Criminality in Brazilian Border Municipalities: an analysis of overrepresentation and its determinants[1]

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Resumo: Este artigo analisa o efeito de um município "ser fronteira" na sua criminalidade, focando especialmente nas cidades gêmeas e nos diferentes arcos. Ademais, também identifica os determinantes da criminalidade desses municípios. Para isso, usou-se primeiramente o método Propensity Score Matching, visando identificar a existência de sobrerrepresentação dos municípios fronteiriços na criminalidade em decorrência de "ser fronteira" e, na sequencia, o modelo Tobit Espacial foi aplicado com o intuito de identificar os determinantes da criminalidade local. Como corolário, não há, na média, um efeito de "ser fronteira" na criminalidade quando considerado todos os municípios fronteiriços e seus diferentes arcos. Entretanto, para as cidades gêmeas há um efeito e ele intensifica a criminalidade local. No caso dos determinantes, existe uma diferença entre os municípios da fronteira versus o Brasil como um todo, em que, as vantagens econômicas se apresentaram como importantes para este último, enquanto a presença do Estado, mitigando as desvantagens sociais, são cruciais para reduzir a insegurança pública da faixa fronteiriça.
Palavras-Chave: Fronteira brasileira; criminalidade; sobrerrepresentação; determinantes.

Abstract: This paper analyzes the effect of a municipality being in the "Brazilian border" on its criminality rates, focusing mainly on twin cities and the different arcs. It also identifies determinants of criminality in those municipalities. Firstly, the Propensity Score Matching Method was used to identify the existence of overrepresentation of municipalities in border areas in criminality due to their location and, next, the Spatial Tobit model was applied aiming to identify the determinants of local criminality. Our results showed that, on average, there is no effect of "being in the border" when all the municipalities in border areas and their different arcs are considered. However, when twin cities were analyzed, such effect exists and intensifies the local criminality. Regarding determinants, a difference was found between the municipalities in the Brazilian border and the country as a whole, in which economic advantages were seen to be relevant in the latter context, while the presence of the State reducing social disadvantages is vital to decrease public safety issues in border areas.
Keywords: Brazilian border; criminality; overrepresentation; determinants.

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1. Introduction

The Brazilian border is one of the largest in the world, comprising 588 municipalities located in eleven States. Geographically, it is characterized for occupying a 150km wide strip that is about 17,000 km long, which represents over a quarter of the national territory.

Its whole territorial extension is divided into three large arcs. The first is the North arc, whose main characteristic is the presence of the Amazon Forest. The second is the Center, where the extension of the farming border is quite evident. The third is the South, which has a strong agroindustry, presenting a well-developed infrastructure with efficient road interconnections and municipalities that are connected by their economy (Pego, 2017). Therefore, the border area is heterogeneous and its productive relations, productive factors and business and integration opportunities, and even public safety are unequal.

In a study put forward by Raiher (2020), the dynamics of the socioeconomic development of each of these arcs was analyzed, confirming the existing discrepancy between them. As a result, 28% of the municipalities belonging to the North arc were in the vicious circle of underdevelopment in 2016, while only 3% of the municipalities in the Center arc and none of the municipalities in the South arc were in that condition. Moreover, when comparing municipalities in the Brazilian border with the other municipalities in the country, greater rigidity of the former group was observed to leave the underdevelopment vicious circle, mainly in those located in the North arc.

In addition, twin cities – referring to those cut by the border line, either dry or fluvial – presented a greater challenge for having to, directly, manage the economic, social and cultural integration with the municipality in the neighboring country. It seems relevant to emphasize that the externalities resulting from the neighborhood with foreign municipalities are not equivalent to the results achieved from the proximity of municipalities that are not located in the border area. Becker (2007) highlights the existence of elements that optimize collective social constructions through partnerships, and at the same time, the fact that these are conflict-prone areas, which require intervention and control by the nation-states.

Also, there is a great cross-border circulation of people and goods, which results in increase in illegal actions, so that great part of the criminality that spreads throughout the country tends to be related to cross-border crimes, which requires people located in border areas to be executed. Salla et al (2014) reported that in the case of homicides, for example, increased rates are associated to the increase in drug dealing and its consequent disputes. There is a general assumption that other illegal economies such as smuggling and arm trafficking might also impact homicide rates, and such actions usually start in the border area.

It seems also important to highlight that many authors defend the non-existence of an expressive correlation between the border local criminality and cross-border illegal actions. Those authors argue that what happens is only the diffusion of illegal acts similar to that observed in large cities as well as medium-sized and small towns. However, Neves et al (2016) pointed out that in certain municipalities in border areas such as Tabatinga, in Amazonas; Abaetetuba, in Pará; Cruzeiro do Sul, in Acre; Coronel Sapucaia, in Mato Grosso do Sul and; Guairá, in Paraná, among others – transnational criminality appears to be more rooted and linked to local public safety issues, with specific characteristics that determine this feedback cycle.

In such context, depending on the socioeconomic characteristics of municipalities in border areas (such as job opportunities, high income, education, etc.) and their link with neighboring counties, the effects of these cross-border crimes on the local criminality

might be intensified. As highlighted by Cantor and Land (1985), the unemployment of a region might act as a motivating agent of criminality, mainly for worsening the individuals' economic situation. The same relation might be verified in the variables related to income and education, so that spaces with high inequality in the distribution of such resources tend to generate, according to Blaus and Blaus (1982), a scenery of frustration and resentment, hopelessness and alienation as well as injustice due to the existing contradiction between values and norms set, on the one hand, and social experience, on the other. Thus, these inequalities and adopted positions produce different abnormalities in society such as social disorientation that also tend to result in criminality.

In addition, Neves et al (2016) observed that municipalities in border areas that present high density of safety institutions aiming to control the cross-border crime flow (such as drug dealing, arm trafficking, smuggling, etc.) might at times have their local public safety neglected due to the focus on actions preventing cross-border crimes.

Taking the context presented into account, this study questions the dynamics of local criminality in the border area, analyzing the existence or not of overrepresentation of criminality in such municipalities, by investigating whether the fact of "being in the border area" might impact local safety. Our objective is to verify whether, in fact, the municipalities located in border areas – mainly regarding twin cities and the different arcs – present disadvantages in relation to criminality when compared to similar municipalities outside the border areas.

We also analyze the determinants of criminality in those municipalities, by investigating the need for specific safety policies in those spaces, and presenting the main axes that might mitigate local criminality.

It seems relevant to emphasize the non-existence of studies analyzing local criminality in municipalities in the Brazilian border and their determinants, since most studies in the literature focus only on crimes committed in border areas (such as drug dealing, arm trafficking, smuggling, etc) and/or only descriptive analyses of the criminality in those municipalities. At the international level, the same focus is observed, without specific analyses of the dynamics of local public safety issues.

In this sense, this paper differs from others, contributing directly to the understanding of the local dynamics of criminality in municipalities in the Brazilian border. The paper is divided into five sections, starting with this introduction. The second section presents the methodological elements and is followed by the third section that analyzes the impact of "being in the border area" on the local criminality. The fourth section presents the determinants of criminality in the municipalities in border areas and other municipalities in the country. The last section presents our final considerations.

2. Methodological elements

Basically, this study has two objectives: to analyze the effect of "being in a border area" on the criminality of a municipality; and, to investigate the determinants of criminality in municipalities in the border area in comparison to other Brazilian municipalities. To achieve these objectives, two empirical strategies were employed: The first objective required the Propensity Score Matching method, while the Spatial Tobit model was used to estimate the criminality determinants.

The strategies employed are described below.

2.1 Propensity Score Matching: effect of "being in the border area" on criminality

In this paper, the Propensity Score Matching (PSM) method is used aiming at investigating the effect of "being in the border area" on the local criminality of Brazilian municipalities. The treatment group includes the municipalities located in the border strip and, the control group includes the remaining municipalities of the country. This method seeks to identify within the control group a subgroup of municipalities that is the closest possible – in terms of observable characteristics – to the municipalities in the treatment group, so that the only difference is to belong to the Brazilian border.

Cavalcanti et al. (2016) reported that the ideal measurement of the effect of any exposure to a factor should be the comparison of the same group in two different contexts: being subjected to exposure or not (that is, being in the border area or not). However, since this is not possible, one alternative is the creation of a statistically identical group, so that the differential is based on the fact that some municipalities are in the border area, while the others are not. The PSM method allows this comparison, finding similarities within the groups of municipalities that are in the border area (treatment group, T=1) and those that are outside that area (control group, T=0). This propensity is generated from the observable characteristics of the municipalities, which affect their probability of being in the border area. Thus, the presence or not of municipalities that are in the border area starts to have a random character (Heinrich et al., 2010).

It seems relevant to highlight that when seeking similarities in a scenery where different characteristics are listed, one might face the multidimensionality problem, that is, municipality **i** might present some characteristics close to those of municipality **j** and other close to those of municipality **m**. In such case, the difficult resides in establishing which one should be compared to **i**. As observed by Rosenbaum and Rubin (1983), PSM minimizes this problem by calculating the likelihood of a municipality being included in the treatment group taking into consideration its observable characteristics (covariate). In this study, such likelihood was measured using the Logit model (1), with the matching being based on the conditional independence assumption.

$$P(T_i = 1|X_i) = \frac{1}{1+e^{-X_i'\beta}} \quad (1)$$

Where: $P(T_i=1|X_i)$ denotes the probability of municipality i being in the border area, considering its covariates (X).

To estimate the likelihood of a municipality being in the border area[3], the covariates in Chart 1 were used, which were chosen according to other studies that also used geography as the determinant to be treated [such as Tavares and Almeida (2014), and Carnicelli and Postali (2012)]. Also, in the same line as suggested by Carnicelli and Postali (2012), this paper considered some variables that were linked to the focus of the analysis – in this case, criminality -, according to the arguments of the "situational action theory"[4] (Wikström and Treiber, 2016).

[3] For the dependent variable of (1) a binary variable was used: "one" if the municipality was in the border area; "zero" if the municipality was outside the border area).

[4] The main premise in this theory is that the interaction between propensity to crime and criminogenic exposure is important to understand crime involvement. Therefore, social and economic disadvantages, along with the criminogenic environment, would be the "cause of causes" of illegal actions.

Chart 1 – Variables used in (1), proxy that they represent, data source and methodology

Variable	acronyms	Methodology	Source	Proxy
Economic deprivation	PE	Variation in the number of people enrolled in the *Bolsa Família* program (Family Support) /Total population in t	MDS and Ipeadata	Economic disadvantage
Social deprivation	PS	Variation in the Education and Health Firjan Indices mean in t	Firjan System	Social Disadvantage
Demographic density	DD	Number of inhabitants per square kilometer in t	Ipeadata	Availability of targets and offenders
Employment per capita	EP	Total employment/ population (age> 15 and < 65 years) in t	Rais and Ipeadata	Economic advantage
Initial criminality	CI	Theft per thousand inhabitants in t	Safety State Secretariats	Criminogenic environment
Location variable 1	LA	Latitude	Geospace	Geographical location
Location variable 2	LO	Longitude	Geospace	Geographical location

Source: Research result.
Note: t refers to the initial year, that is, 2013.

After estimating (1), PSM matches the municipalities with equal or similar scores and, next, evaluates whether the treatment group obtained a statistically higher criminality rate (the proxy used corresponded to the theft rate per thousand inhabitants between 2013 and 2017[5] and theft per thousand inhabitants in 2017) than the control group.

The assumption is that when the matching is carried out, each treated municipality tends to have a corresponding municipality (or more, depending on whether the neighboring method is with or without replacement) in the control group, which would present similar results in terms of criminality if it were not in the border area. This suggests that the treated and control municipalities present similar characteristics, except for the fact that the treatment group is located within the border strip.

In this sense, the municipality in the control group simulates a possible result for the case in which the treated municipality would not be in the border area, since statistically their observable characteristics are similar. Thus, to calculate the treatment effect on those municipalities through matching, each municipality in the treated group must have a corresponding municipality in the control group.

Rosenbaum and Rubin (1983) pointed out that if the propensity score $[\mathrm{P}(\mathrm{T_i} = 1|\mathrm{X_i})]$ is known, the treatment mean effect on the treated group can be estimated through (2), calculated by the mean difference between the treated group (municipalities within the border strip) compared to the untreated group (municipalities not belonging to the border strip), emphasizing that the latter must present a propensity score similar to that of the treatment group.

$$\tau = E\{E[Y_{1i}/D_i = 1, P(X_i) - E[Y_{0i}/D_i = 0, P(X_i)]/D_i = 1\} \quad (2)$$

[5] Data related to crime against property is not systematized in any data base. Therefore, this information was collected from each federative unit, creating a single base, which comprises twenty-four states plus the Federal District. Two states only were not included in the analysis: Acre, which never replied the request for information and; Paraíba, which alleged not having such information.

Where: D = {0,1}is the treatment exposure indicator (being in the border area or not, respectively); P(X) is the propensity score; Y_1 and Y_0 are the potential results (theft rate per thousand inhabitants between 2013 and 2017 and theft per thousand inhabitants in 2017) in both contrafactual situations (treated and untreated municipalities).

When estimating the mean effect using (2), two hypotheses must be considered: 1. Conditional independence, so that the unobserved factors do not affect "being in the border area" or not, and; 2. Common support on the propensity scores between treated and untreated municipalities. These two hypotheses result from the assumption that the propensity score must have the same distribution of observable and unobservable characteristics, regardless of being in the treated or the control group, which means that the only factor that might differentiate the two groups refers to "being in the border area" or not[6].

In addition to having a similar propensity score, to estimate (2) correctly, some method must be devised for the matching of each treated municipality with the untreated municipality, given the low probability of observing two municipalities with the same propensity score value – considering that P(X) is continuous. There are different matching techniques, however, none is considered better than the others (Caliendo and Kopeinig, 2005). For this reason, we chose to employ the most used methods that appear in the literature, namely: closest neighbor (three neighbors, with replacement), caliper of 0.01 and non-parametric regression (Kernel Matching). Moreover, given the satisfactory size of data, an additional trimming was carried out of 10% of the observations in the treatment group that coincided with the lowest densities of the propensity scores in the control group.

Finally, it seems relevant to emphasize that (2) was estimated considering five treatment groups: All municipalities (588 municipalities); North Arc (71); Center Arc (99); South Arc (418) and; Twin Cities (29). For each PSM, the mean difference test and the Propensity Score Matching density function graph (Figure 2 and Appendix B) were carried out, and the covariates used in the logit test were determined through them (Appendix A).

3.2 Spatial Tobit: determinants of criminality in the border area and in other municipalities in Brazil

Different theories explain the individuals' illegal actions. One of the most recent and that is close to the border area context (mainly in twin cities) refers to the Situational Action Theory (SAT). According to this theory, self-control and morality are factors that determine the individuals' actions, including the criminal action. Morality can be described as an individual's moral rules, which guide the alternatives for their actions. Therefore, if the moral standard is low, crime might be a viable alternative for that individual. As for self-control, it refers to the inhibition of an action alternative or the interruption of an action that is already in development but conflicts with the individual's morality (Wikström and Svensson, 2008).

It seems relevant to highlight that in this approach individuals perform illegal actions for having criminality as one alternative of action, that is, it is not only necessary to have poor morality and self-control, it is also necessary to be exposed to criminogenic

[6] With this purpose, the covariate mean difference test was carried out before the matching and after the matching as well as the Propensity Score density graph.

environments[7]. The basic idea is that the motivation (temptations and provocations) starts the action process (being a necessary factor, but not enough) and the moral filter (which depends on the interaction between personal morality and the environment moral norms) endorses the action alternatives in response to a particular and controlled motivation (Wikström and Treiber, 2016).

Therefore, the probability of showing criminal behavior depends on the criminal propensity of a person (morality and self-control) and their exposure to criminogenic environments. In the latter case, it is a precedent factor, which produces impact even before the interaction between propensity and exposure, which is called "cause of causes" (Wikström et al., 2012). These environmental disadvantages are presented as structural disadvantages, restricting the capability of a family and/or society to exercise an effective social control (with rules), affecting the propensity to criminal actions *ex post*. In this sense, SAT relates to social control arguments, in a perspective of formation of this propensity to illegal actions.

From these remarks, model (3) was estimated for Brazilian municipalities:

$$RP_{i(t+1/t)} = f(PE_{it}; PS_{it}; CI_{it}; DD_{it}; TF_{it}; EP_{it}; fPE_{it}; fPS_{it}; fDD_{it}; fTF_{it}; fEP_{it}; DCG_{it}) \quad (3)$$

Where: ***RP*** refers to the growth of theft per thousand inhabitants in municipality **i** in the period between **t** (2013) and **t+1** (2017); ***PE*** are economic disadvantages; ***PS*** refers to social deprivation; ***DD*** is demographic density; **TF** refers to the mean size of families and; ***EP*** refers to employment per capita; ***fPE***, ***fPS***, ***fDD***, ***fTF***, ***fEP***, are dummies of interaction between being in the border area (1 when it is in the border area and 0 when it is not) and economic advantages, social deprivation, demographic density, mean size of families, and employment per capita, respectively. ***DCG*** is a binary variable that is rated "one" if the municipality is a twin city and "zero" if it is not.

The great difficulty when analyzing (3) is the inexistence of data related to crime against property in the Brazilian municipalities, which is the SAT focus. Therefore, this information was requested from each federative unit to create a single base, which comprises twenty-four states plus the Federal District. The only two states not included in the analysis were: Acre, which never replied the request made and; Paraíba, which alleged not having such information[8].

Regarding social deprivation, the proxy used referred to the mean of the Firjan indices for Education and Health. The indicators found in the former portrait both the quantity and quality of education, measuring directly the inputs that the state makes available to the improvement of education in the municipality[9]. As for health, the index focuses on indicators referring to the health quality considering all ages, a direct result of the local infrastructure in this segment[10]. It seems relevant to emphasize that other

[7] Refers to the set of mechanisms and occasions that originate or might cause criminal action such as: social, economic and/or environmental disadvantage, with the presence of criminal peers.

[8] Regarding the State of Ceará, the existing data was per safety integrated area. Then, the municipalities belonging to each area were identified, and the weighting was carried out by population, estimating theft per municipality. As for Mato Grosso and Rio de Janeiro the estimates refer to 2003, considering the growth rate in previous years.

[9] It consists of the following indicators: attendance to child education; elementary school dropping rate; divergence age-school year in elementary education; elementary school teachers with higher education; mean of daily class hours in elementary school; IDEB results (FIRJAN, 2020).

[10] This index is made up of the following indicators: proportion of suitable pre-natal assistance; deaths due to poorly defined causes; child death due to avoidable causes; hospitalization sensitive to basic attention (FIRJAN, 2020).

dimensions are important to measure social deprivation, however, given the availability of data at the municipal level and considering the coverage of the indicators used in the education and health indices – which reflect other dimensions such as availability of sanitation, treated water, etc. – we opted for using the mean of these two indices as a proxy for the local social deprivation.

Social control was also considered in (3) through the proxy "family size[11]". Sampson and Wooldredge (1987, p. 373) observed that "regardless of the person, family composition and even the proximity with offenders, living in a community with low guardianship and surveillance, might increase the risk of victimization". Thus, control or guardianship play a fundamental role in the opportunity for crime locally.

Finally, employment per capita, which is the proxy for economic advantage (Cahill, 2005) and demographic density, representing the availability of targets and offenders (Wilcox et al., 2003), indicates existing crime opportunities in the municipality.

Chart 2 shows the variables used in (2), their sources and what they represent, emphasizing that all Brazilian municipalities and the municipalities located in the border area were analyzed, referring to 2013 and 2017.

Chart 2 – Variables used in the estimates, proxy they represent, data source, and methodology

Variable	**acronym**	**Methodology**	**Source**	**Proxy**
Growth of theft per thousand inhabitants	RP	Variation in the number of thefts per thousand inhabitants between t and t+1	Safety state secretariats	Criminality
Economic advantage	PE	Total employment / population (age> 15 and < 65 years) in t	Rais and Ipeadata	Economic advantage
Social deprivation	PS	Variation in the mean Education and Health Firjan indices in t	Firjan System	Social Disadvantage
Demographic density	DD	Number of inhabitants per square kilometer in t	Ipeadata	Availability of targets and offenders
Mean size of families	TF	Mean number of members of the families assisted by the *Bolsa Família* program in t	MDS	Family guardianship
Dummy Twin city	DCG	Binary variable: "one" if the municipality is a twin city and "zero" if not	-	Twin city

Source: Research.results
Note: t refers to the initial year.

After estimating (3) using the linear regression classic models, spatial autocorrelation was identified in the residue (Appendix C), and, therefore, such estimates should not be taken into consideration, since they tend to be biased and inconsistent, suggesting the use of spatial econometry.

For this reason, (3) was estimated using the Spatial Tobit model. This model is a special case of adjustment for censored data, in which part of the sample is made up of observations that have a null value. Since several Brazilian municipalities present a null variation of theft per thousand inhabitants, the Tobit model was seen as suitable. In the spatial context, a spatial regression model can also be estimated for a latent variable with

[11] For the family mean size factor, the proxy used was the mean size of families assisted by the *Bolsa Família* program.

data censorship, which can be expressed by (4) that represents the spatial autoregressive (SAR) Tobit[12].

$$Y_i^* = \rho W_y + \beta_1 X_i + e_i^* \quad (4)$$

Where X_i is a matrix with exogenous variables correlated to the error term (ε); Y^* is a latent dependent variable, since for some observations it might not exist and be equal to 0. What is observed, however, is the variable *y*, which is determined if the variable y^* is over certain critical level *c*, given by:

$$y = \begin{cases} y^* \; se \; Y_i^* > c \\ 0 \; se \; Y_i^* \leq c \end{cases} \quad (5)$$

If the latent variable is over the critical level, values are observed for this variable; however, if it is below the critical level, null values are observed (c=0). The latent variable conditional mean is $E(y|X)=X\beta$, while the observed variable conditional mean is $y>0$. From the whole sample used, n_1 censored observations and n_2 observed values are obtained, and the estimation technique employing the Tobit model tends to produce a y_1^* for the n_1 observations. To reach this purpose, a Bayesian treatment of unobservable latent utilities shall be carried out, obtaining an estimation through the Markov chain simulation (Lesage and Pace, 2009)

3. Criminality (theft per thousand inhabitants) in municipalities in the border area and in other municipalities

Public safety is one of the most important factors to provide wellbeing in society. In this sense, its understanding enables specific actions aiming at promoting better quality of life to the whole population. However, not all municipalities in Brazil present similar characteristics regarding criminality and in the municipalities in the border area, this heterogeneity is even greater. In fact, Table 1 shows the comparison of theft per thousand inhabitants mean between all Brazilian municipalities and in those located in the border area, subdividing them per arc and per twin cities. On average, municipalities in the border area are seen to present a lower per capita theft rate than that obtained by the other Brazilian municipalities, as well as a smaller variation in criminality between 2013 and 2017. Also, the center arc obtained negative variation of per capita theft throughout the years under analysis, demonstrating a differentiated process regarding their public safety dynamics. The only municipalities in the border area that obtained higher criminality rates than the other Brazilian municipalities were the twin cities, with values well over the country mean.

Neves et al (2016) already reported the existence of certain overrepresentation of criminality in some cities cut by the border line – both dry and fluvial – with other countries, which is justified by the rooting of transnational criminality in these municipalities, with potential correlation with local public safety issues. Figure 1 shows that the municipalities that are directly located in the border with other countries tend to present, on average, greater criminality when compared to other municipalities within the border strip.

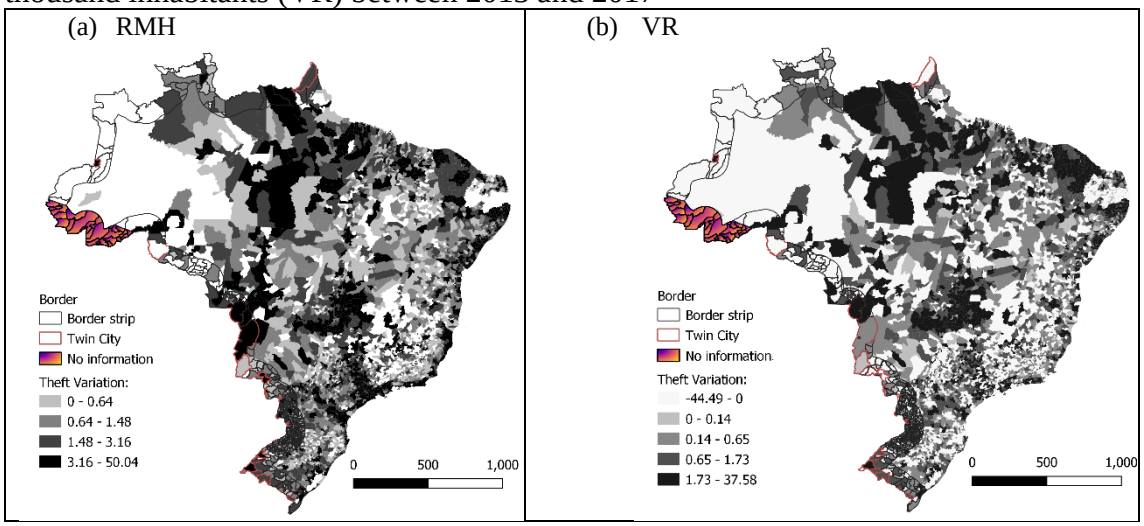
[12] Other spatial models were tested (Spatial Error Model – SEM; Spatial Durbin – SDM; Spatial Durbin Error Model – SDEM), however, the akaike information criterion pointed out the SAR model as the most suitable (SAR= 1662; SEM = 1.785; SDM = 1690; SDEM = 1.699).

Table 1: Theft per thousand inhabitants mean and mean variation in theft per thousand inhabitants in the period – 2013 and 2017

Municipalities	RP13	RP17	Variation 2017/2013
All municipalities	1.33	2.36	1.03
Municipalities outside the border area	1.38	2.50	1.12
Municipalities within the border area	0.85	1.14	0.29
North Arc	0.66	1.08	0.42
Center Arc	1.53	1.52	-0.02
South Arc	0.71	1.06	0.35
Twin cities	**2.01**	**3.11**	1.10

Source: Research results

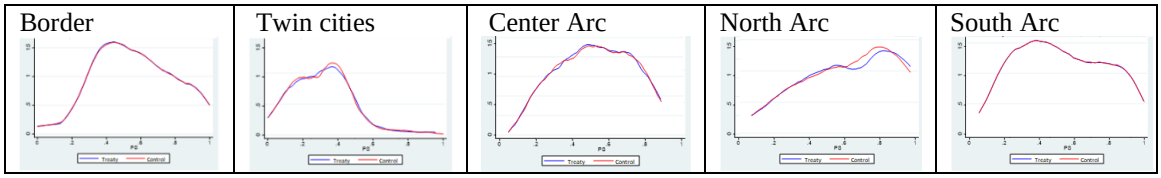
Figure 1: Theft per thousand inhabitants (RMH) in 2017 and variation in theft per thousand inhabitants (VR) between 2013 and 2017



Source: Research results

Taking into consideration the initial results and aiming at deepening the analysis and verifying whether the fact of "being in the border area" increases criminality – focusing especially on twin cities -, treated municipalities ("those within the border strip") were matched with the other Brazilian municipalities using the Propensity Score Matching method (PSM). It seems relevant to emphasize that this method allows the comparison of pairs of municipalities located in the border area and those that are close to them, but outside the border area, given the selected covariates. One of the necessary conditions for the effective use of PSM, as pointed out by Khandker et al (2010), is to respect the common support hypothesis, guaranteeing that the treatment observations have comparison units in the proximity of the propensity score distribution. Figure 2 presents the common support region for the municipalities in each group, which are: all the municipalities in the border strip; municipalities in the center, north and south arcs, and; twin cities. When observing the figure, it is possible to verify the existence of an overlap of the two distribution curves (control group and treatment group) for all subsamples, evidencing that the municipalities in the border area in each group present compatibility with untreated municipalities in terms of the covariates, making the matching process easier.

Figure 2: Propensity score after matching



Source: Research results

After estimating the probability of being in the border area or not using the Logit model (Appendix A) and identifying the existence of a wide common support area in the propensity score distribution between municipalities in the border area and those outside this area (Figure 2), the results of variation in theft per thousand inhabitants between 2013 and 2017 and theft per thousand inhabitants in 2017 were compared.

Table 2 presents the impact of "being the border area" in the variation in criminality, and no difference was found between the municipalities in the border area and the other Brazilian municipalities regarding variation in theft per thousand inhabitants. Therefore, the fact of being located in the border area is not the determinant factor of higher criminality than other municipalities in the country. Conversely, in the center arc the difference found was negative and statistically significant, which indicates that, on average, the municipalities in the center arc tended to present lower variation in thousand per thousand inhabitants between 2013 and 2017 than the other municipalities in the country, with a negative effect of "being in the border area" on the promotion of illegal actions, which is confirmed by the region mean evolution presented in Table 1.

Moreover, when analyzing theft per thousand inhabitants in 2017, all the previous results were confirmed, and the effect of "being in the border area" was not significant for all municipalities in the border strip, presenting a negative impact (that is, reduction in absolute criminality) in the center and north arcs.

Table 2: Mean effect of "being in the border area" on the variation in theft per thousand inhabitants between 2013 and 2017 (VR) and theft per thousand inhabitants in 2017 (RH)

Effect	Matching by:	All municipalities in the border area		Twin cities		Arcs					
						Center		North		South	
		EM	TR	EM	TR	EM	TR	EM	TR	EM	TR
VR	Caliper	0.009	0.009	**0.37***	**0.37***	**-0.79***	**-0.79***	0.63	0.62	-0.02	-0.04
	3 Neighbors	0.06	0.06	**0.48***	**0.48***	**-0.56****	**-0.56****	0.67	0.67	-0.02	-0.03
	Kernel	0.02	0.02	**0.10***	**0.10***	**-0.96***	**-0.96***	0.65	0.66	-0.07	-0.08
RH	Caliper	0.10	0.05	**1.30***	**1.19***	-0.11	**-0.45****	**-2.69***	**-2.70***	-0.10	-0.12
	3 Neighbors	0.04	0.09	**2.01***	**2.09***	-0.43	-0.13	**-2.77***	**-2.78***	-0.09	-0.11
	Kernel	0.09	0.06	**0.72****	**0.81***	-0.42	**-0.75***	**-2.42***	**-2.42***	-0.19	0.14

Source: Research results.
Note:* 5% significance level. EM refers to the mean effect; TR refers to the estimated mean effect using 10% trimming.

However, when twin cities were analyzed, an overrepresentation was observed both in the variation in theft per thousand inhabitants and in theft per thousand inhabitants in 2017. This reinforces the arguments related to the need for special attention to these spaces, considering that, for this group, the proximity with foreign municipalities might result in difficulties regarding social construction, which might also generate local conflicts as a consequence of transnational crimes and even the circulation of people and

illegal goods over the border (Salla et al, 2014). Thus, local criminality control in the border strip should prioritize mainly twin cities.

The next section investigates the factors that might affect criminality both in the municipalities in the border area and other municipalities in the country, aiming at identifying tools to control local illegal actions.

3.1 Criminality determinants in the border strip

The Situational Action Theory assumes that a low morality level added to a poor self-control and a highly criminogenic environment raises the probability of individuals committing illegal acts. It seems relevant to highlight that the individual's exposure to this type of environment does not guarantee that they are going to commit a crime, since this action depends on the individual's propensity to do it (morality and self-control). However, specific combinations of propensity and exposure might result in illegal acts.

From this approach, the determinants of criminality were estimated for the Brazilian municipalities with special focus on municipalities in the border area (Table 3), understanding that some of the municipalities in this space tend to present an environment that favors illegal acts, mainly for being directly linked to municipalities in neighboring countries.

As a result, economic advantage, whose proxy refers to employment per capita – was observed to present a positive relation with crime variation per thousand inhabitants when considering all municipalities in the country. Cantor and Land (1985) proposed two ways in which the economic activity of a municipality – represented by employment – might impact the illegal activity rate. The first results from the increase in criminal motivation levels when the economic conditions deteriorate affecting social tension and control; the second is the result of availability and vulnerability of targets as the economic activity intensifies, increasing crime opportunities.

Taking that into consideration, it is possible to infer that for the Brazilian municipalities, the reduction in employment per capita, on average, reduces the number of targets and consequently decreases theft per thousand inhabitants. Also, there is a spillover effect, in which economic deprivation might affect directly the whole region.

In addition to employment, the population density was also observed to be important to determine the variation in theft per thousand inhabitants in all Brazilian municipalities. This variable also represents crime opportunities, which are intensified as the population concentration raises, increasing the availability of local targets and offenders (Wilcox et al, 2003) with a spillover effect to the neighboring areas.

Regarding social disadvantages, they were only associated to criminality when integrated to the municipalities in the border strip, so that an improvement in the local social aspects tends to reduce, on average, the variation in theft per thousand inhabitants (Table 3). Theoretically, social disorganization tends to increase as the local social infrastructure reduces, weakening existing social relations, reducing the individuals' sense of belonging, and affecting directly social cohesion and control (Sampson, 1986; Wilson, 1987; Massey and Denton, 1993).

It seems relevant to emphasize that according to SAT, morality and self-control are the precursors of individuals' actions, however, when these elements are weakened, the likelihood of committing a criminal action is intensified when the individuals are exposed to environments with poor social infrastructure. When considering municipalities in the border area, mainly twin cities, greater exposure is observed, resulting from transnational crimes that occur locally, with a natural higher contact with

illegal actions, which might intensify the significant effect of negative social aspects on the local criminality.

In addition to the direct relation observed in the municipalities in the border area, an indirect effect of social deprivation was identified in the neighboring municipalities. In this sense, when intensifying the social infrastructure in some municipalities in the border area, a spillover effect is observed in the whole region, decreasing the variation in theft per thousand inhabitants.

Since twin cities present some particularities, their direct effect on the theft per thousand inhabitants was also investigated. As a result, the effect detected by the PSM (Table 2) was confirmed, in which having a twin city in the neighbor foreign country intensifies the variation in criminality, which is not only a local effect, since it is found to affect the region around the municipality.

Table 3 – Estimates of SAR Tobit models – Brazilian municipalities

Variable	Coefficient	Direct	Indirect	Total
ISSO	-0.09	-0.05	-0.04	-0.09
DENS	**0.0004***	**0.0002***	**0.0002***	**0.0004***
EMP	**0.10***	**0.56***	**0.60***	**1.16***
TF	0.01	0.008	0.001	0.001
FISO	**-0.86***	**-0.51***	**-0.55***	**-1.06***
FDENS	**0.004***	**0.002***	**0.003***	**0.005***
FTF	0.001	0.001	0.000	0.001
FEMP	1.19	0.70	0.75	1.45
DUMMY_TWINS	**0.76***	**0.45***	**0.50***	**0.95***
ρ	**0.55***	-	-	-

Source: Research results.

Note: * significant at a 5% significance level; ** * significant at a 10% significance level.

Finally, a spatial phenomenon is observed regarding the variation in theft per thousand inhabitants in Brazil as a whole, indicating that the geographical location of the municipalities matters in this determination.

Final Considerations

This paper analyzed the effect of a municipality "being in the border area" on its criminality rates, focusing mainly on twin cities and the different arcs. It also identified criminality determinants in these municipalities. The results evidenced that the whole border strip might not necessarily present criminality rates that are over the mean of other Brazilian municipalities, on the contrary, some spaces such as the center arc showed lower mean insecurity. When the characteristics observed for each municipality were controlled, lack of statistical significance was confirmed for the effect of "being in the border area" on criminality (variation and theft per thousand inhabitants in 2017), except for the twin cities that presented a positive effect.

Therefore, it is necessary to work on specific local public safety policies in these municipalities, which have a direct connectivity with other countries, in addition to other characteristics such as the intense flow of people and transnational illegal actions, which might impact local conditions. This need for the state presence is confirmed by the estimation of the spatial determinants of the variation in theft per thousand inhabitants, evidencing that in municipalities located in the border area, social disadvantages must be mitigated so that the local criminality can be reduced.

References

Austin, P. C. (2008). A critical appraisal of propensity-score matching in the medical literature between 1996 and 2003. *Statistics in Medicine*, Malden, 27(12):2037-2049.

Becker, B. (2007). *Amazônia: geopolítica na virada do III milênio*. Rio de Janeiro: Garamond.

Blau, J. R. and Blau, P. M. (1982). The cost of inequality: Metropolitan structure and violent crime. *American Sociological Review*, 47:114–129.

Caliendo, M. and Kopeining, S. (2005) Some practical guidance for the implementation of propensity score matching. *IZA Discussion Paper Series* No.1588.

Cantor, D. and Land, K.C. (1985). Unemployment and crime rates in the Post World War II United States: a theoretical and empirical analysis, *American Sociological Review*, 23, 317332

Carnicelli, L.; Postali, F.A. (2012). Rendas do petróleo e tributos locais: uma análise de propensity score. *Anais da Anpec*. Disponível em:<https://www.anpec.org.br/encontro/2012/inscricao/files_I/i4-fdc3484501e62a43bb676e8d282cc8f5.pdf>.

Cavalcanti, D. M., Costa, E. M., da Silva, J. L. M., & Sampaio, R. M. B. (2016). Impactos do programa bolsa família na renda e na oferta de trabalho das famílias pobres: Uma abordagem usando o efeito quantílico de tratamento. *Economia Aplicada*, 20(2):173–201.

Firjan. (2020). *Metodologia*. Disponível em:< https://www.firjan.com.br/data/files/E8/06/F0/D5/58E1B610E6543AA6A8A809C2/Metodologia%20IFDM%20-%20Final.pdf>. Acesso em dezembro 2020.

Heinrich, C., Maffioli, A., & Vázquez, G. (2010). *A Primer for Applying Propensity-Score Matching: Impact-Evaluation Guidelines*. Inter-American Development Bank.

Khandker, R. S; Koolwal, G. B.; Samad, H. A. (2010). *Handbook on Impact Evaluation: Quantitative Methods and Practices.* Washington, DC: The World Bank.

Lesage, J.P.; Pace, R.K. (2009). *Introduction to spatial econometrics*. CRC Press, Boca Raton.

Massey, D. S., Denton, A. (1993). *American Apartheid: Segregation and the Making of the Underclass.* Cambridge, MA: Harvard University Press.

Pêgo, B. (2017).*Fronteiras do Brasil: diagnóstico e agenda de pesquisa para política pública*. Brasília: Ipea, Volume II.

Neves, A.J.; Baptista, G.C.; Engel, C.L.; Misse, M. (2016). *Segurança pública nas fronteiras, sumário executivo: Estratégia Nacional de Segurança Pública nas Fronteiras*. Brasília: Ministério da Justiça e Cidadania, Secretaria Nacional de Segurança Pública.

Raiher (2020). A faixa de fronteira brasileira e o desenvolvimento Humano. Ferreira de Lima, J., editor. *Desenvolvimento Regional Fronteiriço no Brasil*, Toledo: Núcleo de Desenvolvimento Regional, p. 15-35.

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

Salle, F. Alvarez; Alvarez, M.C; Hildebrand, A; Rocha, T. T. (2014). *Violência e a gestão das fronteiras do Brasil*. Brasília : Secretaria Nacional de Segurança Pública (SENASP).

Sampson, R. J. (1986). Neighborhood family structure and the risk of personal victimization. In: Byrne, J. M. and Sampson, R. J., editors, *The Social Ecology of Crime*, pages 25–46. Springer-Verlag, New York.

Sampson, R. J.; Wooldredge, J. D. (1987). Linking the micro-and macro-level dimensions of lifestyle-routine activity and opportunity model of predatory victimization. *Journal of Quantitative Criminology*, 3(4):371–393.

Tavares, F.; Almeida, A.N. (2014). Os impactos dos Royalties do Petróleo em gastos sociais no Brasil: Uma análise usando Propensity Score Matching, *Revista Economia & Tecnologia*, 1-(2): 93-106.

Wikström, P-O H.; Svensson, R. (2008). Why are English youth more violent than Swedish youth? A comparative study of the role of crime propensity, lifestyles and their interactions. *European Journal of Criminology*, 5 (1): 309-330.

Wikström1, P. H.; Treiber, K. (2016). Social Disadvantage and Crime: A Criminological Puzzle. *American Behavioral Scientist*, 60(10):1232–1259.

Wikström, P-O, Oberwittler, D, Treiber, K, Hardie, B. (2012). *Breaking Rules. The Social and Situational Dynamics of Young People's Urban Crime*. Oxford: Oxford University Press.

Wilcox, P., Land, K. C., and Hunt, S. A. (2003). *Criminal Circumstance: A Dynamic Multicontextual Criminal Opportunity Theory*. Aldine de Gruyter, New York.

WILSON, W. J. (1987). *The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy*. Chicago, IL: University of Chicago Press.

Wilcox, P., Land, K. C., and Hunt, S. A. (2003). *Criminal Circumstance: A Dynamic Multicontextual Criminal Opportunity Theory.* Aldine de Gruyter, New York.

APPENDICES

Appendix A- Results of the logit model – probability of being in the border area – variation in theft per capita from 2013 to 2017

Variables	Border	Twin cities	Arcs		
			Center	North	South
Employment	-0.69	0.21	0.90	1.73	-0.18
Density	-0.003*	-0.0003	-0.08*	-0.07**	-0.004*
Health and Education Firjan indices	4.35*	-3.62*	1.74	0.66	8.16*
Bolsa Família per capita	4.58*	1.69	-3.88*	-10.28*	5.57*
Latitude	-0.24*	-0.26*	-0.06*	0.72*	-0.47*
Longitude	-0.65*	-0.35*	-0.29*	-0.55*	-0.53*
Pseudo R	0.57	0.61	0.37	0.82	0.56

Source: Research results.
Note: * Significant at 5%; ** significant at 10%

Appendix B: Difference of means between covariate variables before and after matching

Border strip– Brazilian municipalities

Variables	Before treatment			After treatment		
	Untreated	Treated	t test p-value	Untreated	Treated	t test – p-value
Employment	0.14	0.15	0.04*	0.14	0.150	0.004*
Density	120.04	24.49	0.00*	23.81	24.79	0.85
Health and Education Firjan indices	0.71	0.75	0.00*	0.74	0.75	0.12
Bolsa Família per capita	0.34	0.24	0.00*	0.25	0.24	0.17
Latitude	-15.74	-22.56	0.00*	-21.89	-22.76	0.10
Longitude	-45.16	-55.52	0.00*	-55.27	55.29	0.95

Source: Research result.

Twin cities

Variables	Before treatment			After Treatment		
	Untreated	Treated	t test p-value	Untreated	Treated	t test – p-value
Employment	0.14	0.13	0.48	0.12	0.13	0.60
Density	110.13	29.89	0.44	23.72	29.89	0.73
Health and EducationFirjan indices	0.71	0.66	0.02	0.64	0.66	0.56
Bolsa Família per capita	0.33	0.28	0.10	0.31	0.28	0.46
Latitude	-16.42	-22.14	0.00	-22.47	22.14	0.89
Longitude	-46.18	57.78	0.00	-57.19	-57.78	0.57

Source: Research results.

Center Arc

Variables	Before treatment			After treatment		
	Untreated	Treated	t test p-valor	Untreated	Treated	t test – p-valor
Employment	0.14	0.15	0.53	0.15	0.15	0.90
Density	111.85	8.91	0.07	59.03	8.61	0.23
Health and Education Firjan indices	0.71	0.70	0.18	0.70	0.70	0.76
Bolsa Família per capita	0.33	0.27	0.00	0.31	0.27	0.04
Latitude	-16.44	-17.34	0.28	-16.10	-17.34	0.21
Longitude	-46.03	-58.05	0.00	-52.44	-58.05	0.00

Source: Research results.

North Arc

Variables	Before treatment			After treatment		
	Untreated	Treated	t test p-value	Untreated	Treated	t test – p-value
Employment	0.14	0.07	0.00	0.07	0.07	0.79
Density	111.32	3.31	0.10	3.15	3.20	0.96
Health and EducationFirjan indices	0.71	0.54	0.00	0.52	0.54	0.35
Bolsa Família per capita	0.33	0.47	0.00	0.47	0.47	0.99
Latitude	-16.62	3.44	0.00	-4.38	-4.21	0.83
Longitude	-46.02	-64.14	0.00	-63.69	-63.59	0.93

Source: Research results.

South Arc

Variables	Before treatment			After treatment		
	Untreated	Treated	t test p-value	Untreated	Treated	t test – p-value
Employment	0.14	0.16	0.00	0.17	0.16	0.12
Density	116.34	31.81	0.00	31.62	33.56	0.80
Health and EducationFirjan indices	0.70	0.79	0.00	0.78	0.79	0.05
Bolsa Família per capita	0.34	0.19	0.00	0.18	0.19	0.57
Latitude	-15.60	-26.99	0.00	-27.02	-26.72	0.64
Longitude	-45.66	-53.48	0.00	-53.35	-53.36	0.92

Source: Research results.

Appendix C: Residual space autocorrelation

Model	All municipalities	SAR
Moran I	0.17*	0.03

Source: Research results.
Note: * significant at a 5% level.