Maximum Density			0.172**	(2.97)	0.111**	(2.59)
1.cod_cat2			0	(.)	0	(.)
Land Usage Category 2			0.0501**	(2.85)	0.0402*	(2.44)
Land Usage Category 3			-0.0323	(-1.93)	-0.0428**	(-2.67)
Land Usage Category 4			-0.0131	(-0.33)	0.00288	(0.08)
Stratum 1					0.661	(1.22)
Stratum 2					-0.333	(-1.02)
Stratum 3					-0.166	(-1.05)
Stratum 5					-0.0281	(-1.19)
Stratum 6					0.0746***	(4.20)
Stratum 7					-0.102	(-0.41)
_cons	15.63***	(72.07)	14.64***	(36.64)	15.04***	(43.65)
Controls	OIME		OIME+POT		All Controls	
N	2818		2818		2818	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[10]"0 to 300 Meter Radius" is the variable that indicates whether a certain property received the treatment or not; followed by the various years of the event study, then by the interaction between the treatment variable and the various years, and finally followed by the various controls used.