Property Crimes and Local Structural Characteristics: a Spatial Analysis between Brazilian Municipalities[1]

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Resumo: O objetivo deste trabalho consistiu na análise dos padrões espaciais da distribuição do crime (se referindo especificamente ao crime contra a propriedade) ao longo dos municípios brasileiros, investigando a sua relação com as características estruturais. Para isso, mensurou-se os aglomerados do crime contra a propriedade (AC) e estimou a probabilidade de um município ter um AC por meio do modelo Probit Espacial. Como corolário, identificou-se que o controle formal, o ambiente de supervisão e de intervenção social e a disponibilidade de metas e ofensores, são elementos decisivos na probabilidade de se ter um AC municipal. Regionalmente, o ambiente de supervisão e a disponibilidade de metas e ofensores foram os elementos predominantes.
Palavras-Chave: Aglomerados do crime contra a propriedade; Probit espacial; General multilevel opportunity theory.

Abstract: The objective of this study was to analyze the spatial pattern of crime distribution (mainly property crime) throughout Brazilian municipalities, investigating their relation with structural characteristics. To reach this aim, property crime agglomerates (CA) were measured and the probability of a municipality having a CA was estimated using the Spatial Probit mode. The analysis identified that formal control, surveillance environment and social intervention as well as the availability of targets and offenders are decisive elements for a municipality to have a CA. Regionally, the surveillance environment and the availability of targets and offenders were the predominant elements.

Keywords: Property crime agglomerates; spatial Probit; General multilevel opportunity theory.

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Área 8 - Questões urbanas e metrópoles

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1. Introduction

This paper aims to analyze the spatial patterns of crime distribution (mainly property crime) throughout Brazilian municipalities, investigating their relation to structural characteristics. We start by considering that the geographical context where crimes occur is important for this process, evidencing the space relevance in the distribution of public safety.

Our theoretical background is based on the alignment of the "routine activity theory" (RAT)[3] with the "social control theory" (SCT), which resulted in the "General multilevel opportunity theory" (GOT). Regarding the former, criminal opportunities result from the conjugation of three elements: the existence of potential offenders, targets and guardians (or tutors). Summarizing, it assumes that a motivated criminal agent, a suitable target and the absence of a competent tutor (to inhibit illegal actions) provide the necessary conditions for a criminal event to occur (Cohen and Felson, 1979).

In this theory, illegal activities tend to be fed by other activities, and their location depends on the social organization and the existing daily routines. This is an ecological approach through which theorists attempt to show how people Interact within certain environments, and how preceding and structural aspects affect local criminality.

In the social control theory, the criminal opportunity is related to the surveillance environment and social intervention. Also, it is centered in the capability of the individuals to join to reach a common objective, such as the mitigation of existing crime. In this approach, local structural elements (ex. the region socioeconomic status, high population turnover, family disturbance, etc.) appear as relevant factors in the explanation of the existing criminal actions (Sampson, 1999, 1997).

Therefore, the social control theory is mainly focused on the "local space", but it is also concerned with the individuals, since it analyzes their social and organizational networks. The routine activity theory, in turn, focuses on individual routines and opportunities, also recognizing the importance of social structures that influence those routines. In addition, both present social control or guardianship as one of the main elements strengthening crime.

Taking those characteristics into consideration the "General Multilevel Opportunity Theory" emerges, grouping the RAT and SCT main elements, recognizing the crime context as essential for the understanding of criminal patterns. Basically, two principles are recognized: that the risk of crime in an individual scope is higher in a context of high opportunity and; that the effects of individual protection factors in these crimes are higher in contexts of lower criminal opportunity (Wilcox et al., 2013). Therefore, the individual (potential offenders, targets and tutors) and structural (social, economic, demographic aspects) contexts influence crime opportunity in a certain place.

For this reason, it seems relevant to explore the spatial patterns of crime starting from the idea that individual criminal opportunity can be shaped by the structural characteristics of the environment. Also, theoretically, one can say that the causal processes that lead to a criminal activity tend to vary in space, with differentiated effects on crime concretization. Therefore, identifying the spatial distribution of criminality and the structural factors that contribute to it, becomes fundamental for the efficacy of safety public policies, justifying this research.

It is also important to emphasize that different national studies have discussed the variables that might affect criminality in Brazil. However, most focus on homicide,

[3] It seems relevant to highlight the existence of other criminological theories that seek to explain how and why crimes occur such as the rational choice theory (see Dolu 2009), the situational crime prevention (see Clarke, 1997), among others.

considering that this is the only variable available for all Brazilian spaces (such as Araújo Jr. and Fajnzylber, 2001; Cerqueira and Lobão, 2003; Shikida, 2009; Fernandes et al, 2017; among others). In regional studies, analyses of other crimes have been carried out, focusing on specific states/municipalities, without a general analysis of the whole country (as for example in Beato et al, 2004; Mariano, 2010; Ervilha and De Lima, 2019). In such context, this study contributes to the national literature for investigating property crime by analyzing all the Brazilian municipalities, using an exclusive database, comprising information collected all over the country for around two years. In addition, as it assumes that structural characteristics, theoretically, might be important in this process, spatial econometry using the spatial Probit was employed, which makes it different from most studies.

As for the international literature (such as Blau and Blau, 1982; Sampson, 1987, 1989; Wyant, 2008; Wilcox et al, 2013, among others), the main contribution of this paper is the possibility of analyzing the importance of structural characteristics in spaces with different socioeconomic development levels. In fact, in addition to analyzing the importance of structural characteristics in the criminality of all municipalities in the country, it also carried out an investigation considering each Brazilian region.

To present this study, the paper is organized in five sections, namely: introduction, theoretical background, methodology, results and final considerations.

2. Criminal Multilevel Opportunity Theory

Crime opportunities within the theoretical "routine activity" (RAT) background result basically from three elements: the existence of potential offenders, the targets and the guardians (or tutors). In this approach, the necessary condition that leads to a criminal event is the simultaneous existence of a motivated criminal agent, a suitable target and the absence of a competent tutor (Cohen and Felson, 1979).

In fact, urban development and the disappearance of conventional neighborhoods, tended to reduce the number of social guardians (tutors) such as neighbors, relatives or friends. Also, women's increased participation in the job market impacted this number. In this sense, the guardian is the individual or element (family members, neighbors, police, lighting, safety system, etc) that discourages a criminal to commit a crime. Regarding targets, it refers to the existence of people and properties with a higher subjective or material value, which are something (person, object, place) that might bring instant profit to the offender. Finally, the last RAT component refers to the presence of potential offenders, emphasizing their rational character and, for this reason, the insecurity tends to be higher in places where the level of visibility and accessibility to a target is also higher (Brunet 2002).

For Cohen and Felson (1979), the expression "routine activities" that underlies RAT refers to everyday activities that increase or decrease the risk of individuals becoming crime victims. In this sense, the emphasis on situational aspects, mainly in space, shows crime as a resource embedded in the social organization, highlighting that the time and space structure of routine activities must play an important role in the existing local insecurity (Degarmo 2011).

It seems also relevant to emphasize that a space that presents a motivated offender, a suitable target and lacks guardianship will not necessarily generate crime (mainly regarding property crime) according to RAT, but rather that the presence of these three elements tends to increase the likelihood of a crime to occur.

Therefore, in RAT, the focus is on criminal events and not on individual criminality and, thus the place (space) becomes central in the explanations of existing criminality.

On the other hand, RAT infers that criminality rates are not only affected by the number of offenders, targets or tutors, but also by the factors that affect the frequency of their convergence in space and time (Sherman, Gartin and Buerger, 1989). For example, when potential criminals notice previous attempts as well-succeeded and feel that they are not likely to be punished, they are more inclined to reoffend. (Dugan et al, 2005).

The emphasis on space and time, makes crime a resource embedded in the social organization and daily routines. Cohen and Felson (2003) stated that when illegal activities are fed by other activities, the space and time structures of routine activities play an important role in the determination of location, type and number of illegal acts. This is an ecological approach in which the theorists seek to show how people interact within certain environment, and how preceding aspects interfere in the present insecurity.

The "Social Control Theory" (SCT) infers that the existence of a systemic model of local organization of the neighborhood, with primary and secondary networks that exercise social control, along with the ability of obtaining external resources to fight criminality affects the determination of urban violence. That is, they explain how criminal opportunity increases when there is evidence of low surveillance and intervention (Bursik and Grasmik, 1993).

Basically, some of the structural elements of the "differential social organization" that affect criminality are noticed: low socioeconomic status, high population turnover, family disaggregation (divorce, single parent households, etc) and urbanization (high population density with reduction in the feeling of local belonging), according to Sampson (1997). Social disruption due to different factors tends to affect children socialization, also reaching social controls on the youth's actions, and when urbanization is intensified along with poverty, these controls are further impacted. Regarding the latter, high poverty levels might inhibit the presence of the resources needed to organize the space, weakening social bonds and the informal control networks. In addition, the residents' isolation might be intensified, also weakening the control of deviant behavior.

The main link between RAT and SCT refers to the social control, mainly that of the family. In fact, Sampson and Wooldredge (1987, p. 373) observed that "regardless of the individual, the family composition and even the proximity of offenders, living in a community with low guardianship and surveillance might increase the risk of victimization". Thus the control or guardianship plays a fundamental role in the mitigation of local crime opportunity, and these concepts play a central role in both theories.

In the last few years, authors have considered the risk of the occurrence of a crime as a function of the individuals's routine activities added to the social control composition and structure. Studies such as those by Wilcox et al. (2003) and Wilcox et al. (2013) pointed out important links between these two theories, suggesting that they complement each other, and emphasizing that when they are integrated, they form a more economical and robust theory of criminal events, which is known as the General multilevel opportunity theory.

Therefore, the social disruption-control theory is mainly focused on the community, but it also refers to individuals, by addressing their social and organizational networks. The routine activities theory, in turn, focuses on routines and individual opportunities, also recognizing the importance of the social structures influencing those routines. However, both see the social control or guardianship as one of the main elements strengthening crime.

Taking that into consideration, Wilcox et al. (2003) presented four main principles joining the two theories (RAT and STC): the criminal behavior thrives in a context of opportunity, suitable targets and guardians (or tutors) present in that time and space; such context of individual criminal opportunity is directly related to the individuals' exposure to motivated criminals, the targets' vulnerability, the antagonism between the target and the social control, emphasizing that these factors also apply to a context of criminal opportunity at an environmental level, however, in a higher degree; finally, the probability of occurrence of a criminal act is the result of the direct effects of individual and environmental levels of criminal opportunity, along with the effects of the individual-environment interaction.

However, recently Wilcox et al. (2013) summarized this interaction between the micro and macro factors of criminal opportunity into two principles: "the effects of individual- or place-level crime-event risk factors are greater in high-opportunity contexts than in low-opportunity contexts", and; "the effects of individual- or place-level crime-event protective factors are greater in contexts of lower, as opposed to higher, opportunity" (Wilcox et al., 2013, p. 586).

Therefore, "the general multilevel opportunity theory" recognizes the possibility of interactive effects between the different levels, so that the individual opportunity effect on crime might vary depending on the contextual opportunity in which the individual is placed.

3. Methodology

Aiming at identifying the spatial distribution of criminality and the structural factors that favor it in Brazilian municipalities, spatial econometry was employed. AS emphasized by Wilcox et al. (2003), since the "general multilevel opportunity theory" was developed with the purpose of addressing individual and environmental aspects of the criminal opportunity, it is natural that statistical modelling methods are used that take the later aspect into consideration. Therefore, space matters in the crime distribution process, mainly regarding the neighborhood analysis level.

Moreover, instead of using the robbery direct data, criminality agglomerates were calculated (regarding property crime), as the methodological strategy presented below.

3.1 Data and data source

The great difficulty in analyzing the "General Multilevel Opportunity Theory" throughout the country rests on the lack of property crime data, which is the focus of this theory. Thus, this information was requested from each federative unit, and a single database was created, comprising the 24 Brazilian states plus the Federal District. However, two states did not take part in the analysis: Acre, that did not reply the requests made and Paraíba that informed not having such information available.

After the data was collected, the Brantingham and Brantingham (1997) methodology was employed, mapping criminality through the criminality location quotient (CLQ), identifying its spatial patterns. Those authors infer that when only the criminality rate is used (number of thefts per inhabitant, for example), due to the underreporting, it is difficult to reach reliable estimates, a different situation from that of more serious crimes such as homicide. Therefore, when using CLQ the criminality being analyzed, *k*, is weighted by the total criminality in the space, *i*, comparing it to the same

relative when considering a larger space. Therefore, the underreporting effect is mitigated. Also, in the estimation with the "general multilevel opportunity theory", the independent variables, in general, are weighted by the population and, in that case, when working the criminality rate as a dependent variable, similarity between the denominators of the explaining and dependent variables is found, a problem that is avoided when the CLQ is used (1).

$$CLQ_{ki} = \left(C_{ki}/C_{ti}\right) \Big/ \left(C_{kN}/C_{tN}\right) \quad (1)$$

Where: C_{ki} is the number of crimes k (number of crime reports on theft) in the municipality i; C_{ti} is the total of crimes in municipality i (the sum of theft and homicide was considered); C_{kN} refers to the number of crimes k in the reference region, and; C_{tN} is the total of crimes in the reference region.

If CLQ_{ki} is over one, it indicates the existence of an over-representation of crime k in municipality i when compared to the reference area; if its value is below one, that crime is not representative in that municipality, or, in other words, the relative proportion of that crime in i is below the normal trend in the reference area.

According to Brantingham and Brantingham (1997), when using CLQ, some regions would be identified as centers of violent crimes; while other regions would be center of property crimes, etc. In our study, the focus was on the CLQ of property crimes, due to its use in the "general multilevel opportunity theory". Thus C_{ki} corresponds to the number of thefts in municipality i, and C_{ti} is the sum of theft and homicide crimes in municipality i. Regarding the reference region, the sum of crimes in each of the Brazilian regions was considered.

Also, following Brantingham and Brantingham (1997) considerations, with the purpose of avoiding punctual phenomena that might have occurred in a specific year, the average criminality in five years (2013 to 2017) in each municipality was used, aiming to reduce fluctuations and guarantee the CLQ stability.

It seems relevant to highlight that when the location quotient is used in regional analyses, an overestimation of results might occur (as suggested by Suzigan et al, 2003). For example: let's suppose that in a certain municipality one theft was reported and no homicide, while in the reference area there were a hundred theft reports and fifty homicides; then, municipality i would have a CLQ corresponding to 1.50, indicating an over-representation of theft in that place. Therefore, it is important to be aware that the CLQ might not be accurate in areas in which the criminality total level is low. In such case, when all or almost all crimes are of one kind, high CLQ might be obtained and mistakenly identify areas with disproportionately high levels of certain crimes, when in fact the level is quite low. To solve this problem, when the CLQ found was over the 'unit', it was only mapped for municipalities with a total frequency of crimes over five crimes (following the methodology applied by Brantingham and Brantingham, 1997).

Taking that into consideration, we obtain a trigger for the identification of the existence of property crime agglomerates (CA) in municipality i: having a CLQ equal or over "one" and having more than five total crimes (theft plus homicide). Therefore, a dummy of the property crime agglomeration (CA) was created, receiving "one" if the municipality met the two criteria and "zero" if it did not meet the criteria.

After identifying the municipalities with CA, the exploratory analysis of the spatial data was carried out aiming to investigate the property crime spatial distribution

pattern throughout Brazilian municipalities, using the Moran I statistics (for further details see Almeida, 2012).

Finally, to estimate the "general multilevel opportunity theory", the following explaining variables were collected: number of people registered in the *Bolsa família* program (a social welfare program of the Brazilian government) in relation to the total population (**PBF**), a proxy that seeks to capture an economic disadvantage measure (Cahill, 2005); Gini index (**IG**), measuring opportunity inequalities (Blau and Blau, 1992); family mean size (**TF**) and number of households with children where the mother is the breadwinner (single parent households) in relation to the total of households with children (**MR**), variables that measure housing stability and /or family guardianship (Wilcox et al., 2003); demographic density (**DD**), and percentage of jobs in the commerce (**EC**), both representing the availability of targets and offenders (Wilcox et al., 2003); expenditure with safety per capita (**SP**) and percentage of workers in safety (**TS**), representative of the formal tutors (Cohen and Felson, 1979); jobs per inhabitant (**EP**), proxy for the municipality economic advantage (Cahill, 2005). The point here is that there was certain correlation between some of these variables (Appendix A), and, for that reason, the final model estimated kept: jobs per capita, demographic density, *bolsa família* program, family mean size and the per capita expenditure with safety.

Chart 1 presents sources and year of each variable used in the estimation of the "general multilevel opportunity theory", emphasizing that they were either collected in the initial year of the analysis (2013) or in the year of the last census in Brazil (2010) and Appendix D shows their descriptive statistics. It seems also relevant to emphasize that some of these variables presented high correlation. The spatial econometric model used in this paper is presented below.

Chart 1 – Variables used to estimate the "general multilevel opportunity theory" and data sources

Variable	**acronym**	**Methodology**	**Source**	**Year**
Property crime agglomerate	CA	CLQ >1 and number of crimes >15	State Safety Secretariats	Average 2013-2017
Bolsa Família Program	PBF	People registered in the PBF/total population	MDS and Ipeadata	2013
Family mean size	TF	Family size weighted mean	Census	2010
Demographic density	DD	Number of inhabitants per square kilometer	Census	2010
Expenditure with safety per capita	SP	Safety expenditure / population	Ipeadata	2013
Jobs per capita	EP	Total jobs / population (aged> 15 and < 65 years)	Rais and Ipeadata	2013

Source: Research results.

3.2 Empirical Strategy: Spatial Probit Model

After carrying out the residual spatial correlation tests (Appendix B), spatial dependence was observed, and, therefore, linear regression classical models should not be taken into consideration, since the estimates tend to be biased and inconsistent, suggesting the use of spatial econometry.

For this reason, the Spatial Auto Regressive (SAR)[4] model was employed. This model, according to LeSage and Pace (2009), is the combination of a traditional regression model with a spatial autoregressive structure in which spatial interaction occurs between the dependent variables. The SAR model mathematical specification is:

$$\begin{aligned} &y = \rho Wy + \alpha i_n + X\beta + \varepsilon \\ &y = (I_n - \rho W)^{-1}(\alpha i_n + X\beta) + (I_n - \rho W)^{-1}\varepsilon \\ &\varepsilon \sim N(0, \sigma^2 I_n) \end{aligned} \quad (2)$$

Where: *y* is the dependent variable; *X:* is the explaining variable; I_n*:* vector n x1 with all unitary values; *W:* spatial proximity matrix*; α and β:* regression coefficients and *ρ:* spatial autoregressive coefficient.

Almeida (2012) pointed out that the spatial autoregressive coefficient (ρ) is the element that brings spatial dependence to the model. LeSage and Pace (2009) explain that in a model of the type SAR, the variation of an explaining variable does not affect only the dependent variable region (direct effect), but also affects, through the indirect effect, the dependent variable of other regions. Indirect effects refer to spatial spillover.

Since the dependent variable is binary (having or not a CA), a spatial Probit was estimated. Almeida (2012) observed that this type of estimates incorporates the spatial dependence to the latent variable model. In the spatial model, the geographical space where the event is likely to occur is taken into consideration. This type of model works with a binary dependent variable: if the latent variable overcomes certain critical level *c*, the value obtained is "one", if it does not overcome a determined critical level, the value observed is zero:

$$y = \begin{cases} 1, & y* > 1 \\ 0, & y* < 1 \end{cases}$$

$$y^* = \rho Wy^* + X\beta + \varepsilon \quad \varepsilon \sim (0, \sigma_\varepsilon^2 I_n) \quad (3)$$

Where: ε is the random error term with mean zero and constant variance.

Another point to emphasize is the existence of empirical strategic differences to estimate this type of model. Fuentes (2016) refers to the estimation through maximum similarities, weighted least squares and estimators obtained using the generalized moment method. However, that author indicates the Bayesian method as an important form of estimation, for showing more computational ease, speeding the process. For this reason, this methodology was applied in (3).

In this sense, the variable of interest in this study assumes two values: "one" if a CA was considered and "zero" if otherwise.

Since the Spatial Probit model requires a weighting matrix, in this case, the analysis is based on the geographical distance matrix of *k* closest neighbors. The number of neighbors decision derived from a process of mode estimation, selecting k neighbors that originated the spatial autocorrelation coefficient with the highest statistical significance, following the methodology applied by Fuentes (2016), corresponding to 10 neighbors. Finally, after estimating (3), tested the spatial autocorrelation between the residues of all models again and eliminated the previously existing spatial effect (APPENDIX B).

[4] It seems relevant to emphasize that other spatial models were tested (SEM, SDM and SDME), however, the SAR model was the one presenting the best suitability to the data, according to Appendix C.

4. CRIMINALITY IN BRAZILIAN MUNICIPALITIES: ITS CONCENTRATION AND DETERMINANTS

Criminality is one of the main social problems in Brazil. Its evolution has imposed a stigma of insecurity on the country, affecting directly the population's quality of life.

Different theories have been created seeking to explain the causes of increase in crime. However, studies focusing spatial patterns of its distribution (mainly related to property crime) throughout Brazilian municipalities are still scarce.

Our understanding is that the geographical context where crimes occur is relevant, and its structural features might determine the intensification of such process. Table 1 shows the geographical distribution of theft per thousand inhabitants throughout Brazil, which is intensified in the Northern and Southeastern regions.

Table 1: Descriptive table of theft per thousand inhabitants – Brazilian municipalities – 2013/2014

Region	Mean	Maximum	Minimum	Standard deviation	Variation coefficient
Center-West	1.21	36.25	0.00	1.21	100.13
Northeast	1.33	21.33	0.00	1.22	91.41
North	1.85	39.83	0.00	2.21	119.50
Southeast	1.82	50.75	0.00	2.09	114.79
South	1.18	15.10	0.00	0.97	82.36
Brazil	1.48	50.75	0.00	1.51	102.11

Source: Research results

However, when calculating property crime agglomerates (CA), the Southern region showed the greatest concentration, with 26% of the municipalities presenting this kind of agglomerate, followed by the Southeast (20%) and the Northeast (19%). Also, the South had the lowest per capita mean theft (Table1), and at the same time presented the highest agglomerate percentage, a direct consequence of the greater homogeneity in the distribution of insecurity throughout that region (the lowest variation coefficient among the Brazilian regions). Conversely, the North presented the highest per capita mean theft, and one of the lowest percentages of municipalities with CA, exactly due to its greater heterogeneity in the spatial distribution of this type of crime.

It seems relevant to emphasize that around 20% of the Brazilian municipalities were diagnosed as having a CA.

Table 2: Number of municipalities with property crime agglomerates (CA) and percentage of municipalities with these agglomerates – Brazilian regions - 2013

Region	Number of property crime agglomerates	Percentage of municipalities with CA
Center-West	28	6.01
North	37	9.14
Northeast	293	18.66
Southeast	337	20.20
South	310	26.09
Brazil	1005	18.97

Souce: Research results.

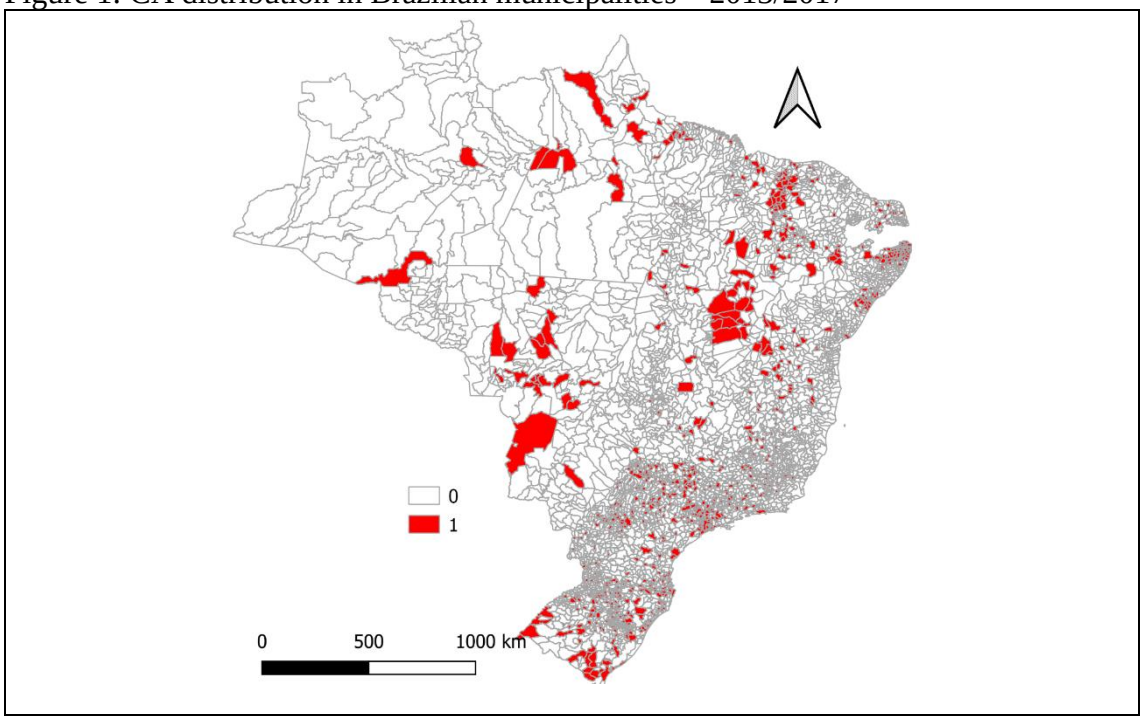
Figure 1 presents the spatial distribution of these agglomerates, observing a stretch along the country. It seems relevant to mention that even with such dispersion, the municipalities with CA tended to be close one to another, a characteristic that is confirmed by the Moran I statistics (Table 3). Therefore, municipalities that had a CA, on average, were surrounded by neighbors with similar characteristics (and vice-versa), showing a spatial distribution pattern of the property crime agglomerates. This suggests that space is a relevant element in the insecurity process in Brazil.

Table 3: Moran I Coefficient – CA – Brazilian municipalities – 2013/2017

Queen	1 neighbor	5 neighbors	10 neighbors
0.18*	0.18*	0.19*	0.20*

Source: Research results.

Figure 1: CA distribution in Brazilian municipalities – 2013/2017



Source: Research results.
Note: (1) refers to municipalities that have a CA.

The "general multilevel opportunity theory" puts forward some considerations about the factors that might determine the formation of such CAs. The first refers to the opportunity context (motivated criminals, suitable targets and guardians) that might incentivize illegal acts. In addition, the probability of some criminal act to occur results from the direct effects of criminal opportunities around the individual and the environment, as well as the effects of the interaction between these two levels.

From this starting point, we analyzed the factors that increase the chances of a property crime agglomerate existing in a Brazilian municipality. In fact, Table 4 shows that the availability of targets and offenders, represented by demographic density, are decisive elements in such likelihood. More specifically, the higher the population turnover is, the higher the chances of having a CA in the municipality are, due to the intensification of local opportunities. Also, this effect is not restricted by boundaries, impacting indirectly the formation of CAs in the neighbourhood (demographic density indirect effect).

Likewise, residential stability and/or family guardianship are also important in this determination, represented by the family size. An environment of surveillance and social intervention might intensify guardianship and, consequently, reduce the existing criminality, inhibiting the probability of formation of a local CA. This means lower chances of having a property crime agglomerate, when the family surveillance is higher, not forgetting that this factor creates an spillover of criminality in the neighborhood.

Moreover, formal surveillance enacted by the public safety expenses was seen as a statistically significant factor decreasing the probability of forming a CA for discouraging the execution of illegal acts. Therefore, both formal and informal controls are important to reduce crime growth throughout the country.

Regarding structural elements, when referring to economic advantages/disadvantages, they were not relevant to the creation of chances of formation of a property crime agglomerate.

Table 4: SAR Model - spatial Probit – coefficient and direct/indirect effects - Brazil

Variable	Coefficient	Direct effect	Indirect effect
Employment per capita – EP	-0.04	-0.03	-0.05
Demographic density –DD	0.0001*	0.00001*	0.00002*
Bolsa Família Program – BFP	-0.003	-001	-0.003
Family mean size – FS	0.15*	0.1*	-0.02*
Public safety expenses per capita – SP	-0.00006*	-0.00005*	-0.0001
WY	0.70*	-	-

Source: Research results

Note: * statistically significant at a 5% significance level.

Since Brazil has a large territorial extension and presents heterogeneity of its structural characteristics, it is unwise to imagine that the same factors that affect the South, for example, will equally impact criminality in the North. Therefore, each Brazilian region was re-estimated as shown in Table 5.

Regarding the North, only the population turnover increased the likelihood of a municipality having a CA, showing that local opportunity is a decisive factor in this process, which is not restricted to the municipal limits, reaching neighboring areas as well.

As for the Northeast, in addition to the population turnover, economic advantages/disadvantages of each municipality might intensify the chances of a property crime agglomerate existing. That is, the lower the job opportunities are, the higher the chances of having a local CA are. Therefore, structural characteristics are important, and they also influence the surrounding municipalities. Moreover, family size appeared as statistically significant, in which the family surveillance environment might inhibit property crime intensification and, consequently, prevent the formation of a CA. In such context, in that region, both the availability of targets and offenders and the existence of individual controls are decisive elements to prevent public insecurity.

The Center-West shows close values to those of the Northeastern region determinants, presenting statistical significance for the proxy economic advantage/disadvantage (*Bolsa Família* Program) and also for family surveillance (family size), which are not limited to local effects, creating a spillover in the neighborhood.

In the Southeast, informal controls (family) did not seem relevant for the CA formation, while the formal controls (public safety expenses) did. These results might be a consequence of the existence of great urban concentrations in the region, where the social control is not so noticeable, therefore, only the formal surveillance interferes in the CA formation process.

Also, the economic advantage/disadvantage was seen to be important, so that, an increase in formal jobs decreased the probability of having a CA, similar result was obtained by Mariano (2010), who analyzed municipalities in the state of São Paulo, and observed that socioeconomic factors are relevant to determine the occurrence of property crimes. Finally, employment per capita as well as public safety expenses per capita affected criminality in the neighborhood, with indirect effects in public insecurity in the neighborhood.

In the Southern region, space did not present any effect in the CA formation, maybe due to the greater presence of CAs all over the region (Table 2), which existed regardless of the spatial characteristics. Population turnover and family size were identified as the variables increasing the probability of having a CA. Therefore, the availability of targets and offenders and the existence of individual controls, are decisive elements in the prevention of public insecurity in the South.

Taking that into consideration, the elements observed as the most relevant between Brazilian regions, with certain degree of difference, were mainly the availability of targets and offenders, and the individual control, emphasizing that for practically all spaces in the country, spatial characteristics were important in the formation of property crime agglomerates, confirming the inference that space matters in this process.

In fact, Beato et al (2004), when analyzing the municipality of Belo Horizonte, observed that environmental characteristics and opportunities are more decisive for the occurrence of property crimes than individuals' characteristics (such as schooling or economic activity). Likewise, Moura and Silveira Neto (2013), when using the Pnad data, identified that the social context is the main element of victimization. Therefore, those authors confirm the results found in this research, demonstrating that environmental characteristics might be decisive in the determination of public insecurity.

Table 5: SAR Model – spatial Probit – coefficient and direct /indirect effects- Brazilian regions

Variable		North	Northeast	Center-West	Southeast	South
EP	Coefficient	0.54	**-0.15***	-0.10	**-0.42***	-0.008
	Direct effect	-0.25	**-0.07***	-0.03	**-0.03***	-
	Indirect effect	-0.04	**-0.04***	-0.01	**-0.006***	-
DD	Cofficient	**0.02***	**0.0004***	-0.0004	0.00005	**0.0006***
	Direct effect	**0.001***	**0.00005***	-0.0002	0.000007	-
	Indirect effect	**0.00004***	**0.00003***	-0.00005	0.000002	-
BFP	Coefficient	-0.07	-0.0000002	**-3.23***	-0.014	-0.02
	Direct effect	-0.06	-0.0009	**-0.59***	-0.03	-
	Indirect effect	-0.009	-0.0005	**-0.15***	-0.007	-
FS	Coefficient	0.09	**0.55***	**2.17***	0.39	**1.64***
	Direct effect	0.04	**0.23***	**0.08***	0.03	-
	Indirect effect	-0.008	**0.12***	**0.01***	0.008	-
SP	Coefficient	-0.003	-0.000007	0.001	**-0.0001***	0.0002
	Direct effect	-0.0009	-0.00005	0.00009	**-0.00002***	-
	Indirect effect	-0.0002	-0.00003	-0.00003	**-0.000005***	-
WY	Coefficient	0.15**	**0.42***	**0.24***	**0.23***	**0.04**

Source: Research results

Note:* statistically significant at 5%. BFP: number of people registered in the *Bolsa família* Program in relation to the whole population; FS: Family mean size; DD: demographic density; SP: public safety expenses per capita; EP: employment per capita; WY: dependent variable space deficit (CA).

Final remarks

The objective of this paper was to analyze spatial patterns of crime distribution (specifically property crime) throughout Brazilian municipalities, investigating their relation to structural characteristics.

A spatial distribution pattern was observed regarding property crimes in the country, with some regions presenting more CA than others. Among the factors influencing the local crime opportunity, the relevance of the individual (potential offenders, targets and tutors), as well as the structural (social, demographic and economic) contexts was confirmed, validating the General Multilevel Opportunity Theory.

It seems important to emphasize that in each region, these elements - individual and structural – had different degrees of relevance. Moreover, this specific identification is also important, mainly for allowing the creation of effective public policies to fight criminality all over the country, considering the particularities of each space. In addition, knowing where the main property crime agglomerates are located and their regional triggering elements increases the chances of inhibiting illegal acts in Brazil.

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APPENDIX

Appendix A: Correlation between explaining variables

TF	MR	PBF	DD	SP	ES	EP	EC	IG	
1.00	-0.02	0.24	0.05	0.01	0.01	-0.03	-0.03	0.46	TF
	1.00	0.27	0.01	0.01	-0.01	-0.02	-0.01	0.08	MR
		1.00	-0.17	-0.09	0.01	-0.01	-0.02	0.30	PBF
			1.00	0.36	0.01	0.01	0.01	-0.03	DD
				1.00	0.01	0.01	0.01	0.01	SP
					1.00	0.99	0.97	0.01	ES
						1.00	0.99	-0.01	EP
							1.00	-0.01	EC
								1.00	IG

Source: Research results

Appendix B: Moran I for Residual – Probit and spatial Probit

Matrix	1 neighbor	4 neighbors	10 neighbors	15 neighbors
Probit	0.4*	0.5*	0.6*	0.5*
Spatial Probit	0.0002	0.001	0.001	0.002

Source: Research results

Appendix C: Akaike Information Criterion – spatial models

SAR	SEM	SDM	SDME
-1766	-1758	-1764	-1760

Souce: Research results

Appendix D: descriptive statistics – explaining variables –spatial Probit model

Regions	TF	PBF	DD	SP	EP
Center-West	1.48	0.16	30.90	11.82	0.25
North	1.91	0.19	24.84	16.31	0.09
Northeast	1.67	0.24	93.64	25.16	0.14
Southeast	1.49	0.14	205.28	345.53	0.18
South	1.42	0.12	81.74	31.45	0.25
Brazil	1.60	0.19	110.74	105.66	0.16

Source: Research results