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Evidence from Brazil

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Climate Change and Sustainable Development Sector

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The Impact of Upgrading Municipal Infrastructure on Property Prices: Evidence from Brazil

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Abstract

We evaluate the effects of municipal infrastructure upgrades on property prices in the Municipality of Campo Grande, Brazil. Using detailed administrative data on property characteristics and sales prices, we implement a differences-in-differences methodology that compares treated and comparison neighborhoods over time to estimate the effects of road infrastructure improvements and revitalization of urban parks. We find that road improvements are highly cost-effective, producing an increase of 6.1% in property prices which translate into a return of $4.25 per dollar invested. On the other hand, we find no effects of the urban parks intervention.

JEL Classification: H43, L91, O18, D04

Keywords: urban development, urban transportation, upgrade of public spaces, Brazil, Latin America

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1. INTRODUCTION

Half of the world's population lives in urban areas, and projections show the number of people living in cities will increase by 50%, from 4 to 6 billion people over the next 15 years[1]. Cities are expanding physically at a rate that exceeds 2 or 3 times the increase in their population, resulting in increased infrastructure and maintenance costs (Habitat 2012). The speed and scale of urbanization poses a challenge for local governments to meet ever increasing demands of urban infrastructure such as transport, water and sanitation and recreational spaces to promote economic development, social sustainability and wellbeing.

The Latin America and Caribbean region is the most urbanized in the world, with almost 80 percent of the population living in cities (Habitat 2012). Brazil, the largest country in the region, accounts for one third of the region's GDP and population. Since 1970 Brazil has experienced a particularly high rate of urbanization. Today approximately 85% of the Brazilian population lives in urban areas (UN Ecosoc 2013), and it is expected to remain as one of the most urbanized countries of the region in the coming decades (Habitat 2012). Commensurate to its population and the size of its economy, Brazil represents a high share of the infrastructure investment in the region, with half of the total investment in transportation in the last decade (World Bank Data, 2016). However, investment in infrastructure has decreased as a percentage of GDP in the last decade, falling behind other Latin America countries such as Chile or Colombia (Calderon and Serven 2014). In 2013 the share of investment in infrastructure represented 2,5% of GDP versus 5% in 1980 (IMF 2015).

With cities that continue to expand geographically, local governments face the challenge of allocating scarce resources towards infrastructure interventions that improve resident's wellbeing in a cost-effective way. Yet evaluating the impacts of urban infrastructure poses methodological challenges both in terms of capturing aggregate and multi-dimensional measures of wellbeing[2],

[1] World Bank (2013).

[2] Efforts to measure wellbeing have increased since the recommendations of the Report by the Commission on the Measurement of Economic Performance and Social Progress (2009) conducted by Joseph Stiglitz, Amartya Sen and Jean Paul Fitoussi. Some examples include the "Better Life Index" developed by the OECD, the "Regional Wellbeing Indicators" in Mexico developed by INEGI, or the "Personal Well-Being, Annual Population Survey" generated at the Office of the National Statistics in the UK.

and identifying appropriate comparison groups that yield a plausible estimate of the counterfactual.

Our study contributes to the existing literature on municipal infrastructure by identifying a plausibly causal impact of infrastructure investments on an aggregate measure of wellbeing as reflected through property values. We study the effects of Procidades[3], an urban upgrading intervention implemented in the Municipality of Campo Grande, Brazil between 2009 and 2013 with support from the Inter-American Development Bank. Under Procidades, the municipality undertook the rehabilitation of two avenues in the western part of the city, and the rehabilitation of two public parks in the city center. We use administrative data on all residential property sold in the municipality over the study period to capture the effects of the infrastructure upgrades as reflected in sales prices. Given that data are available for all property in the municipality, we compare changes in property prices between neighborhoods directly affected by the intervention with other neighborhoods in the municipality that were not in the immediate vicinity of the public works. We find positive and significant effects of the road upgrade component, but no significant effects of the urban revitalization component. The transport component is highly cost-effective, generating an increase in property values of 6.1%.

To date, much of the literature evaluating the effects of urban infrastructure projects uses cost-benefit and cost-effectiveness analysis through simulation tools (such as the Highway Capacity Manual) or macroeconomic models such as computable general equilibrium (CGE) models (Bourguignon et al., 2004; Lofgren and Diaz- Bonilla, 2010, Beguy, 2015). These models simulate the effects of infrastructure on outcomes such as GDP growth, but rely on strong assumptions and fail to distinguish localized impacts of specific interventions. On the other hand, many of the attempts to identify impacts at a micro level use multivariable regressions to control for observable confounders(Rodriguez et al. (2009), Cervero (1999), Debrezion et al. (2006), and Dowall et al. (1991)), but may be prone to omitted variable bias.

A more recent set of evaluations use experimental and cuasi-experimental methods to improve attribution, particularly applied to urban upgrades in the transport[4]. Most related to our study,

3 The Procidades facility, approved in 2006 by the Inter-American Bank, made up to US$50 million available for each Brazilian municipality that qualified for a loan. Municipalities with a population between 100,000 and 1 million, with capacity to finance up to 50% of the project with their own resources, could apply for a loan under the facility.

4 Cerda et al. (2012) analyze the impact of a mobility intervention on criminalization, Chen et al. (2012) study the impact of the Metro on the air quality in Taipei, Lucas (2008) studies the impact of a regulation on air quality in Mexico, and Mahmud (2014) studies the impact of the construction of a bridge in Bangladesh on employment.

Gonzalez-Navarro and Quintana-Domeque (2016) use a randomized control trial to study how street paving in Mexico raises housing values. Using expert's appraisals, they find that paving streets increases housing prices by 16 percent and land values by 54 percent. Furthermore, McIntosh (2014) conducts an experiment of urban infrastructure upgrading in low-income urban neighborhoods in Mexico. The program included a broad set of interventions, including electrification, water, and paving roads. He finds that the program increased the aggregate real estate value in program neighborhoods by two dollars for every dollar invested.

2. CONTEXT and INTERVENTION

Between 1950 and 2010 the Brazilian population increased from 52 to 191 million, the urbanization rate from 36% to 84% and the number of cities from 1,889 to 5,565. During this period, the number of cities with more than 50 thousand habitants increased from 38 to 476 and the number of cities with more than 100 thousand increased from 67 to 250 (IBGE, Census 2010). The rapid increase in population and geographical expansion of cities increased the demand for transportation systems including roadways. At the same time, the development of new suburbs led to the displacement of business and residential areas away from city centers. Thus, many city centers experienced a deterioration of the local economy, creating conditions of insecurity and physical deterioration of buildings (Rojas, 2004).

The Municipality of Campo Grande has an area of 8,096 km2 and a population of 796,252 inhabitants. The municipality is highly urbanized, with 98.6% of the population in urban areas, and in recent decades has experienced significant population and economic growth, increasing its population by 50% in the 20 years between 1991 to 2010[5] (IBGE, Census 2010). Despite the favorable economic conditions in the municipality, accelerated population growth has put stress on the provision of services. To help address the main urban challenges, the municipality implemented the Procidades program with the objective of revitalization of the city center and improving mobility and transportation.

The revitalization of the city center component aimed to promote improvements in the urban environment of the historic center of Campo Grande and reverse the loss of economic and social dynamics. The main intervention consisted of the renovation of idle railway tracks which cross the city center and surrounding areas thru the implementation of two projects: (i) *Orla Morena,* and (ii) *Orla Ferroviária*. The first project, "*Orla Morena,"* financed the creation an urban linear park

[5] http://www.censo2010.ibge.gov.br/sinopse/index.php?dados=29&uf=50

with walkways, bicycle lanes, public spaces, playgrounds, outdoor gyms, gardens, and street furniture and lighting. The second project, "*Orla Ferroviária*," remodeled the abandoned station and its environs which had become a deserted area, which not only hindered the integration between the east and west of the downtown, but also posed security risks in terms of crime and illicit activities. It improved public gardens, street furniture and lighting, as well as the promoted nighttime economic and cultural activities.

The program's second component aimed to address inadequate road infrastructure in the municipality's western sector, through the expansion and improvement of two main arteries: the avenues Via Morena[6], and Julio de Castilho. The component also financed a new traffic light system for a total of 180 intersections in various regions of the municipality. Table 1 shows the investment amount and date of commencement and completion of works for each project financed by the Procidades program. The revitalization intervention was implemented between March 2009 and June 2013, whereas the mobility component started in November 2009 and finalized in July 2013. Figure 1 shows a map of the intervention neighborhoods. Neighborhoods circled in black and red belong to the transportation component, whereas those circled in green belong to the revitalization of the city center component. There are a total of 11 treatment neighborhoods (5 in the revitalization component and 6 in the transportation component) and 24 control neighborhoods in the municipality.

3. METHODS AND DATA

We identify plausible causal effects of the urban upgrades using a difference in difference approach with rich administrative data on property characteristics and sales prices. The identification strategy compares the changes in outcomes over time between areas affected by the program (the treatment group) and untreated areas (the comparison group), thus controlling for time-invariant characteristics of the intervention area as well as time-varying factors that are common between both groups. The identifying assumption, known as the "parallel trends" assumption, requires that the counterfactual change in outcomes would have remained the same between treatment and comparison groups. While the assumption is not testable directly, we show that trends are equal in the pre-intervention period, lending credibility to a causal interpretation of the estimated impacts.

[6] Section of Campo Grande International Airport to Avenida Julio de Castilho.

A special feature of our analysis is rich administrative data from tax records and property sales of all properties in the municipality between 2008 and 2013. We assign properties to the treatment or comparison group based on geographical proximity to the interventions. We assign properties in neighborhoods directly adjacent to interventions to the treatment group, and properties in neighborhoods not directly intervened by the program to the comparison group[7]. The advantage of analyzing treatment and comparison neighborhoods within the same municipality is that they share a common economic environment, helping to control for time varying factors that are common to the municipality. On the other hand, if the infrastructure upgrades affect neighborhoods beyond those in the immediate vicinity of the projects (for example through improved mobility and availability of public spaces for the whole municipality), our identification strategy would down-ward bias the estimated effects of the program (assuming the intervention affects treatment and comparison neighborhoods in the same direction).

Hedonic Prices

To quantify the benefits of the infrastructure upgrades we apply a hedonic pricing approach using variation in housing sales prices over time. Hedonic pricing models capture the value of improvements in individual's quality of life as reflected in changes to property prices in the neighborhood. The hedonic price model (Griliches, 1979) takes the price of a good as determined by the implicit price of each of its components. In this case, the price of real estate would be formed by the implicit prices of attributes of the property, such as the number of rooms and quality of materials, and attributes of the neighborhood including urban infrastructure such as roads and parks. In a competitive market, price is determined by the equilibrium in which the functions of demand and supply of buyers and sellers are equal. According to hedonic price theory, changes in real estate prices by varying one of its attributes (and keeping everything else constant) determine the valuation by individuals of that attribute. In our case, the change in housing prices by providing improved urban infrastructure reflects what must be paid to the individual to maintain their standard of living. The marginal willingness to pay for each of the attributes can be used to infer the welfare effects of a marginal change in one of the attributes for individuals. As such, we will interpret the change in property price resulting from infrastructure upgrades as an aggregate valuation of the effect on wellbeing.

Data

[7] GPS coordinates for individual properties were not available in the data set for a more precise determination of proximity to the projects. Our analysis includes all residential properties in urban areas, excluding "territorial properties" in outlying areas.

Property data are from two administrative databases managed by the municipality. The first is the "Tax on Transmission of Real Property" database (ITBI for its Portuguese acronym[8]) which contains information on property sales prices for all real-estate transactions in the municipality. It includes the property's address, sale price and date of the transaction for each sale. The second database is the Urban Building and Land Tax database (IPTU for its Portuguese acronym[9]) which contains detailed property characteristics for all real estate in the municipality, including construction area, number of rooms, water service provision, lighting, telephone, materials of the walls, floor, ceiling, roof, and other characteristics of the construction.

ITBI registers a total of 21,355 property sales in the municipality between February 2008 and November 2013. Table 3 shows the frequency of sales by property type. The IPTU has data with individual level characteristics of properties in Campo Grande from 2005 to 2013. We merge the data sets and limit the analysis to residential properties, for a total of 12,634 property sale observations out of which 8,306 are properties in the control group, 2,460 properties in the treatment group for the revitalization component, and 1,868 treatment of the transportation component (see Table 3). Though the interventions are multi-year projects from start to finish, we assign treatment status to properties sold in the immediate aftermath of the urban upgrade start date (breaking ground), assuming that prices adjust instantaneously to changes in the expected value. Due to the limited number of property sales per month in each neighborhood, we aggregate observation by semesters.

A third source of information includes all other urban infrastructure projects taking place concurrently in the municipality. This information was provided by the Municipality of Campo Grande in the form of a high resolution map (Figure 2). We control for the location of these interventions in our analysis, however, we don't have information about when they happen, so we cannot exploit the temporal dimension.

Identification Strategy

We estimate the following model

$$P_{ist} = \alpha T_{st} + \mu_s + \pi_t + \beta X_{ist} + \gamma K_s + \varepsilon_{ist} \quad (1)$$

[8] Imposto sobre a transmissão de bens imoveis

[9] Imposto Predial e Territorial Urbano

where P_{ist} is the logarithm of price per square meter of property i located in neighborhood s in semester t, T_{st} takes the value 1 for treatment neighborhoods as of the start of the project and 0 otherwise, μ_s is a neighborhood dummy variable, π_t is time fixed effect, X_{ist} are observable characteristics of the property, K_s is a dummy variable equal to 1 for neighborhoods with other urban infrastructure interventions and ε_{ist} is the error term. Standard errors are clustered at the neighborhood level. The coefficient of interest, α, captures the aggregate impact of the intervention from the start of the intervention.

We also analyze the differential effects before, during or after the period of implementation of the works. For this model 2 is estimated:

$$P_{ist} = \sum_{j=1}^{j=n} \alpha_j T_{stj} + \mu_s + \pi_t + \beta X_{ist} + \gamma K_s + \varepsilon_{ist} \qquad (2)$$

Where T_{stj} is a dummy variable that equals 1 for treatment neighborhoods during the treatment and 0 in the remaining periods of time. The other variables are interpreted as in equation (1).

4. RESULTS

Graphic Analysis

Figure 3 shows the time trends of our outcome variable, the logarithm of price per square meter, for the treatment and comparison groups. The results are adjusted for observable characteristics of the properties and control for the presence of other interventions. The vertical lines show the beginning and end of the period of implementation of the interventions. A visual inspection of Figure 3 indicates that the pre-intervention trends are similar in both groups.

Pre-intervention Trends and Placebo Test

Next, we formally test the pre-program trends in outcomes for the treatment group and comparison groups. Table 4 shows the p-value for the joint significance F test. In all cases we cannot reject the null hypothesis that the pre-intervention trends are equal at the 95% level, thus confirming our previous visual inspection of equality of trends.

We also run a placebo test using the pre-intervention period (see Table 6). we estimate the diference-in-diference model over the pre-treatment period, but with the assumption that the treatment took effect at an earlier date. Since the placebo treatment precedes the intervention, the estimator should be statistically insignificant and close to zero. Due to the limited time periods in the pre-intervention period (only three periods of time for the overall and revitalization component and four for the transportation component), we place the placebo treatment in the

second (and also third for transportation) period of time. As shown in Table 6, none of the placebo-treatments are statistically significant.

Impact of urban upgrades

The effects of the urban upgrade interventions are presented in Table 5. The first two columns show the result of models 1 and 2 for the revitalization component, whereas columns 3 and 4 estimate the same models for the intervention of transportation. The dependent variable is the logarithm of the price of the properties by square meter, so coefficients are interpreted as the percent change in residential property prices over the period of reference. At the end of the table we present the number of observations, the R-squared, and the average value of the logarithm of the price (by square meter) of the control group.

Effects of the revitalization component are presented in Column 1. The estimated treatment effect is small and not statistically different from zero. Analyzing the marginal impacts by semester (column 2) we observe negative marginal effects in two of the ten semesters, and insignificant effects in the rest. Columns 3 and 4 show the results for the transportation projects. In contrast to the revitalization intervention, we find a positive and significant impact of 6.1%, significant at the 95% level. Decomposing the effect by semesters, we see that there is a negative effect (significant at the 10% level) in the first semester, which may be explained by the inconveniences of the construction works that could have offset the anticipation of future benefits in the short run. By the second half of 2012 the intervention starts to show a positive and significant effects. According to the timeline of implementation of works, this increment coincides with the finalization of Via Morena, suggesting that positive effects of the road improvements were only fully realized by the end of the construction phase.

Cost Effectiveness

According the ITBI database, the average price of real estate in the areas affected by transportation investments in the period of the study (2008-2013) was 73,448.79 Reais. Multiplying this value by the price increase attributable to this intervention (6.1%) we estimate an average increase of 4,480.4 Reais in the sale price of homes in the immediate vicinity of the upgraded roads. Assuming a uniform increase for all homes in the treated neighborhoods (39,691

properties), the total value generated by the transport project is equivalent to 177,830,611.3 Reais, a return of USD $4.25 per dollar invested[10].

5. CONCLUSIONS

This paper analyzes the effects of an urban infrastructure intervention in Campo Grande, Brazil on property prices, an aggregate outcome measure that serves as a proxy for wellbeing. Results suggest that the transport interventions, which focused on improving the quality of roads linking the west with the city center, raised property prices in neighborhoods close to the intervention by an average of 6.1% per square meter. Our back of the envelope cost-effectiveness estimates suggest a return on investment of $4.25 per dollar invested. On the other hand, we found no detectable impacts for the city center revitalization interventions.

There are a number of limitations with the analysis that are worth mentioning upfront. First using the neighborhood as the unit of treatment assignment limits our ability to capture spatial variations within neighborhoods, for example if properties on the border are affected more than more distant properties. An extension to this analysis would use GPS coordinates or addresses to calculate the precise distance between a property and each of the projects. A second limitation relates to data availability and in particular a limited number of observations in the pre-intervention period. An expanded data set with more pre-intervention periods would allow for a richer analysis of pre-trends. A third issue is the limited number of observations in some intervention areas and semesters, reducing the precision of the statistical analysis.

Our results are consistent with existing literature that find positive effects of urban transport interventions on the wellbeing of the population. However, we don't find evidence that upgrading of urban parks has an impact on property prices. Although existing evidence from other studies has shown a positive relation between urban parks and property prices (Crompton 2001, Konijnendijk 2013, Koetse 2011), the relationship may not hold if the intervention is conducted in low population density areas (Dehring and Dunse, 2006) or in areas with high insecurity (Troy and Grove, 2008, Chen and im, 2010). In this regard, anecdotical evidence collected after the

[10] That is approximately US$ 88,915,305.6 using an exchange rate of 2 Reais per Dollar, which is an estimated average of the exchange rate during the period of analysis. Dividing by the cost of the transportation component (20,906,000.00) this leads to a rate of return of US$4.25 per every dollar spent.

inauguration of the parks suggest continued security concerns, which may have mitigated the potential benefits of the parks for residents[11].

[11] Campo Grande News 06/09/2014 http://www.campograndenews.com.br/cidades/capital/orla-ferroviaria-atrai-usuarios-de-drogas-e-populacao-pede-seguranca

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FIGURES

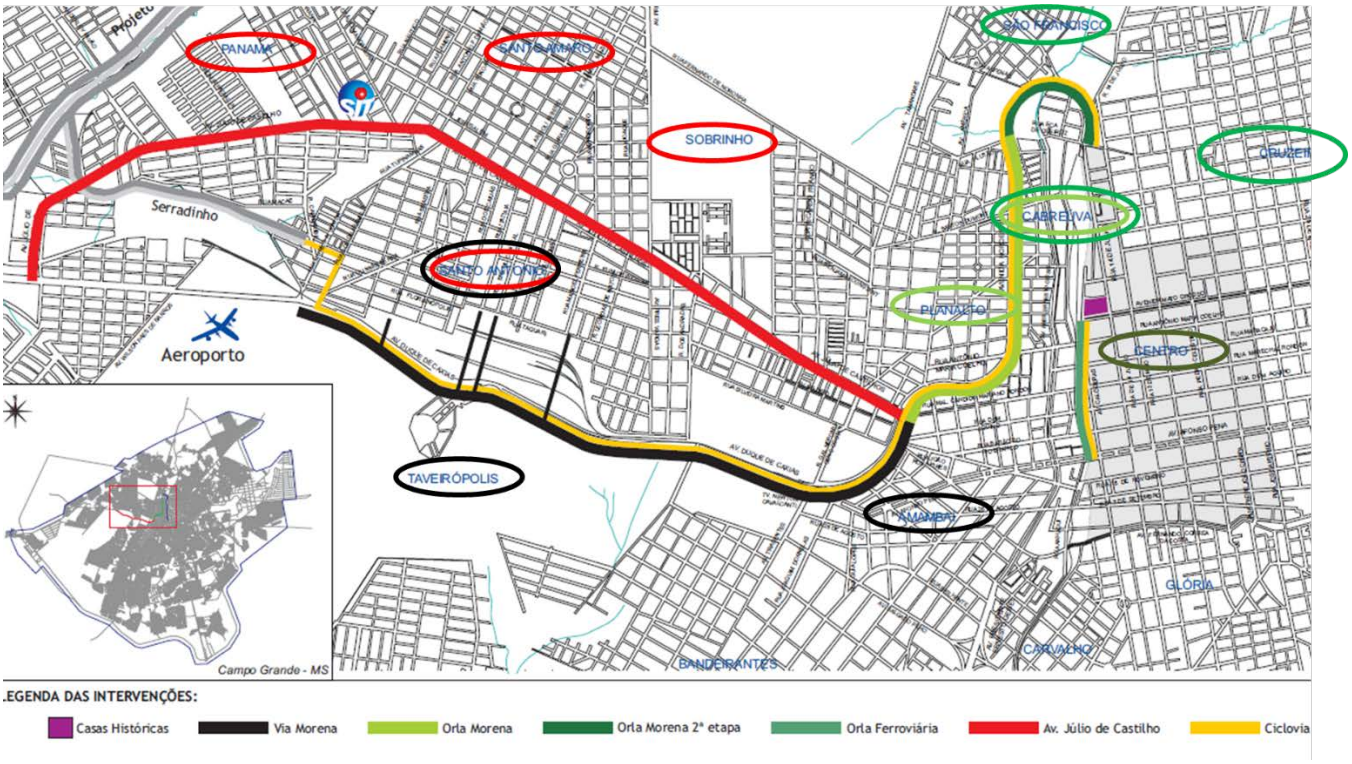

Figure 1. Map of the Investments of Procidades in Campo Grande.

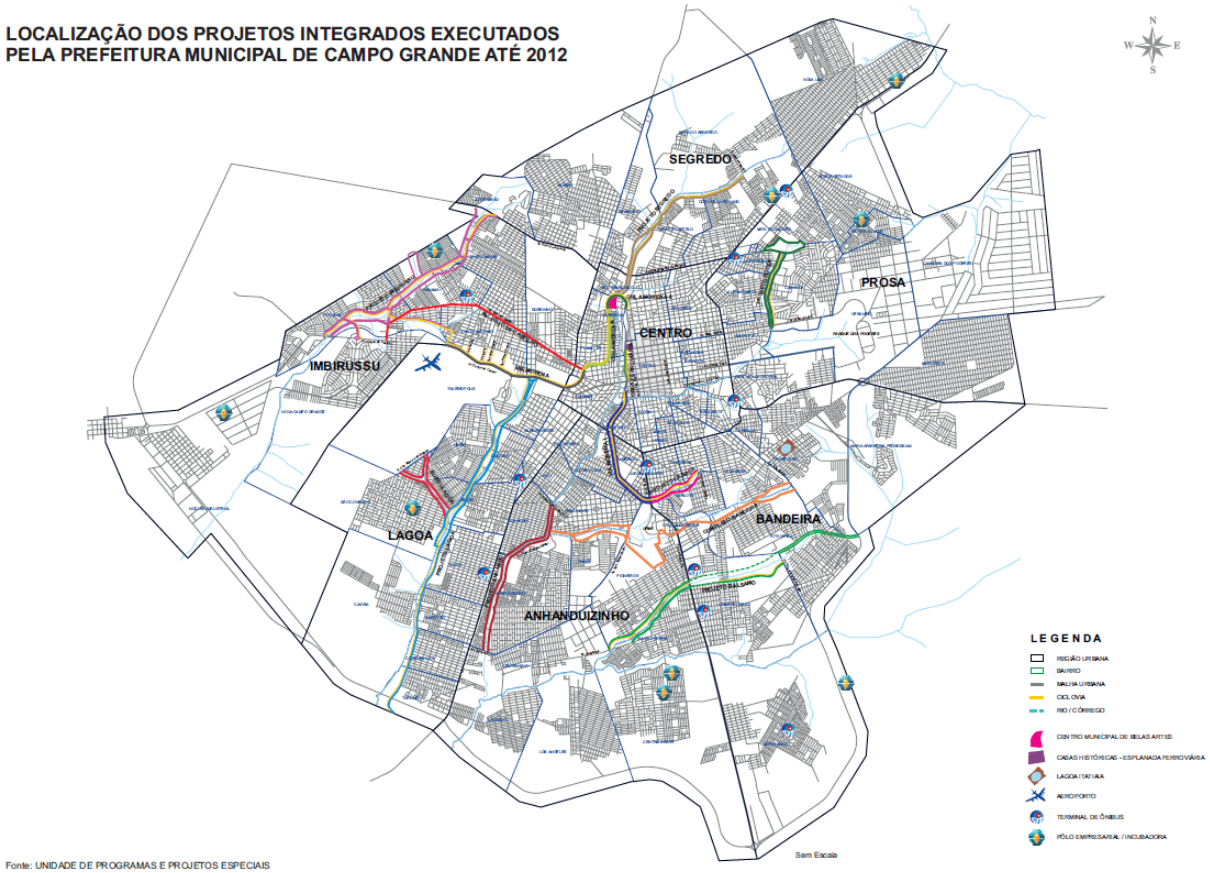

Figure 2. Map of all the urban infrastructure interventions carried out in the municipality of Campo Grande between 2008 and 2012

TABLES

Table 1. Main Infrastructure Interventions of Procidades at Campo Grande (2009-2013)

Infrastructure Work	Amount (US$)	Starting Date	Finalizing Date
1. Revitalization of the City Center	**14,098,000**	**Mar-09**	**Jun-13**
Obra Orla Ferroviária	*2,600,000*	*Feb-11*	*Apr-13*
Orla Morena 1st Stage	*6,498,000*	*Mar-09*	*Dic-10*
Orla Morena 2nd Stage	*5,000,000*	*Feb-11*	*Jun-13*
2. Transport and Mobility	**20,906,000**	**Nov-09**	**Jul-13**
Via Morena	*10,071,000*	*Nov-09*	*Dic-12*
Avenida Júlio de Castilho	*10,835,000*	*Ago-11*	*Jul-13*

Source: Inter-American Development Bank

Table 2. Frequency Chart type of properties sold in Campo Grande (2008-2013)

KIND OF PROPERTY	Freq.	Percent	Cum.
COMERCIAL	110	0.52	0.52
ESSENTIAL PURPOSES	2	0.01	0.52
INDUSTRIAL	2	0.01	0.53
MIXED	105	0.49	1.03
RELIGIOUS	6	0.03	1.05
RESIDENTIAL	12,634	59.16	60.22
SERVICES	309	1.45	61.66
TERRITORIAL	8,187	38.34	100
Total	21,355	100	

Source: administrative data ITBI Campo Grande

Table 3. Number of property sales by semester

Period	Control	Treatment		Total
		Revitalization	Transportation	
2008-1	873	0	0	873
2008-2	1,469	0	0	1,469
2009-1	935	275	0	1,210
2009-2	640	274	271	1,185
2010-1	603	238	260	1,101
2010-2	586	275	253	1,114
2011-1	558	230	231	1,019
2011-2	589	324	192	1,105
2012-1	615	228	217	1,060
2012-2	553	247	197	997
2013-1	558	219	166	943
2013-2	327	150	81	558
Total	8,306	2,460	1,868	12,634

Fuente: Municipal administrative records from IPTU and ITBI

Table 4. Joint significance F-test of equal pre-trends

Interventions	p-value of the F-test of equal trend for the pre-intervention periods [1]
Overall Program	0.5335
Intervention of Revitalization	0.2484
Intervention of Transportation	0.8079

[1]Adjusted by observable characteristics of the properties and for other interventions conducted in the municipality.

Source: administrative data from ITBI, ITPU and information of other works in the municipality of Campo Grande

Table 5. Impact of Procidades in the logarithm of the prices by squared meter in the Municipality in Campo Grande (2009-2013)[1]

VARIABLES	Intervention of Revitalization		Intervention of Transportation	
	(1)	(2)	(3)	(4)
Total Impact period 2009-2013	-0.023		0.061**	
	(0.026)		(0.023)	
Mg impact period 2009-1		-0.012		-
		(0.046)		
Mg impact period 2009-2		-0.070*		-
		(0.038)		
Mg impact period 2010-1		0.111		-0.070*
		(0.066)		(0.041)
Mg impact period 2010-2		-0.007		0.039
		(0.045)		(0.093)
Mg impact period 2011-1		-0.021		-0.003
		(0.041)		(0.037)
Mg impact period 2011-2		-0.083		0.088
		(0.050)		(0.054)
Mg impact period 2012-1		0.035		0.065
		(0.043)		(0.043)
Mg impact period 2012-2		-0.098**		0.222***
		(0.038)		(0.041)
Mg impact period 2013-1		-0.056		0.122***
		(0.039)		(0.036)
Mg impact period 2013-2		-0.014		0.058
		(0.058)		(0.052)
Observations	10,765	10,765	10,171	10,171
R-squared	0.541	0.542	0.482	0.483
Control Mean:	6.307	6.307	6.307	6.307

Robust standard erros in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

[1]NOTES:

1. Inlcudes fixed effects at the neighborhood level, at the period level, and controls for the characteristics of the propoerties and neighborhoods affected by other interventions. The property controls include: whether it is an appartment, the area of the lot, the area of the swimming pool, whether it was constructed before 2000, whether it has access to public transportation, whether it has access to municipal cleaning servicies, whether it has any of the following: water, garbage service, sewage, illumination, curb, paving, electricity, telephone, sidewalks. Also by the characteristics of the materials of the interior and exterior finish of the walls of the building, the roof, ceiling, window frames, structure of the building, floor, installation of electrical and sanitary installation, state of preservation, whether there is a lift and if it is in a regular or irregular situation.

2. Revitalization Interventions include Orla Ferroviaria, Orla Morena, and Transportation Interventions includes Via Morena and Julio de Castilho.

Table 6. Placebo Tests of the urban interventions of revitalization and transportation in Campo Grande

VARIABLES	(1) Overall Program	(2) Revitalization	(3) Transportation (a)	(4) Transportation (b)
"False Impact"	-0.037	-0.063	-0.002	0.042
	(0.059)	(0.054)	(0.063)	(0.067)
Observations	2,342	1,795	2,713	2,713
R-squared	0.508	0.558	0.401	0.401
Control Mean:	5.972	5.999	5.947	5.937

Fixed effects at the neighborhood and semester level. Includes controls of the characteristics of the houses and of the neighborhoods that have received investments in urban infrastructure. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

(a) Uses as pre-treatment the first semesters and as false-treatment second and third semesters

(b) Uses as pre-treatment the first and second semesters and as false-treatment the third semester