

**THE BRAZILIAN ARMED FORCES AND PUBLIC SECURITY ON THE BORDER:
A SPATIAL REGRESSION DISCONTINUITY DESIGN APPROACH**

**FORÇAS ARMADAS E SEGURANÇA PÚBLICA NA FAIXA DE FRONTEIRA:
UMA ABORDAGEM DE REGRESSÃO DESCONTÍNUA ESPACIAL**

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ABSTRACT

Brazil's Border Strip plays a strategic role in national defense, public security, and regional development and is the target of various control and patrol policies. This study investigates the impact of the Armed Forces' actions on public security in municipalities within the Border Strip. To achieve this, we analyzed the variation in municipal homicide rates between 2010 and 2019 and applied the regression discontinuity design (RDD) to estimate the effects of the Armed Forces' presence by comparing municipalities inside and outside the strip. The results indicate that the presence of the military affects violence; however, these effects are not spatially uniform. In the Northern Arc, there was a significant reduction in homicide rates in municipalities within the Border Strip compared to those outside this region. In contrast, in the Central and Southern Arcs, the estimates were either not statistically significant or, in some years, counterintuitive. The analysis supports the hypothesis that the presence of the Armed Forces has a positive effect on public safety, though this impact is concentrated in the northern arc municipalities.

Keywords: Public security; Border Strip; Armed Forces; Regression Discontinuity Design.

RESUMO

A Faixa de Fronteira do Brasil desempenha um papel estratégico na defesa nacional, na segurança pública e no desenvolvimento regional, sendo alvo de diversas políticas de controle e patrulhamento. Este estudo investiga, portanto, os impactos da atuação das Forças Armadas sobre a segurança pública dos municípios da Faixa de Fronteira. Para isso, analisamos a variação das taxas de homicídios municipais entre 2010 e 2019 e aplicamos o método de Regressão Descontínua (RD) para estimar os efeitos da presença das Forças Armadas, comparando municípios dentro e fora da faixa. Os resultados indicam que há efeitos da presença militar sobre a violência, no entanto, esses efeitos não são espacialmente generalizados. No Arco Norte, observa-se uma redução significativa das taxas de homicídio nos municípios pertencentes à Faixa de Fronteira vis a vis municípios fora dessa região; enquanto no Arco Central e no Arco Sul, as estimativas não foram estatisticamente significativas ou, para alguns anos, foram contraintuitivas. A análise dá suporte à hipótese de que a presença das Forças Armadas exerce um efeito positivo sobre a segurança pública, porém esse impacto se concentra nos municípios do Arco Norte.

Palavras-chave: Segurança pública; Faixa de Fronteira; Forças Armadas; Regressão Descontínua.

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1 INTRODUCTION

In 2023, at the launch ceremony of the Plano Amazônia: Segurança e Soberania (AMAS, Amazon Plan: Security and Sovereignty), the Minister of Justice and Public Security at the time, Flávio Dino, indicated that the government was evaluating the possibility of expanding Brazil's Border Strip within the Legal Amazon (Moreno, 2023). The proposal involved extending this strip from 150 km to 250 km from the border, allowing the Armed Forces to engage more intensively in the area. The rationale for this initiative was rooted in the objective of improving national security and addressing illegal activities, such as drug trafficking and environmental crimes, which are prevalent in this particularly vulnerable region.

In light of this possibility, fundamental questions arise: Is there empirical evidence to suggest that the presence of the Armed Forces within the Border Strip improves public safety? Should the strip be expanded, would the municipalities newly encompassed within it achieve heightened security? Furthermore, is there a measurable difference in the incidence of violence between cities located within the Border Strip and those that, despite their geographical proximity, fall outside its boundaries?

This study seeks to address the aforementioned questions by analyzing the potential effects of the Armed Forces' presence within the Border Strip, with a particular focus on the legal frameworks governing their actions. The central hypothesis posits that the military presence positively influences public safety in the border strip region by decreasing the occurrence of homicides. To empirically test this hypothesis, a Regression Discontinuity Design (RDD) was employed to contrast municipalities situated within and outside the strip, thereby isolating the impact of the Armed Forces' actions from other socioeconomic factors. In addition, the study explores alternative classifications of the treatment and control groups to verify the robustness of the findings and discern potential heterogeneities in the observed impacts.

The estimated results suggest that the municipalities that make up the border strip are linked to a substantial decrease in homicide rates within the Arco Norte region. For example, in 2014, the projected effect was a reduction of 39.8 homicides per 100,000 inhabitants, and by 2018, this reduction had increased to 53.4 homicides per 100,000 inhabitants. These findings imply a favorable impact of the policy on public safety. However, this pattern was not observed in the other arcs.

2 MOTIVATION

2.1 Recent Dynamics Of Violence And Economic Development On The Border Strip

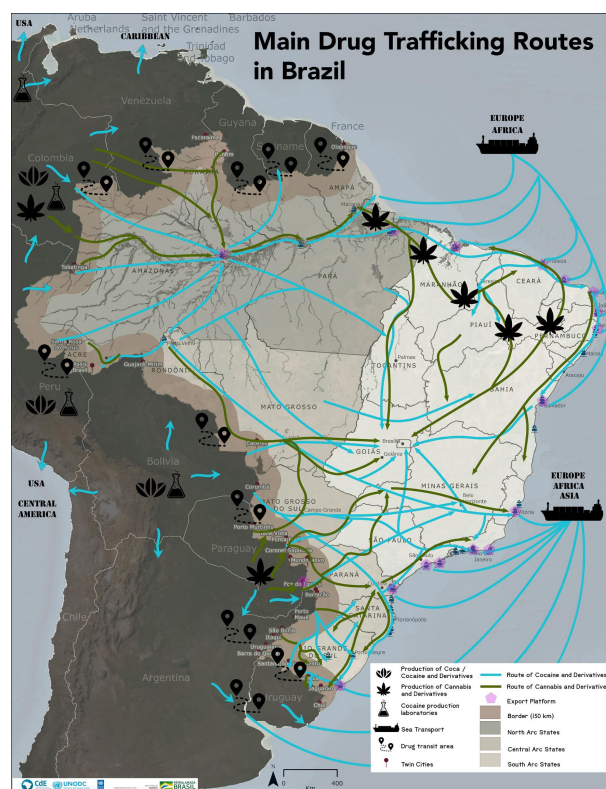
A detailed examination of the issue of public security along the border strip demands a preliminary consideration of the substantial expansion of the region. In its current configuration, the border strip occupies 27% of Brazilian territory, extending along 16,886 kilometers of land border. The border strip is home to 588 municipalities that are located within 11 states.

This expansive geographical region is characterized by a high degree of heterogeneity, which is a natural consequence of its substantial size and diversity. The various sections of the border strip exhibit distinct characteristics, which in turn influence the nature of the public security challenges they face. The existing literature indicates that specific crimes are favored by the geographical and socioeconomic conditions of the location, although it is generally agreed that drug trafficking, smuggling, and environmental exploitation are common in all regions.

The Brazilian border plays a crucial role as a gateway for the transnational flow of drugs, since it connects the main producing countries of South America, such as Colombia, Peru, Bolivia and Paraguay, to national and international consumer markets. This illicit traffic

is not restricted to border regions; rather, it spreads extensively throughout Brazil, as illustrated in Figure 1. The North, Northeast and Southeast regions are particularly affected, given the strategic importance of these regions as the main ports utilized for the exportation of illicit substances. As detailed in the CoE Brazil report (2021), trafficking routes exhibit an intricate pattern of internal distribution, utilizing roads, rivers, and airways to supply major metropolitan areas and strategic outlets to Europe, Africa, and Asia. This phenomenon underscores the necessity for an integrated approach to public security, encompassing not only border control but also the oversight of the logistical infrastructures utilized for international trafficking.

Figure 1 — Main drug trafficking routes in Brazil.



Source: CoE Brazil (2021).

In the Northern Arc, comprising the states of Amapá, Pará, Roraima, Amazonas, and Acre, Dias (2024) examine the dynamics of violence and the role of criminal factions in the macroregion. This article delineates the manner in which proliferation and confrontation between factions, including the First Command of the Capital (Primeiro Comando da Capital, PCC) and the Red Command (Comando Vermelho, CV), have influenced criminal activity and violence in the northern region. In addition, it explores the direct impact of these factions in specific locales, establishing a correlation between their presence and the escalation of violence. The text explores how factions associate themselves with typical illegal activities in the region, such as drug trafficking and environmental crimes, including illegal logging and mining. The various factions establish alliances and rivalries with local and regional groups, contributing thus to an increasing state of instability.

In the context of the preceding discussion on the activities of criminal organizations, Couto (2024) focuses on cross-border drug trafficking in the Amazon region. The study emphasizes the intricate interconnection between drug trafficking networks and ancillary activities, such as illegal mining, emphasizing their direct impact on regional security. As Couto (2024)

emphasizes, drug trafficking not only utilizes the Amazon territory as a transit route, but also integrates itself into the local economy, exploiting natural resources and contributing to the increase in violence and crime in the region.

This insight is pertinent to public security in the Northern Arc, as it demonstrates how the region is susceptible to vulnerability due to the presence of criminal factions that compete for control of trafficking routes and exploitation areas. It also addresses the need for pan-Amazonian cooperation, involving Brazil and neighboring countries, to implement an integrated and coordinated security strategy capable of responding to transnational threats that directly affect local sovereignty and development.

The Central Arc, comprising Rondônia, Mato Grosso, and Mato Grosso do Sul, encompasses a region characterized by significant geographical diversity, located at the intersection of the Amazon and the Center-South of the country. As demonstrated in Moura e Oliveira (2018), when analyzing Brazilian cross-border arrangements, it becomes evident that the central arc has undergone significant changes due to the advancement of the economic frontier, particularly in the agricultural sector, and the subsequent relocation of major companies from the southern region to the area. However, the character of this border strip is predominantly defined by a widespread combination of illicit activities and acts of violence. In the states of Mato Grosso and Mato Grosso do Sul, the highest number of drug seizures is recorded, indicating the presence of extensive "corridors" utilized by major trafficking networks. In other border states, "ant" trafficking can predominate, which is more difficult to recognize due to the multiplicity of routes and small amounts of trafficked goods.

The Southern Arc, which includes the states of Paraná, Santa Catarina, and Rio Grande do Sul, exhibits distinct economic and urban performance characteristics that surpass those observed in the other two regions. The border region exhibits a significantly elevated presence of security forces and is subject to stringent regulations. As with the Central Arc, the country is faced with challenges related to trafficking, a phenomenon exacerbated by its extensive integration with neighboring states. This challenge is further compounded by the increase in smuggling activities. As Andrade et al. (2019) points out, the characteristics of the region are notable, particularly with regard to the potential to advance public security measures along the Brazilian border.

The existing literature that addresses the relationship between violence and social development in the Brazilian border strip highlights the complexity and challenges facing this region in terms of public safety and socioeconomic progress. As Krüger et al. (2017) demonstrates in their analysis of public policies, a focal point of the discussion are the strategies used to encourage sustainable development in the Border Strip. The study's findings underscore the critical need for well-integrated and effective policies in the border strip, a region characterized by pronounced socioeconomic and environmental vulnerabilities. Development initiatives, including the Border Strip Development Program (Programa de Desenvolvimento da Faixa de Fronteira, PDFF) and the North Belt Program (Programa Calha Norte, PCN), have focused primarily on improving socioeconomic factors such as employment, health, and education. However, these initiatives have overlooked the environmental dimension, which is imperative for the sustainability of the region. However, despite certain advances in education and health indicators, employment and income indicators have exhibited a decline in certain regions. This observation suggests a disconnection and absence of continuity in the public policies implemented.

Castro (2011) offers a comprehensive exploration of the impact of external cause mortality, such as homicides and traffic accidents, on human development in border areas. A quantitative analysis of mortality data from 2000 to 2005 reveals that violence and accidents are responsible for a significant proportion of deaths in these regions, with particularly severe im-

pacts observed in the North. The demographic most affected by this phenomenon is young men between the ages of 20 and 49, a group that experiences a considerable loss of potential years of life and productivity. Although the direct impact of mortality from external causes on the Human Development Index (HDI) is limited, the study demonstrates that the resulting economic and social losses are substantial, particularly with regard to gross production and social development.

These studies reveal an interdependence between violence, public safety, and socio-economic development in border regions. The absence of continuity in public policies, in conjunction with the high mortality rate from external causes, underscores the need for more integrated and sustainable strategies. The prevalence of violence in these regions not only undermines security, but also exerts a direct and substantial influence on social development. This underscores the imperative for policies that integrate security, social development, and environmental protection to catalyze transformative change in these areas.

2.2 The Armed Forces And Security In The Border Strip

The Border Strip is defined as the strip extending up to 150 kilometers wide along the land borders, as delineated in the regulation. According to Article 20 of the 1988 Brazilian Federal Constitution (Brasil, 1988), the region is of particular interest to the Brazilian state, from the perspectives of public security, national defense, and sustainable development.

In view of the above, from a legal perspective and with regard to the regional context of public security, the presence of the Armed Forces along the border strip has the potential to affect public security and local development. As Andrade et al. (2019) explain, the Army is engaged in operations that go beyond the scope of conventional national defense. These operations encompass public security initiatives and border security measures, among others. The article emphasizes that military operations are not only intended to ensure security, but also to promote social and economic development in border regions. This perspective offers insights into the indirect consequences of military presence, extending beyond the immediate impact of reducing violent crime.

In the study of Andrade et al. (2019) the contemporary operational framework is categorized into two distinct classifications: defense policies and public security policies. In terms of defense, the article presents PCN, the Integrated Border Monitoring System (Sistema Integrado de Monitoramento de Fronteiras, Sisfron), Operation Ágata, and the National Defense Policy (Política Nacional de Defesa, PND), which accompany the National Defense Strategy (Estratégia Nacional de Defesa, END). The PCN is the oldest of these organizations, having been established in 1985 by the federal government. Initially, its military aspect was more relevant. Social assistance actions are also carried out in the context of Operation Agata, in civic-social actions (ações cvico-sociais, ACISO) (Andrade et al., 2019, p. p.394). In these actions, the population is attended by a variety of professionals, including doctors, dentists, social workers, and barbers. In addition, border crossings receive essential supplies such as medicines, documents, haircuts and schools and health centers in localities undergo painting and renovation (Figueredo, 2017, p. p.77).

In the domain of public security policies, Andrade et al. (2019) presents the Specialized Border Units Project (Projeto Unidades Especializadas de Fronteiras, Pefron) and the Strategic Border Plan (Plano Estratégico de Fronteiras PEF), the National Border Public Security Strategy (Estratégia Nacional de Segurança Pública nas Fronteiras, Enafron) and the Integrated Border Protection Program (Programa de Proteção Integrada de Fronteiras, PPIF). The Perfon initiative was established in 2008 as a pioneering effort to promote and enhance public security agencies' efforts. Subsequently, in 2011, the project was closed and incorporated into Enafron

within the framework of the PEF. At the end of 2016, the PEF underwent an update with the initiation of the PPIF. The evolution of the programs presented in the paper indicates that public security along the border is characterized by a lack of cohesion. The authors observe that the absence of a national public security plan with clearly defined objectives and guaranteed resources undermines the efficacy of policies, particularly in border regions. The absence of continuity in policy and the distressing prevalence of violence are presented as consequences of this disarticulation.

Despite the legal certainty that governs the public security situation, the primary necessity is a clear and organized implementation of the objectives to reduce public security problems on the border. This execution could be guided by indicators produced and monitored by various bodies in addition to the Armed Forces. Performing in concert, these entities possess the capacity to effect improvements in this aspect of social development. The Brazilian Public Security Yearbook, in conjunction with the National Public Security Secretariat (Secretaria Nacional de Segurança Pública, Senasp), has already demonstrated its capacity to generate data on criminal activity in all municipalities, including those located within the border strip. Quantitative and empirical studies are imperative for the implementation of public security policies. These studies provide concrete data that facilitate the identification of pertinent issues and the development of effective solutions.

3 STUDY OBJECTIVE

The objective of this study is to assess the impact of policies applied in the border region on public security, paying particular attention to the role of the Armed Forces. To this end, the work aims to consolidate and analyze data on homicides in the region over the period 2010 to 2019, estimating differences in homicide rates between municipalities on the control and treatment groups and measuring the effects of belonging to the Border Strip.

4 LITERATURE REVIEW

The objective of this section is to provide a nonexhaustive review of the recent literature on the Regression Discontinuity Design (RDD) and its development for spatial data applications. The emphasis is not exclusively on studies that empirically implement these models; rather, it is on works that describe their methodological aspects, with the objective of contributing to the achievement of the research objectives.

4.1 Regression Discontinuity Design (RDD)

RDD is a well-established methodology for causal inference in non-experimental contexts where treatment assignment is determined by whether a continuous variable crosses a threshold.

Various guides on the application of the model, such as Imbens e Lemieux (2007), underscore the efficacy of RDD for causal inferences. This methodology involves the comparison of units located just above and just below the cut-off point, thereby minimizing the influence of extraneous factors. This approach is particularly useful when direct randomization is not feasible; however, it still makes it possible to assess the effect of an intervention by observing a discontinuity in the outcome as a function of the cut-off variable.

As Lee e Lemieux (2010) demonstrated in their seminal work on RDD models, this approach offers a comprehensive foundation to understand the fundamental principles and practical guidelines that underpin the application of these models. The primary argument of this study

is that, under certain conditions, the variation in treatment near the cut-off point is as random as in a randomized experiment. Participation in treatment is exogenous and the cutoff variable cannot be manipulated. This is considered the gold standard for evaluating interventions.

In our case, the running variable is the distance to the international border, and the cutoff is set at 150 km. Assuming units just above and below the threshold are comparable, any discontinuous jump in the outcome variable at the cutoff can be interpreted as the causal effect of the treatment. Following Calonico, Cattaneo e Farrell (2020), we estimate the treatment effect using local polynomial regressions within an optimally selected bandwidth. This approach balances bias and variance by restricting the sample to observations closest to the cutoff, where units are more similar. The estimation is implemented using the `rdrobust` package, which applies a triangular kernel and robust bias-corrected inference.

Formally, the estimated model can be expressed as:

$$Y = \alpha + \tau D + \beta_1 X^{above} + \beta_2 X^{below} + \varepsilon \quad (1)$$

where Y is the outcome of interest (e.g., homicide rate), D indicates treatment status ($D = 1$ if $X < c$), and τ is the treatment effect. The coefficients β_1 and β_2 capture the relationship between the outcome and the running variable on either side of the cutoff. Although the inclusion of covariates is not required, we include them to improve precision (Huntington-Klein, 2022).

We conduct standard robustness checks, including placebo tests and manipulation assessments, to validate the identifying assumptions and ensure that the cutoff is not correlated with other discontinuities in observable characteristics.

4.2 Spatial Regression Discontinuity Design (Spatial RDD)

Although RDD is a widely used method for causal inference in observational settings, its application to spatial contexts presents specific challenges. Traditional RDD relies on a one-dimensional assignment variable and assumes a sharp cutoff, but geographic boundaries are inherently two-dimensional and often irregular. As a result, adaptations are required to preserve the internal validity of the design (Keele; Titiuink, 2015; Kaza, 2018; Jardim et al., 2024).

A pioneering example of spatial RDD is Black (1999), who estimated households' willingness to pay for school quality by exploiting housing prices near school district boundaries. This approach laid the foundation for using geographic discontinuities in causal inference.

More recently, Zimmert e Zorn (2023) investigated how agricultural subsidies in Switzerland affect family labor supply, particularly female participation. Although some farms outside the designated subsidy zones received payments, the study used a spatial RDD design where treatment assignment was instrumented via zone classification, and the running variable was the shortest distance from each farm to the boundary polygon. This approach approximates classical RDD by treating the distance to a geographic cutoff as continuous. Figure 2 illustrates how this variable is constructed.

In the context of labor markets, Jardim et al. (2024) used a spatial RDD framework to examine spillover effects of municipal minimum wage laws. The study compared wages and hours worked on either side of city boundaries with different minimum wages, incorporating parametric decay functions and clustering based on commuting zones to account for spatial spillovers. The results highlight that border discontinuities can produce biased estimates if indirect effects across jurisdictions are ignored.

A major limitation of conventional spatial RDD lies in its simplification of geographic boundaries to a single distance metric. This scalar approach may fail to capture heterogeneity along the border and can be sensitive to irregular shapes or overlapping policies. Address-

Figure 2 — Example of calculating the cut-off variable in Spatial RDD.



Source: Zimmert e Zorn (2023).

ing this, Lehner (2024) proposes a method based on randomization inference using synthetic boundaries. Through simulations, the study shows how heterogeneous treatment effects can be more accurately detected without collapsing spatial variation into a single running variable.

5 METHODOLOGY

5.1 Methodological Approach

It is imperative to acknowledge the profound impact of the Armed Forces' presence on Brazil's border strip, which significantly influences a wide array of national realities. Consequently, it would be imprudent and presumptuous to imply that we intend to evaluate or invalidate the actions of the Armed Forces, considering the wide array of operations they undertake. In this regard, a pivotal initial step involves the systematic identification and evaluation of the potential ramifications that may ensue from the operations of the Armed Forces. A suitable conceptual alternative would be to examine the official objectives described in Brazil's National Defense Policy (PND). (Brasil, 2020).

The roles of the Brazilian Armed Forces, as outlined in PND, encompass three primary objectives: national defense, national security, and regional and social development, detailed in Chart 1. In this context, it is hypothesized that the IMPACTS expected from the presence of the Armed Forces on the border strip are the achievement of the three dimensions. Given the capacity of each of the three IMPACTS to be decomposed into an array of quantitative and qualitative indicators, it is imperative to maintain concision. In this study, we will restrict our analysis to a quantitative impact assessment exercise for the "National Security" objective, with a more specific focus on reducing homicide rates.

5.2 Treatment: Armed Forces In The Border Strip

The Border Strip is a region that measures up to 150 kilometers in width along the Brazilian land borders. As delineated in Article 20 of the 1988 Federal Constitution (Brasil, 1988), it is considered a region of particular concern for the Brazilian state from the perspectives

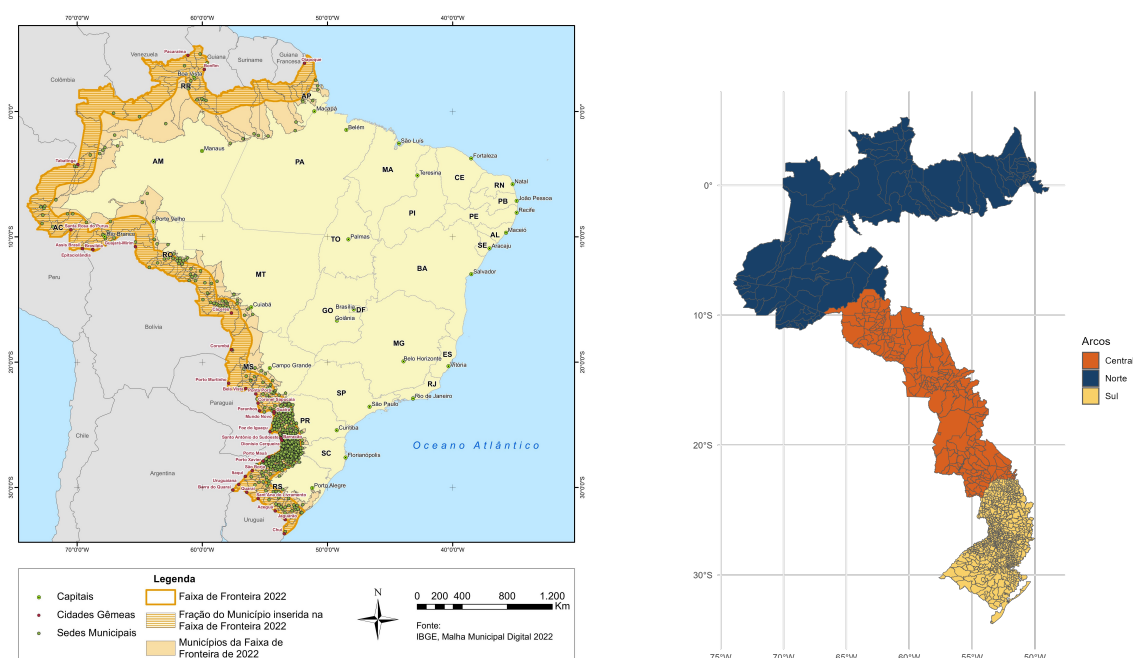
Chart 1 — Expected impacts of the presence of the Armed Forces on the Border Strip.

Area	Summary
National Defense	Defense of territory, sovereignty and national interests against threats
National Security	Preservation of sovereignty and guarantee for citizens the exercise of constitutional rights and duties, with special attention to vigilance against illicit activities at the border
Social and Regional Development	Provision of basic services to the population and development of the region's infrastructure

Prepared by the author (2025).

of public security and national defense, as well as sustainable development (see Figure 3a).

Figure 3 — Brazilian Border Strip.



a. Border Strip in 2022.
Source: IBGE, Digital municipal grid 2022.

b. Border Strip Arcs.

The federal government's actions in the Border Strip were planned on a territorial basis, divided into three arcs. These arcs were defined on the basis of the proposal to restructure the Border Strip Development Program (PDFF-2005). The arcs were further defined on the basis of the Ministry of Integration's National Regional Development Policy (Política Nacional de Desenvolvimento Regional, PNDR). The arcs are illustrated in Figure 3b.

The Brazilian border states exhibit considerable variation in the proportion of their territory that falls within the Border Strip, a factor that can influence the effects estimated in the analysis. As demonstrated in Table 1, while states such as Acre (88.3%) and Roraima (68.9%) have a significant portion of their area encompassed by the strip, others, including Mato Grosso (12.3%) and Pará (7.4%), exhibit a substantially lower degree of integration. These discrepancies can result in heterogeneity in the observed impacts, given that exposure to the Border Strip's regulatory and institutional regime varies considerably between states. Consequently, the magnitude and direction of the effects may be influenced not only by the presence in the

strip but also by the territorial extent of this insertion.

Table 1 — Percentage of the states' area integrated into the Border Strip.

State	Integrated area
Acre	88.275%
Roraima	68.892%
Rondônia	52.388%
Rio Grande do Sul	52.111%
Amapá	49.334%
Mato Grosso do Sul	40.175%
Paraná	27.897%
Amazonas	23.313%
Santa Catarina	15.290%
Mato Grosso	12.302%
Pará	7.414%

Source: IBGE (2024).

The regulatory and institutional development of Brazil's Border Strip reflects a growing concern with national security and territorial sovereignty, particularly in the Amazon region. From Act No. 601 of 1850 to the 1988 Federal Constitution, there has been a gradual expansion of the strip, currently defined as 150 kilometers, and the assignment of strategic functions to this zone, including the regulation of land occupation, resource exploitation, and infrastructure development, all under the supervision of national defense authorities. In recent years, proposals to expand the strip within the Amazon Legal region have reignited debates about the area's vulnerability to environmental and transnational crimes. Although such proposals have not been formally approved, they underscore the state's strategic priorities and have culminated in the creation of the Amazon Plan: Security and Sovereignty (AMAS). This plan coordinates the efforts of the Armed Forces, Federal Police, and state police, focusing on infrastructure investments and increased state presence to strengthen territorial control and promote the protection of the region's natural resources.

In order to ensure that the Border Strip receives the attention it deserves under the Constitution, the actions of the Armed Forces in the region have also been described in different laws throughout history. As indicated by Figueredo (2017), four fundamental normative frameworks regulate the actions of the Brazilian Armed Forces in the Border Strip. These frameworks are described in Chart 2.

The Federal Constitution establishes the strategic significance of the Border Strip and entrusts the Armed Forces with the mission of defending national territory, maintaining constitutional order, and preserving law and order—an institutional role that has remained consistent since the 1891 Republican Constitution. The PND provides the strategic framework for safeguarding national interests, particularly through priorities such as border surveillance, environmental protection, and the sustainable development of the Amazon region. Operationalizing these objectives, the Integrated Border Protection Program, most notably through Operation Ágata ¹, mobilizes the Armed Forces in coordinated actions with public security agencies to confront transnational and environmental crimes. Conducted episodically at key land and riverine entry points, Operation Ágata involves Navy, Army, and Air Force units engaging in surveillance and inspection activities aimed at curbing drug trafficking, smuggling, illegal mining, deforestation, and other illicit practices. These operations are marked by their high visibility and

¹ Appendix A

Chart 2 — Normative frameworks for military action in the Border Strip.

Document	Summary
Federal Constitution	Establishes the strategic importance of the Border Strip and the role of the Armed Forces in the defense of national territory
National Defense Program	Document guiding the planning of actions for national defense, coordinated by the Ministry of Defense
Integrated Border Protection Prog.	Through Operation Ágata, it promotes cooperation between different government agencies to control borders and combat transnational illegal activities
Complementary Law 97/1999	Assigns the Armed Forces to act on the Border Strip against cross-border and environmental crimes

Source: Figueredo (2017).

symbolic strength, reinforcing state presence and asserting territorial control in remote border regions.

The regulatory framework established by Complementary Law No. 97/1999, and later expanded by Complementary Law No. 136/2010, grants the Brazilian Armed Forces a formal mandate to act in support of national development and civil defense, as well as to carry out preventive and repressive actions against cross-border and environmental crimes within the Border Strip, maritime zones, and inland waters. These actions, which can be conducted independently or in coordination with other executive agencies, include patrols, searches of persons and vehicles, and arrests in flagrante delicto, thereby conferring explicit police powers to the Armed Forces under the scope of Guarantee of Law and Order (GLO) operations. This expanded role constitutes a seventh legitimate field of public security engagement, as highlighted by Figueredo (2017), beyond the six constitutionally recognized functions. Ordinance No. 061/2005 of the Brazilian Army defines cross-border crimes broadly, encompassing illegal entry of weapons and drugs, smuggling, environmental crimes, trafficking of flora and fauna, epidemiological violations, and actions detrimental to biodiversity.

As demonstrated in the works of Fagundes (2019) and Figueredo (2017) the police power of the Armed Forces on the Border Strip differs significantly from other GLO operations. Fagundes' observations reveal a notable distinction between the Brazilian Army's operational autonomy and that of GLO operations. The Brazilian army operates with a high degree of autonomy, allowing it to act proactively and repressively against cross-border crimes on the Border Strip without explicit presidential authorization. This autonomy is in contrast to the GLO operations, which require presidential authorization in scenarios where conventional security forces prove inadequate. In a similar vein, Figueredo emphasizes that in the border strip, the Armed Forces wield continuous and explicit police power, allowing patrols and searches to be conducted in a more comprehensive and less restricted manner compared to the episodic and limited nature of GLO operations, which are aimed at temporarily restoring public order in specific areas. This distinction underscores the role of the Armed Forces as a constant and proactive presence along the border, as opposed to a reactive force that is only mobilized in emergency situations.²

² Indeed, the military possesses the capacity to organize operations to combat these crimes along the Border Strip. Recent examples include Operation Ágata and the VIGIA Program, now known as Guardians of the Border. As stated by Figueredo (2017), Operation Ágata is regarded as a significant milestone in the development of public security within the region.

5.3 Definition Of Treatment And Control Groups

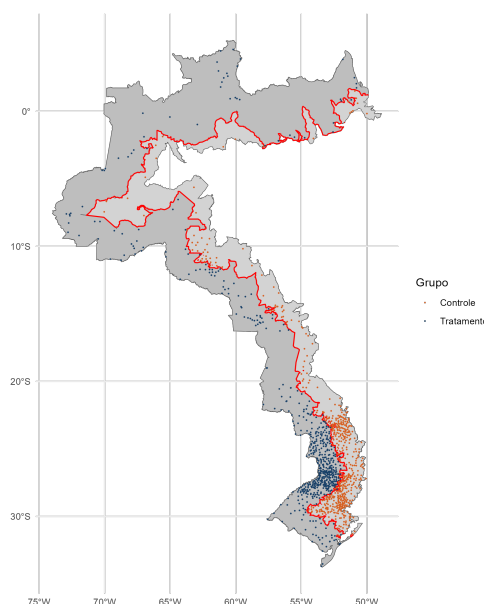
The primary definition of the treatment group considers municipalities with any part of their territory located within the 150 km Border Strip, while the control group is made up of municipalities immediately outside this limit up to 300 km from the border. The details of each group are described in Table 2 and are represented on the map in Figure 4.

Table 2 — Municipalities in the sample by group

Grupo	Northern Arc	Central Arc	Southern Arc	TOTAL
Treatment	69 (75.8%)	101 (54.0%)	418 (48.9%)	588 (51.9%)
Control	22 (24.2%)	86 (46.0%)	436 (51.1%)	544 (48.1%)

Source: Prepared by the author (2024).

Figure 4 — Map of municipal seats and its positions relatively to cutoff.



Source: Prepared by the author (2024).

In this study, the delineation between the treatment and control groups is designated as the cut-off. This element plays a pivotal role in the interpretation of results for two primary reasons. Firstly, the discontinuous regression model, as described in Section 4.1, requires a continuous variable with a clearly defined cutoff point. In this case, the cutoff point corresponds to the distance between the municipal seat and the cut-off. Secondly, the points located on the cutoff have a distance equal to zero in the analysis. The municipalities belonging to the control group, located to the right of the cutoff, have negative distances that decrease as they move away from this dividing line, while the municipalities in the treatment group, located to the left, have positive distances that become progressively greater.

5.4 Database

The main outcome variable is the municipal-level homicide rate per 100,000 inhabitants between 2010 and 2019, obtained from the Atlas of Violence (IPEA, 2023a), which compiles

data from the Mortality Information System (SIM) of Brazil’s Ministry of Health, based on ICD codes. Population estimates from IBGE are used to calculate rates using victims’ place of residence. To control for confounding factors, we include municipal socioeconomic covariates from IPEAdata (IPEA, 2023b), such as income per capita, income inequality, unemployment, and educational attainment. Table 3 provides descriptive statistics for the main variables.

Table 3 — Descriptive statistics for socio-economic variables.

Variable	Control		Treatment	
	Mean	Min–Max	Mean	Min–Max
Illiteracy rate	9.17 (5.26)	[1.1, 39.4]	10.48 (6.41)	[1.4, 40.2]
Unemployment rate (16y)	4.08 (2.66)	[0.1, 19.08]	4.13 (2.96)	[0.16, 27.76]
Gini index	0.48 (0.07)	[0.319, 0.7761]	0.51 (0.08)	[0.3278, 0.778]
GDP per capita	16925.12 (13508.80)	[3742.82, 220358.29]	15887.95 (10266.24)	[3129.35, 150363.03]
Pop. w/ income < $\frac{1}{4}$ min. wage	11.55 (11.41)	[0.33, 72.53]	16.26 (14.96)	[0.07, 77.91]
Child labor rate	17.19 (10.61)	[1.16, 62.29]	17.67 (10.88)	[2.55, 72.09]
Rate of young men	12.57 (1.46)	[8.7, 26.72]	12.50 (1.48)	[7.88, 18.12]

Source: IPEAData (2024).

5.5 The Spatial RDD Model

Estimation of the causal effect in the context of Spatial Regression Discontinuity Design (RDD) follows the traditional formulation of the RDD model, adapted to the two-dimensional nature of the geographical cut-off point. The model can be represented as follows:

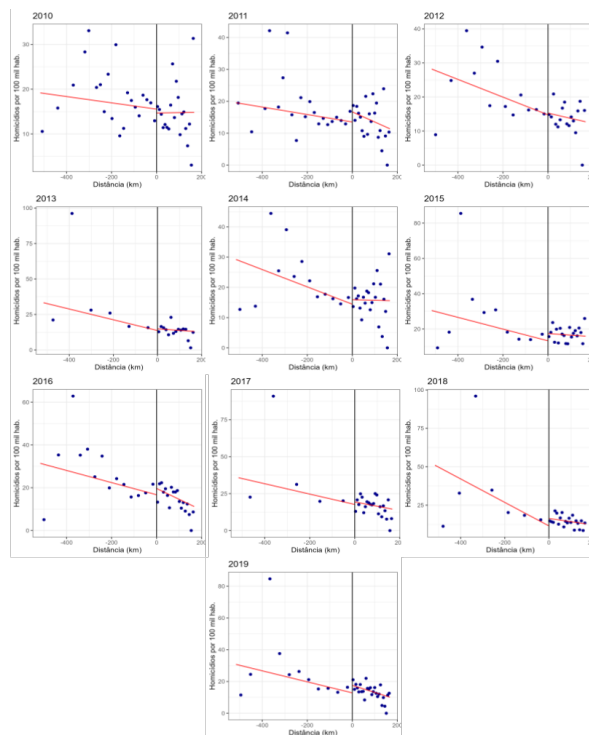
$$Y = \alpha + \tau D + \beta X + Z'\gamma + \varepsilon \quad (2)$$

where Y is the homicide rate variable, D is the variable of the treatment indicator, taking the value 1 for municipalities located within the Border Strip and 0 for the others, and X represents the municipality’s distance from the cut-off, or inner border, which acts as the cut-off variable of the model. The cutoff point is set at 0, thereby establishing a dichotomy between municipalities with positive values of X , which are designated as the treatment group, and those with negative values of X , which are classified as the control group. The symbol Z denotes other covariates, while the symbol ε represents the error term. Identification of the causal effect depends on the hypothesis that, in the absence of treatment, the function $\beta X + Z'\gamma$ would be continuous at the cut-off point, thus ensuring that observed discontinuities are attributable to the presence of treatment.

This study utilizes the `rdrobust` package to estimate the model. This package, which was described in Calonico, Cattaneo D. e Titiunik (2015), implements advanced methods for RD analysis. These methods include optimized estimators for bandwidth choices and flexible trend function specifications. The package facilitates the calculation of robust estimates for various core and bandwidth options. In addition, it provides tools for assessing the validity of the RD design, including balancing tests and cutoff manipulation. The implementation of robustness ensures greater precision in the estimation of local treatment effects, thereby minimizing potential biases arising from the arbitrary choice of model parameters.

We proceed to analyze the spatial RD applied to classification 1. As illustrated in Figure 5, the number of homicides per 100,000 inhabitants exhibits variation according to proximity to the border.

Figure 5 — Homicides per 100,000 inhabitants x distance to cutoff, per year.



Source: Prepared by the author (2024).

In all the years analyzed, there is a downward trend in homicides as the distance from the international border increases. Visually, there is a difference in the intercepts at the cut-off point, indicating that the treatment effect can be positive or negative, depending on the year considered.

Table 4 shows the estimates of the regression discontinuity model. Statistically significant results were observed in 2010 and 2019, indicating a decrease of 8.4 and 9.8 deaths per 100,000 inhabitants in the treatment group, respectively. On the other hand, in 2017, the treatment group showed an increase of 11.1 deaths per 100,000 inhabitants. Consequently, when evaluating the Border Strip in its entirety during the specified period, the impact of regional affiliation remains ambiguous.

In light of the pronounced heterogeneity characteristic of border regions, it was determined that the estimations of the discontinuous regression be conducted for each arc of the border in isolation, with the objective of facilitating a more nuanced interpretation of the effects manifesting within the Border Strip. The results are displayed in Table 5

With the exception of years 2011 and 2017, distance from the cut-off demonstrated statistically significant estimators in all years within the Northern Arc of the border. The observed results, ranging from a 19 to a 53 decrease in mortality rates per 100,000 individuals within the treatment group, suggest a correlation between the municipalities belonging to the Border Strip and a decline in violence within the region.

In the Central Arc, the distance to the border was statistically significant only in 2013 and from 2016 to 2018. In 2013, there was a reduction of 16.3 deaths per 100,000 inhabitants;

Table 4 — RDD model: homicides throughout the Border Strip.

	year 2010	year 2011	year 2012	year 2013	year 2014
distance to cutoff	-8.401*	1.783	-0.495	2.690	0.010
	(3.956)	(3.882)	(3.061)	(3.669)	(3.668)
	year 2015	year 2016	year 2017	year 2018	year 2019
distance to cutoff	0.292	2.228	11.084*	-0.445	-9.809*
	(4.406)	(4.256)	(5.112)	(3.455)	(4.353)
N_obs_treated	417				
N_obs_control	424				

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Source: Prepared by the author (2024).

however, increases ranging from 13.9 to 32.8 were estimated in subsequent years. The alteration in the sign of the estimator, in conjunction with the absence of statistical significance in the subsequent years, underscores the necessity for a prudent interpretation of the findings. This is particularly salient when considering the intrinsic limitations inherent in the discontinuous regression methodology.

In the Southern Arc, no statistically significant estimators were identified at the 5% level of significance ($p < 0.05$). In 2017, a statistically significant outcome was observed at the 10% level, with an estimator of 12.5, indicating an increase in the number of deaths in the treatment group. As with the Central Arc, the interpretation of these results should be approached with caution. In both Arco Central and Arco Sul, regressions were performed with modified optimal bandwidth selection, and all estimators were not significant.

In the case of the Northern Arc, one possible interpretation for the reduction in homicides along the Border Strip is the presence of a robust surveillance apparatus in the region. This interpretation can be rationalized in two ways, which are not necessarily mutually exclusive: i) the existence of a "buffer" effect exerted by the armed forces on the border, which has an impact on transnational crime; or ii) the effect of displacing violent crime practices to the interior of the country, particularly to municipalities located along drug trafficking routes.

In contrast, within the Central Arc, the observed outcomes indicate a contrasting effect, suggesting that the border region exhibits elevated levels of violence compared to the municipalities comprising the control group. One potential explanation for this phenomenon is the proximity to the state of São Paulo, which, according to the classification criteria, included some municipalities in the control condition. São Paulo's security apparatus is widely recognized for its well-organized structure and its integration with the neighboring states of Mato Grosso and Mato Grosso do Sul. This integration may have strengthened the capacity of these municipalities to curb violent actions, making them relatively safer than the border areas.

In the Southern Arc, the absence of significant estimators can be attributed to the almost total incorporation of the region's states into the Border Strip, resulting in greater homogeneity between the treatment and control groups in terms of combating violent crime.

It is important to note that the findings presented in this study are preliminary and require further study to fully understand their implications. Subsequent studies could investigate alternative specifications of the model and integrate novel data sources to enhance the robustness of the results.

Table 5 — RDD model: effect of the border on homicides by arc.

NORTHERN ARC					
	year 2010	year 2011	year 2012	year 2013	year 2014
distance to cutoff	-22.910+ (12.400)	-10.000 (8.847)	-23.103** (8.223)	-30.228* (13.927)	-39.801*** (10.569)
	year 2015	year 2016	year 2017	year 2018	year 2019
distance to cutoff	-19.071* (8.190)	-45.928** (14.205)	-11.731 (13.678)	-53.409*** (11.517)	-32.803*** (7.660)
N_obs_treated	56				
N_obs_control	21				
CENTRAL ARC					
	year 2010	year 2011	year 2012	year 2013	year 2014
distance to cutoff	13.208 (14.451)	13.788 (13.730)	15.098 (10.403)	-16.383* (7.260)	1.836 (9.087)
	year 2015	year 2016	year 2017	year 2018	year 2019
distance to cutoff	6.534 (14.713)	32.823* (12.837)	18.567** (7.073)	13.973** (5.395)	4.860 (16.645)
N_obs_treated	65				
N_obs_control	58				
SOUTHERN ARC					
	year 2010	year 2011	year 2012	year 2013	year 2014
distance to cutoff	-5.326 (3.599)	0.746 (4.244)	1.427 (3.962)	4.971 (4.388)	1.733 (4.558)
	year 2015	year 2016	year 2017	year 2018	year 2019
distance to cutoff	1.487 (5.318)	1.280 (4.007)	12.553+ (6.470)	0.614 (4.141)	-3.744 (4.635)
N_obs_treated	296				
N_obs_control	336				

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Source: Prepared by the author (2024).

6 FINAL REMARKS

The objective of this study was to analyze the relationship between the actions of the Armed Forces in the Brazilian Border Strip and violence, with a focus on the rates of homicide in municipalities within and outside this territorial delimitation. To achieve this objective, a data consolidation approach was employed, which included all recorded homicides from 2010 to 2019. A RDD was used to investigate the variation in the homicide rate per 100,000 inhabitants in the various regions of the Border Strip, with the objective of identifying any potential discontinuities generated by this territorial classification. The study findings indicated that within the Northern Arc, the incorporation of municipalities within the Border Strip is associated with a decrease in the rate of homicide. This observation may be attributed to the increased presence of inspection and surveillance activities in the region. Conversely, in the Central Arc, we iden-

tified a contrasting effect, with the border strip exhibiting significantly higher homicide rates compared to the municipalities within the control group. In the Southern Arc, no statistically significant effects were identified, which may be attributable to the higher degree of homogeneity among the region's municipalities. This reduced the model's ability to discern substantial variations in violence.

Although the present study concentrated on the effects on violence, it is imperative to acknowledge that military action in the region has broader strategic objectives, such as protecting national sovereignty and fostering territorial integration (Brasil, 2020). In our analysis, the repercussions of increased surveillance and the presence of the state on the local economy, infrastructure, and security of border populations were not addressed. Consequently, the results presented should be interpreted within the specified scope, without asserting a comprehensive coverage of the intricacies inherent to border policies. There is an urgent need to expand the research on the Brazilian border in other dimensions, such as socioeconomic development, international trade, and transnational security cooperation. Furthermore, the findings of this study can be refined by improving the econometric model used. Such refinements may include the incorporation of additional variables, more extensive robustness tests, and the application of more sophisticated spatial inference techniques.

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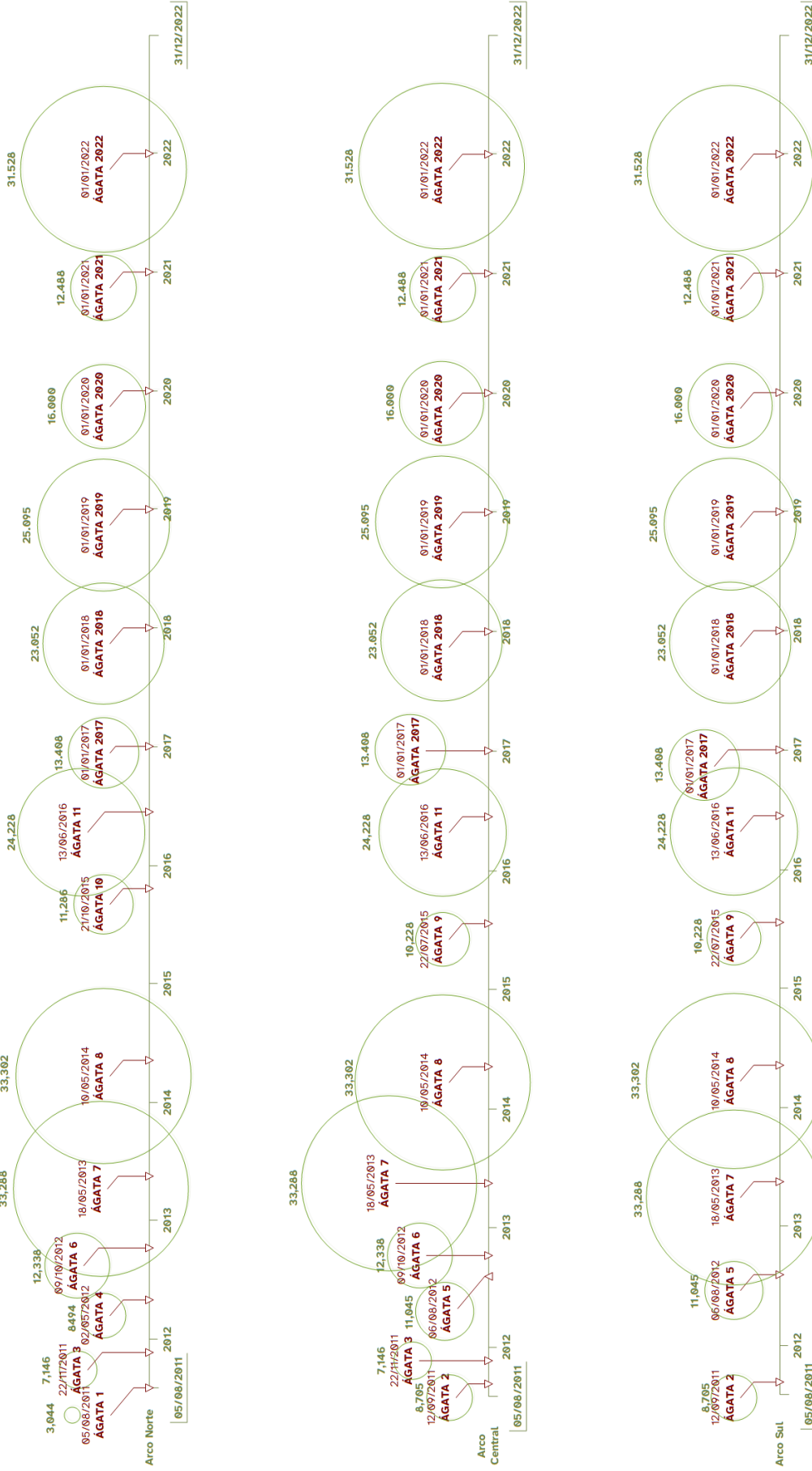
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APPENDIX A - OPERATION ÁGATA TIMELINE

Figure 7 – Timeline of Operations Ágata and their respective personnel, by arc



Source: Prepared by the author (2024).