Avocados: Mexico's green gold.

The impact of the U.S. opioid crisis on Mexico's drug cartel violence*

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Abstract

The growing global demand for avocados has drawn the attention of rent-seeking drug trafficking organizations (DTOs) in Mexico. As a result, farmers and packing houses have become targets of extortion by these organizations. This paper aims to answer whether declining drug revenues have incentivized cartels to target the avocado sector. By leveraging exogenous variation from the introduction of Fentanyl in the U.S., I analyze the impact of reduced heroin demand on homicides and cartel presence in avocado and poppy-growing municipalities between 2011 and 2019. Using municipal-level data, I show that the decline in the demand for heroin increased homicide rates, including those of agricultural workers, as well as truckload thefts in avocado-growing municipalities. Conversely, decreased heroin demand resulted in a reduction in homicides and violent thefts in poppy-growing municipalities. Furthermore, I find no evidence of changes in cartel presence in avocado and poppy municipalities. Consequently, the rise in homicides in avocado municipalities can be attributed to DTOs' increased use of violence against civilians rather than territorial expansion. Overall, this paper provides evidence of inter-sector spillovers resulting from drug demand changes.

Keywords: Crime diversification, Drug cartels, Avocado, Fentanyl, Heroin, Crime, Violence, Mexico
JEL Classifications: K42, O12, O13, O17, Q17

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1 Introduction

> *"It's not only avocados. Mexican organised crime has long mutated away from 'just' drugs trafficking [...]. Today, the model is this: you control a given territory, and within in it you exploit whichever commodity is locally available. That includes avocados [...]"* - Falko Ernst, International Crisis Group.[1]

> *"Where there's money, that's where the bad guys go. With all the publicity that it's going so well for us — this will be the sixth year that Mexican avocados have [been] advertised in the Super Bowl — it draws attention to us"*
> - Avocado farmer from Michoacán, Mexico.[2]

Drug trafficking has ceased to be the only source of income for many drug cartels in Mexico, with some of them resorting to other criminal activities, such as extortion, kidnapping, illegal mining, and fuel theft (Herrera and Martinez-Alvarez, 2022; Jones and Sullivan, 2019). One of the most prominent sectors that has attracted the attention of drug trafficking organizations (DTOs)[3] is the avocado industry, whose exports have contributed over 2.5 billion U.S. dollars every year since 2016.[4] DTOs target avocado farmers and packinghouses through extortion and avocado theft (Linthicum, 2019; de Cordobá, 2014). In 2014, the municipality of Tancítaro–known as the leading producer of avocados in Michoacán– reported an estimated loss of $150 million due to extortion fees in the avocado sector, equivalent to 10% of the national avocado exports for that year (de Cordobá, 2014). Additionally, between 7 and 10 avocado truckloads are stolen every week in the state of Michoacán, contributing to annual losses ranging from $3.6 - 5.2 million (Agren, 2019).[5]

This paper analyzes the impact of declining drug revenues on violent crimes in avocado- and poppy-growing municipalities. I hypothesize that, as the demand for Mexican heroin in the U.S. has declined, cartels have shifted their efforts to target other businesses, such as the avocado sector. In fact, the headline of a 2020 article points this out:

> *"Avocado crime soars as Mexican gangs turn focus from opium to 'green gold' "*
> - *Financial Times (2020)*

[1] Financial Times (2020).
[2] The Guardian (2019).
[3] In this paper, I use drug cartel and drug trafficking organizations (DTOs) as interchangeable terms.
[4] Source: Own estimates based on information from the Mexican Secretariat of Agriculture and Rural Development (SAGARPA).
[5] Own estimates based on the 2019 value per ton of avocado.

The fall in opium revenues has been attributed to a decrease in the demand for Mexican heroin caused by the introduction of Fentanyl in the U.S., a readily available cheap synthetic opioid, 50 to 100 times more potent than morphine, typically used in treating severe pain (Le Cour Grandmaison et al., 2019; Financial Times, 2020; CDC, 2021a). As the availability of Fentanyl rose in the U.S. starting in 2014, drug dealers started using Fentanyl to dilute other drugs, such as heroin, to increase these drugs' potency while lowering the dealers' costs (DEA, 2020b). Additionally, drug consumers have increasingly turned to Fentanyl because it provides a potent and cheap alternative (Felter, 2022). This is of foremost importance to Mexico, the third major producer of heroin and the leading supplier to the U.S., with over 90% of the heroin available in the U.S. market coming directly from Mexico (Le Cour Grandmaison et al., 2019). The fall in the U.S. demand for heroin has led to an opium crisis in Mexico, with opium farmers reporting a decline in revenues of around 50% between 2017 and 2018 (Le Cour Grandmaison et al., 2019).

Therefore, as Fentanyl becomes more available in the U.S. market and heroin less profitable, cartels may have diversified into other lucrative sectors. This paper analyzes the effect of the introduction of Fentanyl on violent crimes in avocado- and poppy-growing municipalities in Mexico. Using detailed information on homicides obtained from the Mexican Department for Health Information (DGIS), and cartel presence data from the Mapping Criminal Organizations in Mexico project, this paper seeks to answer the following questions: i) Did the introduction of Fentanyl increase the number of murders in avocado-suitable municipalities?, ii) Did the opioid crisis increase cartel presence in avocado-suitable municipalities? and iii) What was the impact on poppy-producing municipalities?

Changes in the prices of commodities have been used to measure the effect of violence on changes in the demand for a good (Sobrino, 2019; Dube et al., 2016). However, using this strategy has several problems in this context; for instance, heroin prices measured through undercover purchases are subject to measurement error, are likely to be endogenous to violence in Mexico, and may not reflect changes in the prices perceived by cartels. Instead, I use Fentanyl overdoses as a proxy for the availability of Fentanyl in the U.S. market and rely on overdoses of Fentanyl being exogenous to violence in Mexico for identification.

For this analysis, I study the period between 2011 and 2019, which corresponds to the third wave of the opioid crisis in the U.S. Specifically, I use information on the top eight avocado-producing states in Mexico. The sample encompasses the state of Michoacán, the leading producer and exporter of avocados in Mexico and until 2023, the only state authorized to export avocados to the U.S. Moreover, the sample includes the state of Guerrero, the country's primary producer of opium (Le Cour Grandmaison et al., 2019).

My results show that the decrease in the demand for heroin increased murders in avocado-growing municipalities, particularly among agricultural workers and the general population. Contrary to what would be expected, I observe no effect on the number of cartels present in these municipalities and no impact on potentially inter-cartel-related murders. This suggests that cartels are not more likely to enter these municipalities, and that they mainly target civilians rather than confronting other cartels. Further evidence of this is increasing violent theft rates and truckload thefts in avocado-growing municipalities. Meanwhile, poppy-growing municipalities show significant decreases in homicide rates among agricultural workers and the general population, as well as lower theft rates. I find a negative but small and not statistically significant relationship between Fentanyl and cartel presence in poppy-growing municipalities, suggesting that cartels still have incentives to remain in control of these areas.

This paper contributes to the literature on crime by providing further evidence of the relationship between income and crime. While several papers have looked into the relationship between income and civic conflict, and others have looked into the effect of changes in commodity prices, empirical evidence of this relationship remains ambiguous. On the one hand, a positive income shock can reduce conflict by increasing individuals' opportunity cost to participate in criminal activities (Berman and Couttenier, 2015; Brückner and Ciccone, 2010; Chassang and Padró i Miquel, 2009; Dube et al., 2016; Miguel et al., 2004). On the other hand, more income increases the returns to appropriation (Angrist and Kugler, 2008; Chimeli and Soares, 2017; Dube and Vargas, 2013; Idrobo et al., 2014; Parker and Vadheim, 2017). In other words, increased income raises individuals' incentives to tap into avocado revenues by engaging in criminal activities. In this paper, I provide evidence of the second mechanism, where declining drug revenues have increased incentives for criminal organizations to tap into another sector.

Theoretical models and empirical evidence show that the relationship between income and violence can depend on the commodity type. Dal Bó and Dal Bó (2011) and Dube and Vargas (2013) find a negative relationship between income shocks and violence in labor-intensive industries and a positive correlation in capital-intensive industries. This study contributes to this literature by providing empirical evidence of this relationship by looking into the effects of a change in the demand for heroin on violence in two labor-intensive sectors. Moreover, the findings of this paper provide evidence of a positive relationship between income and violence in a labor-intensive industry. This aligns with growing recent literature showing that raising prices of agricultural goods can lead to increased rapacity from criminal organizations in the presence of weak property rights and illegal institutions (Bandiera, 2021; Kenny et al., 2020; Millán-Quijano and Pulgarín, 2023).

This paper also provides complementary evidence as to why cartels diversify. So far, the literature has found that diversification is driven by greater cartel competition resulting from the Mexican government's kingpin strategy between 2006 and 2012 (Herrera and Martinez-Alvarez, 2022; Jones, 2013; Magaloni et al., 2020).[6] Although this is a reasonable explanation, it does not fully explain more contemporary events as the federal government's strategy against cartels has changed since 2012.

While this study is not the first to look at the effect of changes in the demand for heroin in the U.S. on violence in Mexico (see Sobrino (2019)), it is the first to look into the effect of the introduction of Fentanyl in the U.S., and more specifically its impact in the avocado sector. My paper differs substantially from Sobrino (2019)'s study in three main ways. First, my study focuses on analyzing the post-2010 period when the introduction of Fentanyl decreases the demand for heroin, while Sobrino (2019) looks into the effects of the 2010 OxyContin reformulation. Second, my empirical strategy relies on using the availability of Fentanyl in the market (using Fentanyl overdoses as a proxy) for identification, rather than changes in the prices of heroin. Finally, our studies differ in how we measure poppy suitability. I use a well-established model used by agronomists that uses data on agro-climatic requirements for poppy growing from the UN Food and Agriculture Organization (FAO). On the other hand, Sobrino (2019) uses a machine-learning approach to build an index based on opium yield data and conditions from Afghanistan.

This chapter is organized as follows. Section 2 describes the background. This includes information on the U.S. opioid crisis and its effect on violence in Mexico. Section 3 describes the conceptual framework. Sections 4 and 5 include a description of the data used and the empirical

[6] The kingpin strategy consisted of targeting the heads of criminal organizations. The capture or killing of the cartel leaders led to the internal instability and subsequent fragmentation of cartels (Jones, 2013).

strategy. Finally, Section 6 contains the main results on violence and cartel presence.

2 Background

2.1 Production of Mexican avocados

The *Persea americana*, commonly known as avocado, is a semi-tropical tree native to Mexico, Central America, and South America. The most common variety of avocado used for exportation purposes is the Hass avocado.[7] Hass trees have a long flowering period and can bloom up to three times a year, making it possible for them to be harvested year-round if conditions are optimal.[8] Moreover, avocados ripen off the tree and can be stored in the tree for several weeks. Because of this, avocados are usually sold at the tree for a fixed price (Hass Avocado Board, 2019).

Avocados are labor-intensive goods that take at least five years to be able to bear fruit. Farmers are mainly in charge of cultivating and fertilizing the avocado trees (USDA, 2020). Most of the production in Mexico is carried out by small producers that own or rent land. The picking of trees is considered the most labor-intensive part of the production process. This is usually done by contractors hired by exporters. The contractors choose the avocados that fit the size requirements for exportation and leave the rest to mature at the tree (Hass Avocado Board, 2019).

As the nutritional properties of avocados have become more widely known, avocados have gained popularity in many parts of the world, leading to an increase in the global demand for this fruit. This has important implications for Mexico, the world's largest producer and exporter of avocados, with a total production of over 2 million tons in 2018 (SENASICA, 2017). Currently, Mexico produces more than a third of the global production, from which over 75% of the total volume exported of avocados goes into the U.S (Hansen, 2017).

Most of the avocados in Mexico are grown in the state of Michoacán, located in the west-center area of Mexico. By itself, Michoacán produces over 76% of the total national production, followed by its neighboring state, Jalisco, with 9.2%. Michoacán is also the leading exporter of avocados, accounting for over 90% of the country's exports of this fruit (USDA, 2018). Moreover, as of April

[7]This variety of avocado was discovered in California in 1926 and is preferred in the global market due to its high resistance to plagues, high-quality pulp, and high oil content (Hofshi, 2001).

[8]Mexico is the only country that has the optimal conditions for avocados to be harvested year-round, which gives it a comparative advantage compared to other growing countries (Ambrozek et al., 2018).

2022, Michoacán was the only state in Mexico authorized to export avocados to the U.S., with Jalisco just recently allowed (The Associated Press, 2021).

2.2 Cartel violence in the avocado sector

The increase in the demand for avocados and the resulting increased revenues have attracted the attention of criminal organizations. In recent years, reports have appeared of DTOs demanding protection money from farmers (Linthicum, 2019; de Cordobá, 2014; Padgett, 2013; Rainsford, 2019). While there is no consensus on the amount, reports on the annual fee range between US$150 per hectare in 2014 to $250 in 2019 (de Cordobá, 2014; Linthicum, 2019).[9] Moreover, local authorities in the municipality of Tancítaro–the largest producer of avocados in the country–estimate that, in 2014, Los Caballeros Templarios may have obtained up to US$150 million per year from extortion in the avocado sector (de Cordobá, 2014).

Additionally, avocado theft has increased, with an average of 7 to 10 truckloads stolen every week in Michoacán. Each truck carries about 8 tons of avocados destined for exportation, with an average value of US$10,000 per truck (García Tinoco, 2019; Agren, 2019).[10] Moreover, DTOs have also targeted USDA avocado inspectors. The USDA had to temporarily suspend its avocado inspection program in August of 2019 after its employees in Uruapan received threats (Linthicum, 2019). More recently, the U.S. temporarily banned imports of Mexican avocados for the same reason (The Associated Press, 2022).

In some communities of Michoacán, farmers tired of the increasing levels of violence and extortion, and the government's inability to provide protection, formed self-defense groups, called *autodefensas*. These groups emerged in 2013 as a direct response to the Knights Templar cartel, which targeted civilians through extortion, kidnapping, and murder (Ornelas and Gutiérrez, 2017). However, the arming of civilians quickly became a concern for the government. In January 2014, negotiations commenced between government officials and *autodefensas* leaders, with the government proposing their disarming and integration into a new state security force. Despite initial resistance, by 2015, most of the *autodefensas* had agreed to the government's proposal (Felbab-Brown, 2016).

[9] DTOs are sophisticated. They can charge differentiated prices to farmers, with specific quotes for every avocado plant bought in a greenhouse and more extensive quotes per hectare of production for farmers that export. They can also differentiate each farmer and charge fees accurately because they have access to information on the number of avocado trees planted and the fields' size (Padgett, 2013).

[10] The estimates are based on an exchange rate of 20 Mexican pesos per U.S. dollar.

2.3 Heroin production and distribution

The production of heroin starts with farmers extracting the liquid sap of the *Papaver Somniferum* (commonly known as opium poppy). The opium poppy is a flower used to produce pharmaceutical opiates and heroin. Farmers extract the sap of these flowers by cutting the outer surface of poppy pods (Marciano et al., 2018). The resulting product is known as opium paste or opium gum.

The poppy flower is a low-cost crop that can be grown in small plots (Palmer, 2009).[11] Usually, two hectares of poppy flowers will produce around 22 kilograms of opium paste, which can yield about a kilogram of heroin (Hartman, Travis, 2019). As a reference, in 2013, the price offered to farmers for a kilogram of raw opium paste was about 15,000 pesos (USD$1,175),[12] according to Le Cour et al. (2019).

Poppy farmers are self-employed; in addition to growing poppies, they grow subsistence crops. Because growing poppy in Mexico is illegal, poppy plots are usually located in remote areas, up in the mountains and far from the center of communities. Poppy farmers in these communities rely on gravity-fed irrigation systems, and thus plots usually are strategically located near streams (Le Cour et al., 2019).

After extracting the opium gum, farmers sell it to local drug cartels that assume the role of the *acaparador* (literally, the "gatherer"), responsible for bulk-buying opium. These local groups offer "protection" to local growers and assure them they will buy their opium crop (Le Cour et al., 2019). Since these criminal groups are the sole buyers of the opium paste extracted by farmers, the opium market behaves as a monopsony, where criminal groups mainly determine prices, and farmers have little to no power of negotiation. The local *acaparadores* refine the opium paste to obtain morphine, which they combine with other chemicals to produce heroin. They sell the final product to larger DTOs in charge of the transportation and distribution of heroin across the border. These cartels then sell it to U.S. DTOs at a wholesale price (Le Cour et al., 2019).

U.S. drug trafficking organizations buy heroin from drug cartels in Mexico, divide it into small quantities, and then sell it to consumers at a retail price. At this point in the distribution chain, heroin is often mixed with other substances, such as Fentanyl, as a strategy for retailers to increase

[11] Poppy seeds are cheap and durable. Cultivation of this flower requires smaller amounts of fertilizer than other crops and minimal soil preparation (Palmer, 2009).

[12] This dollar estimate is based on a 2013 exchange rate.

their markups. Border seizures and lab analyses on wholesale heroin show that lacing heroin with Fentanyl is uncommon at the wholesale level (DEA, 2021). In 2019, only 16% of all wholesale heroin seizures had Fentanyl, while Fentanyl-laced heroin constituted 32% of retail heroin seizures. This indicates that U.S. retailers are primarily responsible for lacing heroin rather than Mexican drug cartels (DEA, 2020a).

2.4 The U.S. opioid crisis

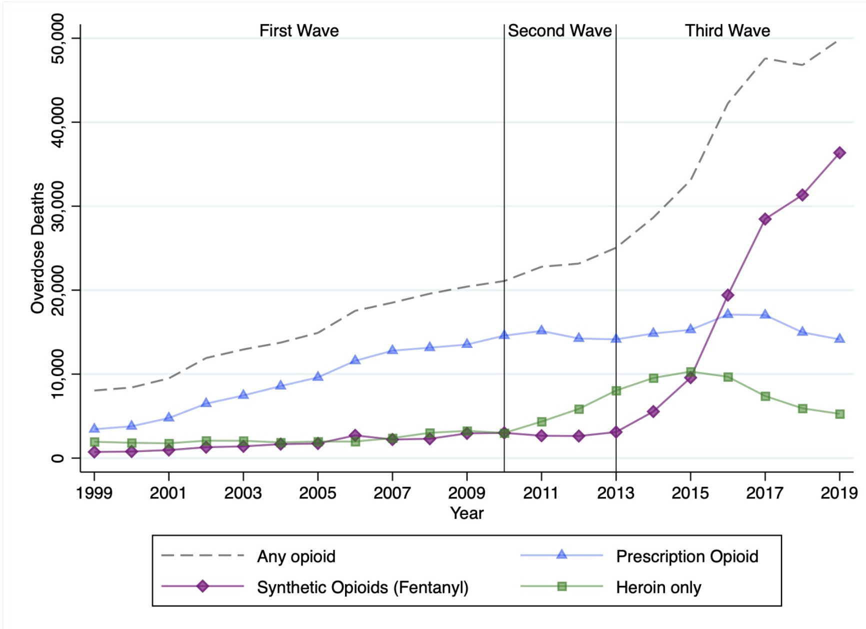
The opioid crisis, as defined by the U.S. Centers for Disease Control and Prevention, unfolded in three distinct waves. The first wave can be traced back to a surge in prescribed opioids starting in the late 1990s, with many pointing to 1999 as the starting point (CDC, 2021b; UN, 2020). This initial wave led to an increase in overdose deaths involving misuse of prescription opioids. The spike in prescribed opioid addiction has been attributed to the pharmaceutical industry's efforts to promote opioid use for pain management while downplaying associated risks and encouraging widespread prescription by doctors (Van Zee, 2009). Additionally, opioids became more affordable; between 2001 and 2010, out-of-pocket prices dropped by 81% (CEA, 2019). These factors—combined with extensive marketing campaigns promoting their broad usage—made opioids easy to abuse and contributed to people becoming addicted (for timeline details see Figure A1 in the Appendix).

The second wave began in 2010 after the U.S. tightened restrictions on opioids to reduce overdose deaths from the first wave. The government imposed stricter regulations on opioid prescriptions and modified the formulation of extended-release pills such as OxyContin to make them harder to abuse (CEA, 2019).[13] As a result, individuals, who used to consume pills, substituted them with readily available and less expensive illegal opioids such as heroin. Between 2002 and 2011, 79.5% of new heroin users had previously taken prescription pain relievers without a prescription (Muhuri et al., 2013). While these measures did succeed in decreasing the misuse of prescribed opioids, they also led to a surge in heroin overdoses (CDC, 2021b). Figure 1 illustrates the evolution of overdose deaths in the U.S. by the type of opioid after each wave.

During the third wave (2013-2021), the U.S. experienced a surge in overdoses involving heroin laced with Fentanyl (CDC, 2021b). Fentanyl is a synthetic opioid analgesic often used to treat

[13] The U.S. government changed the formulation of OxyContin pills to make them harder to crush. The crushing of extended-release pills releases the active component at once, which allows the body to absorb it faster than by taking a pill (Coplan et al., 2016).

Figure 1: Opioid overdose deaths in the U.S. 1999-2019



Notes: Constructed using information from the National Center for Health Statistics (NCHS). Fatalities from synthetic opioids are primarily due to Fentanyl and exclude overdoses from Methadone.

severe pain due to its high potency, which is between 50 to 100 times greater than morphine (CDC, 2021a). Drug dealers often mix Fentanyl with heroin as it provides a similar high to unlaced heroin but at a lower cost. Since traces of Fentanyl can only be detected through a lab test, heroin consumers are unaware of its presence. Due to its potency, small doses of Fentanyl pose a significant risk of overdose, with 2 mg considered a lethal dose according to the CDC (DEA, 2020b). Between 2013 and 2019, overdose deaths related to Fentanyl increased dramatically from 3,105 in 2013 to over 36,300 in 2019.[14]

2.5 The effect of the U.S. opioid crisis in Mexico

Mexico is the third-largest producer of opium in the world, after Afghanistan and Myanmar. It contributes to 6% of the global opium production. The majority of heroin is produced in the northern states of Chihuahua, Sinaloa, Durango (referred to as the Golden Triangle), Guerrero, and Nayarit. Guerrero alone concentrates approximately over 60% of the country's opium production (Le Cour Grandmaison et al., 2019).[15]

[14]Source: Own estimates using data from the National Center for Health Statistics (NCHS).
[15]Figure A2 in the Appendix shows the geographical distribution of poppy cultivation.

Mexico is also the main exporter of heroin to the U.S., responsible for supplying 90% of the heroin consumed in the country (Le Cour Grandmaison et al., 2019). Consequently, fluctuations in heroin demand in the U.S. can impact opium production in Mexico, cartel competition, and even violence. Sobrino (2019)'s study shows evidence that the increase in the demand for heroin, following the reformulation of OxyContin in 2010 (the second wave), led to increased cartel presence in suitable poppy municipalities, and subsequently contributed to a rise in homicides.

News reports and a recent survey indicate that the third wave had a different effect in suitable poppy areas. The introduction of Fentanyl decreased the demand for opium paste and, thereby, reduced the prices received by opium farmers. In 2017, opium farmers in Guerrero reported selling opium resin at $590 per pound but by 2019 this price had fallen by 50% (Semple, 2019). A survey of two villages in the states of Nayarit and Guerrero also found evidence of a decrease in opium prices (Le Cour Grandmaison et al., 2019), with prices falling from $950-$1,050 per kg in 2017 to $420 in 2018 (corresponding to a 50% decrease). Moreover, they estimated a reduction of almost 80% in opium prices in Guerrero over these two years.

With the fall of opium prices, poor farmers in rural areas of Guerrero saw their primary means of income disappear, forcing some of them to migrate out of their communities (Semple, 2019). This led to a reduction in the area of poppy grown by Mexican farmers. UN estimates based on satellite imagery revealed that from 2017-2018, 28,000 hectares of poppy were cultivated as opposed to 30,600 ha in 2016-2017 –corresponding to a 9% decrease (UNODC, 2020). The White House Office of National Drug Control Policy (ONDCP) also estimated a 24% decrease between 2019 and 2020, with an overall drop of 47% compared to 2017 (see Figure A3 in the Appendix, ONDCP (2021)). In summary, empirical evidence points towards a decline in prices and hectares of poppy cultivated since 2017 –four years after the beginning of the third wave.

3 Conceptual Framework

In Section A.3 of the Appendix, I provide a simplified version of the model developed by López Cruz and Torrens (2023) on crime diversification and spatial diffusion of violence to help guide the interpretation of my results. In this section, I summarize the main models' predictions.

In the model, DTOs behave as profit-maximizing firms that operate across multiple locations and are mainly involved in the production and distribution of illegal drugs. It is assumed that DTOs have been engaged in this activity for a while and, therefore, do not pay a fixed cost for this activity. Additionally, DTOs have the opportunity to engage in an extractive activity, such as extortion. This activity directly targets the legal sector. In contrast to drug trafficking, DTOs must pay a fixed cost to engage in an extractive activity. The production and distribution of illegal drugs and the extractive activity are disputable among DTOs, who resort to the use of force to compete, thus, leading to a rise in violence in the locations where they operate.[16]

Consider an economy with only two goods: poppies, used in the production of heroin, and avocados, a legal crop targeted by DTOs through extortion and theft. Locations are heterogenous in their value for each activity, with some best suited for poppy cultivation (drug trafficking) and others for avocado growth (the extractive activity). Additionally, DTOs vary in their ability to exploit and protect each location from their rivals. Taking these factors into consideration, DTOs strategically allocate capital and deploy armed labor (hitmen) for each activity and location. In other words, the market structure is modeled as an oligopoly with multiple products, and markets, where DTOs allocate capital and armed labor across markets and products to maximize their expected profits. The model endogenously yields predictions on the spatial distribution of DTOs' criminal activities and violence.

As profit-maximizing firms, DTOs prioritize allocating resources to the activities that generate the highest revenues and to the locations that offer the greatest return on their investment. For instance, DTOs specializing in drug trafficking funnel a larger portion of their capital and armed labor to the regions most suitable for poppy cultivation. Moreover, as with multi-product firms, a decline in the expected value from one of the DTO's activities (i.e. heroin trafficking) can lead to increased effort in the alternative activity (i.e. the extortion of avocado farmers) (Bernard et al., 2010). Given the fixed costs of the extractive activity, DTOs will only diversify whenever their expected profit from doing so is higher than the profit from specializing in drug trafficking. Therefore, as the value of heroin decreases, compared to the value of the extractive activity, drug trafficking becomes a less attractive activity for DTOs, and the extractive activity becomes more

[16] In López Cruz and Torrens (2023)'s original model criminal organizations can also participate in a non-contestable activity for which DTOs do not need to exert territorial control and, therefore, it does not lead to violent competition (e.g. telephonic fraud). In this model, I focus on the case where the value of the non-disputable activity is considerably lower compared to the alternative options, and, therefore, DTOs decide not to participate in this activity. Instead, DTOs produce and distribute drugs and decide whether to also engage in an extractive activity.

appealing. For DTOs specialized in drug trafficking, this may entail entering the extortion business, while DTOs, already engaged in both activities, will intensify the effort put towards the extractive activity.

Violence. As the profitability of heroin decreases relative to avocados, cartels are increasingly motivated to invest in extractive activities within avocado-suitable municipalities. To capture a larger market share, they escalate their investment in armed labor, which in turn leads to heightened levels of violence. This violence may be in the form of increased homicides and/or violent thefts, as armed labor is frequently used to fight rival cartels, in thefts, and as a coercive tool to enforce extortion payments from civilians.[17] Therefore, as the value for heroin decreases, homicides in an avocado municipality will increase. Conversely, in poppy-suitable municipalities, cartels invest less in capital and require fewer armed personnel, resulting in a decrease in violence.

Cartel presence. The model discussed here focuses on DTO's decision to diversify into an extractive activity. Predictions rely on the free mobility of capital across locations. However, in practice, access to a strategic location is expensive for DTOs. It demands investments in human capital and resources and, potentially, requires them to fight a rival cartel to access a territory. In this section, I delve into the implications of relaxing this assumption on cartel mobility across locations.

Cartels will decide to enter a location if the expected returns net of their entry cost are larger than continuing business as usual in their already occupied locations. Therefore, a decrease in the value of drug trafficking will increase a cartel's incentives to enter an avocado municipality if its expected profits from diversifying outweigh the cost of expanding its operations. If this is the case, a fall in the value of heroin will result in the heightened presence of DTOs in avocado-suitable municipalities.

As for the presence of DTOs in municipalities suitable for illegal crops, whether or not a cartel exists will depend on the expected profitability of the place and the reduction of the market size. I hypothesize that the decrease in the demand for heroin will lower cartels' incentives to fight over a suitable poppy territory, but will not necessarily result in their exit. First, occupied territories can

[17] Evidence from the palm oil sector in Indonesia by Kenny et al. (2020) shows how commodity boom violence can emerge from resource extraction through extortion and from violent competition among criminal groups.

offer other amenities beyond access to poppy, such as access to strategic locations along trafficking routes and ports. Second, DTOs invest not only in capital and armed labor but also allocate funds for bribes to corrupt local officials. There is also evidence that some DTOs make expenditures in public goods and relief to gain the support of the local population (Bustamante, 2020; Calderon et al., 2021). This strategy decreases the costs associated with maintaining a presence in a municipality and lowers their risk of military detection, thereby reducing their incentives to leave an already occupied place. As a result, I hypothesize that a decrease in the value of heroin, will likely not lead to lower cartel presence in poppy-suitable municipalities.

Long run vs short run. Note that previous arguments predict cartel movement by comparing their entry cost to the expected profitability from entering/exiting a territory. In the long run, cartels have the potential to acquire additional capital, enabling them to expand and relocate their operations. In the short run, however, cartels operate with a fixed amount of capital. Consequently, limited capital can hinder their ability to move into a particular location, thus leading to no changes in cartel presence in the short run.

It is important to note that while capital remains fixed in the short run, drug cartels are still able to invest in armed labor. Consequently, even if cartels have limited mobility to other territories due to high entry costs and fixed capital, they can resort to violence as a means to extract profits from their existing territories. Therefore, in the short run, with fixed capital and limited cartel mobility, instances of violence perpetrated by drug cartels are more likely to stem from changes in their behavior along the intensive margin (by increasing their investment in armed labor) rather than from conflicts raising from cartels fighting for entry into a territory (extensive margin).

4 Data

To assess the validity of my hypotheses, I analyze the relationship between the demand for heroin and criminal violence in avocado- and poppy-suitable municipalities. My analysis focuses on the main producers of avocados, using data from states with over 0.2% of their agricultural land devoted to avocado production, resulting in a sample of eight states: Michoacán, Morelos, México, Jalisco, Nayarit, Puebla, Colima, and Guerrero. These states collectively account for more than 94.7%

of average avocado production between 2011 and 2019.[18] These states are contiguous and share similar agro-climatic conditions. Moreover, each of them accounts for at least 2% of the total production of avocados, except for Colima (0.33%). The sample includes the main producer of avocados Michoacán, which until 2023, was the only state authorized to export Hass avocados to the U.S., and Guerrero, the leading producer of poppy in the country (Le Cour Grandmaison et al., 2019).[19]

I analyze the period between 2011 and 2019 for two reasons. First, it enables me to account for the years before and after the start of the third wave of the opioid crisis in 2013. Second, the period post-2010 saw a significant shift in cartel behavior due to a government's "kingpin" strategy during the war on drugs (2006-2012) that led to the fragmentation of Mexico's major DTOs (Atuesta and Ponce, 2017; Calderón et al., 2015; Jones, 2013). This fragmentation increased competition among DTOs and altered their incentives to diversify (Herrera and Martinez-Alvarez, 2022).[20] The resulting sample consists of 6,516 observations with information from 724 municipalities over nine years. A detailed summary of the data sources used in this study can be found in Table A1 in the Appendix.

4.1 Data on violence

To estimate the effect on criminal violence, I use homicide data from the National Department of Health Information (Sistema Nacional de Información en Salud; SINAIS). This database provides individual-level information on deaths from 1998 to 2019, with details on the cause of death (including homicides), location, weapon used (in the case of murder), and characteristics of the deceased such as sex, age, and occupation. Along with municipal-level population data from the National Institute of Statistics and Geography (INEGI), I estimate homicide rates per 100,000 people.

The SINAIS database has two main advantages over other homicide data sources. First, information comes from death certificates, rather than police records, reducing the likelihood of under-reporting for cases not investigated.[21] Second, the SINAIS database includes information on occupation, sex, and type of weapon used which I exploit to identify homicides of agricultural

[18] Source: Own estimates based on information from SAGARPA.

[19] Guerrrero accounts for over 60% of the total national opium production (Le Cour Grandmaison et al., 2019).

[20] The appendix A.2.1 provides more information on the war on drugs.

[21] Homicide data from police records are available from the Ministry of Public Security (SSP). SINAIS records are also contrasted to INEGI's homicide records before their release.

workers and potential murders linked to inter-cartel violence.

I estimate murders resulting from potential inter-cartel violence using data on homicides of males aged 15-40 killed with a firearm. In the absence of more reliable data on cartel-related homicides, other authors have used homicide rates for young men to proxy for murders linked to criminal activity in Mexico (Magaloni et al., 2020), as men between the ages of 15 and 40 are the population group most vulnerable to criminal violence (Calderón et al., 2015; Herrera and Martinez-Alvarez, 2022). In contrast to other studies, I argue that homicides of men by a firearm can provide a better estimate. Ownership of firearms is illegal in Mexico, and their use implies their acquisition through unlawful means. Additionally, cartels often employ firearms in engagements against other DTOs and the military (Mineo, 2022). In fact, over 70% of all guns recovered in crime scenes in Mexico can be traced to drug trafficking organizations (Mineo, 2022).

Lastly, information on extortion reports was obtained from SSP police records. The SSP maintains a comprehensive database covering all cases registered in the country between 2011 and 2019. Cases are reported every month and are available at the municipal level. Despite the availability of detailed information on extortion reports, homicides remain the most reliable proxy for violent crime in countries like Mexico, where incidents often go unreported. According to Mexico's National Survey of Victimization and Perceptions of Public Security (ENVIPE), 93.2% of all crimes in the country are not reported by individuals or were not filed by the police (INEGI, 2019a).[22]. Furthermore, To mitigate issues arising from under-reporting, I rely on homicides for my main results, with estimates on extortion available in Section 6.3

4.2 Drug cartel presence

To evaluate changes in territorial expansion and competition of DTOs, I use municipal-level data from the Mapping Criminal Organizations project (MCO).[23] This database uses a web-crawling technique to identify news related to drug cartels on Google and Google News. In particular, it identifies the number of paragraphs in which a cartel was mentioned in the news alongside a municipality in a given year. I consider a cartel to be present in a municipality if the number of

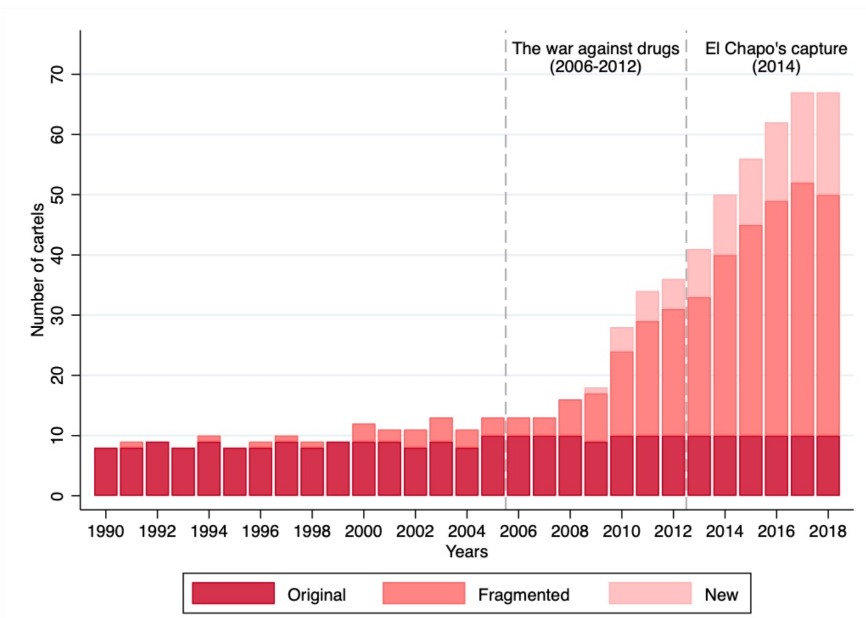
[22] According to the ENVIPE of 2018, 31.7% of the surveyed individuals mentioned that reporting a crime to the police was a waste of time, and 17.4% did not trust the police (INEGI, 2019a).

[23] The Mapping Criminal Organization project is supported by the Center for U.S.-Mexico Studies at the University of California San Diego (UCSD), the Mamdouha S. Bobst Center for Peace and Justice at Princeton University, and the Empirical Studies of Conflict Project (see Signoret et al. (2022) for details).

mentions is non-zero. The MCO database includes information on 75 different DTOs in Mexico (including the top eight cartels identified by the DEA) and their presence at the municipal level from 1990 to 2020. While other data sources have tried to measure cartel presence in Mexico (Coscia and Rios, 2012; Phillips, 2015; Sobrino, 2019), to the best of my knowledge, this is the only one that has information at the municipal level for my period of interest: 2011-2019.

Aside from the number of mentions of a cartel in a municipality, the database includes information on its "mother group" (the cartel from which it splintered).[24] Using the information on the mother group, along with the date on which cartels appeared for the first time in the data, I can distinguish between the cartels that preceded the war against drugs in 2006 (*originals*), cartels that fragmented from other cartels, and new cartels that had no previous affiliation to other cartels.[25] Figure 2 shows the evolution in the number of cartels operating at the national level between 1990 and 2018.

Figure 2: Fragmented and new cartels present by year



Source: Data from the MCO project. Fragmented cartels are defined as originating from other cartels. Original DTOs existed before 2006 and did not originate from another cartel. New cartels emerged post-2006 and have no prior affiliation to a cartel.

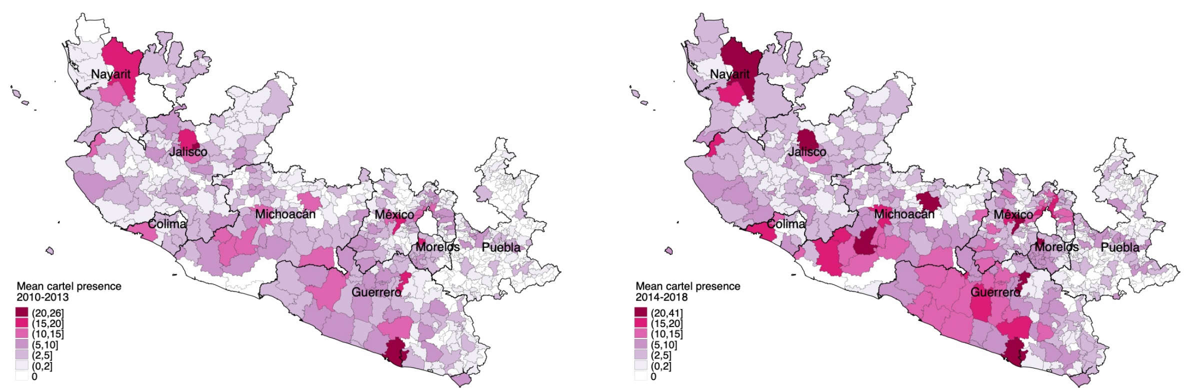
[24]This database does not indicate the history of fragmentation. For example, if Cartel A fragmented into B and C, and then cartel B fragmented again and formed cartel D, I would have cartel A as D's mother group, but no information on it being part of cartel B.

[25]Original cartels were defined as those that preceded the war against drugs (2006) and did not fragment from another cartel. Fragmented cartels are those with a cartel name different than their mother group. New cartels are defined as those that emerge after 2006 and have no prior affiliation to a cartel.

Within the past two decades, the number of cartels in Mexico has increased from around 12 to almost 70. This has occurred mainly as a result of cartels splintering during the war on drugs and after the capture of El Chapo (Mexico's most powerful drug lord at that time) in 2014. Moreover, the increase in cartel presence seems to have also resulted from the formation of new criminal organizations that had no previous link to DTOs. Figure 3 shows the average number of cartels present in my sample for 2010-2013 and 2014-2018. This shows a large increase in the number of cartels between these two periods, particularly in Michoacán, Guerrero, and Jalisco.

Figure 3: Cartel presence before and after the introduction of Fentanyl in the U.S.

(a) Mean cartel presence (2010-2013) (b) Mean cartel presence (2014-2018)



Notes: This figure shows the difference in cartel presence for the sample before and after the introduction of Fentanyl in the U.S. in 2014. Panels (a) and (b) show the mean cartel presence by municipality from 2010-2013 and 2014-2018, respectively.

4.3 Crop suitability measure

Due to the nature of criminal activities, information on illegal crop production is limited in Mexico. The U.S. Drug Enforcement Administration (DEA) has provided estimates on poppy cultivation at the national level since 2011, and the United Nations Office on Drugs and Crime (UNODC) has estimated poppy cultivation using satellite images for 2014-2018. However, neither source includes data at the state or municipal level, and the original databases are not open to the public.

Moreover, while the Food and Agricultural Organization (FAO) of the United Nations has municipal-level information on agro-climatically attainable yields on some crops, this data does not exist for my two crops of interest: avocados and poppy. Therefore, I built a suitability index for each crop based on information on minimum and optimal agro-climatic characteristics obtained from FAO's Ecological Crop Requirements (Ecocrop) database. To build the suitability indices for avocado and poppy, I use a well-established model for crop suitability used by agronomists (Møller et al., 2021): the Ecocrop suitability model, named after the data it uses for its estimation and proposed by Hijmans et al. (2017). The main advantage of this approach is that it uses reliable information based on academic research from experts in the area.

The Ecocrop suitability model uses temperature and precipitation data and compares them to the crop's climatic requirements throughout the growing season to estimate a suitability index for a given area. These requirements are divided between the minimum conditions at which a specific crop can grow (absolute measures) and optimal conditions at which crops deliver the highest yield. The model assigns an index between zero and one, where zero is assigned to areas that do not meet the minimum requirements for growth (unsuitable) and a value of one for areas with optimal conditions (Ramirez-Villegas et al., 2013).

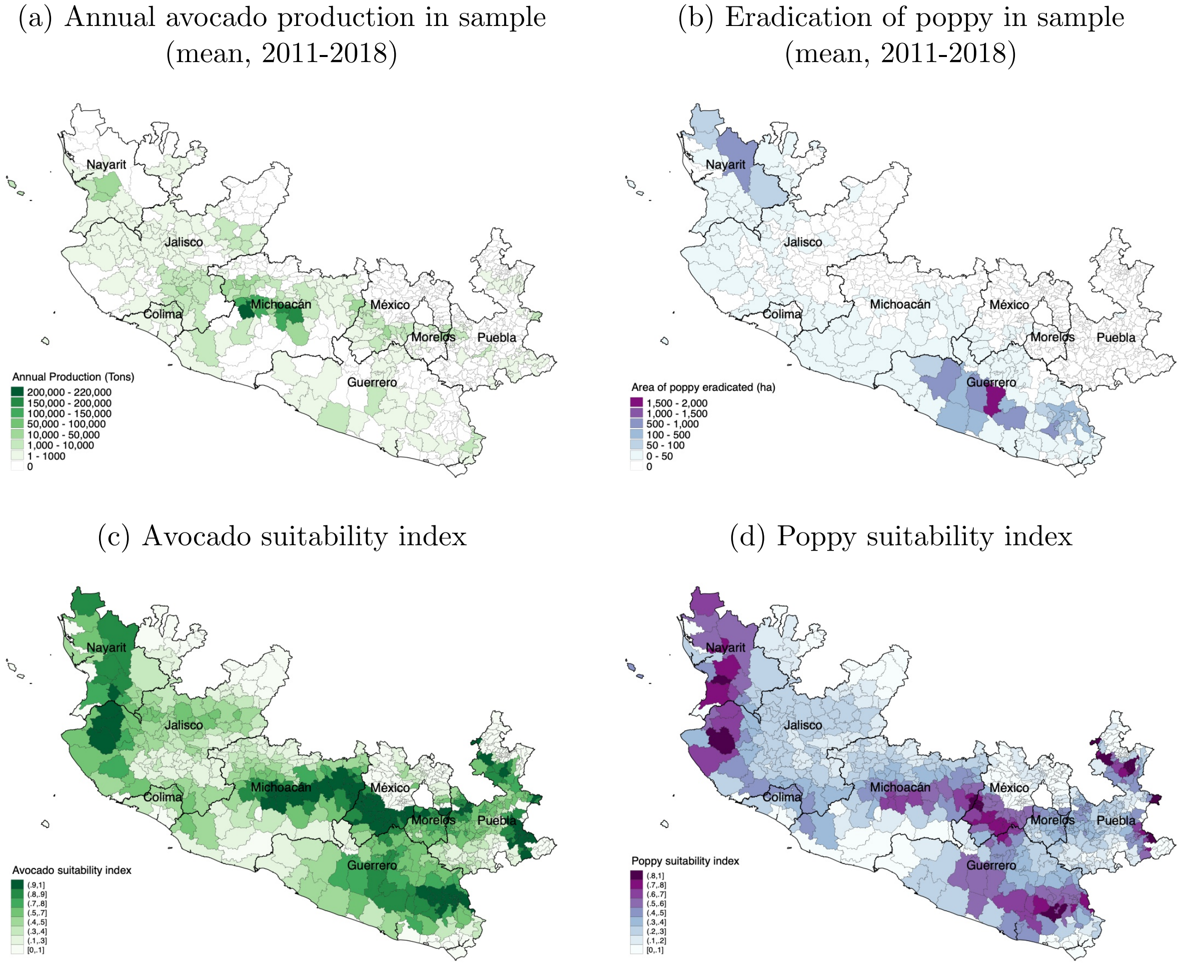
To estimate the avocado and poppy suitability indices, I use information on the specific growing conditions for each crop from the FAO Ecocrop database. I combine this with historical precipitation and temperature data obtained from AgMerra, along with land elevation data from INEGI. A detailed description of how each suitability index was built, including the variables used and the optimal temperature, precipitation, and altitude requirements can be found in Section A.5 of the Appendix.

Furthermore, to assess the validity of each index, I regressed each index against production outcomes such as hectares of avocado cultivated and area of poppy eradicated for the avocado and poppy indices, respectively.[26] The results show a positive and statistically significant correlation between each index and their respective production outcomes for the entire country and within my sample (for more details refer to Section A.5.4 in the Appendix).

Figures 4 (a) and (b) show the mean annual avocado production of avocados and the geographical distribution of poppy-eradicated areas in my sample between 2011 and 2018. Note that, while Michoacán and Guerrero produce both avocados and poppy, Michoacán mostly produces avocados, and Guerrero mostly produces poppy. The proximity between the main producer of avocados and

[26] Information on avocado production was obtained from the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA). Data on poppy eradication was obtained from the Ministry of National Defense (SEDENA) and was used as a proxy for production.

Figure 4: Spatial distribution of avocados and poppy

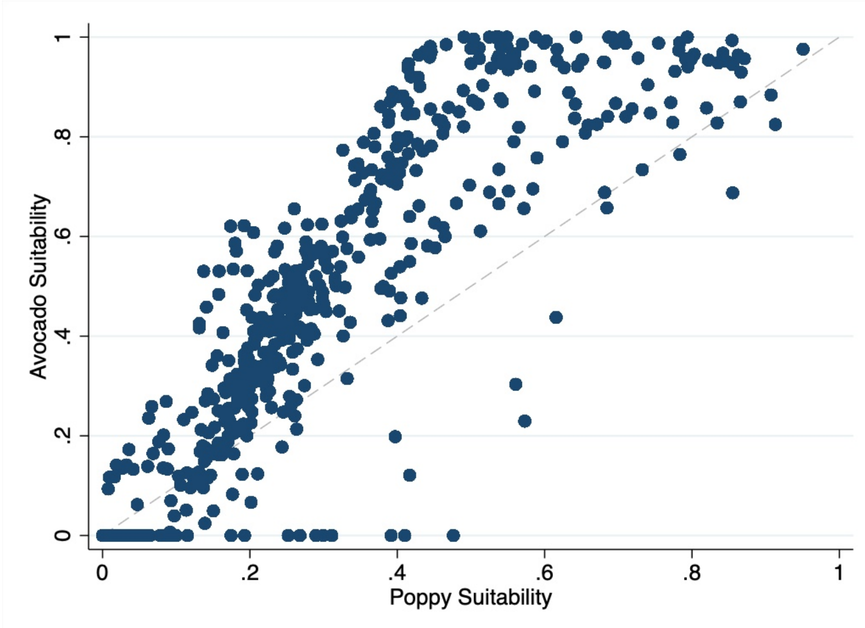


Notes: This figure shows the spatial distribution of the avocado and poppy suitability indices and compares them to production measures for each crop analyzed. Panels (a) and (c) show the mean annual avocado production in 2011-2018 and the avocado suitability index, respectively. Panels (b) and (d) show the mean yearly poppy eradication in 2011-2018 and the poppy suitability index, respectively.

the leading poppy producer contributes to my hypothesis that this proximity played a role in the drug cartels' diversion into the avocado business after a decrease in the demand for heroin.

Figures 4 (c) and (d) show the distribution of the avocado-suitability and poppy-suitability indices, respectively. Measuring an agro-climatic suitability index has the advantage of being completely exogenous to my outcomes (violence). While the suitability index indicates an area's suitability to grow a particular crop, it cannot pick up on why some municipalities decide to produce the crop. For instance, it does not capture whether some municipalities are more likely to produce poppy if they have mountainous areas where poppy farmers can hide the illegal crop.

Figure 5: Avocado and poppy suitability distribution



Notes: This figure shows the distribution of the avocado and poppy suitability indices. The dashed line indicates the 45°line.

Because these two crops share similar weather requirements (i.e., similar optimum temperatures and precipitation), I observe a significant correlation between avocado- and poppy-suitable municipalities. Figure 5 shows how municipalities that are highly unsuitable for avocados are also unsuitable for poppy. Conversely, municipalities that are highly suitable for avocados have a poppy suitability index of at least 0.4. The correlation between these two indices is 0.82. As a result, it is not possible to distinguish between municipalities that are only suitable for poppy and those that are only suitable for avocados. This fact will become relevant later when interpreting the results.

4.4 Heroin prices

Information on heroin retail prices (adjusted per purity) for the U.S. was obtained from the United Nations Office on Drugs and Crime (UNODC) for each year between 1990 and 2018.[27] Figure 6 shows heroin retail prices in the U.S., adjusted by purity, and the price of Afghanistan dry opium paste as a reference.[28] It shows that, without being adjusted for purity, U.S. heroin prices have remained relatively stable over the last two decades, at around USD$300 per gram, with an

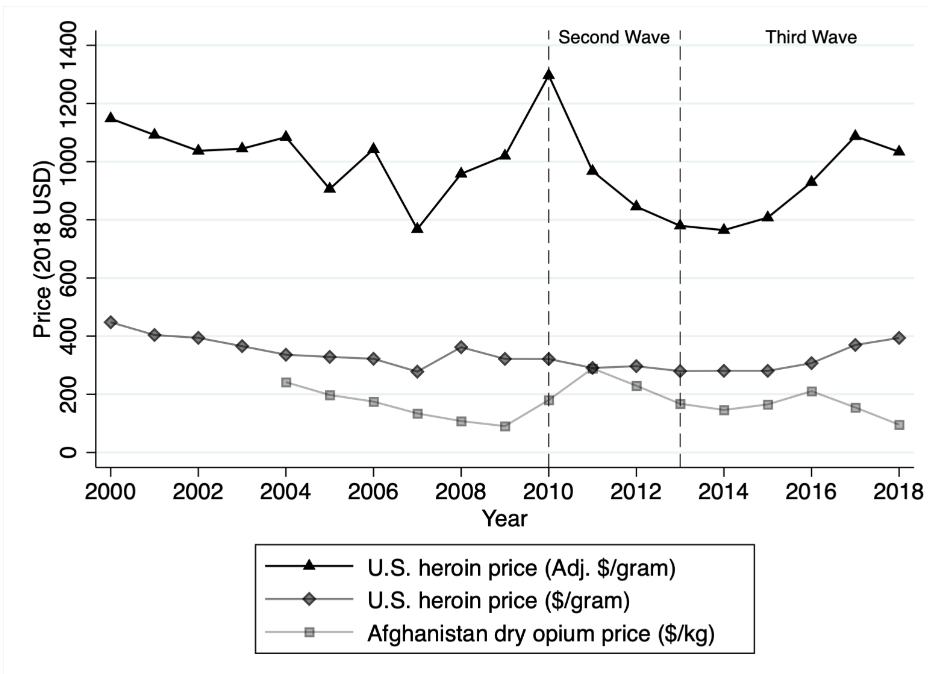
[27] Because heroin is often laced with other substances, such as Fentanyl, it is analyzed in labs to determine its purity, and prices are adjusted to hold quality constant (Hughes et al., 2020; Anthony et al., 2008).

[28] Information on Afghanistan's average farm-gate prices of opium was obtained from the UNODC for 1994-2018.

increase between 2016 and 2018, reaching USD$400 per gram. Meanwhile, prices per gram adjusted for purity show significant fluctuations.[29]

In contrast to non-adjusted retail prices, prices adjusted per purity experienced a decrease after the second wave, when the demand for heroin increased. After 2013, prices of heroin, as reported by the DEA, showed an increase. While this contradicts the prices observed by farmers in Mexico (Semple, 2019; Le Cour Grandmaison et al., 2019),[30] the disparity in prices of opium perceived by farmers and heroin prices in the U.S. can be explained by how these prices are obtained.

Figure 6: U.S. retail heroin prices, adjusted per purity, and Afghanistan dry opium paste price



Source: Data from the UN Office on Drugs and Crime. This graph shows prices of heroin per gram of heroin in the U.S. (retail and adjusted per purity) and Afghanistan dry opium prices per kilogram.

While heroin prices in the U.S. are usually used in the literature (e.g., Sobrino (2019)), in this paper, I argue that they may not be representative of prices perceived by DTOs and farmers in Mexico.

[29]This rare behavior is part of a pricing strategy by dealers. Since the quality of heroin is hardly observable even to the most experienced consumers, dealers sell at a fixed price to consumers but earn higher profits by decreasing the quality of heroin sold (Office of National Drug Control Policy, 2001; Hoffer and Alam, 2013). For instance, between 1990-2000, a one-milligram bag of heroin would be sold for USD$20 (Office of National Drug Control Policy, 2001). This explains why retail prices (not adjusted for purity) remain stable over time. This pricing strategy allows drug dealers to sell heroin mixed with other diluents to lower their costs while maintaining the same price. In contrast to other diluents, Fentanyl allows dealers to continue to provide the same high to consumers while increasing their profits (DEA, 2020a).

[30]As mentioned in Section 2.5, between 2017 and 2018, poppy farmers in the states of Nayarit and Guerrero perceived a decrease in opium prices of around 50% (Le Cour Grandmaison et al., 2019); such a decrease is not observed in Figure 6.

Prices of heroin in the U.S. are estimated based on purchases by undercover agents and informants of the DEA and state and local agencies (Arkes et al., 2008). However, not all acquisitions are part of this database – only the ones sent to a laboratory. Additionally, these purchases are part of criminal investigations, and, therefore, they do not constitute a random sample of the price paid by consumers (Horowitz, 2001). The price in these purchases also varies significantly between agencies, as local law enforcement may be more acquainted than the DEA with local drug dealers and can obtain heroin at lower prices, which raises questions about the internal validity of this data (Horowitz, 2001).

Moreover, heroin prices reported in undercover deals may be biased, because agents pay higher prices than the average consumer (Caulkins, 2007), since i) they have lower bargaining power and ii) they make larger purchases than the average consumer. For instance, DEA undercover purchases must be of at least one gram to ensure a sufficient amount of heroin to identify its origin (GAO, 2002); in practice, purchases by the DEA are more likely to be over 5 grams (Arkes et al., 2008). Prices adjusted by purity obtained through these large purchases are likely to be non-representative of market prices because quality is positively correlated with quantity sold (Office of National Drug Control Policy, 2001).[31]

Finally, the increase in prices observed after 2014 may be partially attributed to changes in sampling. According to the DEA's 2019 National Drug Threat Assessment, new undercover purchases in rural areas, where transportation costs are high, and there is limited availability of drugs, could be the reason behind the increase in the reported price of heroin (DEA, 2020a). Unfortunately, detailed information on each purchase is no longer available, and I cannot correct for the change in sampling. Therefore, I argue that data on heroin prices in the U.S. is not a good proxy for prices perceived by cartels. It is not only subject to measurement error but also fails to capture changes in the opioid market in Mexico. Because of this, I do not use heroin prices for this analysis.

Despite the above, there is increasing evidence on the escalating presence of Fentanyl and a corresponding decline in the demand for heroin. According to the DEA (2021), laboratory reports involving heroin decreased by 13% between 2018-2019. Meanwhile, heroin prices in New Jersey decreased by 18% between 2017 and 2018, in contrast to a 50% increase in the price of Fentanyl

[31] The Office of National Drug Control Policy (ONDCP) estimates that purity for a wholesale distributor would be about 60%, for a mid-level distributor 40%, and 13% for a small distributor (Office of National Drug Control Policy, 2001).

(DEA, 2020a).

4.5 Fentanyl overdoses

Data on Fentanyl overdoses in the U.S. was obtained from the National Center for Health Statistics (NCHS). The data contains information on the national number of overdoses by type of drug for each year between 1990 and 2018. This database allows me to identify the number of overdoses linked to Fentanyl only and those linked to heroin mixed with Fentanyl.

Fentanyl overdose deaths are my proxy for the introduction of Fentanyl in the U.S. market. The sale of non-prescribed Fentanyl is illegal in the U.S., and there is no information on how much Fentanyl has been smuggled from China and Mexico into the U.S. However, it is possible to use overdoses as a proxy for its presence in the market. First, Fentanyl is highly lethal; according to the DEA, 2 milligrams would be enough to cause an overdose, and the market is flooded with counterfeit pills that can go up to 5.1 milligrams (twice as much as the lethal dose) (DEA, 2020b). Second, the presence of Fentanyl is unobservable to consumers. For one, dealers can sell heroin mixed with Fentanyl to maintain the same potency while lowering their costs without consumers finding out about it. Because the amounts of Fentanyl needed to maintain the same high are minimal, it is impossible for even the most experienced drug user to notice its presence by sight or taste. Moreover, even when consumers knowingly buy counterfeit Fentanyl pills, they cannot know precisely how much Fentanyl is in each tablet. While Fentanyl does not kill everyone who consumes it, a higher proportion of illegal drugs and counterfeit pills mixed with Fentanyl would increase overdoses, because consumers are unable to identify its presence and adapt their demand accordingly.

Alternatively, information on the number of Fentanyl reports identified by forensic laboratories in the U.S. can measure the availability of Fentanyl in the market. This information is reported by the National Forensic Laboratory Information System (NFLIS) and is available through the DEA's National Drug Threat Assessment of 2019 and 2020. This data has information on the number of forensic reports in which Fentanyl was found for the whole country between 2005 and 2019.

One disadvantage of using Fentanyl report data as a proxy for presence in the market is that forensic reports are also obtained through undercover purchases and suffer from the same sample bias as heroin prices (see 4.4 for more information).[32] In contrast, Fentanyl overdose deaths do not suffer from this bias and can be more representative of the presence of Fentanyl in the market. More importantly, Fentanyl overdose deaths show a similar trend across time as the DEA Fentanyl reports (see Figure A4 in the Appendix), and both measures exhibit a high and statistically significant correlation.[33]

4.6 Other variables

Data on population by municipality was obtained from INEGI National Census of 2010. The municipal mayor party affiliation information comes from the National Institute for Federalism and Municipal Development (INAFED). It includes information on all elected mayors between 1993 and 2019. I use this as a proxy for enforcement and use of force against drug cartels. Empirical evidence has shown that parties differ in their treatment of DTOs (Magaloni et al., 2020; Dell, 2015). Dell (2015) finds evidence that municipalities governed by the PAN party experienced higher levels of drug-related violence during the war against cartels (2006-2012) led by President Felipe Calderón. Table A2 in the appendix shows the descriptive statistics.

5 Empirical Strategy

5.1 Main specification

To assess whether a decrease in the demand for heroin in the U.S. led to violence in Mexico, I would ideally like to estimate how changes in the price of heroin as perceived by drug cartels led to an increase in violence in avocado-suitable municipalities. However, identification using this strategy is impossible because the prices perceived by DTOs are not observable to researchers and are likely endogenous. Moreover, heroin prices in the U.S., as reported by the DEA, might not be a good proxy for DTO's wholesale prices. First, dealers charge effective prices by modifying the quality of heroin rather than by adjusting its price. Secondly, prices obtained through undercover purchases may not be representative of prices paid by consumers (Horowitz, 2001), and sampling changes

[32] Despite this limitation, report data can still offer valuable insights into trends, relative drug availability, and the prevalence of drug combinations like Fentanyl-heroin.

[33] The correlation between the number of Fentanyl overdose deaths and DEA reports is 0.98, significant at the 0.1% level.

may be overestimating heroin prices (for more detailed information, see Section 4.4). Furthermore, transportation costs, market competition, the intensity of enforcement in the U.S., as well as the dealers' ability to modify quality to deal with fluctuations in the heroin price can decrease the extent to which the prices charged to consumers react to changes in the prices charged by Mexican DTOs.

Therefore, I use the introduction of Fentanyl as an exogenous shock in the demand for heroin. As Fentanyl made its way into the U.S. market, heroin retail dealers started to mix heroin with Fentanyl to increase profitability by maintaining the same level of high for their users (DEA, 2021; Ordonez and Salzman, 2023). Identification is possible under the following two assumptions: i) the introduction of Fentanyl decreased the demand for heroin in the U.S., which shifted heroin revenues for cartels, and ii) the only effect of the introduction of Fentanyl on violence is through its impact on heroin revenues obtained by cartels. I argue below that these two conditions are met.

First, laboratory evidence suggests an increasing presence of Fentanyl in heroin (DEA, 2020a), with Fentanyl and heroin being the most common mixture among all Fentanyl exhibits in undercover purchases that could be verified in 2019 (around 27.5%).[34] Moreover, there is evidence of a drop in opium paste prices received by farmers in Mexico, along with a decrease in the number of hectares cultivated (ONDCP, 2021; Le Cour Grandmaison et al., 2019; Semple, 2019). This supports the first assumption.

Second, I argue that changes in the demand for heroin resulting from the introduction of Fentanyl are exogenous to violence in Mexico. For one, most of the Fentanyl consumed in the U.S. comes from China, which accounts for around 90% of the world's Fentanyl. From China, Fentanyl pills arrive in the U.S., either shipped directly through the mail or smuggled through the U.S-Mexico border. While Mexican DTOs are now active players in the smuggling of Fentanyl into the U.S., their participation is recent; up until 2017, there were no seizures of Fentanyl-laced pills at the border (Dudley et al., 2019). Moreover, heroin seizures at the border show that lacing heroin with Fentanyl is not a strategy followed by Mexican DTOs; instead, heroin and Fentanyl are smuggled separately, and mixing is done at the retail level inside the U.S. (Dudley et al., 2019). Furthermore, my strategy of regarding Fentanyl overdoses as a proxy for the availability of Fentanyl in the U.S. market strengthens my second assumption because Fentanyl overdoses in the U.S. would result in

[34] Source: Own estimates based on information from the 2020 DEA National Drug Threat Assessment (DEA, 2021).

more violence in Mexico only through their effect on the demand for heroin.

Identification is possible if Fentanyl overdoses are a good proxy for the availability of Fentanyl in the U.S. market. I argue this is true since the presence of Fentanyl in heroin, as in other drugs, is unobservable to even the most experienced drug users. Thus, consumers cannot adjust their demand accordingly. This makes Fentanyl overdose exogenous to violence in Mexico. Finally, an advantage of using this identification strategy is that data on overdoses do not suffer from the same measurement problems as the DEA's Fentanyl reports (see Section 4.5).

The main specification is as follows:

$$Y_{it} = \alpha_i + \tau_t + \gamma(S_i^a \times F_{t-1}) + \delta(S_i^p \times F_{t-1}) + X_{it}'\beta + v_{it} \quad (1)$$

where Y_{it} is a measure of violence in municipality i in year t, S_i^a and S_i^p are agro-climatic suitability measures for avocado and poppy, respectively. F_{t-1} is the number of overdoses from Fentanyl in the previous year $t-1$. I use a lag to account for a delay between a decrease in the demand for heroin by domestic dealers in the U.S. and by cartels in Mexico. Meanwhile, X_{it} is a vector of controls that include municipal mayor party affiliation,[35] an indicator equal to one if the municipal mayor party coincides with the president's party,[36] and baseline characteristics interacted with time trends. These baseline characteristics include the number of hectares in municipality i in which poppy was eradicated in 2010, which I use as a proxy for drug cultivation, and the municipality marginalization rate of 2010. The marginalization rate is an index created by Mexico's National Council for the Evaluation of Social Development Policy (CONEVAL) to account for different levels of social deprivation, including access to health care, basic services, dwelling quality, and level of education. Higher positive levels are indicative of severe social deprivation (Aguila et al., 2014). Finally, to account for shocks in time and time-invariant characteristics of each municipality, I include municipality (α_i) and time (τ_t) fixed effects.

Using the main specification, I test the effect of the introduction of Fentanyl (and the subsequent

[35] Empirical evidence suggests that some parties in Mexico are more prone than others to fight cartels (Magaloni et al., 2020; Dell, 2015).

[36] I use this as a measure for enforcement. Matching parties means that the municipal mayor is more likely to be supported by the president. This could mean a higher military presence than in other municipalities and could result in lower murder rates.

decrease in the demand for heroin) on violence in avocado and poppy municipalities. As a measure of violence, I use the log transformation on the number of homicides per 100,000 people. Additionally, I test for the effect on homicides of agricultural workers and potentially drug cartel-related deaths. Since homicide data does not necessarily involve a police investigation, there is no information on who perpetrated the murder. However, I use the homicides of men ages 15-40 killed by a firearm who did not work in the agricultural sector as a measure of potential inter-cartel-related homicides.[37]

The coefficients of interest in the specification are γ and δ, where γ measures the impact of Fentanyl on suitable avocado municipalities, and δ measures the effect on suitable poppy municipalities. For all homicides, I expect to see an increase in suitable avocado municipalities because cartels have incentives to fight to get control of these areas and/or need to employ violence to enforce payments ($\gamma > 0$). Moreover, because cartels have fewer incentives to fight over poppy-suitable municipalities, I expect to see $\delta < 0$.

Evidence on whether cartels use violence to enforce extortion payments or to fight other cartels will be given by results on the effect of homicides against agricultural workers and against individuals potentially linked to cartels. If cartels are using violence to fight against each other, I expect to see a positive correlation between Fentanyl overdoses and potentially cartel-related homicide rates. If, instead, violence is being used to enforce extortion, I would expect to see an increase in murders of agricultural workers and other types of civilians but no effect on cartel-related homicides.

5.1.1 Cartel presence

To shed light on whether changes in homicides are associated with cartels moving into or out of a territory, I estimate Equation 1 on three different measures for cartel presence. The first is the total number of cartels present in a municipality in a given year. For this, I use the number of mentions for each cartel in a given municipality and year; I consider a cartel to be present in a location when the number of mentions is non-zero. I estimate results for the overall number of cartels present in a municipality. I also distinguish the presence of nine of the most dominant DTOs in Mexico,[38]

[37] I argue that I can proxy murders linked to cartel violence using this measure, as DTOs have disproportionately more men than women in their ranks, and most executions involve a firearm (Magaloni et al., 2020). For additional details, see Section 4.1.

[38] The nine most dominant cartels in Mexico are the Sinaloa Cartel, Los Zetas, Gulf, La Familia Michoacana, the Knights Templar, Cartel Jalisco Nueva Generación (CJNG), the Beltrán Leyva Organization, Tijuana and Juárez (Beittel, 2020).

according to the DEA. These are the main cartels specialized in the trafficking of heroin.[39]

The second measure is the overall number of mentions of cartels in a municipality. A particular concern with these measures is that the number of mentions in a municipality is likely correlated with media coverage. For instance, more prominent cities will have more mentions than small rural municipalities. I control for this by including municipality fixed effects in my estimates.

Finally, I estimate a Herfindahl-Hirschman index using the number of times a cartel was mentioned in a municipality. I use this index as a measure of cartel concentration. This index ranges between zero and one, where one would indicate a full concentration of the market (monopoly), and zero would correspond to perfect competition.

6 Results

6.1 Results on violence

In this section, I examine the relationship between a decrease in the demand for heroin in the U.S. and violence in Mexico. The main identification strategy tests for the impact of changes in Fentanyl overdose deaths in the U.S. on the homicide rate of municipalities that are suitable for producing avocados and municipalities that are suitable for poppy.

Table 1 shows the effect on homicide rates. All specifications include municipality and time fixed effects, all controls (the municipal mayor party and an indicator variable equal to one if the mayor's party coincides with the president's party), and baseline trends for municipality marginalization and poppy production. Column (1) shows the effect of Fentanyl overdoses on the overall homicide rate. Results show a heterogeneous impact on homicides for avocado- and poppy-suitable municipalities. In particular, I observe that the introduction of Fentanyl in the U.S. led to increases in the homicide rates of avocado-suitable municipalities, while having the contrary effect on poppy-suitable municipalities.

Columns (2) – (4) show the effect on murders of agricultural workers, homicides that are potentially related to cartel violence, and homicides on the rest of the population (non-agricultural

[39] The main cartels trafficking heroin according to the DEA are the Sinaloa Cartel, Cartel Jalisco Nueva Generación (CJNG), the Juarez Cartel, Gulf, Los Zetas, the Beltrán-Leyva Organization, La Familia Michoacana, Los Rojos and Guerreros Unidos (DEA, 2021).

Table 1: Results on the effect of Fentanyl on violence in avocado and poppy municipalities

	Log(Murders)			
	All	Agricultural workers	Potentially cartel related	Rest of the population
	(1)	(2)	(3)	(4)
Avocado Suitable × Log(Fentanyl$_{t-1}$)	0.208**	0.243***	0.156	0.174*
	(0.103)	(0.093)	(0.104)	(0.090)
Poppy Suitable × Log(Fentanyl$_{t-1}$)	-0.340**	-0.368***	-0.295*	-0.245*
	(0.165)	(0.139)	(0.164)	(0.142)
Observations	6516	6516	6516	6516
Adj. R-squared	0.395	0.332	0.359	0.368
Mean dep. var.	2.441	1.065	1.198	1.682
Year FE	X	X	X	X
Municipality FE	X	X	X	X

Notes: All outcome variables are the log of the number of murders per 100,000 inhabitants. All regressions control for the municipal mayor party, whether the mayor party was the same as the President's party, and baseline time trends on municipal marginalization and poppy eradication. Potentially cartel-related murders are homicides of men ages 15-40 killed by a firearm that did not work in the agricultural sector. The rest of the population are homicides of individuals that are not potentially related to cartels and do not work in the agricultural sector. Standard errors clustered at the municipal level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

workers and non-cartel-related).[40] The results in Column (2) show an increase in homicides of agricultural workers for avocado-suitable municipalities, suggesting that cartels may be using force to extract revenue from farmers, possibly to enforce extortion payments, or through violent robberies. In Section 6.3, I expand on this by examining changes in violent theft rates and extortion.

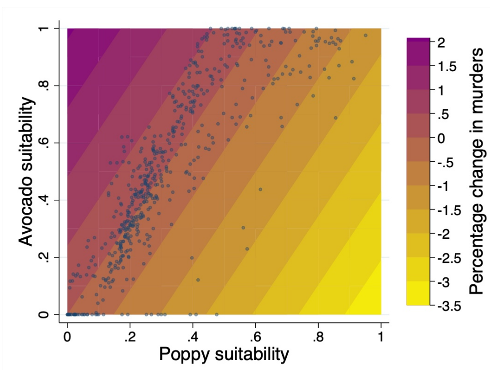
For potentially inter-cartel-related murders (Column 3), I observe no effect in avocado-suitable municipalities and a decrease in poppy-suitable municipalities. This suggests that cartels are less likely to fight each other to control poppy-suitable municipalities as the demand for heroin decreases. Finally, Column (4) shows the results on homicides of the rest of the population, that is, those that are not potentially related to cartels or agricultural workers. The results show a similar pattern as that for murders of agricultural workers but at a lower magnitude, suggesting that cartels target both agricultural workers and the general population in avocado-suitable municipalities. Finally, I find that the introduction of Fentanyl led to fewer homicides of the rest of the population in poppy-growing municipalities.

[40] Potentially related murders are murders of men between ages 15-40 killed by a firearm, who are not agricultural workers. More details can be found in Section 4.1.

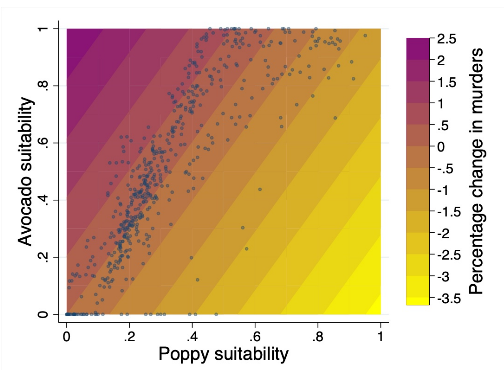
Since the interpretation of coefficients for interactions between continuous variables is not straightforward, I estimated the marginal effects in terms of Fentanyl overdose deaths.[41] To help visualize the results, I present the marginal effects using heat maps. Figure 7 graphs the marginal effect of a 10% increase in Fentanyl overdose deaths on homicides for different degrees of poppy and avocado suitability. For example, Figure 7 (a) shows that a 10% increase in overdose deaths from Fentanyl results in a 2% rise in the homicide rates for municipalities with an avocado suitability index of 0.8 and a poppy suitability index of 0.3.

Figure 7: Marginal effect of a 10% increase in Fentanyl overdose deaths on murders in avocado and poppy suitable municipalities.

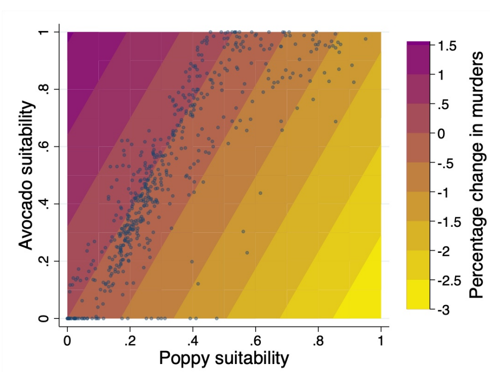
(a) All murders



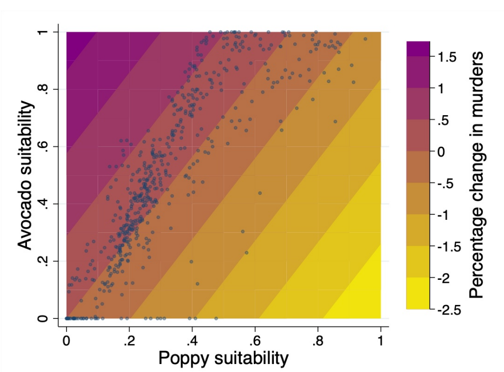
(b) Agricultural workers



(c) Potentially cartel related



(d) Rest of the population



Notes: Figure constructed from the coefficient estimates for Table 1. Panels (a)-(d) show the marginal effect of a 10% increase in Fentanyl overdoses on murder rates for all combinations of poppy and avocado suitability levels. The scatter plot shows the support for the estimations. Potentially cartel-related murders correspond to the homicide rate of men ages 15-40 killed by a firearm who did not work in the agricultural sector. The rest of the population includes all homicides except for potentially cartel-related and agricultural workers.

[41] The corresponding marginal effect equation is as follows: $\frac{\partial log Y_{it}}{\partial log F_{t-1}} = \hat{\gamma} S_i^a + \hat{\delta} S_i^p$. According to this equation, the interpretation of results depends on the relative suitability for poppy and avocado production.

For all outcomes, the observed patterns strongly suggest that municipalities that are more avocado-suitable and less poppy-suitable have experienced an increase in the number of murders as a result of an increase in the presence of Fentanyl in the U.S. market. Meanwhile, municipalities that are more suitable for poppies than for avocados have experienced a decrease in homicide rates. These diagrams also show that highly avocado-suitable municipalities can experience up to a 2% increase in the homicide rate. In contrast, highly poppy-suitable municipalities can observe up to a 3.5% decrease in homicides in response to a 10% increase in Fentanyl overdose deaths. While the previous estimates may appear relatively small, we need to consider that between 2013 and 2019, Fentanyl overdose deaths increased by an average of 55% annually. Consequently, the observed effects of a 10% increase in Fentanyl overdose deaths yield conservative estimates of the actual impact.

6.2 Cartel presence

In this section, I analyze whether the observed changes in the homicide rates in poppy- and avocado-suitable municipalities are linked to changes in cartel presence. Table 2 shows the effect of Fentanyl on the different cartel presence measures. All specifications include municipality and time fixed effects and covariates. Columns (1)-(3) show the results for changes in the number of cartels present in a municipality. All estimates are expressed in logarithmic form. I prefer this specification because of its simplicity and ease of interpretation; however, my estimates are robust to other specifications. Column (1) shows the effect of the number of cartels present in a municipality. Column (2) shows results for the presence of the major DTOs in Mexico, and Column (3) for cartels that work on the distribution of heroin. Finally, Columns (4) and (5) show the results on the total number of mentions of cartels and the HH index.

Overall, the results reveal small and no statistically significant effects on cartel presence and market concentration in municipalities suited for avocados. This suggests that, despite substantial revenue growth in the avocado industry over the past two decades, the potential profits that cartels can extract are not significant enough for them to move into these municipalities.

It is plausible that they are unable to extract sufficient revenue or that the entry costs may be too high (e.g., fighting other cartels is expensive). This observation is consistent with short-run predictions regarding cartel mobility. In the short run, criminal organizations have limited capability to increase capital, such as firearms and artillery needed to confront other criminal

Table 2: Results on the effect of Fentanyl on cartel presence in avocado and poppy suitable municipalities

	Log(Cartels)				
	All cartels (1)	Main cartels (2)	Heroin cartels (3)	Log(Mentions) (4)	HH index (5)
Avocado Suitable × Log(Fentanyl$_{t-1}$)	0.0733	0.0373	0.0223	0.142	-0.0136
	(0.048)	(0.039)	(0.023)	(0.099)	(0.036)
Poppy Suitable × Log(Fentanyl$_{t-1}$)	-0.0911	-0.0611	-0.0269	-0.114	0.0543
	(0.073)	(0.060)	(0.035)	(0.151)	(0.052)
Observations	6516	6516	6516	6516	3390
Adj. R-squared	0.764	0.721	0.543	0.790	0.465
Mean dep. var.	0.781	0.626	0.336	1.336	0.556
Year FE	X	X	X	X	X
Municipality FE	X	X	X	X	X

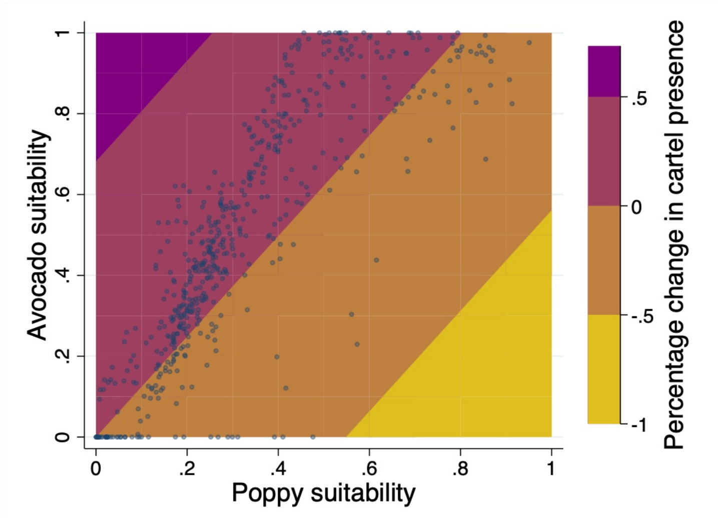
Notes: This table shows the effect of Fentanyl on cartel presence. Fentanyl overdoses are expressed in logarithmic form. The number of cartels and the mentions are also expressed in logarithmic form. The variable mentions correspond to the number of times a cartel was mentioned in the same paragraph as the municipality. The HH index corresponds to a Herfindahl-Hirschman Index calculated using the number of mentions of each cartel in a municipality. All regressions control for the municipal mayor party, a binary variable indicating whether the mayor party is the same as the President's party, and baseline time trends on municipal marginalization and poppy eradication. The number of main cartels corresponds to the nine major DTOs recognized by the DEA. Heroin cartels are DTOs categorized by the DEA as heroin trafficking organizations. Standard errors clustered at the municipal level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

organizations, thereby impeding their relocation to other municipalities. Since results do not show changes in drug cartel presence, the increased violence observed in avocado-suitable municipalities can be attributed to changes in the behavior of already present cartels, who resort to heightened violence against civilians as a means to extract rents.

When examining municipalities suitable for poppy cultivation, results also show no statistically significant changes in cartel presence. However, these results still show a negative correlation between Fentanyl and the number of cartels in poppy-suitable municipalities. Although the result does not reach statistical significance, it suggests that cartels may have reduced incentives to maintain a presence in these areas.

Figure 8 shows the marginal effects for the total number of cartels, corresponding to Column (1) results. While estimates are not statistically different from zero, they follow the same pattern observed for homicides (see Figure 7). This provides further evidence of worsened outcomes for avocado-suitable municipalities and improvements for poppy-suitable municipalities.

Figure 8: Marginal effect of a 10% increase in Fentanyl overdose deaths on the number of cartels in avocado and poppy suitable municipalities



Notes: Figure constructed from coefficient estimates in Table 2. This figure shows the marginal effect of a 10% increase in Fentanyl overdoses on the number of cartels present in a municipality for all combinations of poppy and avocado suitability. The scatter plot shows the support for the estimations.

6.2.1 Fragmented and new cartels

Over the past decade, there has been a notable transformation in cartel behavior due to the emergence of new cartels, some of which arise from existing ones (fragmented), while others have no prior affiliation with any existing drug trafficking organization (new). Even though I observe no changes in the overall cartel presence, I look into whether it is more likely for fragmented or new cartels to be present in avocado or poppy municipalities due to declining heroin revenues.

I use a fixed effects model and estimate Equation 1 using as outcomes the presence of different types of cartels. To test changes in the presence of cartels after the introduction of Fentanyl, I consider cartels to be fragmented or new only if they appeared for the first time in the data after 2013. I consider all cartels that existed before 2013 to be *preceding cartels*, regardless of how they originated.

Columns (1)-(3) in Table 3 show the estimates of the number of cartels present in a municipality. Columns (4)-(6) have as a dependent variable a binary variable equal to one if there is at least one cartel present in a municipality, and zero otherwise. Overall, the results show no changes in cartel presence for any cartel type, except for an increase in the likelihood of the presence of fragmented cartels in avocado-suitable municipalities. A possible explanation is that preceding cartels are established criminal organizations with defined markets, and may not need to expand into avocado-suitable areas. However, newly fragmented and new cartels may need to find new markets. The difference between fragmented and new cartels is that the former have the know-how and the organizational capabilities to enter these municipalities. Not only do they potentially have lower entry costs, but they also have an advantage over new cartels in terms of manpower and infrastructure in fighting over territory. This could explain why any new cartel is less likely to enter an avocado- or a poppy-suitable municipality.

Table 3: Results on the presence of new and fragmented cartels

	Number of cartels present			Cartel presence (1/0)		
	Preceding cartels (1)	Fragmented (2)	New (3)	Preceding cartels (4)	Fragmented (5)	New (6)
Avocado Suitable × Log(Fentanyl$_{t-1}$)	0.190	0.076	-0.051	0.044	0.065*	-0.021
	(0.153)	(0.103)	(0.036)	(0.033)	(0.034)	(0.021)
Poppy Suitable × Log(Fentanyl$_{t-1}$)	-0.251	-0.013	-0.001	-0.055	-0.053	-0.004
	(0.237)	(0.165)	(0.053)	(0.048)	(0.051)	(0.032)
Observations	6516	6516	6516	6516	6516	6516
Adj. R-squared	0.836	0.486	0.328	0.549	0.418	0.302
Mean dep. var.	2.227	0.233	0.0625	0.515	0.127	0.0474
Year FE	X	X	X	X	X	X
Municipality FE	X	X	X	X	X	X

Notes: This table provides estimates of the presence of fragmented cartels and new cartels. Columns (1) - (3) provide estimates of the number of cartels present in a municipality. Columns (4) - (6) are estimates on a binary variable equal to one if one or more cartels were present in a municipality. Preceding cartels are those that first appeared before 2013. Fragmented cartels indicate those that separated from another cartel after 2013. New cartels are criminal organizations that had no previous affiliation to existing cartels. All specifications control for the municipal mayor party and baseline time trends on municipal marginalization and poppy eradication. Specifications also include municipality and time-fixed effects. Standard errors clustered at the municipality level in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.3 Other criminal behaviour

So far, my results show that Fentanyl led to changes in homicide rates for avocado- and poppy-suitable municipalities. However, changes in cartel presence have not accompanied these trends. This suggests that, while cartels are not likely to move in or out of these territories, they have changed their use of force against civilians.

In this section, I analyze the effect of Fentanyl on other types of crime. Using data from police reports, I look into changes in violent thefts, truckload thefts, and extortion reports. Violent thefts are those classified as common theft with violence and include reports of thefts of households, businesses, and pedestrians, among others. Truckload thefts are reports of violent thefts of cargo trucks on a highway. Finally, extortion cases are reported by citizens to the police.

Note that, because of a change in the methodology through which crimes are classified, I cannot estimate the effect on violent thefts and truckload thefts after 2017. Therefore, my estimates for these two variables are only for the years for which there is a consistent data series (2011-2017). Extortion cases were not affected by this change in methodology, and therefore, I estimate the impact on extortion for the entire period of interest: 2011-2019. Finally, all measures are expressed as the log number of cases per 100,000 people.

Table 4 shows the coefficient estimates for these three types of crimes. In general, the results show that the introduction of Fentanyl increased violent thefts and truckload thefts in avocado-suitable municipalities. The latter coincides with reports on thefts of trucks transporting avocados in Michoacán (García Tinoco, 2019; Agren, 2019). Moreover, I observe a negative correlation between Fentanyl and thefts in poppy-suitable municipalities, providing further evidence of improving conditions in these areas. Note that these are reports of thefts in a country where most people do not report a crime because they distrust the police or consider it a waste of time (INEGI, 2019a). Therefore, increased thefts in avocado-suitable municipalities are likely to be a conservative estimate of the effect of Fentanyl. Figure 9 shows the marginal effects of a 10% increase in Fentanyl overdose deaths in rates of thefts with violence and truckload thefts.

Column (3) shows estimates of the extortion reports. In general, they show that Fentanyl decreased extortion cases in avocado-suitable municipalities compared to municipalities that cannot grow avocados. This contrasts with the other results that show an increase in homicides and thefts in these municipalities. Meanwhile, there have been numerous news reports that farmers and packinghouses are targets of extortion, as well as the threats to USDA officials, discussed above (Linthicum, 2019; de Cordobá, 2014; Padgett, 2013; Rainsford, 2019). A likely explanation for this coefficient is that people stopped reporting extortion cases because they fear DTOs, believe police cannot do anything, or have normalized this behavior.

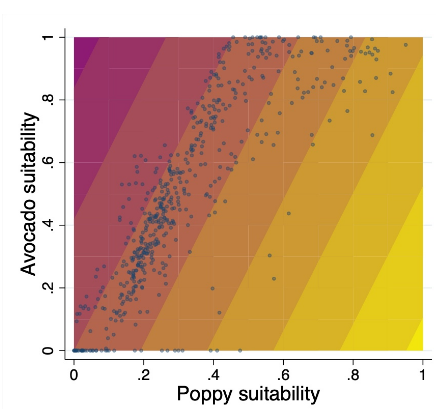
Table 4: Results on the effect of Fentanyl on other crimes in avocado and poppy suitable municipalities

	Violent theft	Truckload theft	Extortion
	(1)	(2)	(3)
Avocado Suitable × Log(Fentanyl$_{t-1}$)	0.477***	0.636***	-0.330***
	(0.181)	(0.131)	(0.091)
Poppy Suitable × Log(Fentanyl$_{t-1}$)	-1.050***	-0.757***	0.112
	(0.296)	(0.201)	(0.126)
Observations	4726	4726	6174
Adj. R-squared	0.638	0.430	0.418
Mean dep. var.	2.902	0.284	0.758
Year FE	X	X	X
Municipality FE	X	X	X

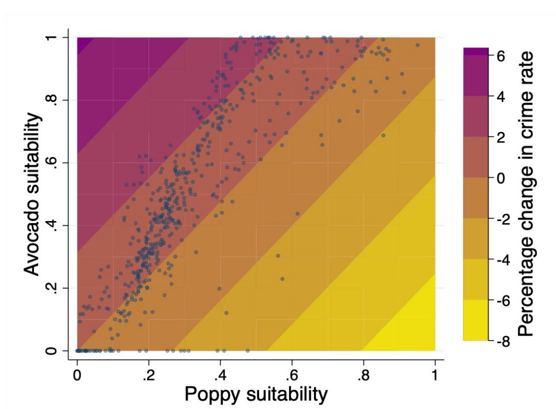
Notes: This table shows the effect of Fentanyl on other crimes. Violent thefts include thefts of households, businesses, and pedestrians, among others in which criminals used violence. Truckload thefts are reports of cargo trucks attacked on a highway. All outcome variables are the log of the number of cases per 100,000 inhabitants. All regressions control for the municipal mayor party, a binary variable indicating whether the party coincides with the President party, and baseline time trends on municipal marginalization and poppy eradication. Standard errors clustered at the municipality level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 9: Marginal effect of a 10% increase in Fentanyl overdose deaths on crime rates in avocado and poppy suitable municipalities

(a) Theft with violence



(b) Truckload theft



Notes: Figure constructed from the coefficient estimates for Table 4. Panels (a)-(b) show the marginal effect of a 10% increase in Fentanyl overdoses on theft rates for all combinations of poppy and avocado suitability levels. The scatter plot shows the support for the estimations.

6.3.1 Threats to identification

This section addresses some potential concerns regarding the main identification strategy. First, I address a potential concern on the correlation between the avocado and poppy suitability measures. Second, I look into potential measurement errors in the outcomes. Finally, I address concerns over omitted variable bias.

One genuine concern for this study is the observed correlation between the poppy and avocado suitability measures. As shown in Figure 5, there is a positive and significant correlation of 0.82 between these two suitability measures.[42] A high correlation between dependent variables can lead to a multicollinearity problem, which results in larger standard errors of the estimated coefficients but does not bias the coefficients. In other words, it yields consistent but less precise estimates.

The presence of multicollinearity becomes particularly pertinent when results lack statistical significance, as it is not possible to distinguish whether this insignificance is a consequence of inflated standard errors or an intrinsic property of the variable. It is important to note that, despite the potential for standard error inflation, the majority of estimates for homicides and other crimes are statistically significant at the 0.05 level. For the results on the presence of drug cartels, inflated standard errors may be contributing to non-statistically significant findings. However, even if they were statistically significant, the results' magnitude is small and economically insignificant.

A second potential concern with the main specification is that it considers the effects of avocado suitability and poppy suitability, separately. To deal with this, I estimated a model in which I interact the number of overdoses of fentanyl with the avocado and poppy suitability measures. The coefficients from these regressions can be found in Section A.6 of the Appendix. I find that my main results are robust to this specification. Not only coefficient estimates are similar in magnitude and maintain the same predicted sign for avocado and poppy suitable municipalities, but the estimated marginal effect also shows a similar behavior.

One caveat when incorporating the interaction term into the main specification is that it amplifies the correlation between the explanatory variables, consequently resulting in larger standard errors. Despite the less precision of the estimates, the results for homicides of agricultural workers,

[42] To further the analysis, I estimated the variance-covariance matrix and the variance inflation factor (VIF) for the main specification in Table 1. I find that the correlation between the coefficients γ and δ is -0.86 with a mean VIF of 4.51.

violent theft, and truckload theft remain statistically significant at the 0.10 level. Because adding the interaction term does not provide additional information to the analysis and leads to higher imprecision of the estimates, I prefer the results from the main specification as they can be considered to be more precise and informative of the true effect.

Another potential concern is the measurement error of the outcome variables. As mentioned in Section 4.1, INEGI estimates that over 90% of crimes in Mexico are not reported by individuals or filed by the police. Because of this, I use the estimates of homicides for my main results. While homicides in Mexico can also be underreported, the measurement error is likely to be classical since homicides are unlikely to be reported differently among avocado and poppy-suitable municipalities. Therefore, this would result in less precise estimates but will not bias the estimates.

In the case of violent theft and truckload theft, we could have biased estimates if thefts are less likely to be reported in avocado-suitable or poppy-suitable municipalities. This could be the case if civilians are scared of potential cartel retaliation for reporting the theft or if they consider it to be a waste of time. If this is the case, estimates for avocado-suitable municipalities would be downward biased and, therefore, they should be considered a lower bound of the real effect. In the case of poppy-suitable municipalities, this would mean the estimated results are overestimating the real effect. However, I do not expect this to change the interpretation of the results, as estimates for homicides signal a decrease in violence in these municipalities.

One final concern is potential omitted variable bias. In the main specification, I control for the municipal mayor party and whether this coincides with the President at the time party to account for municipality-specific government strategies. I also include municipality-fixed effects to control for time-invariant characteristics of a municipality such as distance to a military base, port, main road, or a drug route, as well as the availability of police stations. Unfortunately, information of military deployment is not publicly available as it's protected for national security reasons.

7 Conclusion

Crime in Mexico has increased dramatically over the past two decades. Even though drug cartels have been prominent in Mexico since the 1980s, contemporary organized crime remains relatively understudied. Journalists and scholars have pointed to a change in drug cartels' behavior, where

DTOs have gone from specializing in the production and distribution of illegal drugs to diversifying into other sectors (Herrera and Martinez-Alvarez, 2022; Jones and Sullivan, 2019; Avilés, 2015; Linthicum, 2019; de Cordobá, 2014; Padgett, 2013; Rainsford, 2019; Agren, 2019). However, evidence on the factors driving this change in behavior has been limited, and it mostly points to an increase in competition as the key factor driving these groups to diversify (Herrera and Martinez-Alvarez, 2022; Jones and Sullivan, 2019).

As cartel violence has soared and DTOs increasingly target civilians, it has become more urgent for policymakers to understand more about the factors that shape cartels' behavior. To fill this gap, I examine the case of the avocado sector, a prominent and lucrative sector that has become the target of criminal organizations in the past decade. In this paper, I provide new evidence on a different path that seems to have shaped cartels' behavior. I argue that the 2014 introduction of Fentanyl in the U.S. market led to a decrease in the demand for heroin from Mexican drug cartels, resulting in declining cartel revenues. To deal with this loss, cartels turned to other activities in an effort to diversify their portfolios. These included extortion and theft in licit industries, such as the avocado sector.

Using municipal-level data on annual homicides and cartel presence between 2011 and 2019, I examine the effect of declining heroin revenues on violence in avocado- and poppy-growing municipalities in Mexico. I find that the introduction of Fentanyl into the U.S. market increased homicide rates among agricultural workers and other civilians in avocado-growing municipalities. However, it did not affect homicide rates for potentially cartel-related individuals. At the same time, I tested whether the increase in the demand for heroin led to a higher cartel presence in these municipalities. I find no evidence that cartels moved into these areas. Based on these results, I conclude that Fentanyl increased violent crimes in avodado-growing communities, mainly by targeting civilians, rather than through conflict between cartels. This is supported by evidence that Fentanyl has led to higher rates of other types of violent crime, such as theft with violence and truckload theft. Finally, since I find no evidence of cartels entering avocado-suitable municipalities, I conclude that the overall profits from targeting civil society in these areas do not overcome the potential entry costs (e.g., fighting against existing criminal organizations over control of the territory).

I also test the impact of the introduction of Fentanyl on homicides in poppy-growing municipalities. I find that Fentanyl led to a decrease in the number of homicides in these areas, and, in particular, of agricultural workers and civilians. The results also show no changes in cartel presence in these municipalities, indicating that cartels may not have incentives to leave these areas. One explanation is that municipalities suitable for poppy production may also be advantageous to cartels for other reasons. For one, poppies are usually grown in remote mountainous areas, which are also excellent hiding spots for criminal organizations. Moreover, these territories provide access to roads and other potential places to exploit. Thus, even in the face of declining revenues from heroin, it may be more costly for a cartel to leave a territory in terms of its opportunity cost.

This paper shows contemporary evidence of the effects of changes in the demand for heroin on violence in Mexico and explores a new cause driving these changes. Moreover, it sheds light on how decreases in drug demand can have heterogeneous effects on legal and illegal sectors. This has important implications for policy design, as policymakers are challenged with developing policies that need to consider possible effects in areas dominated by an illegal sector and the potential spillovers to other industries.

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A Appendix

A.1 Tables and figures

Figure A1: Timeline of the U.S. opioid crisis

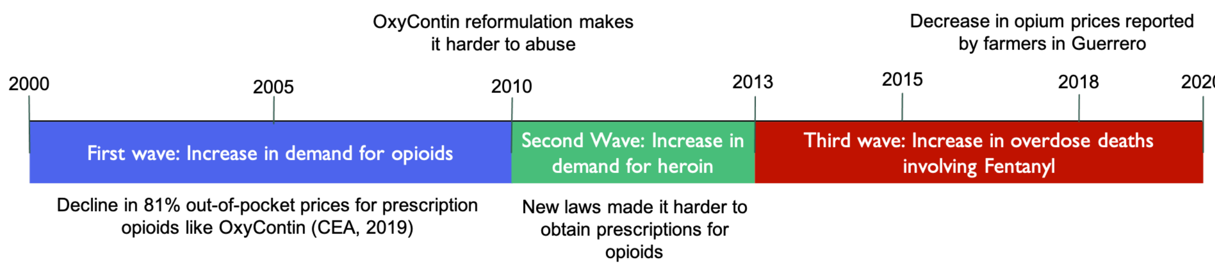
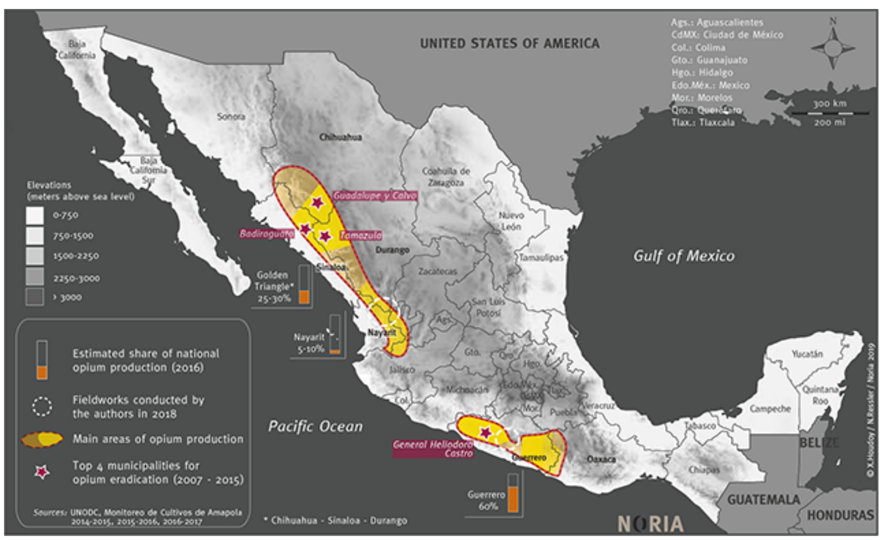
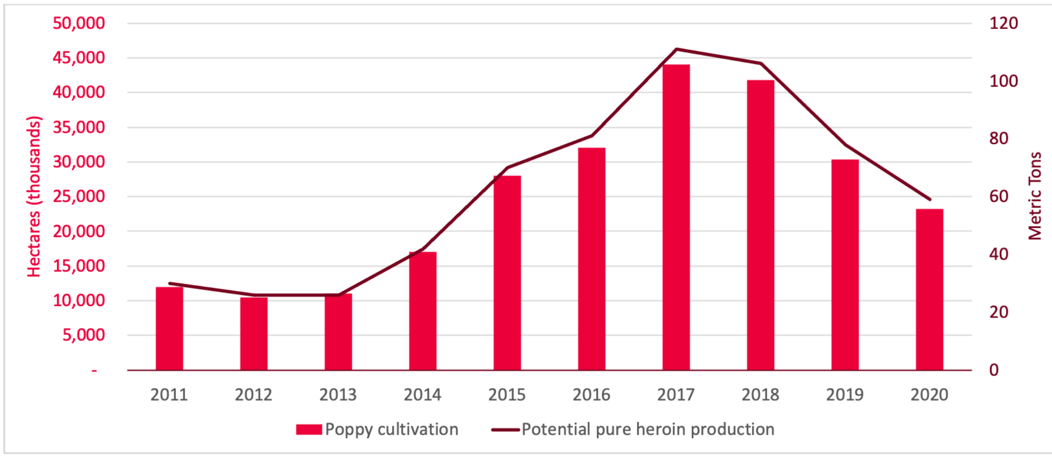


Figure A2: Poppy production in Mexico



Source: Borrowed from Le Cour Grandmaison et al. (2019).

Figure A3: Potential poppy cultivation in Mexico (2011-2020)



Notes: This graph shows annual estimates on potential poppy cultivation (left axis) and heroin production (right axis) from The White House Office of National Drug Control Policy (ONDCP, 2021).

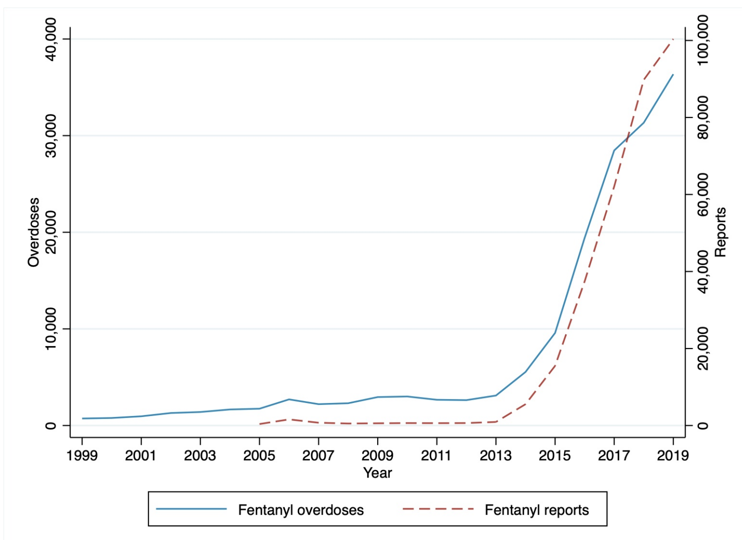
Table A1: Available data by source, frequency, and aggregation level

Data	Database	Years	Aggregation level	Frequency
Violence & Drug Data				
Deaths	Department of Health Information (DGIS)	1990-2018	Individual	Daily
Extortion cases, kidnaps, and thefts	Ministry of Public Security (SSP)	2011-2019	Municipality	Monthly
Eradicated crops of poppy (# of fields & ha.)	SEDENA	1990-2018	Municipality	Annual
Cartel presence	Mapping Criminal Organizations	1990-2020	Municipality	Annual
Heroin and Overdose Data				
US. heroin retail prices per gram (adj. per purity)	UN	1990-2018	National	Annual
Overdose deaths by drug type	National Center for Health Statistics (NCHS)	1999-2019	National	Annual
Avocado Production				
Production and prices per ton	SAGARPA	2003-2018	Municipality	Annual
Value of avocado exports	BANXICO	1993-2018	National	Monthly
Weather Data				
Precipitation and temperature data	AgMerra	1990-2010	Municipality	Daily
Other Data				
Party affiliation of municipal mayors	INAFED	1993-2018	Municipality	Annual
Population	INEGI	2010	Municipality	Annual

Table A2: Descriptive Statistics

	Mean	SD
Violence data		
Murders per 100,000 people	23.49	30.16
Murders ag. workers per 100,000 people	6.06	13.52
Murders non-ag. workers per 100,000 people	17.42	23.10
Murders of potential cartel member	7.00	13.23
Murders of non-potential cartel member	16.48	21.68
Extortion cases per 100,000 people	3.38	6.89
Drug data		
Fields of poppy eradicated	80.21	894.77
Hectares of poppy eradicated	9.85	104.29
Avocado production		
Avocado production (tons)	1,988.51	14,302.39
Price of avocado (MX per ton)	11,752.69	5,548.84
Suitability measures		
Avocado suitability	0.46	0.30
Hass avocado suitability	0.33	0.34
Poppy suitability	0.27	0.21
Annual level data		
U.S. Fentanyl Overdoses	15,455.11	12,856.85
Observations	6,516	
Num. of municipalities	724	

Figure A4: Fentanyl overdose deaths and forensic laboratory reports (1999-2019)



Source: Data from NCHS and the DEA's National Drug Threat Assessment of 2019 and 2020.

A.2 Background

A.2.1 The war against drugs

Despite the existence of Drug Trafficking Organizations in Mexico, the combat against cartels was not a top priority for the Mexican government until the mid-1980s (Chabat, 2010). To limit violence, government officials had established ties with drug traffickers. This implicit pact between cartels and the Mexican government became disrupted when the hegemonic party PRI started losing elections in the late 1980s (O'Neil, 2009).[43] In 2000, the PRI lost for the first time the presidential election against the National Action Party (PAN) candidate, Vicente Fox.

As a result of the breakage in the ties between drug cartels and government officials, violence from DTOs increased throughout the country. Fighting the DTOs became President Felipe Calderón's top priority after his election in December 2006. Just 11 days after his election, he declared the war against drug cartels (Chabat, 2010). His strategy resulted in a sharp increase in violence in states like Michoacán.[44] Between 2007 and 2012, a total of over 120,000 people were killed, compared to 60,000 in the previous six years (2001-2006). During Felipe Calderon's presidency, the lowest number of homicides reported was in 2007, with 8,000 murders. In 2011, however, homicides had reached over (INEGI, 2019b).

Additionally, the government's "kingpin" strategy may have led to an increase in violence. The capture of prominent cartel leaders led to the fragmentation of DTOs, leading to higher levels of violence due to an increase in the competition among cartels (Atuesta and Ponce, 2017; Calderón et al., 2015; Jones, 2013).[45] According to the U.S. Drug Enforcement Administration (DEA), before 2006, Mexico had only four dominant DTOs: the Tijuana (Arellano Felix) Cartel, the Sinaloa Cartel, the Juárez (Vicente Carrillo) Cartel, and the Gulf Cartel. However, as of 2020, the DEA recognizes the existence of at least nine major DTOs (Beittel, 2020).[46] Fragmentation of the four major DTOs started between 2009 and 2010, with the split of the Gulf Cartel. Los Zetas, a group of highly trained military that defected and joined the Gulf Cartel, separated from the

[43] In 1989, the PRI lost its first election for the governor of the state of Baja California (O'Neil, 2009).

[44] On December 12th, 2006, President Felipe Calderón launched the Operation Michoacán and sent over 4,000 troops to combat drug cartels in his home state. In that year, more than 400 people had been killed by drug cartels in Michoacán (Flannery, 2013).

[45] Jones (2013) finds evidence of an increase in homicide and kidnapping rates in Tijuana after cartel leaders are arrested or killed.

[46] The nine cartels identified by the DEA are: Sinaloa, Los Zetas, Gulf, La Familia Michoacana, the Knights Templar, the Cartel Jalisco Nueva Generacion (CJNG), Beltrán Leyva, Tijuana and Juárez (Beittel, 2020).

former in 2010. Meanwhile, a new armed group originated to eliminate Los Zetas, the Cartel Jalisco Nueva Generation (CJNG), and it is, as of now, one of the most violent DTOs operating in the country. Similarly, in 2011, the Familia Michoacana cartel that controlled the states of Michoacán and Guerrero split and gave origin to the Knights Templar (Beittel, 2020).

A.3 Theoretical Framework

To understand cartel behavior, I borrow from López Cruz and Torrens (2023)'s model on crime diversification and spatial diffusion of violence. In this model, drug trafficking organizations (DTOs) behave as profit-maximizing firms. DTOs can be thought of as multi-production firms that mainly produce and distribute illegal drugs but can also engage in an extractive criminal activity (i.e. extortion of avocado farmers, theft of natural resources, illegal mining (Le Billon, 2001; Parker and Vadheim, 2017; López Cruz and Torrens, 2023)).

Consider an economy with $N = \{1, ..., N\}$ criminal organizations that operate in $L = \{1, ..., L\}$ locations. Criminal organizations engage in two illegal activities $A = \{d, e\}$, where d corresponds to drug trafficking and e is an extractive activity.[47] These two activities can be disputed by criminal organizations. Each DTO i is endowed with capital k_i, and decides how much to invest in each location l for drug trafficking ($d_{i,l}$) and for extractive activities ($e_{i,l}$). In this paper, I assume that DTOs always invest in drug trafficking ($d_i > 0$) and decide whether to engage in an extractive activity ($e_i \geq 0$). The capital constraint for a DTO i is given by:

$$\sum_{l \in L} (d_{i,l} + e_{i,l}) \leq k_i,\ d_{i,l} \geq 0, e_{i,l} \geq 0 \text{ for } l \in L$$

Let $v^a_{i,l} \geq 0$ represent the value generated by the activity a in location l for DTO i, and let $v^a_{i,l}(a_{i,l})^\beta$ with $\beta \in (0, 1)$ denote the total revenue generated by criminal organization i for activity a in location l. Intuitively, the total revenue is determined by the suitability of location l for activity a, the efficiency of a criminal organization in realizing the activity, and the level of capital invested. DTOs also allocate $w^a_{i,l} \geq 0$ towards armed labor to safeguard their revenue in each location l and for each activity a. Let $p^a_{i,l} \in [0, 1]$ be the proportion of the total revenue that cannot be disputed

[47] In López Cruz and Torrens (2023)'s original model, criminal organizations engage in three activities. Two are contestable and one (n) is not, which means DTOs do not need to exert territorial control over this activity (e.g., fraud). In this paper, I focus on the case in which DTOs do not invest in the non-disputable good ($n = 0$).

by other organizations. The total profit from activity $a \in \{d, e\}$ for DTO i in location l is given by:

$$\pi_{i,l}^{a} = p_{i,l}^{a} v_{i,l}^{a} (a_{i,l})^{\beta} + \gamma_{i,l}^{a} \sum_{j \in N} (1 - p_{j,l}^{a}) v_{j,l}^{a} (a_{j,l})^{\beta} - w_{i,l}^{a}$$

where $\gamma_{i,l}^{a}$ is the fraction of the total output captured by DTO i in location a. The contest function will depend on how the relative expenditure of each crime organization on armed labor, expressed as follows:

$$\gamma_{i,l}^{a} = \begin{cases} \dfrac{(w_{i,l}^{a})^{m^a}}{\sum_{j \in N} \left(w_{i,l}^{a}\right)^{m^a}} & \text{if } \sum_{j \in N} (w_{i,l}^{a})^{m^a} > 0 \quad \text{with } m^a \in (0, 1] \\ \dfrac{1}{N} & \text{if } \sum_{j \in N} (w_{i,l}^{a})^{m^a} = 0 \end{cases}$$

The overall profits for each activity across all locations are given by:

$$\Pi_i^d = \sum_{l \in L} \left(1 - q_l^d\right) \pi_{i,l}^d, \quad \Pi_i^e = \sum_{l \in L} \left(1 - q_l^e\right) \pi_{i,l}^e - f \chi_i^e$$

where $q_l^a \in (0, 1)$ corresponds to the probability of getting caught in activity a,f is a fixed cost for entering into an extractive activity e and χ_i^e is a binary variable equal to one if DTO i invests in this activity ($e_i = \sum_{l \in L} e_{i,l} > 0$), and equal to one if $e_i = 0$.

The aggregate profit for organization i is given by $\Pi_i = \Pi_i^d + \Pi_i^e$.[48] Each DTO i determines the optimal allocation of capital and armed labor for each activity and location to maximize Π_i. DTOs solve this problem simultaneously and independently. First, each criminal organization chooses the level of capital to invest in each activity and location $((d_{i,l})_{l \in L}, (e_{i,l})_{l \in L})$. Subsequently, DTOs observe $((d_{i,l})_{l \in L}, (e_{i,l})_{l \in L})$ for $i \in N$, and decide $\left((w_{i,l}^d)_{l \in L}, (w_{i,l}^e)_{l \in L}\right)$. Solving the subgame perfect Nash equilibrium through backward induction yields the following conditions.

Choice of armed labor

Given DTOs' capital decisions $(a_{i,l})_{i \in N}$, the Nash equilibrium choice of armed labor for activity $a = \{d, e\}$ is given by:

[48]In López Cruz and Torrens (2023) original model, the payoff is giving by $\Pi_i = \Pi_i^d + \Pi_i^e + \Pi_i^n$, where $\Pi_i^n = v_i^n n_i$, and v^n is the value of the non-disputable activity. In this paper, I assume $n_i = 0$.

$$w_{i,l}^a = w_l^a = \frac{m^a(N-1)}{N^2}\left[\sum_{j\in N}\left(1-p_{j.l}^a\right)v_{j,l}^a\left(a_{j,l}\right)^\beta\right] \text{ for } i \in N \text{ and } l \in L \tag{2}$$

Intuitively, cartels don't have incentives to invest more or less in weapons relative to their counterparts, thus $w_{i,l}^a = w_l^a$. Moreover, w_l^a is increasing in $a_{i,l}$, decreasing in $p_{i,l}^a$ and do not depend on q_l^a. In other words, when capital investment in activity a increases, DTOs tend to allocate more resources to armed labor. Additionally, increased spending on armed labor becomes necessary when their capacity to safeguard a location declines ($p_{i,l}^a$ decreases). Moreover, DTOs do not alter their investment decisions regarding armed labor based on the probability of getting caught (q_l^a).

Capital diversification across locations

Based on the chosen level of armed labor $w_{i,l}^a$, the equilibrium payoff is given by:

$$\Pi_i^a = \sum_{l\in L}\bar{v}_{i,l}^a\left(a_{i,l}\right)^\beta + W_{-i}^a + f^a\chi_i^a \tag{3}$$

where,

$$\bar{v}_{i,l}^a = \left(1-q_l^a\right)\left[p_{i,l}^a + \frac{N-m^a(N-1)}{N^2}\left(1-p_{i,l}^a\right)\right]v_{i,l}^a \text{ for } i \in N \text{ and } l \in L \tag{4}$$

and,

$$W_{-i}^a = \frac{N-m^a(N-1)}{N^2}\left[\sum_{l\in L}\sum_{j\in N, j\neq i}\left(1-q_l^a\right)\left(1-p_{j,l}^a\right)v_{j,l}^a\left(a_{j,l}\right)^\beta\right] \text{ for } i \in N$$

Suppose DTO i chooses to invest a_i in activity a={d,e}. Following this decision, they allocate capital across the different locations. By solving Π_l^a subject to $a_{i,l} \geq 0$ for all $l \in L$ and $\sum_{l\in L} a_{i,l} = a_i$, the optimal capital allocation for criminal organization i in location l is given by:

$$a_{i,l} = \left[\frac{\left(\bar{v}_{i,l}^a\right)^{\frac{1}{1-\beta}}}{\bar{v}_i^a}\right]a_i \text{ for } l \in L \tag{5}$$

where, $\bar{v}_i^a = \sum_{l\in L}\left(\bar{v}_{i,l}^a\right)^{\frac{1}{1-\beta}}$ for $i \in N$ represents the value of activity a for DTO i. Hence, DTOs' decision on capital investment in a location will depend on the activity's profitability in location

l relative to their overall profitability from activity a. This leads to two significant implications. First, criminal organizations will allocate a greater proportion of their capital $\frac{a_{i,l}}{a_i}$ in locations that have a larger return to capital ($\bar{v}^a_{i,l}$), are easier to protect ($p^a_{i,l}$ is higher), and where the risk of detention is lower (decreasing in q^a_l). Second, this also implies that capital allocation in one location will decrease if the expected profitability of another location increases. In other words, $\frac{a_{i,k}}{a_i}$ decreases with $v^a_{i,l}$ and $p^a_{i,l}$, and increases with q^a_l for $k \neq l$.

Note that based on the optimal allocation of armed labor and capital (Equations 2 and 5), cartels will invest more in capital and armed labor in places with a higher return on their investment.

Capital diversification across activities:

Substituting $a_{i,l}$ (Equation 5) in $w^a_{i,l}$ and Π^a_i (Equations 2 and 3, respectively), it yields: $\Pi^a_i = (\bar{v}^a_i)^{1-\beta}(a_i)^\beta + W^a_{-i} - f^a \chi^a_i$. Based on this, DTOs choose the allocation of capital to each activity (d_i, e_i) that maximizes their overall profits, following this maximization problem:

$$\max_{d_i, e_i} \quad \left\{ \Pi_i = \left(\bar{v}^d_i\right)^{1-\beta}(d_i)^\beta + (\bar{v}^e_i)^{1-\beta}(e_i)^\beta + W^d_{-i} + W^e_{-i} - f\chi^e_i \right\}$$
$$\text{s.t.:} \quad d_i + e_i = k_i, d_i \geq 0, e_i \geq 0$$

Suppose that $\bar{v}^d_i \geq \left(\frac{v^n_i}{\beta}\right)^{\frac{1}{1-\beta}} k_i$.[49] The optimal capital allocation among each activity for DTO i is as follows:

$$(d_i, e_i) = \begin{cases} (k_i, 0) & \text{if } \bar{v}^e_i \leq h_1(\bar{v}^d_i) \\ \left(\dfrac{\bar{v}^d_i}{\bar{v}^d_i + \bar{v}^e_i} k_i, \dfrac{\bar{v}^e_i}{\bar{v}^d_i + \bar{v}^e_i} k_i\right) & \text{if } \bar{v}^e_i > h_1(\bar{v}^d_i) \end{cases} \tag{6}$$

where,

$$h_1(\bar{v}^d_i) = \left[\left(\bar{v}^d_i\right)^{1-\beta} + \frac{f}{\left(k_i\right)^\beta}\right]^{\frac{1}{1-\beta}} - \bar{v}^d_i$$

Based on the above equation, criminal organizations will decide to engage in an extractive

[49] This serves as a necessary condition for $n = 0$ and $d_i \geq 0$. In the model proposed by López Cruz and Torrens (2023), the complete payoff function is expressed as $\Pi_i = \Pi^d_i + \Pi^e_i + \Pi^n_i$, where $\Pi^n_i = v^n_i n_i$. However, in this model, I make the assumption that $n_i = 0$. Intuitively, for this assumption to hold true, the revenue generated from drug trafficking by criminal organization i must surpass a certain threshold, such that it lacks the incentive to invest in the non-disputable good.

activity if its potential revenue ($\bar{v}_i^e$) exceeds a certain threshold ($h_1(\bar{v}_i^d)$), ensuring that $\bar{v}_i^e$ covers a portion of the fixed entry cost and of the value of drug trafficking $\bar{v}_i^d$. Below this threshold, criminal organizations invest all their capital k_i in drug trafficking. Moreover, the allocation of capital by DTOs between these two activities will be proportionate to the relative value they can attain from each activity. Therefore, from the above, we can conclude that, as the relative value of an extractive activity to drug trafficking increases, criminal organizations will allocate more capital to the extractive activity.

A.4 Violence

In this paper's context, criminal organizations engage in the production and distribution of heroin. They can also decide to generate revenue from the avocado sector by stealing avocados and extorting farmers (the extractive activity). Drug cartels will decide whether to engage in the extortion of avocado farmers if their expected returns from diversification exceed those from specializing only in the production of heroin (as represented by Equation 6). Therefore, a decline in the demand for heroin reduces the value of drug trafficking ($\bar{v}_i^d$) [50] for all DTOs and raises their incentives to engage in the extractive activity. Additionally, locations vary in their suitability for poppy and avocado growing. For instance, certain areas may be inadequate for avocado growth, resulting in $v_{i,l}^e = 0$ for location l across all DTOs $i \in N$. Similarly, regions unsuitable for poppy cultivation will have $v_{i,j}^d = 0$.

Competition among criminal organizations over disputed profits leads to violence in profitable locations. DTOs invest in armed labor to safeguard their revenues from other criminal organizations. Consequently, violence in location l can be defined as $H_l = H_l^d + H_l^e$, where H_l^d and H_l^e represent the total armed labor invested by DTOs in drug trafficking and extractive activities, respectively. Homicides in location l corresponding to activity a is given by:

$$H_l^a = \sum_{j \in N} w_{j,l}^a = \frac{m^a(N-1)}{N} \left[\sum_{j \in N} (1 - p_{j,l}^a) \frac{(v_{j,l}^a)^{\frac{1}{1-\beta}}}{\left[\sum_{l \in L} (v_{j,l}^a)^{\frac{1}{1-\beta}} \right]^{\beta}} (a_j)^{\beta} \right]$$

This equation implies a positive correlation between homicides and $v_{i,l}^a$, and a negative correlation with the proportion of revenue obtainable without conflict $p_{i,l}$. Moreover, when drug cartels

[50] The decline in the demand for heroin can be thought of more properly as a decline on $v_{i,l}^d$ for all $i \in N$ and $l \in L$.

abstain from extractive activities ($e_i = 0$ for all j), homicides in a location will be exclusively attributed to violence related to drug trafficking.

As the profitability of heroin decreases relative to avocados, cartels have higher incentives to invest in extractive activities in avocado-suitable municipalities. This results in intensified conflict among cartels for revenue, leading to higher homicide rates in these municipalities. Conversely, in poppy-suitable municipalities, cartels invest less in capital and require fewer armed personnel, resulting in a decrease in homicides.

A.5 Suitability index

A.5.1 Temperature suitability index

For the temperature suitability index (T_C^*) corresponding to crop C, let T_{MIN_C} and T_{MIN_C} be the minimum and maximum absolute temperatures, respectively, within which crop C can be grown as described by the FAO-Ecocrop database. Also, let T_{OPMIN_C} and T_{OPMAX_C} be the minimum and maximum optimum temperatures within which crop C can achieve the highest yield. Finally, let the T_{KILL_C} be the temperature at which, if reached, the plant will die plus 4°C.[51] Given data on the mean temperature ($T_{MEAN_{mi}}$) and the minimum temperature ($T_{MIN_{mi}}$) registered in a month m at the municipality i, I estimate a monthly temperature suitability index for each municipality and crop such that:

$$T_{Cmi}^* = \begin{cases} 0 & T_{MIN_{mi}} < T_{KILL_C} \\ 0 & T_{MEAN_{mi}} < T_{MIN_C} \\ \frac{T_{MEAN_{mi}} - T_{MIN_C}}{T_{OPTMIN_C} - T_{MIN_C}} & T_{MIN_C} \leq T_{MEAN_{mi}} < T_{OPTMIN_C} \\ 1 & T_{OPTMIN_C} \leq T_{MEAN_{mi}} < T_{OPTMAX_C} \\ \frac{T_{MAX_C} - T_{MEAN_{mi}}}{T_{MAX_C} - T_{OPTMAX_C}} & T_{OPTMAX_C} \leq T_{MEAN_{mi}} < T_{MAX_C} \\ 0 & T_{MEAN_{mi}} \geq T_{MAX_C} \end{cases} \tag{7}$$

[51] Consistent with (Ramirez-Villegas et al., 2013)'s study, I use the killing temperature plus 4°C since I'm taking the historical average of the minimum temperature, and this accounts for the possibility that the minimum temperature will reach the killing temperature at least one day of the month.

The Ecocrop suitability measure is estimated considering the length of the growing season. This methodology considers each month of the year as being equally likely to be the starting month of the growing season. Therefore, each year is assumed to have 12 potential growing seasons of a given length (Ramirez-Villegas et al., 2013). A mean suitability index (T^*_{Cgi}) is then calculated for each potential growing season g (Møller et al., 2021). Finally, T^*_C is the minimum of all the temperature indices T^*_{Cgi} estimated for each potential growing period g.

A.5.2 Precipitation suitability index

For the precipitation suitability index (R_{Cgi}), I define R_{MIN_C} and R_{MAX_C} as the minimum and maximum precipitation (in mm) at which the crop can grow during the growing season g. Let R_{OPMIN_C} and R_{OPMAX_C} be the minimum and maximum optimum rainfall. For the precipitation index, data is estimated for each growing season rather than monthly. Taking into account the length of the growing season g, I estimate the total precipitation present in a municipality i during that period ($R_{TOTAL-gi}$). Moreover, using the absolute minimum (R_{MIN_C}) and maximum precipitation (R_{MAX_C}) parameters defined by the FAO-Ecocrop database and the minimum (R_{OPTMIN_C}) and maximum optimal (R_{OPTMAX_C}) precipitation, I estimate a precipitation suitability index for each of the potential growing seasons as follows:

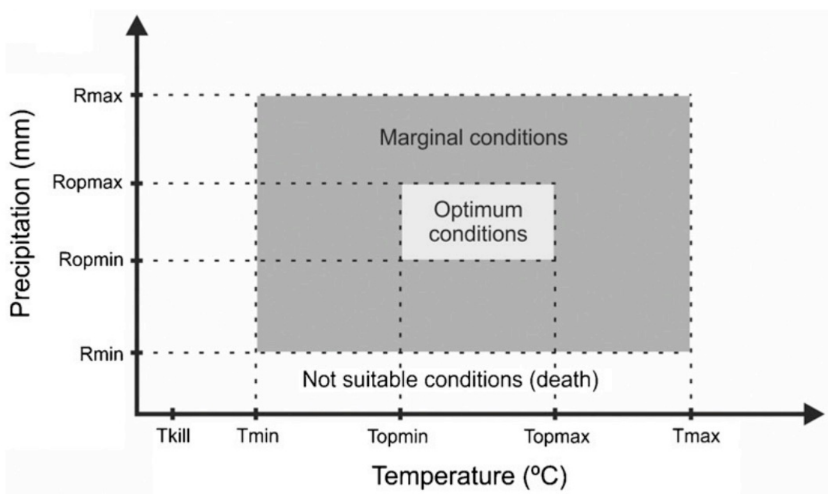
$$R^*_{Cgi} = \begin{cases} 0 & R_{TOTAL_{gi}} < R_{MIN_C} \\ \frac{R_{TOTAL_{gi}} - R_{MIN_C}}{R_{OPTMIN_C} - R_{MIN_C}} & R_{MIN_C} \leq R_{TOTAL_{gi}} < R_{OPTMIN_C} \\ 1 & R_{OPTMIN_C} \leq R_{TOTAL_{gi}} < R_{OPTMAX_C} \\ \frac{R_{MAX_C} - R_{TOTAL_{gi}}}{R_{MAX_C} - R_{OPTMAX_C}} & R_{OPTMAX_C} \leq R_{TOTAL_{gi}} < R_{MAX_C} \\ 0 & R_{TOTAL_{gi}} \geq R_{MAX_C} \end{cases} \tag{8}$$

Finally, R^*_{Ci} is defined as the minimum of the precipitation indices R^*_{Cgi}, I estimated for each potential growing period g.

A.5.3 Final suitability index

The Ecocrop final suitability measure for crop C in each municipality is estimated by taking the product of the temperature T^*_C and precipitation indices R^*_C (Møller et al., 2021). Figure A5 shows that a municipality is considered to be suitable whenever both its precipitation and temperature parameters fall within the dark grey area and will be considered optimal if they are within the area marked in the light gray area. Therefore, the resulting parameter takes a value of zero for areas that do not meet the minimum requirements for growth, a value of one for areas with conditions within the optimal requirements, and a value between zero and one for places that are suitable but do not fall within the range of optimal suitability (the dark gray area).

Figure A5: Diagram of the Ecocrop suitability measure



Source: borrowed from Ramirez-Villegas et al. (2013).

I estimate each of the poppy and suitability indices taking into account the agro-climatic requirements for each crop according to the FAO's Ecocrop database (see Table A3). While precipitation and temperature requirements are precise, growing seasons are defined as a range (i.e. the avocado growing cycle is between 270 to 365 days). Therefore, for the avocado suitability, I take into account a 12-month growing period since trees require suitable conditions throughout the year. Meanwhile, poppy flowers can die during winter and then grow again in the spring. Therefore, unsuitable conditions during winter do not affect potential growth for the next year. To account for this, I eliminate growing periods that start with the autumn and winter months.[52]

Since avocado and poppy have additional altitude requirements, I create an altitude suitable indicator H^*_{iC} equal to one if the municipality has any localities within the range of required altitude for growing crop C. The final suitability measure used in this study is given by: $S_C = T^*_C \times R^*_C \times H^*_C$. The temperature, precipitation, and altitude minimum and optimal requirements used for constructing the poppy and avocado suitability measures are provided in Table A3.

Table A3: Poppy and avocado agro-climatic suitability requirements

	Avocado	Poppy
Temperature (°C):		
Absolute min. temperature	10	3
Absolute max. temperature	28	28
Min. optimum temperature	14	15
Max. optimum temperature	22	24
Killing temperature	-6	-5
Precipitation (mm):		
Min. absolute precipitation	660	300
Max. absolute precipitation	1,800	1,700
Min. optimum precipitation	1,000	800
Max. optimum precipitation	1,400	1,200
Altitude (m.a.s.l.):		
Min. altitude:	800	600
Max. altitude:	3,000	2,400
Hass min. altitute:	1,600	-
Hass max. altitute:	2,200	-
Growing season (months):	12	7

Note: information on crop growing season, and temperature and precipitation requirements are from the FAO-Ecocrop database. Minimum altitude requirements for avocado were obtained from Anguiano et al. (2007); Benacchio (1982); Ruiz Corral et al. (1999) and optimal altitude requirements for Hass avocados from Dubrovina and Bautista (2014).

[52] I restricted my analysis to the months of March-August.

A.5.4 Validation of the suitability index

To assess the reliability and accuracy of my suitability indices, I use information on avocado production and eradication of poppy. For the avocado suitability index, I use data from the Ministry of Agriculture, Livestock, Rural Development, Fisheries, and Food of Mexico (SAGARPA). The database includes the number of hectares cultivated and harvested, prices per ton, annual production, and yields for each municipality in Mexico from 2003 to 2018.

Table A4 shows the relationship between the avocado suitability index and two measures of avocado production: annual tons of avocado produced and the number of hectares harvested. To do this, I regressed the suitability index on these two avocado production measures between 2010 and 2018 for the whole country and for my particular sample. The specification is estimated at the municipality-year level and includes year-fixed effects and clustered standard errors at the municipality level. The coefficients show a positive and significant relationship between the avocado suitability index and avocado production for my sample and the whole country.

Table A4: Test results for the avocado suitability index

	Whole country		Sample	
	Avocado production (1)	Hectares harvested (2)	Avocado production (3)	Hectares harvested (4)
Avocado Suitability	4496.5**	422.2**	12603.5**	1182.4**
	(1933.9)	(176.9)	(5330.9)	(486.9)
Observations	4,801	4,801	2,271	2,271
Adj. R-squared	0.176	0.178	0.163	0.163
Mean	3004.2	295.9	6179.1	602.0
Year FE	X	X	X	X
State FE	X	X	X	X

Notes: This table tests the relationship between the avocado suitability index and two production measures: annual estimates for tons of avocado produced and hectares harvested. This table includes estimates for the whole country and the sample used in this paper. Standard errors clustered at the municipality level are shown in parentheses. All specifications include year and state fixed effects. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

To test the validity of the poppy suitability measure, I use information on drug crop eradication from the Ministry of National Defense (SEDENA) since no official records exist on drug production. This information was obtained through a Freedom of Information Act request and has municipality-level data on the number of fields and hectares of poppy eradicated each year between 1990 and

2018. While eradication is not a production measure, evidence suggests that the military targets the most productive areas, and, therefore, data on eradication can be used as a proxy for production. For instance, between 2014 and 2018, the annual estimated poppy-eradicated area reported by SEDENA corresponded to over 84% of the total cultivated area estimated for the same period by the UNODC using satellite data. Moreover, according to U.S. and Mexican government officials, over 75% of the total drug crop production is eradicated each year (Humphrey, 2003; Dube et al., 2016).

Table A5 shows the relationship between the poppy suitability measure and poppy eradication. The estimates were measured using a fixed effects regression with year and state fixed effects to control for time-invariant characteristics at the state level and for time shocks. The regression also controls for the municipal mayor's party and a binary variable equal to one if the mayor's party coincides with the president's party, to proxy for differences in enforcement among different political parties. The coefficients show a positive and significant relationship between the poppy suitability index and eradication.

Table A5: Test results for the poppy suitability index

	Whole country		Sample	
	Eradicated fields (1)	Eradicated area (ha) (2)	Eradicated fields (3)	Eradicated area (ha) (4)
Poppy Suitability	270.9***	37.6***	382.7**	45.9***
	(85.8)	(12.5)	(151.2)	(17.2)
Observations	22,095	22,095	6,516	6,516
Adj. R-squared	0.051	0.055	0.077	0.083
Mean	50.3	5.8	50.3	5.8
Year FE	X	X	X	X
State FE	X	X	X	X

Notes: This table tests the relationship between the poppy suitability index and two proxies for poppy production: the annual number of eradicated fields and the total hectares of poppy eradicated. This table includes estimates for the whole country and the sample used in this paper. Standard errors clustered at the municipality level are shown in parentheses. All specifications include state and year-fixed effects. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

A.6 Robustness Checks

A.6.1 Violence outcomes

In this section, I present evidence demonstrating the robustness of the results to different specifications. First, I provide robustness checks to mitigate potential concerns regarding the correlation between the avocado and poppy suitability index. Second, I show that my results are robust to using heroin mixed with Fentanyl overdoses, rather than Fentanyl-related overdoses.

Table A6 shows the results of the effect of Fentanyl on homicides when adding an interaction term between the two suitability measures ($S_i^a \times S_i^p$). I find that the estimates closely align in magnitude and show a similar behavior consistent with the main results (elevated homicides in avocado-rich municipalities and reduced homicide rates in poppy-suitable municipalities). Moreover, in all specifications, the interaction coefficient is relatively small and not statistically significant. Thus, there is no evidence of a joint effect.

Table A6: Results on the effect of Fentanyl on violence

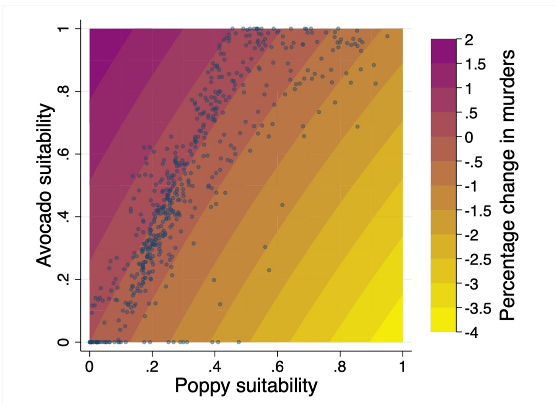
	Log(Murders)			
	All	Agricultural workers	Potentially cartel related	Rest of population
	(1)	(2)	(3)	(4)
Avocado Suitable × Log(Fentanyl$_{t-1}$)	0.194	0.231**	0.156	0.169
	(0.121)	(0.098)	(0.121)	(0.107)
Poppy Suitable × Log(Fentanyl$_{t-1}$)	-0.392*	-0.414*	-0.294	-0.263
	(0.221)	(0.226)	(0.231)	(0.193)
Avocado Suitable × Poppy Suitable × Log(Fentanyl$_{t-1}$)	0.0771	0.0684	-0.00166	0.0258
	(0.268)	(0.243)	(0.285)	(0.246)
Observations	6516	6516	6516	6516
Adj. R-squared	0.395	0.331	0.358	0.368
Mean dep. var.	2.441	1.065	1.198	1.682
Controls	X	X	X	X
Year FE	X	X	X	X
Municipality FE	X	X	X	X

Notes: Clustered standard errors at the municipality level in parentheses. All outcome variables are the log of the number of cases. All regressions control for municipal mayor party, a binary variable indicating whether the party coincides with the President party, a marginalization index, and poppy eradication. Potentially cartel-related murders are homicides of men ages 16-40 killed by a firearm that do not work in the agricultural sector. The rest of the population are homicides of individuals that are not potentially related to cartels and do not work in the agricultural sector. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

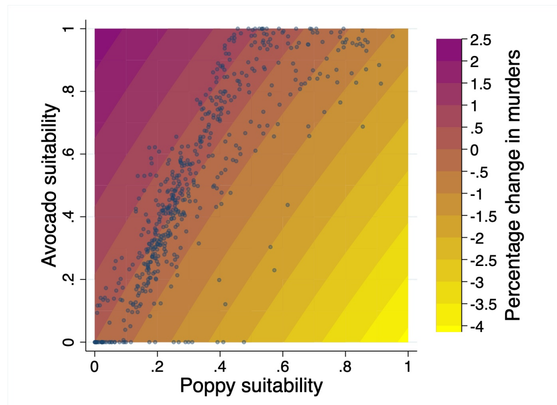
Figure A6 shows the marginal effect of a 10% increase in Fentanyl overdose deaths corresponding to the new specification. Consistent with the previous results, the marginal effect results show a similar pattern as the main results. Finally, Figure A7 and A7 show the estimates from this specification on the effect of Fentanyl on other crimes. In all cases, I find the main results to be robust to this specification.

Figure A6: Robustness check: Marginal effect of a 10% increase in Fentanyl overdose deaths on murders in avocado and poppy suitable municipalities

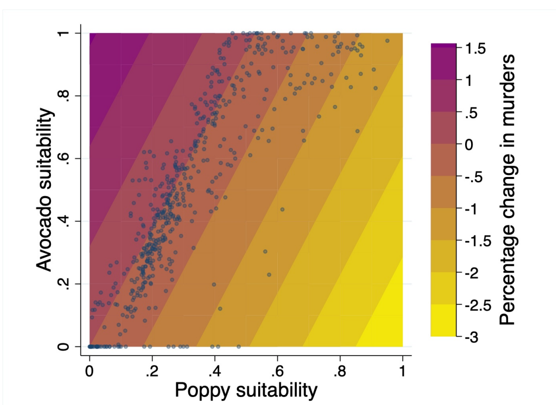
(a) All murders



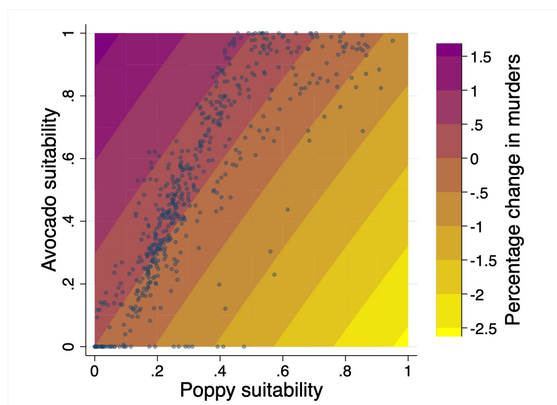
(b) Agricultural workers



(c) Potentially cartel related



(d) Rest of the population



Notes: Figure constructed from the coefficient estimates for Table A6. Panels (a)-(d) show the marginal effect of a 10% increase in Fentanyl overdoses on murder rates for all combinations of poppy and avocado suitability levels. The scatter plot shows the support for the estimations. Potentially cartel-related murders correspond to the homicide rate of men ages 15-40 killed by a firearm who did not work in the agricultural sector. The rest of the population includes all homicides except for potentially cartel-related and agricultural workers.

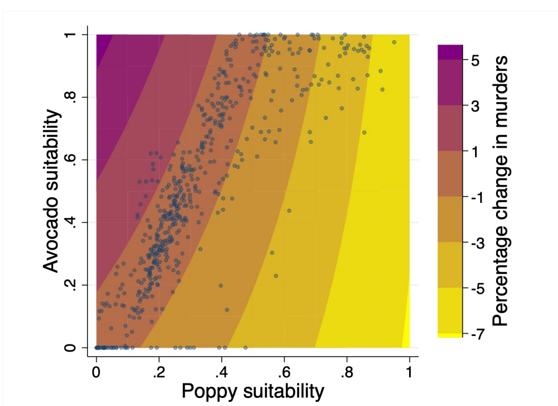
Table A7: Results on the effect of Fentanyl on other crimes

	Violent theft (1)	Truckload theft (2)	Extortion (3)
Avocado Suitable × Log(Fentanyl$_{t-1}$)	0.565***	0.690***	-0.546***
	(0.198)	(0.149)	(0.097)
Poppy Suitable × Log(Fentanyl$_{t-1}$)	-0.718*	-0.553**	-0.710***
	(0.422)	(0.254)	(0.184)
Avocado Suitable × Poppy Suitable × Log(Fentanyl$_{t-1}$)	-0.489	-0.300	1.210***
	(0.454)	(0.315)	(0.218)
Observations	4726	4726	6174
Adj. R-squared	0.638	0.431	0.423
Mean dep. var.	2.902	0.284	0.758
Year FE	X	X	X
Municipality FE	X	X	X

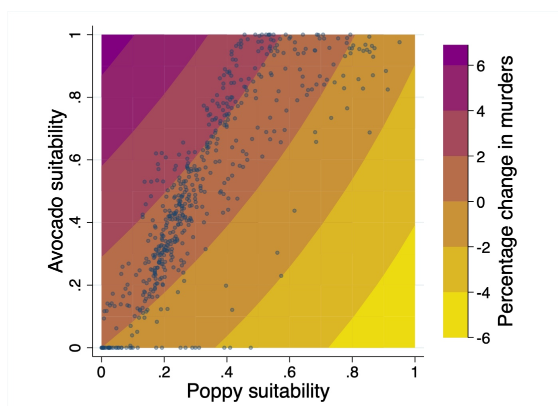
Notes: Clustered standard errors at the municipality level in parentheses. All outcome variables are the log of the number of cases per 100,000 inhabitants. All regressions control for the municipal mayor party, a binary variable indicating whether the party coincides with the President party, a marginalization index, and poppy eradication. Violent thefts include thefts of households, businesses, and pedestrians, among others in which criminals used violence. Truckload thefts are reports of cargo trucks attacked on a highway. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure A7: Marginal effect of a 10% increase in Fentanyl overdose deaths on crime rates in avocado and poppy suitable municipalities

(a) Theft with violence



(b) Truckload theft



Notes: Figure constructed from the coefficient estimates for Table A7. Panels (a)-(b) show the marginal effect of a 10% increase in Fentanyl overdoses on theft rates for all combinations of poppy and avocado suitability levels. The scatter plot shows the support for the estimations.

As mentioned before, the introduction of Fentanyl in the U.S. market can decrease the demand for heroin in two ways: i) dealers mix heroin with Fentanyl and, thus, directly reduce their demand for heroin, and ii) consumers can substitute heroin for the cheaper alternative, Fentanyl. So far, my empirical strategy has only used information on Fentanyl overdoses and does not provide further evidence on whether dealers mixing heroin with Fentanyl is a mechanism for the changes observed in violence in Mexico. To test this, I estimate Equation 1 using overdoses of heroin mixed with Fentanyl. Table A8 shows the estimations for this specification.

Table A8: Results on violence with mixed heroin overdoses

	Log(Murders)			
	All	Agricultural workers	Potentially cartel related	Rest of population
	(1)	(2)	(3)	(4)
Avocado Suitable × Log(Mixed heroin$_{t-1}$)	0.0835*	0.110**	0.0843*	0.0630
	(0.050)	(0.044)	(0.048)	(0.042)
Poppy Suitable × Log(Mixed Heroin$_{t-1}$)	-0.131*	-0.156**	-0.147*	-0.0976
	(0.076)	(0.066)	(0.076)	(0.066)
Observations	6516	6516	6516	6516
Adj. R-squared	0.395	0.332	0.359	0.368
Mean dep. var.	2.441	1.065	1.198	1.682
Controls	X	X	X	X
Year FE	X	X	X	X
Municipality FE	X	X	X	X

Notes: Clustered standard errors at the municipality level in parentheses. All outcome variables are the log of the number of murders per 100,000 inhabitants. All regressions control for municipal mayor party, a binary variable indicating whether the party coincides with the President party, and baseline time trends on municipal marginalization and poppy eradication. Potentially cartel-related murders are homicides of men ages 15-40 killed by a firearm that do not work in the agricultural sector. The rest of the population are homicides of individuals who are not potentially related to cartels and who do not work in the agricultural sector. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Consistent with my previous findings, these results show a positive correlation between heroin mixed with Fentanyl overdoses and homicides in avocado-suitable municipalities and a negative relationship for poppy municipalities. In particular, I find that mixing heroin with Fentanyl led to a rise in homicides of agricultural workers in avocado municipalities and a decrease in poppy municipalities. The main difference with the previous specification is that I find a statistically significant increase in potentially cartel-related murders in avocado municipalities and no effect on homicides in the rest of the population for both types of municipalities. However, the signs remain the same. While these results show evidence consistent with my hypotheses, it is not my preferred specification since heroin is not entirely exogenous to violence in Mexico.

A.6.2 Entry and exit of cartels

To look more precisely into changes in cartel presence, I estimate Equation 1 on different measures for cartel entry and exit. Table A9 shows the results for a fixed effects model with year and municipality fixed effects. All specifications include covariates. Columns (1) and (2) show the results on cartel entry, and Columns (3) and (4) on exit. Columns (1) and (3) show the results using as a dependent variable the number of cartels that entered/exited a municipality at time t. Columns (2) and (4) show the coefficients when using as a dependent variable a binary variable equal to one if the municipality had an entry/exit. For all these, the reference group are municipalities that do not experience a change between time t and $t + 1$. That is, for entry, I omit municipalities that experienced an exit, and for exit, I omit those that had an entry. Table A9 shows no statistically significant effect of Fentanyl for any of these specifications, consistent with my previous findings of no changes in cartel presence.

Table A9: Results on cartel entry and exit

	Entry		Exit	
	One or multiple (1)	Any cartel (1/0) (2)	One or multiple (3)	Any cartel (1/0) (4)
Avocado Suitable × Log(Fentanyl$_{t-1}$)	0.0157	0.0389	-0.00881	0.0173
	(0.118)	(0.037)	(0.099)	(0.024)
Poppy Suitable × Log(Fentanyl$_{t-1}$)	-0.0863	-0.0674	0.0511	0.0342
	(0.186)	(0.056)	(0.145)	(0.036)
Observations	5038	5038	4567	6516
Adj. R-squared	0.385	0.390	0.366	0.0652
Mean dep. var.	0.945	0.387	0.681	0.227
Year FE	X	X	X	X
Municipality FE	X	X	X	X

Notes: This table provides estimates on entry and exit of cartels. Columns (1)-(2) provides estimates on entry and Columns (3)-(4) on exit. One or multiple are continuous variables indicating the number of cartels entering/exiting a municipality. Any cartel is an indicator variable equal to one whenever a cartel entered/exited in that year and zero, otherwise. Fentanyl overdoses are expressed in logarithmic form. Avocado and poppy suitability are indices between one and zero, where one indicates that a municipality has optimal conditions. All specifications include covariates. Clustered standard errors at the municipality level are in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

A potential concern with this specification is that data may be noisy and that, by only looking at changes between t and $t - 1$, I am not capturing the effect on municipalities that did not have a cartel presence. To verify my results, I estimated the equation considering only municipalities with no cartel presence during k years before time t, with k going from 1 through 4. Estimates were robust to any of these specifications.

A.6.3 Estimates on heroin cartels

In this section, I look into the effect of the introduction of Fentanyl on cartel presence of the cartels identified by the DEA as distributors of heroin (DEA, 2021). In particular, I look into the movement of nine cartels: the Sinaloa Cartel, Cartel Jalisco Nueva Generación (CJNG), the Juarez Cartel, Gulf, Los Zetas, Beltrán-Leyva Organization, La Familia Michoacana, Los Rojos and Guerreros Unidos.

Table A10 shows the results on the presence of these cartels. Cartels in Columns (1)-(7) correspond to cartels that are part of the most dominant criminal organizations (*main cartels*) according to the DEA. The results show no statistically significant effects for most of them, except for Los Zetas and Los Rojos. For these two cartels, I observe that Los Zetas and Los Rojos are more likely to be present in avocado-suitable municipalities and less in those suitable for poppy. An interesting characteristic of these two cartels is that both of them have as their mother group the Gulf Cartel. Even though Los Zetas splintered from the Gulf Cartel and Los Rojos is a known faction of the Gulf Cartel, both are considered fragmented in my data since they operate independently and are recognized as different criminal organizations. These results are consistent with the results from Table 3, where I find that fragmented cartels are more likely to enter an avocado municipality.

Table A10: Results on cartel presence by DTO

	Sinaloa	CJNG	Juarez	Gulf	Los Zetas	Beltrán-Leyva	Fam. Michoacana	Los Rojos	Guerreros Unidos
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Avocado Suitable × Log(Fentanyl$_{t-1}$)	0.0224	0.00749	0.00367	0.00463	0.0573**	-0.0409	0.0268	0.0548***	-0.0110
	(0.025)	(0.032)	(0.015)	(0.021)	(0.027)	(0.028)	(0.026)	(0.015)	(0.019)
Poppy Suitable × Log(Fentanyl$_{t-1}$)	-0.0360	-0.0196	-0.0176	-0.00273	-0.0777*	0.0271	-0.0142	-0.0666***	0.0122
	(0.036)	(0.050)	(0.021)	(0.035)	(0.043)	(0.044)	(0.038)	(0.018)	(0.032)
Observations	6516	6516	6516	6516	6516	6516	6516	6516	6516
Adj. R-squared	0.451	0.544	0.418	0.424	0.479	0.562	0.551	0.524	0.547
Mean dep. var.	0.183	0.337	0.0463	0.106	0.200	0.170	0.221	0.0522	0.134
Year FE	X	X	X	X	X	X	X	X	X
Municipality FE	X	X	X	X	X	X	X	X	X

Notes: This table provides estimates on cartel presence for the main DTOs in Mexico linked to the trafficking and cultivation of heroin. All outcomes are binary variables equal to one of a cartel was present in a municipality, and zero otherwise. The cartels in Columns (1)-(7) correspond to the main Mexican DTOs recognized by the DEA. Fentanyl overdoses are expressed in logarithmic form. Avocado and poppy suitability are indices between one and zero, where one indicates that a municipality has optimal conditions and zero is unsuitable. All specifications include covariates. Clustered standard errors at the municipality level in parenthesis. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$