Department of Economics- FEA/USP

Diamonds Are Forever: Long-Run Effects of Mining Institutions in Brazil

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Abstract:

This paper uses a regression discontinuity approach to investigate whether a set of colonial policies adopted in the Diamond District of colonial Brazil have long-run impacts on development. Results regarding household income are still inconclusive. On the other hand, the estimated effects on adult literacy and light density from satellite images are positive. I also try to explore potential channels through which this historical event might influence the present. Using a geospatial road location database, I find that observations inside the District's historical boundaries have denser road networks. Additionally I use microdata from the 1830s to show that slavery was more intense in untreated villages, which has been related in the literature to underdevelopment.

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1 Introduction

The effect of historical events on modern economic development has generated a significant body of literature in recent years (see Nunn, 2009, for a review). Lately, studies have focused on explaining the channels through which history might influence present outcomes. For example, Dell (2010) estimates that districts subject to forced labor in colonial Peru are relatively underdeveloped today, especially through land tenure and infrastructure provision. Nunn (2008) shows that African ethnicities more intensely affected by the slave trade are poorer and Nunn and Wantchekon (2011) find this can be explained by having developed a culture of mistrust. While most studies in this literature focus on large-scale historical events, it would be interesting to evaluate the effects of briefer, more local interventions. Finding long-run effects in such a case would provide strong evidence for the persistence of historical events.

In this paper, I examine the long-run impacts of a set of institutions that existed for about a century in a small part of colonial Brazil. When diamonds were discovered within its domains, the Portuguese Crown singled the area out, creating specific *de jure* institutions in order to extract the largest possible surplus from the mineral. The Diamond District (*Distrito Diamantino*, in Portuguese) existed for about a century from 1731 until the 1830s and was subject to policies that differed from the rest of the colony. Although the rules specific to the diamond-mining area varied along time, they had a constant objective: maximize metropolitan control in order to avoid smuggling and extract rents. Also, as it started to become more difficult to find the stones, regulations became progressively more repressive, distinguishing it further from the surrounding areas. The discrete change at the District's border suggests that a Regression Discontinuity approach might be used to evaluate its effects.

2 Diamond District

2.1 Historical Background

The discovery of diamond mines in colonial Brazil was officially notified to Lisbon in 1729 (the date of the actual discovery is uncertain, but believed to be around 1720). The region was located in the Province of Minas Gerais, already experiencing a gold boom since the previous century. This particular area, on the other hand, was quite marginal in the gold-mining context: its linear distance to the main gold area around Vila Rica is almost 300 km. Another evidence of its limited importance before diamonds is that in 1738 (see Furtado, 2008, p.41) the Comarca do Serro do Frio, that contained this region and the northern half of the Province, had a population of less than 10 thousand (and an area as big as the United Kingdom's).

After realizing that the rules created to control gold extraction were inadequate for the new product[1], the Crown decided to set up a new system. In 1731, the demarcation of the District's boundaries took place, leaving inside of it the places where diamonds were known to occur. At the same time, the Crown tried to discourage extraction by raising tax on the number of slaves employed in the mines. Since these measures were still unable to avoid a sharp decline in international prices, the authorities decided to halt production completely between 1734 and 1739, while also creating a new government department called Diamond Administration to run the District.

Production restarted in 1739 under a new institutional arrangement, becoming the monopoly of a private investor or group that purchased from the Crown the exclusive rights of extraction inside the District for a period of time. In 1745 the authorities decided to control access at the District's boundary, forbidding entrance outside the 6 guarded outposts. In 1771, allegedly to avoid frauds and smuggling, the Crown decided to extract the diamonds directly, creating a state-owned company called the Royal Diamond Extraction that had a legal monopoly on both mining and trading (Furtado, 2008). At the same time, a new legal system went into effect inside the District subjecting its population to an even narrower control[2]. This period, that lasted until 1835, has been described as the most extreme example of colonial despotism in Portuguese America, creating a *de jure* system that standed out even in comparison to the surrounding areas, subject to the already repressive gold-mining regulations (Oliveira Torres, 1980). Furthermore, Boxer (1962) describes the District in this period as "a colony within a colony, cut off from the rest of Brazil by a legal and administrative barrier".

Perhaps the most relevant difference is that the population of the District was largely subject to the authority of the Diamond Administration's Intendant, who reported directly to Lisbon. There were no city councils, courts or other kinds government departments (Prado Jr., 2012). So historical description suggests that the discontinuity did exist and the treatment (being a part of the Diamond District) was indeed effectual. On the other hand, the importance given to the area by the Portuguese and the fact that at the time this was a wealthy place might have bequeathed better infrastructure and human capital.

[1] Physical differences made it more difficult to control diamond production and avoid smuggling. Also the main tax on gold, the fifth, was charged in foundries which made it obviously inadequate for this context.

[2] de Mello e Souza (2008) points that repression against smuggling reached its maximum intensity in this period, being punishable by exile or death.

2.2 The Border Assignment

The only explicit criterion for the border's demarcation was the occurrence of diamonds[3]. Since the presence of diamonds is probably correlated with other geographic variables, those factors might have indirectly influenced the assignment. For example, given that in this region diamonds were found mostly in streams, the authorities probably took them into account. Indeed, historical maps (see Appendix) show that some segments of the boundary encircled the headwaters of the District's rivers and since drainage basins are determined by topography, the borders are probably indirectly influenced by geography. Also, other geographical factors like vegetation might have influenced the assignment, even if historical documents do not mention them.

Another possibility is that the border's location was influenced by human factors, such as previous settlement patterns. This is will not be possible to test due to the paucity of data on human settling before the discovery of diamonds, but historical evidence suggests this is not the case. First because prior to the discovery of diamonds this was quite a marginal area in the mining context, so the region was sparsely populated (as discussed in Section 2.1). Secondly, the events that followed suggest that residents' interests would not be taken into account anyway if there was any conflict with metropolitan objectives.

3 Effects on Long-Run Development

3.1 Data

Diamond District's Borders: Historical maps that show the boundary, urban centers and some geographical features like rivers are available in Costa et al. (2002). Using the latter as control points to georeference the maps in ArcGIS it is possible to correct distortions and digitalize the boundary. This is robust to omitting some control points or changing the adjustment method[4]. The two maps used are from 1776 and 1784, right in the beginning of the most repressive period.

The original maps as well as the georeferenced border are shown in the Appendix. Figure 4 shows that some segments of the georeferenced border coincide with contemporary political limits, motivating me to test for treatment effects in sub-samples formed only by those intersected by the border. By doing this I may be able to identify effects on institutions at the municipality level, and other channels of transmission at the sub-municipal level. Also, this gives further confidence that the georeferencing is robust.

Contemporary Development Outcomes: Household income and adult literacy taken from the Brazilian

[3]In the first years of the Districts' existence its area was expanded whenever new mines were found, remaining stable afterwards (Furtado, 2008).

[4]The software lets you choose different adjustments, such as minimizing errors by 2nd or 3rd order polynomials, or spline.

2010 Population Census (IBGE, 2011), at the Census tract level. Household income is measured as the average among private households within each tract. Literacy is measured as the percentage of people above 40 years of age that are able to read and write a simple note.

I will also use light density obtained from the Defense Meteorological Satellite Program's Operational Linescam System as a proxy for local economic development (see Henderson et al., 2012). In this data the unit of observation will be pixels of the satellite image. I will test effects both on the intensive and on the extensive margin (that is, the probability of a pixel being lit).

It is important to notice that most of the contemporary urban centers already existed in colonial times [5] and are shown on the historical maps, so even if there were still some uncertainty in the border's location it would not make a difference in treatment status for most lit pixels and Census tracts (see Figures 5 and 6) [6].

Geographical Covariates: River locations obtained from IBGE (2010) vector files and elevation from the SRTM satellite image data (Jarvis et al., 2008). River density is measured as the total length in meters within each tract or pixel divided by its area in square kilometers. Elevation is measured in meters within pixels of 3 arc-second (approximately 90 m^2). From the raw elevation data I have also calculated terrain slope and ruggedness [7] for each pixel using ArcGIS.

[5] Although mostly with different names, but they have been matched by dos Santos and de Seabra (2009).

[6] For example, the historical maps show that the urban area then known as Arraial do Tejuco was inside the District. This place today is the city of Diamantina, so I know that the observations within it are treated even if there is some marginal uncertainty in the location of the border.

[7] I have measured ruggedness using the Vector Ruggedness Measure introduced by Sappington et al. (2007), because it is less correlated with slope than other measures. It is an index that varies from 0 (flat) to 100% (completely rugged).

Table I

Summary Statistics

	Sample within :						Sample within :					
	<25 km of District Border			<15 km of District Border			<10 km of District Border			<5 km of District Border		
	Inside	Outside	s.e.	Inside	Outside	s.e.	Inside	Outside	s.e.	Inside	Outside	s.e.
Panel A : Census Tracts												
Terrain												
Altitude (m)	1119	808	(21,8)***	1041	844	(30,8)***	1023	850	(32,7)***	996	893	(43,5)***
Slope (degrees)	7,1	7,4	(0,34)	6,1	7,7	(0,39)***	6,2	8,1	(0,42)***	6,6	7,8	(0,62)**
Ruggedness	0,26%	0,39%	(0,03%)***	0,22%	0,42%	(0,03%)***	0,23%	0,44%	(0,03%)***	0,25%	0,38%	(0,05%)***
River density (m/km2)	712	729	(94,9)	759	741	(122,6)	706	665	(116,2)	661	614	(135,4)
Observations	115	163		65	105		58	78		45	43	
Panel B : Pixels (approx. 1 sq km)												
Terrain												
Altitude (m)	1082	888	(3,6)***	1066	947	(4,2)***	1042	971	(5,0)***	1012	988	(7,1)***
Slope (degrees)	8,2	7,8	(0,06)***	8,3	7,9	(0,08)***	8,3	8,1	(0,09)***	8,2	8,4	(0,12)**
Ruggedness	0,36%	0,37%	(0,01%)**	0,37%	0,37%	(0,01%)	0,36%	0,38%	(0,01%)*	0,36%	0,39%	(0,01%)***
River density (m/km2)	620	630	(11,1)	616	614	(12,7)	623	605	(14,9)	631	608	(20,6)
Observations	4785	12412		4226	7008		3315	4550		1891	2262	

The unit of observation is the Census Tract for data in Panel A and pixels of 3 and 30 arc-second and 5 arc-minute resolution (~ 0.1, 1 and 81 sq. km) in Panel B. Robust standard errors for the difference in means between observations inside and outside the District are in parentheses. The first column includes observations not more than 25 km away from the District's Border, and then the following columns do the same for 15, 10 and 5 km respectively. *, ** and *** denote respectively significance at the 10%, 5% and 1% level.

3.2 Estimation Framework

Being a part of the District's historical area is a discontinuous and deterministic function of geographic location, suggesting estimating its effects using a spatial regression discontinuity design.
The basic regression for Census tract data is:

$$y_{tm} = \alpha + treatment_t D + X'_{td}\beta + f(loc_t) + \delta_m + \varepsilon_{tm} \tag{1}$$

where y_{tm} is the outcome variable in census tract t in municipality m; $treatment_t$ is a dummy variable that takes on value 1 if at least 90% of the tract's area is inside the historical boundary and 0 if less than 10% of it is located within; X'_t is a vector of covariates aggregated at the tract level (terrain variables and river density); and $f(loc_t)$ is the RD polynomial, that controls for smooth variations along the geographic space.
Or, for the pixel-level estimations:

$$y_{ptm} = \alpha + treatment_p D + X'_p\beta + f(loc_p) + \delta_m + \varepsilon_{ptm} \tag{2}$$

with analogous definitions, except that $treatment_p$ takes value 1 if at least 95% of the pixel is inside the District's area, 0 if no more than 5% is outside.
The RD approach requires that all relevant factors other than treatment vary smoothly at the discontinuity. In other words, defining y_1 and y_0 as potential outcomes under treatment and control, $E[y_1|latitude, longitude]$ and $E[y_0|latitude, longitude]$ must be continuous at the District's border. I examine this hypothesis in Table I, testing for differences in terrain characteristics and river density. Although the terrain data seem to be statistically different even in narrow bands, the magnitude doesn't seem to be economically relevant.
In order to adequately identify the treatment effect it is important to correctly adjust the polynomial so that nonlinear variations along the border are not mistaken for discontinuous effects. Following Dell (2010), I will test multiple specifications for the polynomial. Since the running variable is two-dimensional (latitude and longitude), I will use polynomials of order up to 3 in geographical coordinates[8].

3.3 Estimation Results

Tables II and III reports estimates for the development outcome variables across two several specifications. In Table II, we can see that estimates are inconsistent across the household income regressions, which suggests there are still some endogeneity to be dealt with.
For the adult literacy regressions, estimates seem to be more stable, suggesting a treatment effect of about 10 percentage points on the fraction of adults over 40 that can read and write.

[8]For example, the cubic polynomial in longitude (x) and latitude (y) is: $x^3 + y^3 + x^2y + xy^2 + x^2 + y^2 + xy + x + y$.

Table III shows that having belonged to the District seems to have a positive effect on luminosity. Although not significant in most specifications, the point estimates are quite stable, suggesting a pixel inside that District's historical boundaries are around 2% more likely to be lit. The log estimations also show a positive effect of the District on local development.

These estimates are not intended to be final, I am mostly using them to investigate the next steps. Also, I am still going to include precipitation and soil type covariates so I believe I am going to have cleaner results in the future.

Table II – Development Outcomes (Census Data)

Panel A: Full Sample

	Household Income							
Sample within :	<25 km to Border		<15 km to Border		<10 km to Border		<5 km to Border	
	No polynomial							
Treatment	564,3	415,3	48,2	91,9	39,2	94,9	183,9	127,4
	(242,1)***	(144,0)***	(126,1)	(64,8)	(149,7)	(71,7)	(102,8)*	(85,9)
	Linear Polynomial in Latitude and Longitude							
Treatment	551,7	418,5	48,1	95,5	30,8	92,3	208,3	154,8
	(246,3)***	(135,0)***	(117,4)	(73,3)	(136,9)	(79,7)	(95,2)**	(87,6)*
	Quadratic Polynomial in Latitude and Longitude							
Treatment	200,0	152,1	-171,0	-195,3	-219,2	-242,5	95,7	53,7
	(233,4)	(199,5)	(189,0)	(146,5)	(181,0)	(138,8)*	(62,9)	(86,3)
	Cubic Polynomial in Latitude and Longitude							
Treatment	92,1	-29,6	-185,2	-188,9	-238,1	-236,4	93,0	58,1
	(236,0)	(186,8)	(180,9)	(141,8)	(167,1)	(124,1)*	(68,9)	(87,5)
Geo. Controls	No	Yes	No	Yes	No	Yes	No	Yes
Municipalities FE	No	No	No	No	No	No	No	No
Municipalities	28	28	23	23	20	20	16	16
Observations	258	258	157	157	125	125	80	80

	Adult Literacy (p.p.)							
Sample within :	<25 km to Border		<15 km to Border		<10 km to Border		<5 km to Border	
	No polynomial							
Treatment	17,3	16,7	12,8	11,9	12,9	11,3	16,3	12,1
	(2,7)***	(3,6)***	(4,4)***	(4,5)***	(4,9)***	(5,6)**	(6,0)***	(7,3)*
	Linear Polynomial in Latitude and Longitude							
Treatment	16,6	16,8	12,2	11,7	11,7	11,0	17,5	12,8
	(2,7)***	(3,6)***	(4,4)**	(5,0)**	(4,8)**	(5,9)*	(5,6)***	(7,9)
	Quadratic Polynomial in Latitude and Longitude							
Treatment	11,1	10,6	3,1	-0,9	1,5	-4,7	12,5	4,1
	(4,6)**	(5,0)**	(4,3)	(5,0)	(4,2)	(4,9)	(4,4)**	(5,3)
	Cubic Polynomial in Latitude and Longitude							
Treatment	7,4	6,8	0,8	-2,3	-1,2	-5,9	10,8	4,1
	(4,1)*	(4,7)	(3,3)	(5,2)	(3,2)	(5,2)	(4,6)**	(5,5)
Geo. Controls	No	Yes	No	Yes	No	Yes	No	Yes
Municipalities FE	No	No	No	No	No	No	No	No
Municipalities	28	28	23	23	20	20	16	16
Observations	258	258	157	157	125	125	80	80

The unit of observation is the Census Tract. Robust standard errors clustered by municipality are in parentheses. The first column for each variable includes observations not more than 25 km away from the District's Border, and then the following columns do the same for 15, 10 and 5 km respectively. Household Income is measured as the average nominal income in Brazilian Reais earned by private households. Geographic controls include all the covariates in Table I. *, ** and *** denote respectively significance at the 10%, 5% and 1% level.

Table II – Development Outcomes (Census Data)
Panel B: Municipalities Intersected by the Border

	Household Income								Adult Literacy (p.p.)							
Sample within :	<25 km to Border		<15 km to Border		<10 km to Border		<5 km to Border		<25 km to Border		<15 km to Border		<10 km to Border		<5 km to Border	
	No polynomial								No polynomial							
Treatment	583,0	341,1	-32,9	5,0	-37,8	-34,8	238,9	33,2	17,2	15,4	11,9	8,2	12,1	7,0	18,4	6,5
	(314,7)	(177,9)	(210,2)	(123,6)	(230,7)	(131,5)	(121,4)	(175,2)	(2,9)***	(6,0)*	(6,1)	(8,7)	(6,7)	(10,3)	(7,2)	(13,8)
	Linear Polynomial in Latitude and Longitude								Linear Polynomial in Latitude and Longitude							
Treatment	647,1	374,3	17,4	5,4	-5,8	-34,0	95,6	37,9	13,9	14,8	8,6	7,9	7,3	6,2	8,6	7,0
	(464,7)	(254,9)	(193,5)	(131,8)	(211,9)	(139,2)	(96,3)	(124,2)	(6,0)*	(5,2)**	(5,6)	(9,0)	(6,1)	(9,4)	(3,6)*	(11,7)
	Quadratic Polynomial in Latitude and Longitude								Quadratic Polynomial in Latitude and Longitude							
Treatment	-37,8	48,1	-256,6	-324,9	-322,3	-361,3	122,5	43,1	8,4	8,6	3,4	-3,3	2,6	-2,6	16,0	11,3
	(445,0)	(505,9)	(314,0)	(258,2)	(258,4)	(180,2)	(122,0)	(162,0)	(8,7)	(10,0)	(7,4)	(9,7)	(6,5)	(10,5)	'(4,9)**	(7,3)
	Cubic Polynomial in Latitude and Longitude								Cubic Polynomial in Latitude and Longitude							
Treatment	-206,0	-98,2	-237,1	-307,4	-300,9	-329,3	141,5	42,1	4,2	4,8	2,4	-3,7	1,8	-1,7	18,3	11,2
	(454,4)	(567,3)	(325,8)	(254,9)	(289,9)	(179,4)	(151,7)	(161,6)	(7,2)	(8,6)	(6,6)	(9,5)	(5,9)	(11,5)	(4,6)**	(7,3)
Geo. Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Municipalities FE	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Municipalities	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Observations	144	144	89	89	77	77	53	53	144	144	89	89	77	77	53	53

The unit of observation is the Census Tract. Robust standard errors clustered by municipality are in parentheses. The first column for each variable includes observations not more than 25 km away from the District's Border, and then the following columns do the same for 15, 10 and 5 km respectively. Household Income is measured as the average nominal income in Brazilian Reais earned by private households. Geographic controls include all the covariates in Table I. *, ** and *** denote respectively significance at the 10%, 5% and 1% level.

Table II – Development Outcomes (Census Data)
Panel C: Municipalities Intersected by the Border, w/ FE

	Household Income								Adult Literacy (p.p.)							
Sample within :	<25 km to Border		<15 km to Border		<10 km to Border		<5 km to Border		<25 km to Border		<15 km to Border		<10 km to Border		<5 km to Border	
	No polynomial								No polynomial							
Treatment	403,5	280,2	-98,5	-91,1	-158,2	-134,3	73,9	-4,2	9,8	13,5	4,7	6,7	2,3	5,9	8,8	7,2
	(462,6)	(175,8)	(200,2)	(99,6)	(209,2)	(62,2)*	(62,1)	(81,1)	(5,2)	(5,2)*	(3,7)	(7,7)	(2,9)	(7,7)	(6,7)	(10,6)
	Linear Polynomial in Latitude and Longitude								Linear Polynomial in Latitude and Longitude							
Treatment	209,3	86,1	-92,3	-105,5	-153,3	-169,2	50,4	-9,9	9,0	10,5	6,1	6,2	3,9	4,9	7,8	6,8
	(139,3)	(80,5)	(204,8)	(132,2)	(153,8)	(124,5)	(107,1)	(93,1)	(2,8)**	(5,2)	(4,1)	(8,4)	(2,0)	(8,0)	(3,7)*	(8,3)
	Quadratic Polynomial in Latitude and Longitude								Quadratic Polynomial in Latitude and Longitude							
Treatment	-77,6	-27,7	-235,1	-293,8	-245,2	-274,6	274,1	188,1	6,8	7,7	4,4	-0,4	8,5	5,1	25,9	20,9
	(207,9)	(226,7)	(325,7)	(258,2)	(273,8)	(168,8)	(126,1)*	(175,6)	(4,1)	(4,4)	(5,4)	(8,3)	(4,0)	(8,3)	'(7,6)**	(6,9)**
	Cubic Polynomial in Latitude and Longitude								Cubic Polynomial in Latitude and Longitude							
Treatment	-67,1	-9,5	-228,7	-294,8	-245,5	-274,5	274,0	187,8	5,4	6,4	3,8	-2,2	8,6	5,2	26,0	20,9
	(202,3)	(232,1)	(313,7)	(254,9)	(272,6)	(168,4)	(126,0)*	(176,0)	(3,4)	(3,8)	(4,4)	(6,3)	(4,1)	(8,3)	(7,6)**	(6,9)**
Geo. Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Municipalities FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipalities	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Observations	144	144	89	89	77	77	53	53	144	144	89	89	77	77	53	53

The unit of observation is the Census Tract. Robust standard errors clustered by municipality are in parentheses. The first column for each variable includes observations not more than 25 km away from the District's Border, and then the following columns do the same for 15, 10 and 5 km respectively. Household Income is measured as the average nominal income in Brazilian Reais earned by private households. Geographic controls include all the covariates in Table I. *, ** and *** denote respectively significance at the 10%, 5% and 1% level.

Table III – Development Outcomes (Pixel Luminosity)

Panel A: Full Sample

	Lit/Unlit Pixels								ln(1 + luminosity)							
Sample within :	<25 km to Border		<15 km to Border		<10 km to Border		<5 km to Border		<25 km to Border		<15 km to Border		<10 km to Border		<5 km to Border	
	No polynomial								No polynomial							
Treatment	0,047	0,058	0,021	0,037	0,021	0,036	0,020	0,030	0,23	0,28	0,10	0,18	0,10	0,17	0,11	0,15
	(0,018)**	(0,024)**	(0,027)	(0,029)	(0,036)	(0,034)	(0,044)	(0,041)	(0,09)**	(0,11)**	(0,13)	(0,14)	(0,17)	(0,17)	(0,21)	(0,20)
	Linear Polynomial in Latitude and Longitude								Linear Polynomial in Latitude and Longitude							
Treatment	0,046	0,060	0,020	0,039	0,020	0,038	0,020	0,029	0,22	0,29	0,10	0,19	0,10	0,18	0,11	0,15
	(0,016)***	(0,019)***	(0,023)	(0,023)	(0,032)	(0,029)	(0,043)	(0,040)	(0,08)***	(0,10)***	(0,11)	(0,12)	(0,16)	(0,14)	(0,21)	(0,20)
	Quadratic Polynomial in Latitude and Longitude								Quadratic Polynomial in Latitude and Longitude							
Treatment	0,050	0,044	0,049	0,034	0,041	0,022	0,045	0,031	0,24	0,21	0,23	0,16	0,19	0,10	0,22	0,15
	(0,023)**	(0,023)*	(0,023)**	(0,021)	(0,028)	(0,026)	(0,033)	(0,031)	(0,11)**	(0,11)**	(0,12)**	(0,11)	(0,14)	(0,13)	(0,17)	(0,15)
	Cubic Polynomial in Latitude and Longitude								Cubic Polynomial in Latitude and Longitude							
Treatment	0,025	0,020	0,023	0,016	0,024	0,018	0,024	0,023	0,12	0,10	0,10	0,07	0,11	0,08	0,12	0,11
	(0,027)	(0,026)	(0,026)	(0,025)	(0,026)	(0,023)	(0,026)	(0,025)	(0,13)	(0,13)	(0,13)	(0,12)	(0,13)	(0,12)	(0,13)	(0,12)
Geo. Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Municipalities FE	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Municipalities	28	28	23	23	21	21	18	18	28	28	23	23	21	21	18	18
Observations	15156	15156	9880	9880	6890	6890	3587	3587	15156	15156	9880	9880	6890	6890	3587	3587

The unit of observation is the luminosity 30 arc-second pixel (~1 sq. km). Robust standard errors clustered by municipality are in parentheses. The first column for each variable includes observations not more than 25 km away from the District's Border, and then the following columns do the same for 15, 10 and 5 km respectively. Luminosity is measured as the color gradient of the pixel in the nighttime satellite photograph. In the left-hand columns, the dependent variable is a dummy that takes value 1 whenever luminosity is different than 0 (ie, when it is not completely dark). Geographic controls include all the covariates in Table I. *, ** and *** denote respectively significance at the 10%, 5% and 1% level.

4 Channels of Persistence

In this section I try to look for potential channels through which the existence of the Diamond District might influence current outcomes. I decided to test two potential channels: infrastructure and slavery. Although the institutional framework in the District was probably detrimental to long-run development given that it created more extractive institutions in the sense used by Acemoglu et al. (2001), it is possible that the Portuguese Crown provided better infrastructure within it, due to the importance it gave to the area.
On the other hand, different marginal productivities in diamond mining and institutional differences may have made slavery more or less prevalent inside the District. Considering the literature that estimates long-run effects of the presence of slavery, this might lead to long-run effects on development.

4.1 Infrastructure

In order to test whether infrastructure is different under treatment, I will use vector data on road locations from IBGE (2010).
Table VI shows the estimates of the effect on road density (meters per square kilometer), at the pixel level. Estimates are significant across all specifications and rather stable, suggesting that areas inside the former District have between 50 and 80 more meters of road per square kilometer.

Table VI

Road Density (m per km2)

Sample within :	<25 km to Border	<15 km to Border	<10 km to Border	<5 km to Border
Panel A: Linear Polynomial in Latitude and Longitude				
Treatment	57,1	60,3	58,4	55,5
	(17,8)***	(16,3)***	(12,9)***	(14,6)***
R2	0,01	0,02	0,02	0,02
Panel B: Linear Polynomial in Distance to Border				
Treatment	65,2	60,3	57,3	53,6
	(13,3)***	(11,4)***	(13,9)***	(17,1)***
R2	0,01	0,02	0,02	0,02
Panel C: Quadratic Polynomial in Latitude and Longitude				
Treatment	73,2	74,1	90,2	72,1
	(22,0)***	(26,9)***	(30,9)***	(24,7)***
R2	0,01	0,02	0,02	0,03
Geo. Controls	Yes	Yes	Yes	Yes
Municipalities FE	Yes	Yes	Yes	Yes
Municipalities	6	6	6	6
Observations	7957	6249	4904	2811

Table VI – *continued*

Road Density (m per km2)

Sample within :	<25 km to Border	<15 km to Border	<10 km to Border	<5 km to Border
	Panel D: Quadratic Polynomial in Distance to Border			
Treatment	64,8	59,7	57,7	53,6
	(14,6)***	(14,1)***	(14,4)***	(17,1)***
R2	0,01	0,02	0,02	0,02
	Panel E: Cubic Polynomial in Latitude and Longitude			
Treatment	74,3	77,3	90,0	72,1
	(18,0)***	(20,8)***	(31,0)***	(24,7)***
R2	0,01	0,02	0,02	0,03
	Panel F: Cubic Polynomial in Distance to Border			
Treatment	64,8	59,6	58,0	53,5
	(15,7)***	(14,0)***	(13,9)***	(17,0)***
R2	0,02	0,02	0,03	0,02
Geo. Controls	Yes	Yes	Yes	Yes
Municipalities FE	Yes	Yes	Yes	Yes
Municipalities	6	6	6	6
Observations	7957	6249	4904	2811

The units of observation are 30 arc-second pixels (~ 1 sq. km). Robust standard errors clustered by municipality are in parentheses. The first column includes observations not more than 25 km away from the District's Border, and then the following columns do the same for 15, 10 and 5 km respectively. Road density is measured as the road length in meters within each pixel divided by its area in square kilometers. *, ** and *** denote respectively significance at the 10%, 5% and 1% level.

4.2 Slavery

In this section I use microdata from lists of the population of the Province of Minas Gerais in the 1830s (NPHED-UFMG, 2010), right at the end of the District's existence. The data set is organized by community and household, and contain information such as status (free, slave or ex-slave), occupation, age and race. The dependent variable to be tested is a dummy that takes value 1 if the individual was a slave.

Estimates shown in Table VII suggest that a random person that lived inside the district was less likely to be a slave, controlling for age, race and village fixed effects. This might lead to positive effects in the long run on treated observations, considering the literature that connects the presence of slavery with contemporary underdevelopment (e.g., Acemoglu et al., 2012). Specifically this lower incidence of slavery might be related to the effect on literacy investigated in Table II.

5 Concluding Remarks

This paper investigates, by using a plausible source of exogenous variation, whether the colonial policies adopted in the Diamond District had long-run effects. Furthermore I search for possible mechanisms through which this historical event might influence contemporary development.

Table VII

1830 microdata

Sample within :	Slave	
	<20 km to Border	<10 km to Border
Panel A: Linear Polynomial in Latitude and Longitude		
Treatment	-0,35	-0,41
	(0,03)***	(0,15)***
R2	0,61	0,62
Panel B: Linear Polynomial in Distance to Border		
Treatment	-0,28	-0,02
	(0,03)***	(0,05)
R2	0,61	0,62
Village FE	Yes	Yes
Villages	11	8
Households	3595	1762
Observations	15549	9382

Controls : age, race, village FE. Robust standard errors clustered at the household level are in parentheses. *, ** and *** denote respectively significance at the 10%, 5% and 1% level.

Although luminosity from satellite images is used as a proxy for local development, the regressions using this data show a positive effect of the treatment, contradicting the evidence regarding average income from the 2010 Census.

Two possible channels of transmission are explored. Road density is found to be higher in the area historically assigned to the District, while historical microdata from the 19th century show that slavery was less intense on the inside. These two factors should lead to better outcomes on the inside.

Further research is necessary to better estimate the long run effects of the treatment. I also plan to investigate further the channels of transmission presented here by evaluating whether the estimated effects on roads are different across categories (e.g., dirt roads vs highways) and if these outcomes can be more tied across different periods (e.g, if road density was already different in the past and if the difference in slavery has led to racial heterogeneity).

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Appendix

Figure 1: Map of the Diamond District from 1776

Figure 2: Map of the Diamond District from 1784

Figure 3: Location of the georreferenced District border within the state of Minas Gerais

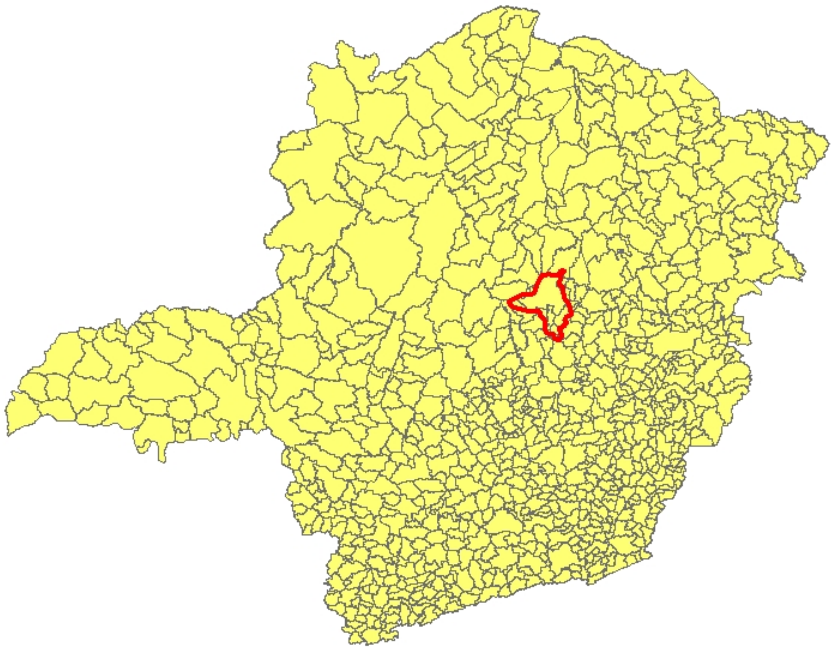

Figure 4: Georreferenced District border and contemporary municipalities

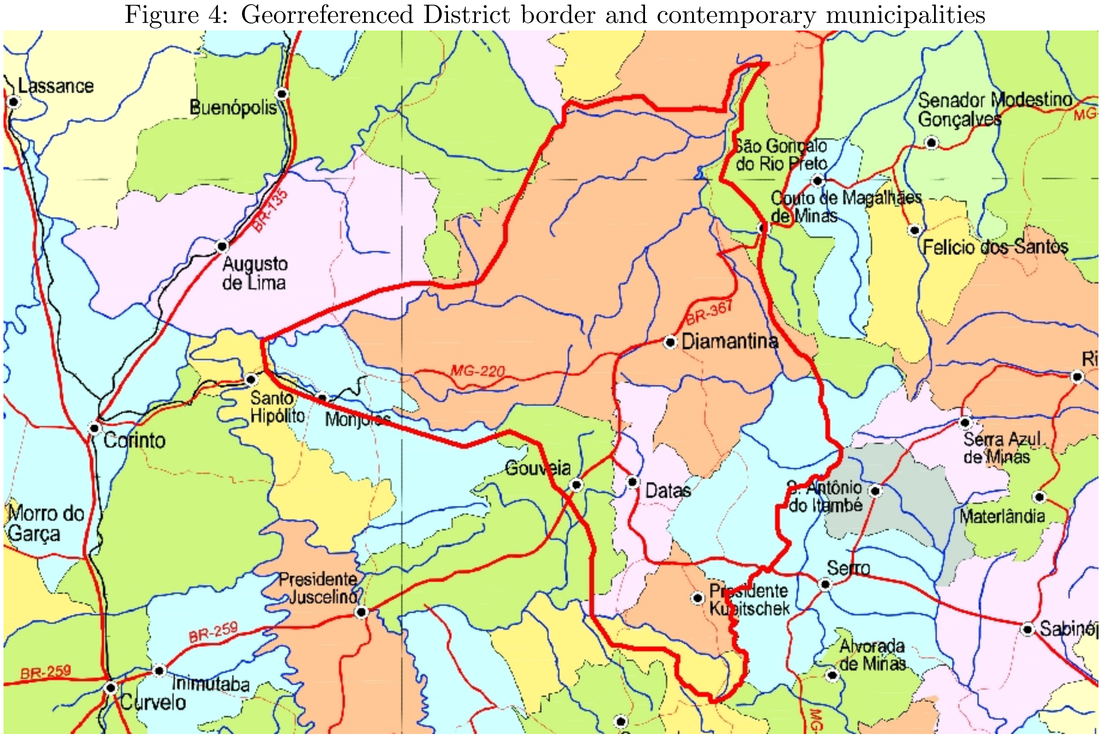

Figure 5: Georreferenced District border and Census tracts - Darker colors represent higher mean Household Income

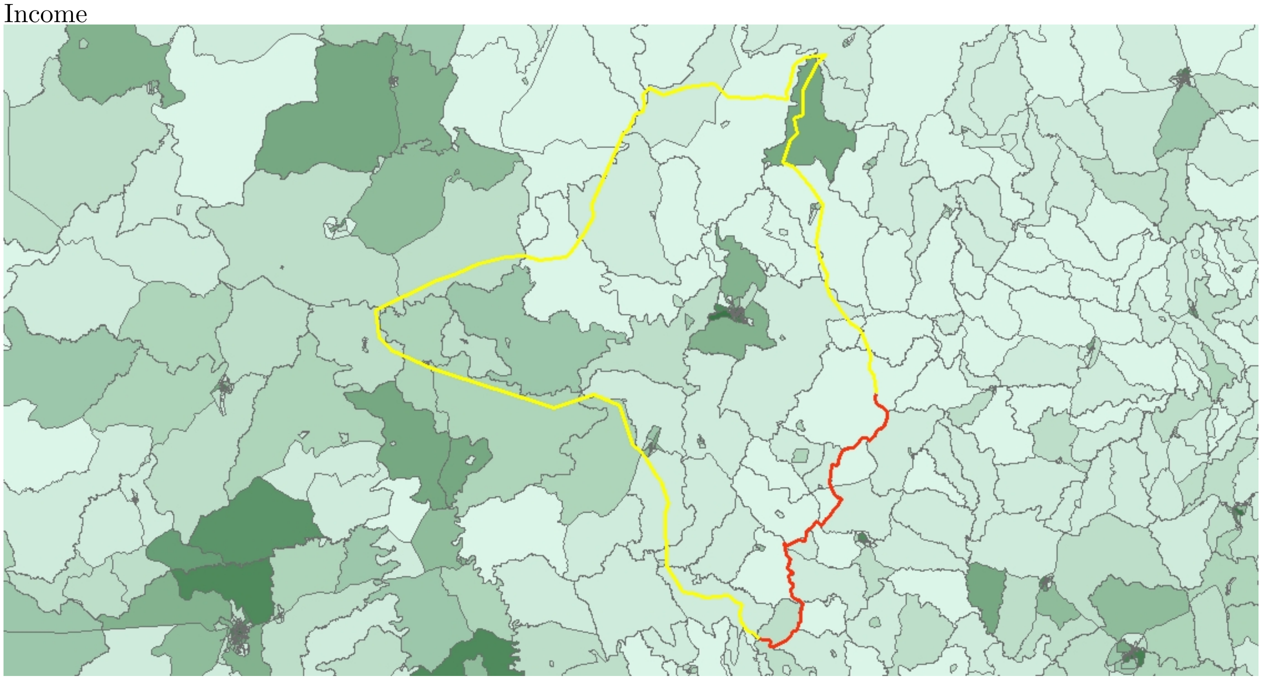

Figure 6: Georreferenced District border and luminosity- Lit/unlit pixels

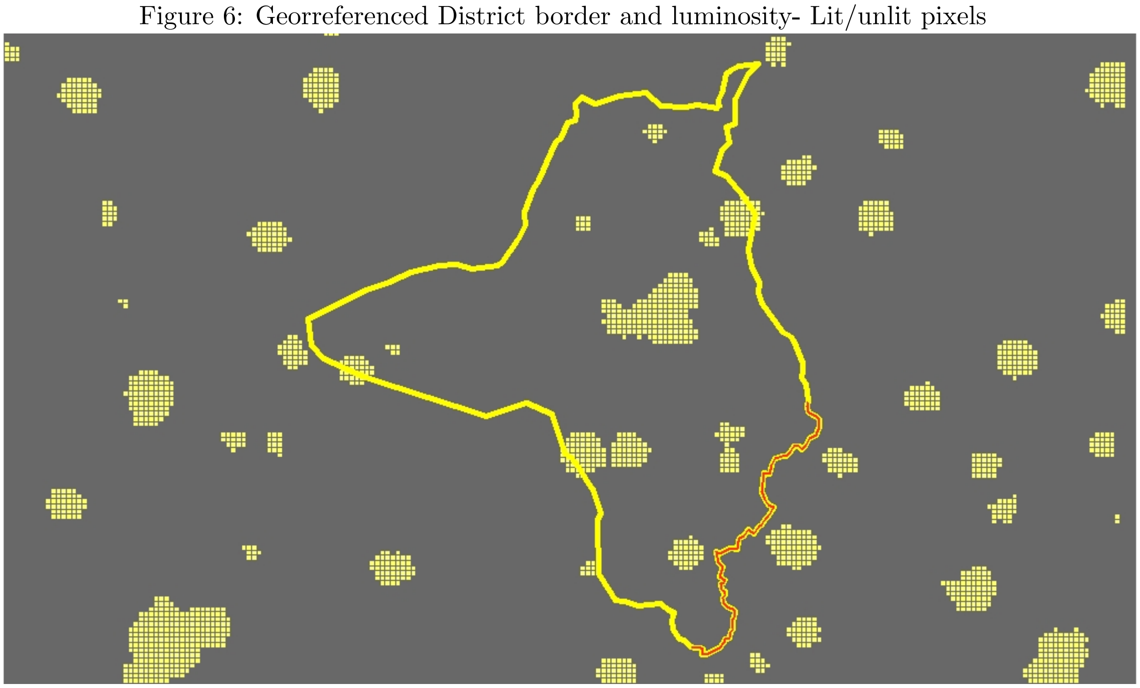

Figure 7: Georreferenced District border and log(luminosity)

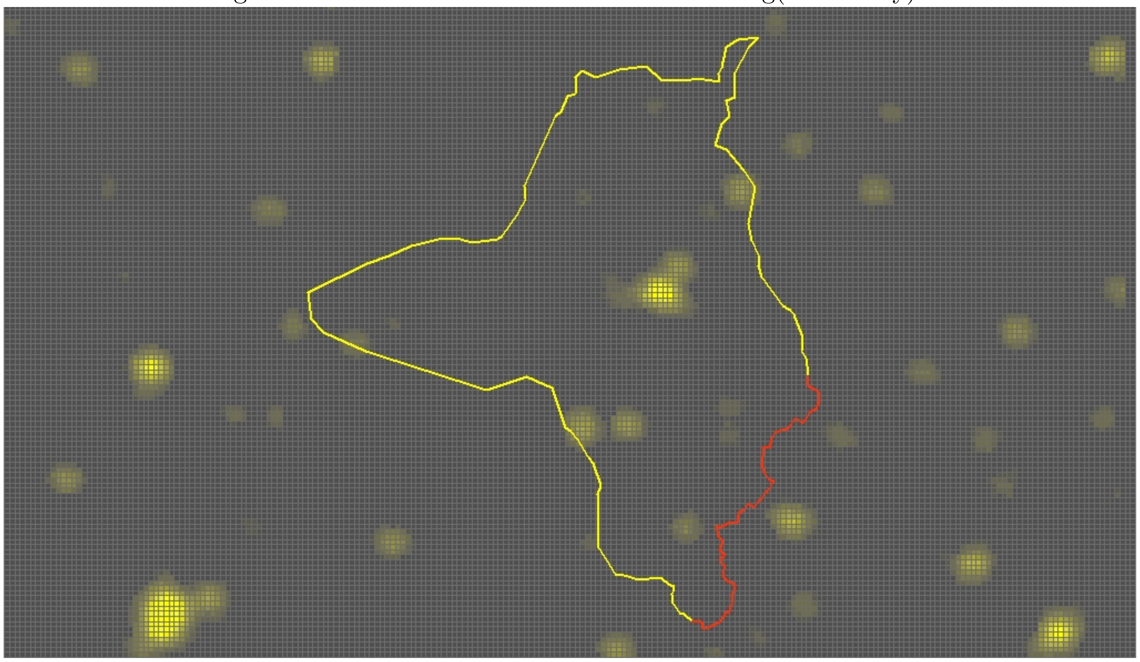

Figure 8: Georreferenced District border and Terrain