CARTELS

Reducing cartel recruitment is the only way to lower violence in Mexico

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Mexican cartels lose many members as a result of conflict with other cartels and incarcerations. Yet, despite their losses, cartels manage to increase violence for years. We address this puzzle by leveraging data on homicides, missing persons, and incarcerations in Mexico for the past decade along with information on cartel interactions. We model recruitment, state incapacitation, conflict, and saturation as sources of cartel size variation. Results show that by 2022, cartels counted 160,000 to 185,000 units, becoming one of the country's top employers. Recruiting between 350 and 370 people per week is essential to avoid their collapse because of aggregate losses. Furthermore, we show that increasing incapacitation would increase both homicides and cartel members. Conversely, reducing recruitment could substantially curtail violence and lower cartel size.

L atin America is home to only 8% of the world's population, but roughly one in three intentional homicides worldwide occur in the region (*1*). Mexico accounts for a relevant share of such homicides, primarily because of the long-standing presence of cartels across many areas of the country. In 2021, Mexico reported 34,000 victims of intentional homicide—nearly 27 victims per 100,000 inhabitants—and was ranked among the least peaceful countries in Latin America (*2*). Between 2007 and 2021, the number of homicides in the country increased by more than 300% (*3*), with institutional sources quantifying that between 2006 and 2018, about 125,000 to 150,000 homicides were related to organized crime in Mexico (*4*).

The effects of cartels on Mexico's society are far-reaching. These entail their presence across a wide array of illegal activities beyond drug trafficking (*5*, *6*), the deterioration of human rights (*7*), and the weakening of institutional stability through extensive acts of violence (*8*, *9*). Furthermore, some cartels have acquired a transnational dimension, expanding their business to the United States and beyond (*10*).

In this context, although cartels lose dozens of members daily as a result of killings and state incapacitation through incarcerations, the violence over the years has not decreased. We tackle this puzzle by studying cartels' evolution, deriving their sizes, and considering four fundamental sources of size variation: recruitment, incapacitation, conflict, and saturation. These sources capture the different exogenous and endogenous dynamics explaining why and to what extent cartels grow or shrink. Recruitment refers to the process of attracting a new workforce that stably carries

out tasks (both strictly criminal and not) for cartels (*11*). Incapacitation measures the ability of the state to counter cartels through incarceration (*12*). Considering all incarcerations allows us to avoid the bias of only focusing on incarcerations for homicides, which are only a fraction of the offenses committed by cartel members. Conflict describes the extent to which cartels clash and fight with each other (*13*, *14*). Finally, saturation characterizes internal instability and dropouts, which lead to organizational fragmentation (*4*, *15*).

Despite Mexican cartels' economic, social, and political importance, we lack essential information to better understand how they function. In fact, we primarily lack estimates of the size of these criminal entities. We also lack systematic estimates of cartel-related killings and kidnappings and figures related to recruitment trends, which makes it extremely difficult to deepen our knowledge about their presence, resources, and goals. The secretive nature of cartels' actions, as well as the insufficient amount of information accessible to map them, makes them conceptually similar to black boxes, from which we can only extrapolate imperfect proxies of activity using, for instance, the daily number of homicides or the number of drug-related

incarcerations that occurred in the country. Although homicide and incarceration trends are imperfect because they do not discriminate between offenses that occurred specifically in the context of organized crime, they can be used to estimate cartels' violence capacity and the state's incapacitation against them. In this work, we build on this intuition and exploit data on murders, missing persons, and incarcerations in Mexico between 2012 and 2022 to derive cartel size. We propose a mathematical system to represent their behavior over 10 years and seek to shed light on the mechanisms within the so-called black box of the cartels.

This work has two main goals. First, we aim to obtain plausible estimates of the cartels' population, including their number of members and recruitment capacity. Second, we seek to simulate different policy scenarios (i.e., increased state incapacitation and recruitment prevention) to disentangle the effects of varying strategies to curb cartels' power and, in turn, violence in the country. Our conceptual framework is built on the evidence that, despite the high number of murders and incarcerations in the past 10 years, cartels have maintained and even increased their power, control, and resources, introducing even more violence in the country. To construct our model, we gauge data on 150 cartels active in Mexico in 2020, including information on their alliances and rivalries and data corresponding to homicides, missing persons, and incarcerations.

Methods

We ask two research questions (RQs). RQ1: What is the size of Mexico's cartel population, and what is their capacity to recruit members? RQ2: To control cartel violence, is a preventive policy strategy (focused on reducing cartel recruitment efforts) more effective than a reactive policy strategy (focused on increasing police efforts to incarcerate cartel members)?

We consider four mechanisms that explain why cartel size varies: recruitment, incapacitation, saturation, and conflict (Fig. 1). We model the conflict between cartels with a
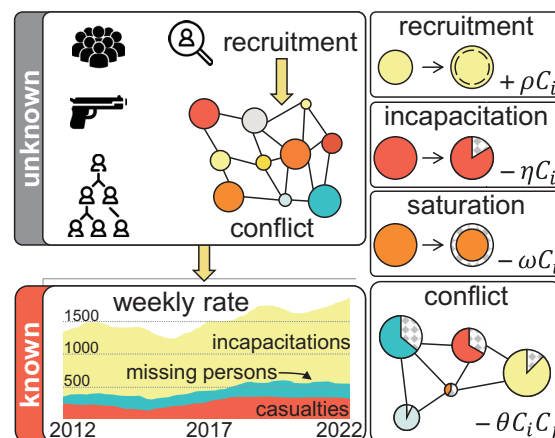
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Fig. 1. Model diagram representing the four reasons why a cartel changes in size. Most cartel-related activities remain undercover, but we observe some of their by-products in casualties and incapacitations.

weighted network, where a node represents each cartel, and an edge represents a conflict in some state in Mexico. Similarly, we construct a weighted network of alliances between cartels across different states. The model is a system of coupled differential equations, one for each cartel. Although we cannot observe most aspects of cartels (such as their recruitment and internal conflicts), we use the observed number of casualties and incarcerations to estimate the model parameters and infer the size of each cartel. We then use those estimates to forecast different scenarios for the next 5 years in Mexico. See the supplementary materials, sections A to F, for details on methodology.

Results

RQ1: Estimating cartels' populations

Most cartel-related activities are organized as dark networks to maintain their operations and activities covered (17, 18). However, their human losses caused by homicidal violence and the state's action through incapacitation provide insights into the overall amounts of such activities. We leverage the trends in homicides, missing persons, and incarcerations over the past decade to motivate our investigation of cartels' sizes in Mexico (supplementary materials, section A). Not all losses are directly related to the conflict between cartels (e.g., domestic violence), and some are a by-product of their dispute (e.g., deaths suffered by family members or bystanders). To study the size and evolution of the cartel population, we exclusively model homicides between cartel members (i.e., homicides in which the victim and the perpetrator are both cartel members). The starting point is that cartels have not seen their power diminished because violence has not reduced either. In Mexico, 686 people were killed each week of 2021, with an additional 137 people reported as missing and yet to be found, and more than 2500 people were imprisoned each week (3, 19, 20).

We use the number of cartel losses to infer otherwise unknown properties, including their size and recruitment rate. Data compiled from open sources by the Programa de Política de Drogas (PPD) (21) enable us to detect the existence of κ = 150 active cartels in Mexico in 2020. Building on such data, we operationally define cartels as those criminal organizations that are found to be active in Mexico, regardless of their size and activity (supplementary materials, section B). Cartels have different interactions: They can be allies, they can have no interactions (particularly from distant locations), or they can fight for territory or resources, creating substantial losses among both groups. To represent these interdependencies, we construct two separate weighted networks—the allies 𝒜 and rivalries ℛ—to recreate conflicting and cooperating cartels,
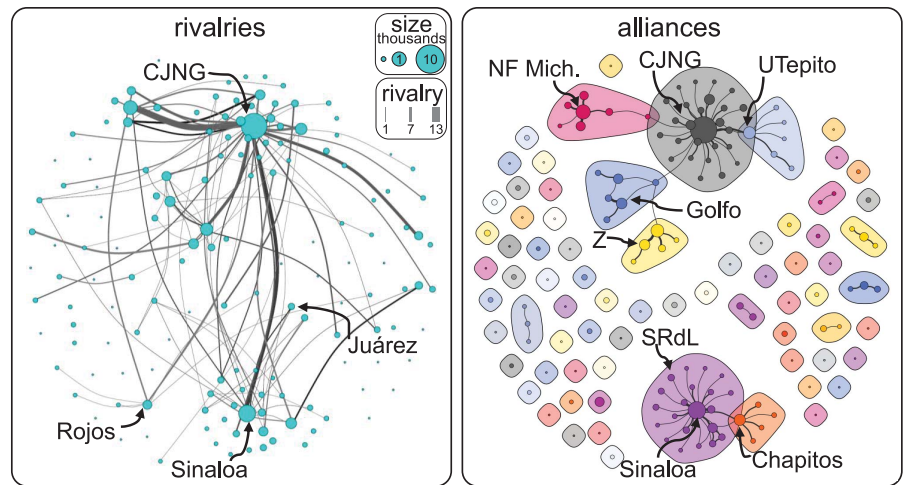

Fig. 2. Rivalries and alliances were observed between 150 active cartels in Mexico in 2020. The size of the node represents the estimated cartel size. If cartels have at least one state rivalry, nodes are connected (left). The width of the edge corresponds to the number of states in which cartels fight. Nodes are connected if they are identified as allies (right). NF Mich., Nueva Familia Michoacana; UTepito, Unión Tepito; Z, Los Zetas; SRdL, Santa Rosa de Lima.

with weights corresponding to the number of states in which two cartels interact (Fig. 2). Major cartels, such as Cártel Jalisco Nueva Generación (CJNG), the Sinaloa Cartel, and Nueva Familia Michoacana, are present almost at a national level and have alliances with many satellite organizations forming three main clusters. These clusters fight against each other, creating most of the violence between cartels (16). Smaller organizations are local to one city and have few interactions (cooperation or conflict) with other cartels.

The number of members of cartel i at time t, expressed as $C_i(t)$, increases instantly according to ρC_i, where ρ is the fixed recruitment rate. Because of state forces, the size of the cartel decreases by $\eta C_i / \sum_j C_j$ for some $\eta > 0$ that represents the incapacitation rate. Because of internal instability, dropouts, and diminishing returns, large groups decrease their size instantly by ωC_i^2 for some small value of $\omega > 0$, known as the saturation rate (22, 23). The impact of conflict between two cartels, i and j, is modeled according to the number of homicide offenders between rival groups, which is assumed to be proportional to cartel size, so cartel i suffers instant casualties according to $\theta C_i C_j$, where $\theta \geq 0$ is the deathly rate of conflict related to homicide offenders within cartels. Combining recruitment, incapacitation, conflict, and saturation, we obtain

$$\dot{C}_i = \underbrace{\rho C_i}_{\text{recruitment}} - \underbrace{\eta \frac{C_i}{C}}_{\text{incapacitation}} - \underbrace{\theta \sum_{j \neq 1}^{\kappa} C_i C_j S_{ij}}_{\text{conflict}} - \underbrace{\omega C_i^2}_{\text{saturation}} \quad (1)$$

where $\dot{C}_i$ indicates the rate of change in cartel size i, and $S_{ij} \geq 0$ captures the interaction be-

tween cartels. We obtain a system of κ = 150 coupled differential equations—one for each cartel (supplementary materials, section C). The number of weekly casualties produced by all cartels is given by $d(t) = \theta \mathbf{C}^{\top} \mathbf{S} \mathbf{C}$, where $\mathbf{C} = (C_1, C_2, \ldots, C_\kappa)$. Cartels recruit ρC individuals, where $C = \sum C_i$, and $i(t) = \eta \sum_{i=1}^{\kappa} \frac{C_i}{C}$ are incapacitated. In line with previous works on other types of organizations, we assume that the initial cartel size is a heavy-tailed distribution (supplementary materials, section D) (24–26). We use the observed weekly number of casualties and incapacitations to estimate the time-varying number of cartel members $C_i(t)$.

Not all observed deaths, missing persons, and incapacitations in the country are suffered by cartel members, and most incapacitations are not linked to the incarcerations of cartel members. In our analysis, we estimate casualties as the sum of missing persons with murders and consider that a fraction $f = 10\%$ of the observed weekly deaths and a fraction $g = 5\%$ of the incapacitations are cartel members (supplementary materials, section D). In total, 50,000 casualties and 55,000 incapacitations directly involve cartel members. On the basis of these figures, we estimate that in 2012, there were 115,000 cartel members and that by 2022, the number increased to 175,000. Thus, despite efforts from the state to hinder their power, cartels have increased their size by 60,000 members in a decade. Incarcerating nearly 6000 cartel members each year has not prevented them from growing into larger organizations. Given the current conditions, we quantify 120 weekly cartel-related deaths, with an increase of 77% between 2012 and 2022. To ensure that our results are not driven by wrong assumptions

about the number of homicides between cartel members and incarcerations of cartel affiliates, we conduct sensitivity tests considering the scenarios between 40,000 and 60,000 cartel casualties and 45,000 and 65,000 incapacitations. By considering the variation of these two parameters, we obtain that the total population of cartel members in 2022 lies between 160,000 and 185,000 units. At the same time, additional sensitivity tests were used to try to quantify the effect of potential missing data at the network level concerning alliances and rivalries. Adding 10% more cartels would, on average, lead to 3.2% more members than the estimated 175,000. Furthermore, we also provide evidence that adding 10% more alliances or rivalries would at most affect the overall dimension of violence by 5% (supplementary materials, section E). Even under a conservative scenario, Mexican cartels have lost around 200 members per week for years (Fig. 3A). Specifically, we estimate that in a decade, 285,000 people acted as cartel units and that—in total—37% of them are either deceased (17%) or incarcerated (20%).

Despite competition with other cartels and state forces' incapacitation, cartels have prevailed for decades. Between January and December of 2021, cartels recruited 19,300 individuals, losing 6500 members as a result of conflict with other cartels and 5700 members as a result of incapacitation, which resulted in a net gain of roughly 7000 members during that year (supplementary materials, section D). A similar estimate is observed for each year between 2012 and 2022. Unless all cartels combined recruit between 350 and 370 people per week, they would have collapsed as a result of conflict, incapacitation, and saturation combined (Fig. 3A).

Given the estimated overall population, all cartels combined are the fifth largest employer in Mexico (27) (Fig. 3B). The 10 largest cartels in Mexico have more than 50% of the active affiliates in the country, but the conflict between them only produces 15% of the fatalities (Fig. 3C). Most cartels are small local organizations playing a critical role in creating violence in the country, often becoming targets of more powerful organizations. Previous research has suggested that large cartels frequently adopt fragmented cells of other weaker and less experienced structures (16). Small cartels play a crucial role because they are more likely to become targets of powerful illicit organizations rather than fighting organizations of similar sizes. We estimate that more than half of the country's casualties result from the fight between the smallest 140 and the largest 10 cartels (supplementary materials, section B).

RQ2: Comparing policy scenarios

On the basis of the size of cartels in 2022 and the trends observed in the past decade, we predict that the weekly number of casualties related to organized crime will keep increasing in the coming years. We estimate that if current trends continue, cartels will keep increasing their power, and we could observe 40% more casualties and 26% more cartel members by 2027. We test the effectiveness of two main policy scenarios designed to reduce future violence in the country: first, a preventive strategy aimed at reducing cartel recruitment, and second, a reactive strategy aimed at increasing incapacitation. On the one side, doubling incapacitation, with all of the associated costs and challenges in increasing security resources (including police personnel, army, prisons, etc.), will still result in an increase of 8% in the number of casualties and an increase of 6% in the number of cartel members. Even doubling incarcerations will translate to a rise in violence (Fig. 4). Cartels have a critical equilibrium where their recruitment compensates for their losses, maintaining a stable size. Yet, if the recruitment rate of a cartel is 10% above its equilibrium, the incapacitation rate must increase by more than 21% to dismantle it (supplementary materials, section F).

Conversely, decreasing the cartel's ability to recruit by half will reduce the weekly casualties by 2027 by 25% and cartel size by 11%. Mathematically, a preventive strategy is far more successful than a traditional reactive strategy. However, the cartel population is so large that, even in the hypothetical scenario where recruitment drops to zero, it would take 3 years to return to the—already high—levels of violence observed in 2012. This further calls for rapid and timely large-scale initiatives to reduce recruitment in the country.

We also assess the effects of two additional ancillary policy scenarios. The first one is designed to alter the type of conflict between cartels (e.g., pushing for a narcopeace), and the second one is targeted at modifying cartels' saturation levels (i.e., making cartels more prone to fragmentation). Neither of the two strategies outperforms the positive effects that a reduction in recruitment could produce (supplementary materials, section E). Decreasing the conflict by 20% reduces the number of casualties by 8.7%, whereas increasing saturation by 20% lowers the number of homicides between cartel members by 5.4% (supplementary materials, section E). In light of the current estimated circumstances, the growth of cartels' size is impeded mainly by the conflict existing among organizations rather than the ability of the state to reduce the levels of violence in Mexico successfully.

Discussion

For the past 15 years, Mexico has suffered from staggering levels of violence. Most of the violence has been perpetrated by cartels fighting against each other (4). Despite the relevance of cartels, we lack basic information on their size and the impact of different policies that seek to curb their power. To the best of our knowledge, this work represents the first scholarly attempt to mathematically quantify the size of the cartel population in Mexico and to compare policy scenarios intended to decrease violence
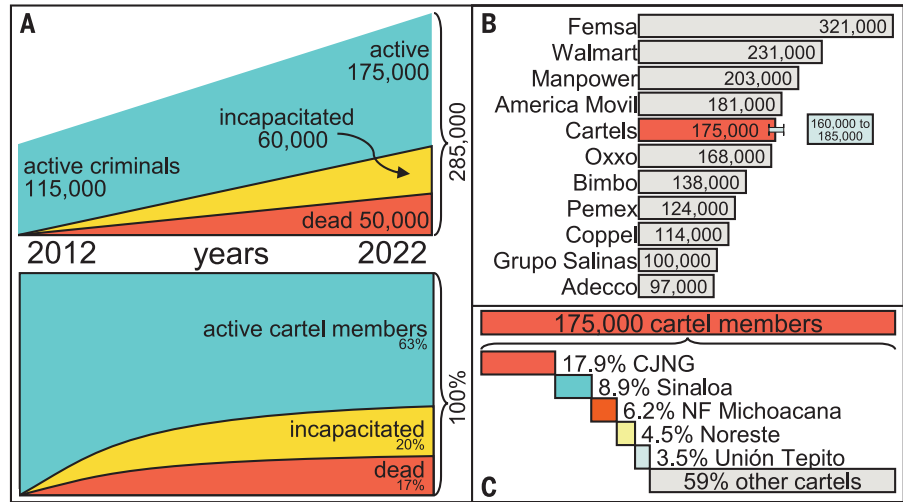
Fig. 3. Current size of cartels and career paths for recruited members. (**A**) Between 2012 and 2022, we estimate that 285,000 people took part as cartel members, but only 60% were still active by 2022. The cartel career is brief and risky. Roughly 17% of them are dead, and 20% are incapacitated. (**B**) Number of employees from the top 10 companies in Mexico and the combined size of cartels (27). We estimate that cartels had between 160,000 and 185,000 members combined. (**C**) Of the 175,000 active cartel members, roughly 17.9% are part of CJNG, 8.9% are part of Cartel de Sinaloa, and 6.2% are from Nueva Familia Michoacana—the top three cartels in size.

Fig. 4. Forecast of the number of casualties and cartel size according to four different strategies. Weekly cartel-related deaths (top) and cartel size (bottom) if trends continue, if incapacitation doubles, if recruitment is reduced by half, and if recruitment is reduced to zero. Estimates for 2027 are obtained by keeping the 2022 estimates and adjusting the corresponding values of incapacitation or recruitment.
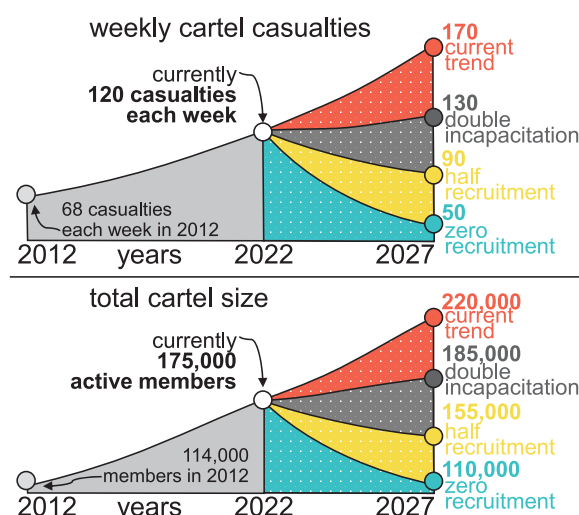
in the country. Overall, our work advances the growing literature on mathematical and statistical simulations for studying complex criminal phenomena (*28–30*).

Our simulations yield some key findings. We estimated that the cartel population counted 160,000 to 185,000 units by 2022 and that, over the 2012 to 2022 period, 285,000 people acted as cartel members. Given these figures, we showed that in 2022, cartels needed to recruit between 350 and 370 units per week to avoid collapse as a result of joint effects of conflict, incapacitation, and saturation. Furthermore, we assessed the effectiveness of two main scenarios to curb cartels' violence: preventive (intended to prevent recruitment) and reactive (designed to increase incapacitation through incarcerations). If current levels of incapacitation are doubled, some violence will be contained, but we would still expect an increase in the weekly casualties. Conversely, reducing recruitment by half leads to a decrease in homicides of 25%. We also tested the effect of two ancillary scenarios—reducing the conflict by pushing for cartel agreement and fragmentation, intended to decrease cartels' power through internal fights (supplementary materials, section E). Results showed that the preventive strategy remained substantially more effective in reducing violence in the country. Tackling recruitment will have a triple effect in the future: First, it will lower the number of cartel members, reducing the violence that it can create by having fewer killers. Second, it will lower the number of targets, so fewer people are vulnerable to suffering more violence. And third, it will reduce the cartel's capacity for future recruitment.

Although offering policy recommendations is beyond the scope of this work, our results can prompt policy-related reflections. Many initiatives to counter organized crime aim to increase incapacitation through incarceration. In this work, we demonstrate how increasing

incapacitation substantially may not necessarily reduce violence. Contrarily, we offer an alternative scenario centered around reducing recruitment and suggest how it may have longer-lasting beneficial effects. More than 1.7 million people in Latin America are incarcerated, and adding more people to saturated jails will not solve the insecurity problem (*31*).

Despite the contributions of this investigation, there were some limitations. First and foremost, although the lack of data on the size of cartels represents the inherent motivation of this work, it also represents a structural limitation because our estimates cannot be meaningfully validated with real-world information. We took all possible precautions to obtain statistically consistent estimates through extensive sensitivity analyses, but this does not eliminate the core validation issue. Additionally, a thorough reflection on other sources of limitation and assumptions is provided in the supplementary materials, section I. These entail (i) temporal variability in rivalries and alliances, (ii) alternative sources of cartels' size variability, and (iii) the lack of a finite population.

Results highlight the need to devote more attention to recruitment. Reducing recruitment requires structural efforts at the state and local levels. This especially applies to areas with high cartel support, where offering educational and professional opportunities that outweigh the short-term benefits offered by cartels represents a critical goal for the future of the country (*32–35*). Future work on this topic should focus on enriching our model of cartel size variation with additional sources, such as cartel fragmentation, and should also consider the possibility of studying recruitment dynamics using data on finite populations to obtain mathematical models that consider individual risk factors (such as age and sex) in the computation of violence and recruitment trends.

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SUPPLEMENTARY MATERIALS

science.org/doi/10.1126/science.adh2888
Supplementary Text

Figs. S1 to S8
Tables S1 and S2
References (*37–66*)
MDAR Reproducibility Checklist
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