UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG

WORKING PAPERS SES

The guacamole curse: Avocados, crime, and violence in Mexico.

Christian Arciniegas

N. 537
XII.2024

Faculté des sciences économiques et sociales et du management
Wirtschafts- und sozialwissenschaftliche Fakultät

The guacamole curse: Avocados, crime, and violence in Mexico

Christian Arciniegas

University of Fribourg

December 16, 2024

Abstract

There is extensive evidence of the impact of natural resource windfalls on violence. However, most of the literature focuses on civil conflict and civil wars and less is known about how resource booms affect other forms of violence and crime. In this paper, I examine the impact of Mexico's avocado production boom over the past 30 years on homicides, drug cartel-related attacks, and non-lethal crimes. To estimate the effects of the avocado boom on these forms of violence, I exploit geographic differences in the exogenous suitability of municipalities to produce avocados with movements in the international price of the fruit. The results reveal that, consistent with the opportunity cost mechanism highlighted in the literature, municipalities more suitable for avocado production experienced a reduction in homicides and drug cartel attacks. This effect is primarily driven by the period following the lifting of an 83-year ban on Mexican avocado imports to the United States. However, municipalities that are highly export-oriented did not experience this reduction in violence. Instead, these municipalities have seen an increase in drug cartel attacks and non-lethal crimes, particularly threats and property crimes.

Keywords: *Resource curse; violence; crime; Mexico; avocados.*

JEL Codes: *D74; K42; O13; Q33*

Special thanks to Christelle Dumas, Lorenzo Casaburi, Paolo Buonanno, Suana Oh, Oliver Vanden Eynde, and Clément Imbert for their helpful comments and discussions. I also thank participants and discussants at the 3rd Workshop on the Economics of Crime for Junior Scholars WEC-Jr (CEP-LSE), 22nd EUDN PhD Workshop on Development Economics (Paris School of Economics), PhD Conference in Economics and Finance (Imperial College London), 17th RGS Doctoral Conference in Economics (University of Duisburg-Essen), 4th EENR Conference (University of Orléans-Léo), ECWE 2024 (University of Verona), 7th conference of the Development Economics Network Switzerland-DENS (University of Geneva), and the Annual Congress of the Swiss Society of Economics and Statistics SSES 2024.

christian.arciniegas@unifr.ch

1 Introduction

Most of the literature on the resource curse focuses exclusively on the effect of commodities' windfalls on civil conflict and civil war (Nillesen and Bulte, 2014). A recent meta-analysis by Blair et al. (2021) reports that more than 350 empirical papers that study the relationship between natural resources and armed civil conflict have been published in the past twenty years. Despite this extensive body of research, there has been a lack of clear evidence on the relationship between *legal* agricultural commodities[1] and conflict (Van der Ploeg, 2011), and the recent evidence about how agriculture export commodities affect conflict and violence is mixed and not yet conclusive (Crost and Felter, 2020; McGuirk and Burke, 2020).

In this paper, I study avocado production in Mexico over the past thirty years to shed light on the effect of a legal commodity export boom on different types of lethal and non-lethal violence: homicides, drug cartel attacks, and crimes. Mexico is the world's largest producer of avocados and the Mexican avocado export industry is worth more than USD 3 billion nowadays. Following the lifting of an 83-year import ban in the US in 1997, exports of Mexican avocados have increased by over 20 times in the past two decades, and per capita consumption of fresh avocados has increased by more than 400% in the US during the same period (Carman, 2019). At the same time, the homicide rate in Mexico has been constantly rising since the mid-2000s. Pettersson and Öberg (2020) show that, only in 2019, 60% of all non-state conflict deaths worldwide occurred in Mexico. In that year, there were 29.1 violent deaths per 100,000 inhabitants in Mexico while the world average was estimated at 5.8.[2] Data on non-lethal crimes show that, before the COVID pandemic, there were eight times more kidnappings and three times more serial assaults in Mexico than the average in the world.[3]

Several international media outlets claim that the avocado boom is the reason behind the increase in violence in some regions in Mexico, as reported by the New York Times, The Guardian, the Deutsche Welle, The Economist and Forbes magazine, among others. According to these reports, avocado-producing municipalities in Mexico have experienced a rise in homicides, extortion cases, and kidnappings due to criminal organizations who

[1] There is a large strand of literature that focuses on illegal resources (such as marijuana, cocaine, and opium) and civil conflict. See for example Angrist and Kugler (2008); Mejia and Restrepo (2013); Gehring et al. (2023).

[2] Onw calcultations based on data from the United Nations Office on Drugs and Crime (UNODC). Data retrieved from https://dataunodc.un.org/content/data/homicide/

[3] ibid.

seek to extract rents from the lucrative avocado market. If these claims are true, one should expect to empirically find that avocado-producing regions in Mexico have experienced higher levels of crime and violence compared to regions with low levels of avocado production.

To causally test the effect of the Mexican avocado boom on crimes and violence, I exploit the fact that climatic and soil conditions determine which municipalities are better suited for avocado production. I construct an exogenous, time-invariant index that measures the biophysical suitability of each Mexican municipality to produce avocados using long-term climate data collected from 1494 weather stations and geo-referenced edaphological data of 9549 soil profiles across Mexico.

The empirical strategy exploits geographical variation in the production suitability of each municipality with temporal variation in the international price of avocados. The causal effect of the avocado boom is identified by the differential impact of price shocks on municipalities with distinct pre-determined suitabilities to produce avocados. This approach follows Gehring et al. (2023) and complements those used in previous studies of the effect of agricultural commodities on civil conflict (e.g. Dube and Vargas (2013); Crost and Felter (2020)).

I estimate the effect of the avocado boom on three different outcomes: homicides, drug cartel-related attacks, and crimes. To do so, I classify municipalities into highly suitable and non-highly suitable according to the time-invariant index. Results on homicides show that municipalities that are more suitable to produce avocados have experienced, on average, a reduction of 2.03 homicides per 100'000 population, equivalent to a reduction of 12.1% compared to the mean homicide rate in low-suitable municipalities. This effect is driven by the lifting of an 83-year import ban on avocados in the US in 1997, as I find no differences in the homicide rate between low- and high-suitable municipalities before this year. I also find that the number of attacks committed by drug cartels have decreased in highly suitable municipalities as well, and that non-lethal crimes have not increased. Unfortunately, administrative data on reported crimes at the municipality level is only available after 2011. This reduces the analysis horizon but still allows me to shed light on the effect on criminality.

The results of a positive effect of avocado production in reducing crime and violence across Mexican municipalities are in line with the broad literature that studies agricultural commodities and violence: higher prices for labor-intensive and agricultural goods attenuate conflict (Dube and Vargas, 2013; Blair et al., 2021; Ferraz et al., 2022). This literature finds that the opportunity cost mechanism prevails over the rapacity effect channel when

agricultural commodities experience positive economic shocks. When this is the case, the opportunity cost associated to engage in crime is higher, as agents have more to lose if they engage in violent or criminal activities. The opportunity cost hypothesis highlights thus that positive economic shocks have a crime-reducing effect, as it seems to be the case with avcoados and homicides across Mexico.

However, media reports affirm that avocado-producing municipalities have experienced an increase in lethal and non-lethal violence due to the avocado export boom (Fisher and Taub, 2018; Linthicum, 2019; Viohl, 2020; France24, 2022). These reports suggest that drug cartels are the main responsible for the surge in criminality in producing municipalities, particularly by threatening and extorting farmers. If these accounts are true, the rapacity effect would be at play in the avocado export sector in Mexico. The rapacity mechanism posits that economic shocks that increase the lootability and profits of a booming market create stronger incentives to extract rents, ultimately leading to more crime and violence.

To further investigate this hypothesis, I study violence patterns in municipalities in the western state of Michoacán, the major producer of avocados in Mexico. The lift of the US import ban in 1997 was conditioned on strict phytosanitary requirements, and only municipalities that are certified by both Mexican and US authorities are allowed to export avocados to the US. To analyze the potential link between avocado exports and violence, I study homicide and crime patterns in the first 24 municipalities in Michoacán that received export authorization in 1997, and compare them to the rest of the state.

Contrary to the country-level results, I find no evidence of a reduction in homicides in municipalities that produce avocados for the export market. I find that, indeed, these municipalities seem to have experienced an increase in property crime and attacks by drug cartels. This result is in line with recent evidence on the effect of agricultural export booms (Crost and Felter, 2020; Estancona and Tiscornia, 2023; Crost et al., 2023) and reflects the claims of newspaper investigations. Although the findings point towards an increase in violence in avocado-producing and export-oriented municipalities in the state of Michoacán, results are not fully robust to some checks, and thus causal interpretation must be cautious.

My results provide evidence of both the opportunity cost mechanism and the rapacity effect, operating within the context of a single commodity in the same country. I observe an overall reduction in lethal violence in municipalities with higher levels of avocado production, consistent with the literature highlighting the opportunity cost mechanism which suggests that improved economic conditions reduce incentives for violence (Dal Bó

and Dal Bó, 2011; Dube and Vargas, 2013; Blair et al., 2021). At the same time, in line with recent findings by Crost and Felter (2020) and Estancona and Tiscornia (2023), I find an increase in drug cartel attacks and other crimes, as well as suggestive evidence of a rise in homicide rates, in a small subset of municipalities heavily exposed to the export market. These seemingly "contrasting" results demonstrate how a single commodity can both mitigate and exacerbate violence, stressing the importance of better understanding how attributes of economic activities can determine its effect on violence (Crost et al., 2023).

This paper contributes as well to the literature that studies the Mexican Drug War. Because of its relevance and the large number of victims, scholars from different disciplines have studied the causes and consequences of the violence that has been ravaging Mexico in the last twenty years. Most of this literature has focused on the institutional and political context (Dell, 2015; Shirk and Wallman, 2015; Trejo and Ley, 2018) or on how changes in the drug-trafficking market -which is the Mexican cartels' main business- are behind the increase in the number of deaths (Kellner and Pipitone, 2010; Castillo et al., 2020). My paper contributes to this growing literature by pointing out how a boom in the production and export of a legal commodity shapes the economic decisions of criminal organizations and can be a causal explanation for the increase in crime and violence experienced in certain regions of the country.

Finally, the paper also relates to the literature on the economics of organized crime and its infiltration in the legal economy (Schelling, 1971; Reuter, 1987; Gambetta and Reuter, 1995; Balletta and Lavezzi, 2023; Piemontese, 2023). As mentioned before, most of the the natural resources and conflict literature is concentrated on the impact on *civil conflict* and *civil war*. There is little scholarly evidence on other forms of violence, particularly the one generated by organized crime. Therefore, this paper also seeks to shed light on the effect of natural resource booms on other forms of violence such as attacks committed by drug cartels and non-lethal crimes.[4] Even though results for the case of Michoacán are not fully conclusive of a causal increase in crimes and drug cartel attacks due to the

[4] A couple of papers have studied how the activities and apparition of mafia-type organizations are related to natural resources. Buonanno et al. (2015) document that the emergence of the Sicilian mafia in Italy in the 19th century is linked to a positive shock in the demand for Sulphur; while Dimico et al. (2017) trace the origins of this mafia-type organization to locations with high levels of income coming from the production of oranges and lemons for overseas export. Murphy and Rossi (2020) argue that the origins of the Mexican drug cartels can be traced back to the Chinese migrants who settled in Mexico in the early 20th century who brought with them poppy seeds and established a trafficking business with the US that eventually shaped the origins of current Mexican drug cartels. However, these papers link the natural resources to the origins of the organizations but do not explain how the current levels of crime and violence are related to the presence of natural resources today.

avocado boom, they are suggestive of how agricultural booms can shape criminal activity patterns.

The rest of the paper is organized as follows: Section 2 presents the background and related literature close to my paper. Section 3 presents the data sources and details the empirical strategy. Section 4 presents the main results on homicides, drug cartel attacks, and crimes at the country level. Section 5 then discusses the case of export-oriented municipalities in the state of Michoacán. Section 6 presents the robustness checks and discusses potential limitations of the paper. Finally, Section 7 concludes.

2 Background and Related Literature

The avocado (*persea americana*) is a perennial tree native to Mesoamerica whose fruit can be harvested all year long. It has been cultivated in central Mexico and northern Guatemala hundreds of years before the arrival of the Spaniards in the 15th century. The name of its fruit (*aguacate* in Spanish) comes from the náhuatl noun "ahuacatl" which means "testicles of the tree". Nowadays there are around 400 different varieties of avocados, with the Hass type being the most commercialized one in the international market.

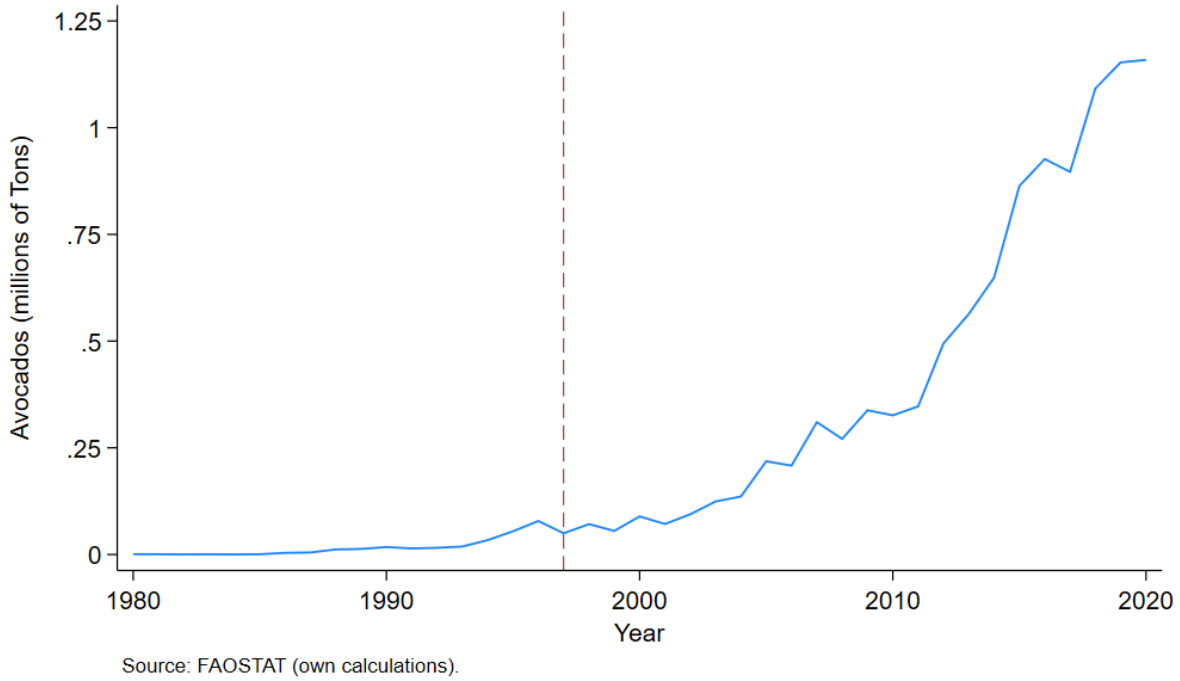
The tree grows at different altitudes, oscillating between 800 and 2500 meters above sea level. It requires between 1000 and 2000 millimeters of annual rainfall to grow, temperatures ideally between 18°C (62°F) and 24°C (75°F), and requires a pH-neutral or mildly acid soil. The Trans-Mexican Volcanic Belt that goes through western Mexico provides mineral-rich soil ideal for avocado growth. A hectare of avocados usually contains between 120 and 180 trees (depending on the variety of avocado and the topography of the terrain), and a single tree can produce between 800 and 1500 fruits per year in the most productive phase of the life cycle (usually at the eighth or tenth year after cultivation), with the first harvest occurring at the fifth year (SAGARPA, 2011).

Mexico has been historically one of the largest producers of this fruit. However, in 1914 the United States banned the imports of Mexican avocados alleging phytosanitary reasons to prevent the spread of weevils, invasive pests, and other diseases that could affect US production. Following the NAFTA agreements of the 1990s, the US Department of Agriculture (USDA)'s Animal and Plant Health Inspection Service passed a rule that lifted the ban on Mexican avocados imports after 83 years of prohibition on November 1997.[5]

[5]Amendment of Title 7 of the Code of Federal Regulations (CFR) 319.56-2ff, governing the importation

The opening of the market was gradual and consisted of four phases that progressively extended the geographical distribution and duration of the shipping season. Initial exports were only allowed to 19 northeastern states and the District of Columbia and only during four months in the winter season (November to February). More states were progressively added to the list and the time window was extended, first to six months in 2001 (mid-October to mid-April) and then year-round in 2007.[6] From February 2007 onwards, imports in the US of Mexican avocados were finally authorized all year long to all the fifty states of the country and the market was completely liberalized (Peterson and Orden, 2008). Figure 1 plots the evolution of Mexican avocado exports in the past 40 years, highlighting the effect of the lifting of the imports ban in 1997.

Figure 1: Evolution of Mexican avocado exports and the US market liberalization in 1997



The avocado industry in Mexico has recently received attention from different media outlets and scholars from the social sciences. Various media reports and qualitative liter-

of fresh Hass avocados from Mexico to the United States. Mexican producers willing to export their fruits to the US must comply with strict phytosanitary, marking, and shipping requirements and only certified producers -both by American and Mexican authorities- are allowed to export avocados.

[6] In 2004 the list was extended to cover all the rest of the states but three: California, Florida, and Hawaii. These three states were only included in 2007, as they are the largest producers of avocados in the US.

ature claim that the number of homicides, extortion cases, and kidnappings in avocado-producing regions have increased as a consequence of the presence of drug cartels who seek to diversify their business and profit from the avocado export bonanza (Fisher and Taub, 2018; Viohl, 2020; Linthicum, 2019; Ornelas, 2018). Homicides are reported to be the consequence of the fight of cartels while they try to gain control and establish their power in a region, while extortion and kidnapping should be the consequence of cartels trying to gain control over the production of avocado and extract rents out of the legal producers. I test these claims in the next sections and try to establish a causal link between the boom generated by the liberalization of avocado imports in the US and the figures of crime and violence in producing municipalities in Mexico.

Earlier literature and cross-country studies have found mixed evidence on the relationship between natural resource windfalls and violent conflicts (Besley and Persson, 2008; Brückner and Ciccone, 2010; Bazzi and Blattman, 2014). However, there appear to be some stylized patterns based on the type of resource. Studies examining the impact of oil, minerals, and other capital-intensive commodities generally find a positive relationship with violence: the extraction of minerals or oil in a country increases the risk and intensity of civil conflict. This aligns with the rapacity effect mechanism, which suggests that positive shocks to resource wealth raise the stakes for controlling rents, thereby increasing the incentive to use violence to secure those rents. For labor-intensive or agricultural commodities—such as avocados—the evidence suggests a negative relationship: higher commodity prices are associated with less conflict (Blair et al., 2021). This aligns with the opportunity cost mechanism, which posits that resource wealth improves economic conditions, thereby reducing conflict as the opportunity cost of engaging in violence increases.

Nevertheless, for legal agricultural commodities and crops there is still mixed evidence about the effect of positive economic shocks on violence. On the one hand, Dube and Vargas (2013) find that an increase in the price of coffee reduces the number of attacks of rebel groups in coffee-producing regions in Colombia; and Dube et al. (2016) show that negative shocks in the international price of maize contribute to higher levels of violence in Mexico when farmers switch to the production of marihuana and drug cartels fight for its control. These results are in line with cross-country evidence of a negative correlation between export revenues and the incidence, intensity, and onset of conflicts in Africa (Berman and Couttenier, 2015; Fjelde, 2015). On the other hand, Crost and Felter (2020) find that a positive shock to banana prices increases conflict in banana-export-producing regions in the Philippines when insurgent groups seek to extract rents

by extorting big producers and export companies; while Kenny et al. (2020) report a similar effect in the case of palm oil in Indonesia.

The works of Yoo (2022), Estancona and Tiscornia (2023), De Haro-Lopez (2023), Erickson and Owen (2024), and De Haro-Lopez (2024) are close to mine and investigate the effects of avocado production in Mexico on lethal violence. These studies rely on different identification strategies, cover different (and shorter) periods, and only a specific group of states or municipalities. Furthermore, they find divergent results. While Estancona and Tiscornia (2023) find that "large increases in the municipality's share of avocado export value are associated with a large number of homicides" between 2004 and 2010, Yoo (2022) and Erickson and Owen (2024) find a negative effect of the avocado boom on homicides, either at the state-level in five states of Mexico between 2010 and 2017 (Yoo, 2022), or at the municipality-level in the states of Michoacán and Jalisco between 2011 and 2019 (Erickson and Owen, 2024).

De Haro-Lopez (2024) analyzes how the U.S. opioid crisis affects violence in avocado-growing municipalities in Mexico between 2011 and 2019. She finds that a decrease in heroin demand in the U.S. (due to increases in Fentanyl availability) increased murders of agricultural workers in avocado-growing municipalities in Mexico, while it reduced violence in poppy-growing municipalities. On the contrary, in De Haro-Lopez (2023) she finds that, between 1990-2006, avocado-growing municipalities experienced a reduction of up to 25% in homicide rate after the U.S. opened its market for Mexican avocados. These opposed results could be the consequence of the different time spans these authors use for their analysis, and/or the subset of states and municipalities they study.

I complement and expand these studies by exploiting a strategy that allows me to analyze all municipalities in Mexico over more than thirty years, and where identification comes from variation in the differential impact of price shocks on municipalities with distinct pre-determined suitabilities to produce avocados. My empirical estimation includes year and municipality fixed effects, and a state-level linear time trend to capture state-specific shocks potentially correlated to violence outcomes. None of the aforementioned studies control for state-specific effects, which in the context of Mexican violence is relevant and necessary to avoid biased estimates.[7] I also use multi-way clustering for the estimation of standard errors, which is not done in the aforementioned studies.

[7]Military operations against drug cartels during the *Mexican Drug War* took place in states where drug cartels were mostly present. For example, only ten days after taking office, President Felipe Calderón declared a crackdown against drug cartels in the state of Michoacán. Between 2008-2012, the "Joint Operation Nuevo León-Tamaulipas" took place in Northeastern states in Mexico. Accounting for those state-specific policies is therefore necessary.

I am also able to examine medium- and long-term effects by analyzing the impact of the avocado boom on thirty years of homicide data (1990–2019) and twenty years of drug cartel-related attacks (2000–2018). Additionally, I extend those studies to include other forms of violence by measuring non-lethal crimes at the municipality level, while also investigating the effect on homicides. Regarding homicides, which are the primary outcome analyzed in the other articles, Yoo (2022), Estancona and Tiscornia (2023), and Erickson and Owen (2024) exploit the lifting of the U.S. import ban but do not discuss nor address violence levels prior to 1997. With the data I collected on homicides from 1990 onwards, I can analyze the period preceding the lifting of the avocado ban to strengthen the causal interpretation of my results.[8]

3 Data and Empirical Strategy

3.1 Data

I use data from administrative and academic sources covering the period between 1990 to 2022 to causally test if the avocado boom has caused an increase in crimes and violence across Mexican municipalities. Specifically, I study the effect of avocado production on three main outcomes: homicides, attacks attributed to drug cartels, and crimes in each municipality-year.

Homicides are widely used in the literature to measure the incidence of crime (Dix-Carneiro et al., 2018) and, as noted by Soares (2004), data on homicides are a low-biased measure of the incidence of crime and violence in the context of developing countries, where underreporting is prevalent and non-random. The main data on homicides come from INEGI, Mexico's National Institute of Statistics and Geography. INEGI records all deaths caused by homicides in each Mexican municipality since 1990.[9] Although my identification strategy does not explicitly rely on the lifting of the US import ban in 1997, the homicide data allow me to check the robustness of my results by comparing homicide trends across municipalities with different production suitabilities before the avocado export boom took off.

To measure the impact of avocado production on drug cartel activities, I use data from the "Organized Crime Violence Event Data" (OCVED) project (Osorio and Beltran,

[8] De Haro-Lopez (2023) is an exception. She examines violence in avocado-growing municipalities before and after NAFTA, covering the period 1990–2006. De Haro-Lopez (2024) further expands the analysis to include non-lethal crimes such as extortion and theft.

[9] https://www.inegi.org.mx/sistemas/olap/proyectos/bd/continuas/mortalidad/defuncioneshom.asp?s=est

2020). OCVED uses web-scraping techniques combined with Machine Learning and supervised Natural Language Processing algorithms to extract information from more than 70 Mexican newspapers to identify and geolocalize violent events committed by drug cartels across Mexico between 2000-2018. The data contain both lethal and non-lethal attacks where the author(s) were identified as members of drug cartels. Although these data do not allow me to separate homicides from other types of crimes, it is a good proxy for the violence committed by drug cartels, a hard-to-measure phenomenon, which is systematically mentioned by press coverage when reporting about violence in avocado-producing municipalities.

Finally, I use data from SESNSP (Mexico's Executive Secretariat of the National System of Security) for the period 2011 - 2022 to categorize crimes by type.[10] Although SESNSP data is only available at the municipality level since 2011, it breaks down crimes in different categories, according to whether the crime was intentional or not, and the type of arm used to commit the crime. Some of the crimes collected by SESNSP include extortion cases, threats, kidnappings, and theft, among others. This allows me to measure the impact of the avocado boom on other forms of crime and non-lethal violence, outcomes that have been less studied in the literature of the resource curse.

I leverage the fact that biophysical geographic conditions determine which municipalities are better suited to produce avocados. I gather data from 1494 weather stations in Mexico (resolution 8" x 8") over the period 1902-2011 to estimate the mean annual temperature (°C), the mean minimum temperature of the coldest month (°C), the mean annual precipitation (mm), and the mean relative humidity (%) for each municipality. Additionally, I use maps of 9,549 soil profiles (scale 1:250,000) collected by INEGI across Mexico between 1985 - 2000, before the lifting of the imports ban and at the onset of the export boom. The soil profiles contain information on the soil's pH, texture, depth, salinity (ECe), organic matter, and cation exchange capacity (meq/100 g). I combine these data to create an exogenous time-invariant avocado suitability following Grüter et al. (2022) which I use to identify the causal effect of the avocado boom on violence. See details in section 3.2.

I also collect data on avocado production from SIAP (*Servicio de Información Agroalimentaria y Pesquera*), an attached organ to the Mexican Secretariat of Agriculture and Rural Development -SAGARPA- that collects geographical and statistical data on agriculture and fishery.[11] SIAP reports the annual number of hectares planted with avocado,

[10] https://www.gob.mx/sesnsp/acciones-y-programas/incidencia-delictiva-299891?state=published
[11] The data is available on -line or remotely through the SIACON database

the production (in tons), the yield per hectare, and the value of production, both at the state level (since 1980) and at the municipal level (since 2003).

I use data from FAOSTAT and the US Department of Agriculture (USDA) Economic Research Service's Fruit and Tree Nuts Yearbook Tables to collect data on various measures of the international price of avocados. FAOSTAT collects data on each country's export and import prices, and USDA presents over 20 years of time-series data for U.S. avocado prices. As the main measure of price for my empirical estimation, I construct an "international import price" for each year since 1990 using the import price in each country (excluding Mexico) to estimate an average global import price. I then standardize this price to have a mean zero and standard deviation of one.[12]

Finally, I use administrative data from Mexico's National Council for the Evaluation of Social Development Policy (CONEVAL) and Mexico's National Population Council (CONAPO) to gather different socio-economic indicators at the municipality level such as poverty, inequality, literacy, and population size.[13] I also retrieved different measures of wholesale and retail cocaine prices in the US and Western Europe from the United Nations Office on Drugs and Crime (UNODC). Table 1 summarizes the different data sources used in this paper.

Table 1: Data sources

Data	**Source**	**Period**	**Level**
Homicides	INEGI	1990 - 2019	municipality
Drug Cartel attacks	OCVED	2000 - 2018	municipality
Non-lethal crimes	SESNSP	2011 - 2022	municipality
Climate	INEGI	1902 - 2011	raster (8" x 8")
Soil profiles	INEGI	1985 - 2000	vector (1:250,000)
Avocado production	SIAP	2003 - 2020	municipality
Avocados prices	FAOSTAT	1980 - 2020	country (world)
Socio-economic controls	CONEVAL & CONAPO	1990 - 2020	municipality
Other	UNODC, USDA		

Descriptive statistics in Table A1 compare high- and low-suitability municipalities across geographic and socioeconomic dimensions, as well as levels of violence. A raw mean comparison confirms that municipalities differ significantly in geographic features, as

[12] See Figure A4 in the Appendix for a detail on the price measures and their evolution in the period of analysis.

[13] In some cases it was necessary to extrapolate data points to complete and balance the panel, since not all indicators have available data for every municipality-year.

predicted by the index, but also in socioeconomic characteristics. However, no statistically significant differences are observed in violence patterns, whether measured by homicides or drug cartel attacks. The empirical strategy described in the next section seeks to identify a causal relationship between suitability to produce avocados and levels of lethal and non-lethal violence across municipalities in Mexico.

3.2 Empirical strategy

To estimate whether the avocado boom has increased violence in producing municipalities, my empirical strategy combines geographical variation in the suitability of each municipality to produce avocados with temporal variation in the international price of the fruit. I construct a suitability index following Grüter et al. (2022) that mimics the FAO's land evaluation approach using geo-referenced data on long-term climate patterns and soil features across the Mexican territory. Each climatic and soil feature is categorized into four suitability classes -high, moderate, marginal, or unsuitable- depending on the requirements for avocado production (see Table A2 in the Appendix). I then aggregate all features to create an aggregated average suitability index that takes on values between 0 and 3, where zero indicates complete unsuitability and three corresponds to the case where all the municipality's biophysical characteristics are optimal for avocado production.[14] Figure 2 shows the avocado suitability index map of Mexico at the municipality level.[15]

To check whether the suitability index is a good predictor of real avocado production, I evaluate if municipalities that have the highest suitability index are the ones that plant and produce more avocados. Figure A2 in the Appendix shows that the average production of avocados in highly suitable municipalities is between 5 and 8 times larger

[14] In cases where soil data is not available at the municipality level, the index considers the climate requirements to assess the suitability of the municipality. As Grüter et al. (2022) note, climate requirements are more important limiting factors than land and soil requirements when assessing the suitability to grow different types of crops, including avocados. Nevertheless, I use both climate and soil features when available to reinforce the index. In the robustness checks presented in section 6, I estimate the main estimation using the climatic component of the suitability index only.

[15] I use existent municipalities in Mexico's administrative census of 1995 to construct the suitability index and estimate the empirical results in the next section. This corresponds to the most recent administrative census before the lift of the US import ban in 1997 and allows me to mitigate potential endogeneity concerns coming from changes in violence levels in municipalities more exposed to the export market after the lift of the ban. The 1995 administrative division of Mexico should not be correlated with endogenous avocado production capacities and violence incidence at the municipality level during the period of analysis. As such, results are estimated for 2428 out of the 2459 current municipalities in the country. Figure A1 in the Appendix presents the suitability index map and the map of avocado production in Mexico.

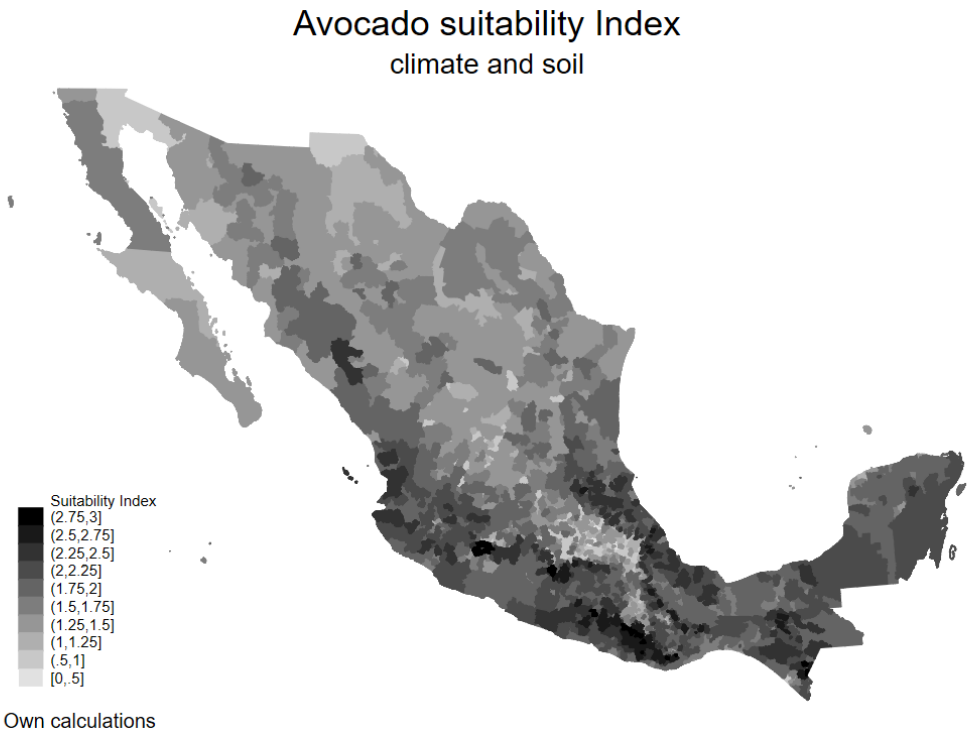


Figure 2: Constructed avocado suitability index at the municipality level

than in moderately and marginally suitable ones. Moreover, Figure A3 shows that in highly suitable municipalities the amount of land dedicated to avocado growing has been continuously increasing since 2003.[16] Tables A3 and A4 confirm that the suitability index correctly predicts avocado production and the number of hectares planted with avocados in the municipality. Municipalities that are classified in the index as highly suitable for avocado production cultivate and produce more avocados than the rest of the municipalities. These results are robust to the introduction of year and municipality fixed effects, and the interaction of the suitability index with the international price of avocados.

In what follows, I classify municipalities as either high- or low-suitable for avocado production, where highly suitable municipalities are the ones with an index between 2.5 and 3.0. I interact this dummy indicator with the international price of avocados to identify the effect of price shocks across Mexican municipalities with different levels of production suitability. I estimate the following equation in reduced form:

$$Y_{m,s,t} = \beta_0 + \beta_1 Suitability_m \times Price_{t-1} + \vec{X}_{m,t}\beta + \mu_m + \lambda_t + \gamma_s \cdot t + \epsilon_{m,t} \qquad (1)$$

[16]Figures show data starting in 2003 since this is the year for which there is available data on avocado production at the municipal level.

where $Suitability_m$ equals one if the municipality m is highly suitable for avocado production, $Price_{t-1}$ is the standardized lagged value of the international import price of avocados, $\overrightarrow{X_{m,t}}$ is a set of socio-economic controls that include the population size, the Gini index and standardized values of the poverty and illiteracy rates in the municipality, and μ_m and λ_t are municipality- and year fixed effects. Since Mexico is the largest producer of avocados in the world, endogenous supply changes in production areas can affect the international price. As Gehring et al. (2023) note, the year fixed effects absorb shocks and changes in the country's avocado supply. Moreover, my preferred specification employs the world import price to further palliate possible endogeneity issues by capturing exogenous demand shocks in other countries that are presumably not affected by levels of violence in Mexico. I also include a state-specific time trend $\gamma_s \cdot t$ to account for state-level policies that target drug cartels or seek to reduce crime and violence in specific areas. The outcome $Y_{m,s,t}$ corresponds to (i) homicides per 100'000 inhabitants in the municipality m in state s between 1990 and 2019, (ii) number of violent and non-violent attacks per 100'000 inhabitants attributed to drug cartels for the period 2000-2018, and (iii) number of reported crimes after 2011 per 100'000 inhabitants.

4 Results

4.1 Homicides

I first study the effect of the avocado boom on homicides. INEGI provides data on homicides at the municipal level dating back to 1990, which allows for analysis before and after the U.S. lifted its avocado import ban in 1997. Table 2 presents results where the outcome is the number of homicides per 100,000 inhabitants in Mexican municipalities between 1990 and 2019.

Table 2: Effect of avocado suitability and world price on homicide rate (per 100,000 pop.)

	Homicide rate in municipality m in year t (1990-2019)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	4.94***	4.95***			
	(1.51)	(1.51)			
Avocado price (lag)	6.13***		5.13***		
	(0.84)		(0.78)		
Suitability Index=1 × Avocado price (lag)	-4.66***	-4.64***	-4.73***	-4.71***	-2.03**
	(1.00)	(1.00)	(1.02)	(1.02)	(0.74)
Observations	68498	68498	68498	68498	68498
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y (Suitability = 0)	16.7	16.7	16.7	16.7	16.7

Outcome: number of homicides per 100,000 population in the municipality. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

The results show that over this 30-year period, increases in the international price of avocados are associated with reductions in violence in municipalities with high suitability for avocado production. This result is robust to estimations that include only municipal or year fixed effects (Cols. 2 and 3), municipal and year fixed effects (Col. 4), and a state time trend (Col. 5). My preferred specification (Col. 5) shows that a one standard deviation increase in the international import price of avocados is associated with a reduction in the homicide rate of 2.03 homicides per 100'000 inhabitants, equivalent to a reduction of 12.1% with respect to the average homicide rate in municipalities with low suitability to produce avocados.

My identification strategy isolates variation due to the differential impact of price shocks on municipalities with distinct pre-determined trends, which are determined by geographic and biophysical conditions. With the homicide data, I can test if there were differences in the number of homicides per 100'000 population between municipalities that are more or less suitable for avocado production before the US lifted the avocado imports ban in 1997. Table 3 splits the homicide results before and after the lift of the ban, and presents the results for the homicide rate between 1990 and 1997 (Cols. 1-4), and 1998

to 2019 (Cols. 5-8).

Table 3: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.)

	Homicide rate in municipality m in year t (1990-2019)							
	Before (1990-1997)				After (1998-2019)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Suitability Index=1	15.61***				2.53**			
	(2.74)				(1.17)			
Avocado price (lag)		2.33				4.86***		
		(2.02)				(1.13)		
Suitability Index=1 × Avocado price (lag)	2.67	2.73	2.54	1.04	-3.59***	-3.70***	-3.71***	-1.74**
	(2.29)	(3.87)	(3.93)	(3.88)	(0.80)	(0.84)	(0.83)	(0.63)
Observations	16534	16534	16534	16534	51964	51964	51964	51964
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes		Yes	Yes	Yes		Yes	Yes
Municipality F.E.		Yes	Yes	Yes		Yes	Yes	Yes
State time trend				Yes				Yes
Sample mean of Y (Suitability = 0)	17.9	17.9	17.9	17.9	16.3	16.3	16.3	16.3

Outcome: number of homicides per 100,000 population in the municipality. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

As Table 3 shows, there were no significant differences in the homicide rate between high- and low-suitable municipalities before 1997. Results in Columns 5-8 indicate that the effect of the increase of international avocado prices in reducing homicides in more suitable municipalities occurred after the US opened its market to Mexican avocados. This result provides evidence in favor of the opportunity cost mechanism discussed in the economics of conflict and resource curse literature (Collier and Hoeffler, 1998; Dube and Vargas, 2013; Ferraz et al., 2022), as opposed to a rapacity effect channel. That is, increases in commodities' prices have a beneficial effect in terms of reducing violence.

To further validate this result, I run a placebo test in the spirit of Crost and Felter (2020) that includes, in the baseline estimation, the interaction of the suitability measure with the international price in year $t + 1$. As Table A5 in the appendix shows, the coefficient for the interaction between the suitability indicator and the international price of avocado in period $t + 1$ is non-significant and of smaller magnitude than the main coefficient reported in Table 3. This result reassures the evidence in favor of a causal effect of the avocado export boom in reducing the homicide rate in municipalities with higher production capacities.

4.2 Attacks by drug cartels and non-lethal crimes

The results on homicides are in line with previous studies on the negative relationship between labor-intensive agricultural commodities booms and violence (Dube and Vargas, 2013; Blair et al., 2021; Crost et al., 2023). Nevertheless, anecdotal evidence from press reports suggests that violence in major avocado-producing regions has increased, particularly due to drug cartels targeting this lucrative industry. These reports claim, in particular, that violence and crime in those regions have increased as a consequence of drug cartels who seek to extract rents from the profitable avocado industry. To examine these claims, I analyze data from the OCVED project and administrative records at the municipal level. Results are reported in Table 4.

Table 4: Effect of avocado suitability and world price on drug cartel violent attacks

	Drug cartel attacks in municipality m (2000-2018)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	-19.54***	-19.43***			
	(6.71)	(6.65)			
Avocado price (lag)	13.86***		18.70**		
	(3.25)		(7.41)		
Suitability Index=1 × Avocado price (lag)	-10.65**	-10.74**	-11.61**	-11.77**	-3.29*
	(3.95)	(3.83)	(4.61)	(4.67)	(1.72)
Observations	46132	46132	46132	46132	46132
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y (Suitability = 0)	26.3	26.3	26.3	26.3	26.3

Outcome: number of attacks commited by drug cartels, per 100,000 population in the municipality. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table 4 shows that, as in the case of homicides, municipalities highly suitable for avocado production experienced a reduction in drug cartel attacks per 100,000 population between 2000 and 2018. Column 4 shows that, without accounting for state-specific trends, this reduction is of more than 40% with respect to the mean of attacks in low-suitable

municipalities. After controlling for state time trends (Col. 5), the effect is still negative and statistically different from zero, although the magnitude decreases significantly to 3.3 attacks per 100'000 population. This is still a relevant reduction in the number of attacks, and it also shows the importance of accounting for state-specific trends, which is not considered in previous studies that study the effects of the avocado boom on violence in Mexico.

Since not all municipalities experience attacks by drug cartels -as cartels are not necessarily active or present in all municipalities across the country-, the distribution of the number of attacks has an important mass zero. For this, I estimate a Pseudo-Poisson likelihood model to better capture this feature of the drug cartel attacks outcome. Results in Table A6 in the Appendix show that, when drug cartel attacks are measured as the count of attacks (instead of cases per 100'000 people) in each municipality, municipalities with a high suitability index experienced, on average, a decrease of 21% in lethal and non-lethal attacks carried out by drug cartels.[17]

To measure the potential impact of the avocado boom on other types of crime, I use administrative data available at the municipality level from 2011 onwards. SESNSP data reports and classifies crimes into more than twenty categories, according to the type of crime (e.g. felony or misdemeanours), the kind of weapon used, or whether the crime is against physical integrity or a private or public good, etc.[18] I classify the list of crimes into seven categories as a function of the media reports and potential income-related crimes that are more susceptible to be affected by the avocado boom. The reduced list of crimes I consider in my specification are: extortion, threatening, kidnapping, robbery, theft, injuries, and others. I test the effect separately for each crime, and I also construct a standardized weighted average index of crimes to mitigate potential inference issues related to multiple hypothesis testing (Anderson, 2008; Schwab et al., 2020). Table 5 below reports the results of estimating equation 1 on the number of non-lethal crimes per

[17]Note that the number of observations is lower compared to the results in Table 4 when municipality (and the state time trend) fixed effects are included. This is due to the presence of singletones or separated observations in the data that can prevent the maximum likelihood estimates for the Poisson regression to exist (Correia et al., 2020). As such, they are dropped from the regression for the estimator to converge.

[18]Some examples of the types of crimes recorded by SESNSP include: breaking and entering, crimes committed by public servants, damage to property, domestic violence, dispossession, extortion, forgery, fraud, robbery, and sexual harassment, and others

100'000 pop. at the municipality level.[19,20]

Table 5: Effect of avocado suitability and world price on crimes (by type)

	Crimes per 100,000 pop. in municipality m in year t (2011-2017)							
	Crime	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Index	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	0.05	-0.20	1.97	1.23	14.91	3.39	32.79	7.47
	(0.10)	(0.33)	(2.64)	(2.72)	(16.03)	(8.78)	(24.47)	(6.62)
Observations	12731	12731	12731	12731	12731	12731	12731	12731
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y (Suitability = 0)	.036	2.63	10.3	22.7	164	165	263	34

Outcome: number of reported non-lethal crimes per 100,000 population in the municipality. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Results indicate no difference in criminality between highly suitable and non-suitable municipalities from 2011 to 2017. Neither the aggregated index nor individual crime categories show varying levels of crime between these municipalities. If anything, the results in Table 5 suggest that highly suitable municipalities did not experience an increase in non-lethal crimes over this seven-year period.

Taken together, the findings for homicides, drug cartel attacks, and non-lethal crimes provide evidence supporting the opportunity cost mechanism in the avocado sector across Mexican municipalities. This overall result supports the hypothesis that the expansion of the avocado market has contributed to reducing violence in avocado-growing regions, and largely contradict the newspaper reports of an increase in criminality in the avocado sector. Moreover, these findings align with the literature on how booms in legal agricultural commodities can have a positive effect in decreasing conflict and violence in producing regions (Blair et al., 2021).

[19] SESNSP started reporting crimes at the municipality level in 2011. In 2018 there was a change in methodology on how crimes are classified, and some of my categories were affected by this recomposition. Therefore, in Table 5 I present the results on crimes between 2011 and 2017, and in Table A7 in the Appendix, I present the results up to 2022 after an attempt to harmonize the change in methodology before and after 2018.

[20] Compared to the previous tables, Table 5 presents only the results of the full estimation (i.e., including controls and all fixed effects, rather than introducing them one by one) to save space.

5 Michoacán and the export market

The previous results show that, across Mexico, municipalities that are highly suitable to produce avocados have experienced a reduction in the homicide rate and in drug cartel attacks per 100'000 population, and that crimes did not increase in those municipalities. Nevertheless, the anecdotal evidence suggests that drug cartels have actually increased their criminal activities in avocado-producing regions, especially in the western state of Michoacán where most of the production of avocados for the export market is concentrated. For instance, Ornelas (2018) and Herrera and Martinez-Alvarez (2022) provide qualitative evidence about how criminal organizations entered the export-agriculture market in Michoacán, where they started to extort avocado farmers as a means of extracting rents from the avocado export boom.

The US Department of Agriculture's (USDA) Amendment that lifted the import ban of fresh Hass avocados from Mexico to the United States in 1997 specifies that only municipalities that satisfy rigorous requirements are authorized to export avocados. Municipalities must comply with strict phytosanitary requirements, field sanitation practices, special packinghouse procedures and shipping requirements, and various other safeguards, to be allowed to export avocados to the US (USDA Animal & Plant Health Inspection Service, 1997). The list of authorized municipalities to export avocados has evolved over time, but in 1997 only 24 municipalities in Michoacán were allowed to export avocados. In what follows, I focus my analysis on the state of Michoacán and compare these 24 municipalities with the rest of the never-approved municipalities within the state (i.e. excluding the ones who have received the USDA approval after the 24 ever-first municipalities did). Figure 3 maps the state of Michoacán and the distribution of municipalities according to their USDA-approval status.[21]

[21] There are 113 municipalities in Michoacán. Among them, 24 received USDA approval in 1997, 19 have obtained certificates for export after 1997, and 70 have never received approval. Rojas and Schaefer (2024) study the effects on market structure and spillovers in violence of a phytosanitary zone expansion for avocado exports from the state of Jalisco in 2022.

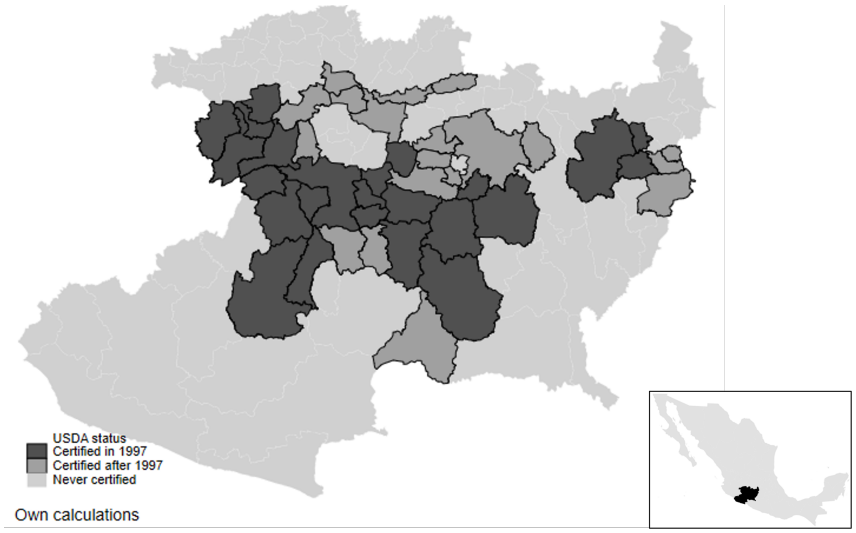


Figure 3: Municipalities in the state of Michoacán by USDA approval status

I replicate the baseline equation and include a binary variable for the ever-first authorized municipalities by USDA. Therefore, I estimate the following equation for municipalities in the state of Michoacán[22]:

$$\begin{aligned} Y_{m,t} = \beta_0 &+ \beta_1 Suitability_m + \beta_2 USDA_m + \beta_3 Price_{t-1} + \beta_4 (Suitability_m \times USDA_m) \\ &+ \beta_5 (Suitability_m \times Price_{t-1}) + \beta_6 (USDA_m \times Price_{t-1}) \\ &+ \beta_7 (Suitability_m \times Price_{t-1} \times USDA_m) + \vec{X_{m,t}}\beta + \mu_m + \lambda_t + \epsilon_{m,t} \end{aligned} \tag{2}$$

If drug cartels have concentrated their criminal activities in avocado-producing municipalities exposed to the export market -where potential profits are higher-, then we should expect to find a positive coefficient for the USDA-authorized municipalities in Michoacán. If this is true, one would expect to find that $\beta_6 + \beta_7 > 0$. Below I present the results of estimating equation 2 for the homicide rate (Tables 6 and 7), the number of drug cartel-related attacks per 100'000 pop. (Table 8), and crimes (Table 9) for municipalities in the state of Michoacán.

[22]Note that this equation does not include the state time trend as it is only estimated for municipalities in the state of Michoacán. Moreover, the equation is written with all the variables and its interactions, although in the full specification the municipality and year fixed effects will absorb β_1, β_2, β_3, and β_4. The tables that report the results only show β_5, β_6, and β_7 for all specifications (progressively including fixed effects) to simplify the visualization of results.

Table 6: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.) - Michoacán

	Homicide rate in Michoacán (1990-2019)			
	(1)	(2)	(3)	(4)
Suitability Index=1 × Avocado price (lag)	-2.04	-0.94	-3.27	-1.92
	(4.52)	(3.92)	(5.18)	(4.60)
USDA=1 × Avocado price (lag)	-2.12	-1.60	-2.33	-1.55
	(1.86)	(1.96)	(2.16)	(2.26)
Suitability Index=1 × USDA=1 × Avocado price (lag)	2.63	2.08	2.15	1.65
	(5.49)	(4.97)	(6.24)	(5.78)
Observations	2726	2726	2726	2726
Controls	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes
Municipality F.E.			Yes	Yes
Sample mean of Y (Suitability = 0)	25.6	25.6	25.6	25.6
Test p-val: $\beta 6 + \beta 7 = 0$	.926	.926	.976	.985

Outcome: number of homicides per 100,000 population in the municipality. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Contrary to the findings in the previous section, which show a negative relationship between the avocado boom and homicide rates across Mexican municipalities, Table 6 indicates that in Michoacán, there was no reduction in homicides in highly suitable municipalities or those USDA-approved for avocado export. The coefficients in Column 4, which account for municipality and year fixed effects, are not statistically significant. Furthermore, Table 7 reveals no differences in homicide rates across municipalities before and after the lifting of the import ban in 1997. These results suggest that the reduction in homicides observed across avocado-producing municipalities in Mexico after 1997 is attenuated in Michoacán, particularly in municipalities focused on the export market. That is, the export market seems to offset the opportunity cost effect as the profits are larger and more important in the export market, as profits in this market are larger than in the local market.

Table 7: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.)

	Homicide rate in Michoacán (1990-2019)					
	Before (1990-1997)			After (1998-2019)		
	(1)	(2)	(3)	(4)	(5)	(6)
Suitability Index=1 × Avocado price (lag)	21.61**	26.74	24.20	-2.89	-3.67	-2.63
	(6.83)	(22.20)	(22.45)	(3.46)	(4.02)	(3.53)
USDA=1 × Avocado price (lag)	-3.79	-3.27	-4.36	-2.04	-2.64	-2.10
	(4.83)	(10.32)	(10.57)	(1.90)	(2.24)	(2.25)
Suitability Index=1 × USDA=1 × Avocado price (lag)	-22.62**	-25.06	-23.13	4.83	4.88	4.43
	(7.59)	(22.25)	(22.81)	(4.24)	(4.88)	(4.45)
Observations	658	658	658	2068	2068	2068
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes		Yes	Yes		Yes
Municipality F.E.		Yes	Yes		Yes	Yes
Sample mean of Y (Suitability = 0)	34.5	34.5	34.5	22.8	22.8	22.8
Test p-val: $\beta 6 + \beta 7 = 0$	.0598	.267	.286	.534	.645	.617

Outcome: number of homicides per 100,000 population in the municipality. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

The results for the drug cartel-related attacks provide further evidence in this direction. Table 8 shows that in the period 2000-2018, municipalities that received USDA approval to export avocados to the US experienced an increase in the number of attacks by drug cartels compared to other municipalities in the state of Michoacán. On average, these municipalities suffered an increase of 21.04 attacks per 100'000 population, which corresponds to a 58% increase with respect to the sample mean. The increase in the number of drug cartel attacks in USDA-approved municipalities is statistically and economically relevant: USDA-approved municipalities have experienced more attacks by drug cartels than highly suitable municipalities that were not allowed to export avocados in 1997. These results seem to confirm the qualitative evidence and the media reports that claim an increase in drug cartels attacks and violence in municipalities that produce avocados for the export market. More importantly, Table 8 shows that the opportunity cost mechanism reverses with the export market, leaving room for the rapacity effect channel to come at play with its consequential increase in violence in municipalities that produce avocados for exports.

Table 8: Effect of avocado suitability and world price on drug cartel violent attacks - Michoacán

	Drug cartel attacks in municipality m in year t (2000-2018)			
	(1)	(2)	(3)	(4)
Suitability Index=1 × Avocado price (lag)	-4.78	-8.01	0.45	-3.71
	(9.90)	(10.11)	(8.19)	(8.63)
USDA=1 × Avocado price (lag)	-9.82	-12.65	-0.43	-4.33
	(8.65)	(8.56)	(8.12)	(7.98)
Suitability Index=1 × USDA=1 × Avocado price (lag)	21.23	24.05*	21.39	25.37*
	(13.35)	(12.72)	(13.45)	(12.72)
Observations	1786	1786	1786	1786
Controls	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes
Municipality F.E.			Yes	Yes
Sample mean of Y (Suitability = 0)	36.8	36.8	36.8	36.8
Test p-val: $\beta 6 + \beta 7 = 0$	.372	.332	.11	.0732

Outcome: number of attacks commited by drug cartels, per 100,000 population in the municipality. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Results by type of crime in Table 9 provide a broader view on the criminality pattern across avocado-producing and exporting municipalities in Michoacán. Press reports claim that drug cartels have particularly increased their non-lethal attacks by threatening, extorting, and even kidnapping avocado producers in these municipalities in order to extract rents from producers.

Column 1 in Table 9 presents the overall criminality index results. Although the coefficients are not precisely estimated, they point towards an increase in crimes in export-oriented municipalities, and the test of joint significance of coefficients β_6 and β_7 is virtually significant at the 10%. Disaggregated results by type of crime (Cols. 2-8) show that extortion cases have not increased in export-oriented municipalities, whereas the number of threats in avocado-growing and exporting municipalities have substantially increased compared to non-exporter localities. There is also evidence suggesting that cases of robbery and theft increased in export-oriented municipalities more than 50% compared to the sample mean. This pattern of results are in line with De Haro-Lopez (2024), who finds an increase in violent thefts and truckload thefts, and a reduction in extortion cases in avocado-suitable municipalities, after the fentanyl epidemic in the US shifted drug cartels attention from the heroin to the avocado market.[23]

[23]She also finds an increase in murders in avocado-suitable municipalities, but her results cover the state of Michoacán plus six other states. Moreover, in Table A51 I report that avocado-growing and export-oriented municipalities in Michoacán experienced an increase in the homicide rate per 100'000

Table 9: Effect of avocado suitability and world price on crime rate (by type) - Michoacán

	Crimes per 100,000 pop. in municipality m in year t (2011-2017)							
	Crime	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Index	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-0.23	-0.44	-9.91	-2.43	-29.47**	-44.53**	61.02	6.66
	(0.15)	(0.97)	(7.77)	(9.50)	(11.97)	(15.19)	(33.13)	(4.42)
USDA=1 × Avocado price (lag)	0.12	-1.08	-2.21	14.56**	56.91*	30.18*	12.77	-1.36
	(0.10)	(0.62)	(3.16)	(5.29)	(28.26)	(14.24)	(14.83)	(3.66)
Suitability Index=1 × USDA=1 × Avocado price (lag)	0.17	-0.40	21.80*	-12.40	49.05	51.42*	-119.55**	-7.27
	(0.19)	(0.71)	(9.55)	(12.68)	(44.91)	(22.01)	(46.18)	(4.85)
Observations	658	658	658	658	658	658	658	658
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y (Suitability = 0)	.0137	1.75	12.4	36.6	85.5	98.9	89.9	10.6
Test p-val: $\beta 6 + \beta 7 = 0$	.106	.146	.0749	.863	.0276	.00758	.0508	.0896

Outcome: number of reported non-lethal crimes per 100,000 population in the municipality. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

The findings in this section show that homicides did not decrease in export-oriented municipalities in Michoacán, compared to an overall reduction in avocado-suitable localities across Mexico. That is, the beneficial effect of the avocado boom in reducing violence in producing municipalities is weakened by attractiveness of the export market.[24] Second, drug cartels increased their attacks in avocado-growing municipalities that were exposed to the export market since the lift of the imports ban in the US in 1997.[25] Third, citizens in these municipalities have experienced an increase in threats and property crimes.[26] These results point towards a prevalence of the rapacity effect in export-oriented municipalities in Michoacán, as compared to the opportunity cost mechanism that is at play at the country level.

The rapacity effect observed in Michoacán's export-oriented municipalities can be bet-

population when I only use the climatic component of the suitability index. Section 6 discuss this case as a robustness check.

[24] It is estimated that the avocado sector in Michoacán generates 310,000 direct jobs and 78,000 indirect jobs. Source: Mexico's Secretariat of Agriculture and Rural Development

[25] For example, farmers in the municipality of Cherán opted to stay out of the avocado market, despite its potential for high revenues and employment. Concerned about the violence and crime associated with the avocado export boom, they decided not only to abstain from production but also to actively prevent avocado farming within the municipality's boundaries. See NZZ's full newspaper report (in German).

[26] For instance, De Haro-Lopez (2024) suggests that drug cartels increased their attacks against civilians in avocado-suitable municipalities, instead of fighting among them for territorial expansion to other municipalities.

ter understood through the lens of established theoretical frameworks on organized crime. As proposed by Schelling (1971) and further developed by Gambetta and Reuter (1995), Lavezzi (2008), and Balletta and Lavezzi (2023), certain characteristics of legal markets make them particularly vulnerable to become targets of criminal organizations who seek to extract rents and monopolize criminal activity under their area of influence. These include weak legal institutions, the presence of industries with high and easy observable output and profits, and fragmented production with many small producers.

The avocado industry in Michoacán exhibits these traits: it operates within a context of institutional fragility (Aguirre and Herrera, 2013; Shirk and Wallman, 2015), and avocado production in Michoacán is concentrated along many micro and small producers.[27] These conditions not only facilitate drug cartels' intrusion into the avocado market but also exacerbate their ability to extract rents and monopolize criminal activity. This highlights how context-specific characteristics of a commodity and its market can shape the interplay between economic development and crime, as suggested in recent studies of agricultural export booms (Crost and Felter, 2020; Estancona and Tiscornia, 2023; Crost et al., 2023).

Importantly, although these results suggest a possibly causal effect of the avocado boom on crime and violence in export-oriented municipalities in Michoacán, it is important to note that crimes are highly underreported in Mexico due to distrust of police (De Haro-Lopez, 2024) or possibly by fear of retaliation. Therefore, these results can be seen as a conservative estimate of the real effect. Additionally, during the period of analysis, farmers in Michoacán organized self-defense militias and vigilante groups to fight drug cartels and other criminal organizations (Alvarez-Rodríguez et al., 2020; Erickson and Owen, 2024), which could have an impact on the violence patterns in the region.

6 Robustness Checks

I conduct a series of robustness checks to validate the results of the previous sections. I first validate the robustness of the country-level results of Section 4, and then I validate the robustness of results for municipalities in Michoacán and the effect of the USDA export approval of Section 5.

[27] For example, more than 95% of Michoacán's 26,000 registered avocado farmers allowed to export to the US cultivate less than 10 hectares of land. Source: https://www.gob.mx/agricultura/articulos/mexico-y-sus-exportaciones?idiom=es

6.1 Country-level results (Section 4)

I conduct eight different robustness checks to validate the results of a reduction in homicides and drug cartel attacks, and no increase of non-lethal crimes, in highly-suitable municipalities for the production of avocados across Mexico.[28] The tests are:

1. a shorter time window depending on the years covered by the OCVED project (2000-2018) and the SESNSP data for non-lethal crimes (2011-2017);
2. measuring the outcome as the log of, and the inverse hyperbolic sine transformation of, the number of homicides in the municipality;
3. excluding one year or one state at a time and then estimating the main regression;
4. a more conservative estimation clustering the standard errors at the state level;
5. wild cluster bootstrap p-values and confidence intervals;
6. random permutations of the suitability index;
7. alternative definitions of the suitability index (using the continuous measure or a indicator using only climatic factors); and
8. State-by-year fixed effects instead of a state-linear time trend.

A discussion of each test, as well as the Tables of results and Figures are presented in the Appendix section A.7.1. Table 10 below summarizes the findings of the robustness checks.

Table 10: Summary of robustness checks on the number of homicides and drug cartel attacks per 100'000 population.

Robustness check	**Homicides**	**Drug cartel attacks**
1. Same time periods	-	-
2. Alternative measures of the outcome	✓	-
3. Exclusion of years and states	✓	✓
4. Clustering of the std. err.	✓	✓
5. Wild cluster bootstrap	✓	✓
6. Permutation of the suitability index	✓	×
7. Alternative definition of the suitability index	✓	-
8. State-by-year Fixed Effect	✓	-

Note: ✓ indicates robustness, - indicates partial robustness (i.e. non-significance but similar magnitude/sign of the coefficient), and × indicates lack of robustness.

The results for the homicide rate are robust to all the aforementioned tests. The only test where the estimated coefficient is not fully robust is when reducing the period of

[28] I do not systematically discuss the robustness checks on crimes, as they are non-significant in the main estimation. Nevertheless, I conduct and present all results for crimes in the Appendix as well.

analysis from 1990-2019 to 2011-2017, which is the period with available data on non-lethal crimes at the municipality level. Overall, this battery of robustness checks reassures the findings of section 4 about the reduction of homicides in highly suitable municipalities following the opening of the avocado market in the US in 1997.

Results on drug cartels are robust to clustering the standard errors at the state level and to wild bootstrap inference, but they fail to be statistically significant to: a shorter, 7-year, time window between 2011-2017 (data on crimes); measuring the outcome as the log of and the asinh transformation of the number of cases; a permutation of the suitability index and alternative definitions of the index; and, the introduction of state-by-year fixed effects. Therefore, the claim of a causal link between avocado production and a reduction in the number of drug cartel attacks per 100'000 population in highly suitable municipalities is uncertain, although the results can be seen as suggestive evidence of a reduction in attacks. If anything, the results show that the rate of attacks per 100'000 people did not increase in more suitable municipalities, as none of the robustness checks nor the main estimation find a positive correlation between the suitability to produce avocados and the drug cartel attacks in Mexican municipalities. The reader should consider these results with prudence.

6.2 Michoacán and the export market case (Section 5)

In this section I repeat the robustness checks previously described, this time for the municipalities in the state of Michoacán.[29] A discussion of each test, as well as the Tables of results and Figures are presented in the Appendix section A.7.2. Table 11 below summarizes the findings.[30] Overall, the results are mildly robust to different tests, although in some cases I lose the statistically significance. They suggest a potential increase in certain types of crimes in export-oriented municipalities, although results must be cautiously analyzed.

The results of a reduction in homicides across municipalities in Mexico, and of a non-decrease in homicides in Michoacán, are highly robust and provide evidence of a causal effect. However, the findings regarding drug cartel attacks and non-lethal crimes, while suggestive of a causal relationship, are sensitive to some tests and model specifications. As such, their interpretation requires caution. However, if anything, the results suggest that

[29] Bear in mind that some of the robustness checks cannot be replicated here because all municipalities correspond to the same state. For example, conservative clustering of the standard errors at the state level, or the introduction of a state-by-year fixed effect.

[30] I exclude the discussion of the results on homicides as they are non-significant in the main estimation.

Table 11: Summary of robustness checks on the number of drug cartel attacks and crimes per 100'000 population in the state of Michoacán

Robustness check	Drug cartel attacks	Crimes
1. Alternative measures of the outcome	-	✓
2. Exclusion of years and municipalities	✓	✓*
3. Wild cluster bootstrap	✓	-
4. Permutation of the USDA-approved status	✓	✓
5. Alternative definition of the suitability index	-	-

Note: ✓ indicates robustness, - indicates partial robustness (i.e. non-significance but similar magnitude/sign of the coefficient), and ✗ indicates lack of robustness. * stands for results on demand, due to large number of estimations.

export-oriented municipalities in Michoacán did not experience a reduction in drug cartel attacks, as observed in other municipalities across Mexico. Moreover, there is evidence that crimes, notably property-related offenses, may have increased in those municipalities.

Several factors could explain the limited robustness of the results regarding drug cartel attacks and other crimes. First, measurement error and underreporting, which are more prevalent for these crime types than for homicides, might bias the estimates. Homicides are generally more accurately reported, even in developing countries, due to their severity and higher likelihood of official documentation (Soares, 2004). Specifically, data on drug cartel attacks is derived from newspaper reports, which may omit incidents due to lack of information or fear of retaliation, among other challenges.

Second, the avocado index might be capturing something else than just the suitability to produce this fruit. For example, avocado suitability could correlate with overall agricultural suitability or even with the potential for cultivating illegal crops such as marijuana or poppy, which have historically been central to drug cartel activities For instance, De Haro-Lopez (2024) shows that municipalities unsuitable for avocado production are also unsuitable for poppy cultivation, while those highly suitable for avocado production often exhibit medium to high suitability for poppy cultivation. Therefore, it is possible that the avocado suitability index may partly reflect suitability for illegal crops, that can potentially influence the results on drug cartel attacks and crimes.

Finally, the availability of municipality-level disaggregated crime data begins only in 2011, limiting the time horizon for analysis. This start date captures the effects of the avocado export boom over a decade after the first municipalities were allowed to export avocados to the U.S. It would be possible that crime patterns change between the early stages of the avocado boom (before 2010) and once the market is stabilized

(after 2011). Therefore, a longer time horizon would help in providing deeper insights into the dynamics of crime during the early phases of market expansion and subsequent stabilization. Unfortunately, this data is not available at the municipal level.

In summary, while the findings provide robust evidence of a causal effect on homicides, the results for drug cartel attacks and non-lethal crimes require more nuanced interpretation. Extensions to this paper could address data limitations and explore the role of other factors, such as illegal crop cultivation or the role of the Mexican war on drugs (the so-called "Guerra contra el narco").

7 Conclusion

Recent media reports claim that Mexico's avocado export boom over the past 20 years has driven increased violence across avocado-producing regions in the country, primarily due to drug cartels seeking to exploit this lucrative market. I empirically test these claims using diverse data sources and exploiting the biophysical suitability of each municipality to produce avocados with movements in the international price of the fruit.

The findings reveal that, in the medium to long term, the avocado boom has reduced homicides and drug cartel attacks across Mexican municipalities, consistent with the opportunity cost mechanism often linked to labor-intensive agricultural booms. These results align with broader evidence on how agricultural growth can decrease violence by increasing legal economic opportunities.

However, the picture changes in the western state of Michoacán, where avocado production is predominantly export-driven. Following the lifting of an 83-year import ban, municipalities that received early approval to export avocados to the U.S. have experienced increases in drug cartel attacks and property crimes, while failing to show reductions in homicides. This outcome underscores the rapacity effect: the substantial economic gains tied to export markets appear to outweigh the opportunity costs of violence, incentivizing criminal organizations to extract rents from this legal market.

This dual effect on violence within the Mexican avocado sector highlights how a production boom of the same commodity can generate contrasting effects within a single country. This paper contributes to the growing body of evidence suggesting that while agricultural booms can reduce violence, the expansion of export markets may offset these benefits, particularly in regions where armed or illegal groups are already present (Crost and Felter, 2020; Estancona and Tiscornia, 2023), and in sectors that share traits that facilitate the intrusion of criminal organizations, such as many small and fragmented

producers and highly observable profits.

These findings contribute to a nuanced understanding of the conditions under which agricultural booms may reduce or exacerbate violence, or both. They also stress the importance of tailoring policy responses to account for context-specific dynamics, especially in regions where the economic gains from exports intersect with institutional weaknesses and active criminal organizations.

From a policy perspective, these findings underscore the critical importance of addressing institutional weaknesses in export-oriented agricultural sectors. In contexts like Michoacán, where weak property rights and fragmented production coexist with lucrative export markets, large efforts are needed to prevent criminal organizations from capturing economic gains. Strengthening local governance, protecting smallholder farmers, and enhancing law enforcement capacity are essential steps to curb violence while fostering sustainable agricultural growth.

References

Aguirre, J. and Herrera, H. A. (2013). Institutional weakness and organized crime in mexico: the case of michoacán. *Trends in Organized Crime*, 16:221–238.

Alvarez-Rodríguez, I., Román-Burgos, D., and Jesperson, S. (2020). Armed legitimacy in mexico: Self-defence groups against criminal violence. In *Rural Crime Prevention: Theory, Tactics and Techniques (1st ed.)*, pages 84–94. Routledge.

Anderson, M. L. (2008). Multiple inference and gender differences in the effects of early intervention: A reevaluation of the abecedarian, perry preschool, and early training projects. *Journal of the American Statistical Association*, 103(484):1481–1495.

Angrist, J. D. and Kugler, A. D. (2008). Rural windfall or a new resource curse? Coca, income, and civil conflict in Colombia. *The Review of Economics and Statistics*, 90(2):191–215.

Balletta, L. and Lavezzi, A. M. (2023). The economics of extortion: Theory and the case of the Sicilian Mafia. *Journal of Comparative Economics*, 51(4):1109–1141.

Bazzi, S. and Blattman, C. (2014). Economic shocks and conflict: Evidence from commodity prices. *American Economic Journal: Macroeconomics*, 6(4):1–38.

Berman, N. and Couttenier, M. (2015). External shocks, internal shots: The geography of civil conflicts. *Review of Economics and Statistics*, 97(4):758–776.

Besley, T. J. and Persson, T. (2008). The incidence of civil war: Theory and evidence. NBER Working Paper 14585, National Bureau of Economic Research.

Blair, G., Christensen, D., and Rudkin, A. (2021). Do commodity price shocks cause armed conflict? A meta-analysis of natural experiments. *American Political Science Review*, 115(2):709–716.

Brückner, M. and Ciccone, A. (2010). International commodity prices, growth and the outbreak of civil war in Sub-Saharan Africa. *The Economic Journal*, 120(544):519–534.

Buonanno, P., Durante, R., Prarolo, G., and Vanin, P. (2015). Poor institutions, rich mines: Resource curse in the origins of the Sicilian Mafia. *The Economic Journal*, 125(586):F175–F202.

Cameron, A. C., Gelbach, J. B., and Miller, D. L. (2008). Bootstrap-based improvements for inference with clustered errors. *The Review of Economics and Statistics*, 90(3):414–427.

Carman, H. F. (2019). The story behind avocados' rise to prominence in the united states. *UCDavis ARE Update*, 22(5):9–11.

Castillo, J. C., Mejía, D., and Restrepo, P. (2020). Scarcity without Leviathan: The violent effects of cocaine supply shortages in the Mexican drug war. *Review of Economics and Statistics*, 102(2):269–286.

Collier, P. and Hoeffler, A. (1998). On economic causes of civil war. *Oxford Economic Papers*, 50(4):563–573.

Correia, S., Guimarães, P., and Zylkin, T. (2020). Fast Poisson estimation with high-dimensional fixed effects. *The Stata Journal*, 20(1):95–115.

Crost, B., Felter, J., and Yamasaki, Y. (2023). Labor intensity, market structure, and the effect of economic activities on civil conflict. Unpublished. Available at SSRN: https://ssrn.com/abstract=4607617.

Crost, B. and Felter, J. H. (2020). Export crops and civil conflict. *Journal of the European Economic Association*, 18(3):1484–1520.

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

De Haro-Lopez, I. (2023). The effect of NAFTA on violence in Mexico's avocado sector. Unpublished.

De Haro-Lopez, I. (2024). Avocados: Mexico's green gold. The impact of the U.S. opioid crisis on Mexico's drug cartel violence. Working Paper 05/2024, Navarra Center for International Development, University of Navarra.

Dell, M. (2015). Trafficking networks and the Mexican drug war. *American Economic Review*, 105(6):1738–1779.

Dimico, A., Isopi, A., and Olsson, O. (2017). Origins of the Sicilian Mafia: The market for lemons. *The Journal of Economic History*, 77(4):1083–1115.

Dix-Carneiro, R., Soares, R. R., and Ulyssea, G. (2018). Economic shocks and crime: Evidence from the Brazilian trade liberalization. *American Economic Journal: Applied Economics*, 10(4):158–195.

Dube, O., García-Ponce, O., and Thom, K. (2016). From maize to haze: Agricultural shocks and the growth of the Mexican drug sector. *Journal of the European Economic Association*, 14(5):1181–1224.

Dube, O. and Vargas, J. F. (2013). Commodity price shocks and civil conflict: Evidence from Colombia. *Review of Economic Studies*, 80(4):1384–1421.

Erickson, M. and Owen, L. (2024). Blood avocados? trade liberalization and cartel violence in mexico. *Comparative Political Studies*, page 00104140241290198.

Estancona, C. and Tiscornia, L. (2023). From cocaine to avocados: Criminal market expansion and violence. Unpublished.

Ferraz, E., Soares, R., and Vargas, J. (2022). Unbundling the relationship between economic shocks and crime. In Buonanno, P., Vanin, P., and Vargas, J., editors, *A Modern Guide to the Economics of Crime*, chapter 8, pages 184–204. Edward Elgar Publishing.

Fisher, M. and Taub, A. (Jan. 18, 2018). Building a mini-state with avocados and guns. *The New York Times*.

Fjelde, H. (2015). Farming or fighting? Agricultural price shocks and civil war in Africa. *World Development*, 67:525–534.

France24 (Feb. 25, 2022). Mexico's avocado heartland held hostage by drug violence. *France24*.

Gambetta, D. and Reuter, P. (1995). Conspiracy among the many: Organized crime in legitimate industries. In Fiorentini, G. and Peltzman, S., editors, *The Economics of Organized Crime*, chapter 5, pages 116–139. Cambridge University Press, Cambridge.

Gehring, K., Langlotz, S., and Kienberger, S. (2023). Stimulant or Depressant? Resource-Related Income Shocks and Conflict. *The Review of Economics and Statistics*, pages 1–47.

Grüter, R., Trachsel, T., Laube, P., and Jaisli, I. (2022). Expected global suitability of coffee, cashew and avocado due to climate change. *PloS One*, 17(1):e0261976.

Herrera, J. S. and Martinez-Alvarez, C. B. (2022). Diversifying violence: Mining, export-agriculture, and criminal governance in Mexico. *World Development*, 151:105769.

Kellner, T. and Pipitone, F. (2010). Inside Mexico's drug war. *World Policy Journal*, 27(1):29–37.

Kenny, P. D., Shrestha, R., and Aspinall, E. (2020). Commodity booms, conflict, and organized crime: The economics of oil palm mafia violence in Indonesia. Working Paper 339, HiCN, Households in Conflict Network.

Lavezzi, A. M. (2008). Economic structure and vulnerability to organized crime: Evidence from sicily. *Global crime*, 9(3):198–220.

Linthicum, K. (Nov. 21, 2019). Inside the bloody cartel war for Mexico's multibillion-dollar avocado industry. *Los Angeles Times*.

McGuirk, E. and Burke, M. (2020). The economic origins of conflict in Africa. *Journal of Political Economy*, 128(10):3940–3997.

Mejia, D. and Restrepo, P. (2013). Bushes and bullets: Illegal cocaine markets and violence in Colombia. Working Paper 2013-53, Documento CEDE, Universidad de Los Andes.

Murphy, T. E. and Rossi, M. A. (2020). Following the poppy trail: Origins and consequences of Mexican drug cartels. *Journal of Development Economics*, 143:102433.

Nillesen, E. and Bulte, E. (2014). Natural resources and violent conflict. *Annual Review of Resource Economics*, 6(1):69–83.

Ornelas, R. G. (2018). Organized crime in Michoacán: Rent-seeking activities in the avocado export market. *Politics & Policy*, 46(5):759–789.

Osorio, J. and Beltran, A. (2020). Enhancing the detection of criminal organizations in Mexico using Machine Learning and Natural Language Processing. In *2020 International Joint Conference on Neural Networks (IJCNN)*, pages 1–7. IEEE.

Peterson, E. B. and Orden, D. (2008). Avocado pests and avocado trade. *American Journal of Agricultural Economics*, 90(2):321–335.

Pettersson, T. and Öberg, M. (2020). Organized violence, 1989–2019. *Journal of Peace Research*, 57(4):597–613.

Piemontese, L. (2023). Uncovering illegal and underground economies: The case of mafia extortion racketeering. *Journal of Public Economics*, 227:104997.

Reuter, P. (1987). *Racketeering in legitimate industries: A study in the economics of intimidation*. Rand Santa Monica, CA.

Rojas, I. and Schaefer, K. A. (2024). Expanding the phytosanitary exclusion zone for mexican avocados: Market impacts and unintended consequences. *Food Policy*, 129:102738.

SAGARPA (2011). Aguacate mexicano: Planeación agrícola nacional 2017-2030.

Schelling, T. C. (1971). What is the business of organized crime? *The American Scholar*, 40(4):643–652.

Schwab, B., Janzen, S., Magnan, N. P., and Thompson, W. M. (2020). Constructing a summary index using the standardized inverse-covariance weighted average of indicators. *The Stata Journal*, 20(4):952–964.

Shirk, D. and Wallman, J. (2015). Understanding Mexico's drug violence. *Journal of Conflict Resolution*, 59(8):1348–1376.

Soares, R. R. (2004). Development, crime and punishment: Accounting for the international differences in crime rates. *Journal of Development Economics*, 73(1):155–184.

Trejo, G. and Ley, S. (2018). Why did drug cartels go to war in Mexico? Subnational party alternation, the breakdown of criminal protection, and the onset of large-scale violence. *Comparative Political Studies*, 51(7):900–937.

USDA Animal & Plant Health Inspection Service (1997). Importation of fresh hass avocado fruit grown in michoacan, mexico. Federal Register, Vol. 62, No. 24, February 5, 1997. 62 FR 5293.

Van der Ploeg, F. (2011). Natural resources: Curse or blessing? *Journal of Economic Literature*, 49(2):366–420.

Viohl, F. (Mar. 3, 2020). Mexico's bloody fight over avocados. *Deutsche Welle*.

Yoo, H. (2022). Does "green gold" breed bloody violence? The effect of export shocks on criminal violence in Mexico. *Social Science Quarterly*, 103(5):1048–1060.

Appendix

A.1 Descriptive Statistics

Table A1: Descriptive Statistics - Municipalities by Suitability Index

	Avocado Suitability		
	0	1	Test
N	2,107 (85.1%)	368 (14.9%)	
Cultivated area (ha)	105.97 (413.10)	690.79 (2805.37)	<0.001
Avocado Production (Ton.)	813.91 (3816.18)	6793.44 (28722.07)	<0.001
Temperature (°C)	19.60 (4.20)	20.73 (2.67)	<0.001
Precipitation (mm)	996.33 (617.32)	1375.82 (341.42)	<0.001
Altitude (masl)	1286.79 (845.22)	1157.00 (679.24)	0.005
Area (sq. km)	878.20 (2288.10)	325.85 (512.22)	<0.001
Gini Index	0.41 (0.05)	0.40 (0.05)	<0.001
Poverty rate	37.40 (15.81)	32.64 (17.12)	<0.001
Literacy (%)	84.90 (10.10)	76.52 (12.29)	<0.001
Population (log.)	9.39 (1.55)	9.23 (1.29)	0.052
Homicides (1990-2019)	7.74 (30.12)	5.08 (17.42)	0.108
Drug cartel attacks (2000-2018)	12.85 (28.75)	10.95 (25.80)	0.406

Note: The Table presents the mean and standard deviation (in parentheses) for each of the variables across the sample period.

Table A2: Biophysical requirements of avocado

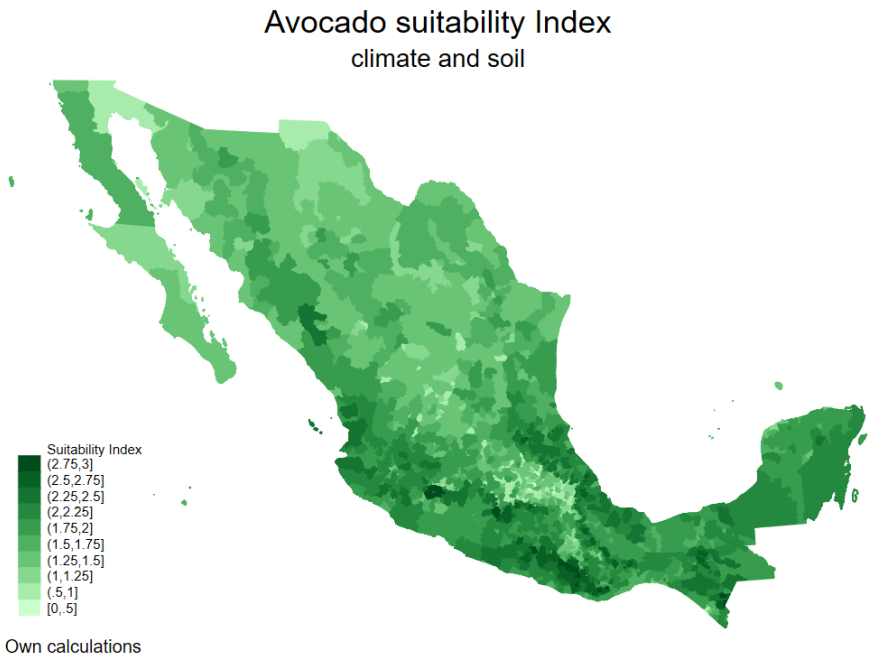
Criteria	S1	S2	S3	N
Climate				
Mean annual temperature (°C)	18–26	15–18; 26–30	10–15; 30–45	< 10; > 45
Mean minimum temperature of coldest month (°C)	> 16	13–16	8–13	< 8
Mean annual precipitation (mm)	1200–1800	1000–1200; 1800–2000	750–1000; 2000–2500	< 750; > 2500
Land and Soil				
Slope (%)	0–8	8–16	16–30	> 30
Soil texture	4–12	2–3	1	-
Soil pH	5–6.5	4.5–5; 6.5–7.5	4.3–4.5; 7.5–8.3	< 4.3; > 8.3
Soil salinity (ECe)	0–3	3–4	4–5	> 5
Depth of the soil profile (cm)	> 100	80–100	50–80	< 50
Organic matter (wt, %)	> 5.0	2.5–5.0	1.0–2.5	< 1.0
Cation Exchange Capacity (meq/100 g)	> 40	20–40	10–20	< 10
Height (msal)	1500–2000	800–1500	0–800; 2000–2500	> 2500

Soil texture classification follows USDA soil taxonomy: 1 = clay, 2 = silty clay, 3 = sandy clay, 4 = clay loam, 5 = silty clay loam, 6 = sandy clay loam, 7 = loam, 8 = silty loam, 9 = sandy loam, 10 = silt, 11 = loamy sand, 12 = sand.

Source: Grüter et al. (2022).

Figure A1: Climate and soil suitability index, and production of avocados of Mexican municipalities

(a) Suitability index



(b) Real production

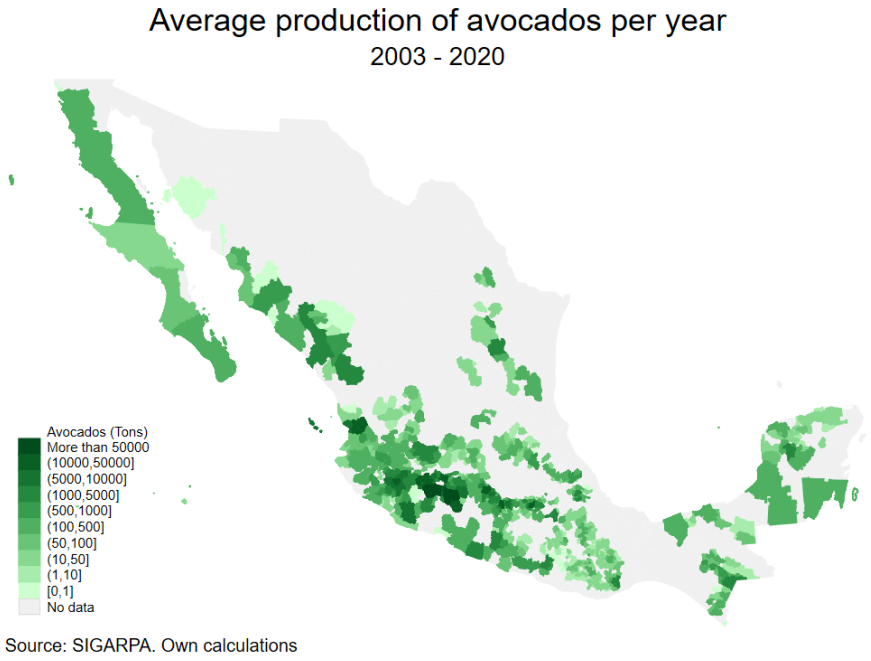


Figure A2: Suitability index and production of avocados in Mexican municipalities

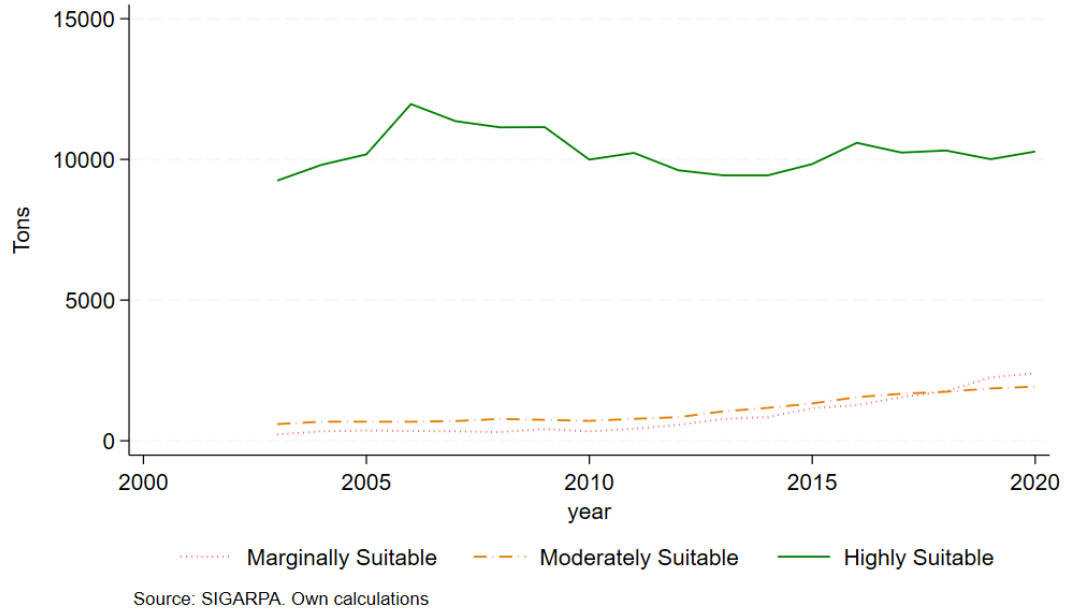
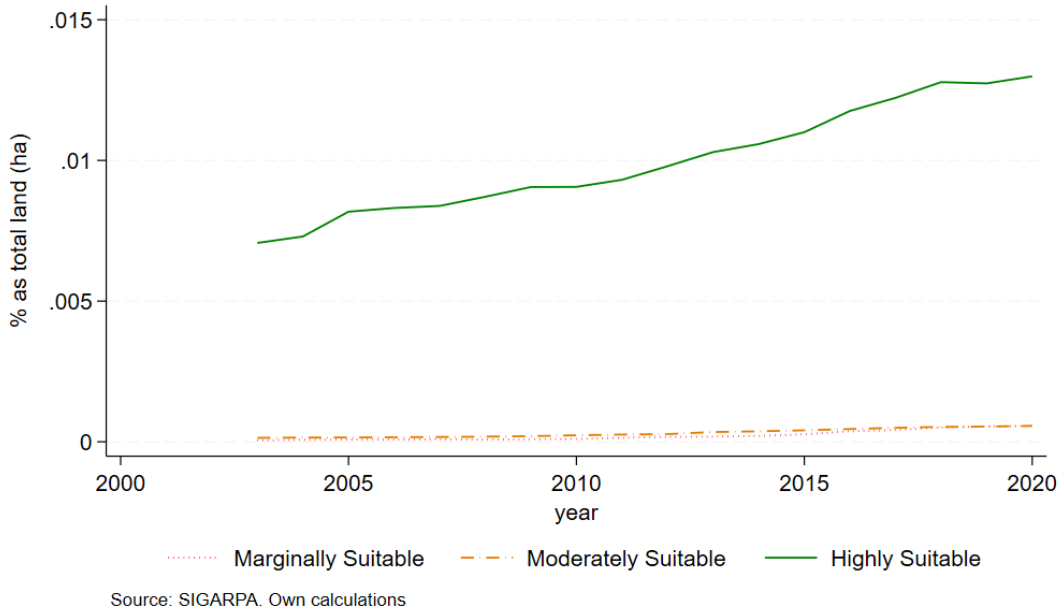


Table A3: Soil and climatic suitability index and actual avocado production

	Total production of avocados in municipality m in year t				
	Only Suitability		Suitability and Price		
	(1)	(2)	(3)	(4)	(5)
Moderately suitable (S2)	-0.38	-0.38	-0.28	-0.29	
	(0.44)	(0.43)	(0.39)	(0.39)	
Highly suitable (S1)	9.06**	9.03**	9.49***	9.50***	
	(3.35)	(3.36)	(3.44)	(3.44)	
Municipality area ha (log)	1.15**	1.16**	1.16**	1.17***	
	(0.45)	(0.45)	(0.45)	(0.45)	
Avocado price (lag)			0.69***		
			(0.22)		
Moderately suitable (S2) × Avocado price (lag)			-0.15	-0.15	0.04
			(0.24)	(0.24)	(0.24)
Highly suitable (S1) × Avocado price (lag)			-0.69	-0.70	1.74**
			(0.56)	(0.56)	(0.83)
Observations	9032	9032	9032	9032	9007
Year F.E.	No	Yes	No	Yes	Yes
Municipality F.E.	No	No	No	No	Yes
Sample mean of Y	2.96	2.96	2.96	2.96	2.96

Base category is Marginally suitable (S3) index. Two-way clustered standard errors at the municipality and year level in parenthesis. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Figure A3: Suitability index and land cultivated with avocados in Mexican municipalities



Source: SIGARPA. Own calculations

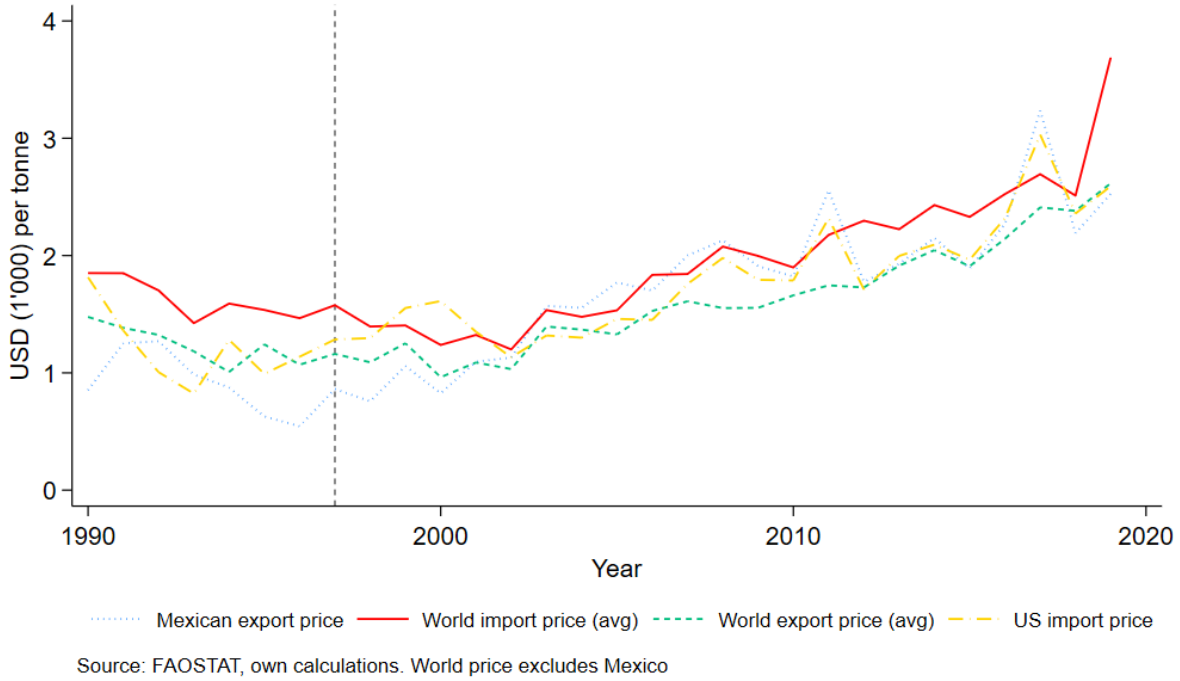
Table A4: Soil and climatic suitability index and actual avocado planted area

	Total planted area (ha) in municipality m in year t				
	Only Suitability		Suitability and Price		
	(1)	(2)	(3)	(4)	(5)
Moderately suitable (S2)	-59.27	-59.57	-42.39	-42.65	
	(53.40)	(53.31)	(44.60)	(44.91)	
Highly suitable (S1)	871.19**	867.99**	931.96**	931.55***	
	(328.92)	(329.21)	(337.84)	(341.64)	
Municipality area ha (log)	120.22**	122.11**	121.84**	122.25***	
	(44.27)	(44.27)	(44.47)	(44.17)	
Avocado price (lag)			82.99***		
			(27.95)		
Moderately suitable (S2) × Avocado price (lag)			-26.80	-26.88	4.36
			(27.14)	(32.34)	(25.89)
Highly suitable (S1) × Avocado price (lag)			-96.51***	-96.59	154.84*
			(21.14)	(62.46)	(76.24)
Observations	9032	9032	9032	9032	9007
Year F.E.	No	Yes	No	Yes	Yes
Municipality F.E.	No	No	No	No	Yes
Sample mean of Y	319	319	319	319	320

Base category is Marginally suitable (S3) index. Two-way clustered standard errors at the municipality and year level in parenthesis. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

A.3 Avocado price measures

Figure A4: World import price and other price measures



Source: FAOSTAT, own calculations. World price excludes Mexico

A.4 Homicides: Interaction with lead price ($t+1$)

Table A5: Effect of avocado suitability and world (import) prices on homicide rate

	Homicide rate in municipality m in year t (1998-2019)					
	(1)	(2)	(3)	(4)	(5)	(6)
Avocado price (lag)	6.59***	6.30***				
	(1.61)	(1.63)				
Suitability Index=1 × Avocado price (lag)	-3.90**	-4.02**	-3.90**	-4.03**	-2.96*	-3.03*
	(1.62)	(1.64)	(1.62)	(1.65)	(1.71)	(1.72)
Suitability Index=1 × Avocado price (lead)	0.39	0.37	0.39	0.36	1.49	1.41
	(1.32)	(1.33)	(1.32)	(1.33)	(1.44)	(1.42)
Observations	49602	49602	49602	49602	49602	49602
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.			Yes	Yes	Yes	Yes
State time trend					Yes	Yes
Controls		Yes		Yes		Yes
Sample mean of Y	15.9	15.9	15.9	15.9	15.9	15.9

Outcome: number of homicides per 100,000 population in the municipality. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

A.5 Drug cartel attacks: Pseudo-Poisson likelihood estimation

Table A6: Effect of avocado suitability and world price on drug cartel violent attacks

	No. of attacks in municipality m (2000-2018)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	0.06	0.02			
	(0.22)	(0.23)			
Avocado price (lag)	0.42		0.50		
	(0.30)		(0.30)		
Suitability Index=1 × Avocado price (lag)	0.07***	0.12***	0.04	0.08*	-0.24***
	(0.01)	(0.02)	(0.03)	(0.05)	(0.08)
Observations	46132	46132	27189	27189	27189
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y (Suitability = 0)	4.93	4.93	8.17	8.17	8.17

Fixed effects models are estimated with Poisson pseudo-likelihood regression with multiple levels of fixed effects. Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

A.6 Crimes 2011 - 2022

Mexico's Executive Secretariat of the National System of Security (SESNSP) data that collect information on the number of reported crimes at the municipality level starts in 2011. Starting in 2018, SESNSP made a change in the mathodology and classification of crimes into different categories. In an attempt to harmonize the old and new classification, I went through all types of crimes and assigned them into the standard categories I use in my analysis. Here I present the results of the estimation that covers the period after the change in methodology in 2017 and expands the analysis up to 2022.

Table A7 presents the results for all municipalities in Mexico. Results show a reduction in the overall index of criminality in higjly suitable municipalities, suggesting evidence of a reduction not only in homicides and drug cartel attacks, but also in crimes. Results by type of crime show a decrease in reported threats and an increase in kidnaps in highly suitable municipalities. However, I cannot rule out whether the results are mainly driven by the effect of avocado prices or by the change in methodology and the classification of crimes into different categories.

Table A7: Effect of avocado suitability and world price on number of crimes (by type)

	Crimes per 100,000 pop. in municipality m in year t (2011-2022)							
	Crime	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Index	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-0.05**	-0.33	-1.33**	1.07***	4.39	-9.35	-7.02	-3.44**
	(0.02)	(0.20)	(0.53)	(0.33)	(4.63)	(6.19)	(7.96)	(1.37)
Observations	20015	20015	20015	20015	20015	20015	20015	20015
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y (Suitability = 0)	.0265	2.83	11.3	17.9	150	164	280	42.1

Outcome: number of reported non-lethal crimes per 100,000 population in the municipality. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A8 below presents the results for crimes in Michoacán in the period 2011-2022. The crime index shows that criminality in export-oriented municipalities increased during this period. The increase in criminality is mainly driven by more cases of threats, with a possibly increase in crime property as well (although estimates for robbery and theft are less precisely estimated).

Table A8: Effect of avocado suitability and world price on crime rate (by type) - Michoacán

	Crime rate in municipality m in year t (2011-2022)							
	Crime	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Index	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-0.30***	-0.34	-11.31***	-5.04	-22.79*	-25.77	22.26	-10.65*
	(0.07)	(0.31)	(2.31)	(5.63)	(11.10)	(17.92)	(22.20)	(5.12)
USDA=1 × Avocado price (lag)	0.08	-0.34	1.67	7.25**	14.09	13.34	0.34	-5.95
	(0.06)	(0.45)	(2.08)	(2.50)	(11.13)	(14.26)	(10.30)	(3.97)
Suitability Index=1 × USDA=1 × Avocado price (lag)	0.27**	-0.71	17.47***	-1.80	24.60	44.02	-44.11	14.21*
	(0.12)	(0.48)	(4.88)	(7.04)	(20.37)	(26.56)	(37.34)	(7.54)
Observations	940	940	940	940	940	940	940	940
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	-.0177	1.26	15.7	29.1	89.9	109	117	21.1
Test p-val: $\beta 6 + \beta 7 = 0$	.00484	.13	.00127	.449	.0823	.03	.221	.225

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

A.7 Robustness checks

A.7.1 Robustness checks of results in Section 4

Comparing outcomes in same time period

As a first check, I compare the different outcomes -homicides, drug cartel attacks, and non-lethal crimes- using the same time window. Unfortunately, there is no municipal-level data for all outcomes since 1990 (only for homicides), and the results in section 4 exploit all the available years for each outcome, which differs depending on the data source. First, I compare the homicide rate and the drug cartel attacks rate for the period 2000-2018, which is the period covered by the OCVED project data (years with data on drug cartel attacks). Table A9 shows that the coefficient for the homicide rate is negative and statistically significant in this restricted time frame as well, following the same pattern of the period 1990-2019 for which there is full available data on homicides.

Table A9: Homicide and Drug Cartel Attacks rate (2000-2018)

	Homicide rate		Attacks rate	
	(1)	(2)	(3)	(4)
Suitability Index=1 × Avocado price (lag)	-3.07***	-1.34*	-11.77**	-3.29*
	(0.79)	(0.64)	(4.67)	(1.72)
Observations	44878	44878	46132	46132
Controls	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes
State time trend		Yes		Yes
Sample mean of Y	16.2	16.2	26.3	26.3

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Second, I compare all the outcomes within the period 2011-2017, for which there is information on all outcomes.[31] Results are presented in Table A10 and show no statistically effect on homicides or attacks. Unfortunately, in this reduced time period the coefficient is not precisely estimated and I cannot reject the null of similar violence patterns among high- and low-suitable municipalities.

Table A10: Homicide, Drug C. Attacks, and Crime rate (2011-2017)

	Homicide	Attacks	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-0.39	3.85	-0.20	1.97	1.23	14.91	3.39	32.79	7.47
	(2.35)	(8.80)	(0.33)	(2.64)	(2.72)	(16.03)	(8.78)	(24.47)	(6.62)
Observations	16534	16996	12731	12731	12731	12731	12731	12731	12731
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	20.6	38.6	2.63	10.3	22.7	164	165	263	34

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Alternative measures of the outcome variable

I also evaluate the robustness of the results to alternative measures of the outcome variables. I measure the outcomes as the log. transformation of the number of cases (homicides, drug cartel attacks, crimes) rather than the number of cases per 100'000 people., and then I do the same but with the inverse hyperbolic sine ($asinh$) transformation of the number of cases. The results for the number of homicides are robust to these transformations (Tables A11 and A12), and roughly indicate a reduction of 3%, on average, in the number of homicides in municipalities that are highly suitable for avocado-growing. The results for the number of drug cartel attacks (Tables A13 and A14) are robust as well when the estimation includes year and municipality fixed effects, but fail to be statistically significant at the 10% for the estimation that includes the state time trend.

In the case of crimes, the results show a statistically significant effect for some of the crimes, in particular when measured as $log(crime)$ (Table A15).[32] The estimated

[31] Municipal-level crime data starts in 2011 but I restrict the analysis to 2017 because of the change in the Secretariat of the National System of Security's (SESNSP) methodology for classifying crimes after that year.

[32] Results in the main estimation (Table 5, Section 4) indicate no difference in non-lethal crimes between high- and low-suitable municipalities.

coefficients are all negative (indicating a reduction in criminality in highly suitable municipalities) and statistically significant for extortion, threats, and theft. With the *asinh* transformation the coefficients are also negative, although not significant. Taken together, these results would further validate the findings in the main section of a reduction in violence in highly suitable municipalities. I keep the number of cases per 100'000 pop. as the main estimation as it is common practice in the literature and in policy to report crimes this way.

Log. of homicides

Table A11: Effect of avocado suitability and world price on homicides (log)

	(Log of) Homicides in municipality m in year t (1990-2019)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	0.09**	0.09**			
	(0.04)	(0.04)			
Avocado price (lag)	0.15***		0.13***		
	(0.02)		(0.02)		
Suitability Index=1 × Avocado price (lag)	-0.09***	-0.09***	-0.09***	-0.09***	-0.03*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Observations	68498	68498	68498	68498	68498
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y	1.04	1.04	1.04	1.04	1.04

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Asinh of homicides

Table A12: Effect of avocado suitability and world price on homicides (asinh)

	Homicides (asinh) in municipality m in year t (1990-2019)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	0.12**	0.12**			
	(0.04)	(0.04)			
Avocado price (lag)	0.18***		0.15***		
	(0.03)		(0.03)		
Suitability Index=1 × Avocado price (lag)	-0.10***	-0.10***	-0.10***	-0.10***	-0.03*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Observations	68498	68498	68498	68498	68498
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y	1.3	1.3	1.3	1.3	1.3

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Log. of drug-cartel attacks

Table A13: Effect of avocado suitability and world price on drug cartel attacks (log)

	Log. of attacks in municipality m (2000-2018)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	-0.06*	-0.06*			
	(0.03)	(0.03)			
Avocado price (lag)	0.20***		0.16***		
	(0.04)		(0.04)		
Suitability Index=1 × Avocado price (lag)	-0.06***	-0.06***	-0.06***	-0.06***	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Observations	46132	46132	46132	46132	46132
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y	.421	.421	.421	.421	.421

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Asinh of drug-cartel attacks

Table A14: Effect of avocado suitability and world price on drug cartel attacks (asinh)

	Asinh transf. of attacks in municipality m (2000-2018)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	-0.08*	-0.08*			
	(0.04)	(0.04)			
Avocado price (lag)	0.24***		0.20***		
	(0.04)		(0.04)		
Suitability Index=1 × Avocado price (lag)	-0.08***	-0.08***	-0.07***	-0.07***	-0.03
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Observations	46132	46132	46132	46132	46132
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y	.515	.515	.515	.515	.515

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Log. of crimes

Table A15: Effect of avocado suitability and world price on crimes (log. of)

	Log. of crimes in municipality m in year t (2011-2017)						
	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-0.11**	-0.10**	-0.04	-0.05	-0.14*	0.01	0.02
	(0.04)	(0.04)	(0.03)	(0.06)	(0.06)	(0.05)	(0.04)
Observations	12731	12731	12731	12731	12731	12731	12731
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	.538	.886	1.59	3.03	2.92	3.49	1.67

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Asinh of crimes

Table A16: Effect of avocado suitability and world price on crimes (asinh)

	Asinh of crimes in municipality m in year t (2011-2017)						
	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-0.08	-0.09	-0.03	0.02	-0.09	0.06	0.13
	(0.05)	(0.06)	(0.04)	(0.09)	(0.10)	(0.06)	(0.07)
Observations	12731	12731	12731	12731	12731	12731	12731
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	.671	1.11	1.97	3.55	3.41	4.06	2.02

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Exclusion of years and states

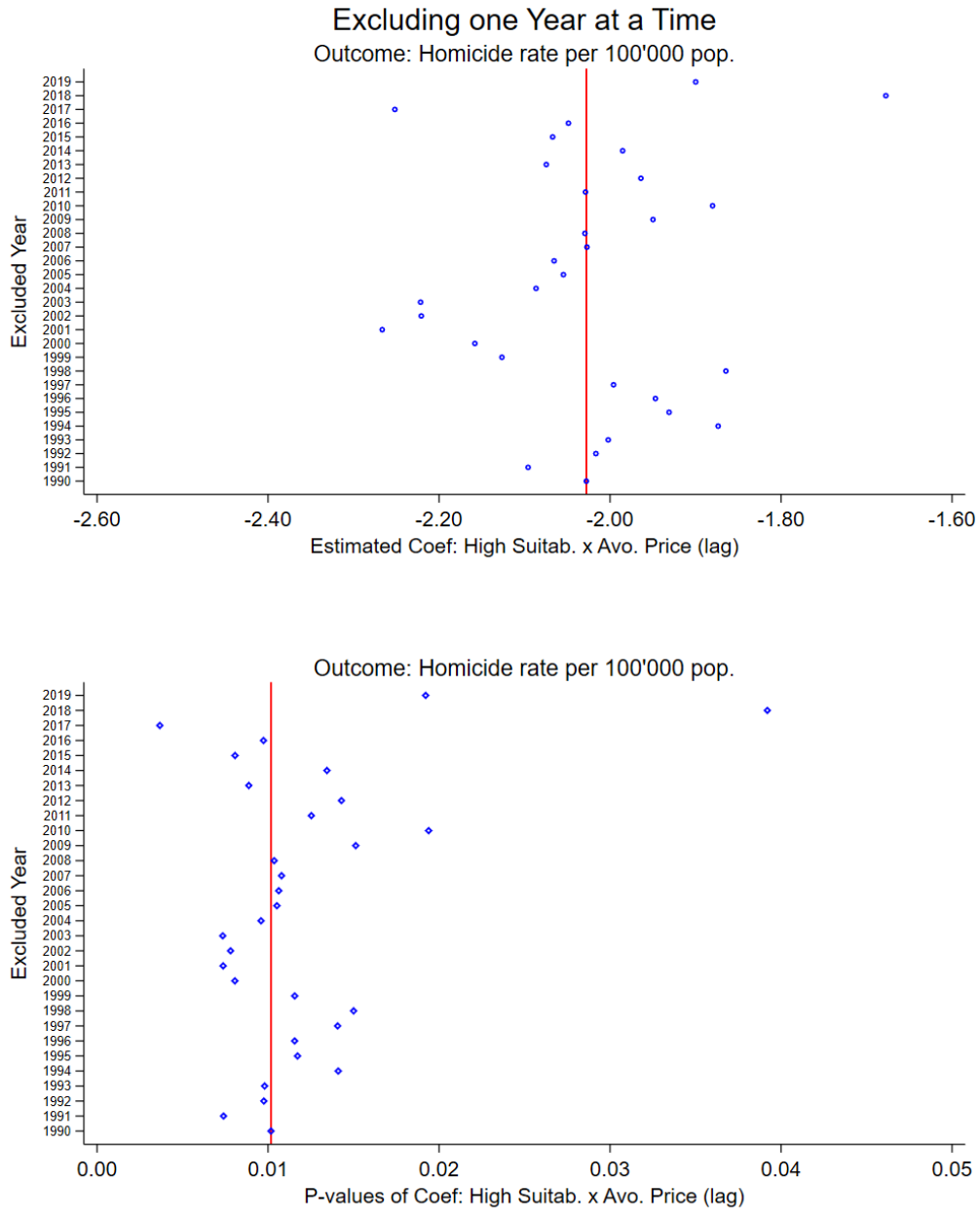
As a third robustness check, I estimate equation 1 excluding one year at a time, and excluding one state at a time, to check if there are years or states that are potentilly driving the results. I plot the coefficient and the p-values of the estimations that exclude one year at a time, and compare them to the coefficient and the p-value of the main estimation. The results for the homicide rate (Fig. A5) are robust to the exclusion of years, showing that the results are not driven by a particular time. All the p-values lie within the 5% significance level and the coefficients are centered around the main estimation result. In the case of the drug cartel attacks (Fig. A6), the results show a bit more of variability and sensitivity to the exclusion of a few years (2002, 2003, 2010, and 2018). All coefficients are negative as in the main estimation, but for those specific years they fail to be statistically significant at the 10% (although they are fairly close to the thereshold).

I then conduct the same check, but to the exclusion of each of the 32 states of Mexico at a time. The results for the homicide rate (Fig. A7 are highly robust to the exclusion of individual states and are precisely estimated. The only exception is when the estimation excludes the state of Oaxaca, where the estimated β is close to zero and statistically non significant. This can be due to the fact that Oaxaca is divided into 570 municipalities, almost a quarter of all the 2460 municipalities across Mexico. The result excluding Oaxaca would indicate a potential lack of power after dropping more than 20% of the observations with respect to the main estimation. The results for the drug cartel attacks (Fig. A8) follow a similar pattern: when excluding Oaxaca the coefficient is not significant. This is also the case of Chiapas, Coahuila, and Yucatán. Overall, out of the 32 states the results for the drug cartel attacks are highly robust.

Excluding one year at a time

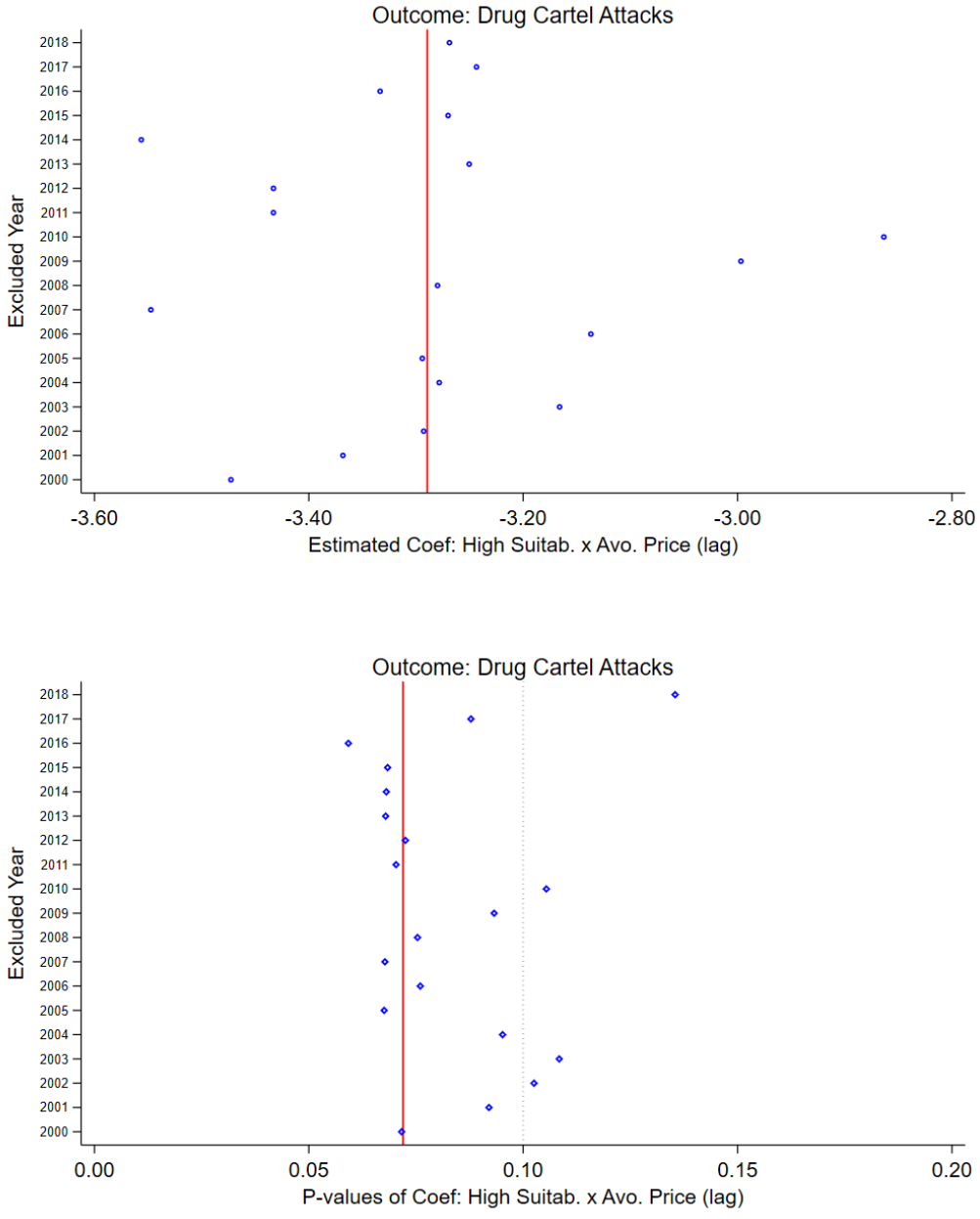
Homicides

Figure A5: Coefficients and p-values of regressions excluding one year at a time



Drug cartel attacks

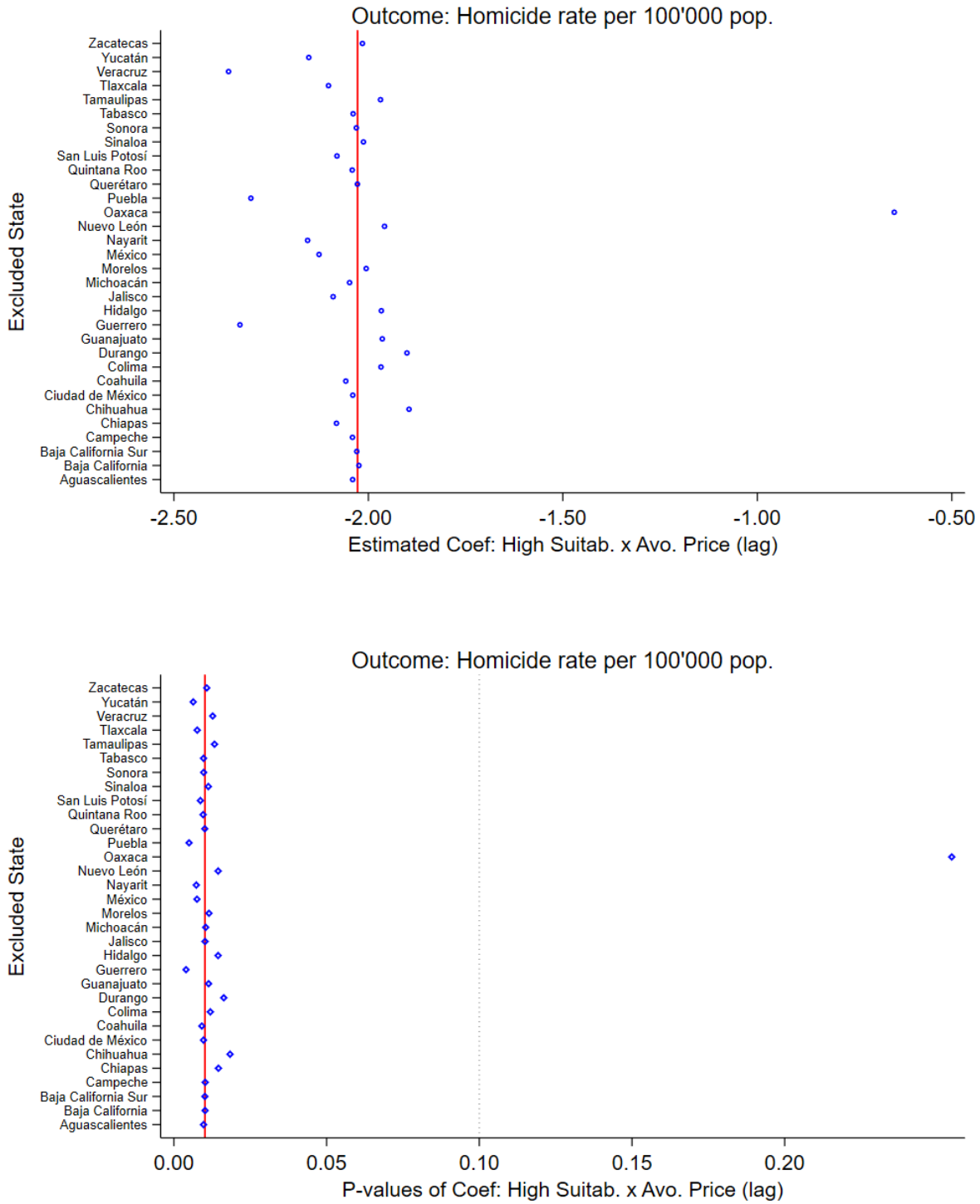
Figure A6: Coefficients and p-values of regressions excluding one year at a time



Excluding one state at a time

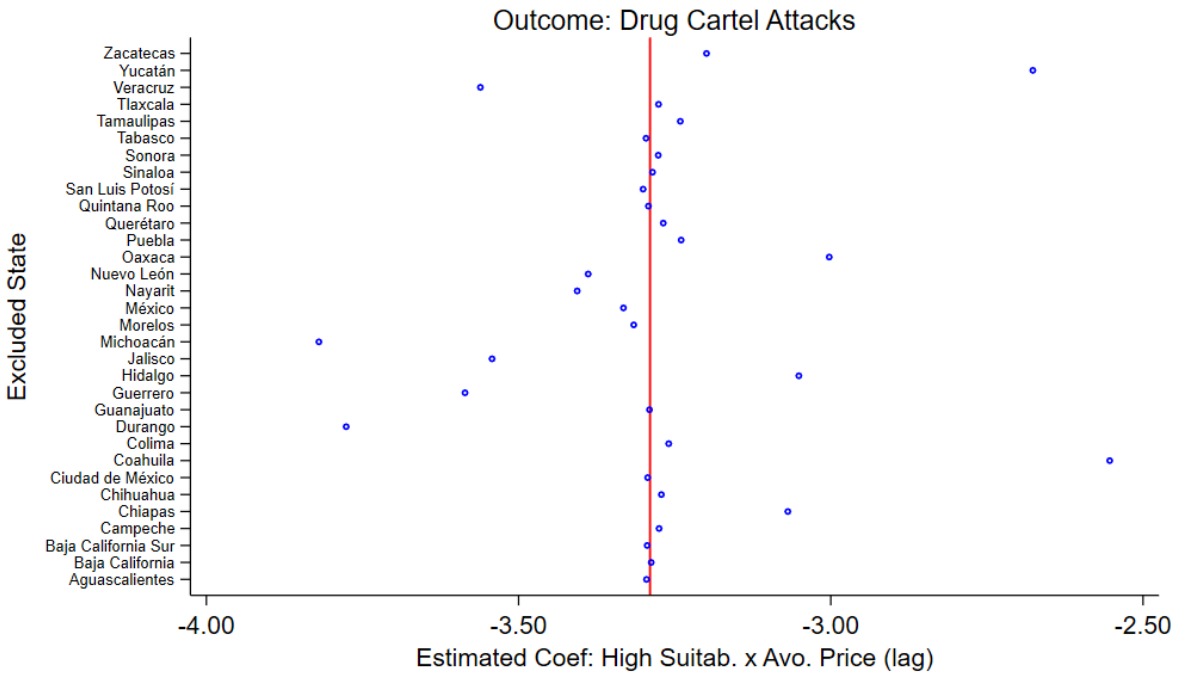
Homicides

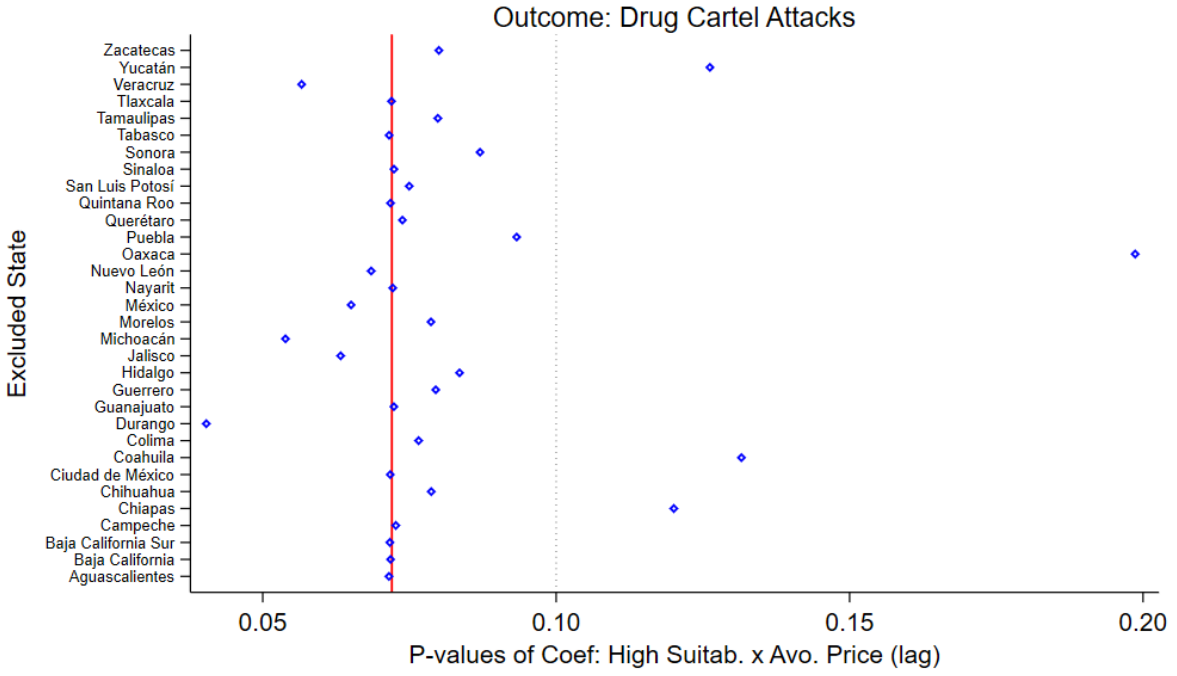
Figure A7: Coefficients and p-values of regressions excluding one state at a time



Drug cartel attacks

Figure A8: Coefficients and p-values of regressions excluding one state at a time





Clustered standard errors at the state level

My main estimation strategy clusters the standard errors at the municipality and year level (two-way clustering). Here, I conduct a most conservative estimation that clusters the standard errors at the state level. Table A17 and Table A18 show that the estimation on the homicide rate is robust as well to this conservative clustering approach. The results for the drug cartel attacks rate in Table A19 confirm as well the robustness of the estimation for this outcome. Table A20 presents the results for crimes.

Homicides

Table A17: Effect of avocado suitability and world price on homicide rate (per 100,000 pop.)

	Homicide rate in municipality m in year t (1990-2019)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	4.94	4.95			
	(4.28)	(4.29)			
Avocado price (lag)	6.13***		5.13***		
	(1.01)		(0.82)		
Suitability Index=1 × Avocado price (lag)	-4.66***	-4.64***	-4.73***	-4.71***	-2.03*
	(1.65)	(1.63)	(1.69)	(1.68)	(1.08)
Observations	68498	68498	68498	68498	68498
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y	16.7	16.7	16.7	16.7	16.7

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Clustered standard errors at the state level are reported in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A18: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.)

	Homicide rate in municipality m in year t (1990-2019)							
	Before (1990-1997)				After (1998-2019)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Suitability Index=1	15.61**				2.53			
	(6.65)				(3.80)			
Avocado price (lag)		2.33				4.86***		
		(2.10)				(1.56)		
Suitability Index=1 × Avocado price (lag)	2.67*	2.73*	2.54*	1.04	-3.59**	-3.70**	-3.71**	-1.74**
	(1.38)	(1.35)	(1.34)	(1.28)	(1.38)	(1.42)	(1.42)	(0.83)
Observations	16534	16534	16534	16534	51964	51964	51964	51964
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes		Yes	Yes	Yes		Yes	Yes
Municipality F.E.		Yes	Yes	Yes		Yes	Yes	Yes
State time trend				Yes				Yes
Sample mean of Y	17.9	17.9	17.9	17.9	16.3	16.3	16.3	16.3

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Clustered standard errors at the state level are reported in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Attacks by drug cartels

Table A19: Effect of avocado suitability and world price on rate of drug cartel attacks (per 100,000 pop.)

	Attacks rate in municipality m (2000-2018)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	-19.54**	-19.43**			
	(8.26)	(8.24)			
Avocado price (lag)	13.86**		18.70**		
	(5.44)		(8.19)		
Suitability Index=1 × Avocado price (lag)	-10.65**	-10.74**	-11.61**	-11.77**	-3.29**
	(4.84)	(4.82)	(5.22)	(5.24)	(1.32)
Observations	46132	46132	46132	46132	46132
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y	26.3	26.3	26.3	26.3	26.3

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Clustered standard errors at the state level are reported in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Crimes

Table A20: Effect of avocado suitability and world price on crime rate (by type)

	Crime rate in municipality m in year t (2011-2017)						
	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-0.20	1.97	1.23	14.91	3.39	32.79	7.47
	(0.33)	(2.33)	(2.15)	(19.75)	(12.71)	(30.20)	(7.53)
Observations	12731	12731	12731	12731	12731	12731	12731
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	2.63	10.3	22.7	164	165	263	34

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Clustered standard errors at the state level are reported in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Wild Cluster Bootstrap (WCB) p-values and CI

Below report the results of a wild bootstrap estimation (Cameron et al., 2008) with 1000 random repetitions with clustering at the municipality level. The bootstrap p-values and confidence intervals of both the estimation on the homicide rate (Table A21) and the drug cartel attacks per 100'000 population (Table A22) report similar and robust statistical significance as in the main estimation.

Homicides

Table A21: Homicide rate (per 100'000 pop.) - Wild bootstrap inference

	Coef	t-stat	Bootstr. p-value	[95% conf.	interval]
1990 - 2019					
High Suitab. x Avocado price (lag)	-2.03	-3.43	0.002	-3.254	-0.914
1990 - 1997					
High Suitab. x Avocado price (lag)	1.04	0.18	0.922	-8.214	10.231
1998 - 2019					
High Suitab. x Avocado price (lag)	-1.74	-3.08	0.002	-2.830	-0.664

The table reports the wild bootstrap estimation using 1000 repetitions for a regression where the dependent variable is the homicide rate (per 100'000 pop.) and the estimation method is OLS regression with high-dimensional fixed effects. The estimation follows the same dependent and indepedent variables as in the main estimation.

Drug cartel attacks

Table A22: Drug cartel attacks (per 100'000 pop.)- Wild bootstrap inference

	Coef	t-stat	Bootstr. p-value	[95% conf.	interval]
Drug cartel attacks					
High Suitab. x Avocado price (lag)	-3.29	-1.77	0.058	-6.619	0.170

The table reports the wild bootstrap estimation using 1000 repetitions for a regression where the dependent variable is the rate of drug cartel attacks (per 100'000 pop.) and the estimation method is OLS regression with high-dimensional fixed effects. The estimation follows the same dependent and indepedent variables as in the main estimation.

Permutation of the Suitability Index

As a sixth check, I validate whether the results of the main estimation are sensitive to 1000 random permutations of the suitability index across municipalities. The squared brackets [] contain the p-value of the regressions with the permutation test. Table A23 shows that the homicide rate results are robust to the random permutations, reassuring of the causality of the results found in Tables 2 and 3 in section 4. In the case of drug cartel attacks, results in Table A24 show that the estimation that includes the state time trend is sensitive to the permutations of the suitability index. In more than 67% of the random permutations, the simulation predicted a placebo coefficient that is larger (in absolute value) than the one using real suitability index, threatening the validity of the results on a reduction in the rate of drug cartel attacks in highly suitable municipalities.

Homicides

Table A23: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.)

	Homicide rate in municipality m in year t					
	All years		Before (1990-1997)		After (1998-2019)	
	(1)	(2)	(3)	(4)	(5)	(6)
Suitability Index=1 × Avocado price (lag)	-4.71	-2.03	2.54	1.04	-3.71	-1.74
	(0.00)	(0.01)	(0.54)	(0.80)	(0.00)	(0.01)
	[0.00]	[0.00]	[0.30]	[0.64]	[0.00]	[0.00]
Observations	68498	68498	16534	16534	51964	51964
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes
State time trend		Yes		Yes	No	Yes
Sample mean of Y	17.4	17.4	19.9	19.9	16.6	16.6

The table presents the results of a permutation test of the Suitability Index with 1000 random permutations, where the dependent variable is the homicide rate. The parentheses ( ) present the p-value of the original estimation. The squared brackets [ ] contain the p-value of the regressions with the permutation test. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the state and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Drug cartel attacks

Table A24: Effect of avocado suitability and world price on attacks rate (per 100'000 pop.)

	Rate of attacks	
	(1)	(2)
Suitability Index=1 × Avocado price (lag)	-11.77	-3.29
	(0.02)	(0.07)
	[0.15]	[0.67]
Observations	46132	46132
Controls	Yes	Yes
Year F.E.	Yes	Yes
Municipality F.E.	Yes	Yes
State time trend		Yes
Sample mean of Y	23.8	23.8

The table presents the results of a permutation test of the Suitability Index with 1000 random permutations, where the dependent variable is the rate of drug cartel attacks. The parentheses ( ) present the p-value of the original estimation. The squared brackets [ ] contain the p-value of the regressions with the permutation test. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the state and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Alternative definitions of the suitability index

My suitability index consist of climatic and soil requirements for the optimal production of avocados. Nevertheless, for some municipalities there is no information on soil characteristics, and as Grüter et al. (2022) note, climate requirements are (e.g. rainfall, temperature) more important limiting factors than land and soil requirements when assessing the suitability to grow different types of crops, including avocados. Moreover, De Haro-Lopez (2023, 2024) uses only temperature and precipitation data to construct her avocado suitability index. Therefore, below I present the results of estimating equation 1 using only the climatic component of the suitability index.

Climatic suitability index

Results for the homicide rate in Tables A25 and A26 show that the magnitude and statistically significance of the interaction coefficient of the (climatic) suitability index and the avocado price (lag) is mostly the same as in the main estimation. Table A27 presents the results on the estimation of drug cartel attacks, and Table A28 for non-lethal crimes. The results show less robust results. In the case of the rate of drug cartel attacks, the coefficient in the estimation that includes the state time trend (Col. 5) is no longer statistically significant, although the magnitude of the coefficient is similar to the main estimation and the direction indicates a reduction in drug cartel attacks.

Table A25: Effect of avocado suitability and world price on homicide rate (per 100,000 pop.)

	Homicide rate in municipality m in year t (1990-2019)				
	(1)	(2)	(3)	(4)	(5)
High Suitability (clim.)=1	5.30***	5.31***			
	(1.42)	(1.42)			
Avocado price (lag)	6.22***		5.25***		
	(0.85)		(0.79)		
High Suitability (clim.)=1 × Avocado price (lag)	-4.28***	-4.29***	-4.34***	-4.35***	-2.00**
	(0.97)	(0.97)	(0.99)	(0.99)	(0.75)
Observations	68498	68498	68498	68498	68498
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y	16.7	16.7	16.7	16.7	16.7

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A26: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.)

	Homicide rate in municipality m in year t (1990-2019)							
	Before (1990-1997)				After (1998-2019)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
High Suitability (clim.)=1	16.13***				2.84**			
	(2.35)				(1.10)			
Avocado price (lag)		2.17				4.91***		
		(2.05)				(1.13)		
High Suitability (clim.)=1 × Avocado price (lag)	2.96*	3.02	2.86	1.86	-3.19***	-3.32***	-3.33***	-1.60**
	(1.36)	(3.06)	(3.10)	(3.29)	(0.71)	(0.74)	(0.74)	(0.57)
Observations	16534	16534	16534	16534	51964	51964	51964	51964
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes		Yes	Yes	Yes		Yes	Yes
Municipality F.E.		Yes	Yes	Yes		Yes	Yes	Yes
State time trend				Yes				Yes
Sample mean of Y	17.9	17.9	17.9	17.9	16.3	16.3	16.3	16.3

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A27: Effect of avocado suitability and world price on drug cartel violent attacks

	Attacks rate in municipality m (2000-2018)				
	(1)	(2)	(3)	(4)	(5)
High Suitability (clim.)=1	-15.19**	-15.16**			
	(6.32)	(6.20)			
Avocado price (lag)	13.98***		18.75**		
	(3.35)		(7.55)		
High Suitability (clim.)=1 × Avocado price (lag)	-8.97*	-8.96**	-9.81*	-9.88*	-1.72
	(4.27)	(4.18)	(4.77)	(4.80)	(2.02)
Observations	46132	46132	46132	46132	46132
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y	26.3	26.3	26.3	26.3	26.3

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A28: Effect of avocado suitability and world price on number of crimes (by type)

	Crime rate in municipality m in year t (2011-2017)						
	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
High Suitability (clim.)=1 × Avocado price (lag)	-0.05	0.81	0.65	5.44	0.79	35.32	2.69
	(0.46)	(2.10)	(2.20)	(13.16)	(7.23)	(20.99)	(5.36)
Observations	12731	12731	12731	12731	12731	12731	12731
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	2.63	10.3	22.7	164	165	263	34

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Continuous measure of the suitability index

I also estimate the main equation using the continuous measure of the suitability index. Remember that the suitability index goes from 0 to 3, and in the main estimation I use a categorical variable for highly suitable municipalities, those with an index of 2.5 or more. Table A29 and Table A30 for homicides show that the coefficient of the interaction between the continuous suitability index and the lagged avocado price is negative and statistically significant, as in the main estimation. Although the magnitude is lower, the results show that municipalities that are more suitable to produce avocados experience a reduction in the homicide rate per 100'000 pop. when the international import price of avocado increases by one standard deviation. This result is statistically significant at the 5%. In the main specification I use the binary variable for ease of interpretation. Results for drug cartel attacks and non-lethal crimes exhibit the same non-significant results as with the climatic component of the suitability index.

Table A29: Effect of avocado suitability and world price on homicide rate (per 100,000 pop.)

	Homicide rate in municipality m in year t (1990-2019)				
	(1)	(2)	(3)	(4)	(5)
suitability_cont	5.21***	5.22***			
	(1.05)	(1.05)			
Avocado price (lag)	11.53***		11.13***		
	(1.73)		(1.72)		
suitability_cont × Avocado price (lag)	-3.26***	-3.27***	-3.58***	-3.61***	-1.14**
	(0.77)	(0.77)	(0.82)	(0.82)	(0.54)
Observations	68498	68498	68498	68498	68498
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y	16.7	16.7	16.7	16.7	16.7

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A30: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.)

	Homicide rate in municipality m in year t (1990-2019)							
	Before (1990-1997)				After (1998-2019)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
suitability_cont	13.54***				3.26***			
	(1.22)				(0.88)			
Avocado price (lag)		-1.23				9.47***		
		(4.05)				(1.89)		
suitability_cont × Avocado price (lag)	1.56	2.09	1.81	0.41	-2.30***	-2.76***	-2.79***	-1.27**
	(1.71)	(2.09)	(2.18)	(2.21)	(0.63)	(0.69)	(0.69)	(0.50)
Observations	16534	16534	16534	16534	51964	51964	51964	51964
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes		Yes	Yes	Yes		Yes	Yes
Municipality F.E.		Yes	Yes	Yes		Yes	Yes	Yes
State time trend				Yes				Yes
Sample mean of Y	17.9	17.9	17.9	17.9	16.3	16.3	16.3	16.3

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A31: Effect of avocado suitability and world price on drug cartel violent attacks

	Attacks rate in municipality m (2000-2018)				
	(1)	(2)	(3)	(4)	(5)
suitability_cont	-12.14	-12.10			
	(8.29)	(8.29)			
Avocado price (lag)	28.51***		36.88**		
	(9.40)		(16.81)		
suitability_cont × Avocado price (lag)	-8.70	-8.69	-10.63	-10.79	-4.03
	(5.40)	(5.41)	(6.63)	(6.66)	(3.41)
Observations	46132	46132	46132	46132	46132
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State time trend					Yes
Sample mean of Y	26.3	26.3	26.3	26.3	26.3

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A32: Effect of avocado suitability and world price on number of crimes (by type)

	Crime rate in municipality m in year t (2011-2017)						
	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
suitability_cont × Avocado price (lag)	-0.17	0.32	-0.87	-23.89	0.13	-6.62	2.07
	(0.51)	(1.16)	(1.38)	(24.98)	(10.27)	(13.13)	(3.17)
Observations	12731	12731	12731	12731	12731	12731	12731
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	2.63	10.3	22.7	164	165	263	34

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

State-by-year fixed effect

The main estimation includes, besides year and municipality fixed effects, a state-level time trend to allow each of the 32 states to follow a specific linear trend over time in the outcome variables. However, this assumption can be too restrictive if the outcome varies in a non-linear manner within each state. Therefore, in section A.7.1 I estimate equation 1 with a state-by-year fixed effect instead of the state-level time trend, a more flexible but less parsimonious approach that allows to capture any state-specific year-specific shocks, such as the launch of the "War on Drugs" in Michoacán in 2006. Results for the homicide rate (Tables A33 and A34) show that results are robust (and almost of the same magnitude) to the introduction of state-by-year fixed effects, showing that there are no state-year specific shocks that drive or alter the results.

Homicides

Table A33: Effect of avocado suitability and world price on homicide rate (per 100,000 pop.)

	Homicide rate in municipality m in year t (1990-2019)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	4.94***	4.95***			
	(1.51)	(1.51)			
Avocado price (lag)	6.13***		5.13***		
	(0.84)		(0.78)		
Suitability Index=1 × Avocado price (lag)	-4.66***	-4.64***	-4.73***	-4.71***	-2.23***
	(1.00)	(1.00)	(1.02)	(1.02)	(0.74)
Observations	68498	68498	68498	68498	68498
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State-by-Year F.E.					Yes
Sample mean of Y	16.7	16.7	16.7	16.7	16.7

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A34: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.)

	Homicide rate in municipality m in year t (1990-2019)							
	Before (1990-1997)				After (1998-2019)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Suitability Index=1	15.61***				2.53**			
	(2.74)				(1.17)			
Avocado price (lag)		2.33				4.86***		
		(2.02)				(1.13)		
Suitability Index=1 × Avocado price (lag)	2.67	2.73	2.54	1.07	-3.59***	-3.70***	-3.71***	-1.62**
	(2.29)	(3.87)	(3.93)	(3.88)	(0.80)	(0.84)	(0.83)	(0.64)
Observations	16534	16534	16534	16534	51964	51964	51964	51964
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes		Yes	Yes	Yes		Yes	Yes
Municipality F.E.		Yes	Yes	Yes		Yes	Yes	Yes
State-by-Year F.E.				Yes				Yes
Sample mean of Y	17.9	17.9	17.9	17.9	16.3	16.3	16.3	16.3

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Drug cartel attacks

In the case of drug cartel attacks (Table A35) the results are not robust, as the coefficient fails to be statistically significant at the 10%. At least, it is reassuring to find that the direction of the coefficient is also negative, suggestive of a possible reduction in the drug cartel attacks per 100'000 inhabitants in highly avocado-suitable municipalities.

Table A35: Effect of avocado suitability and world price on drug cartel violent attacks

	Attacks rate in municipality m (2000-2018)				
	(1)	(2)	(3)	(4)	(5)
Suitability Index=1	-19.54***	-19.43***			
	(6.71)	(6.65)			
Avocado price (lag)	13.86***		18.70**		
	(3.25)		(7.41)		
Suitability Index=1 × Avocado price (lag)	-10.65**	-10.74**	-11.61**	-11.77**	-2.58
	(3.95)	(3.83)	(4.61)	(4.67)	(1.66)
Observations	46132	46132	46132	46132	46132
Controls	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes	Yes
Municipality F.E.			Yes	Yes	Yes
State-by-Year F.E.					Yes
Sample mean of Y	26.3	26.3	26.3	26.3	26.3

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Crimes

In the case of crimes, results are mostly similar to the ones in the main estimation (i.e. non-significant), except for extortion cases. With the introduction of the state-by-year fixed effect, the estimated coefficient is now statistically significant and indicate a reduction in the number of (reported) cases of extortion in highly suitable municipalities for the production of avocados across Mexico. This negative coefficient would help in validating the hypothesis of a reduction in crimes and violence. If anything, it does not hurt the robustness of the results as no coefficient for crimes is positive. De Haro-Lopez (2024) finds a similar result of reduction in extortion cases in her study of municipalities of 7 states in Mexico, covering the same period.

Table A36: Effect of avocado suitability and world price on number of crimes (by type)

	Crime rate in municipality m in year t (2011-2017)						
	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-0.58*	1.02	0.04	4.55	1.08	17.66	3.45
	(0.28)	(2.53)	(2.64)	(13.96)	(7.99)	(20.25)	(5.83)
Observations	12731	12731	12731	12731	12731	12731	12731
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-by-Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	2.63	10.3	22.7	164	165	263	34

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

A.7.2 Robustness checks of results in Section 5

Comparing outcomes in same time period

Table A37 presents the estimation of the number of homicides in municipalities across Michoacán restricted to the period 2000-2018 (years with data on drug cartel attacks). There is no change in the results.

Table A37: Homicide and Drug Cartel Attacks per 100'000 pop. (2000-2018)

	Homicide rate				Attacks rate			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Suitability Index=1 × Avocado price (lag)	-2.43	-2.03	-2.35	-1.60	-4.78	-8.01	0.45	-3.71
	(4.81)	(4.42)	(4.71)	(4.27)	(9.90)	(10.11)	(8.19)	(8.63)
USDA_ever=1 × Avocado price (lag)	-2.02	-1.95	-2.63	-2.41	-9.82	-12.65	-0.43	-4.33
	(1.86)	(1.86)	(2.08)	(2.22)	(8.65)	(8.56)	(8.12)	(7.98)
Suitability Index=1 × USDA_ever=1 × Avocado price (lag)	3.96	3.84	3.86	3.55	21.23	24.05*	21.39	25.37*
	(5.30)	(4.94)	(5.42)	(5.02)	(13.35)	(12.72)	(13.45)	(12.72)
Observations	1786	1786	1786	1786	1786	1786	1786	1786
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes		Yes		Yes
Municipality F.E.			Yes	Yes			Yes	Yes
Sample mean of Y	22.4	22.4	22.4	22.4	36.8	36.8	36.8	36.8
Test p-val: $\beta 6 + \beta 7 = 0$	.722	.716	.821	.831	.372	.332	.11	.0732

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A38 estimate all outcomes for the period 2011-2017, which cover the years with data on non-lethal crimes at the municipality level. Two results are worth noting.

Table A38: Homicide, Drug C. Attacks, and Crime rate (2011-2017)

	Homicide	Attacks	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-35.83	1.73	-0.44	-9.91	-2.43	-29.47**	-44.53**	61.02	6.66
	(20.66)	(59.47)	(0.97)	(7.77)	(9.50)	(11.97)	(15.19)	(33.13)	(4.42)
USDA_ever=1 × Avocado price (lag)	6.64	73.31	-1.08	-2.21	14.56**	56.91*	30.18*	12.77	-1.36
	(5.96)	(38.74)	(0.62)	(3.16)	(5.29)	(28.26)	(14.24)	(14.83)	(3.66)
Suitability Index=1 × USDA_ever=1 × Avocado price (lag)	50.57*	34.66	-0.40	21.80*	-12.40	49.05	51.42*	-119.55**	-7.27
	(22.75)	(84.71)	(0.71)	(9.55)	(12.68)	(44.91)	(22.01)	(46.18)	(4.85)
Observations	658	658	658	658	658	658	658	658	658
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	25.5	72.8	1.75	12.4	36.6	85.5	98.9	89.9	10.6
Test p-val: $\beta 6 + \beta 7 = 0$	.0352	.181	.146	.0749	.863	.0276	.00758	.0508	.0896

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

First, during this shorter period, there is a statistically significant increase in the number of homicides per 100'000 inhabitants in avocado-growing municipalities authorized to export to the US. In particular, this effect is more salient compared to other municipalities that are also authorized to export but do not have the same production suitability. Put differently, the increase in homicides is concentrated in municipalities with large levels of production and that export to the US. Compared to the longer period 1998-2019 where there are no effects on homicides, this result would suggest that lethal violence increased once the market is established, and not in the early periods.De Haro-Lopez (2024) also finds an increase in homicides during the period 2011-2017 in main avocado-producing municipalities across 7 western states in Mexico. Second, the results on drug cartels attacks are not statistically significant (as it is the case in the period 2000-2018). The coefficients are less precisely estimated, but they are still suggestive of an increase in attacks in USDA-approved municipalities.

Alternative measures of the outcome variable

I estimate equation 2 measuring the outcomes as either the $log(y)$ or as the inverse hyperbolic sine transformation *asinh*. In the case of drug cartel attacks, the coefficients are less precisely estimated when measured as both the log or the asinh transformation. Despite the lack of significance, the coefficients still have the expected direction and the results are suggestive of an increase in drug cartel attacks in avocado-producing and exporter municipalities. For the estimation of non-lethal crimes, the results for threats, robbery, and theft are robust and statistically significant as in the estimation that measures the number of cases per 100'000 population. The only crime for which the estimation is not significant is for kidnaps. Overall, these results are robust and validate the findings of an increase in some non-lethal crimes in municipalities of Michoacán that grow avocados and are oriented towards the export market.

Log. of homicides

Table A39: Effect of avocado suitability and world price on homicides (log)

	(Log of) Homicides in municipality m in year t (1990-2019)			
	(1)	(2)	(3)	(4)
Suitability Index=1 × Avocado price (lag)	-0.01	0.02	-0.02	0.01
	(0.09)	(0.07)	(0.12)	(0.10)
USDA_ever=1 × Avocado price (lag)	-0.12**	-0.11*	-0.11*	-0.08
	(0.05)	(0.05)	(0.06)	(0.06)
Suitability Index=1 × USDA_ever=1 × Avocado price (lag)	0.04	0.03	0.03	0.02
	(0.11)	(0.10)	(0.14)	(0.13)
Observations	2726	2726	2726	2726
Controls	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes
Municipality F.E.			Yes	Yes
Sample mean of Y	1.46	1.46	1.46	1.46
Test p-val: $\beta 6 + \beta 7 = 0$	.534	.499	.593	.622

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Asinh of homicides

Table A40: Effect of avocado suitability and world price on homicides (asinh)

	Homicides (asinh) in municipality m in year t (1990-2019)			
	(1)	(2)	(3)	(4)
Suitability Index=1 × Avocado price (lag)	-0.02	0.01	-0.04	-0.00
	(0.11)	(0.09)	(0.14)	(0.13)
USDA_ever=1 × Avocado price (lag)	-0.14**	-0.12*	-0.12	-0.09
	(0.06)	(0.06)	(0.07)	(0.07)
Suitability Index=1 × USDA_ever=1 × Avocado price (lag)	0.06	0.04	0.04	0.02
	(0.13)	(0.12)	(0.17)	(0.16)
Observations	2726	2726	2726	2726
Controls	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes
Municipality F.E.			Yes	Yes
Sample mean of Y	1.83	1.83	1.83	1.83
Test p-val: $\beta 6 + \beta 7 = 0$	.568	.538	.629	.665

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Log. of drug-cartel attacks

Table A41: Effect of avocado suitability and world price on drug cartel attacks (log)

	Log. of attacks in municipality m (2000-2018)			
	(1)	(2)	(3)	(4)
Suitability Index=1 × Avocado price (lag)	0.07	0.02	0.10	0.04
	(0.13)	(0.15)	(0.13)	(0.15)
USDA_ever=1 × Avocado price (lag)	-0.02	-0.06	0.02	-0.05
	(0.14)	(0.14)	(0.15)	(0.15)
Suitability Index=1 × USDA_ever=1 × Avocado price (lag)	0.27	0.31	0.25	0.31
	(0.21)	(0.22)	(0.22)	(0.22)
Observations	1786	1786	1786	1786
Controls	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes
Municipality F.E.			Yes	Yes
Sample mean of Y	.718	.718	.718	.718
Test p-val: $\beta 6 + \beta 7 = 0$	.166	.179	.145	.169

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Asinh of drug-cartel attacks

Table A42: Effect of avocado suitability and world price on drug cartel attacks (asinh)

	Asinh transf. of attacks in municipality m (2000-2018)			
	(1)	(2)	(3)	(4)
Suitability Index=1 × Avocado price (lag)	0.09	0.04	0.13	0.06
	(0.16)	(0.18)	(0.15)	(0.18)
USDA_ever=1 × Avocado price (lag)	-0.03	-0.08	0.02	-0.06
	(0.16)	(0.16)	(0.17)	(0.17)
Suitability Index=1 × USDA_ever=1 × Avocado price (lag)	0.30	0.35	0.28	0.35
	(0.24)	(0.26)	(0.25)	(0.26)
Observations	1786	1786	1786	1786
Controls	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes
Municipality F.E.			Yes	Yes
Sample mean of Y	.872	.872	.872	.872
Test p-val: $\beta 6 + \beta 7 = 0$	.204	.223	.179	.213

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Log. of crimes

Table A43: Effect of avocado suitability and world price on crimes (log. of)

	Log. of crimes in municipality m in year t (2011-2017)						
	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-0.24	-0.62	0.13	-0.19	-0.25*	0.49**	0.36
	(0.22)	(0.45)	(0.23)	(0.12)	(0.11)	(0.20)	(0.22)
USDA_ever=1 × Avocado price (lag)	-0.18	0.08	0.27	0.55**	0.52**	0.12	0.06
	(0.09)	(0.12)	(0.15)	(0.20)	(0.17)	(0.14)	(0.14)
Suitability Index=1 × USDA_ever=1 × Avocado price (lag)	0.15	1.07*	-0.40	0.20	0.09	-0.77**	-0.27
	(0.28)	(0.49)	(0.27)	(0.28)	(0.24)	(0.30)	(0.23)
Observations	658	658	658	658	658	658	658
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	.291	.995	2.02	2.69	2.73	2.79	.997
Test p-val: $\beta 6 + \beta 7 = 0$	.925	.0509	.608	.0125	.0323	.0509	.294

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe) Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Asinh of crimes

Table A44: Effect of avocado suitability and world price on crimes (asinh)

	Asinh of crimes in municipality m in year t (2011-2017)						
	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
Suitability Index=1 × Avocado price (lag)	-0.30	-0.82	0.17	-0.20	-0.25*	0.49*	0.42
	(0.28)	(0.55)	(0.27)	(0.12)	(0.11)	(0.22)	(0.28)
USDA_ever=1 × Avocado price (lag)	-0.23	0.13	0.33	0.61**	0.60**	0.12	0.07
	(0.12)	(0.15)	(0.19)	(0.22)	(0.20)	(0.14)	(0.17)
Suitability Index=1 × USDA_ever=1 × Avocado price (lag)	0.22	1.33*	-0.44	0.21	0.08	-0.80*	-0.31
	(0.35)	(0.60)	(0.31)	(0.31)	(0.26)	(0.33)	(0.28)
Observations	658	658	658	658	658	658	658
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	.375	1.26	2.52	3.25	3.29	3.38	1.26
Test p-val: $\beta 6 + \beta 7 = 0$	.978	.0454	.699	.0126	.0373	.0585	.295

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Exclusion of years and municipalities

Figure A9 shows that the main finding of an increase in the number of drug cartel attacks in highly-suitable export-oriented municipalities in Michoacán during 2000-2018 is not sensible to the exclusion of individual years. In only 2 out of the 18 year-period the p-values are above the 10% threshold of statistical significance. The estimated coefficients have all the main sign as the main β and are in the range of 20-31, with the main estimate being 25.37.

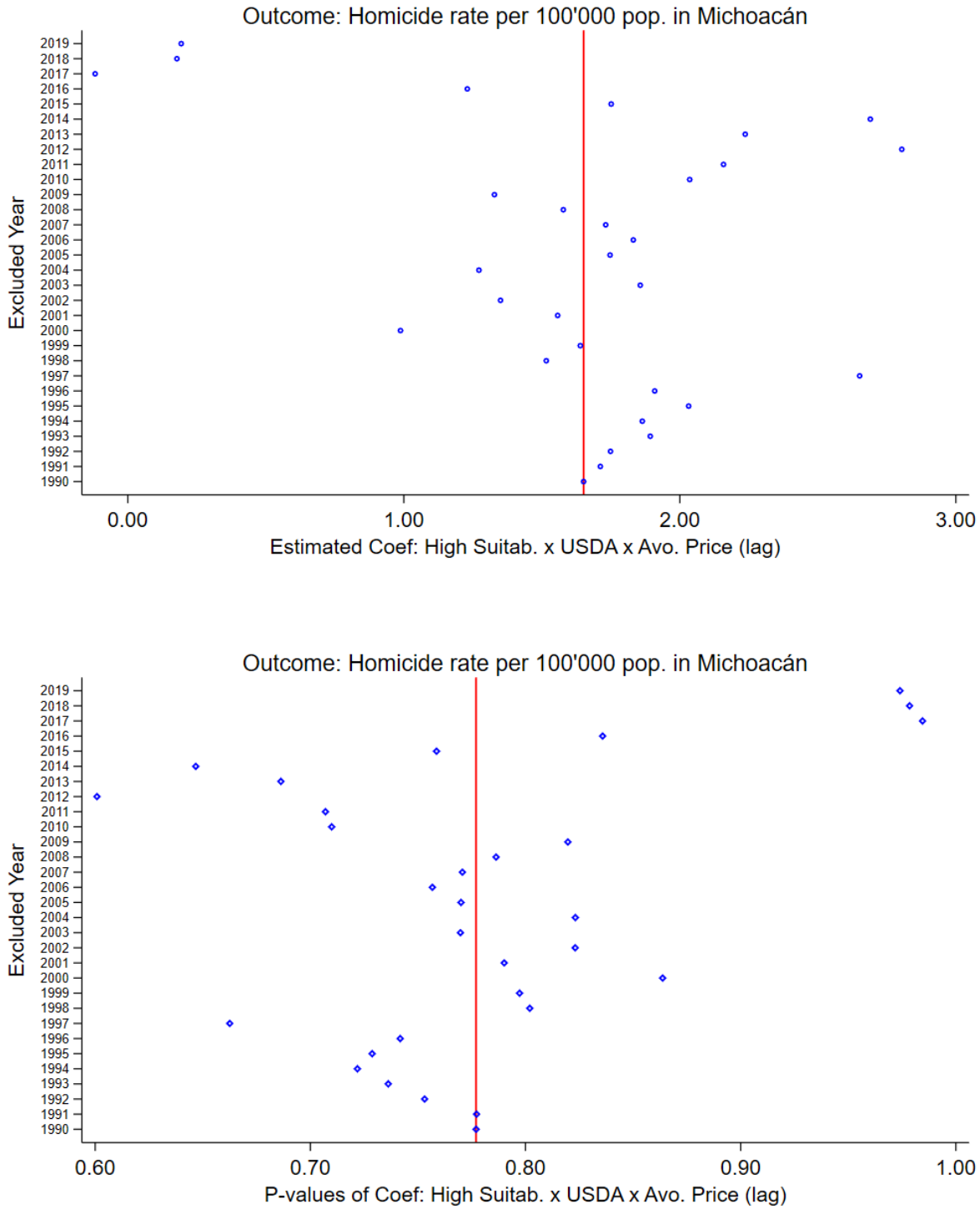
The exclusion of municipalities (one at a time) provide similar results in terms of robustness. Figure A12 shows that, out of the 113 municipalities, only the exclusion of 4 of them yield non-significant estimates at the 10%.[33] Similar to the exclusion of years, the estimated coefficients are all positive and are concentrated in the range 20-30 attacks per 100'000 population.

[33]These municipalities are: Jungapeo, Madero, Nocupétaro, and Tumbiscatío. Among those, Madero is the only municipality authorized to export avocados to the US since 1997.

Excluding one year at a time

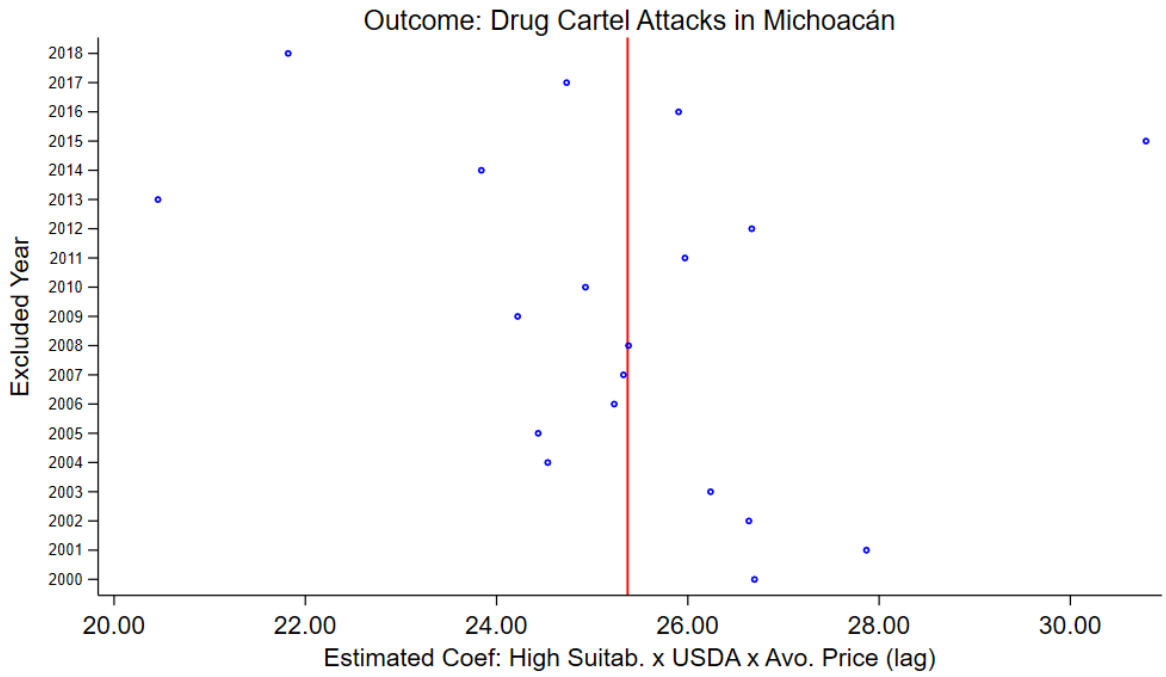
Homicides

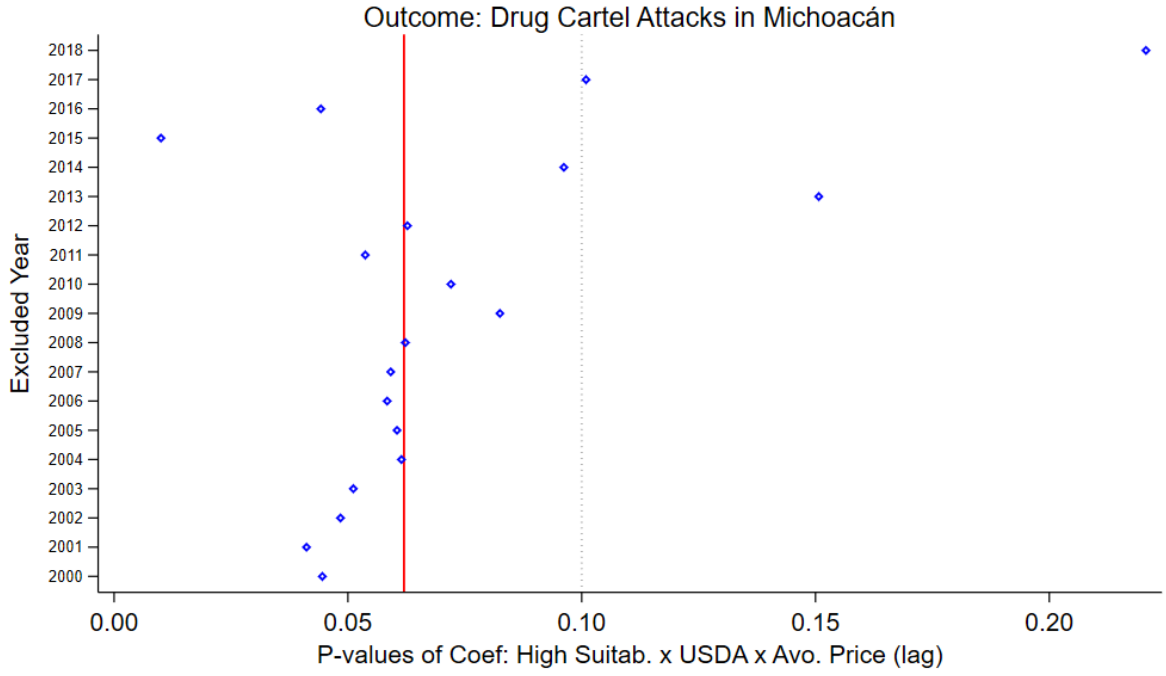
Figure A9: Coefficients and p-values of regressions excluding one year at a time



Drug cartel attacks

Figure A10: Coefficients and p-values of regressions excluding one year at a time

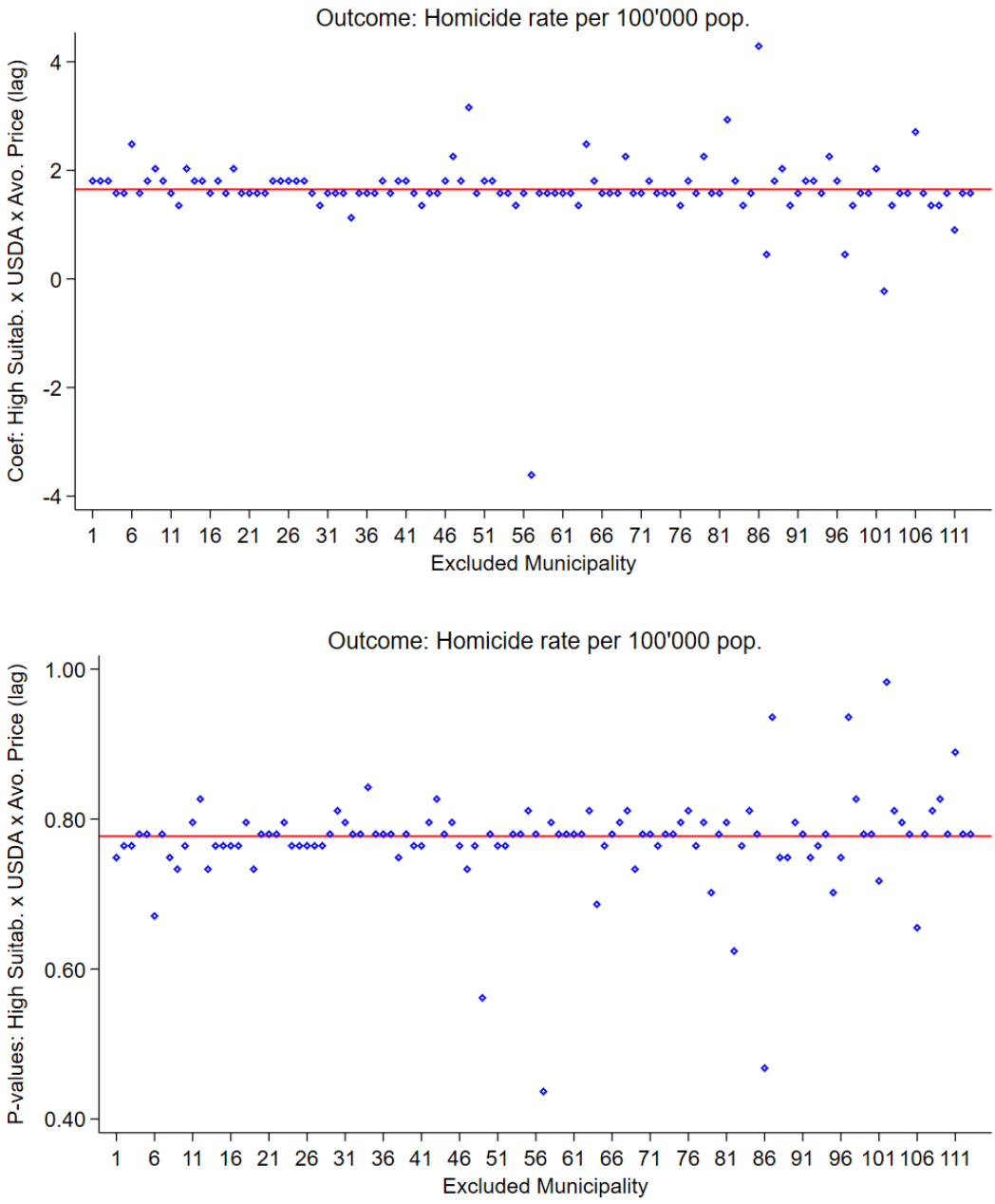




Excluding one municipality at a time

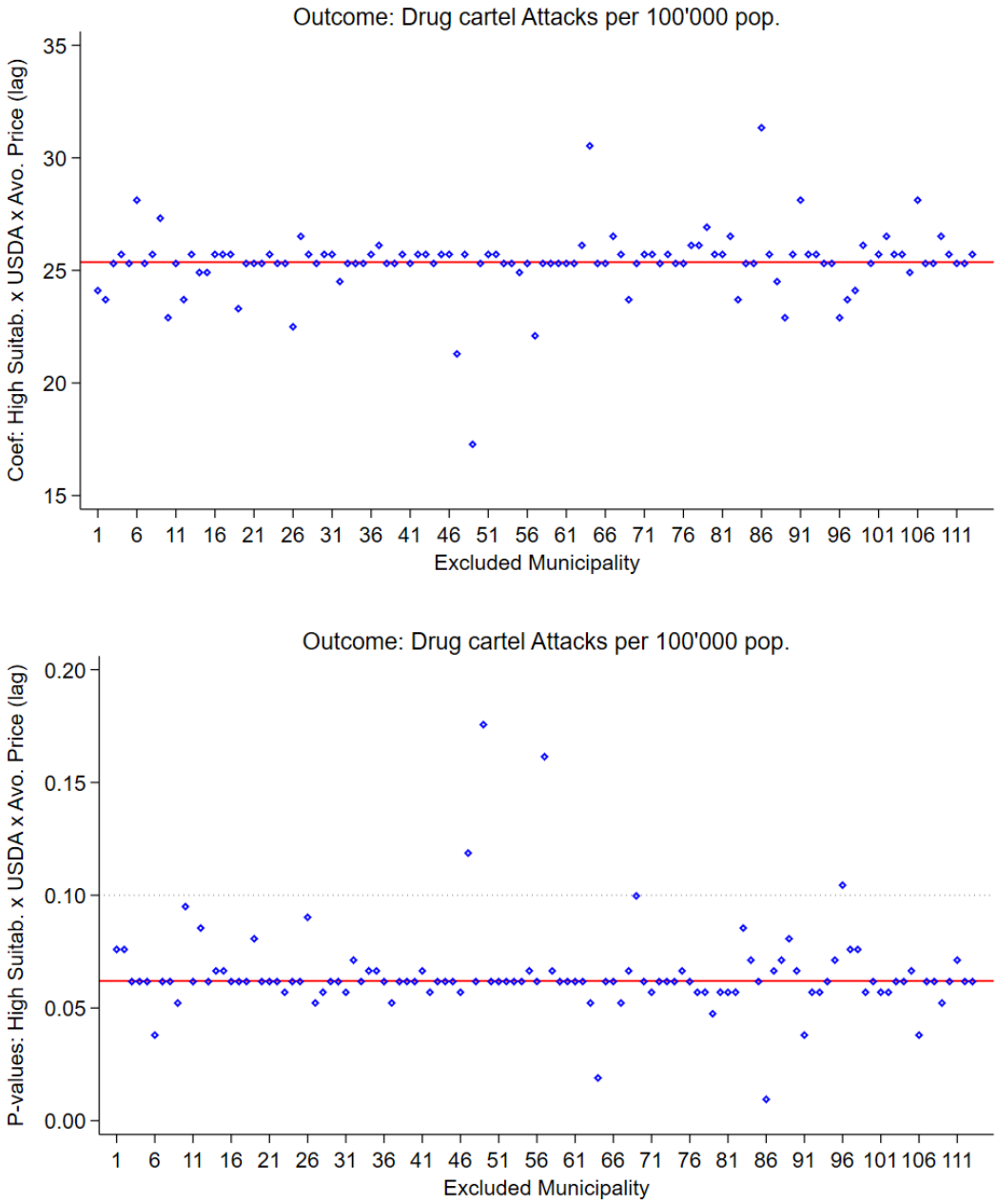
Homicides

Figure A11: Coefficients and p-values of regressions excluding one municipality at a time



Drug cartel attacks

Figure A12: Coefficients and p-values of regressions excluding one municipality at a time



Wild Cluster Bootstrap (WCB) p-values and CI

I run a wildbootstrap estimation of the confidence intervals (CIs) for the main coefficients $\beta_5, \beta_6, \beta_7$ with 1000 repetitions, clustering at the municipality level. Table A45 show that the estimation on homicides does not change with the bootstrap estimation. Table A46 shows that the effects of an increase in drug cartel attacks in highly-suitable USDA-approved municipalities is still marginally significant at the 10%. Table A47 presents the results for crimes. The results for threats and kidnapping are robust to wild cluster bootstrap inference. However, the CIs for robbery ad theft a marginally larger and therefore less statistically significant.

Homicides

Table A45: Homicide rate in Michoacán (per 100'000 pop.) - Wild bootstrap inference

	Coef	t-stat	Bootstr. p-value	[95% conf.	interval]
1990 - 2019					
High Suitab. x Avocado price (lag)	-1.92	-0.43	0.832	-22.650	9.146
USDA x Avocado price (lag)	-1.55	-0.66	0.490	-6.471	3.628
High Suitab. x USDA x Avocado price (lag)	1.65	0.28	0.846	-10.688	18.366
1990 - 1997					
High Suitab. x Avocado price (lag)	24.20	0.79	0.644	-36.612	143.513
USDA x Avocado price (lag)	-4.36	-0.53	0.576	-20.702	12.221
High Suitab. x USDA x Avocado price (lag)	-23.13	-0.70	0.612	-135.785	38.918
1998 - 2019					
High Suitab. x Avocado price (lag)	-2.63	-0.75	0.636	-16.542	7.489
USDA x Avocado price (lag)	-2.10	-0.92	0.366	-6.808	2.908
High Suitab. x USDA x Avocado price (lag)	4.43	0.96	0.430	-5.221	16.493

The table reports the wild bootstrap estimation using 1000 repetitions for a regression where the dependent variable is the homicide rate (per 100'000 pop.) and the estimation method is OLS regression with high-dimensional fixed effects. The estimation follows the same dependent and indepedent variables as in the main estimation.

Drug cartel attacks

Table A46: Drug cartel attacks in Michoacán (per 100'000 pop.)- Wild bootstrap inference

	Coef	t-stat	Bootstr. p-value	[95% conf.	interval]
Drug cartel attacks					
High Suitab. x Avocado price (lag)	-3.71	-0.43	0.678	-22.532	20.195
USDA x Avocado price (lag)	-4.33	-0.50	0.646	-21.435	13.162
High Suitab. x USDA x Avocado price (lag)	25.37	1.80	0.102	-6.520	54.593

The table reports the wild bootstrap estimation using 1000 repetitions for a regression where the dependent variable is the rate of drug cartel attacks (per 100'000 pop.) and the estimation method is OLS regression with high-dimensional fixed effects. The estimation follows the same dependent and indepedent variables as in the main estimation.

Crimes

Table A47: Crime rate in Michoacán (per 100'000 pop.) - Wild bootstrap inference

	Coef	t-stat	Bootstr. p-value	[95% conf.	interval]
Crime Index					
High Suitab. x Avocado price (lag)	-0.23	-1.37	0.218	-0.723	0.153
USDA x Avocado price (lag)	0.12	0.76	0.408	-0.195	0.435
High Suitab. x USDA x Avocado price (lag)	0.17	0.66	0.536	-0.354	0.704
Extortion					
High Suitab. x Avocado price (lag)	-0.44	-0.60	0.530	-2.370	1.264
USDA x Avocado price (lag)	-1.08	-1.22	0.212	-2.840	0.615
High Suitab. x USDA x Avocado price (lag)	-0.40	-0.23	0.812	-4.119	3.265
Threat					
High Suitab. x Avocado price (lag)	-9.91	-0.97	0.328	-34.672	19.792
USDA x Avocado price (lag)	-2.21	-0.46	0.634	-11.437	6.688
High Suitab. x USDA x Avocado price (lag)	21.80	1.80	0.128	-6.745	48.686
Kidnap					
High Suitab. x Avocado price (lag)	-2.43	-0.20	0.874	-40.486	26.242
USDA x Avocado price (lag)	14.56	1.85	0.050	0.290	31.181
High Suitab. x USDA x Avocado price (lag)	-12.40	-0.81	0.414	-43.071	23.207
Robbery					
High Suitab. x Avocado price (lag)	-29.47	-1.48	0.176	-89.891	24.058
USDA x Avocado price (lag)	56.91	1.37	0.148	-23.400	143.727
High Suitab. x USDA x Avocado price (lag)	49.05	0.79	0.398	-81.630	182.008
Theft					
High Suitab. x Avocado price (lag)	-44.53	-1.41	0.232	-136.820	28.587
USDA x Avocado price (lag)	30.18	1.39	0.130	-11.648	74.228
High Suitab. x USDA x Avocado price (lag)	51.42	1.25	0.244	-39.175	138.370
Injury					
High Suitab. x Avocado price (lag)	61.02	1.35	0.208	-33.213	236.661
USDA x Avocado price (lag)	12.77	0.55	0.602	-32.667	60.814
High Suitab. x USDA x Avocado price (lag)	-119.55	-2.08	0.026	-251.927	-7.595
Other					
High Suitab. x Avocado price (lag)	6.66	1.34	0.234	-4.466	18.745
USDA x Avocado price (lag)	-1.36	-0.21	0.836	-13.205	11.362
High Suitab. x USDA x Avocado price (lag)	-7.27	-0.88	0.374	-24.701	9.783

The table reports the wild bootstrap estimation using 1000 repetitions for a regression where the dependent variable is the crime rate (per 100'000 pop.) and the estimation method is OLS regression with high-dimensional fixed effects. The estimation follows the same dependent and indepedent variables as in the main estimation.

Permutation of the USDA-approval status

I run a permutation of the USDA status at the municipality level with 1,000 random permutations. This permutation affects coefficients β_6 and β_7. Results for homicides in Table A48 indicate that results are not affected by the random permutations. Only coefficient β_7 for the period 1990-1997 present a result that would contradict the main estimation. Importantly for the main result, the estimations of the full period (1990-2019) and particularly the period after municipalities were granted the approval to export avocados to the US (1998-2019), are robust to the random permutations, both for β_6 and β_7.

Homicides

Table A48: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.)

	Homicide rate in municipality m in year t		
	All years	Before (1990-1997)	After (1998-2019)
	(1)	(2)	(3)
Suitability Index=1 × Avocado price (lag)	-1.92	24.20	-2.63
	(0.68)	(0.32)	(0.46)
USDA=1 × Avocado price (lag)	-1.55	-4.36	-2.10
	(0.50)	(0.69)	(0.36)
	[0.86]	[0.76]	[0.77]
Suitability Index=1 × USDA=1 × Avocado price (lag)	1.65	-23.13	4.43
	(0.78)	(0.35)	(0.33)
	[0.14]	[0.07]	[0.10]
Observations	2726	658	2068
Controls	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes
Sample mean of Y	26.3	36.4	23.1

The table presents the results of a permutation test of the USDA-approval status with 1000 random permutations, where the dependent variable is the homicide rate. The squared brackets [] contain the p-value of the regressions with the permutation test. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the state and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

The permutation of the approval to export avocados to the US yield robust results for the outcome on drug cartel attacks as well. Table A49 shows that only in 5% of the

permutations the simulation predicted a placebo coefficient that is larger (in absolute value) that the main estimated coefficient. This reassures the finding of an increase in drug cartel attacks in municipalities authorized to export avocados after the lift of the import ban in the US in 1997. De Haro-Lopez (2024) also finds that drug cartels, instead of fighting for territorial expansion, increased their attacks against civilians in avocado-suitable municipalities.

Drug cartel attacks

Table A49: Effect of avocado suitability and world price on attacks rate (per 100'000 pop.)

	Attacks in municipality m 2000-2018
	(1)
Suitability Index=1 × Avocado price (lag)	-3.71
	(0.67)
USDA=1 × Avocado price (lag)	-4.33
	(0.59)
	[0.87]
Suitability Index=1 × USDA=1 × Avocado price (lag)	25.37
	(0.06)
	[0.05]
Observations	1786
Controls	Yes
Year F.E.	Yes
Municipality F.E.	Yes
Sample mean of Y	35.9

The table presents the results of a permutation test of the USDA-approval status with 1000 random permutations, where the dependent variable is the attacks rate. The squared brackets [] contain the p-value of the regressions with the permutation test. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the state and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A50 shows that results for threats, robbery, and theft in highly-suitable export-oriented municipalities are robust to permutation of the USDA status. These results points toward an increase in those crimes in avocado-growing export-oriented municipal-

ities for the period 2011-2017.

Crimes

Table A50: Effect of avocado suitability and world price on crime rate (per 100'000 pop.)

	(1) Index	(2) Extortion	(3) Threat	(4) Kidnap	(5) Robbery	(6) Theft	(7) Injuries	(8) Other
Suitability Index=1 × Avocado price (lag)	-0.23	-0.44	-9.91	-2.43	-29.47	-44.53	61.02	6.66
	(0.18)	(0.67)	(0.25)	(0.81)	(0.05)	(0.03)	(0.12)	(0.18)
USDA=1 × Avocado price (lag)	0.12	-1.08	-2.21	14.56	56.91	30.18	12.77	-1.36
	(0.29)	(0.13)	(0.51)	(0.03)	(0.09)	(0.08)	(0.42)	(0.72)
	[0.74]	[0.58]	[0.90]	[0.45]	[0.55]	[0.51]	[0.84]	[0.97]
Suitability Index=1 × USDA=1 × Avocado price (lag)	0.17	-0.40	21.80	-12.40	49.05	51.42	-119.55	-7.27
	(0.41)	(0.59)	(0.06)	(0.37)	(0.32)	(0.06)	(0.04)	(0.18)
	[0.14]	[0.16]	[0.07]	[0.13]	[0.10]	[0.10]	[0.03]	[0.09]
Observations	658	658	658	658	658	658	658	658
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	.047	2	12.2	37.6	89	104	93.4	11

The table presents the results of a permutation test of the USDA-approval status with 100 random permutations, where the dependent variable is the crime rate. The squared brackets [] contain the p-value of the regressions with the permutation test. Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the state and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Alternative definitions of the suitability index

Below I present the results of estimating equation 2 using only the climatic component of the suitability index (i.e. precipitation and temperature). When only employing the climatic component, the results on homicides (Table A51) follow a similar pattern as in the main estimation. The new coefficients are statistically significant and suggest an increase in the number of homicides per 100'000 pop. in export oriented municipalities in the state of Michoacán. Nevertheless, the join test of the coefficients being different from zero is not statistically significant and I cannot reject the null hypothesis. Using the climatic component of the suitability index does not alter the results of the main estimation of no differences in homicides between export-oriented and non-exporter municipalities in Michoacán.

Climatic suitability index

Table A51: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.) - Michoacán

	Homicide rate in municipality m in year t (1990-2019)			
	(1)	(2)	(3)	(4)
High Suitability (clim.)=1 × Avocado price (lag)	-8.69**	-8.06**	-8.15*	-7.91*
	(3.87)	(3.88)	(4.07)	(4.12)
USDA_ever=1 × Avocado price (lag)	-3.32*	-2.82	-3.66*	-2.85
	(1.89)	(2.07)	(2.12)	(2.31)
High Suitability (clim.)=1 × USDA_ever=1 × Avocado price (lag)	9.59**	9.81**	8.90*	9.65**
	(4.32)	(4.19)	(4.58)	(4.48)
Observations	2726	2726	2726	2726
Controls	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes
Municipality F.E.			Yes	Yes
Sample mean of Y	25.6	25.6	25.6	25.6
Test p-val: $\beta 6 + \beta 7 = 0$	.139	.0891	.251	.135

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

The results on drug cartel attacks (Table A52) and crimes (Table A53) show that employing exclusively the climatic component of the suitability index can affect the results. In the case of drug cartel attacks the coefficient changes the direction of the effect, although it is not well estimated. Using the climatic component of the index suggests, if anything, that there was no an increase nor a decrease in the attacks in export-oriented municipalities. In the case of crimes, the coefficients are less precisely estimated but they

suggest still an increase in property crimes in export-oriented municipalities.

Table A52: Effect of avocado suitability and world price on drug cartel violent attacks - Michoacán

	Attacks rate in municipality m in year t (2000-2018)			
	(1)	(2)	(3)	(4)
High Suitability (clim.)=1 × Avocado price (lag)	55.79*	53.79*	47.32*	44.51
	(29.36)	(30.20)	(25.90)	(26.42)
USDA_ever=1 × Avocado price (lag)	-1.69	-3.99	4.84	1.80
	(6.81)	(6.38)	(7.34)	(7.05)
High Suitability (clim.)=1 × USDA_ever=1 × Avocado price (lag)	-32.00	-32.35	-19.07	-19.21
	(30.77)	(31.62)	(27.69)	(27.91)
Observations	1786	1786	1786	1786
Controls	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes
Municipality F.E.			Yes	Yes
Sample mean of Y	36.8	36.8	36.8	36.8
Test p-val: $\beta 6 + \beta 7 = 0$	.296	.273	.605	.528

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A53: Effect of avocado suitability and world price on crime rate (by type) - Michoacán

	Crime rate in municipality m in year t (2011-2017)						
	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
High Suitability (clim.)=1 × Avocado price (lag)	-0.01	-1.91	1.03	-23.08	-4.18	11.01	2.19
	(1.83)	(7.69)	(8.50)	(15.28)	(9.06)	(22.13)	(3.52)
USDA_ever=1 × Avocado price (lag)	-1.28*	0.43	12.86**	65.64**	34.17**	-0.63	-0.64
	(0.60)	(2.87)	(4.59)	(24.68)	(13.94)	(14.65)	(4.39)
High Suitability (clim.)=1 × USDA_ever=1 × Avocado price (lag)	-0.40	12.05	-15.70	19.08	11.05	-62.32	-6.59
	(1.92)	(10.55)	(11.36)	(51.75)	(23.04)	(37.15)	(8.36)
Observations	658	658	658	658	658	658	658
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	1.75	12.4	36.6	85.5	98.9	89.9	10.6
Test p-val: $\beta 6 + \beta 7 = 0$	.392	.272	.801	.138	.106	.132	.304

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Continuous measure of the suitability index

The tables below show the estimation of equation 2 using the continuous measure of the suitability index to produce avocados. The higher the index, the more the potential of

a municipality to produce avocados. Results on homicides (Table A54) show the same pattern of no differences across export-oriented municipalities and the others. In the case of drug cartel attacks, the coefficient is less precisely estimated but still suggest an increase in the number of attacks in USDA-approved municipalities. Finally, the results on crimes show the same statistically significant increase in threats, and in (less precisely estimated) cases of robbery and theft.

Table A54: Effect of avocado suitability and world price on homicide rate (per 100'000 pop.) - Michoacán

	Homicide rate in municipality m in year t (1990-2019)			
	(1)	(2)	(3)	(4)
suitability_cont × Avocado price (lag)	1.33	1.69	2.43	2.52
	(2.18)	(2.12)	(2.46)	(2.34)
USDA_ever=1 × Avocado price (lag)	-3.16	-2.48	0.43	0.46
	(6.46)	(6.33)	(6.97)	(6.83)
USDA_ever=1 × suitability_cont × Avocado price (lag)	0.52	0.48	-1.64	-1.20
	(3.34)	(3.27)	(3.52)	(3.41)
Observations	2726	2726	2726	2726
Controls	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes
Municipality F.E.			Yes	Yes
Sample mean of Y	25.6	25.6	25.6	25.6
Test p-val: $\beta 6 + \beta 7 = 0$	.438	.552	.746	.843

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A55: Effect of avocado suitability and world price on drug cartel violent attacks - Michoacán

	Attacks rate in municipality m in year t (2000-2018)			
	(1)	(2)	(3)	(4)
suitability_cont × Avocado price (lag)	9.63	8.33	5.25	3.48
	(8.86)	(9.19)	(8.26)	(8.14)
USDA_ever=1 × Avocado price (lag)	-14.06	-18.49	-21.71	-28.64
	(21.21)	(21.59)	(23.07)	(22.95)
USDA_ever=1 × suitability_cont × Avocado price (lag)	4.21	5.16	13.13	14.89
	(11.02)	(11.19)	(11.10)	(10.66)
Observations	1786	1786	1786	1786
Controls	Yes	Yes	Yes	Yes
Year F.E.		Yes		Yes
Municipality F.E.			Yes	Yes
Sample mean of Y	36.8	36.8	36.8	36.8
Test p-val: $\beta 6 + \beta 7 = 0$	.414	.277	.519	.311

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Table A56: Effect of avocado suitability and world price on crime rate (by type) - Michoacán

	Crime rate in municipality m in year t (2011-2017)						
	Category 1			Category 2		Category 3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Extortion	Threat	Kidnap	Robbery	Theft	Injuries	Other
suitability_cont × Avocado price (lag)	1.26	-4.79	1.42	-55.77**	-19.62	55.05*	9.18
	(1.25)	(5.50)	(5.87)	(17.66)	(16.95)	(24.76)	(6.87)
USDA_ever=1 × Avocado price (lag)	3.84	-32.41*	51.38**	-75.42	-53.84	239.40**	11.50
	(3.12)	(14.11)	(19.36)	(101.61)	(42.21)	(79.43)	(23.77)
USDA_ever=1 × suitability_cont × Avocado price (lag)	-2.56	17.05*	-19.76*	72.39	43.89	-124.03**	-7.40
	(1.59)	(7.42)	(9.97)	(48.19)	(24.26)	(40.64)	(11.51)
Observations	658	658	658	658	658	658	658
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample mean of Y	1.75	12.4	36.6	85.5	98.9	89.9	10.6
Test p-val: $\beta 6 + \beta 7 = 0$	.45	.0711	.0188	.958	.622	.0289	.754

Fixed effects models are estimated with linear regression with multiple levels of fixed effects (Stata: reghdfe). Two-way clustered standard errors at the municipality and year level in parenthesis. Where indicated, control regressors include the lagged US retail price of cocaine, population size, Gini index, and standardized values of poverty and illiteracy rates in the municipality. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

Working Paper 537 December 2024

Authors

Christian ARCINIEGAS
Department of Economics, University of Fribourg, 1700 Fribourg, Switzerland
Bd de Pérolles 90, 1700 Fribourg, Switzerland. E-mail: christian.arciniegas@unifr.ch

Abstract

There is extensive evidence of the impact of natural resource windfalls on violence. However, most of the literature focuses on civil conflict and civil wars and less is known about how resource booms affect other forms of violence and crime. In this paper, I examine the impact of Mexico's avocado production boom over the past 30 years on homicides, drug cartel-related attacks, and non-lethal crimes. To estimate the effects of the avocado boom on these forms of violence, I exploit geographic differences in the exogenous suitability of municipalities to produce avocados with movements in the international price of the fruit. The results reveal that, consistent with the opportunity cost mechanism highlighted in the literature, municipalities more suitable for avocado production experienced a reduction in homicides and drug cartel attacks. This effect is primarily driven by the period following the lifting of an 83-year ban on Mexican avocado imports to the United States. However, municipalities that are highly export-oriented did not experience this reduction in violence. Instead, these municipalities have seen an increase in drug cartel attacks and non-lethal crimes, particularly threats and property crimes.

Jel Classification

D74; K42; O13; Q33.

Keywords

Resource curse; violence; crime; Mexico; avocados.

Working Papers SES collection

Last published

528 Buechel B., Klößner S., Meng F., Nassar A.: Misinformation due to asymmetric information sharing; 2022
529 Lettry L. C..: Clustering the Swiss Pension Register; 2023
530 Freundt J., Herz H., Kopp L.: Intrinsic Preferences for Autonomy; 2023
531 Ducret R., Isakov D.: Business group heterogeneity and firm outcomes: Evidence from Korean chaebols; 2023
532 Weil L., Hänggli Fricker R.: How innovation in participation could increase legitimacy; 2023
533 Herzy H., Zihlmann C.: Perceived Legitimacy and Motivation Effects of Authority; 2024
534 Champeaux H., Gautrain E., Marazyan K.: Men's premarital migration and marriage payments: Evidence from Indonesia; 2024
535 Brunne P., Zihlmann C.: "Extra bacon?" Context Effects in Purchases of Additional ItemsCatalogue; 2024
536 Freundt J., Herz H : From Partisanship to Preference: How Identity shapes Dependence Aversion; 2024

Catalogue and download links

http://www.unifr.ch/ses/wp
http://doc.rero.ch/collection/WORKING_PAPERS_SES

Publisher

Université de Fribourg, Suisse, Faculté des sciences économiques et sociales et du management
Universität Freiburg, Schweiz, Wirtschafts- und sozialwissenschaftliche Fakultät
University of Fribourg, Switzerland, Faculty of Management, Economics and Social Sciences

Bd de Pérolles 90
CH-1700 Fribourg
Tél.: +41 (0) 26 300 82 00
decanat-ses@unifr.ch
www.unifr.ch/ses