

The Cartel Wars: Fighting Over Opioid Crisis Profits

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Abstract

The number of major drug trafficking organizations in Mexico increased from four to nine over the last two decades. This was accompanied by an increase in drug trade related violence. This paper examines the relationship between competition and violence in illegal drug markets. In particular, I exploit an external demand shock to the heroin market, the 2010 OxyContin reformulation. I construct a novel data set of cartel presence across municipalities by scraping Google News and using natural language processing. I exploit within municipality variation from combining agro-climatic conditions to grow opium poppy with heroin prices in the United States across time. Event study estimates suggest that cartel presence increases substantially after 2010 in municipalities well suited to grow opium poppy. Homicide rates increase in the number of active cartels per municipality, with the higher increases when a second, third and fourth cartel become active in the territory. These results suggest that some of the increase in violence that Mexico experienced in the last fifteen years could be attributed to criminal groups fighting for market shares of heroin.

1 Introduction

*They understand the prescription drug issue here, and that is one of the major reasons why you are seeing the expansion of poppy production*¹

-Jack Riley former DEA special agent in charge of the Chicago field office.

*Very much like any corporation. They judge the market demand and they shift accordingly, and I would have to say the cartels shift much more efficiently and quickly than any major corporation, because they don't have to deal with the bureaucracy*²

-Mile Vigil former chief of international operations of the DEA.

Drug trafficking is the second most lucrative illegal activity with an estimated global revenue of \$539 billion dollars each year.³ Mexican drug trafficking organizations are some of the most notorious criminal groups, they are the largest foreign suppliers of heroin, marijuana, methamphetamines and cocaine to the United States. The number of major drug cartels⁴ in Mexico increased from four in the early 2000s to nine organizations by 2016. These cartels are usually in constant flux and have splinted, forged alliances and battle each other for territory. This increase in the number of organizations has been accompanied by a peak in violence across Mexico with 250,547 homicides, 330,000 displaced and 37,400 missing persons that can be directly attributed to organized crime.

Understanding how these organizations operate, compete and react to different policies is key to create and implement strategies that might reduce the negative externalities from organized crime. Yet there is limited causal evidence on how these organizations react to market shifts and the relationship between market structure, institutional context and violence. This paper contributes to explore this relationship. First, I create two novel data sets: one that uses online news articles and natural language processing to measure cartel presence across municipalities and the second one that creates an index of how well suited a municipality is to grow opium poppy. Opium poppy cultivation is illegal in Mexico so any production goes to the illegal market and opium is the main precursor for morphine, codeine, heroin and

¹ <https://www.nytimes.com/2015/08/30/world/americas/mexican-opium-production-rises-to-meet-heroin-demand-in-us.html>

² <https://www.businessinsider.com/sinaloa-cartel-sending-mexican-herion-to-the-us-2017-11>

³ <https://gfintegrity.org/report/transnational-crime-and-the-developing-world/>

⁴ Through this paper I will use the word cartel and drug trafficking organizations as interchangeable. This does not mean that drug traffickers collude to diminish supply or set drug prices to increase profits.

oxycodone. Second, I use an external demand shock to the heroin market to estimate the effect of this market shift on cartel entry. Third, I estimate the relationship between entry and violence and finally, I identify the drug trafficking organization that expanded into the heroin market and document how the market became less concentrated.

This paper finds evidence that an increase in the demand for heroin in the United States increased cartel presence and violence across Mexico. There are four main results. First, using an exogenous demand shock to the heroin market, the 2010 reformulation of OxyContin in the United States, I show that when the value of suitable land for growing opium poppy goes up, cartels enter into these territories. The probability of having at least two cartels present increases. After 2010 a highly suitable municipality is 10% more likely to have two or more cartels in its territory compared to a less suitable municipality. Second, I find evidence that the relationship between cartel entry, exit and the homicide rate is non linear. The presence of a single cartel does not increase the homicide rate in a significant way but the entry of the second, third, fourth and fifth cartel increases the homicide rate. The highest increase happens when the fifth cartel enters a municipality with an increase of 17.53 in the homicide rate per 100,000 inhabitants. There is no evidence that the exit of cartels reduces violence expect for going from two to one cartel, the homicide rate decreases by 6 homicides. Third, I show that the demand shock had a direct effect on demographics. There is out migration from the most affected municipalities after 2010 specially of the more educated and wealthier members of these communities. Finally, I identify five cartels that enter, exit or expanded into the heroin market.

To establish these results, I use as a source of plausible exogenous variation the 2010 reformulation of OxyContin in the United States. Between 1996 and 2010 supply and demand for legal opioids shot up in the United States. To reduce the increasing misuse of these legal opioids in 2010 the FDA approved the reformulation of OxyContin to make it harder to abuse. The reformulation shifted demand from legal opioids to heroin. Increasing the heroin overdose related deaths [Pacula \(2018\)](#) and the number of users, it is estimated that around 80% of heroin users started with a legal opioid [Pradip K. Muhuri \(2013\)](#). This resulted in higher heroin prices in the United States and a subsequent increase in heroin production by Mexican cartels. Mexican Drug Trafficking Organizations have historically produced some opium for the US market but the amount of heroin of Mexican origin seized by the DEA increased from 19% in the early 2000s to more than 90% by 2016 [DEA \(2018\)](#).

This shock allows me to use two different sources of variation, agro-climatic conditions to cultivate opium poppy and the change of the heroin prices in the United States. The main outcome variable used in this paper is cartel presence across mu-

municipalities over time. The nature of drug trafficking being an illegal activity imposes data restrictions to this analysis. There does not exist official data on cultivation or distribution of drugs neither a complete panel of which trafficking organizations operate in each territory. To deal with this problem I used several machine learning techniques that allow me to approximate measures for illegal drug trafficking.

First I build an opium suitability index for Mexican municipalities. Ideally I would like to observe opium yields from each Mexican municipality, unfortunately Mexico is relatively new in mass production of opium. There does not exist historical data on opium yields by municipality in Mexico. I use yields from Afghanistan ⁵ and a rich set of agro-climatic conditions to build a suitability index using an elastic net. The agro-climatic variables chosen by the optimal elastic net were used to build the suitability index for Mexican municipalities which is highly correlated with eradication data from the Mexican Military. Time variation comes from the price of heroin in the United States. These two variables together define a municipality-time specific shock which leads to differential exposure from the shock that depends on geographic and climatic characteristics of each municipality.

Cartel presence data exists from different sources, such as the Mexican prosecutor's office, the Mexican military, federal police and the DEA, the problem with these data sets is that they are usually at state level and report in sparse time spans. Inspired by [Coscia and Rios \(2017\)](#) I use web content to obtain information of an otherwise hard to measure phenomena. The idea of using web content in particular Google News to generate a full panel data of cartel presence by municipality is that local and national newspapers combined probably contain more regular, detailed and systematic coverage of when and where criminal organizations are operating. I use a web crawler to extract articles related to a municipality and cartel pair and then used natural language processing to validate whether an article is actually talking about the cartel being active in that municipality. I use a semi-supervised convolutional neural network, that was trained manually using 5,000 sentences. The resulting data set is highly correlated with [Coscia and Rios \(2017\)](#), two data sets collected by hand from local newspapers ⁶ and State level data from the DEA.

The above data sets are complemented with official data from the Mexican Military on eradication and seizures, official data on homicide rates, law enforcement and demographic characteristics of each municipality. These data allows me to observe how

⁵ Afghanistan is the world largest producer of opium and the United Nations have data on yields and hectares cultivated since the 1990

⁶ <https://www.animalpolitico.com/el-blog-de-causa-en-comun/la-nueva-configuracion-del-crimen-en-michoacan/>, <https://www.animalpolitico.com/el-blog-de-causa-en-comun/las-organizaciones-criminales-operan-centro-mexico/>

drug trafficking organizations react to the municipality-time specific shock. An event study specification is used to measure how this shock affected different outcomes.

First, I show that the increase in the price of heroin encouraged drug trafficking organizations to expand their operations into high suitable municipalities. In 2004 there was just one cartel present in territories where opium poppy was eradicated, by 2016 the nine major cartels can be found in at least one municipality producing opium poppy. Before 2010 the number of municipalities with at least two cartels was 31, after 2010 this goes up to 172 municipalities. The probability of having at least two cartels present for the mean suitable municipality when the price of heroin doubles increases by 10% after 2010. The result for the number of cartels is similar with the entry of .46 cartels each year after 2010. These results are in line with the intuition that drug trafficking organizations adapt and react to external market pressures. In particular, the cartels will enter new valuable markets or expand its production along with the increase in demand. These results are robust to different sets of controls and fixed effects.

Second, I explore the relationship between cartel entry, exit and violence. A positive demand shock will increase the value of controlling drug production and drug trafficking but it is not obvious that this should increase violence. In the absence of conditions to reach peaceful agreements to share a bigger pie, drug trafficking organizations will fight for it [Castillo and Kronick \(2019\)](#). Mexico during this period lacked such conditions, so I expect that a demand shock increases violence. The relationship between the number of cartels and the increase in homicides is not linear. The first cartel does not increase violence, it is when there are more than two cartels in the same place when violence increases. The second cartel increases the homicide rate ⁷ by 7, the third and fourth cartel by 13 each of them, the fifth cartel by 17 and the sixth cartel by 10. There does not seem to be any effect after the seventh cartel enters a municipality, but there are too few municipalities with more than six cartels. The exit of cartels from a location is just significant when a municipality goes from two cartels to one, the homicide rate decreases by six. This result suggests that it is not the presence of illegal activities that generates violence but the presence of more than one criminal organizations fighting for profits.

Third, I ask how different demographic outcomes reacted to the external demand shock. There is an increase on the homicide rate per 100,000 inhabitants of 24 more homicides after 2010. This is consistent with increased entry and cartels fighting for heroin profits. I also find that the shock leads to a decrease in population and average years of education and an increase in the number of households with dirt floors and with women as the head of the household. These results suggest that

⁷ All the homicide rates refer to homicides per 100,000 inhabitants

there was outmigration from the exposed municipalities of the more educated and wealthier of their members. Finally, I observe that the military is eradicating more opium and less marijuana in these municipalities, again this is consistent with the value of opium going up as the value of marijuana decreases.

Finally, the data set build for this paper allows me to observe which particular cartel operates in each municipality over time so I can examine which cartels expanded into the newly valuable heroin market. Before 2010 the production of heroin was highly concentrated with just the Sinaloa Cartel present on municipalities where opium poppy was eradicated by the military, by 2016 the nine organizations are present in opium producing municipalities. I am able to identify two expanding cartels, Sinaloa and Los Zetas, two newly created cartels that immediately entered the heroin market, Jalisco New Generation and the Templar Knights and one contracting cartel, La Familia Michoacana. These results are consistent with information from the Mexican Military and the DEA.

There are three main potential concerns with the data and the identification strategy that I am using. First, the measure of cartel presence uses news articles. This could be potentially misleading due to the violence experienced by journalists in Mexico. Since 2000, more than 200 journalists have either disappeared or been killed by criminal organizations. Anecdotal evidence and the subset of news articles used to train the neural network suggest that as long as journalists either just mention large organizations or inform on official data provided by the government, they are safe from the cartels violence. To provide external validity of this data set I use official DEA data and find them to be highly correlated. I also use the official data set of killed and missing journalists and no particular patterns seem to bias reporting towards any subset of cartels. Second, these results could be driven by changes in policing and military enforcement and not necessarily from the increase in heroin demand. Previous work shows that between 2006 and 2010 some of the increase in homicides in Mexico can be attributed to police enforcement strategies [Atuesta and Ponce \(2017\)](#), [Phillips \(2015\)](#) and political party alliance [Dell \(2015\)](#). Despite the change of federal government in the middle of my sample ⁸ the strategy against drug trafficking did not change. I am able to control for both police presence and military activity across the sample in order to isolate the effect of the demand shock from any effect related to law enforcement. I also control for political party of the mayors and state governors. The results are robust to these controls and to an extended set of fixed effects. The last potential concern is that the increase in heroin prices is generated by the cartels and not by the demand shift from legal to illegal opioids. There was a sharp jump of heroin users and overdose deaths in the United States, [Pacula \(2018\)](#)

⁸ In 2012, Enrique Peña Nieto from the Revolutionary Party (PRI) was elected president

show that the reformulation made people switch from legal opioids to heroin. Plus the increase in heroin of Mexican origin seized by the DEA goes from 19% before 2010 to 51% in 2011 and 94% by 2016.

Providing evidence that there does not seem to be reverse causation and that the cartels reacted to the increase demand.

These results provide novel evidence that external policies that shift demand or supply of illegal drugs have direct effects on criminal organizations activity and subsequent effect on violence and other outcomes. This paper speaks to several literatures. First, this paper complements the literature studying the recent increase in violence in Mexico. Most of this literature examines how law enforcement strategies and political alliances increase violence [Osorio \(2015\)](#), [Phillips \(2015\)](#), [Atuesta and Ponce \(2017\)](#), [Rios \(2013\)](#), [Holland and Rios \(2017\)](#), [Dell \(2015\)](#). This study provides evidence of an alternative channel, increase in heroin demand, that might explain some of the increasing violence in Mexico.

This paper also speaks to recent literature that tries to explain how drug trafficking organizations organize, interact and generate violence [Biderman et al. \(2018\)](#), [Acemoglu et al. \(2009\)](#), [Murphy and Rossi \(2017\)](#). In particular, I focus on how the entry of multiple drug trafficking organizations to valuable territories increases violence. These results are in line with theoretical models of how increasing value of territories leads to turf wars between cartels [Mesquita \(2018\)](#), [Castillo and Kronick \(2019\)](#). These results also add up to the literature studying how external demand and supply shocks in illegal markets affect violence [Millán-Quijano \(2019\)](#), [Mejía and Restrepo \(2013\)](#), [Castillo et al.](#) This paper contributes to the literature on illegal markets and its effects on different outcomes [Dell et al. \(Forthcoming\)](#), [Dube et al. \(2016\)](#), [Sviatschi \(2018\)](#). I add to this the effect of how the number of competing cartels affects main demographics across municipalities.

Second, this paper contributes to the literature that explores the curse of natural resources for which there exists a substantial black market and its relationship with armed conflict and violence. Most of this literature has either focus on cocaine in Colombia [Dube and Vargas \(2013\)](#), [Angrist and Kugler \(2005\)](#) or opium in Afghanistan [Gehring et al. \(2018\)](#), [Bounadi \(2018\)](#). I complement this literature by adding Mexico to the list of countries subject to this kind of illegal natural resource curse. Mexico location as the bridge between Latin America and the United States can also be considered part of this curse if we considered location as a natural asset. Finally this paper related to the increasing literature in several social sciences that uses text and images as data to measure otherwise hard to quantify phenomena. [Gentzkow et al. \(2017\)](#) provide an introduction of the techniques and previous work in the economics and politics literature that has used text as data. The data set and

techniques used here can be use in several other applications to create measures of other types of illegal activities across the world.

The rest of the paper is organize as follows. In the next section, I provide the institutional background for my analysis. In section 3, I present the data, in Section 4 I provide a theoretical model and the main econometric specification. Sections 5 and 6 present the results and in the final section I conclude.

2 Background

This section provides background on three relevant aspects of context for my analysis. First, I lay out an overview of the history of drug trafficking in Mexico. This is relevant to understand that despite the fact being prominent organizations they were not the main producer of heroin before the relevant period of study. Second, I summarize the war on drugs and its effects on violence and drug trafficking organizations. Finally, I give an overview of the opioid crises in the United States and its relationship with the heroin market. This is key for my identification strategy.

2.1 Drug Trade in Mexico

Mexico location has make it a key country in transporting goods between Latin America and the United States, this includes narcotics and contraband. The origin of the drug trafficking organizations of today can be traced back to the Prohibition era in the United States, when the first criminal organizations established several routes from Mexico to the US border in order to smuggle alcohol [Grillo \(2011\)](#). At the beginning of the XX century the US and Mexican governments slowly started prohibiting the production and consumption of some substances that included marijuana, opium and cocaine. Mexican traffickers saw this as an opportunity and start smuggling illegal drugs through the same routes they used to smuggle alcohol. Timidly the drug traffickers expanded across Mexico and the United States. The increase demand of marijuana during the sixties in the United States combined with lax laws regarding cultivation in Mexico drove the Mexican production of marijuana up and the consolidation of big trafficking organizations begun. The United States government did not like the careless attitude of their Mexican counterpart and launched the first big anti-drugs campaign know as operation Intercept. This operation nearly shut down the US-Mexican border to stop marijuana shipments but did not had any significant effect on the amount of marijuana crossing the border. The Mexican government launched its first big anti-drug operation known as operation Condor that used the

military to eradicate illegal crops in the Golden Triangle⁹. These two operations reduced the drug traffickers revenue from marijuana and made them shift into the cocaine market. During the late 1980s, the US authorities started breaking the Colombian drug trafficking organizations and closed the Caribbean route between Colombia and Miami. The Mexican traffickers slowly took over the transportation of cocaine between Colombia and the United States. They already had established routes to transport marijuana and used them to cross cocaine across the border. The share of cocaine arriving to the US move through Mexico grew from 50% in the early 1990s to almost 100% by 2000 O'Neil (2009). The origin of most of the current drug trafficking organizations in Mexico can be trace back to the Guadalajara Cartel consolidated during the 1980s by Miguel Angel Felix Gallardo, a former police officer. He established the connection between the Colombian and Mexican organizations and expanded the routes between Mexico and the United States. Mexican Drug Trafficking Organizations have become multi product firms with different levels of organization, they own or control the whole supply chain for several drugs, from the farmland to the gangs that sell the product to the final consumers.

2.2 The War on Drugs

Former Mexican President Felipe Calderon¹⁰ declared the war on drugs in 2006, the drug trafficking organizations violently resisted this war. Violence between drug traffickers had been escalated particularly in Michoacan where the government decided to deployed military and federal police in order to reduce the cartel violence. At the begging of the XXI century they were just four major drug trafficking organizations, sixteen years later the DEA and the Mexican Military identified at least nine mayor actors. Drug Trafficking Organizations (DTOs) have showed their violence with public beheading of corpses, car bombs, murders of journalists and public officers. For example, they shot down a military helicopter in May 2015¹¹. Violence spread quickly beyond the US-Mexican border and into the whole country. Since 2006, there has been an estimated of 250,547 homicides related to organized crime these account for 50% of the country homicides. The number of missing people is up to 37,400 the number of displaced people due to violence is estimated to be around 380,000 and the number of missing or killed media workers exceeds 200. De-

⁹ region known for its high production of marijuana and opium located where the states of Sinaloa, Durango and Chihuahua come together.

¹⁰ In office between 2006-2012

¹¹ <https://www.businessinsider.com/mexico-catch-cjng-jalisco-cartel-gunmen-who-shot-down-army-helicopter-2018-8>

spite President Enrique Peña Nieto (2012-2018) efforts to reduce violence his strategy towards drug trafficking organizations did not change from the one established by Calderon. Violence decrease a little during the first year of his administration but went up again immediately after this year. The government strategy of beheading organizations by targeting high rank kingpins generated a lot of instability in the cartels internal cohesion which lead to more violence Jones (2013), Calderón et al. (2015), Espinosa and Rubin (2015). The extent of corruption and political instability in Mexico adds up to the difficulty of fighting these criminal organizations. The list of former governors, majors, members of congress, policemen and military authorities that had some relationship with drug traffickers is extent¹² and shows how difficult fighting these organizations can be. The war on drugs lead to a spike in homicides and increase violence particularly between 2008 and 2010, less explored is the period just after 2010. This paper adds to the discussion on trying to explain the increase in violence by incorporating a new possible mechanism that might increase violence, demand shocks.

2.3 The Opioid Crises

It is estimated that everyday 130 people in the United States die from overdosing on opioid base drugs¹³. The rate of drug overdose deaths tripled between 1999 and the rate related to opioid six-folded during the same period. At the beginning of the 1990s pharmaceutical companies developed several opioid base pain killers, through marketing campaigns and based on two misleading research articles they assure the medical community that patients will not become addicted to these drugs¹⁴. Prescriptions of opioid base pain killers shot up and eventually led to diversion and misused. Pharmaceuticals companies knew that their products were addictive, as admitted by Purdue Pharma in a lawsuit in 2007. The number of people accumulating pills and reselling them in the black market rapidly increased between mid 1990s and 2010. In 2010 physicians organizations pressure the government to make it harder to accumulate pills, the federal and state governments started to crack down pill mills and Purdue Pharma introduced an abuse deterrent version of OxyContin designed to make it harder to crush or dissolve. The restriction in the legal supply drove some users to switch to the illegal counterpart, heroin. Pacula (2018) use cross sectional variation in OxyContin availability across states and find a clear relation-

¹² <https://www.nytimes.com/2018/12/28/nyregion/el-chapo-trial-mexico-corruption.html>

¹³ <https://www.cdc.gov/drugoverdose/images/data/OpioidDeathsByTypeUS.PNG>

¹⁴ <https://www.nature.com/articles/d41586-019-02686-2>

ship between the reformulation of OxyContin and the increase in heroin deaths. It has been estimated that about 80% of people who use heroin first misused some prescription opioid [Pradip K. Muhuri \(2013\)](#). This reformulation provides plausible exogenous variation for cartel activity in Mexico, particularly their reaction towards the heroin market.

3 Data

The main goal of this paper is to document how Mexican Drug Trafficking Organizations reacted to the opioid crisis and disentangle the relationship between market structure and violence in illegal markets. To answer these questions ideally I would like to observe when each cartel enters a municipality, raw opium production by cartel and homicides and violence related to drug trafficking. Due to the illegality of the market these data either do not exist or are reported in aggregate geographical levels and sparse time. To proxy for cartel presence and opium suitability I use web scraping and machine learning. These techniques can be used to measure other usually hard to quantify phenomena such as illegal crop suitability and cartel presence by municipality. The data sets and how they were built are described below.

3.1 Cartel Presence

The Mexican prosecutor’s office, military and federal police have their own data on presence but usually at the state level and they are not published every year. The same is true for the DEA. To measure cartel presence, I construct a novel data set. This data set tracks presence of the nine major Drug Trafficking Organizations in each Mexican municipality between 1990 and 2016.

I follow and extend [Coscia and Rios \(2017\)](#), they tracked the presence of nine criminal organizations at the municipal level between 1990 and 2010. They used a search algorithm that codes a cartel as being present if the frequency of hits for a particular municipality-organization exceeds certain threshold. I follow their idea and then use natural language processing to classify the articles.

First, I use a web crawler to scrape Google News through the Google interface ¹⁵, the assumption behind scraping web content is that local and national newspapers

¹⁵ Google News has changed since [Coscia and Rios \(2017\)](#) scraped their data in 2012, Google News API no longer allows you to go back in time so I use the crawler in the Google interface instead.

combined contain a more systematic, regular and detailed coverage of cartel activity within Mexico. This web crawler look for any news articles between 1990 and 2016 that contained the pair of municipality-organization. The organizations included in the list are the nine mayor organizations¹⁶ that the Mexican prosecutor's office identifies as major actors in the drug trafficking business.¹⁷ The DEA identifies six of them.¹⁸ Second, I extract the core of the articles and keep just the ones that mention the pair of cartel-municipality. Then I keep the sentences from these articles that contain the pair of words and use natural language processing to classify each sentence as valid presence or not. The algorithm use for this was a semi-supervised Convolutional Neural Network (CNN) that I trained manually by reading 5,000 of these sentences. The particular CNN used has an out of sample accuracy of 0.8644. Finally, each sentence classify as valid was assigned to a pair or pairs of municipality-organization. A full detailed explanation of the algorithm and the particular CNN used can be find in the appendix.

The problem with dealing with non legal activities is that there does not exist an official time series by municipality to validate this data set. To validate this measure as a proxy for cartel presence I use two data sets that also use news articles to measure cartel presence: [Coscia and Rios \(2017\)](#) and data collected by Professor Victor Manuel Sanchez from the Autonomous University of Coahuila in Saltillo, Mexico.

3.1.1 Comparison between this data and other datasets that used news articles to measure cartel activity:

The correlation between these two data sets and mine is positive and statistically significant. In particular correlation between my data set and [Coscia and Rios \(2017\)](#) is 0.3810879 for the whole sample where the data intersects between 1990 and 2010¹⁹. The fact that this correlation is not high can be explain by the change in the Google algorithm between 2012 and 2019. The difference can also come from the differences in the validation techniques, number of hints vs natural language processing. The second data set was generated by Professor Sanchez, he manually recorded data from

¹⁶ These are the Sinaloa Cartel, the Beltran-Leyva Organization, the Golf Cartel, CNJG(Cartel de Jalisco Nueva Generacion), the Juarez Cartel, Los Caballeros Templarios, La Familia Michoacan, Los Zetas and the Tijuana Cartel

¹⁷ https://www.scribd.com/document/286347648/Organizaciones-criminales-EPN?ad_group=xxc1xx&campaign=VigLink&medium=affiliate&source=hp_affiliate

¹⁸ <https://www.dea.gov/sites/default/files/2018-11/DIR-032-18%202018%20NDTA%20final%20low%20resolution.pdf>

¹⁹ All hints before 2000 come from a Google project that digitized newspapers.

local and national newspapers for the state of Michoacan²⁰ between 2011 and 2013 and for the Mexico City Metropolitan Area²¹ between 2014 and 2017. The correlation between this data set and the one used here is 0.7092723.

3.1.2 External validation of this data set:

The DEA has published since 2009 a biannual map of cartel presence across Mexico. In 2009, they published a complete map of cartel presence which turns to be highly correlated with my data set 0.69. For the years 2011, 2013 and 2015 the DEA just recorded presence of dominant cartels and the correlation with my data sets goes down to 0.35. The DEA documents do not explain what they mean by dominant presence and the news articles might be catching non dominant presence. Finally, the increase violence that media workers and specially journalists experience from drug trafficking organizations might affect the measure of cartel presence. The data of missing and killed media workers is public and there does not seem to be any particular bias towards reporting or misreporting a particular organization. Anecdotal evidence shows that as long as journalists media use data coming from the police or the military they are safe from the violence of the cartels. These provides evidence that the proxy use here for cartel presence is close to the data from the Mexican authorities.

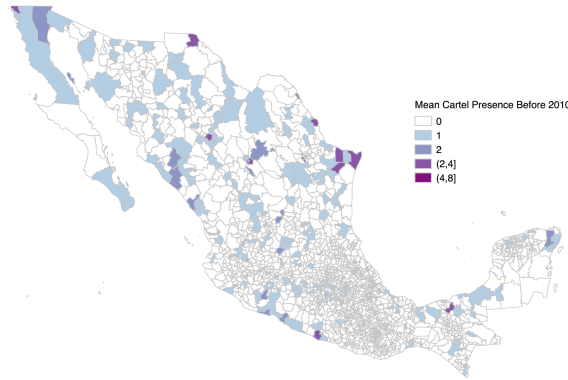
The maps below show the evolution of cartel presence before and after 2010. The first map shows the average number of active cartels between 2004 and 2009 and the second one the average number of active cartels between 2010 and 2016. From this maps is clear that the number of drug trafficking organizations by municipality grew a lot during this period and that this is specially true for the number of municipalities with multiple cartels present.

3.2 Agro-ecological data

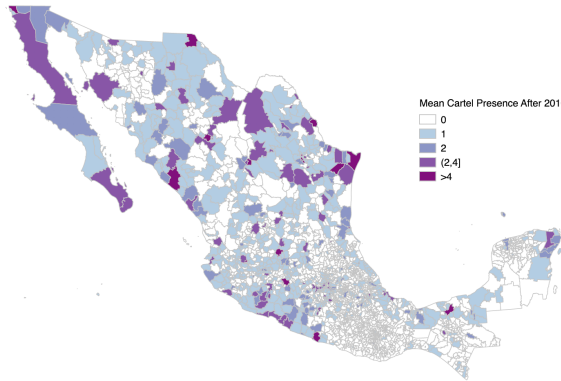
The geographic variation in opium poppy suitability is draw from multiple data sets. A suitability index measures an area comparative advantage for crop cultivation base on geographic and climatic characteristics, while these indexes exist for almost all legal crops they do not exist for papaver somniferum common know as opium

²⁰ <https://www.animalpolitico.com/el-blog-de-causa-en-comun/la-nueva-configuracion-del-crimen-en-michoacan/>

²¹ <https://www.animalpolitico.com/el-blog-de-causa-en-comun/las-organizaciones-criminales-operan-centro-mexico/>



(a) Mean Cartel Presence 2004-2009



(b) Mean Cartel Presence 2010-2016

Figure 1: Cartel Presence

poppy. The only available measure is the FAO overall characteristics for *papaver somniferum* to survive²². Suitability indexes are built using agro-climatic characteristics and actual crop yields. Unfortunately there does not exist historical data on opium production in Mexico²³.

The suitability index that I build here is constructed using Afghanistan data. Afghanistan is the primary world opium producer and the UN has been collecting data (surveys and satellite images) on opium yields and hectares cultivated since the early 1990s²⁴. To build the index I use Afghan yields by district between 2000 and 2018 plus 45 agro-climatic characteristics and all their interactions.²⁵ The main agro-climatic variables I use are temperature, precipitation, elevation, terrain ruggedness, soil quality and river density. A full description of this variables and the data sets they came from can be find in the appendix.

The suitability index is build by regressing log productivity of opium on the geo-climatic characteristics. The number of total regressors will be 903 so I use an elastic net²⁶ Zou and Hastie (2005) to reduce the number of regressors. A 10 fold validation is use and the model chosen has an out of sample accuracy of 0.7535. This model²⁷ is used to predict log productivity of opium in Mexican municipalities given its agro-climatic characteristics. This measure is then standardized and its range set between 0 and 1 for interpretation reasons, so that 1 means perfectly suitable and 0 means not suitable to grow opium poppy. The correlation between the suitability index and the opium poppy eradication data from the Mexican Military between 2000 and 2005 is 0.451248. Figure 3 shows the suitability index for each municipality the more dark the tone of red is the more suitable the area for growing opium poppy. This map and the map show in Figure 2, mean cartel presence after 2010, show similar patterns. The whole area near the Pacific Ocean where the states of Sinaloa, Nayarit, Jalisco, Colima, Michoacan and Guerrero are highly suitable to grow opium and the number of active cartels increased after 2010. Table 1 shows the relationship between the suitability index and eradication data. This table confirms that highly suitable municipalities are at least producing some opium that is later being eradicated by the military.

²² <http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=8296>

²³ UNDOC just started collecting these data in 2014 but they are still unable to provide accurate measures for opium yields by municipality.

²⁴ <https://www.unodc.org/unodc/en/crop-monitoring/index.html?tag=Afghanistan>

²⁵ The suitability index built here is similar to the ones used by Kienberger et al. (2017), Sonin (2019), Bounadi (2018) and ?

²⁶ an elastic net is just a penalized OLS regression

²⁷ the variables selected and the parameters can be find in the appendix

Table 1

	Post2010	Pre2010	All Years
SuitIndex	401.025*** (137.447)	386.471*** (194.678)	788.409*** (283.476)
Constant	-85.514 (59.360)	-75.265 (69.883)	-160.993 (101.758)
Observations	2,455	2,455	2,455
R ²	0.003	0.002	0.003
Adjusted R ²	0.003	0.001	0.003
Residual Std. Error	642.414 (df = 2453)	908.534 (df = 2441)	1,322.943 (df = 2441)
F Statistic	8.513*** (df = 1; 2453)	3.941** (df = 1; 2441)	7.735*** (df = 1; 2441)
<i>Note:</i>		*p<0.1; **p<0.05; ***p<0.01	

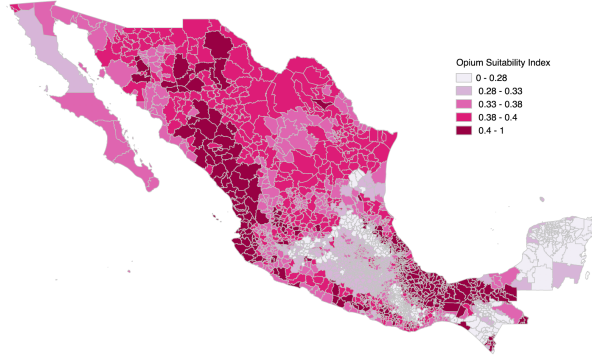
3.3 Municipality level data

The data on homicides per municipality and year are from INEGI, there does not exist a full time series of drug related murders in Mexico the only available one is from 2006 to 2012. Therefore the homicides data use here are the total number of homicides for which a dead certificate was generated and were classified by the authorities by intentional deaths. Demographics by municipality are from the 2000, 2005, 2010 and 2015 censuses and intercensal surveys from INEGI are use to get: population, average years of education, indigenous population, illiterate population, unemployment and basic characteristics of the houses that includes percentage of houses with dirt floor, percentage of houses without electricity, sewage or running water and percentage of houses with TV, refrigerator, washer, phone, Internet or car. I also use the CONEVAL data that report an index of how marginalize is a municipality and the CIDAC and INAFED data sets that provide a complete panel of political party of the mayors and state governors.

3.4 Drugs Time Series

The Mexican National Defense Office publishes each year data on how many hectares of opium and marijuana are eradicated by municipality and the amount of drugs seized by the military and marines. The data on heroin prices come from the UNDOC data set, data on heroin overdose deaths from the national CDC wonder data set and data on heroin users each year from the National Survey on Drug and Health.

Figure 2: Opium Poppy Suitability Index



4 The effect of external demand shocks on cartel presence

In this section I examine the casual effect of a plausible external demand shock to the heroin market on the presence of drug trafficking organizations across Mexico. First, I describe the theoretical framework for the mechanism behind the relationship between the increase in the value of certain territories, entry and violence. Second, I introduce the main econometric specification and address possible threats to my identification strategy. Last, I present the effect of the shock on the probability of having more than one cartel active and in the number of active drug trafficking organizations per municipality.

4.1 Theoretical Framework

In this section I provide a theoretical model that relates cartel entry, investment in military capacity and violence. The mechanism behind is the following one; a positive demand shock to the heroin market increases the value of controlling drug production and drug trafficking routes. In the absence of conditions to reach peaceful agreements to share the market, drug traffickers will fight each other to gain as much market shares as possible.

The following model is a two stage entry game, a variant of the endogenous sunk cost models in [Schmalensee \(1992\)](#), with the addition of a success function that determines the proportion of the total shares that each organization will win. To simplify

the model, I assume that each municipality is an independent production site, an extension of this model will take into account the geographic location of the cartel headquarters and include spill over effects. I will also assume that the government actions are completely known by the cartels and that they have already internalized any possible seizures or extra costs that government interventions might generate²⁸. Finally, the only way a drug trafficking organization can gain market power is through investing in military capacity.

There are N potential cartels that want to enter a production site, each of them invest M_i in military capacity and the total military presence in the municipality will be $M = \sum_{i=1}^{N^*} M_i$. The potential crop production of the site is given by R and that military capacity has no dynamic effect.

In the first stage cartels decide whether to enter or not a site and pay fixed cost F , think this as an exploration fixed costs, cartels need to make sure the site is productive and also know who else is in that territory. In the second stage they decide how much to invest in military capacity.

The contest function is given by:

$$s_i = \frac{M_i^\eta}{\sum_{j=1}^{N^*} M_j^\eta}$$

In the data I observe multiple drug trafficking organizations in one site so this success function can be interpreted as the proportion of the total share that each cartel gets from its investment. Here η describes the returns to military efforts, if $\eta \leq 1$ there are decreasing returns to effort if $\eta > 1$ the returns are increasing.

The profit for a cartel entering a municipality is given by:

$$\pi_i = R s_i - M_i - F$$

where R is the total revenue from this production site.

There will be a byproduct from military expenditure, a negative externality, that I will call violence. Violence will be a function of the total military investment of all the cartels $V(\sum_{i=1}^N M_i)$. The only assumption about this function is that is zero if military capacity is zero and that increases in the total expenditure.

As long as $\eta \leq 2$ there will be well behaved symmetric Nash equilibria in M_i with non negative profits.

The Cournot symmetric NE in military expenditure will be:

$$M = R\eta \frac{n-1}{n^2}$$

²⁸ for a model on how the government interdictions affect violence see [Castillo and Kronick \(2019\)](#)

and the free entry condition is :

$$n^{*2} \frac{F}{R} + n^*(\eta - 1) - \eta = 0$$

The parameter η will determine the relationship between the total revenue from a site and the number of cartels that enter:

If $\eta < 1$ then when $R \rightarrow \infty$ so does $N \rightarrow \infty$.

If $\eta = 1$ then $n^* = \left(\frac{F}{R}\right)^{1/2}$ in this case military expenditure is increasing in the size of the prize as long as $F \geq 9/4R$, the military expenditure per cartel needs to grow as the market grows in order to keep the free entry condition active.

If $\eta \in (1, 2]$ then when $R \rightarrow \infty$ the number of cartels is bounded by $n^{**} = \frac{\eta}{\eta-1}$ here competition is tough and military expenditure increases more than in the previous case.

In all the cases above the number of cartels and the military investment will be increasing in the size of the revenue. This models will predict that an external demand shock that increases the revenue of some production sites (R) will make the cartels entry more and invest in military capacity in order to capture higher market shares. The increase number of cartels and the increase in military capacity will generate more violence in more valuable sites.

4.2 Empirical Strategy

4.2.1 Baseline Econometric Specification

To estimate the causal effect of competition between Drug Trafficking Organizations on violence I ideally will need a policy change or external shock that shifts demand or supply but that does not directly affects violence. This directly disqualifies any shift that might happen through law enforcement, this kind of shock will have two different effects in violence: a direct one from the change in law enforcement and an indirect one from market pressures. Through this paper I use the reformulation of OxyContin in 2010 that make the pill harder to abuse ²⁹. This was followed by an increased in heroin over dose deaths and spike in heroin prices in the US. This seems like a plausible exogenous shock to the heroin market that might affected the decision of the drug trafficking organizations to entry into new territories that are suitable for opium production. I exploit within municipality variation from combining the

²⁹ The ADF pill is difficult to crush and snort, and several studies have found that the move led to a rapid drop in illicit use of the drug.

suitability index and heroin prices in the United States. The main specification is an event study analysis, where the relevant event is the OxyContin reformulation in 2010.

$$Y_{mt} = \sum_{t=2004}^{2016} \beta_t \text{Suit}_m * \text{PriceHer}_t + \psi X_{mt} + \alpha_m + \gamma_t + \sigma_e t + \epsilon_{mt} \quad (1)$$

where Suit_m is a measure of opium poppy suitability of municipality m , this measure is between 0 and 1 where 1 means perfectly suitable and 0 not suitable. PriceHer_t is the retail price of a milligram of heroin in the US adjust by purity and inflation in 2016 dollars and normalize to 2002. The Y_{mt} will be the probability of having more than one cartel and the number of active cartels. The α_m are municipality fixed effects, γ_t year fixed effects and $\sigma_e t$ state specific time trends. These fixed effects control for invariant differences between high and low suitable municipalities and changes in time trends across years. The controls include police presence, military presence, a dummy if the mayor is from the conservative party PAN and a dummy if both the state governor and the mayor are from the conservative party. The only difference between this specification and an standard event study is that here the treatment is continuous variable ³⁰.

The main results are presented by plotting the coefficients β_t to show the evolution of the outcome variables relative to the reformulation in 2010. The year 2009 was normalized to zero and the plots show two different coefficients the simple post average from the event study coefficients and the difference-in-difference coefficient. This difference-in-difference results are estimates using the same specification as equation (1) but with the event dummy years replace by $\text{PostRef}_{mt} = \text{Suit}_m * \text{PriceHer}_t * \mathbb{1}[t \geq 2010]$. Standard errors are clustered using [Conley \(1999\)](#) with a radius of 500 Km, this to address the fact that there is spatial correlation in the suitability index and clustering by municipality might be a too small geographic variation. Results with clustered standard errors at the municipal level can be found in the Appendix.

4.2.2 Threats to Identification

Here I address some potential concerns regarding the main identification strategy. I provide evidence that measuring cartel presence using news articles is not bias towards any particular cartel. Second, I discuss the validity of the reformulation as an external demand shock. Finally, I present a series of robustness checks that address

³⁰ Strategy commonly use to estimate the effect of commodity shocks [Dube and Vargas \(2013\)](#)

the potential of violence and cartel activity being completely driven by the war on drugs and government action and not by market pressures.

The main threat to identification is building the presence data set using news articles. I already showed in the data section that this data set is highly correlated with other data sets on cartel presence build through news papers and also aggregate data from the DEA. Despite this it could be that this measure is bias. Mexico is known for being one of the most dangerous countries in the world to be a journalist. More than 200 media workers have disappeared or killed since 2000. Anecdotal evidence from other journalists show that some of them had stop reporting cartel activities that are not first reported by the police or the military. To train the neural network used to validate the data I read 5,000 sentences to classify them as either presence or not, these sub sample confirms that most of the journalists are either not reporting names of particular cartel members, just the bigger organization or that they are just reporting using official data from local and federal police or the military.³¹ Examples of these sentences can be found in the Appendix. The data set that includes the location, date and media where these journalists either were killed or disappeared is public³². I use this data to test if there are particular regions of the countries or years when crimes against the media happen more. The most lethal state in Mexico to be a journalist is Veracruz, I ran all the analysis excluding this state and all the results of the paper still hold. All the other attacks against the media are distributed mostly evenly across 23 states. States with low cartel or no cartel presence do not experience any attacks against the media. All this provides evidence that the cartel presence measure use here is a good proxy for cartel activity across Mexico.

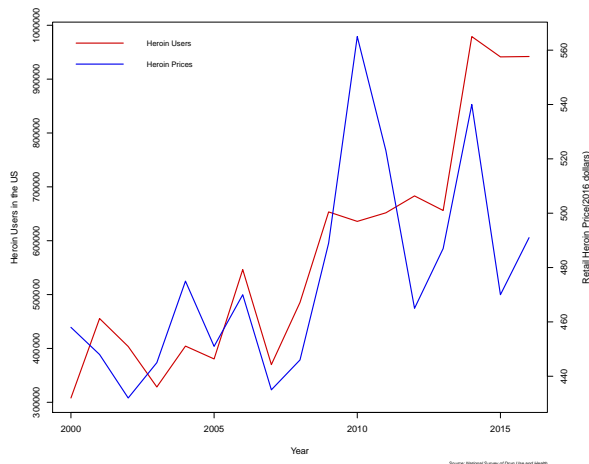
The second potential concern with this identification strategy is that drug trafficking organizations had a direct impact in the price of retail heroin in the United States. Then the price will not be exogenously changing but will be reacting to supply changes. The sharp increase in the heroin of Mexican origin seized by the DEA in the United States from 19% in 2009 to 51% in 2011 and 95% by 2016, suggests that the cartels adapted after the increase in demand in the United States. The drug trafficking organizations reacted by producing more heroin as the demand increased. Figure shows the increase in heroin uses and heroin prices in 2010. Pacula (2018) and Pradip K. Muhuri (2013) have shown that the reformulation drove up the demand for heroin and the overdose deaths from it. Then, it is reasonable to assume that the increase in demand and the subsequent increase in prices attracted more drug

³¹ The police reports are not public so I could not use them to create a data set.

³² https://en.wikipedia.org/wiki/List_of_journalists_and_media_workers_killed_in_Mexico

traffickers to the heroin market.

Figure 3: Heroin Users and Heroin prices in the United States



Finally, one last concern is that the increase in violence and the multiplication of drug trafficking organizations is a direct effect from the war on drugs. To address this I use several controls that include police presence, military bases, garrisons and ports, if the mayor of the municipality is from the conservative party PAN, if the mayor and governor are both from the PAN party. I also add baseline controls for the municipality characteristics interacted with year fixed effects. I also add state specific time trends to control for any other government policies that might affect cartel activity. The results seem to be robust to all of these different specifications. One last identification concern is the fact that marijuana legalization and the opioid crisis happened at the same time. This does not seem to be a big problem because both of this external shocks increase the value of opium and drive cartels to switch to the heroin market and leave the less profitable marijuana market.

4.2.3 Results

The section below shows the cartel presence reaction to the 2010 shock. First, I show how the probability of having more than one cartel active changes after the shock and then how the number of cartels affects this. The results are robust to including the set of covariates describe in the section above, all the fixed effects and

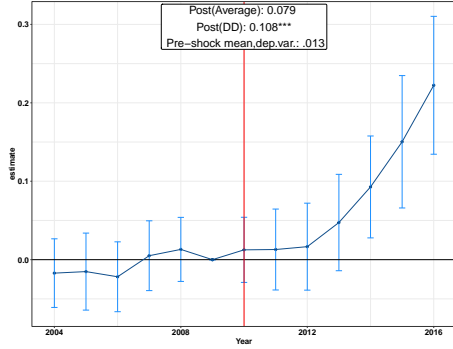


Figure 4: More than one cartel active

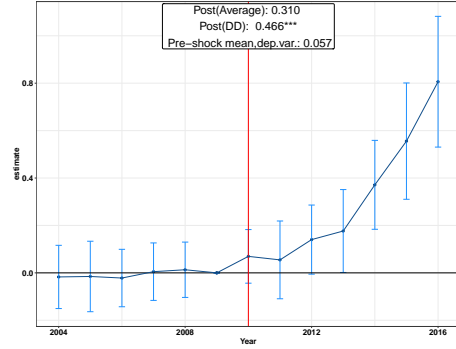


Figure 5: Number of cartels

also the baseline characteristics interacted with fixed effects.

Cartel Activity Figures 1 and 2 in the data section show the increase in the number of municipalities with more than one cartel after 2010 in specially the most suitable areas for opium poppy cultivation. Next, I estimate the casual effect of heroin prices in cartel presence, particularly the price spike experienced in 2010. Figure 4 shows the event study coefficients from equation (1) where the dependent variable is one if the municipality has more than one cartel and zero otherwise. The figure shows that the pre-shock probability of having more than one cartel present is just 0.013. The event study post event average is 0.079 and the difference-in-difference coefficient is 0.108. To understand the magnitude of these coefficients consider the effect of an increase in the price of heroin of 30%, this was the price increase between 2009 and 2010. The probability of having more than one cartel will be 14% higher in a high suitable municipality compared to a low suitable one.

Figure 5 shows the coefficients from specification (1), where Y_{mt} is the number of active cartels in municipality m at time t . As in the case for the probability of having more than one cartel present this coefficients are close to zero before the shock and start slowly increasing in 2010. The figure shows the average post shock event study coefficient that is 0.310, the difference-in-difference coefficient that is 0.466 and highly significant and the pre-shock average number of cartels that was just 0.05 cartels. To understand the magnitude of these coefficients lets compare the high and low suitable municipalities when there is a heroin price increase of 30%. The number of active cartels will increase by 0.6 more cartels each year after the shock.

Robustness Checks: Table 2 addresses some concerns presented in section 4.2.2. The first column uses the specification in equation (1) but just includes municipality

and year fixed effects. The second column includes the same set of fixed effects plus a set of controls that are police presence, military presence, distance to military bases, garrisons and ports interacted with year fixed effects, a dummy if the mayor is from the conservative party PAN and a dummy if both the mayor and the governor are from the conservative party. These controls for potential biases coming from the war on drugs acting different across municipalities with different political alliances or municipalities with higher presence of authorities. Columns 3 and 4 add a set of baseline time trends. These baseline characteristics are population, years of education, poverty index, hectares of drugs cultivated and kilos of drugs seized all of these variables are from 2000 and are interacted with year fixed effects. Column four just adds the same set of controls as Column 2 to the set of baseline controls. The estimates are robust to adding all these controls. Finally, Column 5 includes linear time trends by state and all the covariates from the previous columns. The results for both having more than one cartel active and the number of cartels are robust to all these controls and fixed effects. The standard errors are clustered using Conley (1999) with a radius of 500 Km, the results with standard errors clustered at the municipal level can be find in the Appendix.

Table 2

	<i>Cartel Activity</i>									
	More than one					Number of Cartels				
PshockInst(dd)	0.108***	0.121***	0.064***	0.044***	0.049***	0.466***	0.537***	0.292***	0.227***	0.241***
Radius 500 km	(0.011)	(0.014)	(0.012)	(0.012)	(0.012)	(0.002)	(0.049) (0.038)	(0.039)	(0.039)	
Observations	32,202	31,752	32,202	31,752	31,752	32,202	31,752	32,202	31,752	31,752
Pre-shock mean, dep. var.	0.012	0.012	0.012	0.012	0.012	0.057	0.057	0.057	0.057	0.057
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends			✓	✓	✓		✓	✓	✓	
State trends					✓					✓

Note:

*p<0.1; **p<0.05; ***p<0.01

In sum, patterns of cartel entry are consistent with the theoretical model presented in section 4.1. The increase in the value of some production sites encourage more cartel activity in these places. When the prices of the final product is high more drug trafficking organizations will try to enter the market. These results are also consistent with anecdotal evidence of increase cartel presence in municipalities where cartels were not active before and that now produce most of the opium ³³. The results above do not show a sharp jump in 2010, this is consistent with cartels

³³ <https://www.nytimes.com/es/2015/08/29/las-manos-de-muchos-jovenes-mexicanos-alimentan-la-demanda-de-heroina-en-estados-unidos/>

slowly realizing that these sites are now more valuable and the fact that it takes at least four months between the cultivation of opium and when it can be transformed into heroin. An explanation of how opium is transformed into heroin can be found in the appendix.

5 Entry, Exit and Violence:

This section provides evidence of the relationship between cartel entry, exit and the homicide rate. I use an event study specification that exploits heterogeneity on the time of entry and exit across municipalities. The relevant event of study is the entry or exit of the first, second, third cartel. The relationship between the number of cartels and violence is not obvious. The presence of illegal activities does not necessarily breeds violence. [Snyder and Duran-Martinez \(2009\)](#) and [Castillo and Kronick \(2019\)](#) show that the ability to reach peaceful agreements to share profits between criminal organizations relies on how strong are national institutions. Mexico during this period of time lacked such conditions so it is expected to see the criminal organizations fighting over potential profits. The main econometric specification used in this section is the following one:

$$Y_{mt}^n = \sum_{\tau=-5}^5 \beta_{\tau} \mathbb{1}\{\tau = t - e_m\} + \psi X_{mt} + \alpha_m + \gamma_t + \sigma_e t + \epsilon_{mt} \quad (2)$$

The time relative to the entry of the cartel is indexed by τ . The variable e_m denotes the calendar year in which municipality m experience the entry of cartel number n , so $\mathbb{1}\{\tau = t - e_m\}$ is an indicator of municipality m in year t having experience the entry of the cartel number n τ years ago. In the summation $\tau = -5$ (or $\tau = 5$) term includes all the years greater than or equal to five years before (or five years after) the entry of the first cartel. This specification normalizes the year $\tau = -1$ to zero. I control for a vector of municipality fixed effects α_m , calendar year fixed effects γ_t , the same controls as before X_{mt} and linear state time trends $\sigma_e t$. The results are presented by plotting the β_{τ} coefficients, to show the within municipality evolution of the homicide rate relative to the event of the entry or exit of the n th cartel. The graphs also show difference-in-difference results which are estimated with the same specification as equation (2) but with the event time year dummies replace by a dummy variable $PostEntry_{mt}$ (indicating that in year t municipality m has the entry of the n th cartel).

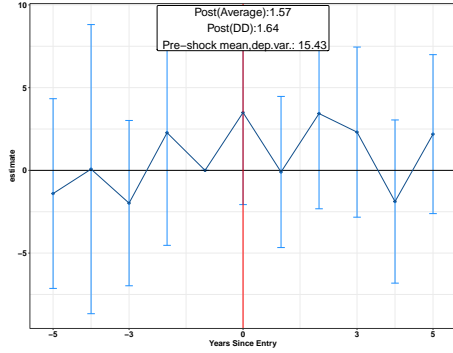


Figure 6: First Cartel Entry

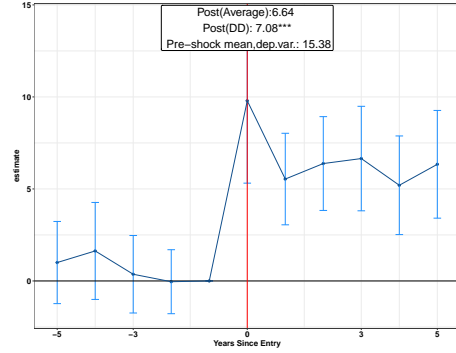


Figure 7: Second Cartel Entry

The standard errors are clustered using [Conley \(1999\)](#) error with a radius of 500Km. The results with clustered standard errors at the municipal level can be find in the appendix.

5.1 Results

: This section shows three main results. First, the presence of a single cartel does not increases violence. Second, there seems to be a non linear relationship between the number of cartels and the increase in the homicide rate. Last, the only significant effect from the exit is when a municipality goes from two to one cartel only.

Figure 7 presents the coefficients from equation (2) where the relevant event is the entry of the first cartel to a municipality. There does not seem to be a significant effect from this entry. This result is consistent with [Biderman et al. \(2018\)](#), that find a decrease in violence in Sao Paulo when a single gang gains monopoly power. This result suggest that is not criminal activity alone that generates violence but is the interaction between different actors that increase violence. It might indicate that as long as a single group can maintain monopoly power in a location there should not be an increase in violence regardless of the illegality of their activity. This result is robust to adding controls for police and military presence, political party affiliations, municipality baseline characteristics interacted with time trends and state specific time trends.

The second result from this analysis is the increase in the homicide rate from cartel entry. Figure 8 shows that when a municipality goes from having one to two

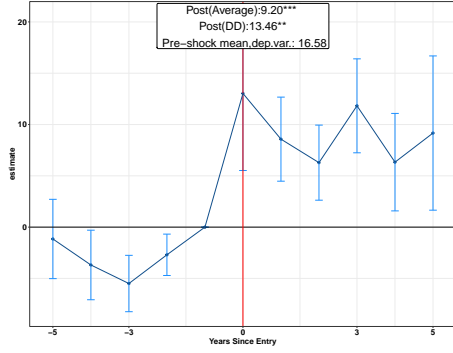


Figure 8: Third Cartel Entry

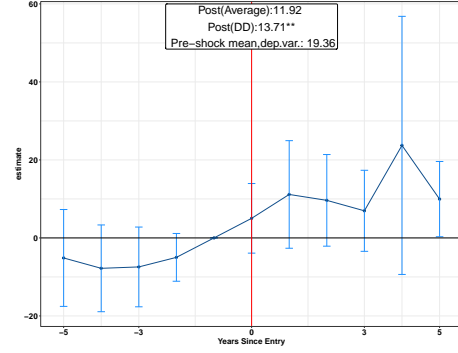


Figure 9: Fourth Cartel Entry

cartels the homicide rate per 100,000 inhabitants increases by 7. The increase peaks at the year the second cartel enters but stays high for the next five years. The entry of the third and fourth cartel both increase the homicide rate by 13. From Figure 8 there is an sharp increase the year the third cartel enters but the effect in the homicide rate the five years after is less stable than for the entry of the second cartel. Figure 9 shows that when the fourth cartel enters there is not a sharp increase the year of its entry but the year after the entry and that after the second year the coefficients get more noisy than in the two events described before. The entry of the fifth cartel increases the homicide rate by 17, this is the biggest increase and from Figure 10 there is a similar pattern when the fifth cartel enters than when the fourth one enters. There is not a sharp increase as there is for the entry of the second and third cartel. The coefficients are increasing and then get noisier. The last significant effect that I find is from the entry of the sixth cartel, the homicide rate increases by 10 extra deaths. There is not significant effect after the sixth cartel, but the number of municipalities with more than 6 cartels is 14. These sets of results are robust to including controls for police presence, military presence, political party, baseline trends and state specific linear time trends. The tables that show the difference-in-difference coefficients for all these specifications can be found in the appendix.

The last result is related to the exit of cartels from a municipality. There does not seems to be any significant effect when a cartel leaves a municipality. The only clear effect is when a municipality goes from two to one cartels. Figure 13 shows the coefficients from the specification (2) when the relevant event is when a municipality with two cartels experience the exit of one of them. This graph shows a sharp drop of the homicides after the exit of the cartel and the homicides keep going down for a couple of years. The homicide rate per 100,000 inhabitants decreases by 6 homicides

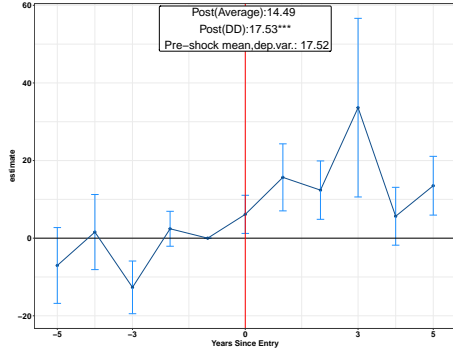


Figure 10: Fifth Cartel Entry

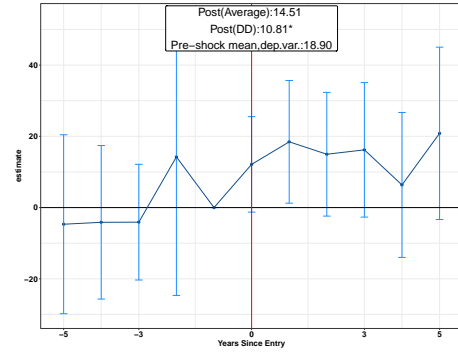


Figure 11: Sixth Cartel Entry

after the exit. This result is robust to including the different controls and fixed effects. The three results presented in this section are consistent with the theoretical model from section 4. The model predicts that when there exists a single criminal organization, violence should be zero and that violence is an increasing function of the number of cartels. The first and last result from this section suggest that when a single organization has the monopoly power of a territory violence should be low. It is not the presence of drug traffickers or their illegal activities that generate violence but the competition in which these organizations engage to win market power that generates the increase in violence.

Figure 12: Going from two to one active cartel

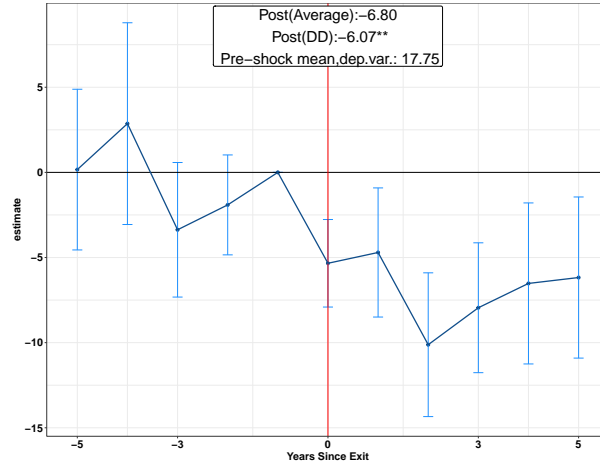
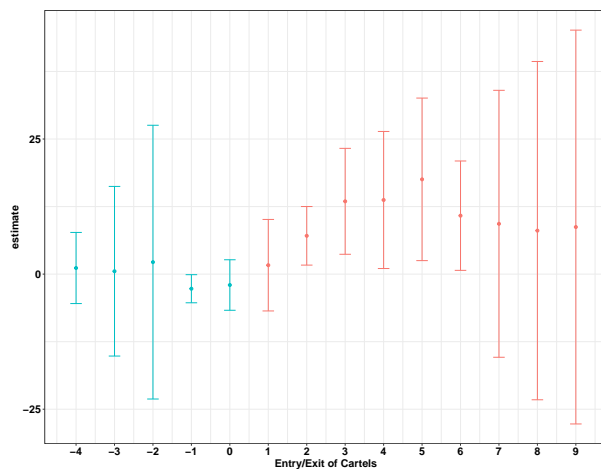


Figure 14 shows the difference-in-difference coefficients from equation (2) but

with the event time year dummies replace by a dummy variable $PostEvent_{mt}$ using just municipality and calendar year fixed effects. The coefficients and error bars in red , 1-9, show the effects of the entry of the first, second and so on cartel. From this graph there is the non linear relationship between the entry of the cartels and the homicide rate per 100,000 inhabitants. The standard errors of these estimates get bigger as the number of active cartels increases in a municipality, this is because there are not that many municipalities with more than five cartels active in their territory. The coefficients and error bars in blue account for the exit of cartels. The coefficient in zero measures the effect in the homicide rate in municipalities that go from having one to zero cartels. The coefficient in -1, is the effect of a cartel leaving a municipality that previously had two cartels. The other three coefficients are the effects from a municipality that experience the exit of one cartel and previously had three of them, -2. The effect of a municipality that goes from four to three cartels, -3, and the first bar shows the coefficient and standard errors from municipalities that had five cartels and experience the exit of one of them. This figure summarizes the relationship between cartel entry, exit and the homicide rate. The significant effects occur when a municipality goes from one to two or two to one, this confirms that when there is just one criminal organization present in one place there is no a notorious increase in violence. The rest of the graph shows that there are not significant effects of exit if there are at least two cartels left and that violence seems to be increasing in the number of cartels.

Figure 13: Entry and Exit of Cartels

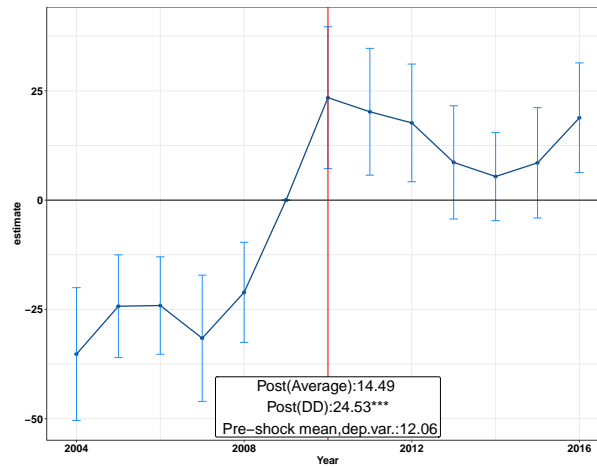


5.2 The effect of the shock in other outcomes

In this section I analyze the effect that the external demand shock had in other outcomes. I use the first specification (1) where the relevant event happens in 2010. First, I show that there was an increase in the homicide rate after 2010. Second, I ask how demographics such as population, average years of education and the percentage of households with dirt floor change after the shock. Finally, I see how the government data on eradication confirms that after 2010 the suitable municipalities were producing more opium than before. These results show that the shock had a direct impact on other outcomes across Mexican municipalities.

Homicide Rate per 100,000 inhabitants Figure 14 shows the coefficients from the event study (1) where Y_{mt} is the homicide rate per a 100,000 inhabitants. There is an increase in the number of homicides after 2010 and it stays high after the shock. The difference-in-difference coefficient is an increase of 24 homicides in the homicide rate. This means that a high suitable municipality will have a homicide rate with 24 more homicides per 100,000 inhabitants compare to a less suitable one. Table 3 shows the results for different specifications. The results are robust to all the different controls and fixed effects. The model that includes all the controls and state specific time trends has an increase of homicides per a 100,000 of 11 extra homicides after 2010.

Figure 14: Homicides per 100,000 inhabitants



Change in demographics: This section analyses the effect of the shock on different demographic outcomes. First I ask if the shock had any effect on the population and households composition. The variables use are log of the population, mean years of

Table 3

	<i>Homicides per 100,000 inhabitants</i>				
Post-shock	24.53*** (8.72)	20.60*** (2.87)	22.19*** (2.94)	15.61*** (2.84)	11.13*** (2.54)
Observations	32,202	31,752	32,202	31,752	31,752
Pre-shock mean, dep. var.	12.06	12.06	12.06	12.06	12.06
Municipalities FE	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓
Covariates		✓		✓	✓
Baseline trends			✓	✓	✓
State trends					✓

Note:

*p<0.1; **p<0.05; ***p<0.01

Conley Standard errors with a radius of 500Km

education, percentage of households with women as the head of the household and mean number of occupants per dwelling. The second set of variables that I analyze suggest that there was probably an income boost in the municipalities exposed to the shock. These variables are the percentage of households without dirt floor and percentage of households that do not have access to basic services (water, electricity and sewer).³⁴ Figure 16 shows an steady decrease in the log of the population after 2010 and Figure 17 a similar steady decrease in the average years of education. Figures 18 and 19 show an increasing share of households with women as the head of the household and an increasing number of occupants in the same dwelling. All these results are consistent with out migration of the more educated and wealthier of the members of these communities. Tables 4 and 5 show the coefficients from specification (1) but with the event-time year dummies replaced by a dummy variable $PostShock_{mt}$ that is the interaction between the suitability index and the heroin prices after 2010. The results are robust after including controls, baseline time trends and state specific linear time trends. To understand the magnitude of these coefficients I will compare a high suitable with a low suitable municipality. The log of the population will be -0.050 and the mean years of education -0.4180 years less in the high suitable municipality after the shock compare to a low suitable one. The number of occupants per dwelling increases by 4.45 and the percentage of households with a woman as the head will be 1.5% higher in a perfectly suitable municipality compare to one that is not suitable.

Income boost: The next set of results suggest that the shock might have had a positive impact in some socio-economic outcomes. Figures 20 and 21 show the coefficients from the event study specification (1). From figure 20 there was an increase in the percentage of houses that had floors made of any other material different from

³⁴ The other variables that I analyzed were percentage of households that own TV, Fridge, washer, car, phone and computer non of these show any change after the shock. They either have an increasing trend or are completely flat during the years analyzed.

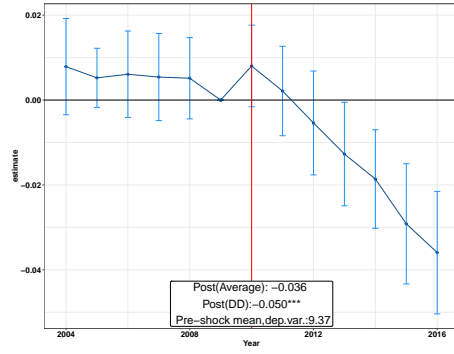


Figure 15: Population

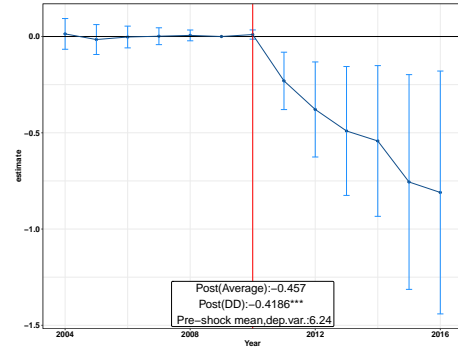


Figure 16: Mean Years of Education

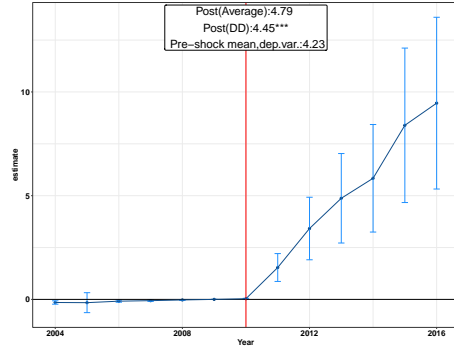


Figure 17: Occupants per dwelling

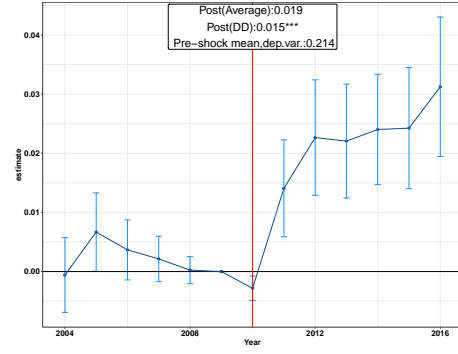


Figure 18: Percentage of households with women as a head

Table 4

	Demographics:									
	log(population)				Years of Education					
Post-shock	-0.050*** (0.008)	-0.013*** (0.004)	-0.062*** (0.012)	-0.076** (0.007)	-0.039*** (0.009)	-0.418*** (0.008)	-0.815*** (0.095)	-0.085* (0.034)	-0.111** (0.035)	-0.366*** (0.089)
Observations	32,202	31,752	32,202	31,752	31,752	32,202	31,752	32,202	31,752	31,752
Pre-shock mean, dep. var.	9.37	9.37	9.37	9.37	9.37	6.24	6.24	6.24	6.24	6.24
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends			✓	✓			✓	✓		
State trends					✓					✓

Note:

Conley Standard errors with a radius of 500Km

*p<0.1; **p<0.05; ***p<0.01

Table 5

	Demographics:									
	% Women Head of Households					Occupants per dwelling				
Post-shock	0.015*** (0.002)	0.011* (0.005)	0.011* (0.005)	0.010** (0.005)	0.021*** (0.006)	4.45*** (0.364)	7.57*** (0.658)	4.31*** (0.334)	4.87*** (0.340)	4.01*** (0.526)
Observations	32,202	31,752	32,202	31,752	31,752	32,202	31,752	32,202	31,752	31,752
Pre-shock mean, dep. var.	0.21	0.21	0.21	0.21	0.21	4.23	4.23	4.23	4.23	4.23
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓		✓	✓	✓	✓		✓		✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends				✓	✓		✓	✓		
State trends					✓					✓
Note:								*p<0.1; **p<0.05; ***p<0.01		

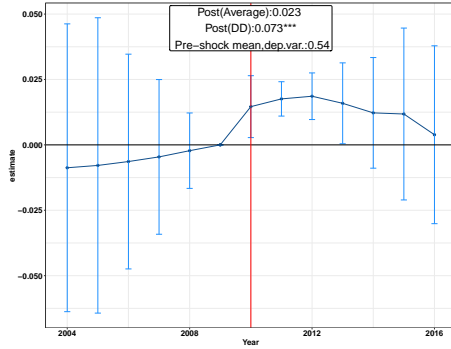


Figure 19: Households with Non Dirt Floor

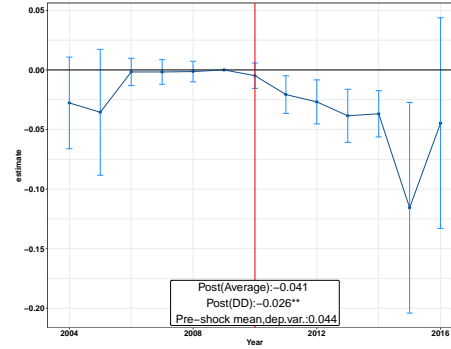


Figure 20: Households without Basic Services (water/sewer/electricity)

dirt, Figure 21 shows an steady decrease in the percentage of households without any basic services. These services are access to piped water, access to sewers and access to electricity. The percentage of households without dirt floor after the shock will be 7.3% higher in a high suitable municipality compare with a low suitable one when the price of heroin remains constant. The percentage of households without services will go down by 2.6% in a high suitable municipality compare to a non suitable one. Table 6 shows the difference-in-difference specifications with the different controls and fixed effects and these results are robust to all of them. These two results suggest that there was an income boost from the increase cultivation of opium in some of these places.

Military eradication In this section I use the eradication data from the Mexican military to see if the shock affected the type of crops the government is finding. Assuming that the military did not became better at eradicating one particular crop during this period and assuming that eradication can be seen as a proxy of total production. Figure 19 shows the coefficients for specification (1) for the log hectares

Table 6

	<i>Demographics:</i>									
	% without Dirt Floor					% of Households without basic Services				
	0.073*** (0.009)	0.038* (0.017)	0.081*** (0.013)	0.081*** (0.013)	0.056*** (0.016)	-0.026*** (0.000)	-0.013* (0.006)	-0.022** (0.008)	-0.012** (0.006)	-0.014*** (0.003)
Post-shock										
Observations	32,202	31,752	32,202	31,752	31,752	32,202	31,752	32,202	31,752	31,752
Pre-shock mean, dep. var.	0.54	0.54	0.54	0.54	0.54	0.044	0.044	0.044	0.044	0.044
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends			✓	✓			✓	✓		
State trends					✓					✓

Note:

*p<0.1; **p<0.05; ***p<0.01

eradicated of marijuana and opium. There is a clear jump in the amount of eradication of opium and an slowly decline in the eradication of marijuana after 2010. There does not seem to be any particular pre-trend for any of the crops. Table 6 shows the difference-in-difference coefficients with the different controls and fixed effects, the results are robust to all of these different specifications. These results confirm that after the shock the value of cultivating opium increase while the value of marijuana was decreasing which lead to the cartels to switch crops.

Figure 21: Log of Hectares eradicated



Table 7

	<i>Eradication</i>									
	log(Hectares Opium Poppy)					log(Hectares Marijuana)				
Post-shock	0.198***	0.157***	0.088*	0.033*	0.040***	-0.220***	-0.192***	-0.235***	-0.210***	-0.166**
Radius 500 Km	(0.001)	(0.045)	(0.038)	(0.008)	(0.004)	(0.002)	(0.048)	(0.047)	(0.047)	(0.054)
Observations	32,202	31,752	32,202	31,752	31,752	32,202	31,752	32,202	31,752	31,752
Pre-shock mean, dep. var.	0.130	0.130	0.130	0.130	0.130	0.295	0.295	0.295	0.295	0.295
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓			✓		✓	
Baseline trends			✓	✓			✓	✓		
State trends					✓					✓
F-test pre-trends	2.51	2.40	0.516	0.256	0.476	0.027	0.848	1.13	0.782	0.124

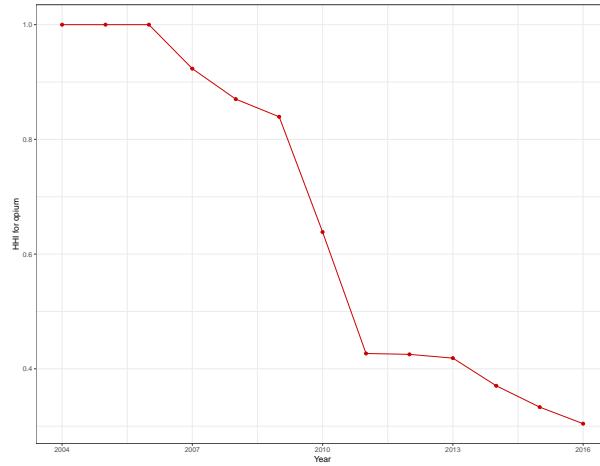
Note:

*p<0.1; **p<0.05; ***p<0.01

6 Cartel Competition and concentration in the heroin market

In this section I provide evidence of the expansion of several cartels into the heroin market after the increase demand in the United States. Historically Mexico has produce some opium and exported it to the United States since the beginning of the XX century. Opium poppy native from the eastern Mediterranean area was introduce to Mexico by Chinese immigrants in the late XIX century and prove to be well suited to be cultivated there. The prohibition laws in the United States regarding psychedelic substances and the political chaos in Mexico after the Mexican Revolution lead to the proper environment for the creation of the first drug trafficking organizations. During the XX century Mexican traffickers mostly produce and trafficked marijuana and eventually entered the cocaine and methampethamine business. They exported some heroin but it was never their main activity. Until 2006 there was just one cartel, the Sinaloa Cartel, in areas where opium poppy was eradicated by the Mexican government by 2016 the nine main organizations can be found in municipalities where opium poppy was eradicated by the military. Figure 20 shows the Herfindahl–Hirschman Index for the raw opium market. The index was calculated using the cartel presence and the eradication data set. I used the military eradication as a proxy for total production and the cartels present in those municipalities to assign market shares. In municipalities where there was more than one active cartel I equally split the production between them. From the image the HHI drops from 1 in 2004 to around 0.3in 2016. The graph also shows that the biggest jump occurs in 2010, after the reformulation of OxyContin this measure confirms the rest of the paper findings that when the demand for heroin increased in the United States the cartels decided to enter or expand their operations into this market.

Figure 22: HH1 Opium



6.1 Identifying Expanding and competitive cartels

This paper considers nine main drug trafficking organizations recognized by the Mexican Military and the DEA as the major actors. The interactions between these organizations are complex with them expanding, fragmenting and disappearing. The last decade saw some of them fragmenting due to the government strategy of capturing kingpins. These strategies left power gaps that lead to internal disputes in these organizations Phillips (2015). Less explored is fragmentation due to market pressures. The increase in the market value of certain territories might incentivize drug traffickers to break from their main organizations or stop previously pacific agreements with former allies in order to capture higher market shares. In the early 2000s the only organization producing and trafficking heroin was the Sinaloa Cartel, around the time of the shock the Jalisco New Generation Cartel split from the Sinaloa Cartel³⁵ and took some of its former parent organization territory suitable to grow opium poppy. The second fragmentation that happened around the time of the shock is the Templar Knights Cartel splitting from La Familia Michoacana, the group that started as a self defense group in order to defend Michoacan against criminal organizations rapidly became a criminal organization itself. These two groups have been fighting with each other for the control of the state of Michoacan. I used the specification below to quantify the effect that the shock had on the presence of each

³⁵ <https://www.insightcrime.org/mexico-organized-crime-news/jalisco-cartel-new-generation/>

of the nine organizations.

Econometric Specification:

$$Y_{mt}^c = \sum_{t=2004}^{2016} \beta_t \text{Suit}_m * \text{PriceHer}_t + \psi X_{mt} + \alpha_m + \gamma_t + \sigma_e t + \epsilon_{mt} \quad (3)$$

where Y_{mt}^c is the probability of having the cartel c active in municipality m and time t . Suit_m is the measure of suitability in the municipality m , PriceHer_t is the retail price of heroin in the United States per milligram of heroin adjust by purity in 2016 dollars, X_{mt} is a set of controls that include: police presence, military presence, political party of the mayor and political party of the governor of the state. α_m are municipality fixed effects, γ_t year fixed effects and $\sigma_e t$ are state specific time trends.

Results The nine major organizations studied in this paper show at least some presence in municipalities well suited to grow opium poppy. Figure 21 shows the coefficients from equation (3) for the five cartels with significant change in presence after 2010. There are two cartels expanding into the heroin market, the Sinaloa Cartel and Los Zetas, two cartels splitting from existing ones and immediately entering the heroin market, Jalisco New Generation and the Templar Knights and one cartel loosing presence, La Familia Michoacana. Tables 7, 8 and 9 show the coefficients from the difference-in-difference specification, which uses the same specification as equation (3) but the event time year dummies replaced by a dummy variable $\text{PostRef}_{mt} = \text{Suit}_m * \text{PriceHer}_t * \mathbb{1}[t \geq 2010]$. The results are robust to adding all the controls and fixed effects. In order to interpret these results lets compare a high suitable municipality with a low suitable one when the prices of heroin increase by 30% in the United States. The probability of the Sinaloa Cartel being present in a high suitable municipality is 3.12% higher each year after the shock compare to a low suitable municipality. The probability of the Jalisco New Generation or the Templar Knights being present increases by 4.42% each year after the shock and the probability of Los Zetas increases by 6.5%. Last the probability of La Familia being present decreases by -2.47% each year after the shock. The other four cartels, Tijuana, Golf, Juarez and the Beltran-Leyva Organizations does not show a significant increase in the probability of being present in high suitable municipalities despite the fact they do enter and expand during these period of time to opium producing territories. The tables with these results can be find in the Appendix. These results suggests that market pressures can also lead criminal organizations to split and fight with previous allies to get control of valuable territory.

Table 8

<i>Cartel Activity by Cartel</i>										
	Sinaloa Cartel					CJNG				
PshockInst(dd)	0.107***	0.102***	0.0714***	0.041***	0.03*** 4	0.080***	0.089***	0.059***	0.052***	0.039***
Radius 500 km	(0.010)	(0.011)	(0.001)	(0.009)	(0.008)	(0.001)	(0.010)	(0.001)	(0.008)	(0.001)
Observations	32,012	31,562	32,012	31,562	31,562	32,012	31,562	32,012	31,562	31,562
Pre-shock mean, dep. var.	0.0104	0.0104	0.0104	0.0104	0.0104	0.0004	0.0004	0.0004	0.0004	0.0004
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends			✓	✓	✓		✓	✓	✓	
State trends					✓					✓

Note: *p<0.1; **p<0.05; ***p<0.01

Table 9

<i>Cartel Activity by Cartel</i>										
	Knights Templar Cartel					La Familia				
PshockInst(dd)	0.022***	0.034***	0.006**	0.006**	0.032***	-0.004***	-0.004**	-0.019**	-0.023**	-0.012**
Radius 500 km	(0.000)	(0.008)	(0.0009)	(0.0008)	(0.007)	(0.000)	(0.0007)	(0.0008)	(0.007)	(0.004)
Observations	32,012	31,562	32,012	31,562	31,562	32,012	31,562	32,012	31,562	31,562
Pre-shock mean, dep. var.	0	0	0	0	0	0.004	0.004	0.004	0.004	0.004
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends			✓	✓	✓		✓	✓	✓	
State trends					✓					✓

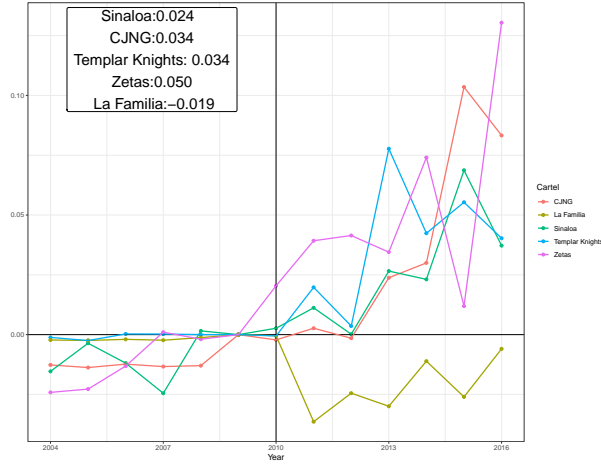
Note: *p<0.1; **p<0.05; ***p<0.01

Table 10

<i>Cartel Activity by Cartel</i>					
	Zetas				
PshockInst(dd)	0.125***	0.138***	0.104***	0.090***	0.054***
Radius 500 km	(0.0001)	(0.014)	(0.001)	(0.012)	(0.011)
Observations	32,012	31,562	32,012	31,562	31,562
Pre-shock mean, dep. var.	0.014	0.014	0.014	0.014	0.014
Municipalities FE	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓
Covariates		✓		✓	✓
Baseline trends			✓	✓	✓
State trends					✓

Note: *p<0.1; **p<0.05; ***p<0.01

Figure 23: Cartel Presence by Cartel



7 Conclusion

This paper provides evidence of the relationship between market structure and violence in illegal markets. I contribute to the literature by adding market pressures and external demand shocks as contributing to the increase violence and number of drug trafficking organizations in Mexico. I also provide two new data sets that can be used elsewhere to have a better understanding of how drug trafficking organizations interact. The techniques used to create these data sets can be easily extent to other settings and used to understand other illegal markets. The results from this paper suggest that a shift in the demand for drugs in consuming countries have direct effects in producing and trafficking countries. Particularly, I emphasize that criminal organizations are profit maximizing players that will decide to enter and expand into profitable markets and in the absence of a strong institutional setting usually they will use violence to win market power. Though the Mexican context and the interaction with the opioid crises is unique in some ways, there are many other example of illegal markets which might have similar unintended consequences from shifts in demand. For example, policies in order to reduce similar overused of legal opioids in Europe might have similar violent effects in Afghanistan and restructure criminal organizations there. Although, the levels of violence and drug crime related homicides in Mexico are an exception and not the rule, some other local illegal markets might experience similar market pressures and lead to spurs of violence or the surge of numerous criminal organizations. Understanding how criminal organizations

organize and how their market structures interact with violence is key to implement policies that aim not just to reduce illegal activities like drug trafficking but the negative externalities associated with them. Overall, this paper provides evidence of how criminal organizations market structure interacts with violence, motivating future research on understanding their structure, competition practices and relationships with the legal economy.

References

- Daron Acemoglu, James A Robinson, and Rafael Santos. The monopoly of violence: Evidence from colombia. Working Paper 15578, National Bureau of Economic Research, December 2009.
- Joshua D Angrist and Adriana Kugler. Rural windfall or a new resource curse? coca, income, and civil conflict in colombia. Working Paper 11219, National Bureau of Economic Research, March 2005.
- Laura H. Atuesta and Aldo F. Ponce. Meet the narco: increased competition among criminal organisations and the explosion of violence in mexico. *Global Crime*, 18(4):375–402, 2017. doi: 10.1080/17440572.2017.1354520. URL <https://doi.org/10.1080/17440572.2017.1354520>.
- Ciro Biderman, João M. P. De Mello, Renato S. De Lima, and Alexandre Schneider. Pax monopolista and crime: The case of the emergence of the primeiro comando da capital in são paulo. *Journal of Quantitative Criminology*, 35(3):573–605, 2018. doi: 10.1007/s10940-018-9393-x.
- Monir Elias Bounadi. Weather and conflicts in afghanistan. *EBA Working Paper, Expert Group for Aid Studies, Sweden.*, 2018.
- Gabriela Calderón, Gustavo Robles, Alberto Díaz-Cayeros, and Beatriz Magaloni. The beheading of criminal organizations and the dynamics of violence in mexico. *Journal of Conflict Resolution*, 59(8):1455–1485, 2015.
- Juan Camilo Castillo and Dorothy Kronick. The logic of violence in turf war. *Working paper*, 2019.
- Juan Camilo Castillo, Daniel Mejía, and Pascual Restrepo. Scarcity without leviathan: The violent effects of cocaine supply shortages in the mexican drug war. *The Review of Economics and Statistics*.

- T.G. Conley. Gmm estimation with cross sectional dependence. *Journal of Econometrics*, 92(1):1 – 45, 1999. ISSN 0304-4076.
- Michele Coscia and Viridiana Rios. Knowing where and how criminal organizations operate using web content. *Proceedings of the 21st ACM international conference on Information and knowledge management*, pages pp. 1412–1421., 2017.
- DEA. 2018 national drug threat assessment. Technical report, U.S. Department of Justice Drug Enforcement Administration, 2018.
- Melissa Dell. Trafficking networks and the mexican drug war. *American Economic Review*, 105(6):1738–1779, 2015. .
- Melissa Dell, Benjamin Feigenberg, and Kensuke Teshima. The violent consequences of trade-induced worker displacement in mexico. *American Economic Review: Insights*, Forthcoming.
- Oeindrila Dube and Juan F. Vargas. Commodity price shocks and civil conflict: Evidence from colombia. *The Review of Economic Studies*, 80(4):1384–421, 2013.
- Oeindrila Dube, Omar García-Ponce, and Kevin Thom. From maize to haze: Agricultural shocks and the growth of the mexican drug sector. *Journal of the European Economic Association*, 14(5):1181–1224, 2016.
- Valeria Espinosa and Donald B. Rubin. Did the military interventions in the mexican drug war increase violence? *The American Statistician*, 69(1):17–27, 2015.
- Susanne Frick, Robert Kramell, Jürgen Schmidt, Anthony J. Fist, and Toni M. Kutchan. Comparative qualitative and quantitative determination of alkaloids in narcotic and condiment papaver somniferum cultivars. *Journal of Natural Products*, 68(5):666–673, 2005.
- Kai Gehring, Sarah Langlotz, and Kienberger Stefan. Stimulant or depressant?: Resource-related income shocks and conflict. *Household in Conflict (HiCN) Working Paper*, (286), 2018.
- Matthew Gentzkow, Bryan T Kelly, and Matt Taddy. Text as data. Working Paper 23276, National Bureau of Economic Research, March 2017. URL <http://www.nber.org/papers/w23276>.
- Ion Grillo. *El Narco: Inside Mexico’s Criminal Insurgency*. Bloomsbury Publishing, 2011.

- Bradley E. Holland and Viridiana Rios. Informally governing information: How criminal rivalry leads to violence against the press in mexico. *Journal of Conflict Resolution*, 61(5):1095–1119, 2017. doi: 10.1177/0022002715600756. URL <https://doi.org/10.1177/0022002715600756>.
- Nathan Jones. The unintended consequences of kingpin strategies: kidnap rates and the arellano-félix organization. *Trends in Organized Crime*, 16(2):156–176, Jun 2013.
- Stefan Kienberger, Raphael Spiekermann, Dirk Tiede, Irmgard Zeiler, and Coen Bussink. Spatial risk assessment of opium poppy cultivation in afghanistan: integrating environmental and socio-economic drivers. *International Journal of Digital Earth*, 10(7):719–736, 2017. doi: 10.1080/17538947.2016.1250828. URL <https://doi.org/10.1080/17538947.2016.1250828>.
- M.M. Lopez and J. Kalita. Deep learning applied to nlp. *arXiv preprint arXiv:1703.03091*, 2017.
- Daniel Mejía and Pascual Restrepo. Bushes and Bullets: Illegal Cocaine Markets and Violence in Colombia. Documentos CEDE 011934, Universidad de los Andes - CEDE, Nov 2013. URL <https://ideas.repec.org/p/col/000089/011934.html>.
- Ethan Bueno de Mesquita. Territorial conflict over endogenous rents. *The Journal of Politics*, 0(ja):null, 2018. doi: 10.1086/705687. URL <https://doi.org/10.1086/705687>.
- Jaime Millán-Quijano. Internal cocaine trafficking and armed violence in colombia. *Economic Inquiry*, 0(0), 2019.
- Tomás E. Murphy and Martín Rossi. Following the Poppy Trail: Causes and Consequences of Mexican Drug Cartels. Working Papers 130, Universidad de San Andres, Departamento de Economía, December 2017. URL <https://ideas.repec.org/p/sad/wpaper/130.html>.
- Shannon O’Neil. The real war in mexico: How democracy can defeat the drug cartels. *Foreign Affairs*, 2009.
- Javier Osorio. The contagion of drug violence: Spatiotemporal dynamics of the mexican war on drug. *The Journal of Conflict Resolution*, 59(8):1403–432, 2015.

- Abby Alpert & David Powell & Rosalie Liccardo Pacula. Supply-side drug policy in the presence of substitutes: Evidence from the introduction of abuse-deterrent opioids. *American Economic Journal: Economic Policy*, 10(4):1–34, 2018.
- Brian J. Phillips. How does leadership decapitation affect violence? the case of drug trafficking organizations in mexico. *The Journal of Politics*, 77(2):324–336, 2015. doi: 10.1086/680209. URL <https://doi.org/10.1086/680209>.
- M. Christine Davies Pradip K. Muhuri, Joseph C. Gfroerer. Associations of non-medical pain reliever use and initiation of heroin use in the united states. *CBHSQ Data Review*, 2013.
- V Rios. Why did mexico become so violent? a self-reinforcing violent equilibrium caused by competition and enforcement. *Trends in Organized Crime*, 16(2):138–155, 2013.
- Richard Schmalensee. Sunk costs and market structure: A review article. *The Journal of Industrial Economics*, 1992.
- David B. Carter Shaver, Andrew and Tsering Wangyal Shawa. Terrain ruggedness and land cover: Improved data for most research designs. *Conflict Management and Peace Science*, 36(2):191–218, 2019.
- Richard Snyder and Angelica Duran-Martinez. Does illegality breed violence? drug trafficking and state-sponsored protection rackets. *Crime, Law and Social Change*, 52(3):253–273, Sep 2009.
- Jarnickae Wilson & Austin L. Wright Sonin, Konstantin. Rebel capacity and combat tactics. *Becker Friedman Institute , working paper No. 2018-74*, 2019.
- Maria Micaela Sviatschi. Making a Narco: Childhood Exposure to Illegal Labor Markets and Criminal Life Paths. Working Papers 2018-03, Princeton University, Woodrow Wilson School of Public and International Affairs, Research Program in Development Studies., March 2018. URL <https://ideas.repec.org/p/pri/rpdevs/2018-03.html>.
- Soujanya Poria Tom Young, Devamanyu Hazarika and Erik Cambria. Recent trends in deep learning based natural language processing. *CoRR*, 2017.
- Hui Zou and Trevor Hastie. Regularization and variable selection via the elastic net. *Journal of the Royal Statistical Society. Series B (Statistical Methodology)*, 67(2): 301–20, 2005.

A Appendix

A.1 Cartel Presence

The algorithm use during the web scraping and the natural language techniques are describe here:

- Web scraping: a unique set of key words that include a drug trafficking organization and municipality was send to the Google News interface to look for any article containing both key words. To reduce ambiguities regarding municipality or DTOs names I followed the same rules as [Coscia and Rios \(2017\)](#). I used the 9 main active cartels that both the Mexican prosecutor's and the DEA recognized. The queries were passed to the crawler that saved all the articles that included the query between 1990 and 2016. The algorithm found 2'249,561 news articles ³⁶. The next step consists on validating which of these articles actually is talking about a cartel being present in some municipality.
- Natural Language Processing: to validate the presence of the cartel-municipality pair I used the approach of using text as data describe in [Gentzkow et al. \(2017\)](#). The first step was to extract and curate each news article, doing this is not trivial and there exists several python libraries that use algorithms plus web scraping to extract the main article from the whole html. This was done in order to prevent false positives, some newspapers htmls include links to other articles that might be the source of Google finding the query in that particular link. After extracting the main article a word recognition algorithm was use to keep the articles that mention the DTO-municipality in their main body. The number of remaining articles after this process is 1'201,483. I used a sentence extraction algorithm to keep each sentence of the articles that contains the cartel and municipality pairs. There are 2'802,224 of this sentences. Next, I manually classified 5,000 sentences as either presence or not in order to address possible concerns regarding the validity of this data set I show some examples of the sentences include in this train dataset both positive and negative.

Examples classify as presence:

-The attorney general in Nayarit started some operations that end up with the capture of two Beltran-Leyva operators in Tepic. ³⁷

³⁶ I restricted the search for articles in Spanish and appearing in Google News Mexico

³⁷ <https://www.debate.com.mx/mexico/Asi-era-el-H9-heredero-del-Cartel-de-los-Beltran-Leyva-20170212-0068.html>

- Apatzingan, the most dangerous place for the self defense groups is still controlled by Knights Templar Cartel. ³⁸
- Mexican Marines caught Hugo Cesar Roman Chavarria, alleged Zetas operator in charge of trafficking drugs through Coahuila and Nuevo Leon. ³⁹
- Gerardo Payan alleged operator of the Sinaloa Cartel was caught by marines las Thursday in Mocorito, Sinaloa. ⁴⁰
- El Garo, operator of the Gulf Cartel in the municipalities of Apodaca, Garcia and Santa Catarina is waiting for trial. ⁴¹
- Yesterday, while investigating a trespassing case federal police had a confrontation with members of the Jalisco New Generation Cartel in Tanhuato. ⁴²
- According to members of the military the Jalisco New Generation Cartel and the Sinaloa Cartel have been fighting for the city of Los Cabos and the border crossing in in La Paz. ⁴³
- State police inform that the 15 death bodies found this morning in Madera, Chihuahua were from a confrontation between the Sinaloa Cartel and the Juarez Cartel. ⁴⁴

As mention early in the paper most of this news either talk about official reports from the police or the military or do not mention particular members of the cartels. This due to how dangerous is to report on cartel activity for journalist. Again it might be that the measure of cartel entry is bias down but as long as there is no one particular cartel that is not being report or being under report this should not affect the general interpretation of the results.

In order to classify the presence of cartel c in municipality m I used a semi supervised convolutional neural network (CNN) [Tom Young and Cambria \(2017\)](#).

³⁸ <https://www.animalpolitico.com/2014/01/michoacan-entre-balazos-la-pgr-y-dettenidos-por-incendio-una-farmacia/>

³⁹ <https://www.milenio.com/policia/detienen-a-operador-de-los-zetas-en-culiacan>

⁴⁰ https://www.zocalo.com.mx/new_site/articulo/cae-el-gringo-payan-presunto-operador-de-el-mayo-zambada-1435099245

⁴¹ <https://noticieros.televisa.com/ultimas-noticias/vinculan-proceso-el-garo-operador-cartel-golfo/>

⁴² <https://www.sdpnoticias.com/estados/delincuentes-dettenidos-presuntos-declaran-tres.html>

⁴³ <https://lasillarota.com/estados/baja-california-sur-el-fin-del-paraiso-turistico/147518>

⁴⁴ https://www.zocalo.com.mx/new_site/articulo/ligan-balacera-de-chihuahua-a-choque-linea-sinaloa

Here the final task is to classify so the CNN seems like a good fit. (Do I need the definition of CNN here: a CNN is deep learning algorithm which can take in an input a sentence/phrase or article. CNN are just several layers of convolutions with nonlinear activation functions applied to the results. In CNN convolutions are used over the input layer to compute the output. This results in local connections, where each region of the input is connected to a neuron in the output. Each layer applies different filters, typically hundreds or thousands and combines their results. [Lopez and Kalita \(2017\)](#) The input I used are sentences represented as a matrix, each word is represented by a vector and each of this vectors is a word embedding (low dimensional representations). I used a pre-trained Embedding in Spanish (trained using Wikipedia articles). A word embedding maps meaning into a geometric space. This transforms each sentence into the vector space and takes into account the position of each word in the sentence. In NLP filters of the CNN slide over word windows. The CNN used here uses sequences of 5 vectors of dimension 128 for the convolutional part and 10 layers of the ReLU function plus one final classification layer that uses the sigmoid function. A CNN is basically a neural based approach which represents a feature function that is applied to constituting words or n-grams to extract a higher level features. Sentences first need to get tokenized into words, which are further transformed into a word embedding matrix of dimension d . Then convolutional filters are applied on this input embedding layer which consists of applying a filter of all possible windows sizes to produce a feature map. This is then followed by a max-pooling operation which applies max operation on each filter to obtain a fixed length output and reduce the dimensionality of the output and that procedure produces the final sentence representation.

In order to train this model I manually classified 5000 sentences and then use bootstrapping to calculate the network weights. Once the sentences were classified as presence or not a word extraction was used to assign each sentence to a municipality-organization pair, some sentences were assigned to more than one pair.

A.2 Agro-ecological data

From opium to heroin: *papaver somniferum* is an annual crop with a short productive cycle that can be harvested 4 times a year. The main product extracted from it is raw opium. Raw opium contains between 8 – 91.2% of morphine

Table 11: Summary of cartel presence

Cartel	First Year Appear	First Mun	Mun Active 1990	Mun Active 2000	Mun Active 2010	Mun Active 2016
Juarez	1990	Chihuahua/Juarez	3	5	42	79
Tijuana	1990	Tijuana/Mexicali	9	2	22	42
Sinaloa	1990	Sinaloa/El Fuerte	9	4	88	160
Beltran Leyva	2004	Sinaloa	0	0	85	118
Fam Mich	1990	Mujica/La Piedad	3	2	47	101
Gulf	1990	Matamoros	1	2	36	89
Zetas	1999	Matamoros	0	9	100	227
CJNG	2010	San Juan de los Lagos	0	0	12	211
Templar Knights	2011	Acuitzio	0	0	0	107

depending on the plant variation [Frick et al. \(2005\)](#). Opium is a low cost crop that doesn't require many inputs but it is land intensive. Usually an hectare of poppy flowers will produce between 8 to 15 kilograms of raw opium. Yields of heroin from raw opium are between 6 to 10 percent. In order to transform the raw opium into heroin first the morphine needs to be extracted from the opium paste and dried. Once the morphine is dry acetic anhydride is added to create brown tar heroin (that can be smoked, inhaled or injected in this state). To produce white high purity heroin ammonia, hydrochloric acid and acetone.⁴⁵ (I'm not sure if I need this in the paper or not but is fun).

Variables used to generate the suitability index:

- Temperature and Precipitation from the WorldClim data set. This data set includes: mean annual temperature, mean diurnal range, temperature seasonality, maximum temperature during the warmest month, minimum temperature during the coldest month, mean temperature of the wettest quarter, mean temperature of driest quarter, mean temperature of warmest quarter, mean temperature of coldest quarter, annual precipitation, precipitation of wettest month, precipitation of driest month, precipitation seasonality, precipitation of wettest quarter, precipitation of driest quarter, precipitation of warmer quarter and precipitation of coldest quarter.
- Elevation data from Shuttle Radar Topography Mission (SRTM).
- Terrain ruggedness from [Shaver and Shawa \(2019\)](#)
- Land Cover from Globcover 2009
- Soil quality from the FAO Harmonized World Soil Database.

⁴⁵ https://www.unodc.org/pdf/research/Bulletin07/bulletin_on_narcotics_2007_Zerell.pdf

- River density: diva-gis data-sets weighted by Strahler stream order.
- Soil climatic characteristics from the yearly Copernicus data set. This data set includes: mean monthly precipitation, mean evaporation, soil temperature, soil water, heat flux and rain.

An elastic net is a penalized OLS that combines lasso and ridge methods. The best model use for the suitability index has a $\alpha = .4$ and $\lambda = 0.07557243$. Here α is the degree of mixing between the ridge and the LASSO regression and the λ is the shrinkage parameter. The number of variables reduces from 903 to 50. Variable selection:

The variables from the model reduction are the following ones: soil temperature, mean annual evaporation interacted with temperature seasonality, mean annual precipitation interacted with: average monthly rain, minimum temperature during the coldest month, mean temperature during the driest quarter and terrain ruggedness. Soil temperature interacted with seasonal precipitation, soil water interacted with : river density and topsoil organic carbon, ruggedness interacted with: mean temperature during the wettest quarter, topsoil grave, topsoil organic content and topsoil clay, heat flux interacted with temporal seasonality, precipitation seasonality, river density and topsoil clay, mean temperature interacted with: minimum temperature during the coldest month and ruggedness, mean diurnal range interacted with mean temperature during the driest quarter, precipitation seasonality and ruggedness, minimum temperature during the coldest month interacted with: mean temperature during the warmest month, precipitation during the wettest quarter, precipitation during the driest quarter, river density, topsoil calcium carbonate and topsoil salinity, mean temperature during the wettest quarter interacted with precipitation during the wettest quarter, precipitation during the warmest quarter, altitude and topsoil sodicity, mean temperature during the driest quarter interacted with mean temperature during the coldest quarter, precipitation during the wettest quarter and ruggedness, mean temperature during the coldest quarter interacted with precipitation during the warmest quarter, precipitation during the warmest month interacted with precipitation during the wettest quarter and ruggedness, precipitation during the driest month interacted with: precipitation during the warmest quarter and river density, precipitation seasonality interacted with precipitation during the wettest quarter, precipitation during the wettest quarter interacted with precipitation during the warmest quarter

ter and ruggedness, altitude interacted with topsoil teb, river density interacted with topsoil organic carbon, topsoil gypsum and topsoil salinity, topsoil sand interacted with topsoil calcium carbonate, topsoil clay interacted with topsoil teb and topsoil cec soil interacted with topsoil teb.

A.3 Robustness checks

Cartel presence

Table 11 shows the coefficients from the difference in difference specification for the probability of having more than one active cartel and the number of cartels but with the standard errors cluster at the municipality level. The results are still robust using this specification.

Table 12

	<i>Cartel Activity</i>									
	More than one active cartel					Number of Cartels				
PshockInst(dd)	0.108 (0.02)***	0.121 (0.021)***	0.064 (.018)***	0.044 (.017)**	0.049 (0.017)**	0.466 (0.072)***	0.537 (0.075)***	0.292 (.058)***	0.227 (0.057)***	0.241 (0.061)***
Observations	32,202	31,752	32,202	31,752	31,752	32,202	31,752	32,202	31,752	31,752
Pre-shock mean, dep. var.	0.012	0.012	0.012	0.012	0.012	0.057	0.057	0.057	0.057	0.057
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends			✓	✓	✓		✓	✓	✓	✓
State trends					✓					✓

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered by municipality

Cartel Entry and Exit:

The next tables show the coefficients from the difference in difference specification for the entry and exit of different cartels. The standard errors are clustered using a radius of 500Km.

Table 13

	<i>Homicides per 100,000 inhabitants</i>									
	First Carte Entry					Second Cartel Entry				
	1.64 (4.23)	2.05 (2.14)	2.07 (1.98)	2.12 (2.18)	1.43 (2.05)	7.08*** (2.71)	8.33** (2.71)	6.41** (2.80)	7.61** (2.68)	5.28* (2.39)
Post-entry										
Observations	42,624	42,624	42,624	42,624	42,624	42,624	42,624	42,624	42,624	42,624
Pre-entry mean, dep. var.	15.43	15.43	15.43	15.43	15.43	15.38	15.38	15.38	15.38	15.38
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓			✓		✓	✓
Baseline trends			✓	✓			✓	✓		
State trends					✓					✓

Note: *p<0.1; **p<0.05; ***p<0.01
Conley Standard errors with a radius of 500Km

Table 14

	<i>Homicides per 100,000 inhabitants</i>									
	Third Cartel					Fourth Cartel				
	13.46*** (4.90)	15.62*** (4.55)	14.70** (5.07)	14.66** (5.05)	12.76** (4.28)	13.71** (6.34)	15.59*** (4.42)	15.55** (4.90)	15.39** (4.85)	13.05*** (3.69)
Post-entry										
Observations	42,624	42,624	42,624	42,624	42,624	42,624	42,624	42,624	42,624	42,624
Pre-entry mean, dep. var.	16.58	16.58	16.58	16.58	16.58	19.35	19.35	19.35	19.35	19.35
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends			✓	✓			✓	✓		
State trends					✓					✓

Note: *p<0.1; **p<0.05; ***p<0.01
Conley Standard errors with a radius of 500Km

Table 15

	<i>Homicides per 100,000 inhabitants</i>									
	Fifth Cartel					Sixth Cartel				
	17.53*** (7.52)	21.08*** (6.80)	19.01*** (7.19)	19.84** (7.28)	16.41*** (4.34)	10.81* (5.06)	14.48** (4.52)	10.53* (4.92)	11.62* (5.95)	6.57* (3.29)
Post-entry										
Observations	42,624	42,624	42,624	42,624	42,624	42,624	42,624	42,624	42,624	42,624
Pre-entry mean, dep. var.	17.31	17.31	17.31	17.31	17.31	18.90	18.90	18.90	18.90	18.90
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends			✓	✓			✓	✓		
State trends					✓					✓

Note: *p<0.1; **p<0.05; ***p<0.01
Conley Standard errors with a radius of 500Km

Table 16

	<i>Homicides per 100,000 inhabitants</i>				
	From 2 to 1 cartels				
Post-entry	-2.70*	-3.27*	-3.35*	-3.23*	-6.07**
	(1.30)	(1.35)	(1.30)	(1.31)	(2.25)
Observations	42,624	42,624	42,624	42,624	42,624
Pre-entry mean, dep. var.	17.75	17.75	17.75	17.75	17.75
Municipalities FE	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓
Covariates		✓		✓	✓
Baseline trends			✓	✓	
State trends					✓

Note:
*p<0.1; **p<0.05; ***p<0.01

Table 17

	<i>Cartel Activity by Cartel</i>									
	Juarez Cartel					Beltran-Leyva				
PshockInst(dd)	0.041*** (0.008)	0.046*** (0.009)	0.027** (0.001)	0.021 (0.009)	0.008 (0.009)	0.046*** (0.006)	0.063*** (0.008)	0.014*** (0.001)	0.012 (0.007)	0.032 (0.017)
Observations	32,012	31,562	32,012	31,562	31,562	32,012	31,562	32,012	31,562	31,562
Pre-shock mean, dep. var.	0.009	0.009	0.009	0.009	0.009	0.007	0.007	0.007	0.007	0.007
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends			✓	✓			✓	✓	✓	
State trends					✓					✓

Note: *p<0.1; **p<0.05; ***p<0.01

Table 18

	<i>Cartel Activity by Cartel</i>									
	Tijuana Cartel					Golf Cartel				
PshockInst(dd)	0.018 (0.009)	0.019 (0.009)	0.009 (0.005)	0.003 (0.004)	0.011 (0.014)	0.029** (0.001)	0.040*** (0.007)	0.019** (0.000)	0.021** (0.006)	0.023** (0.007)
Observations	32,012	31,562	32,012	31,562	31,562	32,012	31,562	32,012	31,562	31,562
Pre-shock mean, dep. var.	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005
Municipalities FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Covariates		✓		✓	✓		✓		✓	✓
Baseline trends			✓	✓	✓		✓	✓	✓	
State trends					✓					✓

Note: *p<0.1; **p<0.05; ***p<0.01