Scarcity without Leviathan: The Violent Effects of Cocaine Supply Shortages in the Mexican Drug War*

Juan Camilo Castillo† Daniel Mejía‡ Pascual Restrepo§

September 2016

Abstract

This paper explores if scarcity increases violence in markets without a centralized authority. We construct a model in which, by raising prices and revenues, temporal supply shortages foster violence. Guided by our model, we examine the link between scarcity and violence in the Mexican cocaine trade. Scarcity created by cocaine seizures in Colombia—Mexico's main supplier—increases violence in Mexico, especially in municipalities near the US border, in municipalities that have multiple cartels, and in municipalities that have strong PAN support—the party that has spearheaded the crackdown on the cocaine trade since 2006. Our estimates imply that, between 2006 and 2009, the sharp decline in the cocaine supply from Colombian could account for 10% to 14% of the increase in violence in Mexico and 25% of the differential increase in the North of Mexico relative to the rest of the country.

Keywords: War on Drugs, Violence, Illegal Markets, Mexico, Cocaine Trade.
JEL Classification Numbers: D74, K42.

*We are grateful to Daron Acemoglu, Michael Clemens, Dora Costa, Leopoldo Fergusson, Bruno Ferman, Claudio Ferraz, Dorothy Kronick, and Otis Reid, as well as seminar participants at Universidad de los Andes, Stanford, UCLA, ITAM and the AL CAPONE and LACEA meetings for their very helpful comments and suggestions. Melissa Dell, Horacio Larreguy, and Viridiana Ríos kindly provided some of the data used in this paper. We gratefully acknowledge funding from the Open Society Foundation and from the Center for Global Development.

†Economics Department, Stanford University, e-mail: jccast@stanford.edu

‡Economics Department, Universidad de los Andes, e-mail: dmejia@uniandes.edu.co

§Cowles Foundation for Research in Economics, Yale, e-mail: pascual.restrepo@yale.edu

1 Introduction

Agents in illegal markets cannot rely on the rule of law. The state cannot solve disputes, protect property rights, nor make sure that contracts are honored. As in other environments that lack a centralized authority, agents use violence as a substitute for the institutions that a well-functioning state provides.[1] Illegal drug markets in places like Colombia, Mexico, and Afghanistan constitute major examples. In these markets, armed groups resort to ruthless violence in order to run the illegal trade, extract rents and protect their revenue and assets.

In this paper, we study the role of scarcity—supply shortages—as one important factor that exacerbates the use of violence in markets that lack a centralized authority. We do so in the context of the cocaine trade in Mexico. At least since the early 2000s, Mexico has been the main point of entry of drugs into the US. Illicit drugs produced in the Andean countries, most importantly cocaine, used to be shipped to North American markets through the Caribbean. Following intensified enforcement in the Caribbean by US authorities, Colombian and Mexican drug traffickers began to smuggle drugs more frequently through Mexico. The industry transformed into a vertical market that has little integration, in which powerful Mexican cartels purchase cocaine from producers in Colombia (and to a lesser extent, in Peru and Bolivia) and smuggle it across the US border.[2]

As Figure 1 shows, the expansion of the cocaine trade in Mexico since 2006 coincided with a dramatic increase in violence that was driven by clashes between cartels (or drug trafficking organizations, DTOs), and between cartels and Mexican authorities. In 2007, there were 8,686 homicides in Mexico, out of which 2,760 were drug-related; in 2010, there were 25,329 homicides, out of which 15,258 were drug-related. Since 2006 there have been more than 60,000 drug-related killings in Mexico, which is twice the death toll observed in Afghanistan between 2001 and 2011 (see Crawford, 2011).

We ask whether the surge in drug-related violence in Mexico since 2006 is related to

[1] This is also the case in developing countries in which local strongmen contest areas in which the state does not centralize authority (see Acemoglu et al., 2013; Fearon and Laitin, 2003; Sánchez de la Sierra, 2015) and warlords fight over the extraction and control of valuable resources (see Skaperdas, 2002).

[2] Although Mexico also produces drugs such as cannabis, heroin and ATS (Amphetamine-type stimulants), a large share of the profits (between 50% and 60%) obtained by Mexican cartels is generated via drug-trafficking activities, especially those related to cocaine, and not via drug production (see Kilmer et al., 2010). Grillo (2011) and Valdés (2013) provide thorough reviews of the history of drug trafficking in Mexico and its nexus with crime and violence.

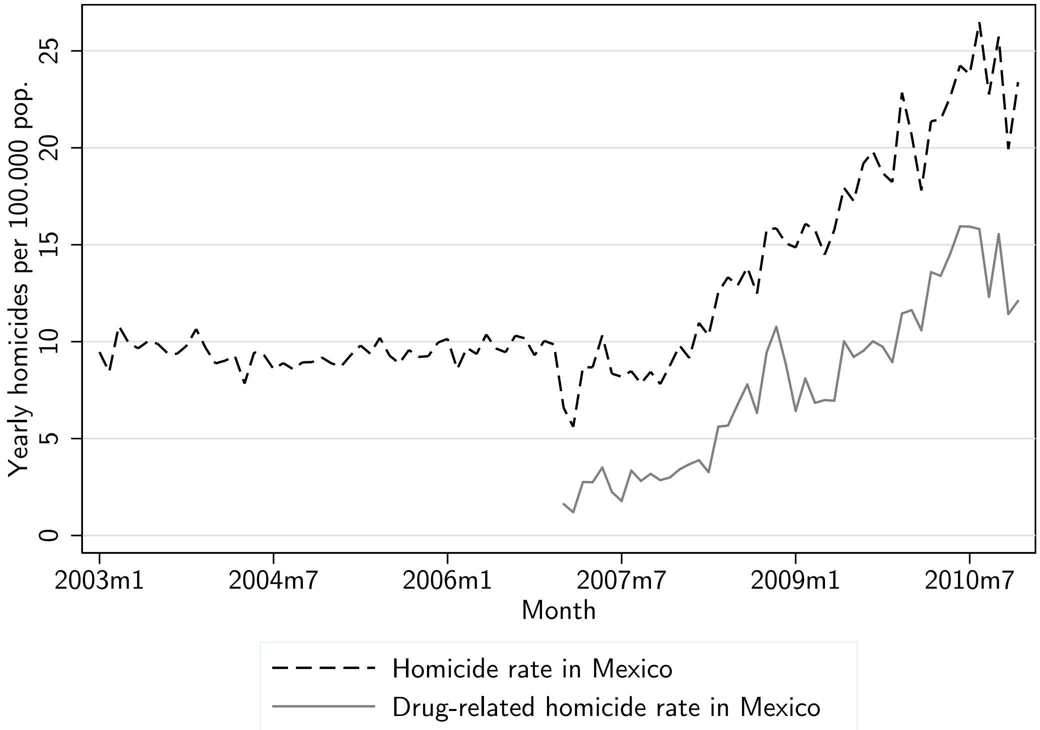

FIGURE 1: The homicide rate (data from INEGI) and the drug-related homicide rate (data published by the President's Office starting in December, 2006) in Mexico.

shortages in the supply of cocaine caused by larger and more frequent seizures in Colombia. In 2006, the Colombian government redefined its anti-drug strategy, emphasizing the interdiction of drug shipments and the detection and destruction of cocaine processing labs over the eradication of coca crops.[3] Cocaine seizures in Colombia went from 127 metric tons per year in 2006 to 203 metric tons in 2009. As Figure 2 shows, the supply of Colombian cocaine fell from 522 to 200 metric tons during this period—at the same time that the homicide rate in Mexico roughly tripled. This large negative supply shock was noticeable in downstream markets. The retail price per pure gram of cocaine in the US went from about $114 in 2006 to about $180 in 2009—a 45% increase—and from $40 to $68 for wholesale purchases between 10 and 50 grams—a 53% increase.

To motivate our analysis, we present a model of conflict in illegal markets. Because these markets lack a centralized authority, revenue is unsecured and cartels dis-

[3]The change followed intense criticism of the Colombian government's focus on the early stages of the cocaine production chain, such as the eradication of coca crops, which account for a low share of the value added. The new focus on later stages greatly increased the efficiency of supply reduction efforts (see Mejía and Restrepo, 2013b).

pute it through violence. If demand is inelastic, exogenous supply reductions in upstream markets—like Colombia—increase revenue. Scarcity raises the stakes, causing drug cartels to invest more resources in the conflict over revenue and increasing violence. Our model also predicts that scarcity has a greater effect on violence in Mexican areas that are especially important for trafficking, like those in the North of Mexico, where there are at least two cartels, and where more frequent arrests and crackdowns against cartel leaders increase turnover, impeding informal cooperation agreements among cartels.

Although our model underscores a particular channel through which scarcity generates conflict in illegal markets, we do not claim that this is the only channel that links scarcity and violence. As we discuss in our concluding remarks, there may be other mechanisms at play. Instead, the purpose of the model is to show that a standard theory of conflict in which cartels contest the cocaine trade revenue, which we believe is a good description that captures the main features of this market, is able to explain all of our empirical findings.

Using monthly data for Mexico from December 2006 to December 2010, we then explore the relationship between scarcity and violence that our model predicts. We use cocaine seizures in Colombia as an external source of scarcity. Although Figure 2 shows that the rise of violence in Mexico since 2006 coincides with the sharp decline of cocaine supply in 2006, it would be naive to interpret this as evidence of a causal effect of scarcity on violence. This low-frequency correlation could simply reflect a change in policies in both countries, such as President Calderón's war on drugs in Mexico and the emphasis on interdiction policies in Colombia. To overcome this difficulty, we exploit monthly deviations in cocaine seizures in Colombia, obtained after flexibly removing time trends. Our empirical strategy investigates whether the scarcity generated by high-frequency changes in cocaine seizures in Colombia generates violence in Mexico, and which municipalities are most affected. The key identifying assumption is that the monthly variation in seizures is exogenous to changes in enforcement in Mexico or unobserved changes in cocaine markets.

Our main finding is that during months that have supply shortages—marked by large cocaine seizures by Colombian authorities—violence increases in Mexico, especially in municipalities close to the US border. The effect is stronger in municipalities that have a cartel presence, but only when two or more cartels are contesting each other. The increase in violence is also larger in municipalities that have historically supported PAN, the governing party which spearheaded the crackdown on the cocaine trade since 2006. Building on the work of Dell (2015), our interpretation is that these municipalities were more likely to support federal government efforts against cartels. As a consequence, cartel

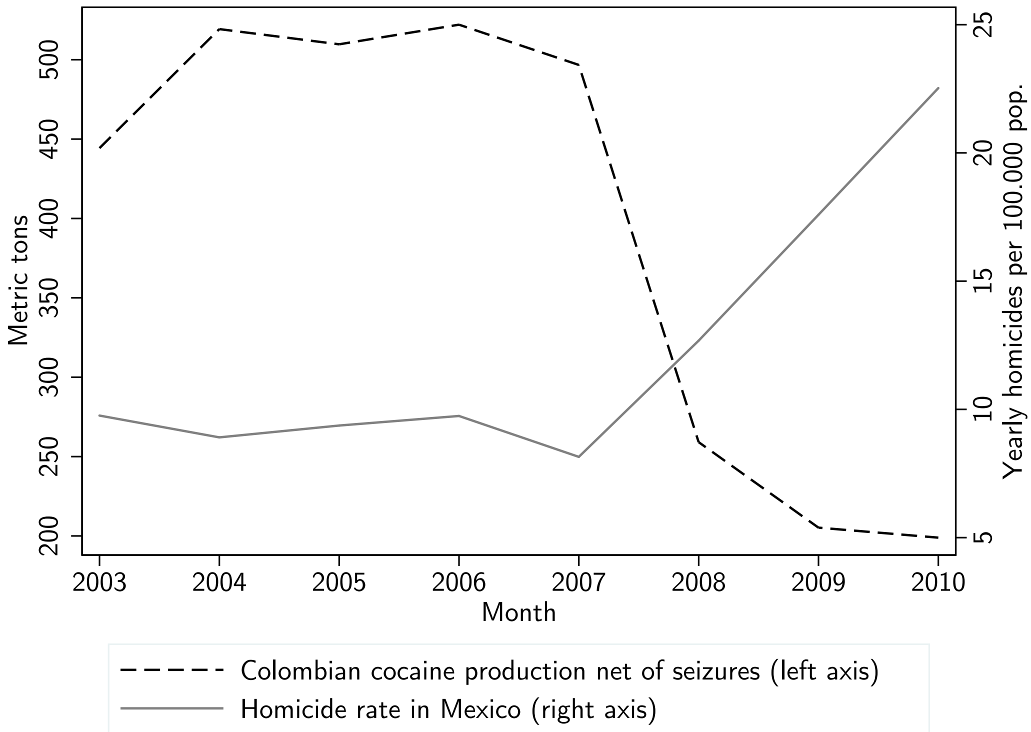

FIGURE 2: Net cocaine production in Colombia (from UNODC) and homicides in Mexico.

leaders were arrested, killed or removed more frequently in these municipalities, precluding non-aggression treaties between cartels and exacerbating the effect of scarcity on violence. All of our empirical findings are consistent with our model if the short-run demand for cocaine is inelastic, as the empirical evidence suggests (Becker et al., 2006).

The effect we measure is substantial. According to our preferred estimates, a 1% increase in monthly cocaine seizures in Colombia raises homicides in Mexico by about 0.059%-0.091%. Under additional assumptions mentioned in the text, this means that the sharp decline in the net cocaine supply from Colombia between 2006 and 2009 (from 520 mt to 200 mt per year) accounts for about 10%-14% of the increase in the homicide rate in Mexico during this period. It also accounts for 25% of the differential increase in violence observed in the North of Mexico relative to the rest of the country.

The rest of the paper is organized as follows. Section 2 outlines the related literature and frames our contribution. Section 3 presents our model and discusses its testable predictions. Section 4 describes our data, empirical strategy and results. Section 5 concludes.

2 Related literature and contribution

Our paper is related to three strands of literature. The first one is the literature on conflict over resources and rents. Our model builds on the economic theory of conflict, which points out that agents rely on violence or the threat of violence to appropriate resources when no centralized authority guarantees property rights (Grossman, 1991, 2001; Hirshleifer, 1991, 1994, 2001).[4] An increase in the value of the contested resources has an ambiguous effect on violence. On the one hand, rapacity over the additional resources—the temptation to prey on others and the necessity to defend against predators (Gambetta, 1996; Skaperdas, 2002; Collier and Hoeffler, 2004; Grossman, 1999)—leads to more violence. On the other hand, resource booms may also increase wages, and, hence, the opportunity cost of engaging in violence (see Becker, 1968; Grossman, 1991; Dal Bó and Dal Bó, 2011).[5]

We contribute to this literature by showing that rapacity dominates in the Mexican cocaine trade: higher revenues from cocaine increase violence, especially in areas contested by several cartels. This adds to the empirical literature that finds a link between resource booms and violence (Collier and Hoeffler, 2004; Buonanno et al., 2015; Couttenier et al., 2016; Dube and Vargas, 2013) and the theoretical literature that emphasizes the role of the number of contenders engaged in conflict (Kalyvas, 2006). Our emphasis on the role of scarcity is in line with the theoretical insights of Acemoglu et al. (2012), who argue that, by raising revenue, scarcity and resource depletion eventually lead to conflict if the demand for the traded good is inelastic.

Our paper is also related to the literature on violence among suppliers in illegal markets, which goes back to Goldstein (1985). We contribute to this literature by showing that higher revenues lead to more drug-related violence in the Mexican cocaine market. This finding is consistent with the results by Angrist and Kugler (2008) and Mejía and Restrepo (2013a), who find that the rise of the cocaine trade spurred violence in Colombia (Lind et al., 2014, show evidence for a causal link in the opposite direction in the case of opium cultivation in Afghanistan). Similar results hold for other illegal markets (García-Jimeno, 2016; Owens, 2014; Chimeli and Soares, 2011).

Finally, our work contributes to the debate on the causes of the upsurge in violence

[4] The idea that interpersonal violence emerges when the state does not centralize authority goes back to Hobbes (1651), and has been treated more recently by Elias (2000) and Pinker (2011).

[5] In line with this channel, other authors finds that national income and commodity prices reduce the likelihood of conflict in Africa (Miguel et al., 2004; Brückner and Ciccone, 2010), and that booms in labor-intensive commodities like coffee may actually reduce violence (see Dube and Vargas, 2013).

in Mexico since 2006. Some observers blame the struggle for power created by the policies implemented by Calderón, who in 2006 started an aggressive strategy of beheading cartels by killing or arresting their leaders (Guerrero, 2010, 2011a; Merino, 2011).[6] Using a regression discontinuity design, Dell (2015) finds a significant increase in anti-drug crackdowns in municipalities in which PAN—Calderón's party—won local elections. She documents that the enforcement spearheaded by PAN resulted in a spike in drug-related violence. Similarly, comparing the area of influence of a cartel with a synthetic control group, Calderón et al. (2015) find that the killing of a cartel leader raises violence.[7]

Unlike most of the existing literature, we emphasize the role of policy changes in Colombia. The dramatic increase in cocaine seizures in Colombia since 2006 created large and frequent shortages in downstream cocaine markets, which translated into more frequent and larger surges of violence in Mexico. This is not to say that PAN and Calderón's policies had no effect; instead, our evidence suggests that Colombian policies and the Mexican policies spearheaded by Calderón and PAN interacted to increase violence.

3 A model of scarcity and violence

We first present the model in a static setting and then extend it to a dynamic setting. At the end of this section we discuss the connections between our model and the cocaine trade in Mexico.

3.1 Static setting

There are I municipalities, indexed by $i \in \mathcal{I} = \{1, 2, \ldots, I\}$. There are N cartels, indexed by $c \in \mathcal{C} = \{1, 2, \ldots, N\}$, each one of which operates in a subset of municipalities $I_c \subset \mathcal{I}$. Also let $N_i \subset \mathcal{C}$ be the set of cartels that operate in municipality i.

Municipalities are heterogeneous in how relevant they are for the total cocaine trade. For instance, municipalities close to the US or those located along strategic routes have a particular importance, which allows cartels that control these areas to obtain a larger share of the cocaine trade revenue. We model this heterogeneity by assuming that in

[6] Other observers have defended this strategy by arguing that, by reducing cartel entry, it could decrease violence in the long term (Poiré and Martínez, 2011; Villalobos, 2012).

[7] Two recent papers shift the focus away from Calderón's policies. Dube et al. (2013b) show that negative agricultural shocks facilitated the rise of the Mexican drug sector and increased violence as a consequence. Dube et al. (2013a) find that the level of violence in Mexico increased as a consequence of the 2004 expiration of the US Federal Assault Weapons Ban which generated a positive shock on gun availability in the North of Mexico.

municipality i a fixed share $s_i \geq 0$ of the total revenue from the cocaine trade is disputed, with the understanding that $\sum_{i \in \mathcal{I}} s_i = 1$.

Let Q^s be the total supply of cocaine supplied by upstream markets (Colombia being the main supplier), which we assume is exogenous. Each cartel buys an amount Q_c^s of cocaine at a price P^s and traffics it to downstream markets at a cost $C(Q_c^s)$, which is increasing, convex, and satisfies $\lim_{Q \to 0} C'(Q) = \infty$ and $\lim_{Q \to \infty} C'(Q) = 0$. The total amount of cocaine trafficked is given by $\sum_c Q_c^s = Q^s$. Cartels sell it in the downstream market at a price $P^d(Q^s)$, which they take as given.[8] The total revenue is given by $R(Q^s) = Q^s P^d(Q^s)$, and the revenue disputed in municipality i is $s_i R(Q^s)$. This amount is initially distributed among the cartels that operate in municipality i, but only a fraction η of each cartel's revenue is protected from expropriation, while the remaining $1 - \eta$ is at risk of predation by other cartels. Thus, η measures the extent to which a centralized authority can credibly protect property rights. The total revenue in municipality i that is vulnerable to appropriation by others and that the cartels that operate in this municipality will dispute is then given by $(1 - \eta) s_i R(Q^s)$.

In order to appropriate or defend the unsecured revenue $(1-\eta) s_i R(Q^s)$, the cartels that operate in municipality i engage in a violent conflict against one another. We model the dispute over revenues with a contest success function, as is usual in the conflict literature (Skaperdas, 2002). Cartels in N_i simultaneously decide amounts $g_{c,i} \geq 0$ to invest in weapons or soldiers in municipality i. As a result, cartel c is able to obtain a fraction $q_{c,i}$ of the total revenue contested in municipality i, where $q_{c,i}$ is determined according to the following function:

$$q_{c,i}(g_{c,i}, g_{-c,i}) = \frac{g_{c,i}}{\sum_{c' \in N_i} g_{c',i}}.$$

The aggregate level of drug-related violence in municipality i is given by the total expense in the local conflict by all cartels, $v_i = \sum_{c \in N_i} g_{c,i}$.

This setup described by $g_{c,i}$ and $q_{c,i}$ is a reduced form representation of all the strategies by which cartels appropriate and extract drug rents. For instance, they can act as toll collectors and extort payments from other cartels operating in municipality i; they can fight for turf in order to use routes and labor for their trafficking activities; they can prey

[8] We have assumed cartels are price takers. The term cartel is therefore misleading. The powerful Colombian drug trafficking organizations of the 1980s and 1990s called themselves *carteles* to emphasize that a few organizations controlled the whole trade, even though they did not collude to increase prices. The name stuck, and present-day Mexican organizations use the same term (see Gonzalbo, 2012). Even if there is some level of collusion, all we require for our results to hold is that the degree of competition be high enough for the market equilibrium to occur in the inelastic part of the demand curve.

on one another by violently stealing cash, weapons, assets or other resources; or they can eliminate competition in key municipalities to increase their market share.

The appendix characterizes the full equilibrium of this market (including cartels' choice of quantities and the equilibrium prices). To characterize the outcome of conflict, notice that the amount paid for drugs, the cost of smuggling, and revenues not subject to appropriation are bygones by the time cartels choose their investment in the conflict $g_{c,i}$. Thus, cartels simply care about the disputed revenue $s_i R(Q^s)$. Also, because the outcomes $q_{c,i}$ are independent across municipalities, it suffices to solve the conflict in each municipality separately. Cartel c's maximization problem in municipality i is thus given by

$$\max_{g_{c,i}} q_{c,i}(1-\eta)s_i R(Q^s) - g_{c,i}.$$

The appendix shows that the unique Nash equilibrium of the conflict among cartels operating in municipality i results in a level of violence

$$v_i(Q^s) = \frac{|N_i|-1}{|N_i|}(1-\eta)s_i R(Q^s). \tag{1}$$

This expression leads to our main proposition.[9]

PROPOSITION 1 *If demand is inelastic, a decrease in the supply of cocaine from downstream markets increases revenue and leads to more violence. The increase in violence is greater in municipality i under the following circumstances:*

1. *If third party enforcement is absent or weak (η is small).*
2. *If municipality i is more important for cocaine trafficking (greater s_i).*
3. *If municipality i has more cartels (greater $|N_i|$). Also, violence only changes if at least two rival cartels operate in the same municipality.*

All results go in the opposite direction if demand is elastic ($R(Q^s)$ increasing in Q^s).

PROOF. The proof follows by differentiating equation 1 to obtain comparative statics on the level of violence. The key observation is that expenditures on conflict increase with total revenue, whose response to supply depends on the elasticity of demand. ■

[9]This expression also helps us clarify which type of scarcity generates violence. Anti-drug policies in municipality i may displace the cocaine trade and reduce s_i. From the perspective of municipality i, such policy creates a scarcity of cocaine in that municipality and could reduce violence. As this example illustrates, it is the aggregate level of scarcity, by raising prices and revenue, which generates violence. The displacement of production from one municipality to other (a reduction in s_i which creates scarcity only in one area but not at the aggregate level) only displaces violence.

3.2 Dynamic setting

We now move on to a dynamic setup, which opens the possibility of more favorable equilibria under the threat of retaliation (see Abreu et al., 1990; Castillo, 2015). This is relevant because when centralized authority is lacking participants rely not only on violence but also on informal cooperation arrangements sustained under the threat of punishment. This feature allows us to model a key dimension of Calderón's strategy: beheading cartels by arresting or killing their leaders can preclude informal cooperation arrangements.

The game described above is played out repeatedly, with an independent draw of Q_t^s in each period. Subscript t denotes time. At the end of each period, a cartel leader in municipality i is arrested or killed with probability a_i, and he is then replaced by a new one. Leaders maximize cartel profits at their own discount rate $(1-a_i)\beta$, and not at the market rate β. Arrests and killings thus make cartel leaders more impatient.[10]

Just as in the static problem, the amount paid for drugs, the cost of smuggling drugs, and the revenues not subject to appropriation are bygones. Also, revenue $R(Q_t^s)$ is fully determined by the realizations of Q_t^s. Thus, in each period, cartel c operating in municipality i chooses $g_{c,i,t}$ in order to maximize expected payoffs

$$E_{t_0} \sum_{t \geq t_0} \beta^{t-t_0}(1-a_i)^{t-t_0} q_{c,i,t}(1-\eta) s_i R(Q_t^s) - g_{c,i,t}. \tag{2}$$

Let $g^N(Q^s)$ be the investment in conflict in the symmetric static Nash equilibrium in municipality i when supply is Q^s, which is the solution to the static model above. We focus on a recursive equilibrium in which all cartels in municipality i spend $g^C(a_i, Q^s) \in [0, g^N(Q^s))$, and revert to $g^N(Q^s)$ as punishment if anyone in that municipality deviates. This is not the most cooperative subgame perfect equilibrium (SPE), but it is the simplest one that helps us illustrate how informal cooperation arrangements work. The following proposition characterizes the equilibrium:

Proposition 2 *If demand is inelastic ($R(Q_t^s)$ decreasing in Q_t^s), the equilibrium that sustains the most cooperation through reversion to the static Nash equilibrium in municipality i is recursive and has $g_{c,i} = g^C(a_i, Q^s) \in [0, g^N(Q_s))$. The function g^C satisfies the following:*

[10] This assumes that, once a cartel leader is arrested or killed, the next leader cannot credibly compensate him for long-term investments. This could stem from the lack of enforceable contracts in environments without a centralized authority.

1. *If revenue is unbounded below, then* $g^C(a_i, Q^s) = 0$ *for* $Q^s \geq \overline{Q}(a_i)$. $\overline{Q}(a_i)$ *is increasing in* a_i.

2. *If revenue is bounded above, then a fully cooperative equilibrium with* $g^C(a_i, Q^s) = 0$ *for all* Q^s *can be sustained if* $\beta(1 - a_i) > \overline{\beta}$ *for some* $\overline{\beta} < 1$.

3. *If revenue is unbounded above, then* $g^C(a_i, Q^s) > 0$ *if* Q^s *is sufficiently small regardless of* $\beta(1 - a_i)$.

4. *Wherever* $g^C(a_i, Q^s)$ *is positive, it is increasing in* a_i*, decreasing in* Q^s*, and the cross partial derivative is negative.*

If demand is elastic ($R(Q^s_t)$ *increasing in* Q^s_t*), the results hold but with the opposite signs for* Q^s*.*[11]

PROOF. See appendix B. ■

The key idea in this proposition is that in the absence of a centralized authority there is room for some *de facto* protection of property rights, which is sustained by the threat of future retaliation. We now explain the results for the case in which the demand is inelastic.

If a_i is low and β high, a no-violence equilibrium can be sustained—a folk theorem. As the effective discount rate decreases, participants value the future less and some level of violence must be allowed, especially when revenues are large. Temporary reductions in supply Q_s increase violence for two reasons.[12] First, they increase current revenues and, hence, the incentives to prey. Second, because of reversion to the mean, expected revenue in the future is lower, which makes the threat of retaliation less effective in preventing violence (see Rothemberg and Saloner, 1986). This second effect becomes stronger when the arrest rate is high, which explains why the function $g^C(a_i, Q^s)$ has a negative cross partial derivative: not only is expected revenue in the future low, but cartel leaders also heavily discount the threat of future retaliation.

[11] For 1, $g^C(a_i, Q^s) = 0$ for $Q^s \leq \underline{Q}(a_i)$ and $\underline{Q}(a_i)$ is decreasing in a_i. For 2, $g^C(a_i, Q^s) = 0$ can be sustained if $\beta(1 - a_i) > \overline{\beta}$. For 3, $g^C(a_i, Q^s) > 0$ if Q^s is sufficiently large regardless of $\beta(1 - a_i)$. For 4, g^C is increasing in a_i and Q^s, and the cross partial derivative is positive.

[12] We have ignored the possibility of storage in our model. A good storage technology partially dampens the effect of temporary supply shortage because cartels hedge against it by accumulating drugs. However, cocaine storage does not remove the influence of large and unanticipated supply shocks.

3.3 Taking the model to the Mexican cocaine trade

In this section we discuss how the model applies to the cocaine trade in Mexico, and we explain the key assumptions behind our interpretation. The basic story that emerges from the model is that scarcity from cocaine seizures in Colombia fosters violence in Mexico. We now break down this story into its two main components.

First, in our model cartels fight over the share of revenue vulnerable to appropriation. When investing in conflict they care about revenue and not profits because payments to Colombian cartels are bygones. Thus, cartels are the full residual claimants of the rents they appropriate and protect from others. The assumption behind this feature is that there is no perfect risk sharing between Mexican cartels and suppliers in Colombia. We believe that the absence of a centralized authority precludes the possibility of this kind of vertical relations.[13]

Second, whether demand is elastic or inelastic plays a key role; the main results of our model go in opposite directions with elastic and inelastic demand. The documented evidence supports the view that the demand for cocaine is inelastic. Becker et al. (2006) summarize the evidence and conclude that it is consistent with an elasticity of demand of less than 1 for most drugs, with a central tendency towards 1/2, especially over the short run.[14] Furthermore, our empirical results are all consistent with inelastic demand. Thus, we focus below on the predictions of the model when demand is inelastic.

Our model suggests that months where the supply of cocaine from Colombia is low because of more seizures should be months that have high levels of violence in Mexico.

[13] If cartels and suppliers were able to establish complex contracts, cartel payments to suppliers would depend on the outcome of the conflict, and cartels could end up fighting over profits rather than revenue. Even if this is the case, violence could increase for a sufficiently inelastic demand, as other models show (see Mejía and Restrepo, 2013b; Castillo, 2015). An alternative view of the trafficking process is that Mexican cartels do not fight over the entire revenue of the cocaine trade; instead, they fight over the control of routes that they use to sell "transportation services." In this model, when the elasticity of demand is smaller than the elasticity of substitution between Mexican routes and Colombian cocaine in the production process, scarcity raises the total value of routes and the violence associated with their control.

[14] The relevant value in our model is the short-run elasticity of demand, which is smaller than that over the long run (see Becker and Murphy (1988)). Early papers found inelastic demands mainly for marijuana and heroin (Nisbet and Vakil, 1972; Roumasset and Hadreas, 1977; Silverman and Spruill, 1977). Wasserman et al. (1991) and Becker et al. (1994) find demand elasticities between -0.4 and -0.75 for cigarette consumption over the short run. In the case of cocaine, results in more recent studies, too, are consistent with an inelastic demand. See, for instance, Bachman et al. (1990), DiNardo (1993) and Saffer and Chaloupka (1999).

There should also be a differential effect in places that are more relevant for the drug trade (where s_i is higher). In our empirical application, we focus on distance from the US as a measure of s_i: since the objective of cartels is to take drugs across the border, places that are close to it have more valuable routes and thus command a larger share of the drug trade. The violence spikes caused by cocaine seizures in Colombia should be stronger close to the US.

Our model also predicts differential effects that depend on the number of cartels present in a municipality. Because violence results from disputes among cartels, our model suggests that scarcity only raises violence in municipalities that are contested by two or more cartels; there should be no effect in municipalities controlled by a single cartel or where no cartels operate. Our model also suggests that supply shortages generate more violence in municipalities where cartel leaders are killed or arrested more frequently. As shown by Dell (2015), because the policies of Calderón and PAN of beheading cartels by killing or arresting their leaders required the cooperation of local authorities, crackdowns against the cocaine trade were more recurrent in municipalities that elected PAN mayors. Thus, we also expect supply shortages to have a larger impact on cartel violence in municipalities that have a strong PAN support, as these are more likely to elect PAN mayors and support their federal anti-drug policies[15]

4 Empirical evidence and data

4.1 Data

We focus on the period from December 2006 to December 2010, which is the period for which drug-related homicide data is available. This coincides with the period of violence and intense cartel activity in Mexico known as the Mexican Drug War. This period also coincides with Calderón's term, which allows us to study the interaction between his policies and scarcity created by seizures in Colombia.

We use a monthly panel of all 2,457 Mexican municipalities (which include 16 boroughs in Mexico City) from December 2006 to December 2010. Our dependent variables are different measures of the monthly homicide rate in each municipality. Our main variable of interest is the monthly homicide rate per 100,000 inhabitants from INEGI (Mexico's

[15]A simple cross-sectional regression shows that a 10% increase in the historical PAN vote share increases the likelihood of electing a PAN mayor during our period of analysis by 7.4%. Also, incumbents in these places may be under more pressure from their electorate to cooperate with PAN's national policies.

Instituto Nacional de Estadística y Geografía, which includes all reported homicides. We also use data on drug-related homicides published by the Mexican Presidency, which only counts homicides related to the illegal drug trade. This dataset further classifies homicides into (1) *assassinations of cartel members*, which involve targeted killings of cartel members by competing cartels, (2) *confrontation deaths*, which are the result of battles either between competing cartels or between cartels and government authorities, and (3) *assassinations of government officials*, which are the result of cartels attacking government forces.[16]

We explore the effect of scarcity on violence and how it is mediated by the relative importance of trafficking, the number of cartels, and the political power of the PAN party. We use proximity to the US border as our proxy for trafficking importance. We compute it as the geodesic distance from the centroid of each municipality to the closest US entry point. Using the data compiled by Coscia and Ríos (2012), we construct dummies for the presence of cartels in all municipalities, for the presence of at least two cartels, and for the presence of at least two non-allied cartels (using the alliances described in Guerrero, 2011b).[17] Finally, to explore heterogeneity with respect to PAN political power, we compute the average voting share for PAN candidates in municipal elections from 1980 to 2000. Because of data limitations, this measure is only available for 1,998 of the municipalities in our sample.

Table 1 summarizes our main data. It presents statistics for all of Mexico (where the average distance from the US is 763 km), for municipalities in the two quintiles closest to the US (average distance 507 km), and for municipalities in the closest quintile (average distance 333 km). The Mexican population is concentrated in the north: The first quintile includes 25% of the national population, while the second quintile includes 35%.

While homicide rates were similar across the Mexican territory in 2006, the north of Mexico (quintiles 1 and 2) became more violent than other parts of the country in recent years, a difference that was driven by a large increase in drug-related homicides in the North. Consistent with the intuition that the north of Mexico is more important for cocaine trafficking, the data shows that the vast majority of homicides in the north are

[16] The Mexican Presidency labeled these homicide categories as (1) executions, (2) confrontations, and (3) aggressions. Although coming from an official source, the classification of homicides as drug-related and into these categories has been criticized (Lizárraga, 2012; Proceso, 2012).

[17] Their data codes whether every major cartel operated in a given municipality in a given year. The cartels included are: Cartel de los Hermanos Beltrán Leyva, Familia Michoacana, Cartel del Golfo, Cartel de Juárez, Cartel de Sinaloa, Cartel de Tijuana and Los Zetas. The data is available from Michelle Coscia's website: `http://www.michelecoscia.com/?page_id=1032`

drug related, whereas homicides in other areas of the country are less so. There also is more cartel activity in quintiles 1 and 2 than in the country as a whole. In 2010, cartels were active in 40% of the municipalities in the first two distance quintiles and in 29% of all Mexican municipalities. Finally, northern municipalities are slightly more supportive of PAN historically, but these differences are not significant.

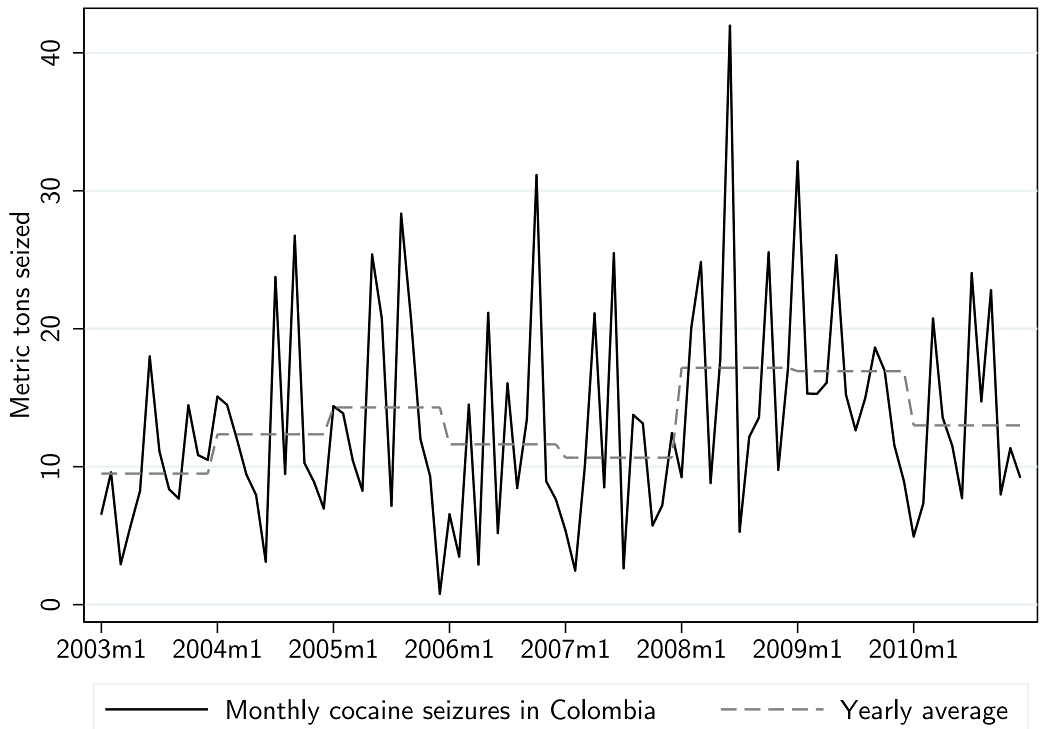

FIGURE 3: Monthly cocaine seizures in Colombia for the 2003-2010 period. The dashed line presents yearly averages.

Our variation in scarcity comes from monthly changes in cocaine seizures by Colombian authorities.[18] The high-frequency series on cocaine seizures comes from the Colombian Ministry of Defense. Figure 3 presents the monthly series for seizures, as well as yearly averages.

[18] We also construct a series for the monthly cocaine supply net of seizures in Colombia, and we use it directly as a measure of the supply of drugs reaching Mexico. However, this methodology requires interpolating annual production figures (there is no information on monthly production). Because our estimates only exploit high-frequency changes, the variation that we exploit in this alternative exercise is fully driven by changes in seizures. The obtained results are very similar to the ones reported here.

4.2 Time series evidence

We start by providing evidence in favor of the main prediction in proposition 1, namely that violence increases in Mexico when cocaine becomes scarce due to higher cocaine seizures in Colombia.

We study the time series effect of supply shocks on violence by estimating the following model

$$\ln h_t = \beta \ln S_t + F_t(\gamma) + \varepsilon_t. \tag{3}$$

Time runs at the monthly frequency from December 2006 ($t = 0$) to December 2010 ($t = 48$). h_t is the homicide rate in Mexico, and S_t are cocaine seizures in Colombia. The term $F_t(\gamma) = \sum_{n=0}^{3} \gamma_n t^n + \eta_y$ includes both a cubic polynomial and year dummies to control flexibly for time trends. It thus absorbs any low-frequency relations or secular trends that could confound our estimates. For instance, the effect we measure is not related to the upward trends in seizures in Colombia and crackdowns in Mexico that started in 2006 with president Calderón. Finally, ε_t is an error term. Our standard errors are robust to heteroskedasticity, but we assume there is no serial correlation in the error term. Appendix C shows that there is no serial correlation in the high frequency variation in homicides or seizures and that both series are stationary. This justifies the use of standard inference and allows us to safely ignore more complicated dynamics in our models.

We interpret β as the effect of supply reductions in Colombia on violence in Mexico, which according to our model should be positive if demand is inelastic. The effect of cocaine seizures in Colombia is identified only from the remaining high-frequency variation, which we plot in figure 4. We treat the resulting high-frequency variation of seizures in Colombia as an exogenous shock to supply, Q^s. The variation is considerable. The standard deviation in monthly seizures is 8 metric tons, which is high relative to the 40 metric tons of cocaine that Colombia produced per month during the period we analyze. Thus, changes in Colombian seizures produce significant shortages of cocaine in downstream markets, especially over short periods of time when other source countries cannot fill this gap. We believe that this monthly variation is determined mostly by chance—for example, by whether an interdiction operation is successful or unsuccessful, and by factors exogenous to Mexico like politics or funding in Colombia. We maintain this assumption throughout and discuss some potential challenges to our interpretation after presenting our results.

We present estimates of equation 3 in Table 2. Each panel has a different dependent

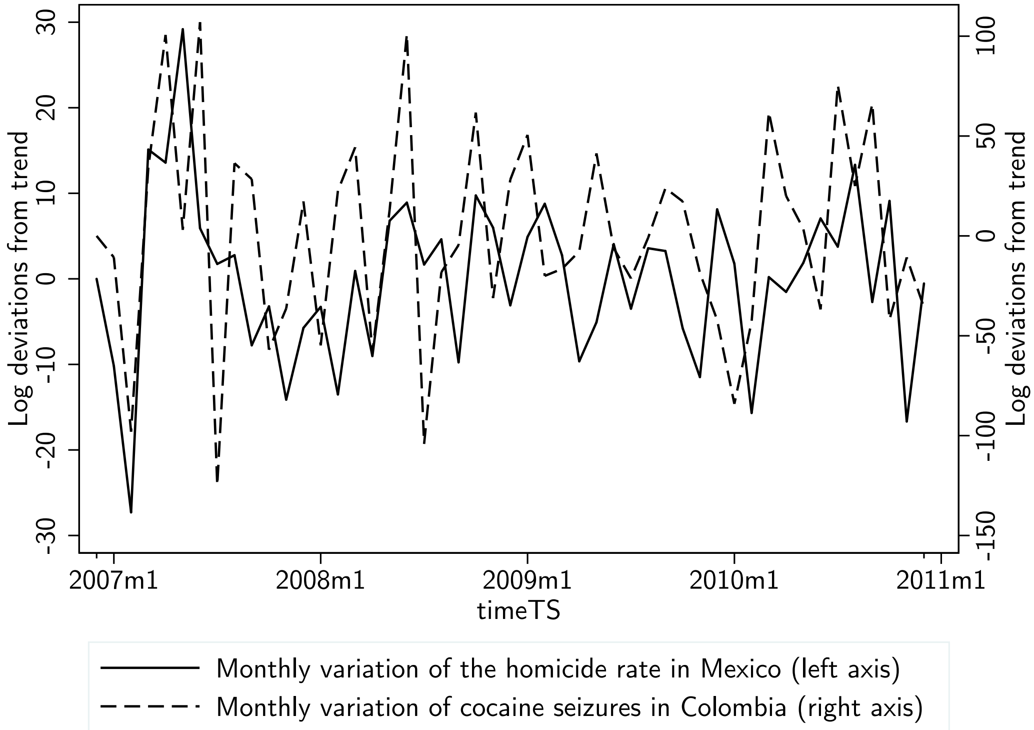

FIGURE 4: Log monthly deviations of cocaine seizures in Colombia from the trend (right axis, dotted line), and log monthly deviations of the homicide rate in Mexico from the trend (left axis, solid line).

variable. In columns 1 to 3, we focus on the homicide rate in all Mexican municipalities. In columns 4 to 6 we focus on the homicide rate in municipalities in quintiles 1 and 2 of proximity to the US, while in columns 7 to 9 we focus on the homicide rate in municipalities in the first quintile of proximity to the US.

Our estimates in columns 1, 4, and 7 of the top panel suggest that a 10% increase in monthly seizures in Colombia raises homicides in Mexico by 0.59% (standard error=0.27%), by 0.82% in municipalities in quintiles 1 and 2 (s.e=0.33%), and by 1.19% in municipalities in the first quintile (s.e=0.33%). In the remaining panels we document a larger increase in drug-related homicides that is driven by assassinations of cartel members and confrontation deaths (though the effect on confrontation deaths is not precisely estimated). We do not find any effect on assassinations of government officials (the effect is small but imprecise). These deaths are unrelated to the conflict between cartels, which we view as supportive of the emphasis on inter-cartel violence in our model.

In columns 2, 5, and 8 we include two monthly controls for all of Mexico, the unemployment rate and a measure of economic activity, the *Índice Global de Actividad*

Económica (IGAE). Although these controls might be endogenous and we prefer our estimates without them, it is reassuring to see that our estimates do not change with their inclusion. Finally, in columns 3, 6, and 9 we control for Mexican weather seasons, which include a dummy for months during the rainy season and dummies for months during the hurricane season. Alhough our estimates are less precise in these cases, the point estimates remain roughly unchanged. These exercises suggest that the estimated effects are not driven by the Mexican business cycle or by seasonality.

In Table 3 we explore in more detail the timing of the uncovered effects by estimating variants of equation (3) with the homicide rate as dependent variable. In column 1 we add three lags of the homicide rate as explanatory variables. These lags are not significant and they do not affect the estimate of our coefficient of interest. Columns 2 to 4 explore the timing of the effects by adding lags and leads of seizures in Colombia. Contemporary seizures in Colombia have the strongest effect on violence, but the effect vanishes quickly and only lasts for an additional month in some specifications. We do not find any significant effect of future Cocaine seizures in Colombia on Mexican violence. This is evidence that seizures in Colombia do not react to lagged market conditions in Mexico and that supply shocks are not anticipated. Columns 5 to 12 present similar estimates that focus on the homicide rate in the north of Mexico and reveal the same patterns.

We also present the response in time of violence to supply shocks in event-study figures. We estimate equation (3), including six lags and six leads of $\ln S_t$. Figure 5 plots the estimated coefficients for the homicide rate in all of Mexico, for the homicide rate in the first two quintiles of proximity to the US, and for the first quintile. The homicide rate quickly rises during a cocaine shortage and then reverts back to its pre-shock level with some small persistence (although individual coefficients are less precisely estimated in this exercise).

To illustrate the quantitative implications of our estimates, we compute the effect of the sharp reduction in the Colombian supply of cocaine from 2006 to 2009 on violence in Mexico. Our calculation requires two assumptions. First, we assume that short-run shocks and persistent supply shocks have the same effect on violence.[19] Second, we assume

[19]This is only a suggestive calculation; in practice there are reasons why short-run and permanent shocks may have different effects. On the one hand, the possibility of storage implies larger effects from persistent shocks. On the other hand, the possibility that cocaine can be substituted from other source countries implies smaller effects from persistent shocks. Likewise, our theoretical discussion highlights the fact that temporary shocks have a larger effect than permanent ones. The reason is that a temporal shortage that is soon reversed implies large revenues today and low revenues tomorrow, which makes

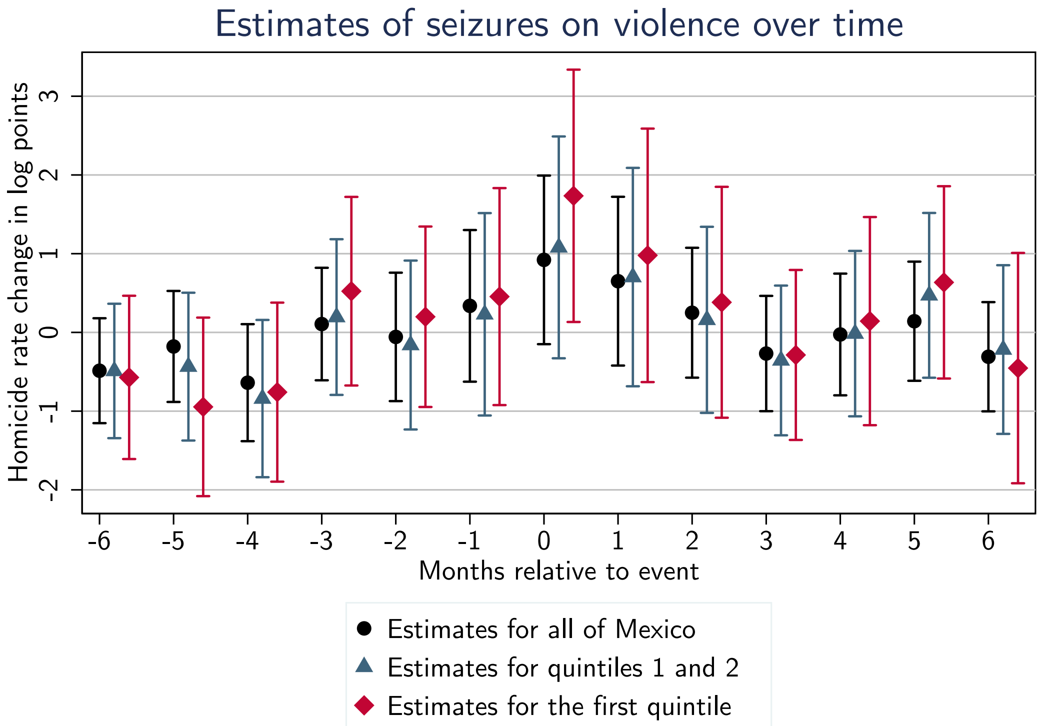

FIGURE 5: Response of the homicide rate in Mexican municipalities at different distances from the US to a 10% increase in cocaine seizures in Colombia. The bars around each estimate represent a 95% confidence interval.

that seizures in Colombia only affect violence through their effect on the net Colombian supply of drugs—an exclusion restriction. Both assumptions imply that β is the effect of a persistent reduction in the supply of Colombian cocaine by 1%.

Between 2006 and 2009, the cocaine supply from Colombia fell by 95.6 log points (from 520 mt to 200 mt). Most of the reduction was triggered by an increase in seizures, although coca cultivation and potential cocaine production also fell. We use the results in columns 1, 4 and 9 in the top panel of Table 2 and the estimates in columns 4, 8 and 12 of Table 3. Our estimates imply that this reduction increased the homicide rate by 5.6-8.7 log points in all of Mexico, which corresponds to about 10%-15% of the increase experienced during this period. They also imply that scarcity in Colombia increased the homicide rate in quintiles 1 and 2 of Mexico by 7.8-10.1 log points, and by 11.37-15.4 log points in the first quintile of proximity to the US. This also accounts for 10% to 15% of the increase in violence during this period in both regions.

future punishment less severe. In contrast, permanent shocks also raise the deterrence power of future punishment, and so they raise violence less.

4.3 Heterogeneity by proximity to the US

We now investigate the prediction in proposition 1 that the effect of shortages on violence is greater in municipalities that are more important for the cocaine trade. We use distance from US entry points as a proxy for the importance for trafficking. The main reason for this is that, unlike heroin or cannabis, cocaine is not produced in Mexico, and internal consumption of cocaine is minor when compared to revenue from exports to the US (see Kilmer et al., 2010). Thus, municipalities close to the US border have a major strategic advantage. As shown in table 1, drug-related violence and cartel presence are concentrated in the North of Mexico, which suggests that these are the places that command a greater share of the drug trade.

To illustrate the heterogeneity in the response to seizures in Colombia as a function of distance to the US, we estimate the time series equation (3) for groups of municipalities in 901 moving windows of distance to the US, each one of which comprises 10 percent of the municipalities. Figure 6 plots the estimated effects. Near the US border, a 10% increase in cocaine seizures causes a 1.6% increase in violence. The effect vanishes gradually as we move away from the US frontier, and there is no consistent impact of cocaine shortages on violence in the South of Mexico.

We next examine the evidence in more detail using a regression framework. Let p_i be proximity, or the negative distance in kilometers from municipality i to the US nearest entry point. We are interested in explaining the expected homicide rate in municipality i during month t, $h_{i,t}$, as a function of municipality fixed effects, time effects, and the interaction $p_i \times \ln S_t$.

We present two types of estimates. First, we estimate a Poisson fixed effects model as in Hausman et al. (1984) and Wooldridge (1999), which assumes the following conditional expectation for the homicide rate:

$$\mathbb{E}h_{i,t} = \delta_i \alpha_t \exp\left(\beta p_i \times \ln S_t + p_i \times F_t(\gamma)\right). \tag{4}$$

Coefficients α_t and δ_i fully control for monthly changes that are common across Mexico and for municipality invariant characteristics.[20]

[20] The Poisson model has several advantages (see Wooldridge, 2010, chapter 18). First, it is designed for applications that have non-negative dependent variables with large dispersion, like homicide rates. Second, it is consistent under very general distributional assumptions. Third, it does not suffer from the incidental parameters problem, which allows us to control for municipality fixed effects directly. We also experimented with negative binomial models and had similar results. In this alternative exercise, instead of controlling for fixed effects, we use as controls a wide range of municipality characteristics.

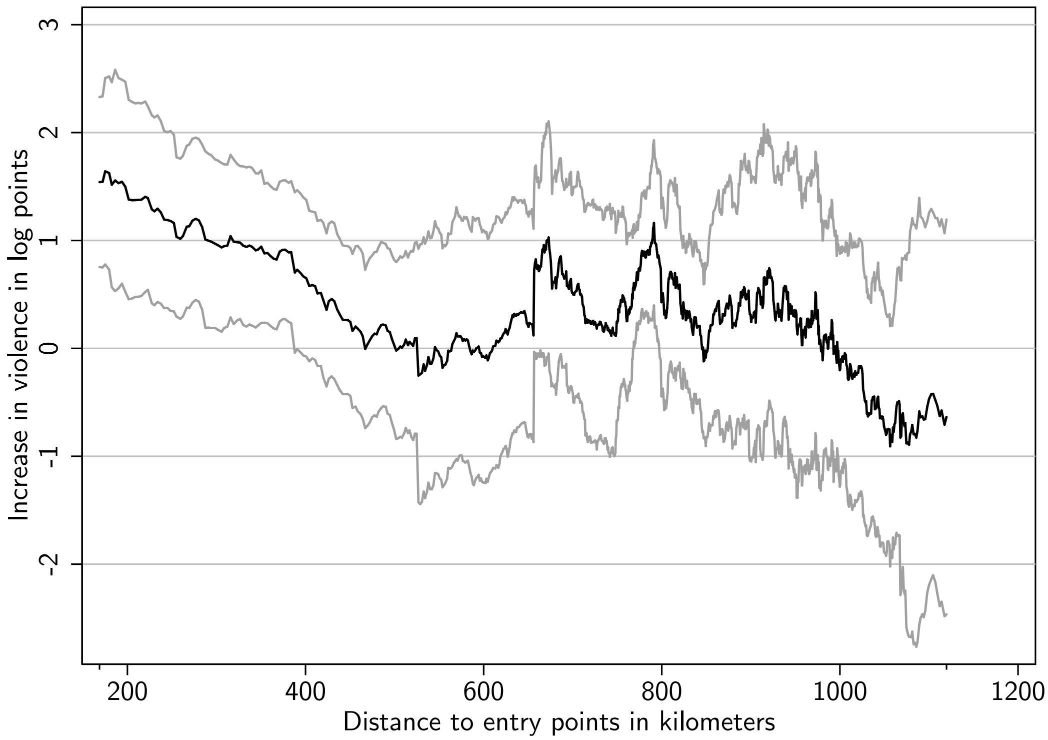

FIGURE 6: Response of the homicide rate in Mexican municipalities to a 10% increase in cocaine seizures in Colombia as a function of their distance to the US border. The black line indicates our estimates and the gray lines 95% confidence intervals.

Second, we also estimate the following simpler linear model

$$\mathbb{E}\ln(h_{i,t}+r)=\delta_i+\alpha_t+\beta p_i\times\ln S_t+p_i\times F_t(\gamma). \tag{5}$$

The left-hand side is a monotone transformation of the homicide rate that deals with the large dispersion in homicide rates and is well defined at zero. The constant $r>0$ is the 90th percentile of the homicide rate in our sample. We choose this particular value for r because the estimated residuals resemble a normal distribution, suggesting that the transformation adequately removes the skewness of homicide rates.[21] The transformed value is approximately equal to $\frac{h_{i,t}+r}{h_{i,t}}\ln h_{i,t}$, so the estimates can be interpreted as elasticities after multiplying them by the sample average of $\frac{h_{i,t}+r}{h_{i,t}}$. To ease the interpretation of our findings, we report estimates obtained after this normalization.

[21] We also experiment with different values of r and obtain similar results. In particular, we set r equal to different moments of the homicide rates distribution, including its minimum positive value, 10th, and 50th percentile. We also obtain similar results when we use the level of the homicide rate as the dependent variable. To save space these results are not presented here.

We compute standard errors that are robust to heteroskedasticity and serial correlation within municipalities. We assume there is no spatial correlation left in the error term for the estimates presented in the main text. Time effects already take into account aggregate shocks, and although there may be correlated shocks, we believe that the differential trends by distance already take into account the bulk of the spatial correlation in violence. The online appendix shows that we obtain similar results when we compute standard errors for our estimates of equation (5) that allow for several forms of spatial correlation, as in Conley (1999) and Conley (2008).

In both models β captures the additional impact of cocaine seizures in Colombia on violence in municipalities located 100 km closer to the US border. Because the term $p_i \times F_t(\gamma)$ flexibly controls for differential trends in Mexico's North, β is identified by comparing how high-frequency changes in Colombian seizures generate spurs in violence for municipalities at different proximities to the US.

Table 4 presents our results, both for municipalities in all of Mexico (columns 1 to 4) and for those in distance quintiles 1 and 2 (columns 5 to 8). The dependent variable in the top panel is the homicide rate. According to the Poisson estimates from column 1, being 100 km closer to the US implies an additional 0.31% (s.e=0.11) increase in homicide rates in response to a 10% increase in seizures in Colombia. [22] In column 2 (and the remaining even columns) we control for differential time trends in municipalities that different levels of historical PAN support, which captures the stronger deployment of Calderón's anti-drug policies in areas where the PAN had more political power. The inclusion of these controls does not change our results.[23]

In columns 3 and 4 we estimate the model in equation 5. A Mexican municipality 100 km closer to the US experiences an additional 0.14% (s.e=0.04) increase in the homicide rate in response to a 10% increase in seizures in Colombia. In columns 5 to 8 we estimate the models in columns 1 to 4 but restrict the sample to municipalities in quintiles 1 and 2 of distance from the US border. We still find a positive and significant interaction that is consistent with the results in the previous columns but is somewhat larger.

The second panel presents results using the drug-related homicide rate as the dependent variable. We find again that seizures in Colombia have a stronger effect on Mexican

[22] The Poisson model drops municipalities with no homicides during our period of analysis, which is the reason why we have fewer observations in columns 1 and 2 than in columns 3 and 4.

[23] We obtain very similar results (not shown here) using the presence of a PAN mayor as a control. Although this control is endogenous, it shows that our estimates are not driven by the election of PAN mayors during Calderón's administration. Because our measure of historical PAN support is missing for some municipalities, the models that control for these variables have fewer observations.

drug-related violence as one moves closer to US entry points. The bottom panels show that, in line with our time series results from Table 2, the differential effect on drug-related homicides in Mexico's North is driven by assassinations of cartel members and confrontation deaths. As before, we find no effects of scarcity on the assassination of government officials.

Our results indicate that the scarcity created by seizures in Colombia contributed to the sharp increase in violence in the north of Mexico relative to the rest of the country. The estimate in column 5 of the top panel implies that the scarcity created by Colombian policies from 2006 to 2009 could explain up to 31 log points of the differential increase in homicides in the north of Mexico relative to the average municipality. This corresponds to roughly 25% of the 128 log point differential increase in violence in the north of Mexico during this period.

4.4 The role of cartels and Mexican policies

In this section we investigate whether the presence of cartels and Mexican anti-drug policies exacerbates the negative consequences of scarcity in cocaine markets. For our analysis, we use the homicide rate as our preferred measure of violence.

We begin by estimating equation 3 separately for the homicide rate in municipalities that have no cartels, one cartel, and at least two cartels, and where there are at least two cartels that are not allies. Figure 7—constructed in the same way as Figure 5—depicts the estimated change over time in the homicide rate following a 10% increase in cocaine seizures in Colombia at month zero. In line with our model, cocaine seizures in Colombia do not have a significant effect on violence in Mexican municipalities that have zero or a single cartel. In contrast, at the time of the cocaine shortage, homicides rise in Mexican municipalities that have at least two cartels present, or that have at least two non-allied cartels.

We also estimate equation 3 for the homicide rate in municipalities that have a historical PAN vote share above and below 28%, which we refer to as high and low PAN support municipalities, respectively. The 28% threshold corresponds to the average PAN vote share in local elections between 1980 and 2000, but our results are robust to using different thresholds. Figure 8 depicts the estimated change over time in the homicide rate following a 10% increase in cocaine seizures in Colombia at month zero. Scarcity has a minor effect on violence in the sample of Mexican municipalities that have low PAN support, which is not significant. In contrast, though not precisely estimated, we find that scarcity has a larger effect on violence in the sample of Mexican municipalities that

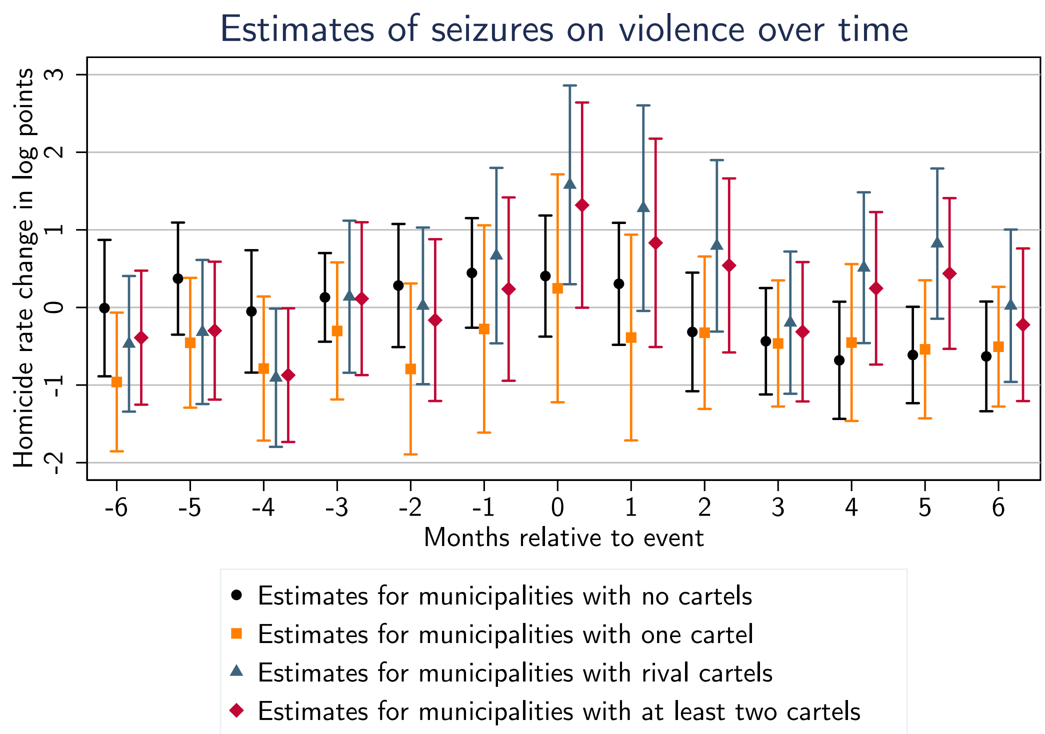

FIGURE 7: Response of the homicide rate in Mexican municipalities that have different numbers of cartels to a 10% increase in cocaine seizures in Colombia. The bars represent 95% confidence intervals.

have high PAN support.

Table 5 summarizes the results from Figures 7 and 8. The left panel (columns 1 to 8) presents our time-series estimates for the homicide rate in Mexican municipalities that have different numbers of cartels. The right panel (columns 9 to 12) presents our time-series estimates for the homicide rate in Mexican municipalities that have different levels of historical PAN support. For each set of municipalities—indicated at the column headers— we present two estimates of equation (3): our baseline specification and one that controls for the dynamics of homicide rates by adding lags of the dependent variable (presented in the even columns).

To simultaneously test if the differences in the time-series responses uncovered above are significant, we estimate extensions of equations (4) and (5) that allow cocaine seizures in Colombia to affect the homicide rate differently in Mexican municipalities that have no, one, or several cartels, and in municipalities that have a low or high PAN support. Let DTO_{iy} be a vector of variables related to cartel presence in municipality i during year y. This vector includes a dummy for the presence of at least one cartel, a dummy

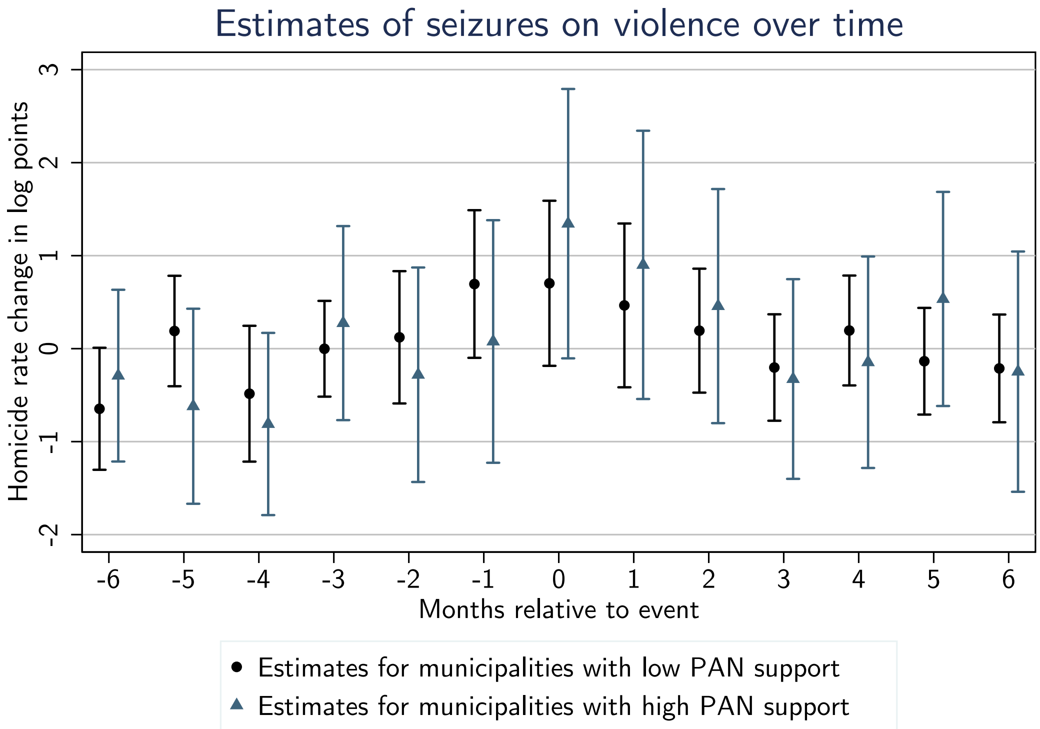

FIGURE 8: Response of the homicide rate in Mexican municipalities that have different levels of PAN support to a 10% increase in cocaine seizures in Colombia. The bars represent 95% confidence intervals.

for two or more cartels, and a dummy for the presence of at least two non-allied cartels. Also, let PAN_i be a dummy for high PAN support. We estimate equations 4 and 5 by adding interactions of $\ln S_t$ and $p_i \times \ln S_t$ with DTO_{iy} and PAN_i. To guarantee that we only exploit the high-frequency variation in cocaine shortages and homicides to identify these interactions, we also include a full set of differential time trends of the form $DTO_{i,y} \times F_t(\gamma_1)$, $p_i \times DTO_{i,y} \times F_t(\gamma_2)$, $PAN_i \times F_t(\gamma_3)$, $p_i \times PAN_i \times F_t(\gamma_4)$. These trends control for different time trends in municipalities that have a different number of cartels, or in municipalities that have different historical support for the PAN party, both in the south and the North of Mexico.

Table 6 presents the results from this exercise. Columns 1 to 3 present the Poisson estimates (equation 4), while columns 4 to 6 present the results from the linear model that have the transformed homicide rate as the dependent variable (equation 5). The top panel presents results using all Mexican municipalities, while the bottom panel restricts the sample to those in the first two distance quintiles. All main effects and double interactions are evaluated at border municipalities that have no cartel presence and low PAN support.

The results in columns 1 and 4 suggest that in areas that have no cartels and low PAN support there is neither an effect of cocaine shortages on violence nor a differential effect of cocaine shortages on municipalities that are closer to the US border. Thus, all the effects we have uncovered so far are driven by violence that is a response to cocaine shortages in municipalities that have some cartels and/or high PAN support. In fact, the estimates in columns 1 and 4 reveal that supply shortages do increase violence when cartels are present (although this effect is not precisely estimated), and this is especially the case in the north, as the triple interaction term indicates.

In the remaining columns we delve into the role of cartels. The estimates in columns 2, 3, 5, and 6 show that there is no effect of scarcity on violence in municipalities controlled by a single cartel, not even in the North of Mexico. On the other hand, as the interaction terms for municipalities that have several or rival cartels indicate, scarcity has a significant impact on violence in Mexican municipalities contested by rival or several cartels, especially for those in the North of Mexico (as indicated by the triple interactions). To illustrate our findings, consider the estimates in column 6. A 10% increase in cocaine seizures in Colombia raises violence by 2.42% more in municipalities with two cartels than in municipalities with a single cartel (standard error=0.93%). This gap narrows by 0.3% as we get 100 km further away from the US frontier, which implies that cartels had a more detrimental effect on the response of violence to scarcity in the North.

As predicted by proposition 2, our estimates suggest that cocaine seizures in Colombia have a larger effect on violence in municipalities that have high PAN support than in municipalities that have low PAN support. The estimates in column 6 reveal that a 10% increase in Colombian seizures raises violence by 1.64% more in municipalities in the north of Mexico that have high PAN support than in municipalities that have low PAN support (standard error=0.76). Moreover, the triple interaction term indicates that this gap narrows by 0.19% as we get 100 km further away from the US frontier. Although it is not very precise, this triple interaction indicates that PAN policies had a more detrimental effect on the response of violence to scarcity in the North of Mexico.

To get a sense of the quantitative implications of these results, consider the case of two border municipalities near US entry points that have different historical PAN support: Ciudad Juarez (Chihuahua) and Nueva Laredo (Tamaulipas). The historical voting for PAN in Ciudad Juarez was about 44%, whereas it was 14% in Nueva Laredo. A reduction in the supply of cocaine of 95.6 log points (as was observed between 2006-2009), would cause a differential increase of 15 to 30 log points in homicides in Ciudad Juarez relative to Nueva Laredo (using the estimates in column 3 or 6 of the top panel). During this period, homicides fell in Nueva Laredo by 23.4 log points and increased by 236.9 log points in Ciudad Juarez. The interaction between the decline in the net supply of cocaine and greater PAN support in Ciudad Juarez might explain 5% to 10% of this differential increase in homicides.

The evidence in this section supports the possibility that, starting in 2006, Calderón's policies and the expansion of Mexican cartels provided a dangerous blend that amplified the response of violence in Mexico to cocaine shortages generated in Colombia. From 2006 to 2010, the percentage of municipalities that have multiple cartels increased from 5% to 17%. Before 2006, there were fewer and isolated cartels, and informal arrangements among cartel leaders presumably kept violence and rapacity low or prevented them altogether. After 2006 there was a very different environment: fragmented cartels contested several key locations, especially in the North of Mexico, and the policy of beheading cartel leaders may have fueled conflict and division among cartels.[24] Our model and evidence indicate that it is in this environment that the scarcity generated by Colombian anti-drug policies contributed to the increase of violence in Mexico.

4.5 Is scarcity (and the price effect it brings) the right channel?

We have documented that cocaine seizures in Colombia are associated with large spikes of violence in Mexico at a monthly frequency. We argued in our theoretical model that this occurs through an increase in cocaine revenues, which is the case so long as demand is inelastic. Our interpretation relies on three key assumptions, which we now discuss.

The first assumption is that the high-frequency changes in seizures generate scarcity; they cannot simply reflect a response to changes in Colombian production or downstream market conditions. This would be the case if, for instance, increases in productivity in Colombia mechanically drove up seizures. If such changes in productivity were driving the variation in seizures, then abundance, not scarcity, would generate violence. Something similar would happen if demand shocks increased prices and seizures in upstream markets such as Colombia, creating a correlation between seizures in Colombia and violence in Mexico through a mechanism that is different from the one we explore.

We do not believe that these concerns confound our interpretation. As Figure 9 shows, estimates of variants of equation (3) reveal that there is no high-frequency relationship between seizures and other anti-drug policies in Colombia. Seizures of chemical precursors, interdiction of solid inputs, and the destruction of cocaine labs do not increase during

[24] In line with this view, we find that when we re-estimate equation (3) for all of the period of 2003-2010, the negative supply shocks only had a significant and robust effect on violence during Calderón's term.

months in which the Colombian government seizes large quantities of cocaine. This finding suggests that the high-frequency variation in cocaine seizures in Colombia does not simply reflect changes in the cocaine market, since in that case all measures of interdiction policies would respond together and would be correlated.[25]

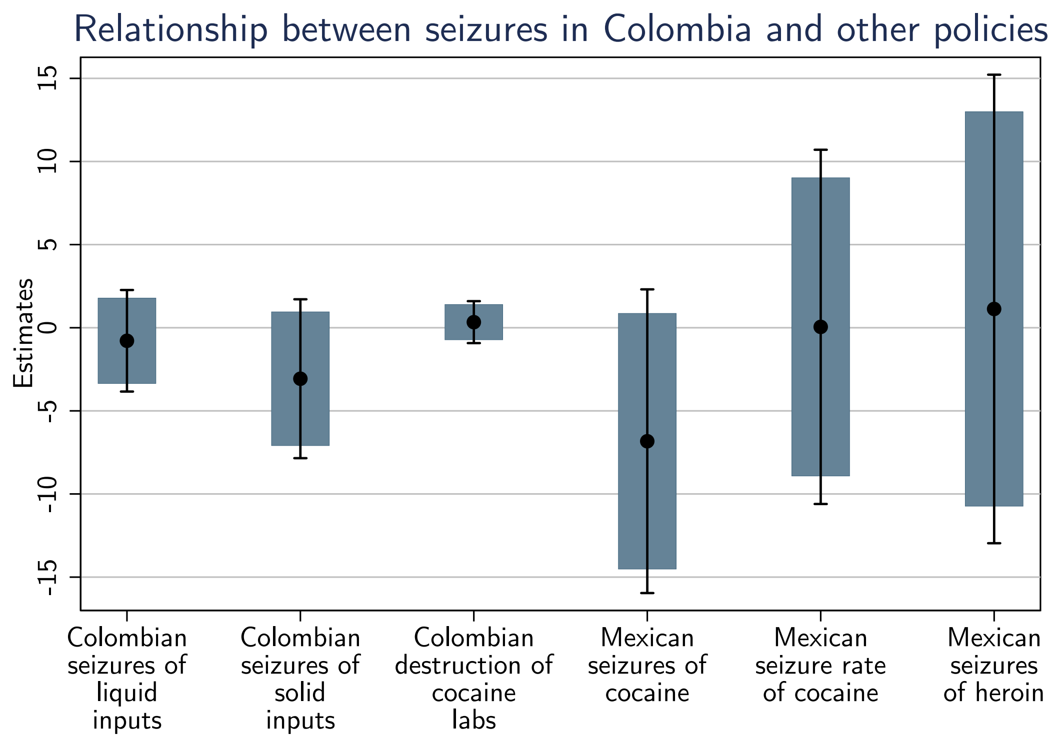

FIGURE 9: Estimates of the high-frequency relationship between a 10% increase in cocaine seizures in Colombia and other anti-drug policies in Colombia and Mexico. The bars around each estimate represent its 90% confidence interval; the capped lines represent its 95% confidence interval.

We also estimate a large and negative elasticity of cocaine seizures in Mexico with respect to high-frequency changes in cocaine seizures in Colombia. Although it is not precisely estimated, this elasticity is telling: a 10% increase in cocaine seizures in Colombia during one month reduces cocaine seizures in Mexico by 6.8% during that month (standard error=4.6), which is a value that roughly corresponds to the share of Andean cocaine supplied by Colombia. This finding suggests that during months in which the supply of

[25]Unfortunately, there are only yearly measures of gross cocaine production and productivity in Colombia. Thus, we cannot directly test if months of high seizures correspond to months of higher temporal productivity or cocaine production. The indirect evidence presented above suggests that this is not the case.

Colombian cocaine turns out to be lower than expected Mexican cartels traffic less cocaine to the US market. At a monthly frequency, cartels do not appear to offset the lack of Colombian cocaine by relying on stored drugs or other suppliers (Peru and Bolivia). This high-frequency relationship is in line with anecdotal evidence that suggests that cocaine trafficking to the US takes place rapidly: once a kilogram of cocaine leaves Colombia, it is sold in U.S. markets and the money sent back to suppliers in about 6 weeks (see Gaviria and Mejia, eds, 2016). Our estimates and the anecdotal evidence support the key assumption that cocaine seizures in Colombia disrupt the cocaine trade downstream and generate significant scarcity, even at a monthly frequency.

The second assumption is that any coincidence in timing between policies or market conditions in Mexico and Colombia breaks down at higher frequencies once we flexibly control for time trends. Otherwise, changes in Mexican policies could confound our estimates. This assumption could fail if there were complementarities in enforcement or cooperation between authorities across countries. Likewise, changes in enforcement or market conditions in Mexico could raise the demand for Colombian cocaine and, hence, cocaine seizures in Colombia.

We do not believe such alternatives explain our findings.[26] The timing of the estimated effects suggests that seizures in Colombia do not react to past violent upsurges in Mexico, which supports our view that seizures in Colombia are not driven by market conditions in Mexico. Additionally, if anti-drug policies in Mexico drove up both violence in Mexico and the demand for Colombian cocaine, one would observe a positive correlation between seizures in both countries, and this is not present in the data. If anything, the opposite holds, as shown in figure 9. Contrary to what these alternative explanations imply, there is no correlation between high-frequency changes in seizures in Colombia and the seizure *rate* of cocaine in Mexico, or other anti-drug actions in Mexico such as heroin seizures.[27]

Additionally, the effects we uncovered are specific to municipalities that have two or more cartels and high PAN support. If market conditions in Mexico affected seizures in

[26]To the best of our knowledge, there was little cooperation between Colombia and Mexico. These countries have joint training programs for their military and police forces, and also share information that is useful for criminal investigations. But joint operations—as the ones performed in cooperation between the US and Colombia—are not common. These observations also suggest that, at high frequencies, enforcement efforts are not mechanically correlated.

[27]We construct the cocaine seizure rate in Mexico as total seizures over the net supply of cocaine flowing out of Colombia. Because we do not observe monthly cocaine production, we interpolate annual production figures to obtain monthly estimates. We then subtract monthly seizures in Colombia to obtain an estimate of the cocaine flowing out of Colombia.

Colombia, one would also observe a spurious correlation between seizures in Colombia and violence in Mexican municipalities that have low PAN support. If there were complementarities in enforcement across countries, one would also observe a spurious correlation between seizures in Colombia and violence in Mexican municipalities that have a single cartel, as operations against this cartel would also induce more seizures in Colombia. Thus, the heterogeneity of the effects we uncovered is consistent with the model and it rules out other potential explanations of our findings.

The third and last key assumption is that cocaine shortages increase revenue, which is theoretically the case so long as the demand for cocaine is inelastic—as the existing evidence suggests. Unfortunately, we cannot measure prices or the amount of cocaine revenue in Mexico on a monthly basis, and this precludes any direct test of this assumption. Instead, we provide some reality checks that suggest that cocaine shortages in Colombia seem to increase cocaine revenues downstream.

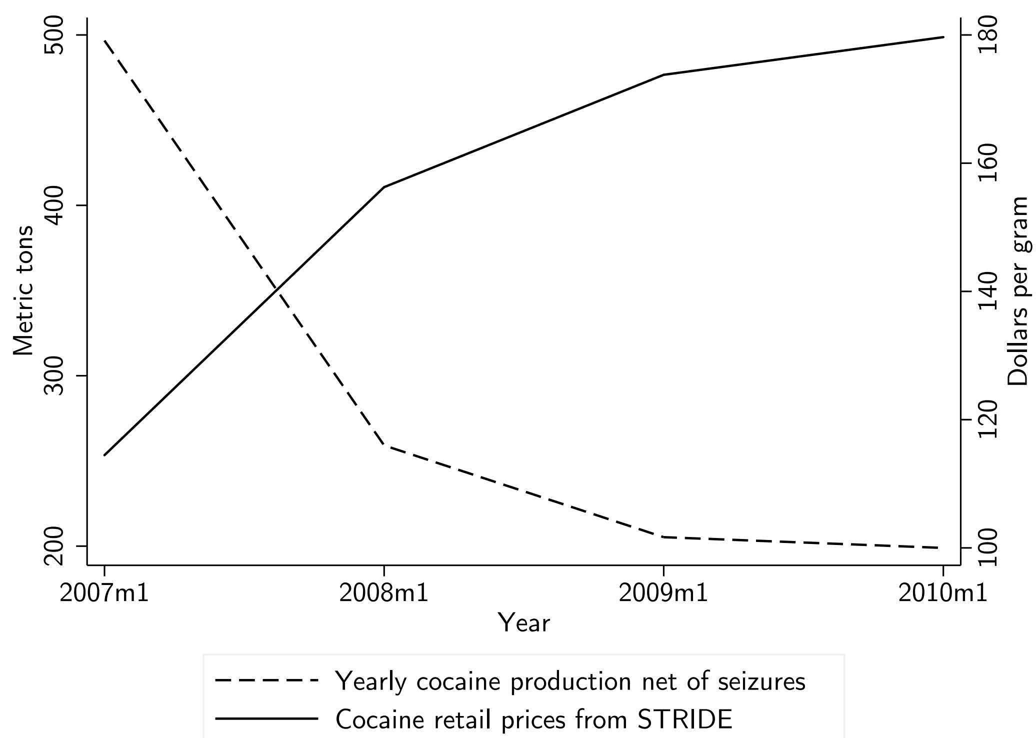

Figure 10: Yearly cocaine production in Colombia net of seizures (left axis) and yearly cocaine prices as reported by STRIDE (right axis). Prices are in dollars per pure gram in wholesale transactions. Production is in hundred metric tons per quarter.

Figure 10 plots retail cocaine prices in the US and the amount of cocaine net of seizures supplied by Colombia. The price data is from STRIDE and the yearly figures are constructed from all purchases of cocaine by undercover agents in the US.[28] The figure shows that cocaine prices increased dramatically from 2007 until 2010 as the supply of Colombian cocaine declined. While net cocaine production in Colombia went down from about 520 MT per year in 2006 to about 200 MT in 2009, the average price per pure gram of cocaine on US streets went up from about $114 in 2006 to about $180 in 2009, and the wholesale price went from $40 to $68 during the same period. Taking into account net production from Peru and Bolivia—which increased from 340 metric tons to 390 metric tons—the total gross drug trade revenue measured using wholesale prices in the US increased from 34 billion to 40 billion dollars—a 15% increase. If we use retail prices we find that between 2006 and 2009, cocaine revenue increased from 98 to 106 billion dollars—a 7% increase. These trends support the possibility that cartels face an inelastic demand, as required by our interpretation.

5 Concluding remarks

Focusing on the case of the Mexican cocaine trade, this paper investigates the role of scarcity as a determinant of violence in markets that lack a centralized authority. A standard conflict model in which cartels dispute unprotected revenue suggests that scarcity increases violence if the demand for cocaine is inelastic. The increase in violence should be larger when there are two or more competing cartels, in locations that are more important for the cocaine trade, and where, because of policies leading to the arrest and killing of cartel leaders, cartels behave more shortsightedly and do not cooperate.

We explore the link between scarcity and violence using monthly data from Mexican municipalities from December 2006 to December 2010. Consistent with the predictions of our model, we find that the scarcity generated by large and temporary increases in cocaine seizures in Colombia increased violence in Mexico, especially at locations close to US entry points. Most of the effect is driven by municipalities that have at least two competing cartels, while there are no effects in municipalities that have one or no cartels. Our evidence supports the view that President Calderón and the PAN's strategy of beheading cartels amplified the effect of scarcity in areas that have high PAN support.

Our results indicate that greater cocaine seizures in Colombia after 2006 raised prices and contributed to the increase in Mexican violence. The sharp decline in the net supply

[28] There is no reliable data on cocaine prices at higher frequencies. While quarterly prices can be constructed using the raw STRIDE data, there are doubts regarding the quality of quarterly variation in these data (Horowitz, 2001; Arkes et al., 2008, see).

of Colombian cocaine from 2006 to 2009 of 95.6 log points may account for 10%-14% of the increase in violence in this period and 25% of the differential increase of violence in the North of Mexico. Our paper documents spillovers from anti-drug policies that transcend national frontiers, and it suggests that, by generating scarcity, anti-drug policies in some Latin American countries may be doing more harm than good—even if the burden is borne by other countries.

Throughout this paper we have emphasized a particular channel from scarcity to violence that is based on the conflict literature and that suggests that cartels use violence to secure the increases in revenue generated by scarcity. There remains the possibility that our channel is not the sole mechanism driving this effect. For instance, it could be that in response to cocaine shortages cartels increase their effort in order to achieve a target level of sales, thereby increasing violence. Also, if cartels cannot perfectly observe seizures, they may confound shortages with wrongdoing on behalf of other cartels or of their members, which could potentially trigger cycles of violence. Our results do not disprove the existence of such mechanisms, which could be explored in more detail in future work.

References

Abreu, Dilip, David Pearce, and Ennio Stacchetti, "Toward a Theory of Discounted Repeated Games with Imperfect Monitoring," *Econometrica*, 1990, *58* (5), 1041–1063.

Acemoglu, Daron, James A. Robinson, and Rafael J. Santos, "The Monopoly of Violence: Evidence from Colombia," *Journal of the European Economic Association*, 2013, *11*, 5–44.

_ , Mikhail Golosov, Aleh Tsyvinski, and Pierre Yared, "A Dynamic Theory of Resource Wars," *The Quarterly Journal of Economics*, 2012, *127* (1), 283–331.

Angrist, Joshua D. and Adriana D. Kugler, "Rural Windfall or a New Resourse Curse? Coca, Income and Civil Conflict in Colombia," *The Review of Economics and Statistics*, 2008, *90* (2), 191–215.

Arkes, Jeremy, Rosalie Liccardo Pacula, Susan M. Paddock, Jonathan P. Caulkins, and Peter Reuter, "Why the DEA STRIDE Data are Still Useful for Understanding Drug Markets," *NBER Working Paper No. 14224*, 2008.

Bachman, Jerald G., Lloyd D. Johnston, and Patrick M. O'Malley, "Explaining the Recent Decline in Cocaine Use among Young Adults: Further Evidence That Perceived Risks and Disapproval Lead to Reduced Drug Use," *Journal of Health and Social Behavior*, 1990, *31* (2), 173–184.

Becker, Gary S., "Crime and Punishment: An Economic Approach," *Journal of Political Economy*, 1968, *76* (2), 169–217.

_ and Kevin M. Murphy, "A Theory of Rational Addiction," *Journal of Political Economy*, 1988, *96* (4), 675–700.

_ , _ , and Michael Grossman, "The Market for Illegal Goods: The Case of Drugs," *Journal of Political Economy*, 2006, *114* (1), 38–60.

_ , Michael Grossman, and Kevin M. Murphy, "An Empirical Analysis of Cigarette Addiction," *The American Economic Review*, 1994, *84* (3), 396–418.

Bó, Ernesto Dal and Pedro Dal Bó, "Workers, warriors, and criminals: social conflict in general equilibrium," *Journal of the European Economic Association*, 2011, *9* (4), 646–677.

Brückner, Markus and Antonio Ciccone, "International Commodity Prices, Growth and the Outbreak of Civil War in Sub-Saharan Africa," *The Economic Journal*, 2010, *120*, 519–534.

Buonanno, Paolo, Ruben Durante, Giovanni Prarolo, and Paolo Vanin, "Poor Institutions, Rich Mines: Resource Curse in the Origins of the Sicilian Mafia," *The Economic Journal*, 2015, *125* (586), F175–F202.

Calderón, Gabriela, Gustavo Robles, Alberto Díaz-Cayeros, and Beatriz Magaloni, "The Beheading of Criminal Organizations and the Dynamics of Violence in Mexico's Drug War," *Journal of Conflict Resolution*, 2015, *59* (8), 1455–1485.

Castillo, Juan Camilo, "Cartel Warfare, Drug Supply, and Policy," *Working Paper*, 2015.

Chimeli, Ariaster B. and Rodrigo R. Soares, "The Use of Violence in Illegal Markets: Evidence from Mahogany Trade in the Brazilian Amazon," *IZA Discussion Paper No. 5923*, 2011.

Collier, Paul and Anke Hoeffler, "Greed and Grievance in Civil War," *Oxford Economic Papers*, 2004, *56* (4), 563–595.

Conley, T.G., "GMM estimation with cross sectional dependence," *Journal of Econometrics*, 1999, *92* (1), 1 – 45.

Conley, Timothy G., "Spatial Econometrics," in Steven N. Durlauf and Lawrence E. Blume, eds., *The New Palgrave Dictionary of Economics*, Basingstoke: Palgrave Macmillan, 2008.

Coscia, Michele and Viridiana Ríos, "Knowing Where and How Criminal Organizations Operate Using Google," in "CIKM 2012" Maui, HI, USA October 29-November 2 2012.

Couttenier, Mathieu, Pauline Grosjean, and Marc Sangnier, "The Wild West is Wild: The Homicide Resource Course," *Forthcoming, Journal of the European Economic Association*, 2016.

Crawford, Neta C., "Civilian Death and Injury in Afghanistan, 2001-2011," *Boston University*, 2011.

Dell, Melissa, "Trafficking Networks and the Mexican Drug War," *American Economic Review*, June 2015, *105* (6), 1738–79.

DiNardo, John, "Law enforcement, the price of cocaine and cocaine use," *Mathematical and Computer Modeling*, 1993, *17* (2), 53–64.

Dube, Arindrajit, Oeindrila Dube, and Omar Garcia Ponce, "Cross-Border Spillover: U.S. Gun Laws and Violence in Mexico," *American Political Science Review*, 8 2013, *107*, 397–417.

Dube, Oeindrila and Juan Vargas, "Commodity Price Shocks and Civil Conflict: Evidence from Colombia," *The Review of Economic Studies*, 2013, *80* (4), 1384–1421.

_ , Omar García-Ponce, and Kevin Thom, "From Maize to Haze: Agricultural Shocks and the Growth of the Mexican Drug Sector," *Princeton University working paper*, 2013.

Elias, Norbert, *The Civilising Process: State Formation and Civilisation*, Wiley-Blackwell, 2000.

Fearon, James D. and David D. Laitin, "Ethnicity, Insurgency, and Civil War," *American Political Science Review*, 2003, *97* (1), 75–90.

Gambetta, Diego, *The Sicilian Mafia: The Business of Private Protection*, Harvard University Press, 1996.

García-Jimeno, Camilo, "The Political Economy of Moral Conflict: An Empirical Study of Learning and Law Enforcement under Prohibition," *Econometrica*, 2016, *84* (2), 511–570.

Gaviria, Alejandro and Daniel Mejia, eds, *Anti-Drug Policies in Colombia Successes, Failures, and Wrong Turns*, Vanderbilt University Press, 2016.

Goldstein, Paul J., "The Drugs/Violence Nexus: A Tripartite Conceptual Framework," *Journal of Drug Issues*, 1985, *15* (4), 493–506.

Gonzalbo, Fernando Escalante, "Crimen organizado: La dimensión imaginaria," 2012.

Grillo, Ioan, *El Narco*, Bloomsbury Press, 2011.

Grossman, Herschel I., "A General Equilibrium Model of Insurrections," *The American Economic Review*, 1991, *81* (4), 912–921.

_ , "Kleptocracy and Revolutions," *Oxford Economic Papers*, 1999, *51* (2), 267–283.

_ , "The Creation of Effective Property Rights," *American Economc Reveiew*, 2001, *91* (2), 347–352.

Guerrero, Eduardo, "Cómo reducir la violencia en México," *Nexos*, 2010.

_ , "La raíz de la violencia," *Nexos*, 2011.

_ , "Security, drugs and violence in Mexico: A survey," *7th North American Forum*, 2011.

Hausman, Jerry, Bronwyn H. Hall, and Zvi Griliches, "Econometric Models for Count Data with an Application to the Patents-RD Relationship," *Econometrica*, 1984, *52* (4), 909–938.

Hirshleifer, Jack, "The technology of conflict as an economic activity," *The American Economic Review P&P*, 1991, *81* (2), 130–134.

_ , "The Dark Side of the Force: Western Economic Association International 1993 Presidential Addres," *Economic Inquiry*, 1994, *32* (1), 1–10.

— , *The Dark Side of the Force: Economic Foundations of Conflict Theory*, Cambridge University Press, 2001.

Hobbes, Thomas, *Leviathan* 1651.

Horowitz, Joel L., "Should the DEA's STRIDE Data Be Used for Economic Analyses of Markets for Illegal Drugs?," *Journal of the American Statistical Association*, 2001, *96* (456), 1254–1262.

Kalyvas, Stathis, *The Logic of Violence in Civil War*, Cambridge University Press, 2006.

Kilmer, Beau, Jonathan P. Caulkins, Brittany M. Bond, and Peter H. Reuter, "Reducing Drug Trafficking Revenues and Violence in Mexico: Would Legalizing Marijuana in California Help?," *Rand Occasional Paper 325*, 2010.

Lind, Jo Thori, Karl Ove Moene, and Fredrik Willumsen, "Opium for the Masses? Conflict-Induced Narcotics Production in Afghanistan," *The Review of Economics and Statistics*, 2014, *96* (5), 949–966.

Lizárraga, Daniel, "Oculta el gobierno cifra de muertos en la guerra contra el narco," 2012.

Mejía, Daniel and Pascual Restrepo, "Bushes and Bullets: Illegal Cocaine Markets and Violence in Colombia," *MIMEO, Universidad de los Andes*, May 2013.

— **and** — , "The Economics of the War on Illegal Drug Production and Trafficking," *Documento CEDE*, 2013.

Merino, José, "Los operativos conjuntos y la tasa de homicidios: Una medición," *Nexos*, June 2011.

Miguel, Edward, Shanker Satyanath, and Ernest Sergenti, "Economic Shocks and Civil Conflict: An Instrumental Variables Approach," *Journal of Political Economy*, 2004, *112* (4), 725–753.

Nisbet, Charles T. and Firouz Vakil, "Some Estimates of Price and Expenditure Elasticities of Demand for Marijuana Among U.C.L.A. Students," *The Review of Economics and Statistics*, 1972, *54* (4), 473–475.

Owens, Emily G., "The American Temperance Movement and Market-Based Violence," *American Law and Economics Review (forthcoming)*, 2014.

Pinker, Steven, *The Better Angels of our Nature: Why Violence Has Declined*, Viking Adult, 2011.

Poiré, Alejandro and María Teresa Martínez, "La caída de los capos no multiplica la violencia: el caso de Nacho Coronel," *Nexos*, 2011.

Proceso, "Pone gobierno "bajo llave" cifras de ejecutados," 2012.

Rothemberg, Julio J. and Garth Saloner, "A supergame-theoretic model of price wars during booms," *The American Economic Review*, 1986, *76* (3), 390–407.

Roumasset, James and John Hadreas, "Addicts, Fences, and the Market for Stolen Goods," *Public Finance Review*, 1977, *5* (2), 247–272.

Saffer, Henry and Frank Chaloupka, "The Demand for Illicit Drugs," *Economic Inquiry*, 1999, *37* (3), 401–411.

Sánchez de la Sierra, Raúl, "On the Origin of States: Stationary Bandits and Taxation in Eastern Congo," *Working Paper*, 2015.

Silverman, Lester P. and Nancy L. Spruill, "Urban crime and the price of heroin," *Journal of Urban Economics*, 1977, *4* (1), 80–103.

Skaperdas, Stergios, "Warlord Competition," *Journal of Peace Research*, 2002, *39* (4), 435–446.

Valdés, Guillermo, *Historia del Narcotráfico en México*, Aguilar, 2013.

Villalobos, Joaquín, "Nuevos mitos de la guerra contra el narco," *Nexos*, 2012.

Wasserman, J., Willard G. Manning, J.P. Newhouse, and J.D. Winkler, "The effects of excise taxes and regulations on cigarette smoking," *Journal of Health Economics*, 1991, *10* (1), 43–64.

Wooldridge, Jeffrey M., "Distribution-Free Estimation of Some Nonlinear Panel Data Models," *Journal of Econometrics*, 1999, *90* (1), 77–97.

_ , *Econometric Analysis of Cross Section and Panel Data*, MIT Press, 2010.

Table 1: Summary statistics.

	2006	2007	2008	2009	2010
	All Mexico: 2,457 municipalities at 763 km from the US				
Homicide rate (annualized)	9.74	8.15	12.68	17.59	22.53
	[22.55]	[19.40]	[28.92]	[38.17]	[50.52]
Drug-related homicide rate	0.69	2.59	6.30	8.69	13.57
	[8.63]	[18.42]	[26.26]	[34.99]	[57.78]
Share of municipalities that have cartels	0.12	0.16	0.24	0.27	0.29
	[0.33]	[0.37]	[0.43]	[0.44]	[0.45]
Population (in thousands)	42.72	43.42	44.15	44.95	45.80
	[127.90]	[129.22]	[130.47]	[131.68]	[132.85]
Historical PAN vote share (time invariant)	0.25	0.25	0.25	0.25	0.25
	[0.13]	[0.13]	[0.13]	[0.13]	[0.13]
	Quintiles 1 and 2: 983 municipalities at 507 km from the US				
Homicide rate (annualized)	8.76	7.79	13.98	19.76	27.81
	[16.83]	[14.55]	[29.49]	[40.99]	[59.12]
Drug-related homicide rate	0.41	2.76	8.42	10.86	17.32
	[5.07]	[21.26]	[30.89]	[40.53]	[70.11]
Share of municipalities that have cartels	0.17	0.24	0.35	0.37	0.40
	[0.38]	[0.43]	[0.48]	[0.48]	[0.49]
Population (in thousands)	64.35	65.32	66.35	67.45	68.62
	[167.97]	[169.61]	[171.21]	[172.76]	[174.27]
Historical PAN vote share (time invariant)	0.28	0.28	0.28	0.28	0.28
	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]
	First quintile: 492 municipalities at 333 km from the US				
Homicide rate (annualized)	9.37	8.62	19.97	28.67	44.46
	[21.14]	[18.14]	[41.17]	[56.50]	[83.54]
Drug-related homicide rate	0.77	3.64	14.03	18.90	31.40
	[7.79]	[31.64]	[42.64]	[57.47]	[103.90]
Share of municipalities that have cartels	0.24	0.34	0.42	0.43	0.49
	[0.43]	[0.47]	[0.49]	[0.50]	[0.50]
Population (in thousands)	53.10	54.00	54.93	55.89	56.88
	[146.47]	[148.71]	[150.80]	[152.74]	[154.53]
Historical PAN vote share (time invariant)	0.30	0.30	0.30	0.30	0.30
	[0.13]	[0.12]	[0.12]	[0.12]	[0.12]

Note.- The table presents summary statistics for the main variables used in our empirical exercises. The data are presented separately for municipalities in all Mexico, in the first two distance quintiles to entry points in the US, and in the first distance quintile to entry points in the US. Standard deviations for each variable are reported below the corresponding mean in square brackets.

Table 2: Time series effects of cocaine seizures in Colombia on violence in Mexico.

	All of Mexico			Quintiles 1 and 2			First quintile		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent variable: homicide rate.								
log of seizures in Colombia	0.059**	0.056**	0.050*	0.082**	0.079**	0.073**	0.119***	0.120***	0.109***
	(0.027)	(0.025)	(0.026)	(0.033)	(0.032)	(0.034)	(0.033)	(0.034)	(0.037)
Observations	49	49	49	49	49	49	49	49	49
R-squared	0.950	0.957	0.961	0.947	0.953	0.955	0.950	0.952	0.953
	Dependent variable: drug-related homicide rate.								
log of seizures in Colombia	0.120**	0.123**	0.117*	0.126**	0.126**	0.125*	0.134**	0.137**	0.141**
	(0.055)	(0.055)	(0.060)	(0.057)	(0.057)	(0.063)	(0.060)	(0.061)	(0.066)
Observations	49	49	49	49	49	49	49	49	49
R-squared	0.952	0.955	0.956	0.961	0.964	0.964	0.959	0.961	0.961
	Dependent variable: assassinations of cartel members.								
log of seizures in Colombia	0.123**	0.131**	0.126**	0.124**	0.128**	0.127*	0.122*	0.130*	0.132*
	(0.057)	(0.056)	(0.060)	(0.060)	(0.059)	(0.064)	(0.065)	(0.066)	(0.072)
Observations	49	49	49	49	49	49	49	49	49
R-squared	0.951	0.955	0.956	0.957	0.961	0.961	0.956	0.958	0.958
	Dependent variable: confrontations deaths.								
log of seizures in Colombia	0.140	0.096	0.107	0.095	0.048	0.050	0.266	0.222	0.224
	(0.221)	(0.223)	(0.228)	(0.191)	(0.196)	(0.205)	(0.184)	(0.187)	(0.194)
Observations	48	48	48	47	47	47	46	46	46
R-squared	0.720	0.731	0.734	0.733	0.747	0.747	0.720	0.739	0.740
	Dependent variable: assassinations of government officials.								
log of seizures in Colombia	-0.047	-0.043	0.001	-0.061	-0.070	-0.026	0.035	-0.018	0.026
	(0.168)	(0.175)	(0.191)	(0.151)	(0.166)	(0.178)	(0.280)	(0.256)	(0.264)
Observations	43	43	43	41	41	41	34	34	34
R-squared	0.588	0.595	0.620	0.426	0.434	0.476	0.348	0.393	0.425
Time series controls:									
Unemployment rate		✓	✓		✓	✓		✓	✓
Economic activity		✓	✓		✓	✓		✓	✓
Seasonality			✓			✓			✓

Note.- The table presents estimates of the effect of cocaine seizures in Colombia on violence in different groups of municipalities in Mexico. The dependent variable is the log of the homicide rate indicated in each panel, aggregated at the monthly level. The explanatory variable is the log of the monthly cocaine seizures in Colombia. We estimate the model for all 49 months from December, 2006, to December, 2010. All models include a cubic polynomial in time (months) and year dummies, so that only high frequency variation is exploited. Columns 1 to 3 present estimates for Mexico as a whole; columns 4 to 6 for quintiles 1 and 2; and columns 7 to 9 for the first quintile. Columns 2, 5 and 8 add the monthly unemployment rate and a measure of economic activity as controls. Columns 3, 6 and 9 control for the rainy and hurricane season in Mexico. Standard errors robust against heteroskedasticity are reported in parenthesis. Coefficients with *** are significant at the 1% level, with ** at only the 5% level and with * at only the 10% level.

Table 3: Additional time series estimates of the effect of cocaine seizures in Colombia on the homicide rate in Mexican municipalities.

	All Mexico				Quintiles 1 and 2				First quintile			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
log homicide rate $t-1$	0.036				0.077				0.151			
	(0.162)				(0.182)				(0.152)			
log homicide rate $t-2$	-0.012				-0.021				0.064			
	(0.168)				(0.203)				(0.189)			
log homicide rate $t-3$	-0.176				-0.090				0.028			
	(0.227)				(0.240)				(0.184)			
log of seizures in Colombia $t+3$			0.024	0.025			0.040	0.042			0.072	0.074
			(0.026)	(0.028)			(0.037)	(0.038)			(0.046)	(0.047)
log of seizures in Colombia $t+2$			-0.011	-0.006			-0.019	-0.013			0.012	0.018
			(0.043)	(0.033)			(0.052)	(0.041)			(0.060)	(0.048)
log of seizures in Colombia $t+1$			0.029	0.047			0.025	0.040			0.040	0.061
			(0.032)	(0.039)			(0.044)	(0.052)			(0.051)	(0.059)
log of seizures in Colombia t	0.056**	0.073**	0.062*	0.091**	0.080**	0.092**	0.082*	0.106**	0.112***	0.137***	0.125***	0.161***
	(0.025)	(0.028)	(0.032)	(0.040)	(0.037)	(0.036)	(0.041)	(0.051)	(0.039)	(0.036)	(0.043)	(0.054)
log of seizures in Colombia $t-1$		0.065*		0.072*		0.067		0.070		0.083		0.090
		(0.038)		(0.043)		(0.049)		(0.054)		(0.057)		(0.062)
log of seizures in Colombia $t-2$		0.019		0.033		0.005		0.019		0.026		0.043
		(0.026)		(0.029)		(0.035)		(0.040)		(0.043)		(0.048)
log of seizures in Colombia $t-3$		-0.023		-0.023		-0.037		-0.040		-0.037		-0.041
		(0.028)		(0.025)		(0.036)		(0.033)		(0.048)		(0.045)
Observations	49	49	46	46	49	49	46	46	49	49	46	46
R-squared	0.953	0.958	0.953	0.962	0.948	0.954	0.950	0.957	0.953	0.956	0.953	0.960

Note.- The table presents estimates of the effect of cocaine seizures in Colombia on violence in different groups of municipalities in Mexico. The dependent variable is the log of the homicide rate, aggregated at the monthly level. We estimate the model for all 49 months from December, 2006, to December, 2010. All models include a cubic polynomial in time (months) and year dummies, so that only high frequency variation is exploited. Columns 1 to 4 present estimates for Mexico as a whole; columns 5 to 8 for quintiles 1 and 2; and columns 9 to 12 for the first quintile. Standard errors robust against heteroskedasticity are reported in parenthesis. Coefficients with *** are significant at the 1% level, with ** at only the 5% level and with * at only the 10% level.

TABLE 4: The differential effect of cocaine seizures in Colombia on violence in Mexico by distance from the nearest US entry point.

	All of Mexico				Quintiles 1 and 2			
Estimation method:	Poisson model		Dep. var. $\ln(p+x)$		Poisson model		Dep. var. $\ln(p+x)$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: homicide rate.							
Seizures in Colombia × Proximity to the U.S.	0.031***	0.023**	0.014***	0.013***	0.043**	0.045**	0.022***	0.023***
	(0.011)	(0.011)	(0.004)	(0.004)	(0.019)	(0.019)	(0.008)	(0.008)
Observations	98,245	85,309	120,296	97,902	42,973	42,189	48,167	47,089
	Dependent variable: drug-related homicides rate.							
Seizures in Colombia × Proximity to the U.S.	0.067***	0.062**	0.026***	0.026***	0.128***	0.127***	0.053***	0.054***
	(0.024)	(0.025)	(0.008)	(0.008)	(0.044)	(0.044)	(0.017)	(0.017)
Observations	56,203	53,214	120,296	97,902	27,342	27,097	48,167	47,089
	Dependent variable: assassination of cartel members.							
Seizures in Colombia × Proximity to the U.S.	0.037*	0.029	0.016***	0.016**	0.073*	0.073*	0.031**	0.032**
	(0.021)	(0.021)	(0.006)	(0.007)	(0.039)	(0.039)	(0.014)	(0.014)
Observations	53,900	50,911	120,296	97,902	25,970	25,725	48,167	47,089
	Dependent variable: confrontation deaths.							
Seizures in Colombia × Proximity to the U.S.	0.124*	0.124*	0.023***	0.026***	0.198*	0.197*	0.053**	0.054**
	(0.070)	(0.070)	(0.009)	(0.010)	(0.108)	(0.107)	(0.021)	(0.021)
Observations	20,090	19,943	120,296	97,902	12,348	12,299	48,167	47,089
	Dependent variable: assassination of government officials.							
Seizures in Colombia × Proximity to the U.S.	0.041	0.042	0.001	0.001	-0.017	-0.017	0.002	0.002
	(0.124)	(0.124)	(0.002)	(0.002)	(0.221)	(0.220)	(0.004)	(0.004)
Observations	7,448	7,448	120,296	97,902	4,655	4,655	48,167	47,089
Covariates:								
Differential trend by distance to US	✓	✓	✓	✓	✓	✓	✓	✓
Differential trend by PAN support		✓		✓		✓		✓

Note.- The table presents estimates of the interaction between cocaine seizures in Colombia (measured at the monthly level in logs) on violence in Mexican municipalities located at different proximities to US entry points (measured in 100km). The dependent variable is the log of the homicide rate indicated in each panel. All estimates include a full set of municipality and time fixed effects as well as a differential cubic time trend by distance from US entry points. Additional covariates are indicated at the bottom of the table. Columns 1 to 4 present estimates for all of Mexico. Columns 5 to 8 present estimates for the first two quintiles of distance to the US border. Columns 1,2,5 and 6 use a Poisson fixed effects model, while columns 3,4,7 and 8, use a monotone transformation of the dependent variable, $\ln(p+x)$, with p the 90th percentile of x. Standard errors robust to heteroskedasticity and serial correlation within municipalities are reported below each estimate in parenthesis. Coefficients with *** are significant at the 1% level, ** only at the 5% level, and * only at the 10% level.

Table 5: Additional time series estimates of the effect of cocaine seizures in Colombia on the homicide rate in different subsamples of Mexican municipalities.

	Panel A: Heterogeneity by Cartel presence								*Panel B: Heterogeneity by PAN support*			
	No cartels		One cartel		Non-allied cartels		Various cartels		Low PAN support		High PAN support	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
log homicide rate $t-1$		-0.209		-0.013		0.049		0.044		-0.135		0.181
		(0.134)		(0.127)		(0.151)		(0.150)		(0.128)		(0.156)
log homicide rate $t-2$		-0.187*		-0.242*		-0.024		-0.016		-0.187		0.065
		(0.104)		(0.125)		(0.173)		(0.161)		(0.143)		(0.199)
log homicide rate $t-3$		-0.287*		-0.351		0.030		0.008		-0.351**		-0.046
		(0.144)		(0.221)		(0.208)		(0.208)		(0.142)		(0.222)
log of seizures in Colombia t	0.021	-0.001	0.053	0.038	0.083**	0.079**	0.084**	0.082**	0.028	0.009	0.102***	0.103**
	(0.023)	(0.025)	(0.039)	(0.037)	(0.033)	(0.034)	(0.032)	(0.033)	(0.028)	(0.023)	(0.034)	(0.038)
Observations	49	49	49	49	49	49	49	49	49	49	49	49
R-squared	0.809	0.847	0.913	0.935	0.936	0.936	0.943	0.943	0.926	0.943	0.943	0.946

Note.- The table presents estimates of the effect of cocaine seizures in Colombia on the homicide rate for different groups of municipalities in Mexico. The dependent variable is the log of the homicide rate. The explanatory variable is the log of the monthly cocaine seizures in Colombia. We estimate the model for all 49 months from December, 2006, to December, 2010. All models include a cubic polynomial in time (months) and year dummies; consequently, only high frequency variation is exploited. Each model is estimated for the subsample of municipalities in the group indicated on the top rows. Standard errors robust against heteroskedasticity are reported in parenthesis. Coefficients with *** are significant at the 1% level, with ** at only the 5% level and with * at only the 10% level.

Table 6: Differential effects of cocaine seizures in Colombia on the homicide rate in Mexican municipalities located at different distances from US entry points, with different cartel presence and PAN support.

	Poisson model			Dep. var. $\ln(p+x)$		
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: All Mexico.					
Seizures in Colombia × Proximity to the U.S.	-0.007	-0.006	-0.007	0.004	0.004	0.004
	(0.016)	(0.016)	(0.016)	(0.006)	(0.006)	(0.006)
Seizures in Colombia × Cartel presence	0.238	0.124	-0.026	0.107*	0.017	-0.034
	(0.159)	(0.175)	(0.173)	(0.062)	(0.070)	(0.081)
Seizures in Colombia × Proximity to the U.S. × Cartel presence	0.034*	0.016	-0.003	0.015*	0.002	-0.004
	(0.020)	(0.022)	(0.023)	(0.008)	(0.009)	(0.010)
Seizures in Colombia × Non-allied cartels		0.226			0.236**	
		(0.179)			(0.103)	
Seizures in Colombia × Proximity to the U.S. × Non-allied cartels		0.041*			0.036***	
		(0.024)			(0.014)	
Seizures in Colombia × Various cartels			0.400**			0.242***
			(0.172)			(0.093)
Seizures in Colombia × Proximity to the U.S. × Various cartels			0.057**			0.033***
			(0.023)			(0.012)
Seizures in Colombia × High PAN support	0.373**	0.343**	0.330**	0.163**	0.153**	0.164**
	(0.164)	(0.160)	(0.161)	(0.076)	(0.076)	(0.076)
Seizures in Colombia × Proximity to the U.S. × High PAN support	0.041*	0.037	0.035	0.019**	0.018*	0.019**
	(0.025)	(0.024)	(0.024)	(0.010)	(0.010)	(0.010)
Observations	85,309	85,309	85,309	97,902	97,902	97,902
	Panel B: Quintiles 1 and 2.					
Seizures in Colombia × Proximity to the U.S.	-0.007	-0.005	-0.007	0.005	0.005	0.003
	(0.029)	(0.029)	(0.029)	(0.013)	(0.013)	(0.013)
Seizures in Colombia × Cartel presence	0.232	0.086	-0.104	0.101	-0.010	-0.073
	(0.208)	(0.229)	(0.216)	(0.085)	(0.094)	(0.103)
Seizures in Colombia × Proximity to the U.S. × Cartel presence	0.036	0.003	-0.028	0.012	-0.008	-0.018
	(0.038)	(0.043)	(0.040)	(0.014)	(0.016)	(0.017)
Seizures in Colombia × Non-allied cartels		0.264			0.262**	
		(0.216)			(0.118)	
Seizures in Colombia × Proximity to the U.S. × Non-allied cartels		0.063			0.046**	
		(0.041)			(0.020)	
Seizures in Colombia × Various cartels			0.490**			0.290***
			(0.208)			(0.110)
Seizures in Colombia × Proximity to the U.S. × Various cartels			0.094**			0.049**
			(0.039)			(0.019)
Seizures in Colombia × High PAN support	0.419**	0.380**	0.371**	0.207**	0.200**	0.217**
	(0.193)	(0.189)	(0.188)	(0.101)	(0.101)	(0.102)
Seizures in Colombia × Proximity to the U.S. × High PAN support	0.065*	0.056	0.055	0.034**	0.032**	0.035**
	(0.036)	(0.035)	(0.035)	(0.016)	(0.016)	(0.016)
Observations	42,189	42,189	42,189	47,089	47,089	47,089

Note.- The table presents estimates of the interaction between cocaine seizures in Colombia (measured at the monthly level in logs), proximity to US entry points (measured in 100km), cartel presence, and PAN support on violence in Mexican municipalities. The dependent variable is the log of the homicide rate. All estimates include a full set of municipality and time fixed effects, as well as a differential cubic time trend by distance from US entry points, by the number of cartels, and by PAN support. The top panel present estimates for all of Mexico. The bottom panel presents estimates for quintiles 1 and 2. Columns 1 to 3 use a Poisson fixed effects model, while columns 4 to 6 use a monotone transformation of the dependent variable, $\ln(p+x)$, with p the 90th percentile of x. Standard errors robust to heteroskedasticity and serial correlation within municipalities are reported below each estimate in parenthesis. Coefficients with *** are significant at the 1% level, ** only at the 5% level, and * only at the 10% level.

Appendix (for publication)

Details on the solution of the model

The timing of the full model is as follows:

1. Nature draws Q^s randomly from distribution F with support $[0, \infty)$.

2. After observing Q^s, cartel c buys Q^s_c units of cocaine at price P^s, traffics it, and sells it at price $P = P^d(Q^s)$. It incurs cost $C(Q^s_c)$ from running the trafficking operation, which is increasing, convex, and satisfies $\lim_{Q\to 0} C'(Q) = \infty$ and $\lim_{Q\to\infty} C'(Q) = 0$.

3. Cartels choose their conflict strategies, $g_{c,i}$, to defend their revenue and expropriate others' in all municipalities where they operate.

4. Payoffs are realized. Cartel c obtains profits

$$-P^s Q^s_c - C(Q^s_c) + \eta P Q^s_c + \sum_{i\in I_c} \left(q_{c,i}(1-\eta)s_i P \sum_{c'\in\mathcal{C}} Q^c_s - g_{c,i} \right)$$

As mentioned in the main text, payments for cocaine from suppliers and the cost of trafficking are sunk costs. Thus the solution of the conflict is symmetric and given by:

$$g^*_{c,i} == \frac{|N_i| - 1}{|N_i|^2}(1-\eta)s_i R(Q^s).$$

Plugging the optimal choice of $g_{c,i}$ into the cartel's objective function yields

$$-P^s Q^s_c - C(Q^s_c) + \eta P Q^s_c + \sum_{i\in I_c} \frac{1}{|N_i|^2}(1-\eta)s_i P \sum_{c\in\mathcal{C}} Q^s_c. \tag{A1}$$

Therefore, the optimal choice of $Q^s_c \geq 0$ satisfies the condition:

$$P^s + C'(Q^s_c) \geq \eta P + \sum_{i\in I_c} \frac{1}{|N_i|^2}(1-\eta)s_i P, \tag{A2}$$

with equality if $Q^s_c > 0$. The convex cost, C, guarantees that it is possible for this equation to have a solution for more than one cartel. Otherwise, one cartel—the one present at the best locations—would buy all of the drugs and the others would simply prey on it. We do not think that this alternative situation is unrealistic, as many cartels are toll collectors and simply prey on others, while not involved in cocaine trafficking directly. In fact, even with the convex cost, it is possible for some cartels to specialize in preying on others while not trafficking at all.

Here, P^s and P are taken as given by the cartel. The equilibrium prices, $P, P^s(Q^s)$, are the only prices that guarantee market clearing.

Proof of proposition 2

We prove only the results for inelastic demand because the other proof is essentially the same.

Let $g^C(a_i, Q^s)$ be the maximum level of cooperation that can be sustained with a threat of reversion to static Nash. Here, we focus only on symmetric equilibria. Let $A(Q^s) = (1-\eta)s_i R(Q^s)$ be a random variable that describes vulnerable revenue in municipality i. The incentive compatibility constraint at this level is given by

$$\frac{1}{N_i}A(Q^s) - g^C(a_i,Q^s) + \mathbb{E}\left[\sum_{t=1}^{\infty}\beta^t(1-a_i)^t(g^N(Q^s)-g^C(a_i,Q^s))\right] \geq \max_x \frac{x}{x+(N_i-1)g^C(a_i,Q^s)}A(Q^s) - x. \tag{A3}$$

Let $\Theta(a_i) = \mathbb{E}\left[\sum_{t=1}^{\infty}\beta^t(1-a_i)^t(g^N(Q^s)-g^C(a_i,Q^s))\right] \geq 0$. At this point, it is not clear that this amount is uniquely determined for each value of Q^s. Nonetheless, we demonstrate it below. The incentive compatibility constraint simply states that the gains from deviating to any other level of violence x are dominated by playing the cooperative strategy $g^C(a_i, Q^s)$ and obtaining the differential continuation value $\Theta(a_i) > 0$.

Solving for x, we obtain

$$x = \sqrt{(N_i-1)g^C(a_i,Q^s)A(Q^s)} - (N_i-1)g^C(a_i,Q^s) \geq 0. \tag{A4}$$

Plugging in this value yields the incentive compatibility condition

$$\left[\frac{1}{N_i}-1\right]A(Q^s) + \Theta(a_i) \geq N_i g^C(a_i,Q^s) - 2\sqrt{(N_i-1)g^C(a_i,Q^s)A(Q^s)}. \tag{A5}$$

The right-hand side is decreasing for $g^C(a_i, Q^s) \in [0, g^N(Q^s)]$ and has a minimum at $g^N(Q^s)$. This means that the above condition implies a lower bound for $g^C(a_i, Q^s)$, or the smallest possible level of conflict that can be sustained with a reversion to static Nash upon deviation.

The most cooperative equilibrium is thus given by the unique solution, $g^C(a_i, Q^s) \geq 0$, to the functional equation

$$\left[\frac{1}{N_i}-1\right]A(Q^s) + \Theta(a_i) \geq N_i g^C(a_i,Q^s) - 2\sqrt{(N_i-1)g^C(a_i,Q^s)A(Q^s)}, \tag{A6}$$

which achieves equality if $g^C(a_i, Q^s) > 0$. Let $\overline{Q}(a_i)$ be such that

$$(N_i-1)A(\overline{Q}(a_i)) = N_i\Theta(a_i). \tag{A7}$$

For $Q^s \geq \overline{Q}(a_i)$, the above condition holds as an inequality, so $g^C(a_i, Q^s) = 0$ for large values of supply Q^s, as stated in the proposition. If $A(Q^s)$ is bounded, the above condition also holds as an inequality where $g^C(a_i, Q^s) = 0$ when $\beta(1-a_i) \to 1$. Thus, for sufficiently low discounting there is always an equilibrium that exhibits no violence along the equilibrium path if revenue is bounded. If, on the other hand, revenue is unbounded, there is a sufficiently low Q^s such that the above condition does not hold for $g^C(a_i, Q^s) = 0$, meaning that $g^C(a_i, Q^s) > 0$ for sufficiently low values of Q^s. These observations establish the first three parts of the proposition.

Before continuing, we claim that $\Theta(a_i)$ is decreasing in a_i. We start from

$$\Theta(a_i) = \frac{\beta(1-a_i)}{1-\beta(1-a_i)} \left(\frac{N_i - 1}{N_i^2} \mathbb{E}[A(Q^s)] - \mathbb{E}[g^C(a_i, Q^s)] \right). \tag{A8}$$

For $Q^s < \overline{Q}(a_i)$,

$$g^C(a_i, Q^s) = \left(\frac{\sqrt{(N_i - 1)A(Q^s)} - \sqrt{N_i \Theta(a_i)}}{N_i} \right)^2. \tag{A9}$$

Plugging this into the above expression yields

$$\left(\frac{1-\beta(1-a_i)}{\beta(1-a_i)} N_i^2 + N_i \right) \sqrt{\Theta(a_i)} = 2\sqrt{(N_i - 1)N_i} \mathbb{E}\left[\sqrt{A(Q^s)} \right]. \tag{A10}$$

This expression implies that $\Theta(a_i)$ is unique (hence, the uniqueness of the solution) and also that it is decreasing in a_i as desired. The above claim, together with equation A7, also implies that $\overline{Q}(a_i)$ is increasing in a_i, as mentioned in the first item of the proposition. Using the formula for $g^c(a_i, Q^s)$ derived above, this also implies that g^c is increasing in a_i as mentioned in the proposition.

Now, we focus on the role of Q^s:

$$\frac{\partial g^C(a_i, Q^s)}{\partial Q^s} = \left(\frac{\sqrt{(N_i - 1)A(Q^s)} - \sqrt{N_i \Theta(a_i)}}{N_i} \right) \sqrt{\frac{N_i - 1}{A(Q^s)}} A'(Q^s) < 0. \tag{A11}$$

The inequality follows from the observation that for $Q^s < \overline{Q}(a_i)$ we have $\sqrt{(N_i - 1)A(Q^s)} > \sqrt{N_i \Theta(a_i)}$. In the above derivation, note that because of the independence assumption on the draws, $\Theta(a_i)$ does not depend on the current realization of Q^s. This shows that in this equilibrium, too, violence increases when the supply tightens. Thus, informal arrangements are not enough to eliminate the impact of supply shortages on violence when there is sufficient discounting and supply is sufficiently tight.

Moreover, we get

$$\frac{\partial^2 g^C(a_i, Q^s)}{\partial Q^s \partial a_i} < 0, \tag{A12}$$

because $\Theta(a_i)$ is decreasing in a_i. This proves the item in the proposition regarding the cross partial derivative.