POLICY FORUM

DRUG POLICY

Modeling cartel size to inform violence reduction in Mexico

Estimating stocks and flows is an innovative first step

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Immense violence and corruption in Mexico, and their connections to illegal drugs in the United States, are a great problem of our time. Mexico's homicide rate in 2022 was 25 per 100,000, similar to Colombia's and more than triple the US rate. Measuring corruption is notoriously difficult, but some Mexican criminal organizations have a history of intimidating and bribing government officials (*1*). On page 1312 of this issue, Prieto-Curiel *et al.* (*2*) take on two important tasks: estimating how many people are employed by, and flow into and out of, Mexican criminal organizations responsible for much of the violence and corruption, and creating a model that permits "what-if" analysis of policy interventions. Concluding that increasing incarceration will lead to higher criminal employment and violence, the authors argue that restricting organizations' ability to recruit, such as by offering better alternative employment, is "the only way to lower violence in Mexico."

These organizations (usually called "cartels" although they do not meet the economic definition of the term) participate in multiple illegal activities, but trafficking drugs such as cocaine, fentanyl, heroin, and methamphetamine is thought to account for a large share of their revenues (*3*). Prieto-Curiel *et al.* provide the first systematic estimates of individual cartel sizes and total cartel employment. Prior to their paper, there were only expert guesses at the size of a few of the more prominent organizations. The article accomplishes this in part by assembling a variety of data that had been accessible but scattered and also by integrating those data through a stocks and flow model. The data included official government statistics on the number of homicides, missing persons, and incarcerations, as well as data from open sources on the number of cartels and their distribution across states gathered by the social science research organization Programa de Política de Drogas. The model is an important contribution, as there had previously been few serious attempts to write down equations that capture the "physics" of what drives cartel size or violence.

ESTIMATING STOCKS AND FLOWS

Stocks and flows models are common across many scientific disciplines but remain relatively rare in the study of crime and drug policy. Even the pivotal recognition that the population of people with opioid use disorder (OUD) is a dynamic system is relatively recent (*4*). The associated idea that long-term reductions in opioid overdose deaths requires reducing the flow into the stock of people with OUD (*5*) is parallel to Prieto-Curiel *et al.*'s focus on reducing the flow of employees into the cartels.

There are nuances with counting the stock of cartel employees. For example, does the stock represent the number of people who were involved within the last year, even if only briefly, or just the regular workers? [It has long been recognized that, at least in US drug markets, many more individuals work in drug distribution than there are "full-time equivalent employees" because there is so much part-time or "gig" work (*6*)]. And does the stock count only traffickers or also those involved in drug production (from farmers growing poppies to chemists synthesizing fentanyl)? Nonetheless, the concept of studying these organizations' labor force as a stock with associated inflows and outflows is an innovative and interesting perspective.

In round terms, the analysis by Prieto-Curiel *et al.* implies that

175,000 staff in 2022 = 115,000 staff in 2012 – 110,000 lost to outflows + 170,000 recruits

where the outflows are from violence, incarceration, and all other exits, which they aggregate under the term "saturation."

The outflows from death and incarceration are not measured perfectly (e.g., it is not always easy to know who was or was not a cartel member), but they are known at least roughly. Being able to "scale" them relative to the previously unknown stock size gives a useful sense of perspective. For example, if as the paper claims, there are now about 175,000 cartel employees, and their annual risk of death or disappearance due to conflict is 6500/175,000 = 3.7% per year, that is about 1.5 times greater than the death risk for US men and women who served in World War II (overall, not just per year). It is also substantially higher than one estimate of the annual risk of being killed in drug markets in Washington, DC, when the crack cocaine market was near its height in the mid-1980s: 1.4% (*6*).

Those figures would imply that, from the perspective of a typical cartel employee or prospective employee, incarceration risk is not the primary cost to be traded off against the benefits of criminal income, camaraderie, and whatever other benefits they may perceive. Even if the probabilities of death and incarceration are about the same, the consequences of being a homicide victim presumably weigh more heavily. Doubling or tripling the incarceration rate might then not decisively alter the balance of perceived pros and cons from joining a cartel—a perspective entirely consistent with the authors' pessimism about the limitations of "reactive" policies that rely on incarceration.

That said, there are some questions about whether the model can really show that there were about 175,000 employees in 2022. To a first-order approximation, the model's estimate of the cartels' collective size should scale to the numbers of cartel member deaths and incarcerations, which in turn are equal to (reasonably) well-measured national totals multiplied by weakly justified presumptions by the authors that f = 10% of deaths and g = 5% of incarcerations are suffered by cartel members. If those two proportions f and g turned out to be twice as large, then the cartels could all be twice as large while keeping the model basically the same.

This is easiest to see from equation 1 of the supplementary material's section on cartel size and parameter estimation. In that equation, if one doubles the incarceration flows, violence flows, and cartel sizes (C_i's) while halving the internally estimated parameters governing exits from conflict and saturation (Θ and ω) and keeping the recruitment rate parameter (ρ) the same, one gets exactly the same differential equation.

Indeed, it is not clear why the total size of the cartels (C) combined with the f and g parameters is not essentially indetermi-

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nate. The authors' figure 4 implies a highly nonlinear relationship between the best-fitting C and the values of f and g, which is puzzling. Perhaps that emerges from the particular form of the matrix of S_{ij} inter-cartel violence intensity parameters and/or the assumption that initial cartel sizes C_i follow a power-law distribution, either of which would seem to be a highly indirect basis for determining the total scale of cartel employment.

"WHAT-IF" POLICY MODELING

Even if it is granted that total cartel employment is now about 175,000, the other question the article tackles is even more ambitious. It is one thing to build a model that reproduces historical stocks and flows, and quite another to have a model that continues to capture well the stocks and flows in a future world characterized by substantially different policy conditions. Cartel members are not billiard balls or atoms locked into mechanistic reactions to external shocks. Cartels are adaptive organizations often run by intelligent people who can alter behavior in response to changing conditions.

For example, even if over the period of historical data (2012–2020) the cartels recruited in a manner that is well captured by the model's constant per-capita recruiting rate, ρ, cartel leaders could alter their recruiting practices (e.g., offer to pay higher wages) if that became necessary to counteract some government initiative designed to slow their recruiting.

There are historical instances of drug trafficking's growth being limited by scarcity of certain skilled roles, such as a shortage of chemists capable of synthesizing large amounts of LSD circa 2000 after some major LSD producers were shut down (*7*). But we are not aware of any historical instances in which a highly profitable drug-marketing opportunity lay unexploited because criminal enterprises were unable to recruit enough workers more generally.

Consider this from the perspective of the entire supply chain. Suppose the Mexican government intervened to reduce the appeal of working for cartels and the cartels needed to counteract that by raising wages. If final consumers in US markets could accept a 1% increase in retail prices without major reductions in purchases, how much would that free up for incentive payments to Mexican cartel workers? Retail sales in US markets were about $150 billion per year in 2016 (*8*), so that 1% price increase could generate about $1.5 billion in additional revenue. That is more than $8500 per cartel member (at 175,000 members), or almost the average gross domestic product per capita in Mexico. Surely, that would help maintain the workforce.

If cartels were for some reason unwilling or unable to raise wages, they might instead innovate to develop less labor-intensive ways of distributing drugs, perhaps sending fewer small shipments across the border by human couriers and sending more large shipments hidden in shipping containers. From 2013 to 2018, Chinese producers shipped illegally manufactured fentanyl (IMF) powder to the United States largely through postal and parcel services, which presumably required very few workers (*9*). More generally, the model imagines that recruitment is governed by a fixed parameter, ρ, whereas one could argue that recruitment is essentially a business decision taken by resourceful "managers" who will do whatever it takes to find the necessary staff.

IDEAS FOR ADVANCING THE RESEARCH

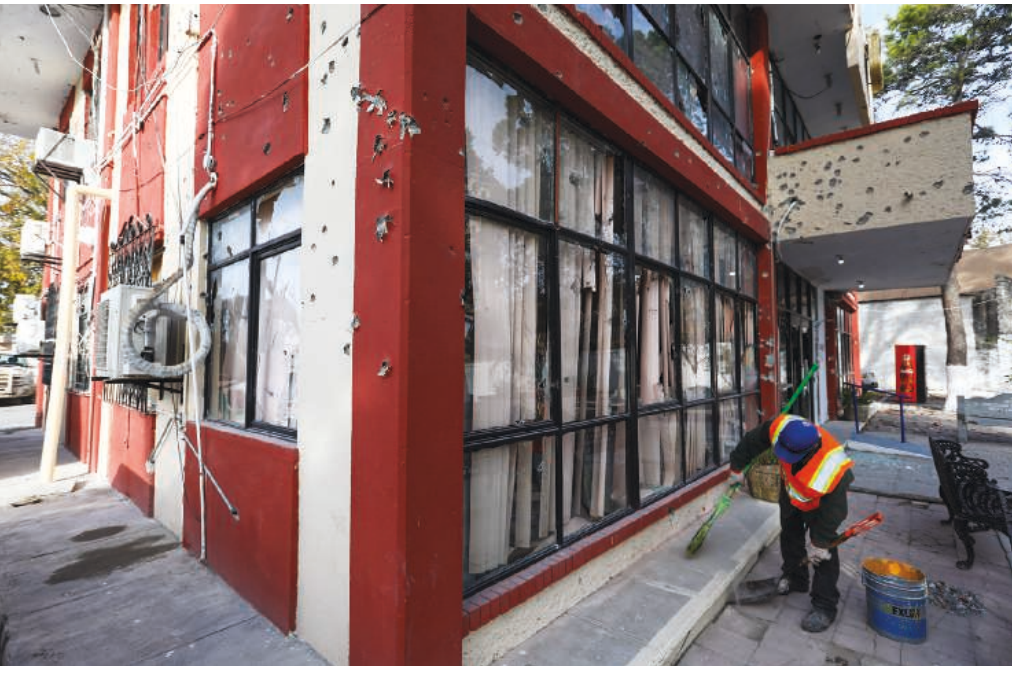
Although we raise these questions about the paper's specific conclusions, we close by offering three ideas for advancing this general line of research, about which we are very supportive.

Articulate which "first principles" drive cartel staffing and behavior

The current model is something of a mechanical black box and does not account for markets and incentives. That may not prevent it from generating credible population estimates, but an understanding of the underlying dynamics is essential for projections and policy analysis.

For example, the paper does not address why cartels' staffing levels have been growing—by 50% between 2012 and 2020 according to the model—when drug market trends might suggest the need for smaller, not larger staffs. The post-2012 development of legal cannabis supplies in many US states has reduced demand for Mexican-produced cannabis. Furthermore, cannabis prices have been falling (*10*), so revenues from selling have fallen even more than the volume sold. Also, IMF became dominant in many US opioid markets over this period (*9, 11*). Although the vast majority of IMF and heroin used in the US is produced in Mexico, and IMF may generate as much revenue for cartels as did heroin, its production and distribution probably require fewer Mexican workers.

It is not known what happened to total cartel drug revenues over this period (discussed below), but if they did decline, perhaps this prompted cartels to diversify into other lines of business that are more labor intensive such as illegal mining, kidnapping, human trafficking, and extortion. Or perhaps cartel labor is increasingly employed to defend drugs and workers from attacks by rivals, or to intimidate officials, not to produce or distribute drugs. After all, total annual US consumption of (pure) fentanyl circa 2021 was likely in the single digits of metric tons (*11*), which is tiny compared to the annual volume of other imported goods (e.g., 1,000,000 metric tons of Mexican avocados). The current model ap-



City Hall in Villa Union, Mexico, is riddled with bullet holes from a gunbattle that began on 30 November 2019 between cartel members and security forces that left 22 people dead.

PHOTO: AP PHOTO/EDUARDO VERDUGO

pears to be silent about such possibilities.

Likewise, the model assumes that staff size drives violence: The more staff the cartels employ, the greater the number of killings of cartel members. But one could imagine a causal arrow running in the other direction. Perhaps cartels recruit more members in response to growing violence, e.g., to deter attack or to retaliate effectively. All this points to the field's weak understanding of what fundamentally determines the levels of staffing and violence in drug markets. We hope that Prieto-Curiel *et al.*'s bold action of writing down equations forces the literature to engage in more explicit discussion about what fundamental principles drive cartel size and violence, even if that discussion ultimately leads the equations to be revised.

Improve understanding of drug consumption and prices on both sides of the border

Scientific investigation of fundamental principles must be grounded in data, but there are currently severe—albeit remediable—deficiencies in relevant data systems. Understanding cartel dynamics requires understanding their biggest market: Drug consumption in the US. Estimating the size of illegal markets is a complex exercise requiring information from multiple sources; one cannot simply rely on national household surveys because they miss most of the consumption of cocaine, fentanyl, heroin, and methamphetamine (*12*). However, starting in the 1990s, the Office of National Drug Control Policy (ONDCP) regularly produced estimates of US drug consumption, expenditures, and numbers of consumers by synthesizing a wide variety of data indicators, including information from the (since defunded) Arrestee Drug Abuse Monitoring (ADAM) program. Unfortunately, the most recent estimates only extend through 2016 (*8*). Estimates of Mexico's drug export revenues are even older (2012) (*13*).

Another key piece of the puzzle is understanding how prices escalate as drugs move down the multilayered domestic distribution network that stands between Mexican cartels and people who use drugs. Most of the money that US consumers spend purchasing illegal drugs remains with the domestic distribution network. Cartel revenues are basically retail sales revenue multiplied by the ratio of cartels' high-level wholesale prices divided by the (much higher) retail price. Estimating prices by market level is not easy, especially given the need to adjust for drug-purity levels across the supply chain, but it is possible. Data about seizures and undercover buys are recorded in databases such as the National Forensic Laboratory Information System (NFLIS) and the Drug Enforcement Administration's System to Retrieve Information from Drug Evidence (STRIDE, now called STARLiMS). Additional insights lie in court documents from prosecuted cases. Methods exist for harnessing these data, and the US federal government used to regularly generate and report purity and price information, but the ONDCP price series stopped after 2012. The government could be doing much more to support analyses of illegal drug markets, but this is not a new recommendation (*8*, *9*).

Expand scope beyond murders of cartel members

The authors' focus on cartel size and violence leads to consideration of a limited set of policy choices, primarily greater incarceration or programs that reduce recruitment of cartel workers. Adopting a broader vision of how cartels harm social welfare may expand the option set. Even granting that violence is the single greatest problem that cartels pose for Mexican society, the model only tracks lethal violence suffered by cartel members. It ignores violence perpetrated by cartels against others, including journalists, politicians, and law enforcement. It also only tracks violent acts, whereas harm is also done by violence that is merely threatened, e.g., when business owners are extorted for "protection" money or political leaders cooperate and accept bribes instead of fighting cartels.

There is no rigid rule connecting cartels' size—or at least the volume of their drug trafficking—with levels of violence. Consider that for many years prior to 2007, even though most of the illegal drugs exported to the US passed through Mexico, the number of killings then was much lower, just one-third of the 2020 level. The standard explanation for the relatively modest level of violence associated with the cartels then is that there had been a politically mediated settlement that corruptly linked the ruling Institutional Revolutionary Party (PRI) and the then small number of cartel leaders. Felipe Calderón, whose 2006 election to president was widely contested, attacked the cartels to bolster his legitimacy. That destabilized the agreement, leading to more than 15 years of violence.

We are not arguing nostalgically for restoration of Pax PRI, but want to point out that there is nothing inherent in these massacres, either to drug distribution or smuggling, or to Mexico. As the costs of maintaining protective armies grows, and as older cartel leaders get killed off by their rivals or the military, perhaps a new set of leaders will prefer to come to some accommodation that reduces their costs. These markets are in fragile equilibria, if in equilibria at all. As suggested in the framework of Evolutionary Economics (*14*), the decisions by a few leading figures may lead to quite different market outcomes.

It is also worth noting that increasing the effectiveness of law enforcement is not synonymous with more incarceration. Kleiman (*15*) suggested that US agencies might be able to reduce violence in Mexico by focusing their enforcement efforts on US importers who buy from the most violent Mexican cartel. That would provide an incentive for Mexican cartels to avoid being known for violence, because US buyers would try to purchase from their less violent competitors. Kleiman acknowledged potential implementation challenges, but the idea illustrates the concept that intervening to reduce violence need not entail maximizing incarceration or minimizing cartel size.

Finding ways to incorporate insights about markets and incentives into this type of model should be part of the next wave of research in this area. A richer understanding of the underlying dynamics of markets may help inform more effective policy innovation. ■

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