Territorial Criminal Enterprises: Evidence from Rio de Janeiro*

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Abstract

Some criminal groups are able to avoid confrontation and diversify their economic activities while others are constantly contested by rival groups and the state. To understand why, we propose a model to investigate criminal groups' incentives to invest in military capacity and the state's response to arming. Typically it is difficult to map criminal groups' presence and document their economic activities. We build a novel panel dataset to map presence and characterize the economic activities of criminal groups in Rio de Janeiro, where drug factions and militia groups have controlled territories for at least three decades. We provide evidence that both groups are multi-product enterprises that explore a wide range of licit and illicit goods and services. We empirically test the predictions of our model. Our findings suggest that more groups in the territory increase conflict and state repression and reduce economic diversification. In addition, we argue that the ability to collaborate with the state is crucial for groups to exploit more markets. To the best of our knowledge, this is the first study that uses systematic data to show how criminal groups in Rio de Janeiro evolve over time and diversify their economic activities.

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1 Introduction

Many peripheral areas in urban cities are marked by the presence of criminal groups, which are considered one of the most significant urban and national security challenges of the 21st century (World Bank, 2011). These groups include drug factions, militias, vigilante groups, and prison and street gangs,[1] and have driven a substantial proportion of violence in several countries. The highest number of homicides and homicides rates are located in Latin America (UNODC, 2019; Yashar, 2018), where criminal conflict has ravaged several countries. Citizens in countries such as Brazil, Mexico, Colombia and El Salvador now live in areas in which criminal groups have established subnational criminal governance regimes and dictate the main parameters of social, economic, and political life (G. D. S. Feltran, 2012; Lessing, 2020a; Mantilla & Feldmann, 2021; Trejo & Ley, 2021). Their presence and disputes over territories negatively impact economic development by reducing human capital investment, earnings and labor mobility (Melnikov et al., 2018; Monteiro & Rocha, 2017; Sviatschi, 2021a, 2021b).

A recent body of literature has discussed how these groups emerge, expand, and govern populations (Blattman et al., 2018a; Lessing, 2020a; Magaloni et al., 2020; Trejo & Ley, 2021). Yet, we still lack knowledge about criminal groups' relationship with the state and their infiltration into legal activities. One challenge that persists in this scholarship is mapping criminal group's presence and how they finance themselves, including the economic activities they exploit. Given the illegal nature of their activities, we have little systematic evidence on other businesses run by criminal groups and the literature considers that criminal groups engage mainly in drug trafficking. However, as we show in this article, criminal groups often enter markets of licit goods and services to diversify their portfolios and increase profit margins. Their capacity to exploit news markets depends on whether their turf is challenged by the state and other groups. Conflict is costly and divert efforts from business activities, but is necessary when an enemy challenge their territorial control. Therefore, crucial questions regarding criminal groups are: Under what conditions are criminal groups able to diversify their economic activities? What are the incentives for criminal groups to engage in violence?

In this paper, we first conceptualize criminal groups as territorial firms — more specifically, territorial criminal enterprises (TCE), a definition coined by Arias (2006) to explain different types of criminal governance. In contrast to Arias, we instead focus on the economic aspects of criminal groups.

[1]Some scholars tend to define all these groups as Organized Criminal Organizations (Barnes, 2021) We prefer to refer to them as criminal groups since not all these groups have highly organized structures.

Territorial criminal enterprises are criminal groups that monopolize coercion over a given territory in order to establish local monopolies of illegal and legal goods and services. To establish the monopoly of coercion, these groups must stop threats and attacks from two opponents: (1) the state enforcement apparatus, especially the police, which retain *de jure* a monopoly of use of force and (2) other criminal groups who dispute territories with them. Therefore, criminal groups decide whether to fight these contesters while maximizing their profits from territorial control.

We build a model with two scenarios to illustrate the strategic interaction between criminal groups and the state. In the first scenario, there is only one criminal group and the state. The criminal group extracts rents from its local territory and decides whether to fight or bribe the police. The state balances the political return to its use of military force versus the bribe it collects to not repress criminal activities. There is a peace dividend that arises when there is no military confrontation because criminal groups are able to put resources into exploiting additional markets. Therefore, this game has two equilibria. One equilibrium has a high level of conflict and low economic diversification. There is also a peaceful equilibrium where the criminal group is able to bribe the government, avoid repression, and exploit the provision of other goods and services. Politically connected groups that are able to avoid losses from state repression end up in the second equilibrium. In addition, the model shows that the bribe needed to avoid state repression increases with the political return to the use of military force. In the second scenario, there are two criminal groups and the state. The incumbent criminal group chooses to invest in military capacity to protect its territory from the two enemies and conquer new territories to increase its profits. Therefore, we expect higher levels of conflict, which affect criminal groups' capacity to diversify economically.

To test this, we use a unique dataset to map and describe the geospatial distribution of territorial criminal enterprises in Rio de Janeiro as well as their economic activities. The data come from *Disque Denuncia* (Dial Report in English), a well-established crime tip line with more than 1.4 million reports related to criminal groups in Rio de Janeiro. We use Natural Language Processing techniques to classify transcribed text reports into group activities and use a strict rule to measure whether a neighborhood has the presence of a criminal group that militarily controls the territory and illegally explores different economic activities. We cross-check our data with official records to assess the accuracy of our estimates and supplement our empirical analysis.

We have three sets of results. First, we present the first measure of yearly

presence of criminal groups at the neighborhood level.[2] We find that on average, 41% of neighborhoods in the Rio de Janeiro metropolitan area have at least some of its area controlled by a criminal group from 2008 to 2019. According to the 2010 Census, these neighborhoods contain 72% of the population of the metropolitan area. We show that despite the state's effort to curb these groups in the past years, the number of neighborhoods with group presence has not varied much in the city of Rio de Janeiro, but we document an expansion in the outskirts of the city. Second, we identify that criminal groups participate in several economic activities and their portfolio of activities change over time. Third, we build a measure of criminal consolidation that indicates when militia groups and drug factions operate in geographical areas further away from other criminal groups. We explore variation over time in criminal consolidation, violence and business activities and show that criminal consolidation is associated with lower levels of violence and higher business diversification. We also document a different equilibrium according to group type. We show that when militia groups govern solely in a neighborhood, without the threat of a drug faction, homicide levels, shooting and police killings are lower, while economic diversification increases.

We contribute to a burgeoning literature that uses several methods and data sources to measure the presence of criminal groups.[3] Although our paper is not the first to explore the richness of Disque Denuncia[4], our study is the first one to apply cutting-edge techniques to the detailed Disque Denuncia dataset to systematically measure specific armed groups presence in Rio de Janeiro for 12 years. We contribute to seminal works that describe the presence and operation of criminal groups in Brazil (Cano & Ioot, 2008; Misse, 2011; Zaluar & Barcellos, 2013).[5] These studies have provided evidence on how these groups operate in Rio de Janeiro based on qualitative research, case studies, surveys, focus groups and ethnographic work. The present study advances this agenda by measuring different criminal groups and how their presence and economic diversification changes over time.

[2]The reports from *Disque-Denuncia* provide addresses as references to the reported events, which does not allow us to calculate the extension of the territory within neighborhoods controlled by groups.

[3]See Sobrino (2019) for the use of Google news, Dipoppa (2020) collects articles discussing typical mafia-related crimes from a national newspaper in Italy, Lonsky (2019) uses crime reports on the Russia mafia, and Bruhn (2021) exploit police intelligence data on Chicago's gangs.

[4]Cano and Duarte (2012) uses a sample of Disque Denuncia reports to measure the presence of militia groups from 2006 to 2011.

[5]Recently, a collaborative project of five organizations led by the group GENI-UFF created a map of armed groups in Rio de Janeiro. The map can be accessed through the website: https://nev.prp.usp.br/mapa-dos-grupos-armados-do-rio-de-janeiro/.

Additionally, our paper expands our understanding about criminal groups' relationship with the state and other criminal groups and how it impacts their ability to diversify economically. Armed groups often have relations with at least some state officials and varying combinations of these relationships determine greater confrontation or even cooperation with the state (Arias, 2006). Lessing (2020b) conceptualizes the symbiotic relationship between criminal groups and the state, which is also known as *mercadorias politicas* or political goods (Misse, 2006, 2010), the hybrid state (Jaffe, 2013), the gray zone of criminality (Trejo & Ley, 2021), state sponsored protection rackets (Snyder & Duran-Martinez, 2009), and the complicit state (Yashar, 2018). In this paper, we detail the incentives criminal groups face to engage in negotiations and bribe state agents, thus not only avoiding repression but also allowing them to exploit additional markets. Our paper is closely related to Castillo and Kronick (2020) in examining the effects of state repression on criminal groups' interactions. However, to the best of our knowledge, previous work does not explicitly examine the impacts of state repression and turf wars on the economic diversification of criminal groups.

Our framework also allows us to highlight a key distinction between territorial criminal groups, which is their ability to collude with the state. This distinction makes highly connected groups less subject to police military repression, which enables an equilibrium with low levels of violence and higher economic diversification. Therefore, we explore the role of criminal groups as firms to understand the equilibrium in which they are able to expand their activities and connect our paper with the literature that analyzes the activities of criminal firms (Blattman et al., 2018b; Brown et al., 2021; Fiorentini & Peltzman, 1997; Gambetta, 1996; Gambetta & Reuter, 1997; Levitt & Venkatesh, 2000). This suggests that governments should fight organized crime not only militarily but also economically. Poor results associated with government crackdowns suggest that the "war" against criminal groups requires new strategies and a better understanding on how these groups rule their territories, their sources of revenue, networks and motives to engage in turf wars.

2 Overview of Territorial Criminal Enterprises in Rio de Janeiro

Rio de Janeiro is a city with 6.7 million people, where 20% of the population lives in very densely populated informal settlements known as *favelas*.[6]

[6]According to the 2010 Census (Brazilian Institute of Geography and Statistics).

These are not stateless areas. In the past 30 years, police raids and state programs have been frequent in order to improve urban conditions.[7] Over the years, the state has invested in street lighting, pavement, asphalt, sewers, and cash-transfer programs to poor families. However, it has not been able to maintain a monopoly over the use of force. This has contributed to create a complex environment where social and urban conflict co-exist with high levels of violent crime. The most important attempt to provide public security in *favelas* was the Pacifying Police Units (UPPs) which were launched in 2008 with the aim of reducing gunfights between drug gangs and to boost the urban integration of the *favelas*. Though highly successful in the first five years, the UPP policy did not sustain its results following that (Ferraz et al., 2021).

Most of the people living in *favelas* experience violence on a daily basis. They are exposed to turf wars and to highly militarized police raids. While criminal groups fight for territorial control to exploit illegal markets (Arias & Barnes, 2017; Zaluar & Conceição, 2007), the state fights against these groups to seize guns and illegal goods as well as arrest gang leaders. The actions that these groups undertake generate high economic, social and political costs, from regular shootings (Cavalcanti, 2008) to disrupting school routines (Monteiro & Rocha, 2017). Broadly, there are two types of criminal groups in Rio: drug factions and militias — paramilitary groups usually formed by current and former police officers. Below we discuss these groups, how they emerged and rose, their relationship with the state, and their main economic activities.

2.1 Drug Factions

The first prison-based gang in Brazil was born in Rio de Janeiro. Scholars link the emergence of *Comando Vermelho* (CV) to the dictatorship's attempt to repress armed political opposition (Amorim, 1993; Lima, 2001; Misse, 2006).[8] According to Penglase (2008), the CV emerged in the 1970s in a prison where members of armed political groups and regular prisoners were housed in the same unit. The group of prisoners gathered together and organized

[7]The Popular Settlements Urbanization Program of Rio de Janeiro, popular known as *Favela Bairro* was implemented in 1993 by the city hall of Rio de Janeiro. In 2007, *favelas* received investments from the Growth Acceleration Program (PAC), a federal government program. In 2010, the *Favela Bairro* became *Morar Carioca*, a rebranding of the program. Additionally, the government invests in several cash transfer programs that target low-income residents of *favelas* such as *Cheque Cidadão*, *Renda Melhor*, and *Familia Carioca*.

[8]The CV was born as *Falange Vermelha* when political prisoners and common prisoners were sharing prison cells. Inspired by guerrillas and other left wing groups, political prisoners organized a movement within the prison (Silva, 2014).

a movement against state repression and for better living conditions within the prison system (Amorim, 1993). However, violence was always present and was often used among them to establish order (Lima, 2001). The CV's authority was not restricted to the prison. The order established by the faction as well as the group's foundational ideas expanded beyond the prison walls to Rio's *favelas* (Penglase, 2008). Prisoners went back to their homes in *favelas* with the message to organize a "fighting front" to protect people in *favelas* (Amorim, 1993). The faction quickly complemented the state and also started governing these areas. For instance, rules prohibiting rival organizations and establishing order, such as banning theft and rape, were implemented in several places around the city of Rio de Janeiro.

The rise of the CV and the high profitability of the cocaine trade led to increasing disputes among gang members. As a result, some members left *Comando Vermelho* and created *Terceiro Comando* (TC), in the late 1980s (Misse, 1999). In the early 1990s, *Amigos dos Amigos* (ADA) emerged in alliance with TC to contest CV's power. In 2001, the *Terceiro Comando* became *Terceiro Comando Puro* (TCP) when its leader was assassinated in one of the biggest *favelas* in Rio, Complexo da Maré (Silva, 2014). Historically, these gangs have disputed territories around the city to monopolize drug sales.[9] In addition, they impose restrictions on residents' rights to entry and exit *favelas* partly as a response to these conflicts. Residents of a *favela* controlled by a drug faction cannot enter a *favela* dominated by a rival gang for any business or personal reason (Zaluar, 2012). The conflict between these groups generates much of the crossfire and gun violence that mark the city of Rio de Janeiro (Monteiro & Rocha, 2017).

The conflict is not only between members of drug factions. Clashes with the police and state forces are also very common. These disputes often resemble civil conflict as military capabilities of drug factions increase (Lessing, 2008). The police in Brazil is also highly militarized, and repressive crackdowns on drug factions often produce escalation (Lessing, 2015). Additionally, drug factions differ in how they interact and deal with the state. They use different strategies to avoid state repression, such as bribing state forces to evade enforcement or building alliances with the state (Barnes, 2017). In the case of Rio de Janeiro, for instance, the faction ADA follows a strategy of integration while the CV engages in confrontation (Magaloni et al., 2020). These distinct strategies also affect the results of police interventions, which can often backfire (Magaloni et al., 2020).

The contentious relations with security forces affect *favelas'* security systems. Without the state to provide security, order and access to justice, and,

[9]For more on turf wars, see: Dowdney (2003) and Gay (2015).

in addition, with state officials often generating more insecurity, residents had to create their own security forces and find ways to resolve conflicts among residents. Since the 1980s, this role has been captured by drug factions that have been "managing neighborly disagreements and suppress conflict" (Arias & Barnes, 2017). Therefore, the drug gangs assume several functions, from policing and law enforcement to resolving disputes and enforcing contracts (G. Feltran, 2018; Lessing, 2020a).

Additionally, they often regulate illicit and licit markets. Notwithstanding the fact that drug factions started operating the illegal drug markets, they have expanded their operations. There is anecdotal evidence that they engage in several legal and illegal activities, such as loansharking to taxing legal goods such as gas, transportation, and electricity.[10] Yet we do not know how and when they are able to enter new businesses and expand their activities.

2.2 Militias

While drug factions were fractionalizing and fighting against each other and the state, another type of group emerged in Rio: militias. These groups are often formed by members of the military police and other public security agents that use extra-legal methods to combat organized crime and drug trafficking.

The term militias has also been broadly used to name any corrupt or violent police officer, leading to a very broad and imprecise definition of this type of criminal group (Santos, 2007). The first organizations of police officers specialized in killings were called *grupos de exterminio* (death squads) and go back to the period of military dictatorship in Brazil during the 1960s to the 1980s. Some scholars do link these groups to what we have came to know as militias (Souza, 2012). However, some *grupos de exterminio* are still in operation to this day. They are often hired by businessmen or politicians to execute competitors, political opponents, or other targets (Cano & Duarte, 2012).[11]

In this study we focus on militias that seek territorial control to extract rents from extortion or other economic activities.[12] These groups consolidate

[10] https://oglobo.globo.com/rio/trafico-milicia-sequestram-antenas-de-telefonia-em-105-comunidades-no-estado-do-rio-1-25222468

[11] Soares (2022) describes how militias work in Rio de Janeiro.

[12] Our definition of militias is similar to the one used by Cano and Duarte (2012). They characterize militias using a five-point definition: (1) territorial control; (2) coercion over residents in controlled territories; (3) individually rationally-motivated profit; (4) discourse based on protection and establishment or order; (5) participation of state agents within

their power by monopolizing violence mostly with the intention to expel drug traffickers from the community. As such, they use coercion to create protection rackets (Tilly, 1985). In *favelas* and poor neighborhoods, where people do not have access to the legal system, security agents become local authorities and enforce extralegal rules (Zaluar, 2012). Citizens have to pay taxes to militia groups for "security". However, people were often paying taxes to protect themselves from the same group that was charging them. According to a victimization survey by Zaluar and Conceição (2007), most people agree that military police use excessive force and are corrupt. Additionally, 25% of people interviewed admitted they had some form of private security. In that sense, militias resemble the Sicilian mafia that rose in a vacuum of power or of the inability of the state to ensure public order in a society that had turned away from state power to private means of protecting power and ensuring order (Catanzaro, 1992).

Militias are politically connected and have a symbiotic relationship with the state that has allowed them to expand.[13] This symbiotic relationship between criminals and state agents is called the "gray zone of criminality" by Trejo and Ley (2021). Instead of recognizing the state and crime as two separate entities, the gray zone of criminality is where members of public security institutions co-exist alongside criminal groups. In other words, police forces and state agents cooperate with organized crime and coordinate actions to serve them. Using Trejo and Ley (2021)'s definition, militias belong to the gray zone. The main consequence of this is that areas controlled by them are able to reduce state repression. Militias often enjoy impunity and their ties with city and state politicians have allowed them to foster and spread. One consequence of this is that conflict is lower in areas controlled by militias compared to areas controlled by drug factions because militias rarely engage in violent confrontation with the police (Arias, 2013).

Regarding their economic activities, militias operate several lines of business. Historically their main activity has been extortion and private security. However, their sources of income are not limited to violent illicit activities.

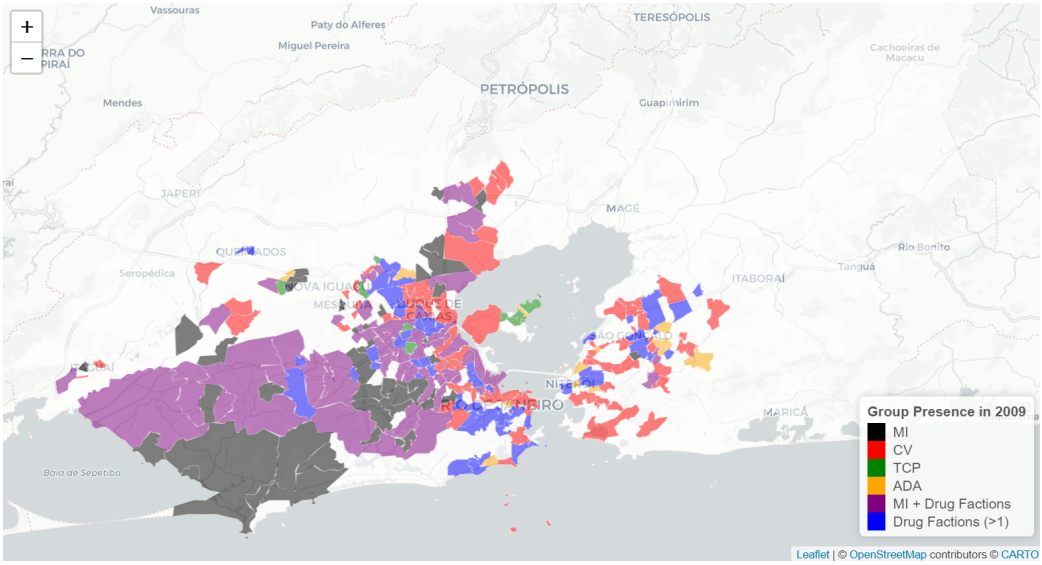
public security institutions.

[13]Using qualitative research techniques such as focus groups and interviews with locals, Mesquita (2008) reconstructs the violent formation process of the Rio das Pedras militia in the early 1990s, and shows how this had an impact on people's daily lives. The events are also described in a resident's report published by O Globo newspaper (https://oglobo.globo.com/epoca/rio/o-nascimento-da-milicia-em-rio-das-pedras-pela-visao-de-um-morador-23831103), in which the participation of public security agents is emphasized. More recently, in an ethnography carried out in the Batan *favela*, also in the West Zone of Rio de Janeiro, Mendonća (2014) describes how, in September 2007, a group of policemen, military men and firefighters "expelled" a drug trafficking faction from and established territorial control over the place.

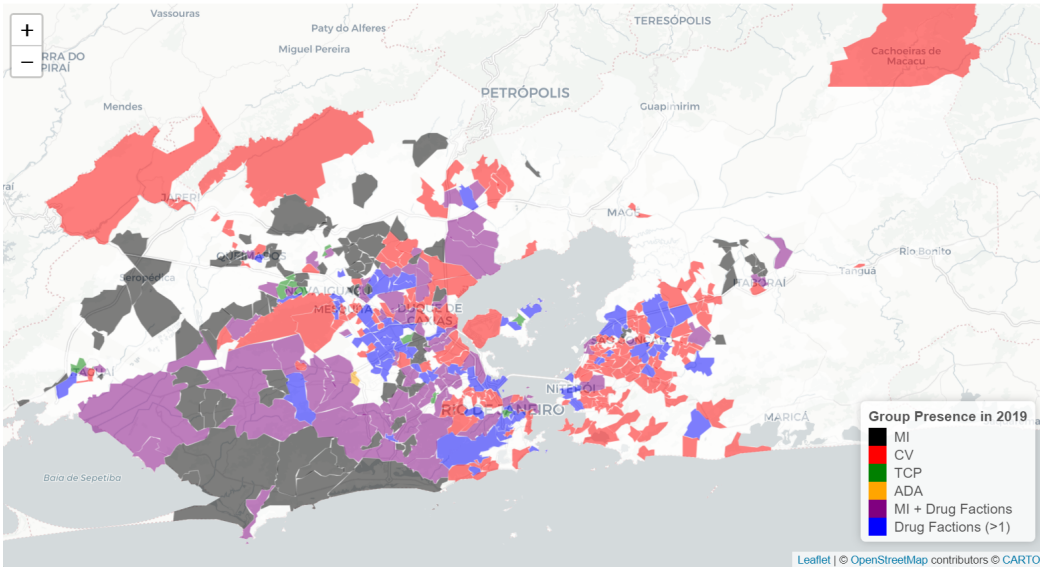
They often operate legal markets, such as cable TV, gas, and transportation. More recently, there are several reports that they have entered real estate investment.

In this paper, we study how these two types of criminal groups, that have such distinct origins are now operating in similar ways and exploiting licit and illicit economies. Figure 5 shows how both types of groups are spread out in the Metropolitan Region of Rio de Janeiro. The maps indicate the neighborhoods that had some presence of criminal groups in 2009 and 2019, respectively. Each color indicates a specific group or combination of groups in the territory. We can see that there was an expansion of areas occupied by criminal groups in Rio de Janeiro in the period. In the next section, we describe how we created this measure of group presence and the consequences for economic activities in these areas.

Figure 1: Presence of TCE at the neighborhood level in Rio's metropolitan area



(a) Presence of TCE at the neighborhood level in 2009



(b) Presence of TCE at the neighborhood level in 2019

Notes: This figure shows a map of the Metropolitan Region of Rio de Janeiro to illustrate the spatial variation of presence of territorial criminal groups using data from *Disque Denuncia*. Figure (a) shows the presence of groups at the neighborhood level in 2009. Figure (b) shows the presence of groups at the neighborhood level in 2019. In black, we have the presence of militia groups. In red, we have territories controlled by drug gang Comando Vermelho. Green refers to drug gang TCV and yellow drug gang ADA. In purple, we have territories with presence of at least one militia group and one drug faction. In blue, territories with more than one drug faction.

3 Mapping Territorial Criminal Enterprises

3.1 Definition of Territorial Criminal Enterprises

Criminal groups such as Brazil's drug factions and militia groups, Colombia's *combos*, *maras* from El Salvador, and Mexico's drug cartels share similar behaviors and dynamics. In contrast to rebel and insurgent groups, criminal groups do not seek to contest the political power of regional or national governments. Rather their primary motivation is to obtain economic rents. In our case, we are particularly interested in analyzing the economic operations and growth of the two types of criminal groups that control territories in Rio de Janeiro.

We propose a definition that embraces both types of groups and builds on the scholarship of political science and the economics of organized crime. Arias (2006) claims that Latin America and Caribbean criminal groups may have different compositions and structures, but many operate as territorial criminal groups, i.e., they seek to control and defend a particular territory as an operational base for illicit activities. The economics of organized crime literature emphasizes the importance of territorial control as a way to monopolize markets. According to Schelling (1971), the core business of the criminal organization is to acquire a rule-making role in a given area (geographical or economic) so as to levy taxes and impose regulations over legitimate and/or illicit business. Fiorentini and Peltzman (1997) define organized criminal groups as organizations competing and/or colluding with the government and among themselves to obtain a monopoly over coercion in a given territory.

3.2 Data on Criminal Groups

The main challenge in understanding armed group characteristics is to gather information on their activities and presence in the territory due to their illegal nature and violent practices. Many existing studies for different contexts use crime reports, police intelligence data (Bruhn, 2021), newspaper data (Daniele & Dipoppa, 2017; Trejo & Ley, 2017), and Google news (Sobrino, 2019). In the case of Brazil, previous works mostly focus on case studies of specific groups or lack systematic information on group activities.

Our paper circumvents these problems using information from *Disque-Denúncia* (DD), a hotline that receives anonymous reports from citizens regarding an array of criminal behavior in the state of Rio de Janeiro (Cano & Duarte, 2012). Running since 1995, the Non-Governmental Organization (NGO) has compiled a dataset of more than 2 million reports registered be-

tween 2002 and 2019. The calls received by the hotline are directly forwarded to civil and military police, which decide whether and how to respond to each report.

We were granted access to all 1.4 million reports for Rio de Janeiro's metropolitan area from 2008 to 2019.[14] This region embraces the city of Rio de Janeiro and 21 neighboring cities, where a total of 13.1 million people live. The DD dataset records the transcription of the reported event, its time, date and address. Even though there is a degree of uncertainty on the precision of reports individually, we argue that the combination of numerous reports represents a unique source of data in understanding criminal dynamics in the state.

Our goal is to use this set of reports to locate groups across time and space and understand their main practices of territorial control and choices of business streams. Therefore, we first filtered reports that explicitly mention armed groups (gang names or militia) or popular names of their members (e.g. drug dealers and militia members), keeping around 420,000 reports. In order to understand how these groups behave in the territory, we then automatically interpret the content of each report, propose a rigorous definition of group presence and validate our approach with data from other sources.

There are a few challenges to use Disque Denuncia data to map the presence of criminal groups. First, the reports are anonymous claims from citizens that have not been confirmed by any investigation. We argue that although a single report might not provide enough evidence to indicate the presence of a criminal group, several similar reports are a good indication of criminal group presence. In section 3.5, we explain how we aggregate reports. Second, we aim to identify different criminal groups that exert control over a territory. For instance, we are not interested in reports that refer only to the drug trade, that give the location of a criminal boss who is a fugitive, or that mention locations where militia men use to hang out. Therefore, we propose a rigorous definition of group presence based on territorial control *and* the exploitation of economic activities and automatically interpret the content of each report to filter reports that indicate the presence of a Territorial Criminal Enterprise. The last challenge is that Disque Denuncia data originate from people requesting help. As a consequence, if criminal groups go quiet and do not harm people despite still controlling the territory, people might be less likely to denounce them. To deal with this issue, we use a

[14]When studying only militia groups, Cano and Duarte (2012) analyze in total 41,542 reports. The mentions to militias are sporadic prior to 2008. The years of 2006 and 2007 count for only 12% of all the reports analyzed by the authors. Therefore, we opted to begin our analysis in 2008 since this was the year which the mentions to militias were more consolidated as described in the previous section.

more strict definition to identify the presence of a group for the first time. Then, we lower the bar and request fewer reports to indicate that the group is still operating in the area. We validate this approach combining our data with qualitative research that maps criminal groups in 950 *favelas* and official records for years which data are available.

3.3 Other Sources of Data

We cross-check our measure of group presence based on Disque-Denuncia data with three sources of information. We obtained access to two pieces of information from government authorities that provide information for specific years. The State Attorney's Office of Rio de Janeiro (MPRJ in Portuguese) gathers information on group presence from local police officers that support the work of prosecutors responsible for investigating members of these organizations. The information is organized at the locality level, which can be either a *favela*, a housing project or other poor territory. We were granted access to data at the neighborhood level for 2019. In addition, we gathered data from the Institute of Public Security of Rio de Janeiro (ISP), a state government body responsible for disclose crime records in Rio de Janeiro. ISP compiled a unique map depicting the areas of the state that were subject to illegal territorial control based on police sources in 2016.

These data is complemented by records of field work from Alba Zaluar, a prominent anthropologist from Rio de Janeiro (Zaluar, 2012; Zaluar & Barcellos, 2013). Zaluar carried out field work in more than 950 *favelas* of the city of Rio in 2009, 2010 and 2013. As we previously mentioned, criminal groups are not restricted to *favelas*, which means these data do not cover the universe of groups in these years. Still, *favelas* are arguably the most common type of territory that is run by militias and drug gangs of Rio, so these data depict the most relevant picture of TCE presence in the city. These data help us evaluate the quality of our measure of group presence in the territory and allow us to test the consequences of criminal consolidation on group economic decisions.

Finally, we gather police records on homicide and police killings provided by the Institute of Public Security (ISP) and a measure of shootings based on reports to *Fogo Cruzado*, an NGO created in 2016 to collect citizen reports on gun violence in Rio de Janeiro through an app and social media. These data allow us to understand how patterns of violence correlate with group presence and consolidation in the territory.

3.4 Content classification

Our goals with the DD data are two-fold. First, we want to create a measure of TCE presence in the territory. We take two dimensions into consideration: military territorial control and exploitation of economic activities. After identifying groups in the territory, we move to our second goal, which is to build a profile of economic activities of criminal groups. We thus employ a rule-based classification method to automatically classify citizen reports that describe these activities. In order to make the processes more clear and precise when classifying reports, we propose definitions for the practices that characterize each dimension.

Our definition of *Territorial Control* captures the overt actions to protect the territory, i.e. practices of armed circulation (when group members ostensibly bear firearms to maintain control of the territory), roadblocks and surveillance (means of restraining access to the territory). This is shown in Table 1. On Table 2, we show how we measure *Exploitation of Economic Activities*, which may involve extortion (direct payments for protection rackets), illicit goods and services (such as drug trade and gambling) and also licit goods and services (TV and internet, cooking gas and electricity).[15]

Table 1: Definition of practices of Territorial Control

Practice	**Definition**
Armed circulation	Illegally and ostensibly bearing firearms in order to maintain the illegal control of the territory
Roadblocks	Attempts to impede or impose difficulties of access to rivals in the territory – other armed groups or state forces
Surveillance	Surveillance mechanisms aiming at informing the proximity of a rival or other type of threats to the controlled territory

[15]We describe specific cases of two activities, transportation and water distribution, in the appendix D.

Table 2: Definition of practices of Exploitation of Economic Activities

Practice	**Definition**
Extortion	"Fee-for-services" in which the groups demand direct payments for protection rackets
Illegal goods and services	Selling illegal products or services such as drug trade, gambling and loan sharking
Legal goods and services	Illegal provision of services to households (TV and internet, cooking gas, water and electricity), transportation, exploitation of lands and properties

In order to classify the reports into these dimensions, we manually studied random samples of the data and defined rules to automatically interpret hundreds of thousands of reports using regular expressions. Since *Disque-Denuncia*'s transcriptions are standardized, this method has an overall good performance, is less costly to implement and more straightforward to interpret compared to other NLP techniques. [16]

To evaluate our classification method, we manually classified a random sample of 3,000 observations into the practices of territorial control and economic activities to test the performance of our algorithm. Table 3 details the overall performance of our methods. It shows the accuracy, precision, recall, and F1-Score of each indicator of territorial control and economic activities (Appendix B describes each of these measures). In sum, the results indicate that our algorithm performs well, indicating that we rarely identify a dimension incorrectly.

[16] See Appendix A for examples of reports and classification.

Table 3: Measures of algorithm performance

Dimension	Practice	Measures of algorithm performance				Prevalence
		Accuracy	Precision	Recall	F1-Score	
Territorial Control	Armed Circulation	0.939	0.942	0.941	0.941	52%
	Roadblocks	0.961	0.893	0.665	0.762	10%
	Surveillance	0.986	0.900	0.791	0.842	5%
Economic Activities	Extortion	0.973	0.737	0.737	0.737	5%
	TV and Internet	0.998	0.947	0.947	0.947	2%
	Drug trade	0.897	0.974	0.813	0.886	51%
	Transportation	0.994	0.750	0.600	0.667	1%
	Gas*	-	0.920	-	-	<1%
	Loan Sharking*	-	0.860	-	-	<1%
	Water*	-	0.780	-	-	<1%
	Properties and Land*	-	0.780	-	-	<1%
	Electricity*	-	0.760	-	-	<1%
	Gambling*	-	0.640	-	-	<1%

Notes: This table reports measures of algorithm performance for each of the dimensions used to map group presence. Column 3 depicts results for Accuracy (total share of true positives and true negatives in the samples). Column 4 depicts results for Precision (share of positives that are true). Column 5 depicts results for Recall (share of relevant cases that are true positives). Column 6 depicts results for F1-Score (harmonic mean between Precision and Recall). Column 7 depicts the prevalence of each practice in the sample. Appendix B details the exact definition of each measure. *For practices that are rare in the sample (less than 1 %), we randomly re-sampled 100 positive cases to evaluate our rate of predictive power (Precision).

3.5 Territorial Presence

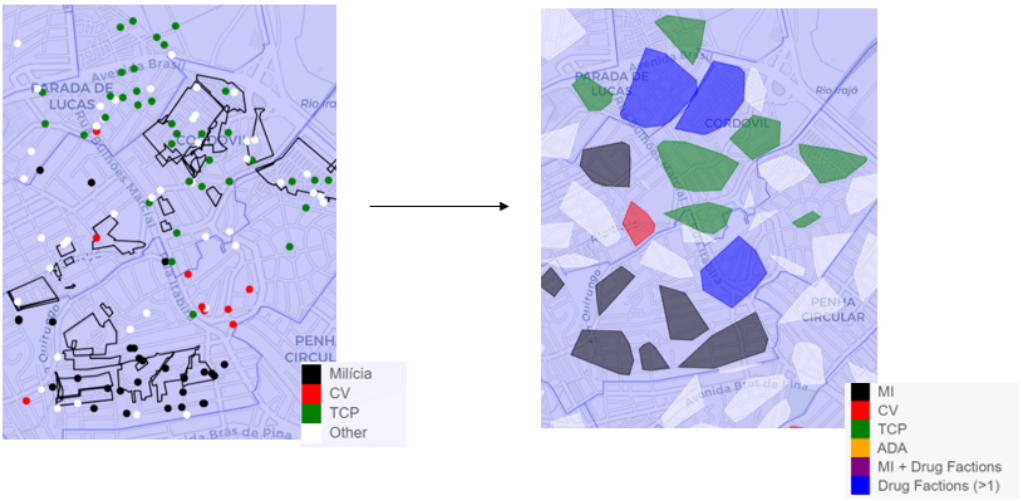
The results from the previous section make us confident that we are able to interpret the content of the reports to Disque Denuncia reasonably well. We then move to the task of using information on the content of each report to build a panel of Territorial Criminal Enterprises in Rio de Janeiro between 2008 and 2019.

When studying the territorial dynamics of Rio de Janeiro's TCE, most studies focus on *favelas* as the main unit of analysis. However, drug factions and especially militias also control territories outside the boundaries of the slums and inside formal areas of poor neighborhoods. Therefore, we avoid using regular *favela* limits when mapping these groups and take advantage of information on the addresses of the calls to Disque Denuncia to geo-reference their exact location. With the coordinates of each report, we group them in order to identify those that refer to the same territory. We apply a hierarchical clustering algorithm, which aggregates points that are close by 300 meters.[17] Figure 2 exemplifies how groups of reports are clustered depending

[17]Intuitively, the method consists of the repeated process of collecting observations that

on their spatial distribution.

Figure 2: Example of clustering

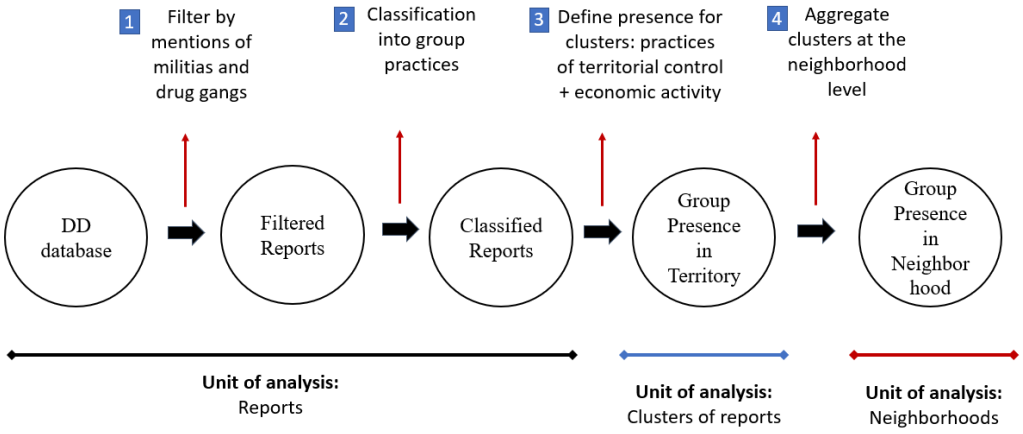


Notes: This figure illustrates how reports from Disque Denuncia are clustered according to their spatial distribution. In black, reports refer to militia groups. In red, reports are about drug gang Comando Vermelho. Green and Yellow refer to TCP and ADA respectively. In purple, we have territories with presence of at least one militia group and one drug faction. In blue, territories with more than one drug faction.

After building clusters of territories based on the exact location of reports, we identify which group is present in each cluster for a particular year if the reports in the cluster mentioned a criminal group name plus the two crucial characteristics of territorial criminal enterprises: use of force to control territories and exploitation of economic activity. Finally, we aggregate these clusters at the neighborhood level to carry out our empirical analysis since our measures of violence are available at this level. Figure 3 summarizes how we use the data from the original database to develop our measure of group presence in the neighborhood.

are closest together to form clusters until the distance of a cluster to a point is greater than an arbitrary value. We use d = 300m and the average linkage, which means we compute the average distance of points in a cluster rather than the closest (single linkage) or the farthest (complete linkage). One advantage of this clustering strategy is that we do not need to impose the number of clusters in advance.

Figure 3: Summary of the process to map group presence



3.6 Cross-check Disque-Denuncia measure with other data on criminal group presence

To evaluate the performance of our algorithm, we use three sources of information of criminal group presence that are avaliable for specific years of our period of analysis: (1) intelligence unit data from the State Attorney's Office of Rio de Janeiro for 2019, (ii) a map created by the Institute of Public Security based on police intelligence information for 2016, and (iii) field work records from Alba Zaluar that has identified criminal group presence at the *favela* level for 2009, 2010, and 2013. We aggregate data from these different periods at the neighborhood level for the city of Rio de Janeiro to make comparisons between different sources feasible. For the five years for which we have benchmark information, the correlation between these data and our measurement regarding the number of groups in each neighborhood is around 0.57 on average and around 0.61 if compared with government data. This is similar to previous efforts to map criminal groups.[18] In addition, compared with State Attorney's office data, our algorithm has a recall score (low level of false negative) of 84% and a precision rate (low level of false positives) of 0.65. This validity check makes us more confident in extending our analysis to other years.

[18]Sobrino (2019)'s efforts in identifying criminal groups in Mexico correlates between 0.34 and 0.69 with official data depending on the year of reference. Dipoppa (2020)'s accuracy to locate Mafia presence in Italy is 78%.

Table 4: Performance compared to other sources of data

	Mean	State Attorney's Office (2019)	ISP (2016)	Zaluar (2013)	Zaluar (2010)	Zaluar (2009)
Correlation (# of groups)	0.567	0.625	0.607	0.539	0.524	0.541
F-Score	0.697	0.729	0.707	0.653	0.682	0.711
Recall (1 - %FN)	0.688	0.837	0.622	0.614	0.676	0.614
Precision (1 - %FP)	0.717	0.646	0.819	0.698	0.689	0.731

Notes: This table provides scores to evaluate the performance of our measure of presence calculated using the Disque-Denuncia dataset. It compares our measure to existing datasets that captured group presence at specific years. Column 1 indicates the performance measure. Columns 2 takes the mean of columns 3-7. Columns 3-7 indicates the performance values for each dataset. F-score represents the harmonic average of recall and precision scores. Recall evaluates the ability of correctly classifying reports as positive, conditional on the totality of true positive cases in the sample. This cross-check is made only for the city of Rio de Janeiro.

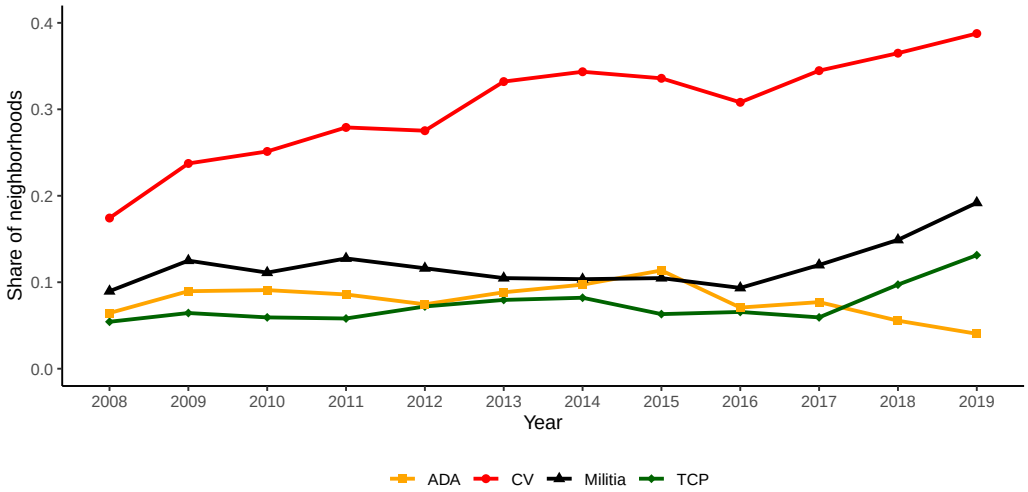
4 Descriptive Analysis

In this section, we document descriptive evidence on TCE presence in Rio de Janeiro using our novel panel data. First, we describe how these groups expanded in Rio's metropolitan area between 2008 and 2019. Additionally, we analyze the portfolio of goods and services that these groups exploit in the territories controlled by them. In the next section, we present a theory to explain under what conditions these groups expand and diversify their economic activities.

We start our descriptive analysis presenting recent trends in the presence of each TCE in neighborhoods of Rio de Janeiro's metropolitan area. Figure 4 shows that the Comando Vermelho (CV) is the most active group in the region, being present in 39 percent of neighborhoods in 2019. Comando Vermelho has increased its presence since 2008, while militia groups and Terceiro Comando Puro (TCP) presented a marked increase in 2018 and 2019. Our data also indicate a decreased presence of the gang Amigo dos Amigos (ADA) since 2018, which matches accounts that this drug gang lost power during that year.[19] Even though *favelas* and housing projects in the city of Rio are still subject to active changes of power, most of the recent upward trend in group presence is explained by the expansion of criminal groups to neighborhoods in the outskirts of Rio. The maps from figures 1a and 1b present the spatial evidence of this expansion between 2009 and 2019.

[19]See https://projects.theintercept.com/death-of-a-rio-cartel/

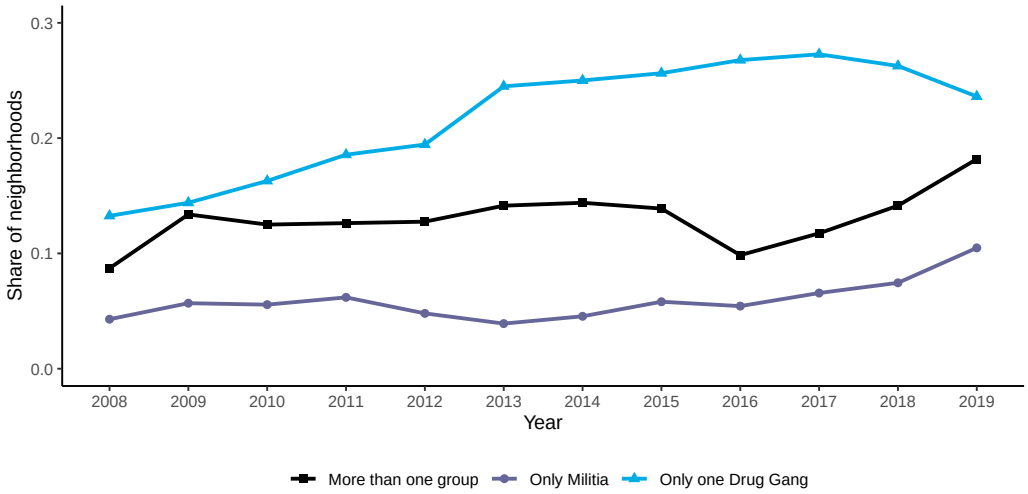
Figure 4: Percentage of neighborhoods with presence of each TCE



Notes: This figure illustrates the share of neighborhoods in the city of Rio de Janeiro with an indicator of presence of each criminal groups. This is identified by our algorithm using the Disque Denuncia data. The black line indicates the presence of militia. The red line indicates presence of the drug gang Comando Vermelho. Green refers to drug gang TCV and yellow refers to drug gang ADA.

We next analyze whether groups operate alone or govern *favelas* close to other groups' turf. Figure 5 depicts the evolution in the percentage of neighborhoods that are ruled by TCE in three mutually exclusive categories: i) only one militia group; ii) one drug gang; and iii) more than one group in the neighborhood (militia or drug gang). In comparison to earlier years, it has become more common for groups to be the only group in a neighborhood. This is one indication of higher levels of criminal consolidation. In the next sections, we explore the broader implications of this surge for criminal groups' economic decisions and violence levels.

Figure 5: Percentage of neighborhoods with different types of TCE



Notes: This figure illustrates the share of neighborhoods in the city of Rio de Janeiro with the presence of criminal groups by type. The black line indicates that there is more than on criminal groups. The dark blue line indicates presence of only militia groups. The light blue line indicates presence of only drug gangs.

Finally, another central contribution of this article is to analyze the economic side of TCEs. We then proceed our descriptive analysis to report the different economic activities exploited by TCEs. Many definitions of organized crime are restricted to illegal business. Reuters (2009) define organized criminal groups as private firms that operate illicit markets. These groups often grow by exploiting illegal markets and many studies overlook the economic diversification of criminal groups. Yet, economic diversification is seen in several contexts. The engagement of organized criminal groups into the trade and service of licit activities has been documented in studies about the mafia (Anderson, 1997) and for combos that operate in Medellin, Colombia (Blattman et al., 2018b). TCEs do not restrict their activities to illegal markets and they do not only seek to govern and control the whole economic structure of the underworld Schelling (1971) but to maximize profits.

Table 5 describes the share of different types of economic activities exploited by the TCEs in Rio de Janeiro. Panel A presents illicit activities, i.e. goods and services that are considered criminal businesses such as drug trafficking, extortion, loan sharking, and gambling. Panel B presents licit activities or services that are also provided by private companies and firms not related to crime, such as cable TV and gas.[20] Historically, militias have

[20]Gas and water refer to cooking gas cylinders and water gallons.

focused on extortion while drug gangs, which often have members that grow up in the communities they govern, are known to avoid extorting community members. Their main business is centered around drug trafficking. However, Table 5 shows that both militias and drug gangs exploit a wide range of economic activities.

Panel A of Table 5 shows that while drug trafficking is exploited by virtually all drug gangs, the militias' main source of revenue is extortion fees.[21] Importantly, we show that militias often sell drugs (22% in 2019) and drug gangs extract rents from extortion (30% in 2019). This evidence highlights the necessity of studying these groups through the unique lenses of Territorial Criminal Enterprises, since criminal groups are not restricted to unique economic activities. Moreover, the results from the table point to a relative change for militias from illegal gambling to loan sharking between 2009 and 2019.

To expand our analysis to licit goods and services, Panel B in Table 5 presents the share of groups exploring activities such as the provision of cable TV and internet, informal transportation, and the distribution of water and cooking gas, among others. To reinforce our previous results, the main result from this panel is that militias engage in more licit markets than drug gangs. Around 10% of drug gangs control the provision and distribution of these services — with the exception of land and real estate, in which 21% of gangs explore these markets. On the other side, it is more common for militias to control shares of provision of services and goods. Despite the fall between 2009 and 2019, militias are still very strong in the market of cable TV and internet for territories controlled by them. Furthermore, while their investments in the distribution of cooking gas and transportation seem to have declined, they have increased their participation in water distribution, electricity, and construction — markets with high entry costs.

In summary, there has been a change in the composition of activities exploited by these groups. Militias now invest in the selling of illegal substances and increased their participation in legal activities such as the provision of electricity and the distribution of water. Drug factions maintain drug trafficking as their main business, but also engage in extortion. Most importantly, drug factions have not changed their portfolios as much as militias. In the next section we explore the reasons behind this difference.

[21] This confirms previous studies that describe the activities of these groups in selected territories.

Table 5: Share of Militias and Drug Gangs exploiting economic activities

	TCE					
	Militias			Drug Gangs		
	2009	2019	$\Delta(p.p.)$	2009	2019	$\Delta(p.p.)$
Panel A: Illicit Goods and Services						
Drugs	19%	22%	3	100%	98%	2
Extortion	92%	91%	-1	28%	30%	2
Loan Sharking	10%	28%	18	2%	6%	4
Gambling	28%	11%	-17	7%	7%	0
Panel B: Licit Goods and Services						
TV & Internet	66%	41%	-25	11%	15%	4
Transportation	31%	14%	-14	14%	2%	-12
Properties and Land	19%	24%	5	19%	21%	2
Electricity	7%	19%	12	5%	6%	1
Water	15%	27%	12	5%	7%	2
Gas	38%	38%	0	7%	10%	3

Notes: This table illustrates the variation of criminal activities exploited by militias and drug gangs. Panel A shows activities that are illegal while panel B shows activities that are legal, i.e. they are usually provided by non-criminal firms. Δ (p.p.) is the variation between the years of 2009 and 2019.

5 Theoretical Framework

We define territorial criminal enterprises as criminal actors that can exert coercion in a given territory in order to establish local monopolies of illegal and legal goods and services. In order to accomplish this goal, these groups need to fight two enemies: the state, which holds by law a monopoly over coercion and other criminal groups that also seek to exploit these markets. Therefore, a key decision for criminal groups is whether to invest in military capacity to protect their turf from the state and rival groups. This investment is costly and prevents the group from investing in their business enterprise. However, military capacity is crucial to guarantee property rights. In this section, we present a model in order to analyze how criminal groups' decisions depend on state and rival groups' response. This allows us to understand the conditions needed to achieve two different equilibria: one with high levels of violence and low economic diversification and the other with low levels of violence and high economic diversification. This model also helps us to understand how the characteristics of drug gangs and militia groups may make the equilibrium with lower violence easier to achieve.

5.1 Intuition of the Model

The theory is based on a game theoretic model that sheds light on the strategic interactions between criminal groups and the state. A criminal group controls a territory when it successfully uses force or threats to suppress competition and maximize profits in this territory. In practice, to achieve this, the group may employ different levels of military control over an area to deter contestants.[22]

The first contestant is law enforcement agents that represent the state repression apparatus, especially the police. When law enforcement agents use military means to enforce the law and criminal groups engage in direct confrontation the results are intense conflict and violence. When the state is willing to negotiate with criminal groups and these groups decide to engage in corruption and bribery, an equilibrium with low violence emerges alongside opportunities to exploit more markets. Therefore the decision on whether and how aggressively to seize illegal goods or jail or kill crime bosses affects criminal groups' time horizons (Castillo & Kronick, 2020), and thus their ability to invest in more markets. In this case, group connections with police officers to avoid repression may affect violence and economic outcomes.

On top of the state, the control over a particular area can be constantly challenged by other criminal groups who also want to exploit markets in the territory to extract rents. Hence, if criminal groups have to dispute the territory with other groups, they have to spend more in conflict, and they can lose their territory and profits from economic activities within the territory at any moment. Conversely, if a group dominates an area such as there are no threats from other groups to challenge their power, they consolidate their local authority affecting aspects of everyday life — such as who enters and exits a community — and are able to diversify their economic activities. Therefore, territorial criminal enterprises must engage in dispute or collusion with the legal government in order be able to coerce the population and establish its domain. This theory not only helps understand the behavior of these groups, but also allows us to explain violence and when groups expand

[22]Blattman et al. (2018b) document the role of *razones* in supplying protection and regulating conflict among Combos in Medellin. In El Salvador, violence levels dramatically dropped after the truce between the gangs broke (Cruz & Durán-Martínez, 2016). In Italy, *cosca mafiosa* manages relationships among the criminal groups and regulates disputes (Anderson, 1995). There is very limited research on whether these territorial criminal enterprises engage in negotiations to set boundaries and resolve disputes but historically criminal groups in Rio de Janeiro are intermittently involved in gunfights (Monteiro & Rocha, 2017) which suggest that there is no mechanism in place to resolve disputes with less violence. Nevertheless, the literature has emphasized that gang truces and other types of negotiations have proven unstable (Cruz and Duran-Martinez, 2016).

their economic activities.

5.2 A Model of Territorial Criminal Enterprises

5.2.1 Setup

Our framework is based on a normal-form game with two types of agents: criminal groups and the state. An Incumbent criminal group i controls a territory that can be contested by a Rival group j or the State s. We present this model for two scenarios.

First, the incumbent criminal group i does not have to deal with rival groups nearby and is only contested by the state. This is the case for territories that are either isolated or when there are large areas controlled by a single group. In the second scenario, besides the state, there is a rival criminal group posing a threat to the incumbent. Rival group j faces the exact same incentives as incumbent group i in his territory and is contested both by the other criminal group and the state.

5.2.2 One Criminal Group and State Intervention

In this case, the only players are the incumbent criminal group i and the state s. Criminal group i chooses whether to invest or not in arming to fight and protect its territory, which we model as strategies {*Fight, Not Fight*}. Simultaneously, the state s decides whether to intervene militarily in a territory and repress the group or not, i.e. it chooses from the strategy set {*Intervene, Not Intervene*}. Table 6 presents the payoffs each agent gets for each combination of strategies.

Table 6: Payoff matrix - one criminal group and the state

		State	
		Intervene	*Not Intervene*
Incumbent	*Fight*	$\pi_i - c_f, \rho - c_g$	$\pi_i - c_f, 0$
	Not Fight	$\pi_i - g, \rho - c_g$	$\pi_i + \pi_i^k - b, b$

The incumbent i always manages to extract profit π_i from local economic activities. Fighting is costly for criminal groups and they incur a cost c_f when they choose to arm themselves. However, fighting avoids economic losses g from state intervention, which negatively impact the criminal group's payoff otherwise. This economic loss is associated with seizures, disturbances in economic activities and arrests or deaths of members of the criminal group.

When the incumbent decides not to fight and the state does not intervene, a bribe b is transferred to the police. In this case, colluding with state allows the criminal group to expand its business and exploit an additional market $k : \pi_i^k$.

For the state, besides the bribe b it may receive from the incumbent group, the parameters that govern its decision are related to the costs and benefits of the intervention. In order to contest the criminal group, it incurs c_g, which are associated with the costs of military capacity. On the other hand, there is a political return ρ of being tough on crime and fighting criminal groups.

We assume that $\pi_i^k > b$, which implies that rents from economic activities are high enough to bribe state agents. Since we observe the state's military repression in the data, we assume $\rho > c_g$, otherwise the state would not have an incentive to repress criminal groups.

Best Responses and Nash Equilibria

Incumbent's strategy $S_{incumbent}$ is as follows:

$$S_{incumbent} = \begin{cases} Fight & \text{if } S_{state} = Intervene \text{ and } g > c_f \\ Not\ Fight & \text{if } S_{state} = Not\ Intervene \end{cases}$$

If the state intervenes, the criminal group invests in military capacity and fighting if $g > c_f$. If the state does not intervene, the criminal group does not fight because $\pi_i^k - b > -c_f$.

For the State, the best strategy is:

$$S_{state} = \begin{cases} Intervene & \text{if } S_{incumbent} = Fight \\ Not\ Intervene & \text{if } S_{incumbent} = Not\ Fight \text{ and } b > b^* \end{cases}$$

If the criminal group invests in military capacity, the state intervenes because $\rho > c_g$. If the criminal group does not invest in military capacity, there is a level of bribe $b^* = \rho - c_g$ that makes the state indifferent in using repression. Therefore, for bribes $b \in (b^*; \pi^k)$ this game has two Pure Strategy Nash equilibria: {Fight, Intervene} and {Not Fight, Not Intervene}.

This simple framework leads to interesting insights. First, the bribe needed to avoid state repression increases with the political return to the use of military force. Second, there is an incentive for groups not to engage in fights whenever there are rents they can collect in a peace environment.

This setup also helps us think about the difference between drug gangs and militia groups. While both can collude with the government, militia groups are better able to avoid economic losses from government crackdowns.

This occurs because they have policemen in their ranks who provide key pieces of information used to avoid seizures and arrests even when the state decides to intervene. In our context, this could be modeled as lower levels g for militias in comparison with drug gangs: $g_m < g_d$.[23] Therefore, for militia groups that are able to influence g_m to the point that it is lower than c_f, investment in military capacity is a dominated strategy because there is not a threat of big economic losses due to state repression, and the only equilibrium is {Not Fight, Not Intervene}.

5.2.3 Two Criminal Groups and State Intervention

We advance our framework to incorporate another criminal group, a rival group j. Intuitively, when another group controls a nearby territory, an incumbent faces the threat of losing its territory to the contestant. Rival group j is symmetric to the incumbent, which means it is choosing whether to fight or not to protect its territory from the state and the nearby group. Table 7 presents the payoff matrix for this scenario.

The main difference from Table 6 is that the decision of the rival group j affects the payoff of the incumbent i. If one criminal group fights and the other concedes, the criminal group takes its rival's territory and rents. $I(j = F)$ is an indicator function that turns on when the rival group invests in military capacity to contest the incumbent group. π_i represents the income from territory controlled by i and π_j represents the income from territory controlled by j.

Table 7: Payoffs for the game with two criminal groups and the state

		State	
		Intervene	*NotIntervene*
Incumbent	*Fight*	$(\pi_i + \pi_j * (1 - I(j = F)) - c_f, \rho - c_g)$	$(\pi_i + \pi_j * (1 - I(j = F)) - c_f, 0)$
	NotFight	$(\pi_i - \pi_i * I(j = F) - g, \rho - c_g)$	$(\pi_i + \pi_i^k - (\pi_i + \pi_i^k) * I(j = F) - b, b)$

Best Responses and Nash Equilibria

First, the decision of the state is equivalent to the previous scenario with only one group: the state intervenes whenever the incumbent group invest

[23] Given their proximity with state agents, militias are more likely to be informed about state interventions in controlled territories. Therefore, they can prepare beforehand, avoiding apprehension and seizure of products. According to statements by a prosecutor, when there is a state operation in an area controlled by drug factions, the police seize drugs and guns. This is a huge cost for drug factions. However, when operations happen in territories controlled by militias, the operation is less likely to be successful. Militias can hide and avoid the economic loss caused by interventions.

in military capacity, and does not intervene otherwise provided $b > \rho - c_g$.

The criminal group's decision follows the strategy profile below:

$$S_{incumbent} = \begin{cases} Fight & \text{if } S_{state} = Intervene \text{ and } S_{rival} = Fight \\ Fight & \text{if } S_{state} = Intervene \text{ and } S_{rival} = Not\ Fight \\ Fight & \text{if } S_{state} = Not\ Intervene \text{ and } S_{rival} = Fight \\ Fight & \text{if } S_{state} = Not\ Intervene,\ S_{rival} = Not\ Fight \text{ and} \\ & \quad \pi_j - c_f > \pi_i^k - b \end{cases}$$

The first and third decisions to fight are straightforward because losing its territory and rents π_i heavily impacts the incumbent's payoff ($\pi_i - c_f > 0 > -g, -b$). Likewise, the possibility to take the rents from the rival's territory exceeds the opportunity cost of not fighting whenever the rival decides not to fight and the state intervenes ($\pi_j - c_f > 0 > -g$).[24]

When the state does not intervene and the rival does not fight ($j = N$), the incumbent decision depends on the economic return of acquiring the rival's territory ($\pi_j - c_f$) and net profits from exploiting additional markets locally ($\pi_i^k - b$). If $\pi_j - c_f > \pi_i^k - b$, then the only Nash equilibrium is the one in which groups fight and the state intervenes. However, the model indicates that it is possible to have a second Nash equilibrium equilibrium where nobody fights if $b > \rho - c_g$ and $\pi_i^k - b > \pi_j - c_f$.

5.3 Predictions

This game with two scenarios allows us to understand why equilibria with different levels of violence and economic diversification may emerge. While the state's decision depends on the political benefits of repressing the groups, the criminal groups are affected by their disputes and attacks from enemies — the state and a rival criminal group — and the economic incentives of governing in a peaceful environment — which allows groups to exploit more economic activities. In other words, the interaction between criminal groups and the state determines the outcomes of interest: violence and economic diversification.

The economic opportunities that emerge in a more peaceful and consolidated environment are captured by π_i^k in our model. These activities include

[24] If the state intervenes and the rival group fights ($j = F$), the incumbent always fights ($\pi_i - c_f > 0 > -g$). If the state intervenes and the rival group does not fight ($j = N$), the incumbent always fights ($\pi_j - c_f > 0 > -g$). If the state does not intervene and the rival group fights ($j = F$), the incumbent always fights ($\pi_i - c_f > 0 > -b$).

the provision of a diverse range of goods and services such as local transportation, the selling of gas canisters, the wholesale of bottled water, internet services and cable TV, and gambling, among others. These are markets that criminal groups generate profits by using its coercive power to suppress competition. However, this requires more investment and time horizon than selling illicit drugs or charging fees for protection. For instance, in order to enter the market for internet services, criminal groups must install cables and cut the infrastructure of other suppliers. Therefore, groups will diversify their activities when they are not being contested in a territory.

Our framework with state and criminal group interactions leads to three predictions for what we should observe in the data. The first prediction refers to the level of consolidation in the territory. When criminal groups are not isolated from rival groups, they invest in more military capacity, increasing the level of conflict and state repression. This is summarized in the Prediction 1:

Prediction 1 *Areas with more than one criminal group experience more conflict and state repression.*

The equilibrium where groups and the state collude is more likely to emerge when criminal groups are alone or consolidated in an area. When there is more than one group, on top of the state condition regarding the amount of the bribe ($b > \rho - c_f$), the equilibrium without conflict only emerges if the net profits from exploiting additional markets locally are high enough $(\pi_i^k - b) > (\pi_j - c_f)$.

In addition, this game also sheds light on the comparative advantages of militia groups relative to drug gangs, which is stated in Prediciton 2.

Prediction 2 *Areas with militia groups experience less state repression in comparison with areas with only one drug gang.*

We argue that militia groups are better suited to minimize the economic loss from state intervention, reducing g. This is supported by qualitative evidence. When criminal groups do not face rival groups nearby and the economic loss g generated by the state is lower for militias ($g_m < g_d$), then this type of group has no incentive to fight, and it is more likely to observe the equilibrium with low levels of conflict and state repression.

Prediction 3 refers to the change in the number of economic activities exploited by the criminal groups that facing rival groups generates relative to scenarios of criminal consolidation.

Prediction 3 *Criminal groups, especially the militia groups, exploit more markets when not facing the threat of a rival group.*

Territorial criminal enterprises, which we argue control territories to extract rents, are more likely to exploit more markets when they are not being contested by other groups. In this case, the equilibrium in which criminal groups colludes with the state becomes more feasible, especially for militia groups that always avoids violent equilibria and end up exploiting more markets.

6 Empirical Strategy

This section details how we measure the effect of interactions between territorial criminal enterprises on violence and the portfolio of economic activities exploited by them. First, we test whether the number or type of criminal enterprise at neighborhood level is associated with several indicators of violence. As pointed out by Sobrino (2019) for Mexican Drug Cartels, the number of groups in the territory represents an important driver of local violence.

We run the following regression:

$$violence_{nt} = \alpha + \beta NumberTCE_{nt} + \delta_n + \gamma_t + \epsilon_{nt} \quad (1)$$

where $violence_{\text{nt}}$ takes three different measures of violence for neighborhood n in year t: i) the total number of homicides; ii) the number of gunshots using *Fogo Cruzado* NGO data, and iii) an indicator variable of police killings. Both homicide and police killings are offical data registered by the police and disclosed by ISP. The main explanatory variable is $NumberTCE$ refers to the total number of TCE in the neighborhood and is based on our Disque-Denuncia algorithm. We also include in the regression neighborhood and year fixed effects. The parameter of interest β captures how the number of criminal groups are associated with violence at the neighborhood level. In order to test whether the type of criminal group matters, we also run alternative regressions replacing $NumberTCE_{nt}$ by indicator variables for whether there is the presence of militia groups, one drug faction and more than one drug faction at neighborhood n. This allows us to estimate changes in violence associated with changes in the type of group that rules an area. Therefore, any neighborhood characteristics that do not vary in the short run are controlled in our analysis.

The second outcome of interest is economic activities and diversification. We test whether the interaction between territorial criminal enterprises is related to a higher degree of economic diversification within groups. To investigate this question, we combine information on economic activities reported to *Disque-Denúncia* and previous field work data from Alba Zaluar

in 2009 and 2013, which identifies TCE presence at the *favela* level. We refrain from using data from *Disque-Denuncia* to identify group presence in this exercise because our algorithm is a function of reports of TCE exploiting economic activities. Therefore, we use an independent source to determine which *favela* is controlled by which group in order to make our test cleaner. In this case, we define that a group exploits a given market if there is at least one report for this practice in its territory. Our dependent variables are three-fold: i) whether a group extorts or charges of fees for protection; ii) whether a group engages in illegal drug retail trade and iii) the sum of other exploited markets (gas canister, water, internet, transportation, electricity, gambling, real state and loan sharking). Equation 2 specifies the model.

$$EconActivity_{fy} = \alpha + \beta I(Rival = 0)_{fy} + \delta_f + \gamma_y + \epsilon_{fy} \tag{2}$$

For a given *favela f*, we test whether changes in having at least one rival nearby affects the economic activities ($EconActivity$) exploited by the incumbent. We define that a group in a *favela* faces a rival in its surroundings if another group rules another *favela* that is within 1000 meters.[25] We use the lack of a rival group as a measure of criminal consolidation. Equation 2 adds *favela* fixed effects and year fixed effects to uncover the effect of having a rival nearby controlling for a specific time and *favela* invariant characteristics.

7 Results

Our model suggests that areas with more than one group experience more conflict and state repression (Prediction 1) and that criminal groups exploit more markets when not facing the threat of rival groups (Prediction 3). In addition, it indicates that militia groups are more likely to end in the peaceful equilibrium because they are able to avoid the losses produced by state repression and even reduce state intervention. This implies that areas where militia groups consolidate their territorial control experience less state repression than areas with only drug gangs (Prediction 2).

Violence Levels

Conflict with other criminal groups and the state influences local violence. To evaluate how the presence of other criminal groups influence conflict, we look at the number of territorial criminal enterprises at the neighborhood-level. The odd columns of Table 8 presents the results of estimating two-way

[25]The results are robust to alternative distances: 500m, 1500m and 2000m.

fixed effect models from equation 1 for each of the three measures of violence. Columns (1), (3) and (5) show the relationship between the total number of TCEs and homicides, shootings and police killings. Since police killings are rare events in the data, the dependent variable in column five is the probability of observing any death in a given neighborhood-year (linear probability model). Controlling for neighborhood and year fixed effects, the results indicate that an additional criminal group in a neighborhood is associated with 0.69 more homicides (or 34%), 2.08 more shootings (or 82%) and an increase in 0.04 in the likelihood of having someone killed by police (or 33%).

Columns (2), (4), and (6) replicate the same regressions changing the explanatory variables to categorical variables indicating four possible types of ruling in the neighborhood, as shown in Figure 5. The coefficients associated with *TCE >1*, *Only Militias* and *Only one Drug Gang* refer to the increase in violence relative to periods without any groups in the neighborhood (reference category). Homicides are 27% more common in territories with only one drug gang and 71% higher when there is more than one TCE. Interestingly, the results indicate that neighborhoods controlled by militia groups do not register more homicides than neighborhoods without criminal groups. As expected, shootings are a lot more likely when more than one criminal group is present at the neighborhood, 124% on average. The results confirms prediction 2 and indicates that state military intervention is less frequent in neighborhoods where only militia groups are present. Similar to homicide results, these areas do not register more police killings than neighborhoods without criminal groups. On the other hand, neighborhoods where more than one criminal group is present experience at least one police killing 10 percentage points more often than no criminal groups (or 83%), while neighborhoods with just one drug gang are 5.6 p.p. more likely to register this type of event at least once (or 47 %). In sum, these results support the previous evidence that having more than one group increases overall levels of violence and our model's prediction that the police uses more force against drug gangs.[26]

[26]Appendix E presents results using Poisson regression models with roughly the same conclusions.

Table 8: Group presence and violence

	Dependent variable:					
	Homicides		Shootings		Police Killings	
	(1)	(2)	(3)	(4)	(5)	(6)
Number of TCE	0.691***		2.076***		0.042***	
	(0.160)		(0.613)		(0.009)	
TCE >1		1.462***		3.097**		0.103***
		(0.298)		(1.318)		(0.022)
Only Militias		−0.530		0.314		−0.042
		(0.339)		(0.759)		(0.026)
Only one Drug Gang		0.554***		−0.039		0.056***
		(0.142)		(0.801)		(0.015)
Model	OLS	OLS	OLS	OLS	LPM	LPM
Mean DV	2.04	2.04	2.50	2.50	0.12	0.12
Neighborhood FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
R^2	0.818	0.818	0.886	0.886	0.493	0.495
Observations	9,504	9,504	2,376	2,376	9,504	9,504
Neighborhoods	792	792	792	792	792	792
Years	12	12	3	3	12	12

Notes: This table illustrates the main effects of territorial criminal enterprises on violence. The table reports coefficients obtained from the estimation of the equation (1). *Number of TCE* is the total number of groups in the neighborhood. $TCE > 1$ is an indicator variable taking value 1 if there is more than one group. *Only Militias* is an indicator variable taking value 1 for neighborhoods with only militia presence. *Only one Drug Gang* is an indicator variable taking value 1 for neighborhoods with the presence of only one drug gang presence. For Homicides and Shootings, the dependent variable is the sum of events in a given year-neighborhood whereas for Police Killings it is an indicator variable that indicates whether there is at least one event for a neighborhood in a year (Linear Probability Model). Mean DV refers to the mean value for each dependent variable in neighborhoods without any group. Std. Error clustered at the neighborhood level. *p<0.1; **p<0.05; ***p<0.01.

Economic Activities and Diversification

To test Prediction 3, that criminal groups, especially the militias, exploit additional markets when not facing the threat of a rival group, we look at three different economic outcomes: (1) extortion, (2) drug trafficking, and

(3) other markets. These variables are measured using the Disque Denuncia data. To avoid using the same data source for both our dependent and independent variables, we use data on group presence at the *favela* level provided by Zaluar. In this analysis, we reduce our sample for the period of 2009 and 2013.

Table 9 presents the results in two different panels, one for *favelas* run by militias (Panel A) and another one for *favelas* whose incumbent is one of the three drug gangs (Panel B). The results indicate that when militias are alone in a territory and unlikely to be contested by other criminal groups, the probability of engaging in extortion increases in 25 percentage points or 43%. Also, as predicted by our model, the number of markets exploited by militias is four times higher when there is no rival group threatening its territory.

Interestingly, this does not seem to be the case for drug gangs, as shown in Panel B. We do not find that drug factions expand their activities, including drug trafficking, when they are alone in a territory. From our model and the results from Table 8, we argue that this key difference is explained by their relationship with the state: relative to militias, drug gangs are more likely to be contested by the state when not facing threat from rival groups. In sum, the heterogeneity of our results most likely reflects the different degrees of interaction that these groups have with the state.

Table 9: Criminal consolidation and economic activities

	Dependent variable:		
	Extortion	Drugs	Other markets
	(1)	(2)	(3)
Panel A: Militias			
I(Rival = 0)	0.254**	0.154	1.011**
	(0.117)	(0.147)	(0.498)
Constant	0.589***	0.000	0.236***
	(0.026)	(0.019)	(0.067)
Observations	534	534	534
R^2	0.658	0.570	0.716
Panel B: Drug Factions			
I(Rival = 0)	0.039	0.006	−0.045
	(0.079)	(0.101)	(0.173)
Constant	−0.007	0.925***	0.087
	(0.042)	(0.053)	(0.095)
Observations	718	718	718
R^2	0.582	0.622	0.716

Notes: This table illustrates the main effects of territorial criminal enterprises interactions on economic activities. The table reports coefficients obtained from the estimation of the equation (2). Panel A reports the coefficients using the sample of only favelas with militia presence. Panel B reports coefficients using the sample of favelas with drug gangs. $I(Rival = 0)$ is an indicator variable taking value 1 when the groups do not have other groups occupying neighboring territories. Std. Error clustered at the neighborhood level. *p<0.1; **p<0.05; ***p<0.01.

8 Conclusion

Criminal groups are one of the main public security threats in many countries around the world. They govern territories, increase violence, and affect the life of millions of people. This paper analyzes these groups through the lens of territorial criminal enterprises — i.e. profit-maximizing firms that monopolize violence and coercion in a given territory to control economic markets. We create a novel dataset to map the presence of territorial criminal enterprises in neighborhoods of Rio de Janeiro and analyze the different illegal and legal markets exploited by them.

Our paper reveals that the levels of territorial domination of criminal groups in the city of Rio de Janeiro have not changed much over the last 12 years. Instead, we document a continuous increase in criminal group presence in the outskirts of the city of Rio de Janeiro. We also document that militia groups and drug factions are multi-product enterprises that exploit a wide range of licit and illicit goods and services. It is often assumed that militias engage mostly in extortion as their primary business and drug factions would never extort and focus mainly on drug trafficking. Our paper shows that these groups have converged towards territorial criminal enterprises, and that both groups exploit a wide range of economic activities. However, the main difference between them is their capacity to cooperate with the state. Past research has studied how state repression can affect cartel-state conflict (Lessing, 2018) or cooperation between traffickers (Castillo & Kronick, 2020). We contribute to this scholarship by studying how turf wars and state repression can affect not only violence levels but also the diversification of economic activities.

We build a model to explain how criminal groups interact with the state and other criminal groups, leading to conflict and the expansion of criminal activities. We test the predictions of our model using a novel dataset combined with existing detailed data on criminal groups in Rio de Janeiro. Our main results show that territories with more than one TCE are more violent. Also, territories controlled by gangs are more likely to experience state repression than territories controlled by militia groups. Finally, we show that territorial consolidation is important for economic diversification, but only for territories controlled by militias.

The difference between militias and drug gangs is of remarkable importance to our understanding of criminal groups. We demonstrate that this is possible because militias have better skills to collaborate with the state. This result applies to other criminal groups that are able to negotiate with the state and corrupt police officers, as in the case of Mexico and Italy. Once the group diversifies, it grows and can reduce even more violence by avoiding

repression. At the same time, militias strengthen their local power while subjecting citizens to the control of criminal groups. This indicates that even in scenarios with low levels of violence, these groups are flourishing and becoming even bigger threats to state power.

Our data also suggest that most of the policies that governments have pursued so far have been inefficient in curbing the expansion of these groups. In particular, our framework helps to shed light on the fact that the war on drugs pursued by many governments in Latin America, which is highly focused on direct confrontation has limited efficacy in restraining the power of territorial criminal groups. The survival and growth of TCEs depend on state policies and interactions with state agents. Any policy to curb these groups needs to consider that many people who are supposed to implement these policies are oftentimes colluding with criminal groups. Therefore, the fight against territorial criminal enterprises must encompass approaches to discipline and monitor government repression apparatus and increase the provision of public goods in poor areas to combat these groups by affecting their businesses.

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A *Disque Denuncia* reports

This section presents two examples of transcribed calls to *Disque-Denúncia*. The first refers to regular parties promoted by drug dealers to they sell drugs while heavily armed. The second report mentions militia members using firearms to charge monthly cash fees from residents. The words in bold exemplify how we used regular expressions to filter and classify reports.

"Informs that (. . .) **drug dealing** is intense during these parties and that these **drug dealers** are usually heavily armed (. . .)"
"Informs that (...) where local **militia members** (. . .), **carrying firearms**, **charge monthly cash fees** from local residents (. . .)"

B Measures of validity check

Precision evaluates the ability of correctly classifying reports as positives, conditional on being classified as positives — when there are no false positives, precision equals one. Recall evaluates the ability of correctly classifying reports as positive, conditional on the totality of true positive cases in the sample — when there are no false negatives, recall equals one. F1-score is the harmonic mean of the previous two measures — if F1-Score equals one, then the algorithm is always correct when it identifies a dimension in a report and never fails to classify reports of that dimension.

$$Precision = \frac{TruePositives}{TruePositives + FalsePositives} \tag{3}$$

$$Recall = \frac{TruePositives}{TruePositives + FalseNegatives} \tag{4}$$

$$F1 - score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \tag{5}$$

C Neighborhoods with presence of territorial criminal enterprises

Figure 6: Presence of groups at cluster level in 2019

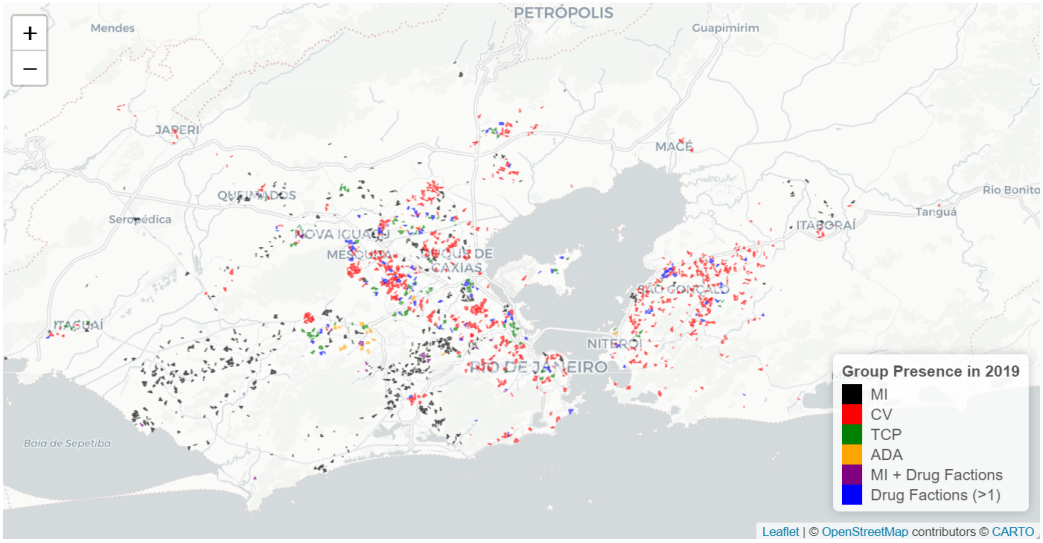


Figure 7: Percentage of neighborhoods with group presence - City of Rio de Janeiro

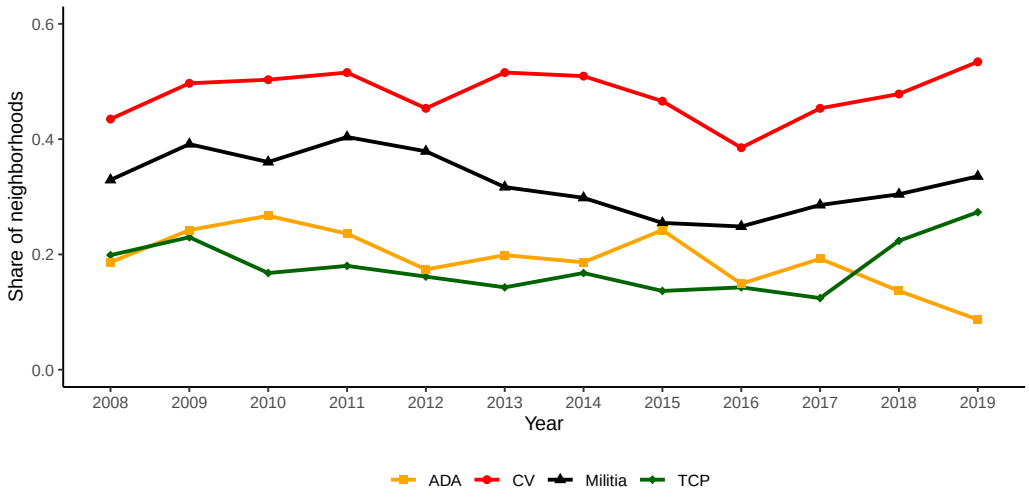
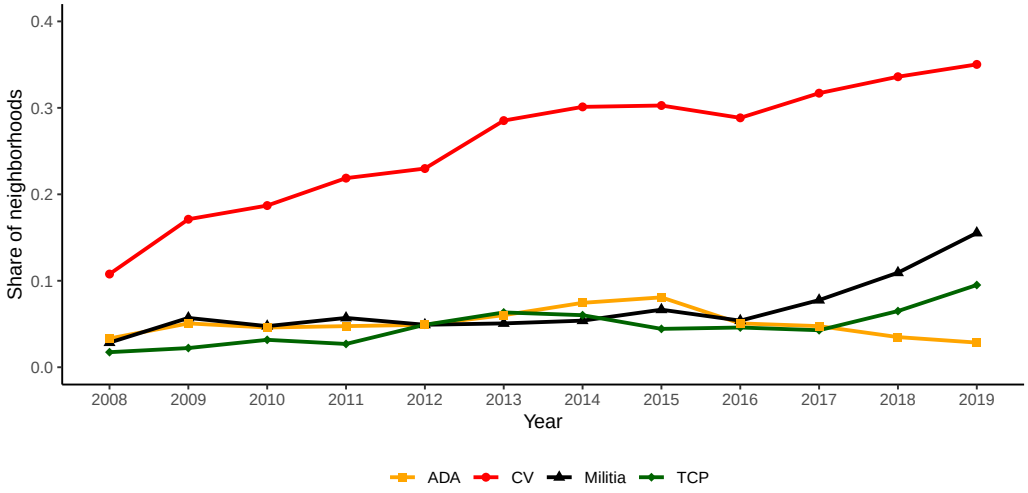


Figure 8: Percentage of neighborhoods with group presence - Metropolitan Area (excluding Rio de Janeiro city)



D Economic activities

D.1 Transportation

To describe the business of transportation, we use the case study of Ilha do Governador, a neighborhood in Rio with more than 200,000 people. This information is based on a lawsuit and the investigation conducted by Rafael Soares, journalist at O Globo.

The neighborhood was historically controlled by drug trafficker Fernandinho Guarabu. He was known for his long-lived sovereignty, which is rare given that most drug traffickers are killed or captured. Fernandinho Guarabu had a strategy of high level interaction with the state: instead of confrontation, he preferred to bribe police officers and negotiate arms and other equipment with them. In exchange, he was able to run the drug trade freely, his main business. He had 15 arrest warrants that were never implemented by the police. Another consequence of this, as expected by our theory, is that shootings and gunfights at Ilha do Governador rarely occur.

Fernandinho Guarabu started working with ex-police officer Antonio Eugenio de Souza Freitas, known as Batoré. Batoré was dismissed from the Military Police for diverting guns seized in operations to drug dealers on Ilha do Governador. In partnership with Fernandinho Guarabu, he starts controlling the business of vans in the neighborhood. They exploit the transportation market by charging fees to van drivers. According to the lawsuit,

they charged approximately US$ 70 per week plus one dollar per day for each vehicle to circulate in the area. In total, 505 vans and kombis were subjected to the fees. From the legal document:

> "A final aspect that demonstrates the special peculiarity of the case are the amounts collected by the criminal group, in fact, millions of reais per month, as evidenced in the case file, that there were 505 Vans and Kombis linked to Cooperative Shalon Fiel and that each one paid BRL 350.00 per week, in addition to BRL 5.00 reais per day, all of this combined with the exploitation of dozens of *bocas de fumo* (points of drug sales), reaching, without any major effort, the amount of millions of reais monthly collected, giving the criminal group, each month, more power to refinance itself, expand criminal activities, corrupt and dangerously infiltrate the state apparatus." (page 642, Case file n. 0076551-23.2013.8,19.0001, Rio de Janeiro State Court)

Violence was used to enforce the payment. In addition to violence, they used other strategies, as described by the lawsuit:

> "... vehicles of recalcitrant drivers, when not set on fire, were taken to the interior of the *Dendê favela* (main stronghold of "Fernandinho Guarabu") and were only returned to the owners after payment of the full amount of the extortion. Added to this is the fact that extortionists make use of the entire military apparatus, routinely used in the exploitation of drug trafficking, as a means of coercion against Van and Kombis drivers who dared to rise up." (page 21, Case file n. 0076551-23.2013.8,19.0001, Rio de Janeiro State Court)

D.2 Water distribution

Another business that is explored by criminal groups is water distribution. Documents by the Public Prosecutor's Office of Rio de Janeiro which is responsible to file criminal charges, describe the activities of militia groups in the west zone of Rio de Janeiro. The militia group established a duopoly for the sale of water gallons in two districts of Rio de Janeiro.

The head of the militia group of Jacarepagua, Orlando Curicica, partnered with a merchant who purchased higher quality water for a lower price. They agreed to segment the market between them and each would operate in a specific area with a margin of 100% on the highest quality product and 158% on the lowest quality product.

E Results - Poisson

This section presents the results from Poisson models analogous to equation 1. The conclusions are virtually the same as in our main specification.

Columns (1), (3) and (5) show that an additional criminal group in a neighborhood is associated with 9.9% more homicides, 13.1% more shootings and 17.7% more police killings. Columns (2), (4), and (6) show that the coefficients associated with *TCE >1*, *Only Militias* and *Only one Drug Gang* refer to the increase in violence relative to periods without any groups in the neighborhood (reference category). Homicides are 15% more common in territories with only one drug gang and 27.4% higher when there is more than one TCE. Neighborhoods controlled by militia groups do not register more homicides than neighborhoods without criminal groups. As expected, shootings are 32% more likely when more than one criminal group is present at the neighborhood. On the other hand, neighborhoods where more than one criminal group is present experience 66% more police killings than areas with no criminal groups, while neighborhoods with just one drug gang are 33% more likely to register this type of event.

Table 10: Group presence and violence

	Dependent variable:					
	Homicides		Shootings		Police Killings	
	(1)	(2)	(3)	(4)	(5)	(6)
Number of TCE	0.094***		0.123***		0.163***	
	(0.014)		(0.035)		(0.031)	
TCE >1		0.242***		0.280***		0.508***
		(0.035)		(0.093)		(0.086)
Only Militias		−0.007		0.107		−0.015
		(0.044)		(0.135)		(0.147)
Only one Drug Gang		0.140***		0.087		0.287***
		(0.032)		(0.095)		(0.071)
Model	Poisson	Poisson	Poisson	Poisson	Poisson	Poisson
Mean DV	2.04	2.04	2.50	2.50	0.23	0.23
Neighborhood FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Observations	9,504	9,504	2,376	2,376	9,504	9,504
Neighborhoods	792	792	792	792	792	792
Years	12	12	3	3	12	12

Notes: This table illustrates the main effects of territorial criminal enterprises on violence. The table reports coefficients obtained from the estimation of the equation (1). *Number of TCE* is the total number of groups in the neighborhood. $TCE > 1$ is an indicator variable taking value 1 if there is more than one group. *Only Militias* is an indicator variable taking value 1 for neighborhoods with only militia presence. *Only one Drug Gang* is an indicator variable taking value 1 for neighborhoods with the presence of only one drug gang presence. Std. Error clustered at the neighborhood level. *p<0.1; **p<0.05; ***p<0.01.