From Maize to Haze: Agricultural Shocks and the Growth of the Mexican Drug Sector*

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Abstract

We examine how commodity price shocks experienced by rural producers affect the drug trade in Mexico. Our analysis exploits exogenous movements in the Mexican maize price stemming from weather conditions in U.S. maize-growing regions, as well as export flows of other major maize producers. Using data on over 2200 municipios spanning 1990-2010, we show that lower prices differentially increased the cultivation of both marijuana and opium poppies in municipios more climatically suited to growing maize. This increase was accompanied by differentially lower rural wages, indicating that households were adversely affected by the lower return to maize farming. We also find impacts on downstream drug-trade outcomes, including the operations of drug cartels and killings perpetrated by these criminal groups. Our findings demonstrate that maize price changes contributed to the burgeoning drug trade in Mexico, and point to the violent consequences of an expanding drug sector.

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1 Introduction

The international drug trade poses a multitude of challenges to security and the rule of law worldwide. Violence permeates the market, from brutal conflicts between international drug traffickers to street violence associated with retail drug dealing. Powerful criminal groups threaten to overwhelm local law enforcement institutions in regions as diverse as Latin America and Central Asia (Global Commission on Drug Policy 2011, USDS 2012). The violence surrounding this market underscores the importance of understanding the determinants of drug production.

Policymakers are confronted with two distinct approaches for curbing the supply of illicit drugs. One view focuses on criminal groups such as drug cartels, and targeting legal enforcement effort toward traffickers. For example, Moore (1990, p. 134) writes that "A conventional theory is that supply-reduction efforts will be effective if only the major traffickers are arrested and successfully prosecuted."

A second view focuses on rural producers, and their economic incentives to cultivate drug crops. Under this perspective, drugs are subject to the same basic forces of economic production as other goods. Thus the return to other legal alternatives will play a key role in determining drug supply. In particular, changes in the price of other commodities should influence household decisions to grow drugs via standard substitution and income effects. As such, policies aimed at rural households, including price stabilization and income support, serve as the key policy levers for determining drug supply.

Distilling the relative import of these two policy approaches requires gauging the extent to which drug production responds to the legal alternatives of farmers. To examine this question, we assess how commodity price shocks faced by rural producers affect illicit crop production and drug war dynamics in Mexico. We focus on exogenous fluctuations in the price of maize, the nation's most important agricultural commodity. Mexico offers the ideal context for studying this question given the prevalence of drug cultivation and burgeoning drug war violence. Long the world's largest producer of marijuana, it recently became a leading player in the international heroin market (USDS 2011). Between 1990-2010, illicit crops were grown in over a third of all municipios.[1] Violence also increased drastically especially during the 2000s: over 50,000 drug-war killings occurred between 2007 and 2010.[2]

To examine the relationship between maize prices and the drug trade, our empirical strategy exploits time variation in prices stemming from weather shocks in the United States Corn Belt, as well as the export behavior of other major players in this market.[3] We also use cross-

[1] Calculated on the basis of eradication data from the Mexican military (SEDENA), discussed in detail in Section 4.

[2] Calculated on the basis of data from the Mexican National Security Council, discussed in Section 4.

[3] Note that we use the words maize and corn interchangeably to reference the same crop.

sectional variation in the agro-climatic maize suitability of Mexican municipios. Combining these together via a difference-in-differences strategy, we determine whether maize prices exert larger impacts on municipios that are more suited to growing this crop. Our empirical strategy is closely related to that of Nunn and Qian (forthcoming), who use time variation in U.S. wheat production driven by weather conditions in the U.S. wheat region to examine the impact of food aid on conflict.[4]

We construct a panel dataset of 2200 municipios over 1990-2010, and gauge the impact of price changes on a series of outcomes. We show that the sharp fall in maize prices during the 1990s led to differential increases in the cultivation of both marijuana and heroin poppies in more maize-suitable areas, as proxied by the eradication of these drug crops. Our estimates imply that the 59% fall in maize prices between 1990 and 2005 resulted in 8 percent more marijuana eradication and 5 percent more poppy eradication in municipios at the 90th percentile of the maize suitability distribution, as compared to municipios at the 10th percentile of this distribution. We also observe that these price changes differentially affected labor market outcomes, lowering rural wages by 19 percentage points while increasing subsistence farming by 12 percentage points among young men.

However, drug crop planting is only the first step in the narco-trafficking chain. After harvest, drug crops are subsequently processed and transported to international markets through the operations of drug cartels. Thus, we also examine post-cultivation outputs and find that adverse maize price shocks led to greater seizures of raw marijuana and opium gum (the paste used to manufacture heroin). Moreover, violence may accompany this chain as cartels fight for control of these activities. Consistent with this account, we demonstrate a negative relationship between maize prices and cartel presence, as well as killings perpetrated by these groups in connection with the drug war over 2007-2010. These results suggest that cartels fight to control economically depressed territories where farmers are willing to supply more illicit crops.

Overall, our findings establish that drug crop cultivation responds to the returns from other legal alternatives, and show that production in drug markets functions like production in other markets. This suggests that policies aimed exclusively at drug traffickers may overlook the import of policy levers such as income and price supports, which can influence drug supply through their effects on household economic conditions. Since we demonstrate that price changes affect the strategic decisions of cartels, the results indicate that even policies aimed at rural cultivators may ultimately influence the operations of criminal groups.

We conduct a number of checks to address potential threats to identification and demonstrate the robustness of these results. Since eradication may reflect state enforcement efforts,

[4]It is also related to other studies that use cross-sectional variation in crop suitability, including Qian (2008) which utilizes variation in tea and orchard cultivation in China, and Nunn and Qian (2011) which focuses on variation in regional potato suitability.

we show that the results are unaffected by the inclusion of trends based on proximity to police stations as well as controls for the mayor's political party, which plays an important role in shaping local drug-war policies (Dell 2012). Additionally, since maize suitability may be correlated with suitability for marijuana, poppy, and legal crops besides maize, this raises the possibility that drug production may have increased in maize-suitable areas for reasons unrelated to the evolution of the maize price. To address this concern, we control for overall land quality and the suitability of 15 other agricultural commodities, all interacted with year effects. In addition, we use marijuana and poppy eradication at the outset of our sample period as a proxy for drug crop suitability, and control flexibly for these characteristics as well. Our estimates are unaffected by these covariates as well as controls for weather conditions in Mexican municipios and trends by rurality and beginning period agricultural income.

To the best of our knowledge, our paper is the first to examine how shocks to legal income opportunities affect drug crop cultivation and the growth of the illicit drug market. The existing literature on drug production has instead focused on the impact of changes in illegal drug prices stemming from enforcement-related demand shocks. Angrist and Kugler (2008) demonstrate that an interruption of the air-bridge ferrying coca out of Peru and Bolivia in 1994 subsequently increased coca cultivation and violent killings in Colombian coca-growing states, while generating only modest increases in workers' earnings in these areas. Mejia and Restrepo (2013) also show that this 1994 policy change, along with increased cocaine interdiction in other countries, induced greater coca production in Colombian municipios more geographically suited to growing this drug crop. Mejia and Restrepo (2011) estimate a game-theoretic model of enforcement choices and find that the large violence costs associated with drug production exceed those associated with trafficking activities in Colombia. In addition, Castillo, Mejia and Restrepo (2013) find that enforcement in Colombia affects drug trafficking violence in Mexico.[5]

Our paper also contributes to a number of other literatures. First, it adds to studies examining income shocks and civil conflict. Theoretically, the direction of this relationship is ambiguous, since higher income may increase conflict by promoting predation (Hirshleifer 1991 and Grossman 1999) or reduce it by diminishing the opportunity cost of fighting (Becker 1968 and Grossman 1991). Consistent with the opportunity cost account, a number of studies find a negative relationship between income and conflict both across countries (Collier and Hoeffler 1998, Fearon and Laitin 2003, Miguel et al. 2004, Besley and Persson 2011) and within countries (Do and Iyer 2010, Hidalgo et al. 2010, Gwande et al. 2012). However, consistent with predation, other studies have found that exporters of oil and other natural resources face a higher risk of civil war (Fearon 2005). Nunn and Qian (2011) also show conflict effects associated with

[5] Conversely, Lind, Moene and Willumsen (forthcoming) show that conflict in Afghanistan increased the cultivation of opium poppies.

food aid, which can be interpreted as reflecting predation of a resource windfall.[6]

Another branch of the literature investigates the relationship between commodity prices and conflict. A change in a commodity price might operate through either the opportunity cost or predation channels discussed above, depending in part on the nature of the affected commodity. For example, Dal Bó and Dal Bó (2011) show theoretically that the labor intensity of the sector determines which channel dominates. In line with larger opportunity cost effects, several studies report a negative relationship between export price indices and conflict, including Brückner and Ciccone (2010) and Berman and Couttenier (2013). Bazzi and Blattman (2013) present more limited evidence of this effect, showing impacts on conflict intensity but not outbreak in the cross-national setting. Consistent with predation accounts, Maystadt et al. (forthcoming) estimate a positive relationship between conflict and natural resource prices, while Besley and Persson (2008 and 2009) also report positive price effects. Dube and Vargas (2013) show that both effects can operate in the same empirical setting: in Colombia, higher prices of labor intensive agricultural commodities reduce conflict, while higher prices of non-labor intensive natural resources increase conflict.

Our finding of a negative relationship between maize prices and drug war outcomes is in line with the negative association observed between income and conflict in previous studies, including those examining price shocks to labor intensive commodities. This result is broadly consistent with an opportunity cost effect in that a fall in the price of maize reduces an agricultural worker's cost of participating in illicit crop cultivation. However, our interpretation departs from the canonical story in explaining how greater criminal activity leads to more violence. In the standard account, declining opportunity costs fuel violence by increasing the pool of combatants or time spent on combat activities (Becker 1968, Grossman 1991, Dal Bó and Dal Bó 2011).[7] However, we posit that violence rises in our empirical scenario not from the number of fighters, but from the increased value of controlling territories adversely affected by price shocks. In particular, the reduction of agricultural wages in an area increases the rents that cartels can extract from farmers supplying drugs. Indeed, our results suggest that cartel location and drug-trade violence respond to these changes in the outside options of local farmers.

Finally, our paper adds to the literature studying the determinants of the drug war in Mexico. Dell (2012) examines the role of enforcement policy, and shows that drug trade violence rises substantially in municipalities after the close election of mayors from the PAN political party.

[6] Differential income shocks across groups within a country have also been shown to affect conflict. Mitra and Ray (forthcoming) show that higher incomes for members of an ethnic minority can increase violence perpetrated against them.

[7] Esteban and Ray (2008) show theoretically that one factor promoting ethnic conflict is the ease of forming within-group, cross-class alliances that pair conflict labor supplied by the poor with low-opportunity costs and financing from the rich.

In particular, drug cartels contest areas in which incumbent traffickers have become weaker in the wake of crackdowns by PAN mayors. Our results are highly complementary in emphasizing the importance of in-fighting and territorial contestation as key elements of rising violence. Osorio (2012) focuses on another domestic political factor, analyzing the role of rising electoral competition. Dube et al. (2013) also show that access to guns from the United States have contributed to rising violence along the border. However, we are not aware of past work that has examined the role of economic shocks in shaping Mexico's drug war dynamics.

The remainder of the paper is organized as follows: section 2 provides institutional background; section 3 discusses the mechanisms that link maize prices and drug production; sections 4 and 5 describe our data and empirical strategy; sections 6-8 present our results on drug production, labor market outcomes and drug cartels ; section 9 addresses threats to identification; and section 10 concludes.

2 Background

This section provides background on two relevant aspects of the institutional context. First, we discuss the evolution of Mexico's drug trade. Second, we examine dynamics of the maize price over the course of our sample period.

2.1 The Mexican Drug War

The drug trade has been present in Mexico from the turn of the twentieth century. However, it increased sharply during the 1960s with rising demand for marijuana in the U.S., and grew further during the 1980s with rising demand for cocaine north of the border. During this latter period, Mexican and Colombian drug cartels began working together to traffic cocaine manufactured in South America (Astorga 2005, Toro 1995). Though initially sub-contractors for their Colombian counterparts, the Mexican cartels grew in power and by the 2000s dominated the drug distribution network. Simultaneously, the share of cocaine arriving to the U.S. via Mexico rose dramatically, from about 50 percent in the early 1990s to over 90 percent in the 2000s (O'Neil 2009).

Besides increased trafficking of South American cocaine, the growth of the Mexican drug trade has also been characterized by the production and distribution of home-grown drugs. Mexican cultivators grow both marijuana and opium poppies, which are used to manufacture heroin. While Mexico has long been a leading supplier of marijuana, it became an important supplier of heroin in the 1990s. Between 1993 and 2008, opium production increased more than six-fold, growing from a low base of 49 to 325 metric tons (USDS 2011). As of 2009, Mexico ranked the world's third largest opium poppy supplier after Afghanistan and Burma.

Drug-trafficking violence was relatively restrained through the 1980s, but started rising in the 1990s, and ultimately skyrocketed in the 2000s. The stability of the 80s is attributed in part to underlying political conditions in Mexico. The PRI political party had dominated electoral politics since the 1930s, and the absence of political competition facilitated consolidated patron-client relationships between drug traffickers, the police, and local elected officials. In essence, implicit agreements with officials enabled some cartels to operate in particular locations with relative impunity limiting in-fighting (O'Neil 2009). However, the entry of other political parties in local elections during the early 1990s undermined these arrangements (Bartra 2012, O'Neil 2009), incentivizing territorial expansion and in-fighting among rival cartels (Osorio 2012).[8]

Continued cartel de-stabilization fueled further drug-related violence 2000s. Two major turning points are worth noting. First, in 2001, the leader of the Sinaloa cartel, Joaquín "El Chapo" Guzmán, escaped from prison and attempted to take over important drug routes near Texas and California. Violence subsequently increased in both the drug production areas and crossing points along the U.S.-Mexico border (Luhnow and de Cordoba 2009). Second, in December 2006, President Felipe Calderón launched an aggressive military campaign against the drug cartels. These operations were phased-in geographically, and resulted in dramatic and haphazard violence increases throughout the country.[9] For example, Ríos and Shirk (2011) estimate that up to 50,000 organized crime homicides took place in Mexico during 2006-2011.

While the drug war has been largely concentrated in urban areas, rural areas engaged in drug crop cultivation have also witnessed rising violence (Escalante 2009). This has been linked to rival cartels contesting territory in the attempt to control trafficking routes from production areas to the border (Astorga 2007, Ravelo 2008). For example, in the northern state of Sinaloa, La Linea cartel has challenged their rival, the Sinaloa cartel (STRATFOR 2013). Similarly, disputes among cartels in the southern state of Michoacán have been linked to attempts to take over production areas and routes (Maldonado Aranda 2012).

2.2 Evolution of the Maize Price

The focus of our paper is to assess how changes in the price of maize have affected these drug trade dynamics. Over the course of the 1990s and 2000s, several major fluctuations in the maize price impacted the income opportunities of maize workers in Mexico. Figure 1 displays the Mexican and international maize prices over 1990-2010. The implementation of the North American Free Trade Agreement (NAFTA) in 1994 initiated liberalization of this sector, expanding import quotas and reducing tariffs. This process culminated in 2008 in

[8]The pervasiveness of drug gangs throughout Mexico also manifests itself in the wide-spread presence of other criminal activities such as extortion of citizenry (Díaz-Cayeros et al. 2011).

[9]According to data from the Instituto Nacional de Estadística y Geografía (INEGI), homicide rates increased nearly four-fold in 2008 in municipios within 100 miles of the border.

the elimination of both restrictions on trade with the U.S. and Canada. The introduction of NAFTA precipitated a large decline in the price of maize in Mexico: between 1993 and 1994, it dropped by 20%, the largest one-year decline in our sample period. With the exception of a spike in 1995-1996, prices continuously declined throughout the 1990s. The price jump in 1995-1996, which also appears in the international price, has been attributed to the restriction of Chinese exports and adverse drought conditions in the United States that impacted the maize crop (Stevens 2000). Another weather-related price jump occurred in 2002-2003 in response to a drought episode in the United States. Finally, prices increased sharply in 2005 in what has become known as the International Food Crisis. This has been attributed to a variety of causes, including rising global demand for food and biofuels, as well as weather shocks in important producing countries (Trostle 2008).

3 Mechanisms

3.1 A Snapshot of Maize and Agricultural Workers

To understand the link between maize price fluctuations and the incentives to produce illicit drugs, it is useful to examine the characteristics of agricultural workers in Mexico at the beginning of our sample period. Using data from the 1990 Mexican Census, we construct a sample of 748,486 working men between the ages of 18 and 65 in rural municipios.[10] Census occupation codes allow us to identify agricultural workers, and within this population to further identify workers associated with a particular crop. Table 1 presents summary statistics for some basic demographic and labor variables for three groups in these municipios: all workers, agricultural workers, and maize workers.[11] About 48% of all workers held occupations classified as agricultural. Maize has historically dominated the Mexican agricultural sector. About 29% of agricultural workers (representing 14% of all workers) were identified as maize workers in 1990. However, this likely understates the number of individuals dependent on maize for a substantial fraction of their monetary income. Forty-one percent of all agricultural workers were not associated with any particular crop, and these unassigned individuals likely grew a variety of crops including maize. By contrast, coffee and cacao workers represent the second largest group tied to a specific crop, and account for only 4% of agricultural workers.

The agricultural sector is characterized by a mix of small-scale family farmers and individuals

[10] Rural municipios are defined as those that do not contain any individuals who live in sub-municipio localities of population 100,000 or more in the 1990 Census.

[11] It should be noted that the workers we identify as maize workers are actually classified as "maize and bean workers" in the Census and other surveys administered by INEGI, the official Mexican statistical agency. This unified classification reflects the fact that maize and beans are often intercropped. Workers engaged in the production of one crop are commonly engaged in the production of the other.

working for wages on larger farms. Table 1 shows that 48% of agricultural workers (62% of maize workers) are classified as "own-account," meaning that they do not have a boss or supervisor. Owners of family farms would fall into this category. A substantial number of agricultural workers thus find work as paid employees (38%), yet only about 1% of agricultural workers report directly hiring other workers.

Workers at nearly every point in the agricultural income distribution can be characterized as poor in comparison to non-agricultural workers in these rural areas. A large number of agricultural workers engage in subsistence farming which generates little or no monetary income. About 27% of the agricultural workers (37% of maize workers) report earning zero income despite currently working. By contrast, only 2% of non-agricultural workers report earning zero income. This reflects both the prevalence of subsistence agriculture and the fact that some individuals work without pay for family farms that generate monetary income. Conditional on earning positive income, the average worker in these municipios earns about 4,500 pesos per month. This is about $450 (in 2005 dollars). The income of the average agricultural worker is substantially lower (about 3,150 pesos per month), and the average maize worker earns even less (about 2,500 pesos per month). While there is substantial variation within the set of agricultural workers, it is clear that the vast majority are poor. The 75th percentile of the positive income distribution for agricultural workers (2650.451) is below the median positive income for non-agricultural workers in these rural areas (3232.592). In short, maize workers earn relatively little even within the impoverished agricultural sector.

3.2 Price Changes and Drug Production

Maize price fluctuations will impact rural households in different ways depending on their production and labor supply choices. First and foremost, such changes directly impact households that initially produce and sell maize. These households must decide how much labor to allocate to crop cultivation, market labor, and leisure. Jointly with this time allocation problem, they must decide how much land and time to devote to each possible crop. A fall in the price of maize will tend to increase drug crop cultivation as the result of both a substitution and an income effect. It will provide agricultural households an incentive to substitute the production of other crops for the production of maize. At the same time, this will make households poorer, increasing their incentives to spend more time and effort on income-generating activities as the marginal value of wealth increases. As the price of maize falls, both forces will push maize-producing households in the direction of greater drug production.

It is important to note that a fall in the price of maize can cause an increase in the production of drugs even in the absence of a reduction in household production of maize. As described in Steinberg (2004), some small holder maize farmers of the Yucatan peninsula have incorporated illicit drug production into their tradition cropping system (milpa) by intercropping marijuana, maize, and bean plants. Greater drug production can thus be achieved by increasing the total number of plants grown on a fixed plot of land, even if a household does not make a decision to reduce the amount of land devoted to maize.

A second set of households to consider are those that do not produce maize for market sale. These households may or may not produce other crops for the market, but any maize that they produce is strictly for household consumption. Changes in the price of maize should not directly alter the income and production behavior of these households. However, if such changes induces general equilibrium effects that alter the prices of other commodities, then their incomes might be affected.

Finally, a change in the price of maize will also affect the wages of those individuals who work as paid employees in the local labor market. A significant fraction of agricultural workers are included in this group. The wage earned by workers on maize farms is clearly tied to the price of maize. Equilibrium in the rural labor market would require that a reduction in the wage of maize laborers ripple through other sectors, reducing the wages of other laborers, agricultural or otherwise. Declining wages in the rural labor market will in turn encourage individuals to increase time spent on other income-generating activities, including drug production.

4 Data

4.1 Measurement of Key Variables

Our goal is to assess how price shocks that influence the income generating opportunities of rural households impact drug crop cultivation and other drug-trade outcomes. While there are no official statistics tracking illicit crop production across regions of Mexico, we are able to use drug crop eradication as a proxy for cultivation. Eradication activities undertaken by the Mexican military unfold in two stages. First, military surveillance identifies individual fields in each municipio that are planted with marijuana and opium poppy. Next, on the basis of that surveillance, the military engages in eradication efforts to destroy the illicit crops grown on those fields. Data from the Mexican military — the Secretariat of National Defense (SEDENA) — record the hectares of marijuana and poppy eradicated in each municipio, over 1990-2010. According to U.S. and Mexican officials, about 75 percent of drug production is eradicated each year (Humphrey 2003), which suggests that eradication is a good proxy for cultivation. As such, we assume that the total area eradicated is informative of the total amount of underlying drug cultivation in a given municipio-year. Figure 2 maps the mean marijuana and poppy eradication across Mexican municipios over our sample period. It is immediately clear that drug eradication is concentrated in the western spine of the country, along the western and southern ranges of the Sierra Madres and the adjacent coastal areas. According to the SEDENA data, marijuana eradication increased from approximately 5400 hectares in 1990 to 34,000 in 2003, and decreased to 17,900 in 2010. Poppy eradication started at 5950 hectares in 1990, peaked at 20,200 in 2005, and fell to 15,300 in 2010. We also obtain SEDENA data on drug seizures for the 1990-2010 period. Categories include raw and processed marijuana; opium gum and heroin; as well as cocaine and crystal meth.

To study the relationship between maize price fluctuations and cartel activity across municipios, we use a novel data set constructed by Coscia and Rios (2012). The data track the presence of 10 criminal organizations in each Mexican municipio over 1991-2010. The data set is constructed using a search algorithm that queries archived publications in Google News. The algorithm codes a criminal organization as being present in a municipio if the frequency of hits for a particular municipio-organization pair exceeds a threshold determined by the searchable material available for a given municipio-year. We use the data to generate three measures of cartel presence: an indicator of whether any cartel is present in the municipio (designated "Any cartel"); an indicator for the first year in which any cartel is present in that municipio in our sample ("Cartel entry"), and an indicator for the operation of multiple cartels in that municipio ("Multiple cartels").

Data on drug-related killings come from the Mexican National Security Council, and are available for the 2007-2010 period. Executions are killings attributed to criminal organizations on the basis of tell-tale signs such as the use of beheadings and incinerations, or explicit messages left at the crime scene. Drug-related confrontations measure deaths stemming from fights among cartels, or between cartels and the army. Cartel attacks refer to deaths stemming from attacks by drug cartels on state security forces. These three variables are aggregated into total drug-related killings. Figure 3 maps this variable in per capita terms. Clearly this type of violence is concentrated around the border region and areas with drug crops in the northern part of the country.

To account for enforcement, we use data from the Mexican Attorney General's Office (PGR, by its Spanish acronym), to generate a measure of distance to the nearest state security station, defined as either a federal police headquarter, military garrison, or air-force base in 2000. Municipal-level electoral data from the Center of Research for Development (CIDAC) provides the political affiliation of the mayor, specifically whether he or she is from the left-leaning PRI, conservative PAN or other political party. We also control for distance to the nearest point on the U.S.-Mexico border, and whether the municipio has a major highway, both of which are likely to affect the extent of trade in the municipio.

Data on rainfall and temperature at the municipio-month level originate from the University of Delaware's Center for Climatic Research. In addition, we utilize a soil quality variable from the Workability dataset of the Food and Agricultural Organization (FAO) of the United Nations

(FAO 2012b). This variable measures land workability constraints that hinder agricultural cultivation. We also develop a measure of municipal ruggedness. The ruggedness in a grid point inside of a municipio is defined as the average difference in elevation between the point and its neighbors, and we take the average across all points in a municipio.

We utilize data from the 1990 Mexican Census to obtain start-of-sample characteristics for our municipios of interest. These include the fraction of males employed in agriculture as a proxy for rurality, and the average agricultural income in each municipio in 1990. To explore the relationship between the maize price and economic outcomes for rural workers, we construct a sample that pools observations from the various waves of the Encuesta Nacional de Ingresos y Gastos en los Hogares (ENIGH). The ENIGH is a nationally representative survey of Mexican households which focuses on gathering detailed information about household income and expenditures. We combine the 10 biennial waves from 1992 to 2010 with a 2005 wave.

4.2 Sample

For all outcomes, we restrict our samples to municipios that can be classified as rural. This is important for several reasons. First, we are primarily interested in the impact of maize prices on drug crop cultivation among agricultural producers. This is an inherently rural phenomenon. Furthermore, the relationship between maize prices and illicit activities may be fundamentally different in urban areas where individuals are the consumers of maize rather than producers. In addition, inclusion of urban municipios may lead us to over-estimate the impact on homicides, since dense urban areas with little maize cultivation witnessed a dramatic increase in violence in the late 2000s as maize prices rose.

To exclude largely urban municipios, we use data from the 1990 Census to calculate the fraction of individuals in each municipio who live in very large urban localities with populations of 100,000 or more. We include in our sample those municipios where no individuals in the 1990 Census lived in such large urban areas. Applying this criterion eliminates 104 municipios, leaving us with a final sample of 2,299 municipios.[12]

5 Empirical Strategy

Although one could simply regress a drug outcome in a particular municipio-year against the national price of maize, such an empirical strategy is problematic for three reasons. First, this would estimate the impact of price using only national-level time-series variation, making it difficult to separately identify the effect of the price from an ongoing trend. Second, this would ignore an important source of variation in the sensitivity of drug trade activity to the

[12] Our panel also does not include 51 municipios that were newly created over the sample period.

price of maize. In particular, the impact of price fluctuations on total drug crop cultivation in a particular municipio should depend on the extent to which individuals there depend on maize cultivation. Our empirical strategy therefore employs a difference-in-differences approach: we examine whether changes in the maize price lead to differential effects on illicit activity in the municipios more suited to cultivating maize.

The FAO provides municipio-level measures of agro-climatically attainable yields for maize under different assumptions about available inputs (FAO 2012b). These indices are based on exogenous factors such as location-specific geography, rainfall, and temperature over the period 1961-1990. Our measure of maize suitability is the average of these FAO indices across different input levels. This suitability measure is preferable to direct measures of maize production or cultivation, which may endogenously respond to both eradication and contemporaneous maize prices. This concern is exacerbated in the Mexican context since complete municipio-level data on land devoted to maize cultivation and production are only available after 2003. As Figure 4 demonstrates, all states and regions in Mexico contain substantial variation in maize suitability, ensuring that the effects of maize price fluctuations are not driven by any one particular geographic area.

A third problem with directly examining the impact of the Mexican maize price is that the domestic price may be endogenous to the outcomes of interest. For example, suppose that there is a shock external to maize markets which causes farmers in maize suitable areas to produce more drugs at the expense of maize output. This would cause a reduction in the maize price through a supply effect, generating an upward bias (toward zero) on the estimated relationship between maize prices and differential drug eradication. To circumvent endogeneity concerns, we use an instrumental variables strategy that exploits changes in the maize price induced by the production behavior of major global maize players — the U.S., Argentina, France and China, which are the four largest maize exporters over this period. These instruments are unlikely to be correlated with changes in differential drug production across Mexican municipios through channels unrelated to the maize price.

Over 99 percent of Mexican maize imports come from the United States.[13] This partly reflects the reduction of import tariffs and expansion of import quotas for maize under the NAFTA trade agreement. The extent of maize trade between the two countries, as well as their geographic proximity and political ties creates the concern that U.S. exports could reflect crop production patterns in Mexico. For example, greater drug crop production in maize areas could affect maize production in Mexico, which in turn could influence U.S. production decisions. Therefore, we exploit weather conditions in the U.S. Corn Belt, which exogenously influence crop production. We focus on the five largest maize producing states (Iowa, Illinois,

[13] This calculation is based on data from the United Nations COMTRADE database, covering the 1990-2010 period (UN COMTRADE 2012).

Nebraska, Minnesota, Indiana). Global gridded data from the University of Delaware's Center for Climatic Research are used to create state-level measures of average rainfall (millimeters) and temperature (C) for each month in our sample period. For each year, we track average rainfall in these states over June and July, since these are critical months for maize planting, when drought can severely damage the crops (Tannura et al. 2008). In addition, we also track temperature during April and May, since frosts early in the planting season prove particularly harmful. The state-level monthly temperature and rainfall variables are weighted by each state's share of national corn production to create the national-level variables. We generate deviations of both national weather variables relative to their means over our sample period, and utilize their lag, as harvests take place at the end of the calendar year, over October and November. Figure 5 shows the negative relationship between lagged U.S. weather conditions and the international and Mexican maize prices.

We directly utilize the export volumes of the three non-U.S. producers as instruments for the national maize price in Mexico. The data for these series come from the FAO (FAO 2012a). Mexico imports trivial volumes from non-U.S. countries and given this market segmentation, total export volumes from these countries are unlikely to respond to differential drug production across municipios. Indeed, all three export series are negatively correlated with maize prices, which is inconsistent with the idea that export volumes react positively to price spikes brought on by drug production. Figure 5 also shows the export volumes of these three countries alongside the maize price series.

Chinese export policy, in particular, appears to be heavily influenced by idiosyncratic political factors. The U.S. Department of Agriculture claims that Chinese policy is a substantial driver of the international market, noting that "China has been a significant source of uncertainty in world corn trade." Moreover, Chinese policy seems to be driven by political considerations that are exogenous with respect to production fundamentals and any economic development in Mexico:

> China's corn exports are largely a function of government export subsidies and tax rebates, because corn prices in China are mostly higher than those in the world market. Large corn stocks are expensive for the government to maintain, and Chinese corn export policy has fluctuated with little relationship to the country's production, making China's corn trade difficult to predict. (USDA 2013)

This further underscores the idea that Chinese export behavior is unlikely to respond to Mexican drug production, bolstering the validity of these instruments.

Let Y_{it} refer to the value of dependent variable Y in municipio i during year t. Our basic second-stage specification is given by:

$$Y_{it} = \alpha_{2i} + \tau_{2t} + (\widehat{MAIZE_i \times PRICE_t})\delta + \mathbf{X}'_{it}\phi + \varepsilon_{it} \quad (1)$$

Here the α_{2i} are second-stage municipio fixed effects that control for time-invariant characteristics of Mexican municipios; τ_{2t} are second-stage year fixed effects that account for common shocks in a given year; $MAIZE_i$ is the average agro-climatically attainable yield for maize per hectare in municipio i; $PRICE_t$ is the natural log of the national maize price in year t; and the coefficient δ is our main parameter of interest measuring the differential effect of maize prices on the outcome in municipios with higher maize suitability.[14] $\mathbf{X}_{it}$ is a vector of additional controls which varies across specifications, and we detail our full control set below.

The first stage equation explaining $MAIZE_i \times PRICE_t$ is given by:

$$\begin{aligned} MAIZE_i \times PRICE_t \;=\; & \alpha_{1i} + \tau_{1t} + (MAIZE_i \times CHN_t)\psi + (MAIZE_i \times ARG_t)\sigma \quad (2) \\ & + (MAIZE_i \times FRA_t)\,\theta \; + (MAIZE_i \times US\_TEMP_{t-1})\beta \\ & + (MAIZE_i \times US\_RAIN_{t-1})\gamma + \mathbf{X}'_{it}\rho + \omega_{it} \end{aligned}$$

Here α_{1i} and τ_{1t} represent first-stage municipio and year fixed effects, respectively. CHN_t, ARG_t and FRA_t represent the log of Chinese, Argentine and French maize exports in year t. US_TEMP_{t-1} denotes the temperature deviation in April and May in major U.S. maize states in the previous year. US_RAIN_{t-1} denotes the annual rainfall deviation in these states over June and July of the previous year. Certain dependent variables are scaled by either the area or population of each municipio. Since $MAIZE_i$ is the attainable yield per hectare, we also scale the marijuana and poppy eradication by total municipal area, measuring these outcomes per 10,000 hectares. Killings are measured as a rate per 10,000 population. We take the log of all dependent variables after adding a one. This ensures that municipio-year observations with zero eradication or homicide levels are included in our specifications. Unless otherwise noted, all parameters are estimated via 2SLS, and our standard errors are clustered at the municipio level.

Since our empirical strategy utilizes the interaction of municipal maize suitability with annual prices and the time-varying instruments, this raises the concern that the first stage will appear to display a strong relationship owing solely to the inclusion of the suitability variable on both sides of Equation (2). However, Table 2 presents simple time series regressions which show that the lagged U.S. weather variables, alongside the export volumes of China, France and Argentina are important determinants of the Mexican maize price. Column 1 includes no controls and the R-sqr indicates that these variables alone explain up to 75 percent of the

[14] Note that the base terms of the interaction do not appear separately in equation (1) since $PRICE_t$ is absorbed by year fixed effects while $MAIZE_i$ is absorbed by municipio fixed effects.

variation in the price series. Columns (2) and (3) introduce controls for the U.S.-Mexico real exchange rate and a linear time trend. The instruments are jointly significant at the 1 percent level (with F test-statistics of 15.64 and 12.93 in the two columns). This underscores the strength of the time series relationships underlying our empirical strategy.

Our preferred specifications include a gamut of weather, enforcement and economic controls to address potential confounds. If places suited to growing maize generally have higher land quality, this raises the possibility that increases in drug production estimated with our empirical strategy may reflect trends based on land quality differences, rather than the effect of maize *per se*. We therefore control flexibly for the effect of soil quality by introducing interactions of year effects with our land workability measure. We also control for time-varying rainfall and temperature conditions in Mexican municipios over June and July, as well as temperature conditions during the early maize planting period in April and May.

Another concern is that measured eradication efforts reflect both drug crop cultivation and policy decisions around state enforcement. Since the degree of enforcement within a municipio will vary based on proximity to police stations and other state security facilities, we include controls for linear time trends interacted with (log) distance to the nearest security station. We also control for trends by distance to the U.S. border. This helps account for confounds related to the fact that the drug trade burgeoned in the less maize suitable maize areas along the border in the post-2005 period (see Figure 4), precisely when maize prices started rising. This border variable, along with trends based on the presence of a major highway also address potential differences in the evolution of our outcomes based on the degree of market integration. This is important since NAFTA's implementation in 1994 may have facilitated trade in illegal as well as legal goods (Andreas 1996).

In addition, drug-related violence has increased disproportionately in urban areas over this period, where little maize is cultivated. Although our core sample already eliminates 104 large urban areas, we further account for this effect with trends interacted with our rurality measure. Analogously, since agricultural workers residing in maize areas are relatively poor, we control for trends based on average agricultural income in the beginning of our sample period. We refer to this collection of controls as our full municipal-level control set in the remainder of the paper. Table 3 presents the descriptive statistics of the key variables in our analysis.

6 Maize Prices and Drug Production

In this section we examine the relationships between maize price changes and the key drug trade outcomes in our analysis: drug eradication and drug seizures.

We begin with drug production as proxied by eradication. The first four columns in Table 4 present a motivational specification that examines the impact of the annual maize price, without exploiting the cross-sectional variation in maize suitability. Since the national price varies annually, we are not able to include year fixed effects but instead control for a year trend, along with the real exchange rate. Columns (1)-(2) show the OLS estimates. In Columns (3)-(4) we instrument the national price with the export volume of China, France and Argentina along with planting season temperature and rainfall deviations in the United States. All four columns indicate a negative relationship between the maize price and both drug crop outcomes: when the prize falls, there is greater eradication of marijuana and heroin poppies.

Our main estimation strategy moves beyond these suggestive time-series relationships and tests for differential impacts of the price change across municipios of varying maize suitability. We begin by presenting visual evidence of these difference-in-differences effects. Figure 6 graphs the national maize price alongside the difference in log eradication and seizure outcomes between municipios with above and below mean maize suitability. For all four outcomes, the differences increased as the maize price fell sharply over 1990-2005. The differences also fell after 2005 when the maize price started rising, and generally remained low as the price continued increasing. The exception to this pattern can be seen for opium seizures in 2009-2010, owing to increased seizures of this drug in border areas, which have low maize suitability. This figure is merely suggestive as it is devoid of any controls, and divides the suitability measure discretely around the mean cutoff. Nonetheless, the patterns strongly suggest that increases (decreases) in the maize price correspond to differential decreases (increases) in drug-related outcomes among more maize dependent municipios.[15]

The second half of Table 4 builds on this visual evidence by examining the interactive effect of the maize price and the continuous index of municipal maize suitability. Columns (5)-(6) present the OLS estimates while (7)-(8) present the IV estimates, corresponding to equation (1). The significant, negative coefficients across these specifications indicate that a rise in the maize price leads to a differential fall in drug crop cultivation among municipios with higher maize suitability. The IV coefficients are somewhat larger in magnitude, which is consistent with reverse causality stemming from supply effects biasing the least squares estimates toward zero.

Columns (9)-(10) include the full control set of weather, economic, and enforcement controls enumerated in the Empirical Strategy section, including those related to land quality, border proximity and distance to the nearest police station. This specification, featuring our broad set of controls, serves as our baseline. The coefficients of -.03 and -.02 for marijuana and poppy eradication imply economically meaningful effects. To interpret the magnitude, we consider a municipio at the 10th percentile of the maize suitability distribution ($MAIZE$=4.48) and another at the 90th percentile ($MAIZE$=8.63). For marijuana, moving from the 10th to the

[15] The difference in opium seizures is relatively low over this period since the level of opium seizures was low nation-wide at this time.

90th percentile of this distribution implies that a 59 percent price fall would induce 8 percent more eradication. The equivalent calculation for poppy implies 5 percent more eradication.

The first stage is strong, as indicated by a large rk Wald F statistic ($2.8x10^9$), which exceeds the relevant Stock Yogo critical value. Since both sides of the first-stage equation are products of time-invariant maize suitability and the time-series variables (maize price, U.S. weather conditions, and exports of other major maize producers), this raises the possibility that the strength of the first stage is driven solely by the cross-sectional suitability. However, as discussed in the Empirical Strategy section, the time-series instruments stand on their own as strong predictors of the Mexican maize price (see Table 2).

The planting decisions of farmers represent the first steps in the narco-trafficking chain. After drug crops are grown, they are harvested, packaged, and processed. Given our results on eradication, we next explore whether there are differences in post-cultivation outputs. We utilize data on drug seizures, which offer a completely separate measurement of production in a municipio. These data distinguish manufactured from raw drug products — heroin vs. opium gum, and processed marijuana vs. raw marijuana.

In Table 5 we find a significant negative impact on seizures of raw marijuana, but no equivalent impact on processed marijuana. The effect on raw marijuana seizures is substantial: a 59 percent maize price fall implies 16.4 percent more seizures in a municipio at the 90th percentile of maize suitability compared to one at the 10th percentile. We also observe significant negative effects on opium gum seizures, without corresponding impacts on processed heroin seizures. Since Figure 6 reveals a large spike in differential opium gum seizures in 2009 and 2010, we verify that the results continue to hold when we exclude these two years, without a meaningful change in estimated effects.[16] However, the opium gum effect is relatively small in our full sample. The estimate implies that a 59 percent maize price fall would result in 1.2 percent more opium seizures in municipios at the 90th versus those at the 10th percentile of maize suitability. Although this average effect is small, below we uncover larger heterogenous impacts on this outcome.

The larger estimates for raw versus processed components accord with our expectation that the maize price affects the output decisions of farmers, but does not necessarily affect cartel incentives to process drugs in particular areas. These results are consistent with home-grown drug crops being produced in rural locations, even if processing takes place elsewhere. We also observe small, but significant impacts on the seizure of cocaine (largely imported from Colombia), suggesting spillovers into other types of drug trafficking. The coefficient in Column (5) implies that there are 2.7 percent more cocaine seizures in municipios at the 90th vs. 10th percentile owing to the 59 percent price fall. However, we do not find any significant relationship between maize price changes and the production of methamphetamines.

[16] These estimates are available upon request.

The relationship between the maize price and drug cultivation in a municipio should depend on the ease with which farmers can respond to an income shock by growing illicit drugs. We therefore expect the effect of a price change on marijuana or opium poppy cultivation to be larger in those areas that are better suited to growing these crops. In the absence of pre-existing data on drug crop suitability, we use the average values of marijuana and poppy eradication in a municipio over the period 1990-1993 as a simple measure of a municipio's suitability for growing either of these crops.

Panel A of Table 6 presents estimation results for our eradication and seizure outcomes when we split the sample into groups with above and below median marijuana suitability. In line with expectations, we consistently estimate larger effects across all of our outcomes in those municipios with above median marijuana suitability. For marijuana eradication, we estimate a differential maize price effect of -0.082 in the municipios with above median marijuana suitability (Column 2), compared to an estimated differential effect of -0.003 in the below median group (Column 1). Similarly, we estimate a differential effect of -0.131 on raw marijuana seizures in the marijuana-suitable municipios (Column 6), while we again find a small, statistically insignificant effect in the less suitable sub-sample (Column 5). The magnitude of the effect on marijuana eradication in the marijuana-suitable municipios is substantial. The estimates in Columns 2 and 6 suggest that a 59% decline in the maize price would result in a 20 percentage point larger increase in marijuana eradication and a 32 percentage point larger increase in raw marijuana seizures in a municipio at the 90th percentile of maize suitability versus one at the 10th percentile.

Panel B of Table 6 presents estimation results when the sample is split on the basis of the poppy suitability index. Across outcomes, we again consistently find larger differential price effects in those municipios with above median poppy suitability. The estimated differential impact is -0.073 for poppy eradication (Column 4) and -0.020 for opium gum seizures (Column 8). The coefficients suggest that a 59% decline in the maize price would yield an 18 percentage point larger increase in poppy eradication and a 5 percentage point larger increase in opium gum seizures in the 90th percentile municipio versus the 10th percentile municipio.

Table 6 also reveals that there are important cross-crop suitability effects. There are larger differential price effects on both marijuana and poppy outcomes in municipios with above median marijuana suitability, and above median poppy suitability. These cross-crop effects are consistent with the important role that mountainous areas play in drug crop production (Humphrey 2003). High elevation is required for poppy cultivation. In turn, mountainous areas may be well suited to the production of marijuana both because of the existing drug-trade infrastructure and because the rugged terrain helps farmers conceal illegal activity. Indeed, Panel C of Table 6 indicates that when we split the sample based on our ruggedness measure, we find substantially higher differential price effects in the more rugged areas.[17]

7 Maize Prices and Household Economic Outcomes

As emphasized in our mechanisms section, we should expect to observe that these maize price fluctuations induce households in more maize suitable areas to experience larger declines in their legal income opportunities. We therefore utilize several waves of the ENIGH spanning 1992-2010 to explore impacts on a range of labor market outcomes, including measures of rural wages computed on the basis of reported income. While the ideal data would distinguish data on income generated from legal and illegal production, we are only able to observe total reported income, which may reflect income generated from the cultivation of drug crops. Thus, our estimates should be interpreted as reflecting the impacts of the maize price on households after they have made decisions around labor supply, occupation and crop adjustments, including the decision to grow drugs.

For all of our variables of interest, we estimate the individual-level equivalent of Equation (1). In addition to the full municipal-level control set, we also include individual-specific controls for age, education, and survey month.

In Panel A of Table 7, we first examine whether fluctuations in maize prices alter the labor supply behavior of rural individuals. Here we restrict our sample to men between the ages of 18 and 65 who reported working last month and live in locations with populations less than 2,500. The dependent variable in Column 1 is a dummy for working 40 or more hours in the past week, which we take to be full time work. We find a positive and significant coefficient on the interaction between the maize price and maize suitability suggesting that the propensity to work full-time rises as the price of maize rises. The estimated coefficient of 0.031 suggests that a 1 percent increase in the maize price increases the relative probability of full time work by 0.001 in a municipio at the 90th percentile of the maize suitability distribution, as compared to a municipio at the 10th percentile of the distribution. This implies that as the maize price declined by 59 percent between 1990 and 2005, the fraction of men working full-time fell by an additional 8 percentage points in the more maize suitable municipio.

It is possible that a reduction in the price of maize can reduce a household's incentives to produce a surplus for the market, and increase the propensity to engage in subsistence work that does not generate monetary income. For example, if the price is sufficiently low, households will not find it optimal to incur fixed costs of market participation, and may instead only produce for household consumption and informal exchange. Indeed, de Janvry et al. (1995) and

[17]Ruggedness in a particular geographic point inside of a municipio is defined as the average difference in elevation between a grid point and its neighbors. The ruggedness measure is the average ruggedness for all points in a municipio.

Yunez-Naude and Serrano-Cote (2010) argue that such an increase in subsistence activity has occurred in Mexico in the wake of NAFTA. We can measure subsistence behavior in our sample in two ways. First, the ENIGH survey asks workers to identify their job classification (e.g. paid employee, self-employee etc.). One worker type indicates an unpaid worker in a family farm or business, and this classification represents our first measure of subsistence employment. Second, we can directly measure whether individuals report earning zero income, regardless of their worker type. Columns 2-5 of Panel A present results on the effect of maize prices on these subsistence measures among full-time workers. In Columns 2-3 of Panel A, we find negative coefficients on both measures, although only the coefficient on the zero income variable is significant at the 0.10 level. However, we know that unpaid labor is a phenomenon associated with relatively young workers, so in Columns 4-5, we repeat these regressions restricting the sample to workers aged 30 or younger. In this young sample, we find large, positive, and statistically significant coefficients on both subsistence measures which are very similar in magnitude. The estimated coefficient of -0.050 in the zero income specification suggests that in the response to the 59 percent maize price decline between 1990 and 2005, the fraction of zero-income workers increased by 12 more percentage points in the more maize suitable municipio. Since about 8% of young workers in the entire sample earn zero income, this differential effect is sizable.

In Panel B of Table 7, we examine the impact of a change in the maize price on log hourly wages, which are computed from survey items on income and hours worked. We restrict our sample to those working 20 or more hours per week. We first examine the impact on all such rural workers, not only those identified as maize workers in the ENIGH. We do this for at least two reasons. First, many farming households grow a variety of crops, making it difficult to identify them with any one particular output. Indeed, in the 1990 Census, over 40 percent of agricultural workers were not classified as cultivating any one particular crop. Ethnographic studies suggest that even those farmers associated with non-maize crops devote a non-trivial fraction of their land to maize cultivation (Eakin 2006, pp. 54-82). As such, only considering individuals identified as maize workers will understate the fraction of farmers whose income stream is sensitive to changes in maize prices. Second, households may endogenously change the mix of crops they plant, or may move out of agriculture in response to changing crop prices. We consider the impact of a change in the maize price on all workers to avoid bias stemming from compositional changes.

Column 1 of Panel B indicates that the wage elasticity with respect to the maize price is significantly higher in those municipios that are more suited to growing maize. To interpret the magnitude of the coefficient estimate, we again compare the implications for the difference in wages between workers in a high and low maize municipios. The estimated coefficient of 0.078 suggests the wage elasticity with respect to the maize price is higher by 0.32 in the more maize suitable municipio. This implies that as the maize price declined by 59 percent between

1990 and 2005, average wages of rural workers in the more maize suitable municipio fell by an additional 19 percentage points.

In Column 2, we restrict the sample further to only include agricultural workers. The point estimate from this specification is similar to the estimate in Column 1, but reducing the sample size increases the standard error and this estimate is insignificant at the .10 level. In Column 3, we restrict the sample to only include workers identified as maize and bean workers. In this specification we estimate a large and significant coefficient of 0.261. This suggests that in response to the 59 percent decline in the maize price between 1990 and 2005, the average wages of maize and bean workers fell by about 64 more percentage points in the high maize municipio. Finally, in Column 4, we restrict the sample to workers who identify themselves as cultivating specific crops which are not maize.[18] We do not find differential effects for these workers, consistent with the argument that our difference-in-difference strategy isolates a change in income opportunities that is specifically related to maize workers.

Taken together, the results in Table 7 provide evidence that changes in the maize price over our sample period generated substantial differences in the labor market outcomes of municipios with varying levels of maize suitability. A fall in the maize price not only reduced full-time employment rates, but also increased the propensity for subsistence work and substantially reduced the wages of those who work full-time.

8 Cartel Activity and Violence

The results in the previous section provide evidence that declining maize prices stimulate increased drug production. Such activity is inextricably tied to the operation of cartels which play a key role enabling the transport and sale of drugs in international markets. Cartels either directly purchase drugs produced by small holders or hire laborers to cultivate drugs on lands that they control (Humphrey 2003). In either case, we posit that Mexican cartels act as monopsonies in local drug crop markets. These cartels, like other criminal organizations, are highly territorial and use violence to defend claims to particular bases of operation (Kan 2012, Knight 2012). If a cartel controls a swath of territory from which it sources illegal drug crops, we assume that it maintains complete market power in dictating the price paid to small holder producers or the wage paid to hired cultivators. This is consistent with accounts of marijuana farming in the mountainous regions of Sinaloa (Río Doce 2012).

Suppose that cartels purchase drug output from small holders at a chosen farm gate price, and then sell these drug crops abroad at the prevailing international market price. The farm

[18] Specifically, we include any cultivator who identifies a crop-specific occupation code which is not related to maize. This definition includes cultivators of cereals (e.g. rice and sorghum), cotton, henequen, fruits and vegetables, coffee, cocao, tobacco, and flowers.

gate price that a cartel offers local farmers will be determined both by the international price and by the supply curve of local farmers. When the value of alternate income generating activities falls, as is the case when the maize price declines, cartels can exploit their monopsony power, reduce the farm gate price, and extract greater surplus from their suppliers. As such, the value of controlling a particular territory should increase as the outside options of local farmers deteriorate.

This account implies a set of predictions related to the expansion of cartel activity and patterns of inter-cartel violence. In addition to solving a local monopsonist's problem, cartels must also decide where to base their operations, whether or not to expand into other territories, and whether or not to actively contest the hegemony of an incumbent cartel. If falling maize prices make maize-dependent areas more valuable, we should expect cartels to expand into these areas, increasing the likelihood of violent confrontations between multiple cartels.

Table 8 presents results on the cartel activity variables derived from the Coscia and Rios (2012) data. First, we find substantial effects on cartel presence. Our estimates in Column (1) suggest that the 59% price fall would imply that the likelihood of any cartel being present in a municipio increases by 0.05 more in a municipio at the 90th versus 10th percentile of the maize suitability distribution. Given the mean of this outcome variable (.058), the estimate represents an 80 percent increase in cartel presence owing to the maize price fall. Analogously, Column (2) shows that first-time cartel entry into a municipio increases differentially by .01 more in municipios at the 90th vs. 10th percentile, which represents a 95 percent increase over the mean. Finally, the estimate in Column (3) indicates that the operation of multiple cartels in a given municipio increases differentially by .03 which represents a 122 percent increase when benchmarked against the small base of .028.

We next investigate the relationship between changes in the price of maize and killings related to the drug war. Total drug war-related killings are composed of cartel executions (85%), deaths from cartel confrontations with each other and the army (13%) and deaths related to cartel attacks on state security forces (2%). Although the data on violence outcomes are only available for the 2007-2010 period, we obtain 2SLS estimates by using first stage data for the entire sample period (1990-2010). We do not restrict both stages to the later period because doing so would severely limit the time-series variation in the data and would prevent us from using all of our time-varying instruments. For these specifications with unequal first and second stage sample sizes, we estimate standard errors by bootstrapping.[19]

[19] To bootstrap, we draw 100 samples with replacement for each specification, and re-estimate the model for each sample to obtain a distribution of parameter estimates. We re-sample at the level of the municipio, so if there are N_m municipios in the sample for a particular specification, we randomly draw N_m municipios with replacement and use the entire time-series for each re-sampled municipio. This re-sampling procedure accounts for serial correlation in the error terms. We use the standard deviation of a particular parameter estimate in the bootstrapped distribution to form the appropriate test statistics for hypothesis testing.

The estimates in Columns (4)-(7) of Table 8 suggest that reductions in the price of maize produce a significant increase in drug war killings across categories, with the largest effect in the sub-category of executions. The coefficients suggest that the 8 percent increase in the maize price over 2007-2008 led to 7 percent fewer total drug war killings and 6 percent fewer executions, among municipios at the 90th versus 10th percentile of the maize suitability distribution. The coefficients in Columns (6)-(7) imply equivalent effects of 3 and 1 percent fewer deaths from confrontations and cartel attacks, respectively.

9 Threats to Identification

Next, we address several possible threats to our identification strategy. These threats cover three main themes. First, eradication may be a problematic measure of drug crop cultivation if it reflects endogenous policy decisions, or if it affects future drug production. Second, maize suitability could be correlated with the growth of drug production for reasons other than income changes due to price shocks. Third, changes in maize prices could be correlated with other systematic changes in Mexican agricultural policy.

9.1 Eradication as a Measurement of Production

We have assumed that the number of hectares of a particular drug crop eradicated serves as a good measure of the overall quantity of drug production taking place in a given municipio-year. This assumption is bolstered by studies suggesting that a very high percentage of drug crops are actually eradicated in a given year.[20] Our interpretation of the results will be threatened if maize price fluctuations cause officials to alter the differential volume of eradication across municipios for reasons other than production changes. Local political dynamics represent the most plausible context in which this could occur. For example, it could be the case that declining maize prices cause differential shifts in political attitudes in maize suitable municipios which are translated into local policy responses. Indeed, Dell (2012) provides evidence that the local political party affiliation of a municipio's mayor exerts a substantial impact on the dynamics of the drug war. To alleviate this concern, we re-estimate our main specifications including a time-varying regressor indicating whether or not a municipio's mayor was a member of PAN, the political party associated with more aggressive drug policy.[21] As indicated by the results in Table 9, all of our coefficient estimates retain their significance and magnitude, with the new estimates all lying in the 95% confidence intervals of our base specifications.

[20] As previously mentioned, Humphrey (2003) suggests that about 75% of marijuana production is eradicated.

[21] Note that the samples for these specifications are smaller than in the baseline specifications because of missing data on mayoral party affiliation.

An alternate critique of our results posits that eradication could differentially change in maize dependent municipios as the maize price falls if budgetary resources endogenously adjust. However, the most likely scenario is that as the price of maize falls, maize dependent municipios would see greater strain placed on local budgets, decreasing resources to be used in support of federal eradication efforts. To the extent that this is important, we would expect endogenous budgetary resources to attenuate our estimates of the impact of maize prices. This would imply that our estimates represent a lower bound on the true differential effects.

Our interpretation of the results is also threatened if the process of eradication fundamentally alters the incentives to produce drugs in the future. Eradication not only offers a proxy for cultivation, but it is an enforcement activity which destroys cultivated crops and might change the incentives for future production. For example, it could be the case that heavy eradication in one year discourages future production, either by destroying household resources, or by changing household expectations about the future risks of drug production. This concern is allayed by the fact that marijuana and poppy are annual crops that need to be replanted each year. Thus, eradication in a particular year does not reduce a household's ability to grow drugs in the future as would be the case for a perennial plant like coca (which is used to manufacture cocaine). It is reasonable to presume that the risk of eradication is understood by growers as one of the features of illicit crop cultivation. We can also directly assess the nature of serial correlation in the eradication process. In the first two columns of Table 10, we re-estimate our baseline specifications for the eradication of marijuana and poppy, but now add in a lag of the dependent variable. In both cases, we find coefficients on the lags which are large, positive, and statistically significant. There appears to be quite a bit of persistence in eradication, which is inconsistent with stories in which heavy eradication in one period leads to a substantial reduction in eradication in the next.

9.2 Crop Suitability

We interpret our results as stemming from the larger impact of maize price changes on income generating opportunities in maize suitable regions. However, if maize suitability is correlated with suitability for other crops whose prices covary with the price of maize, this could confound our interpretation. For example, if the price of sorghum rises (falls) with the price of maize, and if sorghum suitability is positively correlated with maize suitability, this would bias our estimated effects upwards (downwards). To control for this, we gather FAO suitability measures for 15 other crops besides maize, which rank among the top 30 most important agricultural commodities in Mexico in terms of production value.[22] In Columns 3-4 of Table 10, we re-

[22] These crops are wheat, barley, carrots, pasture grass, sorghum, rice, alfalfa, banana, cotton, oats, onions, potatoes, soybeans, tomatoes, and beans.

estimate our eradication results for marijuana and poppy, but now add interactions between municipio suitability for 14 crops (excluding beans) and year dummies. Adding this extensive set of controls actually increases our point estimates for the differential effect of maize prices on eradication in both cases. In Columns 5-6, we also add interactions between year dummies and bean suitability. We still estimate a large significant effect on marijuana eradication, but our estimate for poppy eradication becomes small and statistically insignificant. This is unsurprising, since maize suitability exhibits the highest degree of correlation with bean suitability among the crops we consider. As mentioned previously, "maize and bean worker" is a unified occupational category in the Census because these crops are so frequently grown together. Adding interactions of year dummies with bean suitability thus comes close to soaking up all of the variation that could be used to identify a differential impact.

Another natural concern emerges if municipios with high maize suitability are also well suited to growing drug crops. Suppose this is true and the drug trade has expanded over time for reasons unrelated to price changes. Since maize prices are falling for most of our sample period, we might then expect to find the same difference-in-differences results even in the absence of income changes. To account for this, we re-estimate our specifications in Table 11 but now include as controls interactions between annual dummies and the average value of the dependent variable over the period 1990-1993 in Panel A.[23] When examining cartel outcomes in Panel B, we include the interaction of year dummies with both average marijuana and poppy eradication from 1990-1993. These controls flexibly account for the differential evolution of the drug trade in those municipios better suited to growing illicit crops. For all outcomes, the new point estimates lie within the 95% confidence intervals of our original specifications.

9.3 Other policies

As described in section 2.2, the maize price witnessed a dramatic decline in Mexico over the course of the 1990s and early 2000s with the implementation of NAFTA and the gradual elimination of import restrictions. However, NAFTA introduced several policy changes to the Mexican agricultural sector beyond the reduction of trade barriers for U.S. maize. Perhaps the most dramatic of these changes was the dismantlement of CONASUPO, a state agency which administered agricultural support and purchased and stored commodities from smallholders to guarantee demand. CONASUPO also directly marketed certain products through its retail arm, DICONSA. Since the dismantlement of CONASUPO coincided with the decline in maize prices over the course of the 1990s, this raises the concern that our results are driven not by income shocks related to price fluctuations, but by the disruption of rural market structure related to

[23] In results not reported, we also repeat this exercise with a measurement of drug crop suitability based on cross-sectional regressions explaining average 1990-1993 eradication as a function of plausibly exogenous agro-climatic factors. We find similar results, which are available upon request.

this policy change. However, we do not believe that these policy considerations are driving our results for two reasons. First, this concern is allayed by the IV component of our empirical strategy. We rely on exogenous variation in maize prices brought about by weather shocks and fluctuations in export volumes. These factors should not be correlated with the pace of internal agricultural reform in Mexico. Second, data on the municipio-level prevalence of DICONSA stores allow us to directly control for time-trends by CONASUPO presence. We take the average number of DICONSA stores located in a municipio over the period 1994-1996 as a cross-sectional measurement of CONASUPO's activity within a particular municipio.[24] In Panel A of Table 12, we re-estimate our basic specifications adding interactions between year dummies and this measure to control for the shift in market structure brought on by agricultural reform. All of the coefficients in these specifications are similar to the baseline estimates, suggesting that our results are not primarily driven by the elimination of CONASUPO.

Post-NAFTA agricultural reforms also reallocated state support from small-holders to commercial maize producers located largely in the North. Most state resources for maize support have been concentrated on assisting commercial maize operations in the state of Sinaloa. For example 70% of the marketing subsidies currently targeted at maize producers go to farmers in that state (Yunez-Naude and Serrano-Cote 2010). Since Sinaloa has historically been a major hub for drug activity, our results could be biased if the shift in agricultural policy coincides with the escalation of the drug trade there. To rule out this account, we re-estimate our main specifications in Panel B of Table 12 excluding Sinaloa from the sample. This sample restriction does not alter the results.

9.4 The Border

As a final robustness check, we re-estimate our specifications excluding the 31 municipios along the US-Mexico border. Since these municipios have seen the most dramatic rise in drug-war activity, especially in the late 2000s, it is reasonable to ask whether our results are driven by changes in drug-trade outcomes in this influential subset of municipios. The results in Table 13 suggest that this is not the case, as the coefficient estimates are all quite similar to the baseline values when these municipios are excluded from the sample.

[24]Our aim is to create a variable which measures the prevalence of DICONSA at the start of our sample period since the scope and role of CONASUPO changes over time. The earliest year for which DICONSA data are available is 1994, and we average over two more years to create a more complete measure in the face of missing data.

10 Conclusion

We examine how maize price dynamics affect the drug trade in Mexico. Using data from 1990-2010, we demonstrate that price changes induce differential drug market outcomes across municipios of varying maize suitability. We instrument the Mexican maize price with the maize exports of China, France and Argentina, and weather conditions in the United States Corn Belt. We include a number of controls and sample restrictions to address concerns regarding targeting of enforcement and differential trends in border and rural areas.

We show effects along the entire narco-trafficking chain, starting with increases in illicit drug crops and ending with cartel violence. In particular, we document impacts on the cultivation of marijuana and opium poppies, as well as seizures of raw marijuana and opium gum. These effects are larger in municipios more suited to cultivating drug crops. In addition, adverse maize price shocks influence the location of drug cartels, and exert large effects on drug-war related killings at the end of our sample period. Our results suggest that the economic impact of price changes on households and their subsequent decisions to grow illicit crops ultimately affect the industrial organization of violence in Mexico. This points to an inter-connection between what are typically described as two distinct policy efforts to curb drug production – those that target enforcement toward drug cartels, and those that focus on the economic incentives facing rural producers. In fact, policies designed to mitigate household economic shocks may ultimately influence the operations and geographic locations of cartels.

Our findings are relevant for understanding drug sector dynamics in many other settings. Countries such as Afghanistan and Colombia also confront narco-trafficking chains tied to the rural production of drug crops. In both instances, drugs fund armed groups and violence, whether it is the FARC insurgency in Colombia or the Taliban in Afghanistan (Labrousse 2005). Our study suggests that as these countries pursue broader development strategies, policies influencing the income opportunities of the rural poor may shape the narcotics trade. Policymakers should therefore consider the implications of measures such as trade agreements and agricultural reforms on the rural narco-economy. For example, in the case of Mexico it was hoped that NAFTA would deliver economic gains by more efficiently allocating resources. Relative price changes (e.g., a fall in the price of commodities such as maize) were expected to initially reduce agricultural incomes but ultimately encourage workers to join more productive, export-oriented sectors. While Mexican manufacturing has expanded, the reduction in maize prices following the Agreement may have also contributed to the growth of the illicit drug sector. More generally, policies that alter agricultural supports or increase the exposure of rural households to international prices may have similar implications.

Our analysis highlights the importance of better understanding the economic determinants of drug supply, as well as the development consequences of the narcotics trade. Beyond factors affecting the rural economy, how do economic shocks to urban areas affect drug production? Does the expansion of the drug sector divert labor and other resources away from manufacturing? Would stronger law-enforcement institutions prevent such diversion and therefore promote the efficacy of structural reforms? These questions should be explored in future research.

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Table 1: Characteristics of Rural Workers (1990 Census)

	All Workers		*Agricultural Workers*		*Maize Workers*	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age	35.22	12.56	36.93	13.44	37.15	13.4
Education	5.13	4.16	3.41	3.12	2.94	2.85
Full Time	0.75	0.43	0.73	0.44	0.75	0.43
Agricultural Worker	0.48	0.5	-	-	-	-
Maize Worker	0.14	0.35	0.29	0.45	-	-
Class of Worker:						
Own Account	0.35	0.48	0.48	0.5	0.62	0.49
Unpaid	0.04	0.2	0.07	0.26	0.1	0.29
Employer	0.02	0.13	0.01	0.1	<0.01	0.06
Paid Employee	0.56	0.5	0.38	0.49	0.23	0.42
Zero Income	0.14	0.35	0.27	0.44	0.37	0.48
Monthly Inc. (if >0)	4,517.66	21,115.26	3,153.839	19,855.35	2,519.218	20,230.78
Total Observations	748,486		361,511		105,643	

Notes. Full Time indicates an individual working at least 40 hours per week. For each subsample, we list total observations, which is the largest number of observations in the subsample used to calculate a particular sample mean. However, for some variables, we use fewer observations because of missing data. For All Workers, we have 748,486 total observations, but fewer for education (735,441) and monthly income conditional on positive income (716,819). Similarly, for Agricultural Workers, we have 361,511 total workers but fewer for education (357,371) and monthly income (343,317). For Maize Workers, we have 105,643 total observations, but fewer for education (104,812) and monthly income (100,890).

Table 2: Maize Price, U.S. Weather, and Exports

VARIABLES	(1) Log national maize price	(2) Log national maize price	(3) Log national maize price
CHN	-0.031	-0.050	-0.110***
	(0.019)	(0.029)	(0.029)
FRA	-0.366**	-0.358*	-0.513***
	(0.164)	(0.186)	(0.164)
ARG	-0.498***	-0.547***	-0.194
	(0.078)	(0.096)	(0.137)
US_RAIN	-0.071*	-0.089**	-0.063*
	(0.034)	(0.040)	(0.031)
US_TEMP	-0.026	-0.044	-0.043
	(0.037)	(0.035)	(0.026)
Real exchange rate?		Y	Y
Year trend?			Y
F-statistic for instruments	21.76	15.64	12.93
Observations	21	21	21
R-squared	0.748	0.761	0.861

Notes. CHN, FRA and ARG represent the log of Chinese, French and Argentine maize exports. US_TEMP denotes the temperature deviation in April and May in major U.S. maize states the previous year, and US_RAIN denotes the rainfall deviation in these states over June and July during the previous year. The real exchange rate refers to the U.S.-Mexico exchange rate. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

Table 3: Descriptive Statistics of Municipal and Annual Variables

	Observations	Mean	Standard Deviation
Panel-level municipal variables			
Log marijuana eradication	46,872	0.132	0.470
Log poppy eradication	46,872	0.070	0.392
Log raw marijuana seizures	46,872	0.175	0.919
Log processed marijuana seizures	46,872	0.258	1.231
Log opium gum seizures	46,872	0.007	0.129
Log heroin seizures	46,872	0.002	0.067
Log cocaine seizures	46,872	0.025	0.328
Log meth seizures	46,872	0.006	0.157
Log total drug-related killings	8,928	0.225	0.551
Log drug-related executions	8,928	0.200	0.505
Log killings from confrontations	8,928	0.038	0.244
Log killings from cartel attacks	8,928	0.007	0.089
Log population	46,872	9.266	1.279
Temperature April-May	46,872	22.436	4.148
Temperature June-July	46,872	22.652	4.542
Rainfall June-July	46,872	175.267	111.946
PAN mayor	40,731	0.133	0.339
PRD mayor	40,731	0.118	0.323
Other mayor	40,731	0.035	0.184
Any cartel	44,640	0.058	0.235
First cartel presence	41879	.0155	.124
Multiple cartels	44,640	0.028	0.165
Cross-sectional municipal variables			
Maize suitability (Kg DW/ha)	2,232	6.632	1.601
Log distance to security station	2,232	3.082	0.798
Log distance to U.S. border	2,232	6.024	0.644
Highway indicator	2,232	0.559	0.497
Border indicator	2,232	0.014	0.117
Ruggedness	2,232	173.971	136.436
Predicted poppy suitability	2,232	0.068	0.043
Predicted marijuana suitability	2,232	0.160	0.069
Soil workability	2,232	2.254	1.003
Average agricultural income (1990)	2,232	12.058	0.721
Fraction of agricultural workers	2,232	0.670	0.335
Diconsa (1994-1996)	2,195	8.125	12.109
Annual-level variables			
Log national maize price (2010 pesos)	21	1.077	0.277
Log Chinese maize exports (tons)	21	14.800	1.726
Log French maize exports (tons)	21	15.742	0.158
Log Argentine maize exports (tons)	21	15.972	0.494
Lag U.S. rainfall	21	-0.066	0.974
Lag U.S. temperature	21	-0.065	0.975
Log exchange rate	21	2.437	0.106
Individual-level variables			
Sample: Agricultural workers			
Age	28,866	38.700	13.784
Education	28,865	4.266	3.322
Maize Worker	28,866	0.410	0.492
Labor Income (2005 Pesos)	20,351	2462.471	6555.133
Sample: All workers			
Age	48,672	37.410	13.201
Education	48,660	5.257	3.788
Agricultural Worker	48,672	0.600	0.490
Maize Worker	48,672	0.246	0.431

Notes: Individual-level variables are from the ENIGH surveys. See data section for definitions of variables

Table 4: Maize Price, Maize Suitability, and Illicit Crops

VARIABLES	(1) Log marijuana eradication	(2) Log poppy eradication	(3) Log marijuana eradication	(4) Log poppy eradication	(5) Log marijuana eradication	(6) Log poppy eradication	(7) Log marijuana eradication	(8) Log poppy eradication	(9) Log marijuana eradication	(10) Log poppy eradication
PRICE	-0.135***	-0.052***	-0.166***	-0.068***						
	(0.012)	(0.008)	(0.013)	(0.009)						
MAIZE x PRICE					-0.017***	-0.012***	-0.027***	-0.022***	-0.032***	-0.022***
					(0.005)	(0.004)	(0.005)	(0.004)	(0.006)	(0.005)
Weather, economic, and enforcement controls?									Y	Y
Estimation method	OLS	OLS	IV-2SLS	IV-2SLS	OLS	OLS	IV-2SLS	IV-2SLS	IV-2SLS	IV-2SLS
Observations	48,279	48,279	48,279	48,279	48,279	48,279	48,279	48,279	46,872	46,872
Municipios	2,299	2,299	2,299	2,299	2,299	2,299	2,299	2,299	2,232	2,232

Notes. Robust standard errors clustered at the municipal level are shown in parentheses. Variables not shown include municipio fixed effects and log population in all columns. Log marijuana and poppy eradication are measured as log of area eradicated per 10,000 hectares plus 1. Columns (1)-(4) control for a linear time trend and the log U.S. Mexico real exchange rate. In columns (3)-(4) the log national maize price is instrumented with lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. Columns (5)-(10) control for year fixed effects and the interaction of maize suitability with the (log) U.S. Mexico real exchange rate. In columns (7)-(10), the interaction of maize suitability and the log national maize price is instrumented with the interaction of maize suitability and the lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. Weather, economic and enforcement controls in columns (9)-(10) include: temperature and rainfall conditions in Mexican municipios, land quality interacted with year effects, as well as trends by average agricultural income in 1990, the fraction of agricultural workers, major highway presence, distance to the U.S. border, and distance to the nearest security station. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

Table 5: Maize Price, Maize Suitability, and Drug Seizures

VARIABLES	(1) Log raw marijuana seizures	(2) Log processed marijuana seizures	(3) Log opium gum seizures	(4) Log heroin seizures	(5) Log cocaine seizures	(6) Log meth seizures
MAIZE x PRICE	-0.067***	-0.014	-0.005***	-0.001	-0.011**	-0.001
	(0.014)	(0.024)	(0.002)	(0.001)	(0.005)	(0.003)
Observations	46,872	46,872	46,872	46,872	46,872	46,872
Municipios	2,232	2,232	2,232	2,232	2,232	2,232

Notes. Robust standard errors clustered at the municipal level are shown in parentheses. Variables not shown and included in all regressions are: municipio and year fixed effects, log population, the interaction of maize suitability with the (log) U.S. Mexico real exchange rate, temperature and rainfall conditions in Mexican municipios, land quality interacted with year effects, trends by average agricultural income in 1990, the fraction of agricultural workers, major highway presence, distance to the U.S. border, and distance to the nearest security station. Log raw marijuana, processed marijuana, opium gum, heroin, cocaine, and meth seizures are measured as log of kilograms seized plus 1. The interaction of maize suitability and the log national maize price is instrumented with the interaction of maize suitability and the lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

Table 6: Heterogeneous Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Log marijuana eradication		Log poppy eradication		Log raw marijuana seizures		Log opium gum seizures	
	Panel A: Results by Marijuana Suitability							
Suitability	*Below Median*	*Above Median*	*Below Median*	*Above Median*	*Below Median*	*Above Median*	*Below Median*	*Above Median*
MAIZE x PRICE	-0.003	-0.082***	-0.006**	-0.046***	-0.007	-0.131***	-0.001	-0.009**
	(0.004)	(0.015)	(0.003)	(0.012)	(0.008)	(0.035)	(0.001)	(0.004)
Observations	30,513	16,359	30,513	16,359	30,513	16,359	30,513	16,359
Municipios	1,453	779	1,453	779	1,453	779	1,453	779
	Panel B: Results by Poppy Suitability							
Suitability	*Below Median*	*Above Median*	*Below Median*	*Above Median*	*Below Median*	*Above Median*	*Below Median*	*Above Median*
MAIZE x PRICE	-0.009**	-0.113***	-0.006**	-0.073***	-0.005	-0.230***	-0.000	-0.020***
	(0.004)	(0.031)	(0.003)	(0.027)	(0.009)	(0.069)	(0.000)	(0.008)
Observations	38,703	8,169	38,703	8,169	38,703	8,169	38,703	8,169
Municipios	1,843	389	1,843	389	1,843	389	1,843	389
	Panel C: Results by Ruggedness							
Ruggedness	*Below Median*	*Above Median*	*Below Median*	*Above Median*	*Below Median*	*Above Median*	*Below Median*	*Above Median*
MAIZE x PRICE	-0.003	-0.074***	-0.003	-0.050***	-0.010	-0.124***	-0.000	-0.012***
	(0.006)	(0.011)	(0.005)	(0.009)	(0.014)	(0.026)	(0.001)	(0.003)
Observations	23,436	23,436	23,436	23,436	23,436	23,436	23,436	23,436
Municipios	1,116	1,116	1,116	1,116	1,116	1,116	1,116	1,116

Notes. Robust standard errors clustered at the municipal level are shown in parentheses. Variables not shown and included in all regressions are: municipio and year fixed effects, log population, the interaction of maize suitability with the (log) U.S. Mexico real exchange rate, temperature and rainfall conditions in Mexican municipios, land quality interacted with year effects, trends by average agricultural income in 1990, the fraction of agricultural workers, major highway presence, distance to the U.S. border, and distance to the nearest security station. Log marijuana and poppy eradication are measured as log of area eradicated per 10,000 hectares plus 1. Log raw marijuana and opium gum seizures are measured as log of kilograms seized. In Panel A, the sample is split into municipios with below and above median marijuana suitability. In Panel B, the sample is split into municipios with below and above median poppy suitability. In Panel C, the sample is split into municipios with below and above median terrain ruggedness. The interaction of maize suitability and the log national maize price is instrumented with the interaction of maize suitability and the lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

Table 7: Maize Price, Maize Suitability and Labor Market Outcomes

	(1)	(2)	(3)	(4)	(5)
			Panel A: Labor supply behavior		
VARIABLES	Full time	Unpaid	No income	Unpaid	No income
MAIZE x PRICE	0.031**	-0.013	-0.020*	-0.044**	-0.050**
	(0.015)	(0.009)	(0.011)	(0.020)	(0.021)
Worker type	All workers	Full time workers	Full time workers	Full time workers	Full time workers
Age group	18-65	18-65	18-65	18-30	18-30
Observations	48,554	37,160	37,160	12,944	12,944
Municipios	869	868	868	817	817
			Panel B: Log hourly wages		
VARIABLES	Log wage	Log wage	Log wage	Log wage	
MAIZE x PRICE	0.078**	0.075	0.261***	0.043	
	(0.036)	(0.049)	(0.095)	(0.084)	
Worker type	All workers, ≥ 20 hours	Agricultural workers, ≥ 20 hours	Maize and bean cultivators, ≥ 20 hours	Non-maize and bean cultivators, ≥ 20 hours	
Age group	18-65	18-65	18-65	18-65	
Observations	41,717	23,058	9,040	4,558	
Municipios	868	828	644	424	

Notes. Robust standard errors clustered at the municipal level are shown in parentheses. Variables not shown included in all columns are: municipio fixed effects, year effects, temperature and rainfall conditions in Mexican municipios, land quality interacted with year effects, trends by several variables (average agricultural income in 1990, the fraction of agricultural workers, major highway presence, distance to the U.S. border, distance to the nearest security station), survey month, age, and education. The interaction of maize suitability and the log national maize price is instrumented with the interaction of maize suitability and the lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. Panel A columns 2-5 and Panel B columns 1-4 include full time workers with non-missing income data. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

Table 8: Maize Price, Maize Suitability, and Drug Cartels

VARIABLES	(1) Any cartel	(2) First cartel presence	(3) Multiple cartels	(4) Log total drug-related killings	(5) Log drug-related executions	(6) Log killings from confrontations	(7) Log killings from cartel attacks
MAIZE x PRICE	-0.019***	-0.006***	-0.014***	-0.233***	-0.202***	-0.085***	-0.028***
	(0.003)	(0.002)	(0.002)	(0.045)	(0.044)	(0.022)	(0.009)
Observations	44,640	41,876	44,640	8,928	8,928	8,928	8,928
Municipios	2,232	2,229	2,232	2,232	2,232	2,232	2,232

Notes. Robust standard errors clustered at the municipal level are shown in parentheses. Variables not shown and included in all regressions are: municipio and year fixed effects, log population, the interaction of maize suitability with the (log) U.S. Mexico real exchange rate, temperature and rainfall conditions in Mexican municipios, land quality interacted with year effects, trends by average agricultural income in 1990, the fraction of agricultural workers, major highway presence, distance to the U.S. border, and distance to the nearest security station. Any cartel, First cartel presence, and Multiple cartels are dichotomous indicators of whether a municipio has *any* cartel, a cartel operating for the *first time*, or *multiple* cartels, respectively, in any given year. Log total drug-related killings, drug-related executions, killings from confrontations, and killings from cartel attacks are measured as log count per 10,000 people plus 1. The interaction of maize suitability and the log national maize price is instrumented with the interaction of maize suitability and the lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

Table 9: Accounting for Mayoral Political Party

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: Drug Eradication and Seizures							
	Log marijuana eradication	Log poppy eradication	Log raw marijuana seizures	Log processed marijuana seizures	Log opium gum seizures	Log heroin seizures	Log cocaine seizures	Log meth seizures
MAIZE x PRICE	-0.037***	-0.023***	-0.069***	-0.014	-0.006***	-0.001	-0.011*	-0.001
	(0.006)	(0.005)	(0.015)	(0.026)	(0.002)	(0.002)	(0.006)	(0.003)
Observations	40,731	40,731	40,731	40,731	40,731	40,731	40,731	40,731
Municipios	2,228	2,228	2,228	2,228	2,228	2,228	2,228	2,228
	Panel B: Drug Cartels							
	Any cartel	First cartel presence	Multiple cartels	Log total drug-related killings	Log drug-related executions	Log killings from confrontations	Log killings from cartel attacks	
MAIZE x PRICE	-0.015***	-0.005**	-0.013***	-0.269***	-0.232***	-0.102***	-0.031***	
	(0.003)	(0.002)	(0.003)	(0.049)	(0.044)	(0.030)	(0.012)	
Observations	38,657	35,912	38,657	7,474	7,474	7,474	7,474	
Municipios	2,228	2,225	2,228	1,869	1,869	1,869	1,869	

Notes. Robust standard errors clustered at the municipal level are shown in parentheses. Variables not shown and included in all regressions are: the mayor's political party, municipio and year fixed effects, log population, the interaction of maize suitability with the (log) U.S. Mexico real exchange rate, temperature and rainfall conditions in Mexican municipios, land quality interacted with year effects, trends by average agricultural income in 1990, the fraction of agricultural workers, major highway presence, distance to the U.S. border, and distance to the nearest security station. Log marijuana and poppy eradication are measured as log of area eradicated per 10,000 hectares plus 1. Log raw marijuana, processed marijuana, opium gum, heroin, cocaine, and meth seizures are measured as log of kilograms seized. Any cartel, First cartel presence, and Multiple cartels are dichotomous indicators of whether a municipio has *any* cartel, a cartel operating for the *first time*, or *multiple* cartels, respectively, in any given year. Log total drug-related killings, drug-related executions, killings from confrontations, and killings from cartel attacks are measured as log count per 10,000 people. The interaction of maize suitability and the log national maize price is instrumented with the interaction of maize suitability and the lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

Table 10: Accounting for Previous Eradication and Legal Crop Suitabilities

VARIABLES	(1) Log marijuana eradication	(2) Log poppy eradication	(3) Log marijuana eradication	(4) Log poppy eradication	(5) Log marijuana eradication	(6) Log poppy eradication
MAIZE x PRICE	-0.010**	-0.007**	-0.101***	-0.031**	-0.085***	-0.017
	(0.005)	(0.003)	(0.019)	(0.012)	(0.021)	(0.013)
Lag marijuana eradication	0.283***					
	(0.017)					
Lag poppy eradication		0.358***				
		(0.027)				
Beans suitability?	No	No	No	No	Yes	Yes
Other crops suitability?	No	No	Yes	Yes	Yes	Yes
Observations	44,640	44,640	46,872	46,872	46,872	46,872
Municipios	2,232	2,232	2,232	2,232	2,232	2,232

Notes. Robust standard errors clustered at the municipal level are shown in parentheses. Variables not shown and included in all regressions are: municipio and year fixed effects, log population, the interaction of maize suitability with the (log) U.S. Mexico real exchange rate, temperature and rainfall conditions in Mexican municipios, land quality interacted with year effects, trends by average agricultural income in 1990, the fraction of agricultural workers, major highway presence, distance to the U.S. border, and distance to the nearest security station. Log marijuana and poppy eradication are measured as log of area eradicated per 10,000 hectares plus 1. Columns (1)-(2) control for lagged eradication. Columns (3)-(6) include 14 crop suitabilities interacted with year effects. Additionally, columns (5)-(6) control for beans suitability interacted with year effects. The interaction of maize suitability and the log national maize price is instrumented with the interaction of maize suitability and the lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

Table 11: Accounting for Drug Crop Suitability

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: Drug Eradication and Seizures							
	Log marijuana eradication	Log poppy eradication	Log raw marijuana seizures	Log processed marijuana seizures	Log opium gum seizures	Log heroin seizures	Log cocaine seizures	Log meth seizures
MAIZE x PRICE	-0.027***	-0.020***	-0.062***	-0.009	-0.005***	-0.002	-0.009*	-0.001
	(0.006)	(0.005)	(0.014)	(0.024)	(0.002)	(0.001)	(0.005)	(0.003)
Observations	46,872	46,872	46,872	46,872	46,872	46,872	46,872	46,872
Municipios	2,232	2,232	2,232	2,232	2,232	2,232	2,232	2,232
	Panel B: Drug Cartels							
	Any cartel	First cartel presence	Multiple cartels	Log total drug-related killings	Log drug-related executions	Log killings from confrontations	Log killings from cartel attacks	
MAIZE x PRICE	-0.018***	-0.005***	-0.014***	-0.228***	-0.198***	-0.083***	-0.028***	
	(0.003)	(0.002)	(0.002)	(0.045)	(0.045)	(0.022)	(0.009)	
Observations	44,640	41,876	44,640	8,928	8,928	8,928	8,928	
Municipios	2,232	2,229	2,232	2,232	2,232	2,232	2,232	

Notes. Robust standard errors clustered at the municipal level are shown in parentheses. Variables not shown and included in all regressions are: municipio and year fixed effects, log population, the interaction of maize suitability with the (log) U.S. Mexico real exchange rate, temperature and rainfall conditions in Mexican municipios, land quality interacted with year effects, trends by average agricultural income in 1990, the fraction of agricultural workers, major highway presence, distance to the U.S. border, and distance to the nearest security station. Log marijuana and poppy eradication are measured as log of area eradicated per 10,000 hectares plus 1. Log raw marijuana, processed marijuana, opium gum, heroin, cocaine, and meth seizures are measured as log of kilograms seized plus 1. Any cartel, First cartel presence, and Multiple cartels are dichotomous indicators of whether a municipio has *any* cartel, a cartel operating for the *first time*, or *multiple* cartels, respectively, in any given year. Log total drug-related killings, drug-related executions, killings from confrontations, and killings from cartel attacks are measured as log count per 10,000 people plus 1. In Panel A, regressions include the interaction of year effects with average dependent variable over 1990-1993. In Panel B, regressions include the interaction of year effects with both average marijuana and poppy eradication over 1990-1993. The interaction of maize suitability and the log national maize price is instrumented with the interaction of maize suitability and the lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

Table 12: Controlling for Other Policy Changes

VARIABLES	(1) Log marijuana eradication	(2) Log poppy eradication	(3) Log raw marijuana seizures	(4) Log processed marijuana seizures	(5) Log opium gum seizures	(6) Log heroin seizures	(7) Log cocaine seizures	(8) Log meth seizures	(9) Any cartel	(10) First cartel presence	(11) Multiple cartels
	Panel A: Controlling for Diconsa stores 94-96 interacted with year effects										
MAIZE x PRICE	-0.032***	-0.023***	-0.066***	-0.013	-0.006***	-0.000	-0.011**	0.001	-0.017***	-0.006***	-0.013***
	(0.006)	(0.005)	(0.015)	(0.025)	(0.002)	(0.001)	(0.005)	(0.002)	(0.003)	(0.002)	(0.002)
Observations	46,095	46,095	46,095	46,095	46,095	46,095	46,095	46,095	43,900	41,295	43,900
Municipios	2,195	2,195	2,195	2,195	2,195	2,195	2,195	2,195	2,195	2,192	2,195
	Panel B: Excluding the state of Sinaloa										
MAIZE x PRICE	-0.028***	-0.022***	-0.061***	0.008	-0.005***	-0.002	-0.009*	-0.000	-0.017***	-0.005***	-0.013***
	(0.006)	(0.005)	(0.014)	(0.023)	(0.002)	(0.001)	(0.005)	(0.003)	(0.003)	(0.002)	(0.002)
Observations	46,557	46,557	46,557	46,557	46,557	46,557	46,557	46,557	44,340	41,705	44,340
Municipios	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,216	2,217

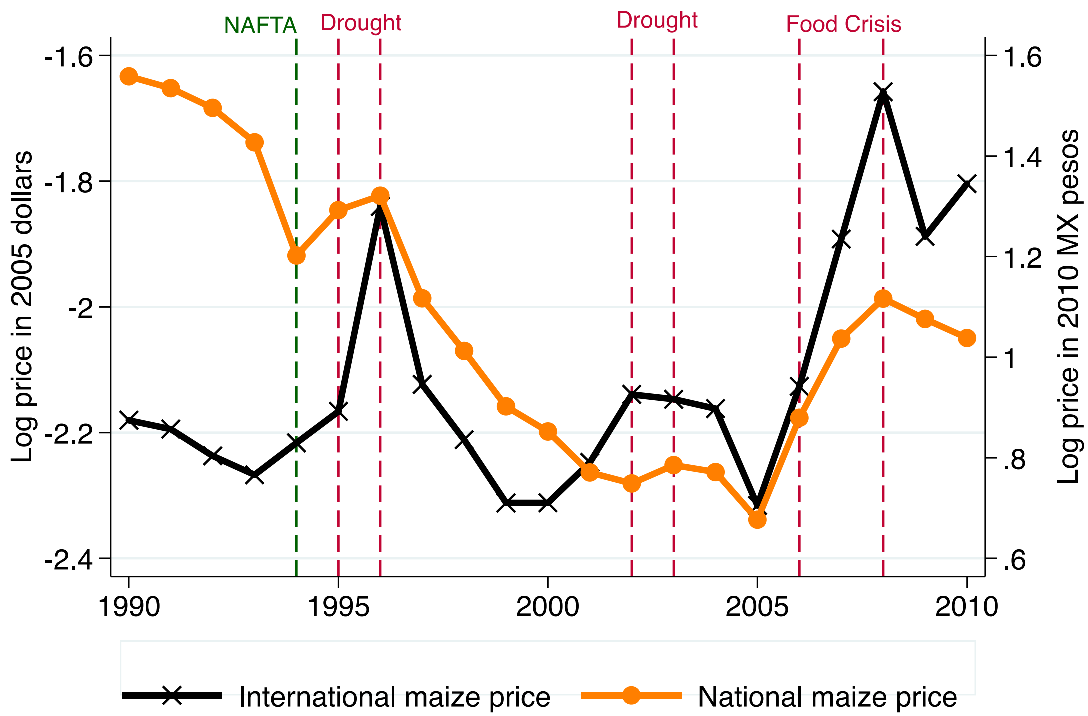
Notes. Robust standard errors clustered at the municipal level are shown in parentheses. Variables not shown and included in all regressions are: municipio and year fixed effects, log population, the interaction of maize suitability with the (log) U.S. Mexico real exchange rate, temperature and rainfall conditions in Mexican municipios, land quality interacted with year effects, trends by average agricultural income in 1990, the fraction of agricultural workers, major highway presence, distance to the U.S. border, and distance to the nearest security station. Log marijuana and poppy eradication are measured as log of area eradicated per 10,000 hectares plus 1. Log raw marijuana, processed marijuana, opium gum, heroin, cocaine, and meth seizures are measured as log of kilograms seized plus 1. Any cartel, First cartel presence, and Multiple cartels are dichotomous indicators of whether a municipio has *any* cartel, a cartel operating for the *first time*, or *multiple* cartels, respectively, in any given year. In Panel A, all regressions include the average number of Diconsa stores between 1994 and 1996 interacted with year effects. In Panel B, the state of Sinaloa is excluded from all regressions. The interaction of maize suitability and the log national maize price is instrumented with the interaction of maize suitability and the lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

Table 13: Excluding Border Municipios

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: Drug Eradication and Seizures							
	Log marijuana eradication	Log poppy eradication	Log raw marijuana seizures	Log processed marijuana seizures	Log opium gum seizures	Log heroin seizures	Log cocaine seizures	Log meth seizures
MAIZE x PRICE	-0.031***	-0.021***	-0.071***	-0.036	-0.006***	0.000	-0.008*	0.001
	(0.006)	(0.005)	(0.013)	(0.022)	(0.002)	(0.001)	(0.005)	(0.002)
Observations	46,221	46,221	46,221	46,221	46,221	46,221	46,221	46,221
Municipios	2,201	2,201	2,201	2,201	2,201	2,201	2,201	2,201
	Panel B: Drug Cartels							
	Any cartel	First cartel presence	Multiple cartels	Log total drug-related killings	Log drug-related executions	Log killings from confrontations	Log killings from cartel attacks	
MAIZE x PRICE	-0.017***	-0.007***	-0.011***	-0.215***	-0.184***	-0.072***	-0.029***	
	(0.003)	(0.002)	(0.002)	(0.042)	(0.042)	(0.022)	(0.009)	
Observations	44,020	41,478	44,020	8,804	8,804	8,804	8,804	
Municipios	2,201	2,199	2,201	2,201	2,201	2,201	2,201	

Notes. Robust standard errors clustered at the municipal level are shown in parentheses. Municipios along the U.S.-Mexico border are excluded from all regressions. Variables not shown and included in all regressions are: municipio and year fixed effects, log population, the interaction of maize suitability with the (log) U.S. Mexico real exchange rate, temperature and rainfall conditions in Mexican municipios, land quality interacted with year effects, trends by average agricultural income in 1990, the fraction of agricultural workers, major highway presence, distance to the U.S. border, and distance to the nearest security station. Log marijuana and poppy eradication are measured as log of area eradicated per 10,000 hectares plus 1. Log raw marijuana, processed marijuana, opium gum, heroin, cocaine, and meth seizures are measured as log of kilograms seized. Any cartel, First cartel presence, and Multiple cartels are dichotomous indicators of whether a municipio has *any* cartel, a cartel operating for the *first time*, or *multiple* cartels, respectively, in any given year. Log total drug-related killings, drug-related executions, killings from confrontations, and killings from cartel attacks are measured as log count per 10,000 people. The interaction of maize suitability and the log national maize price is instrumented with the interaction of maize suitability and the lagged rainfall and temperature deviations in the major maize producing U.S. states and the log export volume of China, France and Argentina. *** is significant at the 1% level, ** is significant at the 5% level, and * is significant at the 10% level.

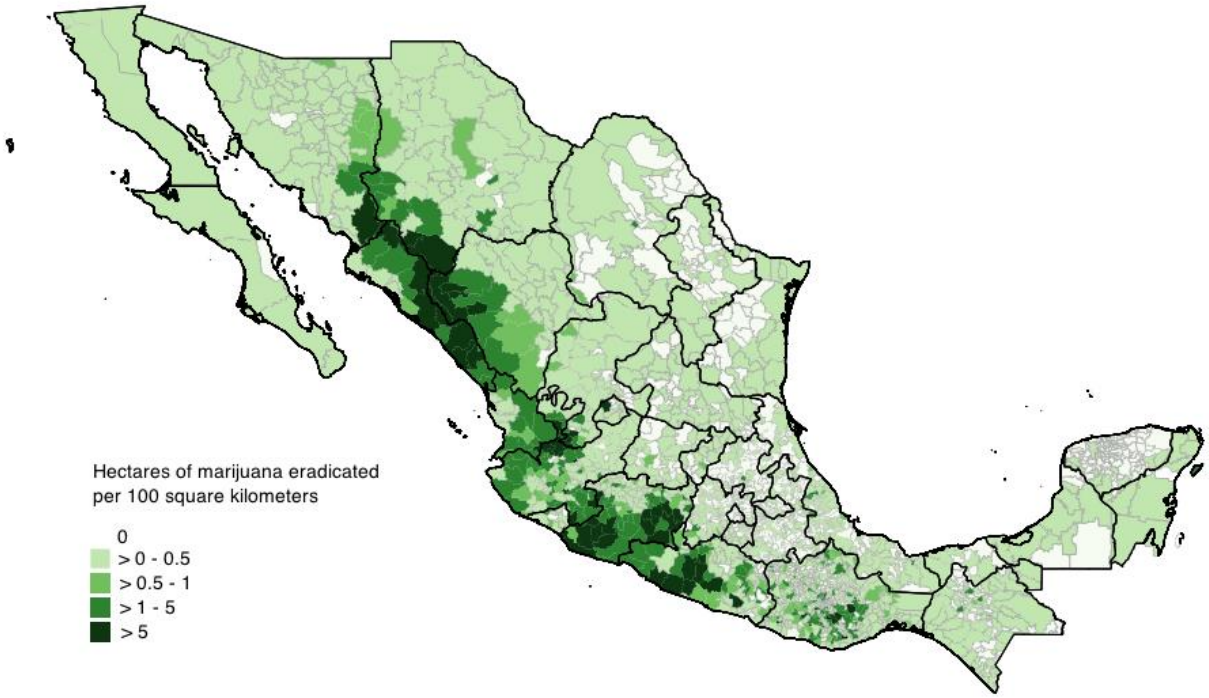
Figure 1: Maize Prices



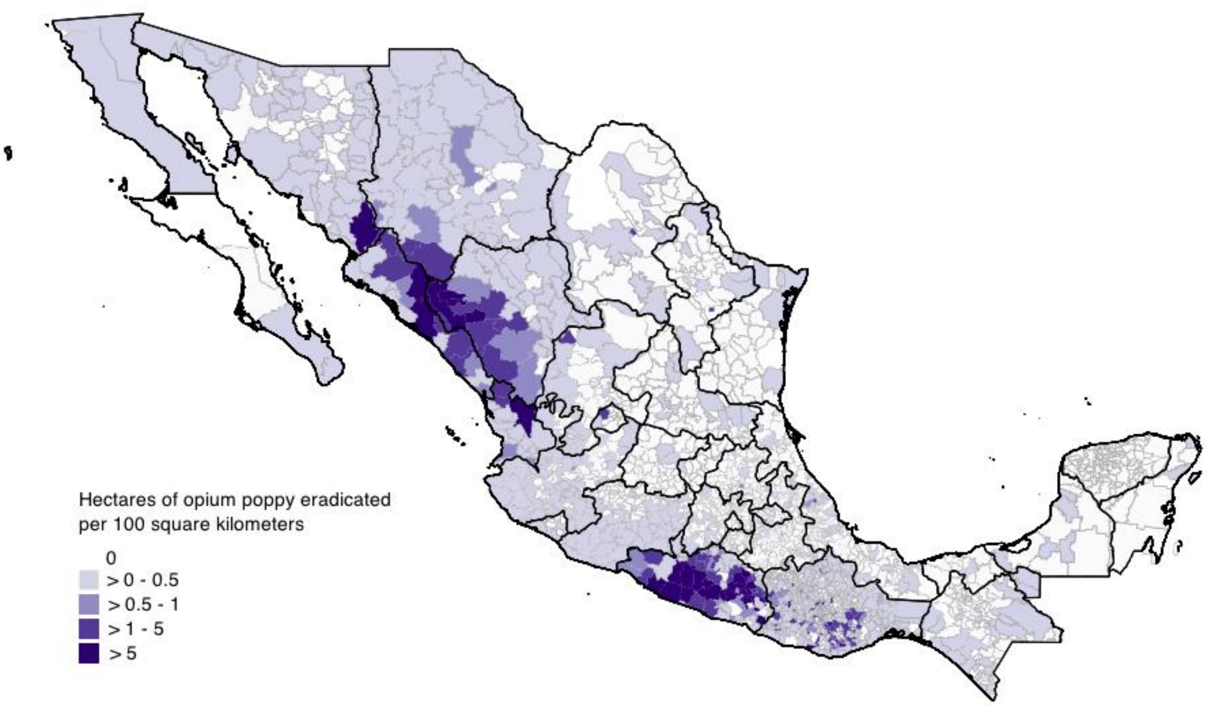
Notes. This figure shows the international maize price and Mexican maize price over the 1990-2010 period. The data for the international price come from the World Bank. The data for the national price come from the Servicio de Información Agroalimentaria y Pesquera (SIAP), in the Mexican Ministry of Agriculture. The green line marks the introduction of NAFTA in 1994. The red lines denote U.S. droughts and the international food crisis.

Figure 2: Drug Crop Eradication in Mexico

Panel A: *Average Eradication of Marijuana in Mexican Municipios*

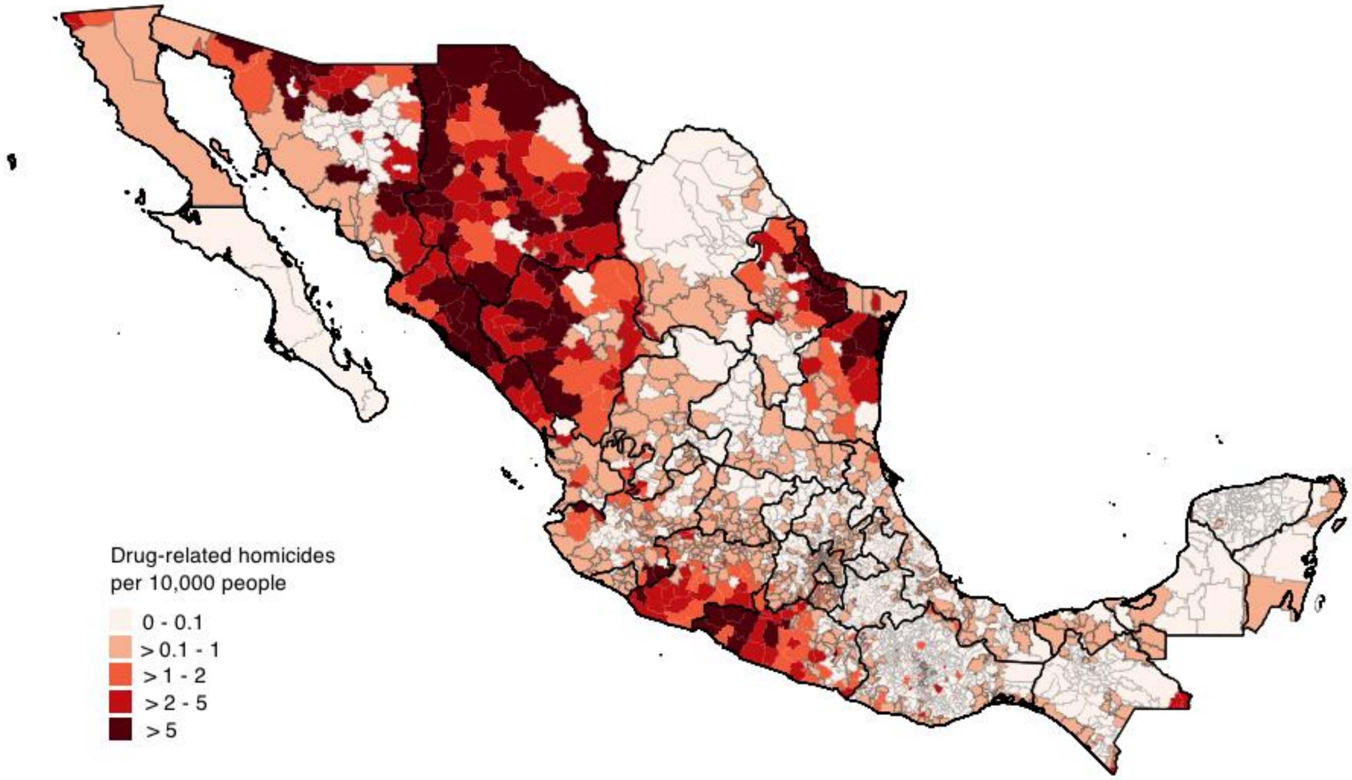


Panel B: *Average Eradication of Poppy in Mexican Municipios*



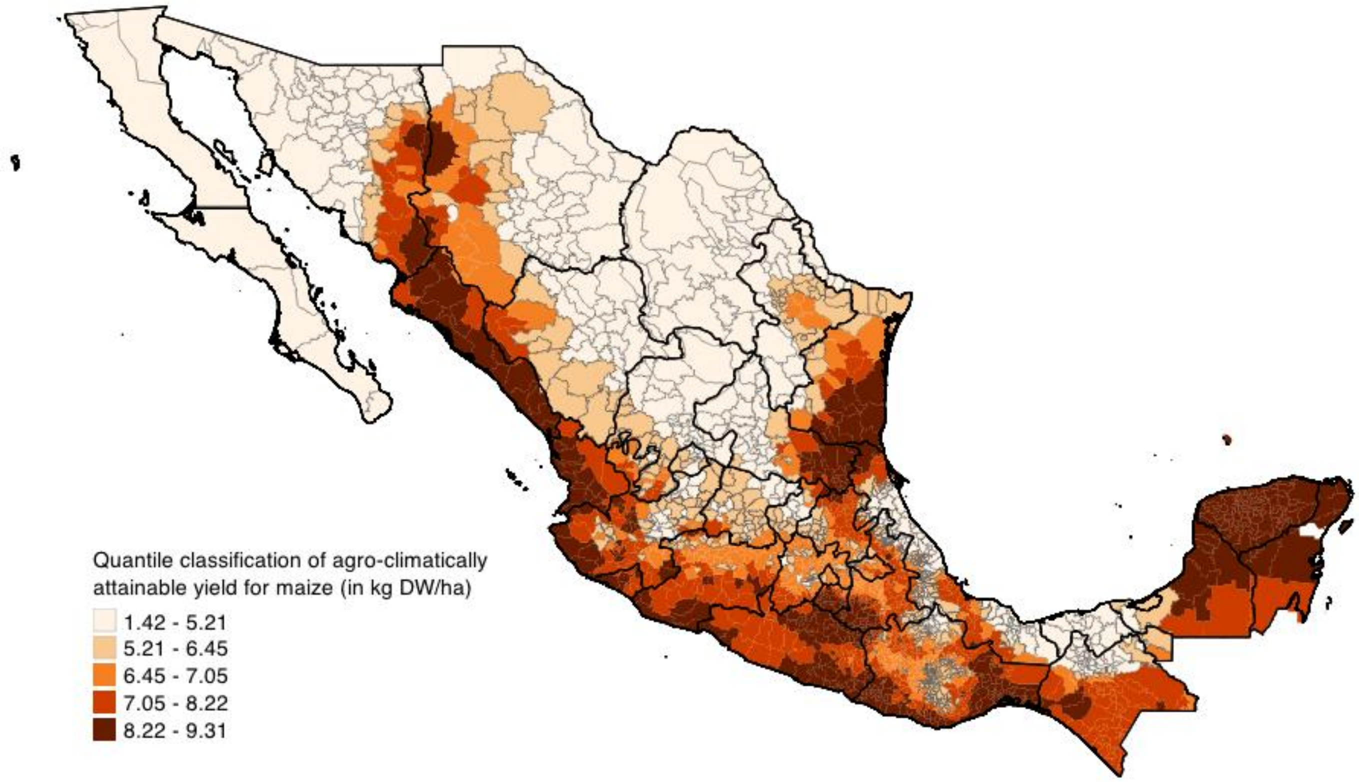
Notes. This figure shows annual averages of marijuana (Panel A) and poppy (Panel B) eradicated per 100 square km. in each Mexican municipio between 1990 and 2010. The data were obtained from SEDENA. Darker colors denote higher levels of eradication.

Figure 3: Drug-related Killings



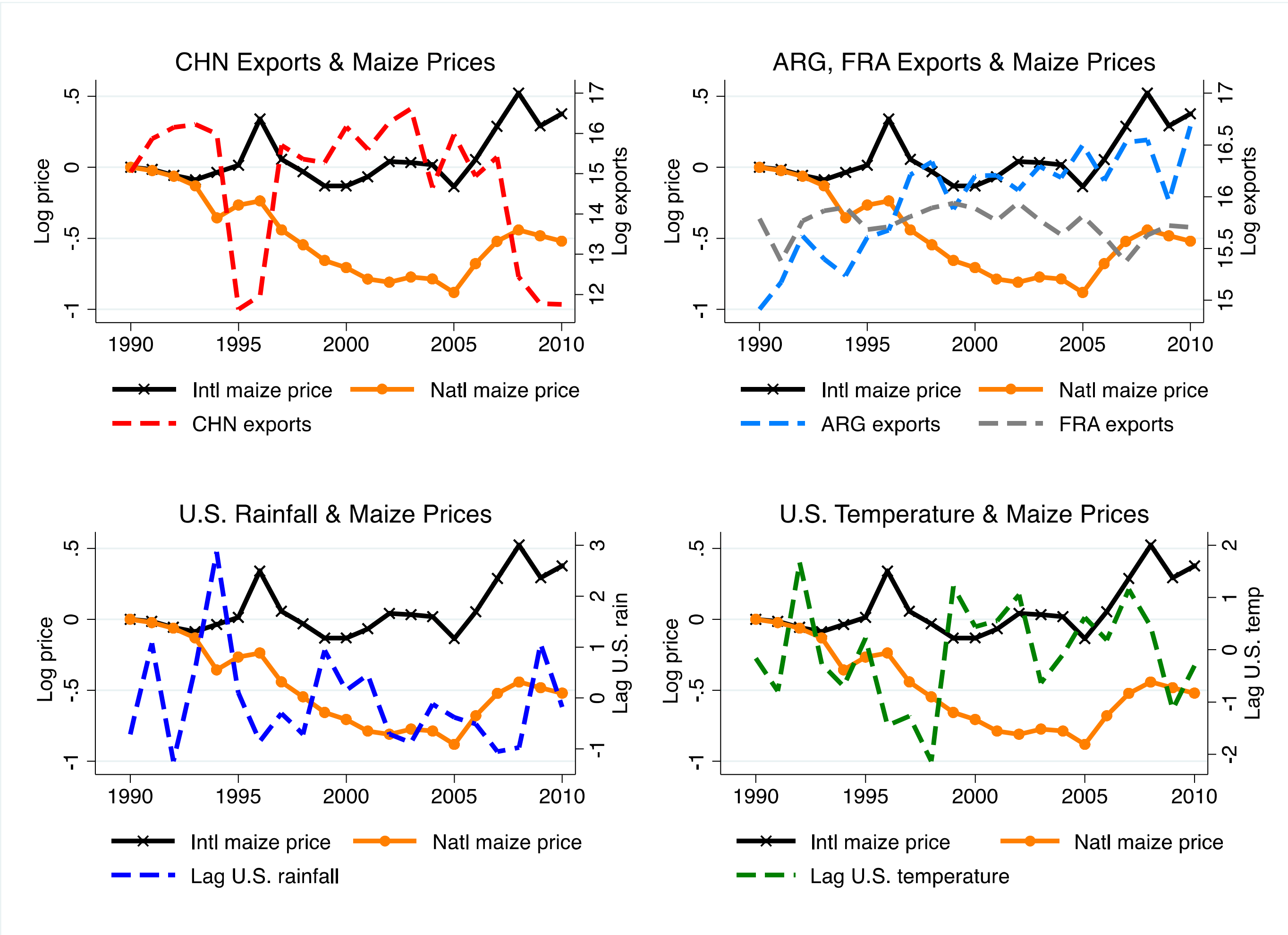
Notes. This map shows the annual average of drug-related killings per 10,000 people in each Mexican municipios between 2007 and 2010. The data come from the Mexican National Security Council. Darker colors denote higher levels of drug-related killings.

Figure 4: Maize Suitability



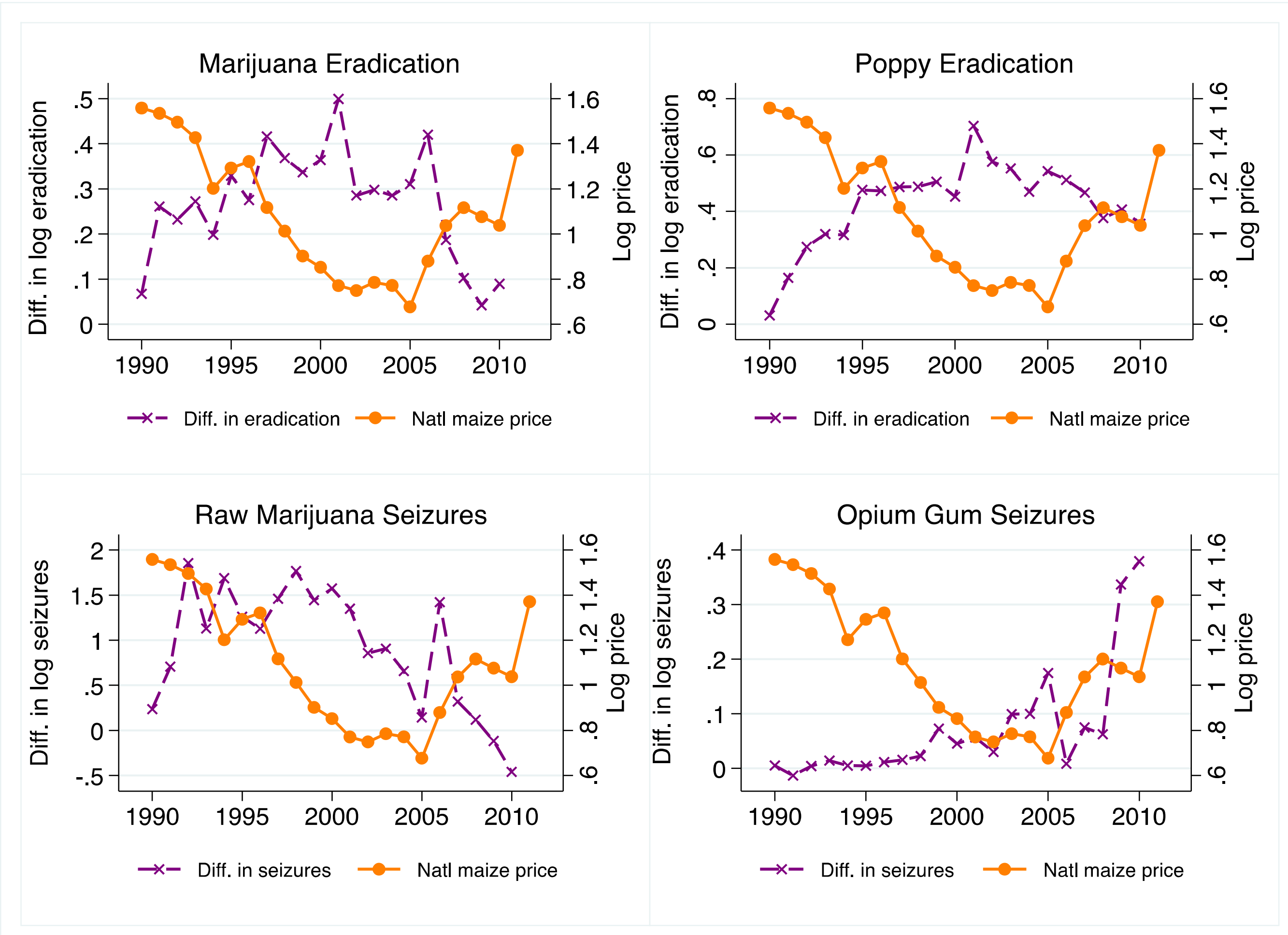
Notes. This figure shows the average agro-climatically attainable yield for maize (measured in kg DW/ha) for each Mexican municipio. This measure was constructed using 0.083-degree resolution data from the FAO's Global Agro-Ecological Zones (GAEZ v3.0). Darker colors denote higher suitability and potential yield for maize.

Figure 5: Maize Prices, Maize Exports, and U.S. Weather Shocks



Notes. The top-left panel shows the (log) volume of maize exported by China (CHN). The top-right panel shows the (log) volume of maize exported by Argentina (ARG) and France (FRA). The bottom-left panel shows the lagged annual rainfall deviation in June and July in major U.S. maize states. The bottom-right panel shows the lagged annual temperature deviation in April and May in major U.S. maize states. All panels also show the (log) national and international maize prices deviations from 1990 over the 1990-2010 period.

Figure 6: The Maize Price, Maize Suitability and Drug-Related Outcomes



Notes. The top-left panel shows the difference in (log) average marijuana eradication in municipios above and below mean maize suitability. The top-right panel shows the difference in (log) average opium poppy eradication in municipios above and below mean maize suitability. The bottom-left panel shows the difference in (log) average opium raw marijuana seizures in municipios above and below mean maize suitability. The bottom-right panel shows the difference in (log) average opium gum seizures in municipios above and below mean maize suitability. All panels also show the (log) national maize price over the 1990-2010 period.