Bushes and Bullets: Illegal Cocaine Markets and Violence in Colombia.

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Abstract

This paper explores the effects of cocaine booms on violence in Colombia during the period 1990-2011. We exploit within municipality variation obtained by combining a suitability index for coca cultivation interacted with a non-monotonic measure of external demand for Colombian cocaine. Our suitability measure is based on a survey of coca farmers, and depends on the altitude, erosion, soil aptitude, and precipitation of a municipality. The measure of external demand combines proxies for consumption in the U.S., and changes in enforcement in transit countries and other source countries that shape the demand for Colombian cocaine. We find that increases in the external demand for Colombian cocaine create cocaine booms in municipalities with a high suitability index. As a consequence, homicides increase significantly both in the short and long run. We argue that the cocaine booms bring violence because this is an illegal commodity. In particular, we find that while cocaine booms bring violence independently of state presence, other commodities' booms (cocoa, sugar cane and palm oil) typically reduce it, unless institutions are bad enough.

Keywords: Violence, Illegal Markets, Organized Crime, Cocaine, Colombia.

JEL Classification Numbers: D74, K42.

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1 Introduction

This paper explores the role of illegal commodities' booms in fostering violence and conflict. Examples abound of conflicts fueled by rapacity over resources: from diamonds in West Africa to rare minerals in the Democratic Republic of Congo; or exotic tropical hardwood in Cambodia and Brazil. However, chief among these examples, is the salient violence and intense conflict associated with thriving black markets. The practices of Al Capone and other famous Chicago mobsters during the alcohol prohibition era in the U.S. are the prototypical examples of violence in an illegal market. But such examples are not only confined to the U.S. or the distant past: the large black market for cigarettes in the Balkans that emerged due to the Yugoslavia embargo in the 1990s was plagued with violence; the Taliban in Afghanistan exercises violence in order to dominate poppy fields, opium, and the heroin trade; violence has considerably increased in Mexico since the upsurge of large drug trafficking organizations since the early 2000s; and Colombia has been submerged in high levels of violence at least since the mid 1980s, when it became one of the world's most violent countries following the consolidation of drug cartels and, after their demise, the entry of Marxist guerrillas and right-wing paramilitary groups in the cocaine trade.

We study this question in the context of the cocaine trade in Colombia—the world's largest cocaine producer after cultivation shifted from Peru and Bolivia in 1994. Colombia has been submerged in long and pronounced cycles of violence since the beginning of the 20th century. The *Centro de Memoria Historica*, recently reported that since 1958, about 218,000 persons were killed in Colombia's persistent armed conflict, with 81% being civilian victims. The scale and salience of conflict in the country makes it important to understand its determinants and the role played by a thriving cocaine market in fostering violence. Anecdotal evidence linking cocaine production to violence is not enough to establish a causal relation. For instance, some scholars have suggested that both are symptoms of the underlying lack of state presence and dysfunctional organization of the Colombian society (see Robinson (2013) for an exposition of this view). In the words of Colombian writer R.H. Moreno Duran: "In Colombia, politics corrupts drug dealing." Though this may be the case, and both violence and the thriving cocaine market may reflect the underlying politics of Colombia, we argue in this paper that drug production causes violence, and this channel operates beyond the Country's dysfunctional organization, exacerbating the country's problems. In our view, illegal drug markets contributed to Colombia's violent past and present. Drug trafficking brought the violence of Cartels, and with it a tripling of the homicide rate from the late 70s to 1990, when it reached 70 homicides per 100.000 inhabitants (Gaviria (2000)). From 1994 onwards, as cultivation shifted from Peru and Bolivia to Colombia, it brought violence to the countryside and the surge of new paramilitary armed groups, or the involvement of existing insurgent guerrilla groups in the business. By 1998 the FARC guerrillas had gained so much power thanks to the cocaine trade that Colombia was at the verge of becoming a failed state. In this paper we substantiate this view by providing evidence of a causal impact of the thriving cocaine market on violence since 1990, and documenting how the cocaine market contributed to the persistence and shaped the geographical distribution of violence in Colombia since the early 1990s.

During our period of interest, drug-related violence in Colombia has been associated with coca cultivation and production in rural areas of the country and the involvement of large armed groups: guerrillas— known as the FARC— and paramilitaries— known as the AUC (see Rangel (2000), Rabasa and Chalk (2001), and Villalon (2004). In contrast, the violence of cartels in the 80s was concentrated in cities, and related to trafficking). Cocaine is produced from coca leaf cultivated by farmers in the country-side, who sell the leaf (or paste) to armed groups. Armed groups process the leaf into cocaine in laboratories near plantations and sell it to international traffickers, obtaining profits from this trade.[1]. Our hypothesis is that cocaine booms cause violence in municipalities suitable for coca cultivation in a number of ways: First, violence is used to control the territory. In particular, to run the cocaine trade, armed groups must be able to credibly resist the state enforcement efforts against large cocaine plantations. Moreover, they also fight each other for the control of turf, or suitable land, in order to obtain the rents from cocaine production. Suitable land is a valuable resource supplied inelastically, allowing the group that controls it to extract rents during cocaine booms. Second, violence (or the threat of violence) by armed groups is required to run the cocaine trade. Given the illegal nature of the cocaine trade, participants cannot rely on the government to enforce contracts or protect their property rights, but must instead rely on self-protection or armed groups. Thus, violence is used to maintain internal cohesion, resolve disputes and enforce contracts; all of which are required to run the cocaine trade in the absence of a legitimate state.[2] Thus, armed groups fit the description of a *mafia* in Gambetta (1996). Third, armed groups may use their unchecked power and exercise violence to coerce market participants and be able to extract additional rents, so violence also serves a coercive purpose. Finally, violence may also increase during a cocaine boom because the whole apparatus set up in place by armed groups may misfire, and homicides occur incidentally when you have a bunch of armed people together unchecked. All these channels imply that cocaine booms cause increases in violence by armed groups against each other, the state and the civilian population.

In this paper, we test this prediction in a panel of Colombian municipalities from 1990 to 2011. To do so, we first construct a coca suitability index by using a nationally representative household survey conducted by UNODC between 2005-2010, which contains self-reported data

[1]See Mejía and Rico (2010) for a thorough description of the process of coca cultivation and cocaine production in Colombia, and Mejía and Posada (2008) for a description of wholesale cocaine markets. Some farmers sell coca paste, derived from the leaf. There are different ways in which the market is organized. In some cases, armed groups tax coca farmers as a payment for their protection services (a tax known as *gramaje*) and in others they directly participate in the production chain.

[2]We use the word "legitimate" because many of these services are similar to what the state usually does, with the difference that punishments by the state are not considered acts of violence in the official statistics.

on coca crops' yields. We combine this survey with geographic and weather information to estimate the determinants of the suitability of each municipality for coca cultivation. The results from this initial exercise reveal a strong and robust non-linear relationship between different measures of coca yields and geographic and weather information available at the municipality level, including altitude of the municipality (meters above sea level), a soil erosion index, a soil aptitude index, and a precipitation index (rainfall). Using the results of these estimations we construct a suitability index for coca cultivation as the predicted yield of coca crops for 1,052 municipalities in Colombia. Our suitability index is a good predictor of the cross sectional location of crops and their expansion after 1994, and provides cross sectional variation in the incidence of cocaine booms. Second, we construct different yearly proxies of external demand for Colombian cocaine. Our proxies combine measures of consumption and prevalence in the U.S.—the main market for Colombian cocaine during our period of analysis— and changes in seizures in other sources (Peru and Bolivia) and transit countries (Mexico, Central America, the Caribbean and the U.S.). We show in a simple model that seizures in other sources increase the demand for Colombian cocaine and, as long as demand is sufficiently inelastic, seizures in transit countries also increase the demand for Colombian cocaine. Our empirically strategy exploits both sources of variation by comparing municipalities with different suitabilities in years with different external demand controlling for municipality and year fixed effects.

Figure 1 previews our main result. The solid line presents the yearly deviation in the log of the homicide rate implied by one additional standard deviation in the cocaine suitability index (relative to the mean difference during the period). As can be seen, homicides increased relatively in high suitability areas from 1994 to 2000; with a large spike in homicides in 2005-2007 and a recent decline. The pattern aligns consistently with our preferred external demand proxy, plotted in gray. In particular, violence increase from 1994-2000 when seizures in Peru and Bolivia displaced the cocaine trade to Colombia, and during 2005-2007 when there was a moderate increase in consumption in the U.S. and higher seizures in transit countries. Remarkably, as external demand fell in recent years due to a fall in consumption and lower seizures in transit countries, the homicide rate in high suitability municipalities decreased relative to the rest of the country. This graphical analysis shows that homicides increase in high suitability municipalities relative to other areas during cocaine booms caused by external factors, both in the long run (the trend behavior) and in the short run (our external demand proxy matches temporal increases in violence and reductions as well).

Our empirical exercise exploits the within municipality variation obtained by the interaction of our suitability index with different proxies of external demand shocks for Colombian cocaine. Intuitively, external demand shocks for Colombian cocaine increase cocaine production and revenue in municipalities with a high suitability for coca cultivation relative to the national mean, inducing a cocaine boom (relative to other municipalities). Consistent with this intuition, we find that cultivation, cocaine revenue and several proxies related to the cocaine trade increase disproportionally in high suitability municipalities when external demand is higher, either temporarily or permanently. For instance, following an increase in external demand of 10% (increase in quantities holding prices constant), cocaine revenue increases by about 2% more for every additional standard deviation in suitability. Simultaneously, we observe homicide rates increasing by 1% more for every additional standard deviation in suitability. These results are robust to various constructions of the external demand proxy, the suitability measure, and if we focus on short run reactions by removing trends in violence and demand. The results are also robust to controlling for a wide range of municipal characteristics interacted with our external demand proxy. We also find long run effects of cocaine booms on attacks by armed groups, armed group expansion, and incidents with land mines (though some of these results do not hold when we control for differential trends by suitability). Interestingly, kidnappings and acts of terrorism fall in high suitability municipalities during cocaine booms relative to the rest of the country. This suggests armed groups reallocate their efforts towards the more profitable cocaine trade.

In addition to documenting these patterns, we emphasize the role of illegality as the main characteristic making cocaine booms breed violence. Conceptually, if cocaine was legal, a boom would be less likely to foster violence for the following reasons: First, competition by suppliers in highly institutionalized areas would put a limit to the rents that armed groups can extract from the cocaine trade in areas under their control, reducing rapacity over turf. (alternatively, production may be entirely reallocated to highly institutionalized areas.) Second, the state has more incentives to remove the armed actors because it can tax the legal commodity, whereas the illegal commodity cannot be taxed by a legitimate state without risking sanctions or protests. Third, market participants would be able to use the state to some extent (even if weak) to enforce contracts and protect their property, reducing their reliance on non-state armed actors. Market participants would also be able to use the state's protection against coercive violence by armed groups. Overall, there is a powerful logic as to why illegal markets attract armed groups and foster violence: while legal markets function well with transactions and contracts secured by the state (and presumably, informal arrangements); a large scale illegal trade requires the violence of a substitute non-state armed actor to operate. In the first case, armed groups are a hindrance, their role is extortive, and market participants and the government are eager to remove them. In contrast, participants in an illegal market have a demand for the services of an armed group, and are willing to put with the cost of its unchecked power to use violence. The alternative interpretation is that cocaine booms cause violence simply because of the weak state presence in the Colombian country side. In this theory, property rights over commodities are poorly defined, and a boom increases rapacity over the additional revenues (i.e., armed groups extort market participants, and this requires violence). In weakly institutionalized settings, rapacity dominates offsetting effects on wages, and commodity booms will end up causing violence. According to these alternative view, any resource boom leads to violence in weakly institutionalized environments, and there is nothing special about cocaine: the same would occur for flowers, coffee, cocoa, sugar cane or palm trees. This is a key policy question: if the alternative view holds, legalizing illegal markets would not eliminate the violence associated with these trades, and state consolidation would be required to reduce violence.

We provide some evidence against the alternative view and consistent with illegality being the key driving force behind our results. First, we show that controlling flexibly for institutions and state presence does not change our results, suggesting that we are not simply capturing the possibility that high suitability areas tend to have poor institutions, and resource booms of any type cause violence in these areas. Second, we show that external demand has similar effects on violence in high suitability municipalities independently of state presence. Finally, we compare our results to that of a bundle of agricultural commodities produced in municipalities with similar institutional characteristics as those producing cocaine. We focus on cacao, palm oil, and sugar cane, which are agricultural commodities similar to coca crops (they are transacted in international markets and have a similar labor intensity), but their production is legal. We find that municipalities with high suitability for the cultivation of these products do not suffer from increases in violence when their international prices increase. All these results suggest that we are not capturing the possibility that armed groups tax all agricultural products (legal or not) in weakly institutionalized places, but a phenomenon unique to illegal cocaine booms.

In order to give our estimates a structural interpretation, we also compute 2SLS estimates of the effect of an increase in cocaine revenue on violence. This requires strong assumptions that may not hold in practice, and therefore this is offered simply as an illustration of the magnitudes of the effects uncovered. Our 2SLS estimates imply that a 10% increase in cocaine revenue increases homicides by 4% to 5%. From 1994, until the mid 2000s, cocaine revenue due to cultivation and production increased in Colombia by 120 log points, as the external demand for Colombian cocaine increased. Assuming all this increase was driven by external conditions, our 2SLS estimates imply that the thriving cocaine trade causes from 11 to 16 of the 35 homicides per 100.000 inhabitants per year that are currently committed in the country (from 5,500 to 8,000 homicides per year). Our results imply that the cocaine trade has excluded many Colombians in the country side from enjoying the reductions in violence experienced since 2002, which were, as figure 2 shows, concentrated in municipalities without coca cultivation and production. In contrast, violence has been more persistence in municipalities growing cocaine. In 2006, when homicides in non-growing municipalities plummeted due to aggressive security policies implemented by the Uribe administration, there were still about 30 more homicides per 100,000 inhabitants in growing municipalities. These divergence in violence—despite the gains in security at the national level— coincides with a growing external demand for Colombian cocaine from 1994 until the mid 2000s. Coca-growing municipalities only started to converge to the lower levels of violence exhibited in the rest of the country in recent years, as external demand for Colombian cocaine decreased. Taken our estimates and interpretation at face value, they imply that legalizing cocaine production, or removing the cocaine market, would reduce the contemporary homicide rate in Colombia to 20 to 25 homicides per 100.000 inhabitants. Though high by developed countries' standards, this counterfactual homicide rate is close to the level of the safest Latin American countries. As figure 2 show, this is equivalent to closing the current gap in violence between coca-growing and non-grower municipalities: the thriving cocaine market is the reason why some municipalities still suffer higher than average homicide rates.

The rest of the paper is organized as follows: Section 2 reviews the related literature and frames our contribution. Section 3 describes our data. Section 4 presents the estimation framework and the main results. Section 5 revisits the role of illegality. Section 6 presents results for other outcomes. Finally, section 7 presents the 2SLS estimates and illustrates their size. The last section concludes.

2 Related literature

There is a large literature studying the role of commodities in fostering (or reducing) conflict and violence (see Ross (2004) for a summary of the literature). The literature started with cross-country regressions exploring the effect of resource booms on the onset of conflict. Some contributions include Collier and Hoeffler (2004) and Fearon (2005) who study the which commodity exports induce conflict, and Brückner and Ciccone (2010) who document the effect of commodity prices on conflict. Miguel, Satyanath and Sergenti (2004) use an IV approach for African countries, and instrument overall economic booms using rainfalls to find that it reduces conflict.

Recently, the literature has moved to analyze which particular commodities affect conflict or violence within countries. Several characteristics of commodities have been studied. For instance, Nisbett and Cohen (1996) argue that herder communities develop cultures of violence because herd is easy to loot, and hence they face a large risk of expropriation. Sánchez de la Sierra (2014) shows that coltan contributed to ongoing conflict in the Democratic Republic of Congo because it was easy to observe and tax by non-state armed groups. In contrast, gold, which was easy to hide, did not foster conflict. Dube and Vargas (2013) highlight to opposite effects of a commodity boom based on the theoretical analysis of Dal Bó and Dal Bó (2011). On the one hand, there is a rapacity channel, wherein armed groups fight over the unprotected revenue generated. On the other hand, there is an opportunity cost channel, wherein wages increase as a consequence of the boom and armed groups face higher costs to recruit manpower (this channel is named following Becker (1968) seminal contribution). The opportunity cost dominates when commodities are labor intensive. Dube and Vargas illustrate this by showing that coffee booms reduce violence in Colombia whereas oil booms increase it (coffee is more labor intensive than oil). Other analysis have emphasized not so much the characteristics of commodities but the institutional environment in which the trade takes place. Buonanno, Durante, Prarolo and Vanin (2012) and Couttenier, Grosjean and Sangnier (2014) are two related papers showing that mineral discoveries create mafia-type organizations in weakly institutionalized environments. The later paper also finds there is no such effect when institutions are strong. The most reasonable explanation is that institutions determine property rights over the revenue generated by a commodity boom. In weakly institutionalized environments, property rights are poorly defined and rapacity over resources intensifies. The theoretical role of rapacity in fostering conflict was first highlighted by Hirshleifer (1991)—who referred to the possibility to expropriate others as "the dark side of the force"— and Grossman (1991), and later explored in models by Skaperdas (2002).

We contribute to this literature by highlighting the role of illegality, as a key characteristic that makes a commodity particularly prone to be associated with violence. The theoretical foundations for this role were first discussed by Gambetta (1996) and Goldstein (1985), who emphasized how mafia-type organizations could secure transaction and property in illegal markets, which by definition are excluded from the state protection. Our evidence in this paper suggest that cocaine booms foster violence not because of increased rapacity over unprotected revenue in weakly institutionalized areas of Colombia, but because cocaine is illegal. Our results regarding cocoa, sugar cane and palm tree suggest that the rapacity channel is not strong enough to explain the documented relation between an agricultural product— like coca crops— and violence, even in a country with weak institutions and state presence like Colombia. In fact, our results, together with Dube and Vargas (2013) results for coffee and other agricultural commodities, suggest that the opportunity cost may dominate for legal agricultural commodities; suggesting a key role for illegality in the case of cocaine.

Several papers have studied the link between illegal markets, and illegal drugs in particular, on violence. Cross-country evidence suggests that homicide rates are positively related to the intensity of drug enforcement (see Miron (2001)). Within-country analysis provide different results. Evidence from Afghanistan indicates that violence by armed groups increases opium cultivation by destroying the infrastructure required for legal production, and not the other way around (see Lind, Moene and Willumsen (2013)). In a study that is similar to ours, Angrist and Kugler (2008) explore the coca-conflict nexus in Colombian and find that coca cultivation causes conflict without significantly improving economic opportunities. This paper uses a similar identification strategy exploring how an external demand increase (the shift in cultivation from Peru and Bolivia) affected violence in states with coca crops in 1994. Though related, our identification strategy allow us to study non-monotonic changes in demand and verify that we are not capturing secular changes. We also utilize less aggregated and more precise data on conflict and cultivation. Finally, Angrist and Kugler (2008) focus on the labor market consequences of the cocaine boom, and do not study the question of what makes cocaine booms foster violence. We contribute to this literature by proposing a new identification strategy which credibly identifies the effect of cocaine booms on violence. Contrary to the findings for Afghanistan, and in line with the findings for Colombia, we find that cocaine booms foster violence.

Changes in the legal character of a commodity are ideal to isolate the role of illegality because the commodity characteristics and the institutional environment remain unchanged. Unfortunately, we do not observe changes in the illegal character of cocaine. Some studies that do not have this limitation include Chimeli and Soares (2010), who find that violence increased after the Brazilian government prohibited the extraction and trade of mahogany, a tropical wood grown in the Brazilian Amazon. The paper exploits variation in the legal status of a market, and shows that the illegal status is a key determinant of systemic-type violence, while the type of goods being produced and traded is less relevant. In a similar vein, García-Jimeno (2012) and Owens (2014) show that dry laws that criminalized alcohol distribution increased violence in U.S. states, suggesting that once a large market becomes illegal violence thrives. Our contribution to this literature is to document a similar relation between illegal cocaine markets and violence, and provide evidence suggesting that illegality plays a key role in determining this relation—though the evidence is indirect in our case, and based in a comparison with similar legal agricultural products.

3 Data, the suitability index and external demand proxy

3.1 Description of our data

Our main data set consist of a panel of 1,052 Colombian municipalities for the period 1990-2011. For each municipality we have a coca suitability index, which measures its comparative advantage for coca cultivation based on geographic characteristics (altitude, soil erosion, precipitation and a measure of soil aptitude). The construction of the index is explained in detail in the next subsection. Table 1 summarizes our data and presents it separately for municipalities at different terciles of the suitability index. The top panel presents data related to conflict and violence. Most of these data comes from the Colombian Vice President's Office (VPO) and the CEDE municipal panel and are available at varying degrees over the 1990-2011 period (see Acevedo and Bornacelly (2014) for a description of the data). Our main variable of interest is the homicide rate per 100,000 inhabitants, available from 1990 to 2011 for 1,050 of the municipalities in our sample. The homicide data reveals two important features: First, Colombia is a very violent country with high levels of violence, as was already shown in figure 2. The average homicide rate in the municipalities with the higher suitability indices was 70 per 100,000 inhabitants during our period of analysis. Colombia is even a very violent country when compared with other Latin American countries with similar levels of development. For instance, the average homicide rate in other Latin American countries is 25 per 100,000 inhabitants, only comparable to the homicide rate of Colombian municipalities in the lowest tercile of the suitability index. The second important fact is that the homicide rate increases with the suitability index, suggesting that coca cultivation and cocaine markets may be responsible for these differences.

We also have data on AUC (paramilitaries) and FARC (guerrillas) presence—the two main armed groups involved in the cocaine trade (the ELN is another important guerrilla group that has not been involved in the cocaine trade); counts of attacks by these groups and overall attacks by all armed groups against the state, population or other groups; forced displacement from CODES; civilian and military personnel incidents with land mines; kidnappings; acts of political terrorism; and a measure of robberies reported by different public institutions. Unfortunately, many of these secondary data sources do not cover the entire 1990-2011 period, limiting the scope of our analysis with these alternative measures of conflict. For the count variables, we calculate the rate for each of these violent events (e.g., number of incidents per 100,000 inhabitants per year). The resulting rates are summarized in Table 1.

Additionally, we have several measures indicative of a burgeoning cocaine trade. First, we have coca cultivation figures from SIMCI[3], which are obtained from satellite images. Coca cultivation figures in Colombia are available at the municipality level from 1999 through 2011[4]. We supplement this data with an estimation of coca crops for the year 1994 at the municipality level from the Colombian National Police. We obtain the total number of eradicated hectares per year in each municipality from 1994 to 2008 as another proxy for coca cultivation activities and a measure of enforcement against the drug trade. Finally, we have the number of anti-narcotic operations and drug-related captures from 1993 to 2008 in each municipality. The second panel in Table 1 shows summary statistics for these variables. As expected, municipalities with a high suitability index tend to have more coca crops and the police reports more eradication, anti-narcotic operations and drug-related captures.

The bottom panel of Table 1 presents summary statistics for the geographic characteristics for the geographic characteristics used in the construction of the suitability index. Finally, it also presents suitability indices for the cultivation of palm tree, sugar cane and cocoa. These are obtained from the ministry of agriculture and based on potential yields. To ease their interpretation we present standardized them.

Table 2 has a similar format and summarizes additional fixed municipal characteristics obtained from the CEDE (Centro de Estudios Economicos) municipal panel. These variables are used to control for unbalanced characteristics across municipalities with different suitabilities for cocaine production, or some as measures of institutional quality and state presence. Our covariates include dummies for the production of the main export commodities in Colombia. We also have several measures of state presence and institutional quality. Besides the total

[3]Sistema Integrado de Monitoreo de Cultivos Ilicitos, a UN Office based in Bogota in charge of monitoring illicit crops and drug production activities in Colombia.

[4]See Mejía and Posada (2008) for a thorough description of how satellited images are collected and processed to correct for several factors that might affect the estimations of the area under cultivation.

number of state institutions per 100.000 inhabitants, we also have dummies for the existence of particular public institutions, including schools, health centers, tax offices, among others. These are not reported in the table to save space. Finally, we also have proxies of the initial level of development of a municipality in the early 90s, historical levels of violence and conflict and geographical characteristics related to how remote a municipality is. Though some of these measures are observed at different points in time during the 90s, many are time invariant and the rest are highly persistent. Thus, we regard these variables as predetermined fixed municipality characteristics in our analysis, determined mostly by historical events unrelated to the rise of coca cultivation and production since 1994.

3.2 The coca suitability index

We start by constructing a suitability index based on different exogenous geographic characteristics at the municipality level. We use several rounds of a survey conducted yearly by SIMCI among farmers growing coca in different municipalities in Colombia between 2005 and 2010. Growers were selected randomly using satellite images to pinpoint their location, so they constitute a representative sample for each of the Colombian regions and at the national level. The total number of observations in the survey is 13,493. Each observation refers to a coca field and includes its location and self-reported data on productivity (SIMCI verifies part of the data on the field and reports it to be accurate), and an identifier for the farmer who owns it or takes care of it. The fields in the sample are located in 64 (out of 1,052) municipalities scattered across the country, as shown in the left panel of Figure 3, and belong to 1,678 different farmers. Gray municipalities are those in which no survey was conducted. The red color scale indicates higher yields of coca crops among fields in each municipality. We match the data on productivity to geographical characteristics in the municipality where each coca field is located. These geographical characteristics include altitude above sea level, soil erosion, aptitude (an index of suitability for common agricultural crops, based on soil nutrients, minerals and topography), and a precipitation (rainfall) index.

To uncover the determinants of the productivity of coca cultivation, we estimate the following model:

$$(1)\qquad \ln(productivity_{hm}) = \begin{array}{c} \beta_0 + \beta_1 altitude_m + \beta_2 altitude_m^2 + \beta_3 aptitude_m + \beta_4 aptitude_m^2 \\ \beta_5 water_m + \beta_6 water_m^2 + \beta_7 erosion_m + \beta_8 erosion_m^2 + \varepsilon_{hm} \end{array},$$

where $productivity_{hm}$ is the reported productivity of coca field h in municipality m. Table 3 presents estimates of several variations of this model, wherein we use different measures of productivity available in the survey and specifications with productivity in logs or levels. Our preferred specification is presented in Column 4, top panel, though all reveal very similar results. The dependent variable is the log of production per planted hectare after adjusting production by the number of harvests (different plots may yield different amounts per harvest and different number of harvests). In this model, the included geographical covariates explain 20% of the variation in productivity. There is a robust quadratic relation between productivity and the geographic characteristics of municipalities included in the model (except precipitation), which holds across specifications. Productivity is low in municipalities at a low or high altitude, and reaches a maximum in municipalities located 1,000 meters above sea level. Productivity falls again at higher altitudes. The F-statistic of a joint significance test for altitude and its square is 4.45. An intermediate level of erosion and precipitations is also required to maximize productivity. The F-statistic of a joint significance test for erosion and its square is 3.76, and that for precipitation and its square is 1.32. Finally, the relationship between productivity and aptitude is convex, and maximum productivity is obtained at low aptitude land. The F-statistic of a joint significance test for erosion and its square is 4.24.

We see these results as broadly consistent with the Botanical evidence on *Erythroxylum coca*— the genus to which coca bushes containing the cocaine alkaloid belong, and described by Plowman (1979) and Plowman (1983). The varieties containing cocaine include E. coca var. coca— or Bolivian coca, E. coca var. ipadu— or Amazonian coca, E. novogranatiense var novogranatiense— or Colombian coca, and E. novogranatense var Truxillense— or Trujillo coca. These names were given based on the areas where these varieties were predominant in the past. However, this geographical distribution is less accurate in the present. As a UNODC 2005 census of coca growers in Colombia reveals, about 59% grow Bolivian coca, 21% Amazonian coca and 20% Colombian coca. Bolivian coca is not only the most important variety in the Colombian cocaine trade in recent years, but it is also the species from which all other varieties were derived through selection, inheriting many of its traits. Bolivian coca grows well under a limited range of ecological conditions, which motivates our approach for constructing a suitability index. In particular, it naturally grows between 500 and 1,500 meters above the sea level, consistent Consistent with this we find more productive plantations at these altitudes (see also Mejía and Rico (2010)).[5] Colombian coca was obtained after extensive selection and manipulation, and is able to resist dry habitats and other environmental conditions not suitable for other crops— including coca Boliviana. This helps explain many of the non-linearities found: different characteristics may affect varieties differently. Also, though the original Bolivian coca required a wet environment, this became less important, and in some cases damaging, for newer varieties, which could explain why an intermediate level of precipitation is ideal. Finally, coca crops are not well suited for chalky soils, but very eroded soils are also a problem, suggesting that an intermediate level of erosion is optimal.

Using our estimated results from Column 4, top panel, we create a measure of expected

[5]These also holds for Colombian coca, but not for Amazonian, which grows better at lower altitudes (about 500 meters). An additional piece of evidence comes from records of leaves collected in Colombia from 1960 to 1980, and available at the Fields Museum collections. Though there are several Erythroxylum species, during this period, mostly Colombian coca was found. The records reveal most of the leaves were found at altitudes near 1,000 m above sea level.

productivity of coca bushes for the 1,052 Colombian municipalities with geographical data as

$$s_m = \exp\begin{pmatrix} \widehat{\beta}_0 + \widehat{\beta}_1 altitude_m + \widehat{\beta}_2 altitude_m^2 + \widehat{\beta}_3 aptitude_m + \widehat{\beta}_4 aptitude_m^2 \\ \widehat{\beta}_5 water_m + \widehat{\beta}_6 water_m^2 + \widehat{\beta}_7 erosion_m + \widehat{\beta}_8 erosion_m^2. \end{pmatrix}.. \quad (2)$$

We call this the *suitability index*, since it measures how productive a municipality is for coca cultivation based only on its geographic characteristics. The suitability index varies across municipalities but not over time. We normalize the suitability index in terms of standard deviations from the mean to facilitate its interpretation. The right panel in Figure 3 shows a plot of the suitability index. Gray municipalities are those for which there is no data of the soil characteristics required to construct the index. The red color scale indicates different suitabilities, with lighter colored municipalities being the less suitable. The figure reveals some plausible patterns: suitability is high in the Andes mountains' sides, which resemble the ecological conditions similar to those of the Peruvian and Bolivian areas where Bolivian coca grows typically. Suitability is also lower at high attitudes in the north of the Andes, where cities such as Bogota and Medellin are located. Suitability is also low deep into the Amazon, where only the Amazonian coca grows but yields a low cocaine content, and in the coastal areas as one moves away from the Andes. Other areas with high suitability include the Catatumbo in the northeast at the frontier with Venezuela, which has had coca crops consistently over the our sample. Finally, we also find large suitabilities in the south of the country in Meta, Guaviare, Caqueta and Putumayo— which are traditional coca-growing areas; while suitability becomes lower as one moves to the southeast frontier with Venezuela.

Appendix A shows that the expansion of coca cultivation since 1994 occurred mostly in municipalities with a high suitability index. These municipalities also experienced a larger increase in aerial and manual eradication, and in anti-narcotic operations. Thus, the index not only predicts the cross sectional location of coca crops, but also their expansion during the second half of the 1990s. For instance, coca cultivation grew 25% more between 1994 and 2000 in municipalities with a suitability index one standard deviation above the national average. Appendix B shows that the main empirical results presented below hold if we use other specifications to estimate the determinants of productivity and construct the suitability index.

3.3 Demand shocks

The demand for Colombian cocaine is shaped to a large extent by external conditions unrelated to the Colombian conflict. Since 1990, the major changes in transnational cocaine markets affecting the demand for Colombian cocaine were:

- The shift of demand from Peru and Bolivia to Colombia, following increasing anti-narcotic efforts in Peru and Bolivia. And other temporal spikes in seizures in Peru and Bolivia redirecting demand to Colombia (see Angrist and Kugler (2008)).

- An increase in cocaine consumption in the mid 2000s in the U.S. followed by a recent decline since 2008.

- Large spikes in seizures in transit countries, specially in Mexico, in the mid 2000s and late 1990s, with recent declines. Seizures in transit countries increase demand from sources to compensate for the extra losses in downstream markets if demand is inelastic (see Mejía and Restrepo (2013) for a full model rationalizing this effect).

We construct a simple model of demand determination that captures all these relevant forces. The model is only meant to provide guidance for the construction of a proxy for external demand, and so we make a number of stark simplifications. Suppose the demand for cocaine by consumers is fully inelastic and equal to A_t at year t. This only simplifies the model, but similar results hold as long as demand is inelastic, as it is widely believed to be the case (see Becker, Murphy and Grossman (2006)). A fraction $1-\chi_t$ of the demand is served exclusively by Peruvian and Bolivian suppliers; while the remaining fraction, χ_t, is served by international traffickers who can buy cocaine from Colombia or Peru and Bolivia. An increase in χ_t allows us to model the shift in cultivation from Peru and Bolivia to Colombia since 1994.

Suppose also that prices in Colombia are fixed (so that we evaluate changes in the demand for Colombian cocaine at fixed prices). Let Q_{ot} be the production from other sources, and S_{ot} seizures by Peruvian and Bolivian authorities, so that $Q_{ot}-S_{ot}$ is the net supply from other sources. Q_{ot} is supplied with an elasticity ε. Likewise, let Q_{ct} be the production in Colombia, and S_{ct} the seizures in Colombia, so that $Q_{ct}-S_{ct}$ is the net supply from Colombia. The international traffickers demand cocaine from source countries as to maximize profits, given a production technology $Q_t = F(Q_{ct}-S_{ct}, Q_{ot}-S_{ot}) - S_{mt}$, where F is a regular production function, S_{mt} are seizures in transit, and Q_t is the resulting supply in consumer markets. Let σ be the elasticity of substitution between cocaine from both sources. Market clearing implies that $A_t\chi_t = F(Q_{ct}-S_{ct}, Q_{ot}-S_{ot}) - S_{mt}$. Appendix C shows that log linearizing the model around its equilibrium, and assuming σ and ϵ are large (as suggested by the calibration in Mejía and Restrepo (2013)), yields a formula for deviations in demand based on changes over time in consumers' demand, A_t, seizures, S_{ot}, S_{mt}, and changes in χ_t. Taking this approximation as valid for larger changes yields the following proxy for external demand:

$$(3) \qquad \ln D_t = \frac{h_c}{z_c}\left(h_m \ln A_t + h_m \ln \chi_t + (1-h_m)\ln S_{mt} + (1-z_c)\left(\frac{1}{h_o}-1\right)\ln S_{ot}\right).$$

Here h_c is the average fraction of cocaine not seized by Colombian authorities, h_o is the average fraction of cocaine not seized by other source country authorities, h_m is the average fraction of cocaine not seized in transit, and z_c is the share of the cocaine trade supplied by Colombia. To compute the proxy, we set $h_c = h_o = 0.8$ and $h_m = 0.6$ based on the UNODC world reports average seizure figures for our period of analysis (see UNODC (2013)). To model the shift in coca cultivation during the 1990s, we take χ_t as a variable that grows from .4 to 1 at a constant rate from 1990 to 2000, and set $z_c = .5$. This guarantees the share of production supplied by Colombia goes from 20% at the beginning of 1990 gradually until it reaches an average of 50% after 2000 (which coincides with the average production shares in the data). For A_t we use the number of treatment episodes involving cocaine in the U.S. for each year from 1990 to 2011 as a proxy for consumption. The data were obtained online from the Drug Abuse Warning Network (DAWN) site. It closely matches other proxies of demand we use in our robustness tests, including the number of U.S. citizens that reported consuming cocaine during the last year or month, annual prevalence figures among the adult population or high school students, and an inverse measure of harm perception. These alternative measures of consumption were constructed using the National Survey on Drug Use and Health and the Monitoring the Future study. For seizures in transit we use mainly seizures in Mexico, which is the main transit hub for cocaine bought in Colombia en route to the U.S. markets. In robustness checks we add seizures in Central America and inside the U.S. territory. Seizures data is obtained from the UNODC yearly drug reports, and the DEA web page. Finally, for seizures in other sources we use reports from Peru and Bolivia, obtained from the UNODC yearly reports.

Intuitively, the above formula shows that demand for Colombian cocaine increases when market demand is high (the term $d \ln A_t$); or when less cocaine is demanded directly from Peru and Bolivia, following the shift in cultivation in 1994 (the term $d \ln \chi_t$). Demand for Colombian cocaine also increases when seizures in transit are higher (the term $d \ln S_{mt}$), because traffickers demand more cocaine to compensate for the additional losses in transit. The fully inelastic demand guarantees prices adjust to provide enough incentives for traffickers to do so, and this will be the case as long as consumers' demand is inelastic. Finally, the demand for Colombian cocaine also increases when Peru and Bolivia seize more cocaine (the $d \ln S_{ot}$ term), because traffickers substitute away from these sources and towards the relatively easier-to-smuggle Colombian cocaine.

Figure 1 depicts our baseline measure of $\ln D_t$, constructed as explained above. As it is apparent from the figure, our measure has several desirable properties. First, it increases from the early 1990s to 2000, capturing the shift in coca cultivation from Peru and Bolivia. This is essentially the variation exploited by Angrist and Kugler (2008), and constitutes and exogenous demand change triggered by a change in policies in Peru and Bolivia. Second, it shows an increase in demand in the mid 2000s, specially from 2004 to 2008, due to higher consumption and more seizures in transit. This is unlikely to be driven by internal circumstances in Colombia. In fact, Colombia supply was stable until 2005 and fell sharply afterwards, suggesting that the increase in consumption—revealed by more treatment episodes involving cocaine—and seizures in Mexico was not driven by an increase in supply from Colombia. Instead, we believe the high value of $\ln D_t$ from 2004 to 2008 reflects changes in consumption in the U.S. (for instance, risk perceptions were lower), and policy changes in Mexico. Consistent with our view, farm-gate prices of Colombian cocaine increased sharply from 2000 to 2008 (see Mejía and Restrepo

(2013)). Third, our measure is not only trending upwards, but also falls sharply from 2008 onwards (specially between 2009 and 2010). The main cause is a decline in consumption of about 20-30%, apparent using several proxies for cocaine demand. Again, we do not believe this decline in consumption is driven by a lower supply from Colombia for two reasons: first, cocaine farm-gate prices were stable at roughly the same level of 2008 during 2009, 2010 and 2011, suggesting that a shrinking supply cannot by itself explain the fall in consumption. Second, consumption falls sharply since 2009, while supply shrinks before, starting in 2005. Thus, we believe our measure captures a genuine decrease in external demand in recent years driven by falling consumption in North America. Though it is true that traffickers have compensated by redirecting the flow of cocaine to European markets, this comes at a cost which still makes business less attractive and reduces the demand for Colombian cocaine (plus, these markets face more competition from Peruvian and Bolivian cocaine). Finally, our demand measure also shows temporal spikes due to changes in seizures in transit, Peru and Bolivia. Again, these are unlikely to be driven by changes in supply, which typically varies more smoothly. All the same, we believe our external demand index summarizes the main external forces shaping the demand for Colombian cocaine since 1990 and until 2011. Our argument above suggest that this variation is largely driven by external circumstances, and can be safely used to explore its effects on cocaine markets in Colombia.[6] Appendix D provides time-series figures for each of the series used in the construction of our external demand proxy separately, as well as alternative measures.

4 Coca booms and their effect on violence

4.1 External demand shocks cause cocaine booms in high suitability municipalities

In this section, we explore if external demand increases for Colombian cocaine cause a cocaine boom in high suitability areas relative to the rest of the country. Figure 4 previews our results. The solid line presents the yearly deviation in the log of cocaine revenue in a municipality implied by one additional standard deviation in the cocaine suitability index (relative to the mean difference during this period). We construct the cocaine revenue in a municipality as the product of the cultivation figures, national yields and national cocaine prices (unfortunately, these are available only at the national level). As can be seen, cocaine revenue increased sharply after 1994 in high suitability municipalities relative to the rest of the country. As demand spiked in the mid 2000s, so did cocaine revenue in high suitability areas. Reassuringly, the gap

[6]Even if our demand index picks some variation caused by aggregate changes in the Colombian cocaine market, this does not necessarily posses a problem for our identification strategy. As long as these aggregate changes are exogenous to a given municipality we can use them in the spirit of a Bartik-style instrument.

between high suitability and other areas became smaller in recent years as demand decreased. Thus, the evidence in this figure suggests that increases (or decreases) in cocaine demand are primarily accommodated by increases (or decreases) in cultivation—and hence revenue—in high suitability areas. Our evidence suggest that external demand shocks have a stronger incidence in high suitability areas. This occurs not only in the long run, but also in the short run (after detrending the data as we will show below).

We explore this pattern in a regression framework. In particular, we estimate the model

$$y_{mt} = \alpha_m + \delta_t + \beta s_m \times \ln D_t + \varepsilon_{mt}. \tag{4}$$

Here, y_{mt} are various proxies meant to capture a booming cocaine trade in a municipality. The error term ε_{mt} is allowed to be heteroskedastic and serially correlated within municipalities. Thus, all of the standard errors we present are robust against heteroskedasticity and serial correlation within municipalities. The coefficient on the interaction term $s_m \times \ln D_t$ captures the differential effect of a 1% increase in the demand for Colombian cocaine on municipalities with suitability one standard deviation above the mean. α_m and δ_t are a full set of municipality and year fixed effects. The inclusion of these effects guarantees that β is identified only from within municipality variation.

Table 4 presents our results. The top panel presents estimates of equation 4, with the dependent variable listed in the top row. Column 1 in the top panel uses the log of coca crops as dependent variable.[7] The reported estimate suggest that a 10% increase in the demand for Colombian cocaine increases cultivation by 1.7% more for every additional standard deviation in suitability (standard error=.48%). Column 2 implies that a 10% increase in the demand for Colombian cocaine increases the likelihood of cultivation by 0.12 percentage points for every additional standard deviation in suitability (standard error=0.05 percentage points). In columns 3 to 5 we use measures of drug related enforcement. These are also meant to capture a cocaine boom, since one would expect more eradication of coca crops, more captures and more anti-narcotic operations when the cocaine trade is booming. Consistently, we find positive effects of demand shocks on the likelihood of eradication and the log of the rate of captures and anti-narcotic operations per 100.000 inhabitants.

In the bottom panel we add the term $s_t \times t$ as a control. This fully controls for secular trends in municipalities with different suitabilities that may be correlated with our demand proxy. More importantly, it guarantees that β is identified only from comparing the deviations of y_{mt} from its trend at years in which external demand is also above its trend. Thus, we refer to these models as identifying the short-run response to external demand shocks in areas with higher suitability for cocaine production. Remarkably, we find a similar short run response for most of our variables, except for eradication. All the same, the evidence from Table 4

[7]Throughout the paper, we use the transformation $x \to \ln(x)$ if $x \geq 1$ and 0 otherwise and refer to it simply as the log of x. This is a monotone transformation of x, approximately equal to $\ln(x)$ and which simply weights the extensive margin differently depending on the scale of x.

demonstrates that demand shocks have a differential effect on municipalities and tend to create cocaine booms in higher suitability ones following temporal or persistent changes in demand.

4.2 Main estimates on homicides and cocaine revenue

In this section we explore the effects on violence caused by external demand shocks in municipalities suitable for cocaine production. We focus on the homicide rate, which covers more municipalities and the entire time period, and offers the most complete metric of conflict. We explore results for other outcomes in section 6. Figure 1 already previewed our results, and showed clear evidence that external demand shocks increase violence disproportionally in high suitability areas.

We estimate equation 4 using the log of the homicide rate as dependent variable.[8] The top panel of Table 5 presents our results using several alternative constructions of the demand proxy $\ln D_t$. In particular, in each column we use alternative measures of seizures at transit or other sources as indicated in the bottom rows. The results uniformly reveal that external demand shocks have a differential effect on homicides in high suitability municipalities, consistent with the view that cocaine booms breed violence. Column 1 presents the results using our preferred external demand proxy; that is, the one constructed using seizures in Mexico—as a measure of seizures in transit— and seizures in Peru and Bolivia—as a measure of seizures in other source countries. The result in this column suggest that a 10% increase in external demand increases the homicide rate by 1.05% (standard error=0.35%) for every additional standard deviation in suitability. The third panel shows that this is a consequence of a 1.99% increase of coca revenue in the municipality; that is, of the cocaine boom created by the combination of increases in external demand and high suitability. In the second and fourth panel, we add $s_m \times t$ as a covariate to control for differential trends among municipalities with different suitabilities. As before, this implies we identify the effects on homicides (second panel) and coca revenue (fourth panel) only from short term responses of violence and cultivation to temporal changes in external demand around its trend. The estimates remain roughly unchanged, suggesting that our estimate is not driven by long-run relationship between the expansion of the cocaine industry and violence, but more importantly by short-term responses to changes in external demand that are stronger in high suitability municipalities.

The results in columns 2 to 7 confirm that our findings are robust to the particular construction of $\ln D_t$ utilized. Column 2 shows our results hold if we add U.S. seizures to seizures in transit. Column 3 to 5 show that most of our results hold if we use any combination among seizures in the U.S., Mexico and Central America as our measure of seizures in transit. In Column 6 we use the seizure rates, rather than the actual seizures to construct $\ln D_t$. This is motivated by the possibility that seizure rates may better capture other countries anti-narcotic

[8]In this case, the transformation used to compute the log of the homicide rate is less of an issue, as homicides are pervasive among all Colombian municipalities in our sample, specially at the yearly level.

efforts. Again, this hardly changes our results. Finally, in column 7 we remove seizures in Bolivia, since some analysts have argued that Peru is the main competition Colombia faces in the U.S. cocaine market. Bolivian cocaine, on the other hand, is bounded primarily for Europe. In any case, our results hardly change.

Table 6 has a similar structure as the previous one, but now we explore the use of alternative proxies for cocaine demand by U.S. consumers, $\ln A_t$, specified in the bottom rows. Our main specification uses $\ln TEDS_t$, where $TEDS$ is the acronym for treatment episodes involving cocaine in U.S. facilities. In the first column, we use $0.5 \ln TEDS_t$, and in column 2 we use $1.5 \ln TEDS_t$. These specifications account for the fact that treatment admissions may be related to demand by consumers with an elasticity different than one. In column 3 we use the log of the number of U.S. people reporting to have consumed cocaine during the last year; while in column 4 we use the number reporting consumption last month. In column 5 we use the log of annual prevalence rates among the general U.S. population, and in column 6 we use the log of annual prevalence rates among U.S. high school students. Finally, in column 7 we use minus the log of harm perception associated with cocaine consumption among U.S. high school students. The estimates show that our results are robust to using different proxies of demand for cocaine in the U.S.. This occurs primarily because all these proxies capture an increase in demand in the mid 2000s and a significant decline in recent years, which matches the differential behavior in homicides and cultivation in high suitability municipalities.

One potential issue with the estimates in the previous tables, is that suitability may be correlated with other municipality characteristics. For instance, as shown in Table 2, high suitability areas have more gold production, coffee production, or may have different institutional backgrounds for historical reasons. Let X_m be the vector of municipal fixed characteristics related to suitability. To fully control for their time varying influence on the path of violence in equation 4, it is enough to add interactions of each of the X_m with $\ln D_t$ as covariates. Assume the conditional expectation function $\mathbb{E}[s_m|X_m])$ is linear in X_m, or can be well approximated by a linear function. Then, by adding these controls we are effectively estimating

$$(5) \qquad y_{mt} = \alpha_m + \delta_t + \beta(s_m - \mathbb{E}[s_m|X_m]) \times \ln D_t + \gamma \mathbb{E}[s_m|X_m] \times \ln D_t + \varepsilon_{mt},$$

so β is identified from the cross sectional variation in suitability that is orthogonal to all characteristics X_m, as desired. This is intuitive: any confounding effect occurs only through the relationship between X_m and s_m—namely, $\mathbb{E}[s_m|X_m]$—and only if it is correlated in time with $\ln D_t$. Note that the main effect of X_m is not an issue because of the municipality fixed effects.

Table 7 presents our results obtained after controlling for several municipality fixed characteristics correlated with suitability. The top panel uses the log of the homicide rate as dependent variable. The second panel controls for differential trends by suitability, $s_m \times t$. The last two panels use the log of coca revenue as dependent variable. Column 1 presents our baseline estimates for comparison. In column 2 we control for the time varying influence of dummies for the presence of the main commodities in each municipality, measured during the 90s (but highly persistent). The commodities include coffee, palm tree, flowers, banana, cattle, oil, coal, emeralds and gold (see Table 1 for a summary of these variables). As can be seen, our results are slightly less precise but of a similar magnitude. In column 3 we control for the influence of various measures of state presence from the early 90s which are highly persistent. These include dummies for the presence of notaries, public banks, churches, public libraries, health office, public schools, police, the military and other state institutions; the number of judges per capita, and the year of creation of the municipality. Our coefficients remain largely unchanged, suggesting that we are not capturing different paths of violence among municipalities with different state presence or institutional quality. In column 4 we control for the influence of proxies of the level of development in the early 90s, including urbanization, population, and several indexes of poverty and inequality (some of them at the provincial level). In column 5 we control for the influence of remoteness, including the distance to capitals and main cities, as well as the area of the municipality and a dummy for whether a main road passes by the municipality. Again, our estimates remain unchanged, suggesting we are not capturing different trends among municipalities in the center and the periphery of the country, or simply the effect of being a remote area during an ongoing conflict. In column 6 we control for the influence of measures of historical violence (from 1900-1958, a period covering *la violencia* and further conflicts). We also control for the homicide rate in 1990 (to capture dynamical effects or other unobserved characteristics), and dummies of the tactical and strategic position of the municipality in the conflict. We find larger effects on homicides in this specification, suggesting there was a long term convergence in violence among high violence and low violence areas (high suitability municipalities were more violent historically and in 1990), or some form of mean-reverting dynamics. In column 7 we control for department dummies, so that we eliminate differential trends in violence across departments and exploit only within municipality variation in our suitability index. Finally, in column 8 we control for the influence of all the previous characteristics simultaneously. Despite the fact that jointly, these characteristics explain nearly 50% of the cross sectional variation in suitability, we still find that external demand shocks increase violence and cocaine revenue in more suitable areas once we drop this explained variation. This is the pattern we would expect if our estimates are not capturing differential trajectories of homicides in municipalities with other characteristics correlated with X_m: a stable estimate, with less precision as we add controls.

To further increase our confidence that our suitability index is not related to any other secular changes, we explore an alternative data set on homicides from the national police covering the 1983-1998.[9] Before 1994, coca cultivation was confined mostly to Peru and Bolivia, so municipalities with different suitabilities should exhibit similar dynamics of violence. As

[9]This database is highly unbalanced. It includes about 500 municipalities before 1990 and 950 afterward. The figure is constructed using the unbalanced panel, but it is very similar if we restrict it to the balanced one.

figure 5 shows, this is exactly what we see in the data. Though there is considerable noise, there are no discernible trends in violence before 1994 for municipalities with different suitabilities; while homicides become statistically higher in high suitability areas in 1997. This suggest that, absent the thriving cocaine market, suitability is not related to different trajectories of violence, as wanted.

Appendix E provides additional robustness checks of our results. In particular, we show that our results are robust to dropping outliers, and remain stable across different sub samples (rural areas, low population areas, removing 10th percent higher or lower municipalities, among others). We also present estimates correcting standard errors for the noise introduced in the estimation of the suitability index using a joint GMM estimator.

4.3 The role of government enforcement

One potential issue with the previous estimates is that they may be capturing the effects of government enforcement on violence. The concern is understandable, as the exercise of enforcement is a violent activity on itself, and may independently cause violence (see for instance Dell (2011)). The first concern is the possibility that our demand measure may be correlated spuriously over time with the deployment of Plan Colombia— a major counter-narcotics program between the U.S. and Colombia, which started at the end of 2000— or an increase in enforcement during Alvaro Uribe's presidency from 2002 to 2010. If the additional enforcement targeted high suitability areas, this may confound our estimates.

To address it, we control in a number of ways for enforcement and the deployment of Plan Colombia in equation 4, using the homicide rate as dependent variable. Table 8 presents our results (estimates controlling for differential trends by suitability are very similar and not presented to save space). We follow a number of strategies. In column 1 we control directly for the log of eradicated hectares per unit of area, and the log of drug-related capture and operations per 100.000 inhabitants. Though these controls are endogeneous, and hence the estimates not consistent, it is illustrative to see that cocaine booms are independently associated with violence in high suitability municipalities once we remove the role of enforcement. In column 2 we control for the interaction of a dummy indicating police reinforcements during Uribe's administration. In column 3 we control for an interaction of suitability and a dummy for the Plan Colombia period (2001-2011). In column 4 we control for the interaction of total eradication in Colombia with our suitability index. This captures the fact that total eradication efforts could have been deployed specially on high suitability municipalities. In column 5 we use the interaction between the proximity to the nearest military base (from Dube and Naidu (2015)), the nearest army brigade, and a dummy for the existence of a police station with a dummy for the Plan Colombia period as controls. Instead, in column 6 we interact all these variables with national eradication efforts (as a proxy for the aggregate level of enforcement) and add them as controls. Finally, in column 7 we interact these measures of military and police presence with $\ln D_t$, to capture the possibility that areas near army and police locations may be subject to tougher enforcement during cocaine booms. The results suggest that we are not capturing the possibility that Plan Colombia, or tougher enforcement efforts have disproportionally affected high suitability areas (columns 3 and 4); or the possibility that Uribe's efforts were directed at these areas as well (column 2). Columns 5 to 7 show that we are not capturing tougher enforcement responses of the government in areas near military strongholds. Thus, after we control flexibly for enforcement in a number of ways, we still find that cocaine booms bring more violence to high suitability municipalities.

A second, and more subtle, concern is that our estimates are consistent, but the response of government enforcement is the channel through which cocaine booms foster violence. In particular, this view suggest that the government responds to cocaine booms by cracking the trade down in booming areas. Violence is observed as a consequence of this additional enforcement efforts. The results in table 4 suggest this is a plausible channel, as we see increases in most proxies of drug-related enforcement in high suitability municipalities during cocaine booms, not only in the long run, but also following temporal booms. Though this is less of a concern (one could argue this is part of the effect we want to estimate), we still find it important to distinguish between violence created by armed groups fighting for rents and running the cocaine trade, from violence generated as a mechanical byproduct of enforcement by the government, even if both are caused by the cocaine boom. The results in Table 8 partially suggest that this mechanical effect through enforcement cannot be the complete story: many of our estimates in this table hold enforcement constant, and this hardly affects our estimates. Indeed, Column 7 shows that controlling for the government response to the external demand for Colombian cocaine near military bases or army brigades does not change our conclusions. To add to the evidence, we also explored if cocaine booms had heterogeneous effects in high suitability municipalities with different levels of exposure to the military (measured by distance to bases, brigades or existence of police stations). One would expect government enforcement responses to be stronger near existing military deployments, and thus the increase in homicides should be larger for cocaine booms near military bases. However, we find no evidence of any positive interaction, suggesting a small role for government responses in fostering violence: violence increases in a similar way independently of whether the government military arm is nearby to crack on the cocaine trade or not. Finally, we think the role of Plan Colombia is limited because enforcement was concentrated in Putumayo and Caqueta. Reductions in cultivation in these two departments since 2000 account for almost all the national reduction in cocaine cultivation. However, our estimates do not change if we remove these departments, suggesting that government responses during Plan Colombia do not confound our estimates and are not a very relevant channel amplifying violence for the rest of the country. We do find, however, that cocaine booms had a larger effect on violence in Putumayo and Caqueta.

5 The role of illegality

In this section we provide evidence to support our view that cocaine markets cause violence because they are illegal. As mentioned in the introduction, the literature has recently emphasized instead the role of the institutional environment. In particular, the alternative interpretation is that cocaine booms are like any other agricultural boom in a weakly institutionalized setting—as many rural areas in Colombia. (Illegality at most plays an indirect role by driving producers to these areas, but once located there, cocaine is as any other commodity.) According to this view, the state is absent to secure property rights and enforce contracts, not only in illegal markets but for legal agricultural commodities as well. Any boom leads to more violence as armed groups fight over the unsecured property and tax producers, or as producers resort to violence in order to enforce their property rights and contracts. Booms may have an offsetting effect by increasing wages (see Dube and Vargas (2013) and Dal Bó and Dal Bó (2011)), but if institutions are weak enough rapacity over the resources dominates and violence increases. (Though this view certainly explains why some legal commodities are associated with violence for instance oil, as documented by Dube and Vargas (2013).) We provide three pieces of evidence against this view that led us to favor our view that cocaine booms are violent because it is illegal. First, an initial piece of evidence weighing against a central role of institutions is in Table 7, which shows the component of our suitability index that is orthogonal to a large set of institutional characteristics is also associated with violence. Second, we show cocaine booms are not more violent in weakly institutionalized municipalities. Finally, we show that other legal agricultural commodities produced in municipalities with similar institutional features to those of cocaine (cocoa, sugar cane and palm tree) do not foster violence.

We start by showing that cocaine booms are not more violent in weakly institutionalized municipalities. In particular, we estimate the model

$$y_{mt} = \alpha_m + \delta_t + \beta_1 s_m \times \ln D_t + \beta_2 \theta I_m \times \ln D_t + \beta_3 s_m \times \theta I_m \times \ln D_t + \varepsilon_{mt}, \tag{6}$$

with I_m a measure of state presence, or institutional quality, and y_{mt} the log of the homicide rate (or cocaine revenue in other exercises). The view that it is not illegality but state weakness, implies that $\beta_3 < 0$. In other words, cocaine booms in high suitable areas only cause violence when institutions or state presence are weak and I_m is low. To construct proxies for I_m we use the principal factor of several municipality characteristics and standardize it to ease the interpretation. These measures are summarized in Table 2, measured in the early 90s, and highly persistent.

Table 9 presents our results for several proxies of state presence I_m. The table is divided in four panels. The first two present results using the log of the homicide rate as dependent variable; while the last two use the log of coca revenue. The second and last panels control for differential trends by suitability. All main effects are evaluated at the mean. In each column we use a different group of measures related to state presence, and present the triple interaction of cocaine booms in high suitability areas with their principal factor. In column 1 we use measures of judicial quality to compute I_m, including number of judges per capita, jails, notaries and courts. In column 2 we use measures of military presence by the state, including presence of police stations, distance to army brigades and bases. In column 3 we use measures of state capacity, such as total public institutions, public employees per capita, and the presence of a tax office. In column 4 we use measures of public good provision as a proxy for state presence. These include the density of paved roads, number of hospitals and public schools. In column 5 we use the age of a municipality as a measure of historical state presence. In column 6 we use measures of proximity of the municipality to main cities, ease to reach, and an inverse measure of extension that determine geographical barriers against state presence. Finally, in column 7 we include all these measures simultaneously to construct the institutional quality index I_m.

A clear pattern emerges: there is no significant interaction between cocaine booms and institutional quality for homicides; while there is some evidence of a negative interaction for the size of the boom (i.e., cultivation). In fact, in the first two panels the interactions do not have a consistent sign, are not significant when negative, and are small. This suggest institutional quality does not mediate the relationship between cocaine booms and violence: high suitability areas become more violent when external demand increases independently of state presence. The results for coca revenue suggest that cocaine booms are accommodated through more production primarily in weakly institutionalized municipalities. Thus, institutions are only helpful in preventing a cocaine boom from emerging in response to increases in external demand. The downside is that, once a cocaine boom is in place, it is actually *more* violent, explaining why on net there is no differential effect on homicides. This last feature does not fit the view that cocaine booms foster violence because they occur in a weakly institutionalized environment.

We now move to the third piece of evidence against the alternative view. A key prediction of the view that cocaine breeds violence only because of the weak institutions in Colombian rural areas, is that booms of lega agricultural commodities produced in municipalities with similar institutions as those engaged in cocaine production should also increase violence. We show this is not the case. In particular, we selected among a large set of agricultural products (about 30), the 6 crops produced in an institutional environment closer to that of cocaine in Colombia.[10] These products include peas, plantains, yuca, oil palms, sugar cane, and cocoa, consistent with anecdotal evidence suggesting that cocoa, *yuca* and plantains are frequently found near coca plantations. Among these products, we focus on cocoa, sugar cane and palm tree.[11] We do so because their derivatives are transacted in international markets (like cocaine), and there are

[10]We did this by computing the distance between a vector containing the mean institutional characteristics of municipalities producing each product to those producing cocaine.

[11]Dube and Vargas (2013) also present some estimates for sugar cane, banana, tobacco and palm trees. Like us, they do not find these commodities' booms create violence— though they use actual cultivation data in 2005 and focus on armed groups' attacks and clashes.

large variations in their price driven by external conditions (Colombia is not a big player in any of these markets). Moreover, they have a similar labor intensity as cocaine and structure of production.[12]

We explore if international price increases in cocoa, sugar and palm oil have an effect on violence in municipalities with high suitability for these products. For each of these crops, we use suitability figures for potential yields constructed by a team of specialists at the Colombian Vice President Office, and standardized them (so they are comparable to our results for cocaine). We also obtained yearly international prices from the IMF. Using this data we estimate

$$(7) \qquad y_{mt} = \begin{array}{c} \alpha_m + \delta_t + \beta s_m \times \ln D_t + \beta_{cocoa} s_{cocoa,m} \times \ln P_{cocoa} + \beta_{palm} s_{palm,m} \times \ln P_{palm} + \\ \beta_{sugar} s_{sugar,m} \times \ln P_{sugar} + \varepsilon_{mt}. \end{array}$$

Here, $s_{cocoa,m}, s_{palm,m}$ and $s_{sugar,m}$ are the standardized suitability measures for cocoa, oil palm, and sugar cane, respectively. Each of them is interacted with its corresponding international price $\ln P_{cocoa}, \ln P_{palm}$ and $\ln P_{sugar}$. The dependent variable is the log of the homicide rate. If the institutional environment explains why cocaine booms are violent, we would expect $\beta = \beta_{cocoa} = \beta_{palm} = \beta_{sugar}$, or at the least, all the β's to be positive and significant.

Table 10 explores this prediction. Column 1 estimates equation 7 without the interaction term for cocaine. There is no evidence that increases in international prices translate into more violence in municipalities with high suitability for sugar cane, oil palm or cocoa production. Importantly, standard errors are of a similar size as the ones estimated for cocaine booms, and yet they cannot reject a null effect. In column 2 we add the interaction term for cocaine. Again,

[12] The labor share for cocaine production is estimated at around 30%. On average, there were about 100,000 hectares of cocaine and the trade employed near 60,000 families (see Mejía and Rico (2010)). For sugar cane, the data by Arbelaez, Estacio and Olivera (2010) suggest a labor share of 30% as well. Moreover, sugar cane has many similarities with cocaine production. About 76% of the 200,000 sugar-cane hectares in Colombia are owned by farmers who sell sugar cane to *ingenios*. The trade employs directly near 40,000 workers. Sugar cane is then refined and processed into sugar and other derivatives used for internal consumption—mostly in large cities— and exported (about 30% of the production is transacted in international markets). Still, Colombia is a small player in international markets and only produces about 1.5% of the world's production. In the case of cocoa, there are 100,000 hectares cultivated. Colombia is again a small player in this market dominated by Africa. Though exports of Colombian cocoa have risen in recent years due to reductions in the African supply. Cocoa is grown by farmers in small plantations, who harvest the crops and collect the cocoa beans, dry them and sell them to large companies producing chocolate (either national or international). Palm tree is used to extract palm-tree oil, which is used mainly in the production of bio diesel transacted in international markets. Unlike the other commodities, it is cultivated in larger plots own by private companies employing farmers, or by organized groups of farmers (an increasingly popular model). The palm-tree fruit is then sold to oil mills for processing and distribution. Currently, there are about 340,000 palm-tree hectares, and the trade employs directly near 40,000 workers. Though we do not have data on the labor share for cocoa and palm trees, the information we have accessed suggest there should not be many differences in this dimension relative to most agricultural commodities. Interestingly, the production of these commodities has been promoted with alternative development programs, aimed at helping coca growers transition to legal crops. This underscores the similarity between these crops and the environments where they are produced.

while cocaine booms have a significant effect on homicides in municipalities suitable for cocaine production, international price increases for the other agricultural products do not have a similar effect. Not only are the coefficients not significant, they are also small in comparison to the 0.106 coefficient on the cocaine interaction. In column 3 we control for time trends interacted with all crops' suitabilities to isolate short-run responses of violence and eliminate secular trends. We find that cocaine still has a positive impact on homicides in municipalities suitable for cocaine production; while cocoa, oil palm and sugar cane booms create, if anything, a reduction in violence, at least in the short run. In column 4 we pool all other agricultural products together and impose the restriction $\beta_{cocoa} = \beta_{palm} = \beta_{sugar}$. Still, the average effect of increases in the prices of these agricultural products on municipalities with high suitability for their cultivation is small and not significant; while the cocaine interaction is large, positive and significant. In column 5 we control for differential trends by crops' suitabilities. As in column 3, we find that short run increases in international prices of coca, sugar cane and palm oil reduce violence in municipalities that are highly suitable for their cultivation. This is exactly the opposite of what we have documented for cocaine. In columns 6 and 7 we add interactions with the proxy of state presence and institutional quality, I_m, used in column 7 of Table 9. Column 7 controls for differential trends by crops' suitabilities. While the relationship between legal commodities' booms and violence depends on institutional quality, as emphasized in the literature, the same is not the case for Cocaine. Sugar cane, coca and palm-tree booms reduce violence on average, but more so when good institutions are in place. Presumably because property rights are well defined, contracts enforced and hence, rapacity over the revenues reduced. In short, we find that rapacity over legal agricultural commodities may operate in the municipalities with the worst institutions, but on average, it is not as strong to explain why cocaine is consistently associated with more violence. This suggest illegality plays a key role and makes cocaine special.

We mentioned in the introduction some of the theoretical reasons why we would expect illegal commodities to be more likely to generate violence (holding the institutional environment constant) and why a legal cocaine market would be less likely to foster violence. The results in Table 10 support this view: legal cocaine would be just like cocoa, sugar cane or palm trees. As the evidence shows, booms of these other agricultural commodities are not consistently associated with more violence, and if anything they reduce violence in the short run. Instead, cocaine booms cause violence in high suitability municipalities independently of state presence. This difference underscores that the key feature making cocaine markets so violent is their illegal character. Taken at face value, our result imply that violence could be reduced if cocaine production was legal. In particular, cocaine booms would have an effect closer to that of the other legal agricultural products summarized here. Importantly, this reduction in violence would come even without improvements in the country dysfunctional institutions.

6 Other outcomes

In this section we explore the effects of cocaine booms in other conflict-related outcomes. Table 11 presents estimates of equation 4 for other outcomes. The left panel (columns 1 to 4) present estimates exploiting the long-term variation; while the right panel (columns 5 to 8) remove differential trends by suitability. We focus first on the long-term variation, as we do not expect many of these outcomes to react in the short run. We find that cocaine booms driven by external demand increase the likelihood of FARC and paramilitary presence (AUC), as well as attacks by both groups against the state, each other, and the civil population. In fact, we also see the total number of attacks perpetuated by any group increasing during cocaine booms in high suitability municipalities. Forced displacement increases, but the effect is not significant. Finally, incidents with landmines (used to keep away the military from coca crops) increase during cocaine booms. However, not only the military are affected by mines, we also find an increase in incidents involving civilians. Interestingly, we see a negative effect of cocaine booms on kidnappings and terrorism on high suitability municipalities. We believe this occurs because armed groups reallocate their efforts towards the booming and more profitable cocaine trade. Kidnappings become a less attractive source of revenue; while terrorism, which consists of bombings and other acts with a political motivation, may be also left aside as efforts are concentrated in exploiting the cocaine trade. Finally, there is no effect on robberies, nor in attacks by the ELN, another guerrilla group not involved in the cocaine production, which is reassuring.

In the right panel, we find some short-run effects on Guerrilla attacks and incidents with mines. We also find negative effects on kidnappings, terrorism and robberies. However, these results are harder to interpret in this case, as the short time span for which these outcomes are available makes it difficult to remove trends.

7 From reduced-form to structural estimates.

The previous estimates support our view that a thriving black market causes violence. However, they are reduced form estimates and have no structural interpretation. In this section, we present 2SLS estimates that combine our previous reduced-form models. However, the structural interpretation of these estimates requires strong assumptions that we discuss below. Thus, these results are only meant to illustrate the range of qualitative implications of our estimates.

To introduce our discussion, let R_{mt} be a sufficient statistic that summarizes the effect of the illegal cocaine market in municipality m at time t on violence. Different models suggest different measures, and the choice of R_{mt} constitutes a theoretical restriction that our data cannot validate or refute. We assume that R_{mt} is a measure of the rents, or profits, accruing to armed groups in control of the cocaine trade in municipality m at time t. This assumption is based on models of conflict— as Grossman (1991) or Skaperdas (2002)— in which rents are a first order determinant of investments in conflict, and hence violence. Some theories suggest that cocaine revenue is the relevant channel, but others point to profits; while in others the shadow value of a unit of land effectively controlled to produce cocaine determines violence. It is also not clear if these measures should be aggregates or normalized. In summary, there is no consensus about the right structural model to estimate, and ours is one of many plausible models.

Our goal is to estimate the structural model

$$y_{mt} = \alpha_m + \delta_t + \beta \ln R_{mt} + \varepsilon_{mt} \tag{8}$$

using $s_m \times \ln D_t$ as an instrument for rents, R_{mt}. In our setting, we have the additional complication that we do not observe rents and have to rely on imperfect proxies for it. To illustrate these problems, suppose these rents can be written as

$$\ln R_{mt} = \ln P_{mt} + \ln L_{mt} + \ln \lambda_{mt} + \ln \tau_{mt}, \tag{9}$$

with P_{mt} the price of cocaine (this varies by municipality depending on quality and location, and this may refer to a shadow price since armed groups may attempt to traffic the cocaine by their own), L_{mt} the land cultivated with coca crops, λ_{mt} the cocaine yield per hectare, and τ_{mt} the share of total revenue accruing to armed groups controlling the cocaine trade in municipality m. However, we can only observe a proxy of these rents: the municipal coca revenue measure, constructed in the previous sections as

$$\ln \widetilde{R}_{mt} = \ln P_t + \ln \widetilde{L}_{mt} + \ln \lambda_t, \tag{10}$$

with P_t and λ_t the national price of cocaine and yield per hectare, and $\widetilde{L}_{mt}$ the satellite cultivation figures.

Thus, we cannot directly estimate the structural model, but instead, we have to deal with the alternative one:

$$y_{mt} = \alpha_m + \delta_t + \beta \ln \widetilde{R}_{mt} + \left(\varepsilon_{mt} + \beta(\ln L_{mt} - \ln \widetilde{L}_{mt}) + \beta(\ln P_{mt} - \ln P_t) + \beta(\lambda_{mt} - \lambda_t) + \beta \ln \tau_{mt}\right). \tag{11}$$

Equation 11 underscores why our 2SLS estimates need to be interpreted with caution: while we only observe one indicator of the extent of the cocaine market in a municipality, $\widetilde{R}_{mt}$, other non-observable features of this boom related to our instrument appear in the error term (i.e., local variation in prices, productivity and profits' share). These unobserved channels may load into our 2SLS estimate and make it larger than its structural counterpart, as long as our instrument is correlated with them. Thus, our 2SLS estimates capture the broad effect of a cocaine boom using our proxy of cocaine revenue as a coarse indicator, and not simply the structural effect of $\widetilde{R}_{mt}$.

With this caveat in mind, we know present some 2SLS estimates of equation 11 in Table 12. The table contains two panels, the first one has opur basic estimates and the bottom one controls for differential trends by suitability. Column 1 presents two-sample 2SLS estimates (see Angrist and Pischke (2008)), obtained by estimating the reduced form over the whole 1990-2011 period, and the first stage only for the years with available data (1994, 1999-2011). The coefficient $\beta = 0.526$ in the top panel equals the ratio between the reduced form and first stage coefficients presented in Table 5 in column 1, in the first and third panel. The standard error is computed via bootstrapping, and is robust against serial correlation within municipalities. Column 2 present the usual 2SLS estimates computed using the years 1994, 1999-2011 for which our coca revenue proxy, $\widetilde{R}_{mt}$, is available. These estimates suggest that a cocaine boom, measured by a 10% increase in our coca revenue proxy increase homicides by 4-5%. Results are similar in the bottom panel where we control for differential trends by suitability. Given our previous results and the first-stage F statistic reported below each model, we are confident that we do not have any weak instrument problems. We discussed the quantitative implications of these estimates in the introduction.

Column 3 presents OLS estimates of the model in equation 11. Column 4 presents a long-difference estimate using changes between 1994 and 2007 (the period with the largest increase in external demand). The OLS estimates are one order of magnitude smaller than their 2SLS counterparts; while the long-difference estimates are close to .1, but still about one quarter of their 2SLS counterparts. The fact that the long-differences estimates are way larger than the fixed-effects estimates in column 3 suggest our proxy of coca revenue has considerable measurement error. This is understandable: not only it relies on imperfect satellite images, but it is also only meant as an indicator for a cocaine boom, with prices, productivity differences and many other features of it being left out of the measure. Columns 5 and 6 confirm there is considerable measurement error: when we instrument coca revenue using its lag, or eradication figures, the estimates get closer to their 2SLS counterparts. These estimates are less vulnerable to some types of measurement error but do not solve obvious endogeneity concerns. The difference between the 2SLS estimates and OLS is a telling tale that the exclusion restriction may not hold. As we discussed above, we do not think this is caused by a correlation between our instrument and the structural error (ε_{mt} in the estimation equation), but because of the fact that we are using an imperfect proxy to measure the extent of a cocaine boom. If this is the case, 2SLS estimates are large because the unobserved features of the cocaine boom correlated with our instrument get loaded into our 2SLS estimates; while they attenuate the OLS estimates. In short, our 2SLS estimates capture the broad effect of a cocaine boom, measured in an imperfect way by our coca revenue proxy; while our OLS estimates capture an attenuated estimate of the correlation of this proxy with homicides.

8 Conclusions

In this paper, we provided evidence that the thriving cocaine market fosters violence in Colombia, and explains the persistence of violence in large parts of the country side. In particular, we show that homicides and other conflict-related outcomes increase during cocaine booms. We uncover this causal relation using within municipality variation obtained by combining a suitability index for coca cultivation with a non-monotonic measure of external demand for Colombian cocaine. Our results show that coca revenue, cultivation and other measures related to a cocaine boom increase in high suitability municipalities when external demand for Colombian cocaine is high. Homicides and other forms of violence increase as a consequence, suggesting that cocaine booms cause violence in Colombia. This is a robust finding, that holds when we use different variations of our external demand measure or our suitability index. Moreover, it also holds when we exploit the component of suitability that is orthogonal to a wide range of municipality fixed characteristics, including institutions and geography.

While a growing literature shows that agricultural products like coffee (see Dube and Vargas (2013) and flowers (see Hernandez (2014)) reduce violence even in the weakly institutionalized rural areas of Colombia, these gains have not been materialized for cocaine. Instead, cocaine booms have brought salient levels of violence to the Colombian country side. We argued in this paper that this is because cocaine is illegal and provided evidence against the alternative view suggesting that any agricultural boom, including cocaine, causes violence in a weakly institutionalized environment. We do so by comparing the effects of cocaine with those of similar products, including sugar-cane, cocoa and palm-tree, which, if anything, reduce violence. We also show cocaine booms cause violence independently of the institutions in place. These results underscore the role of illegality as the main driving force behind our estimates. Our interpretation suggest that legalizing cocaine production would reduce violence in the rural areas of Colombia, even holding institutions in their current state.

We also provided some structural estimates that require stronger assumptions, and whose interpretation is complicated by the fact that we do not really observe the extent of the cocaine market in a municipality. Our 2SLS estimates imply that a 10% increase in cocaine revenue increases homicides by 4% to 5%. Our 2SLS estimates imply that the thriving cocaine trade causes up to 11 to 16 of the 35 homicides per 100.000 inhabitants per year in the country (from 5,500 to 8,000 homicides per year). Legalizing cocaine production, or removing the cocaine market, would reduce the contemporary homicide rate in Colombia to 20 to 25 homicides per 100.000 inhabitants. Though high by developed countries' standards, this counterfactual homicide rate is close to the level of the safest Latin American countries. Colombia's exceptionally high violence can be fully explained by the presence of the thriving cocaine market.

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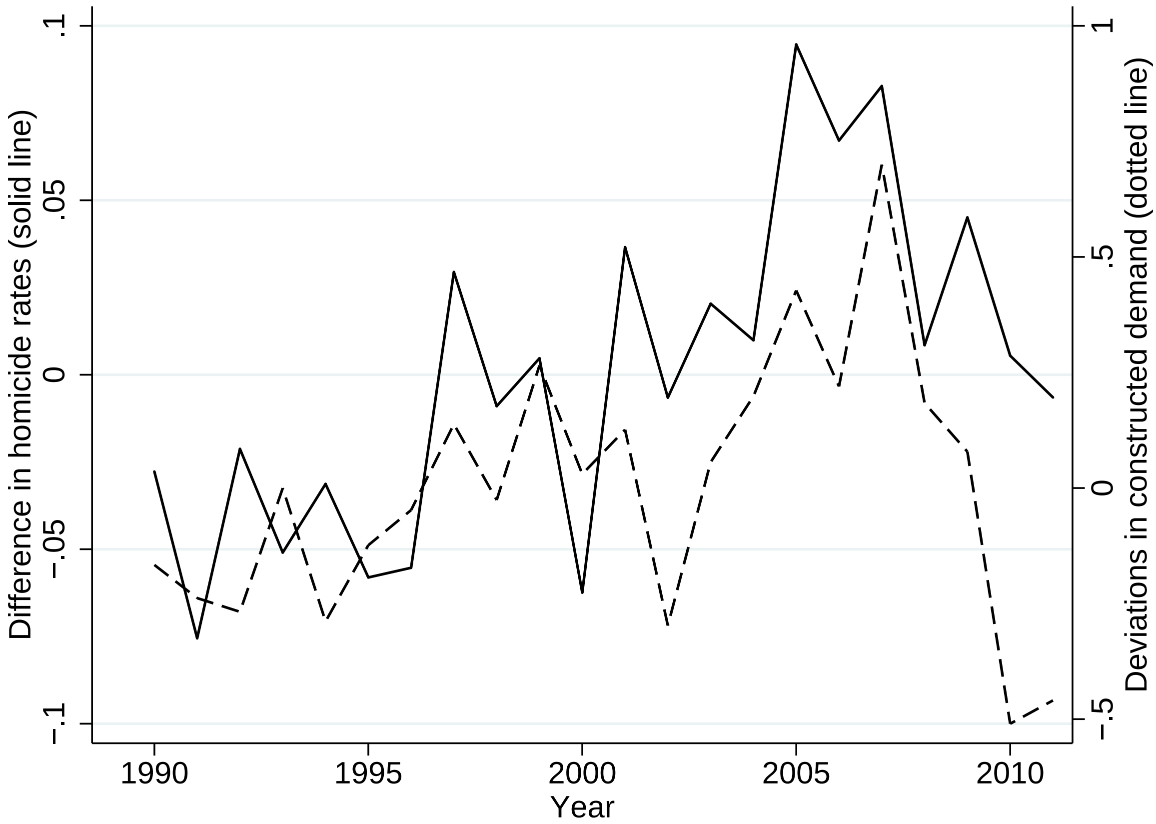


Figure 1: Relationship between differential violence in high suitability municipalities and demand. The figure plots both series relative to their mean.

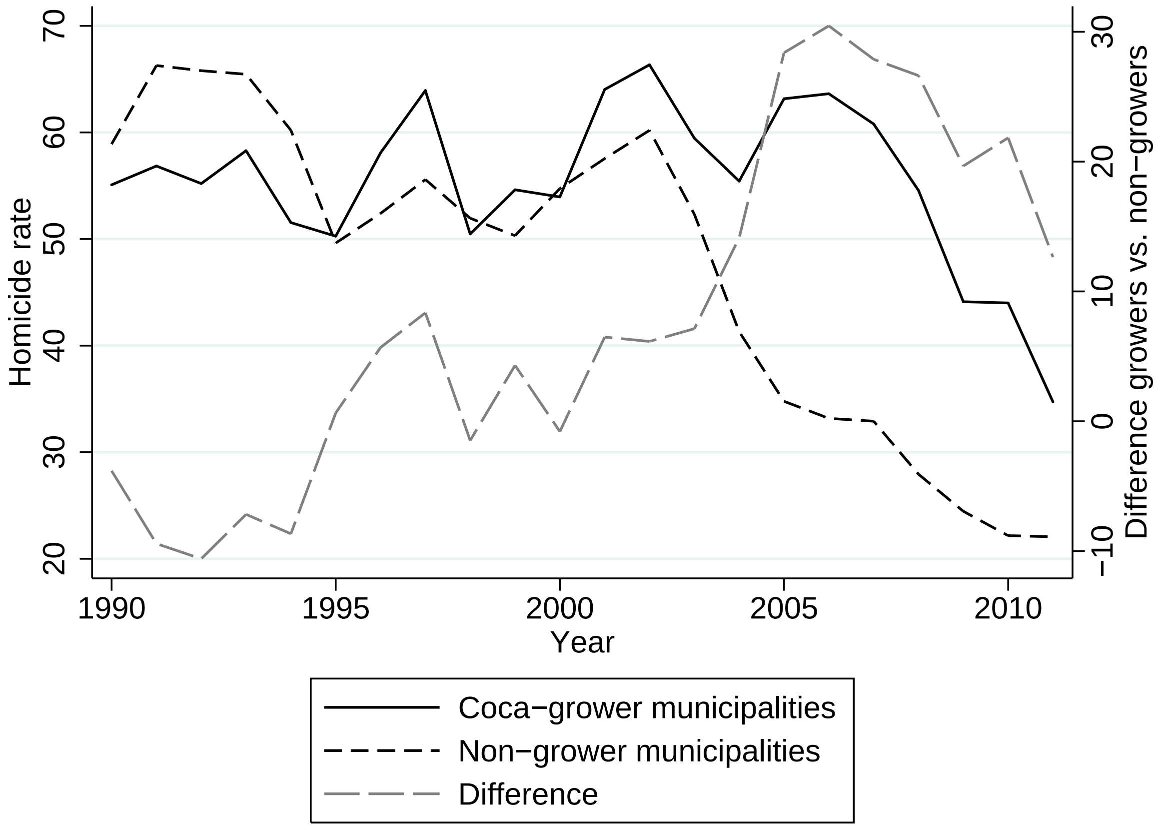
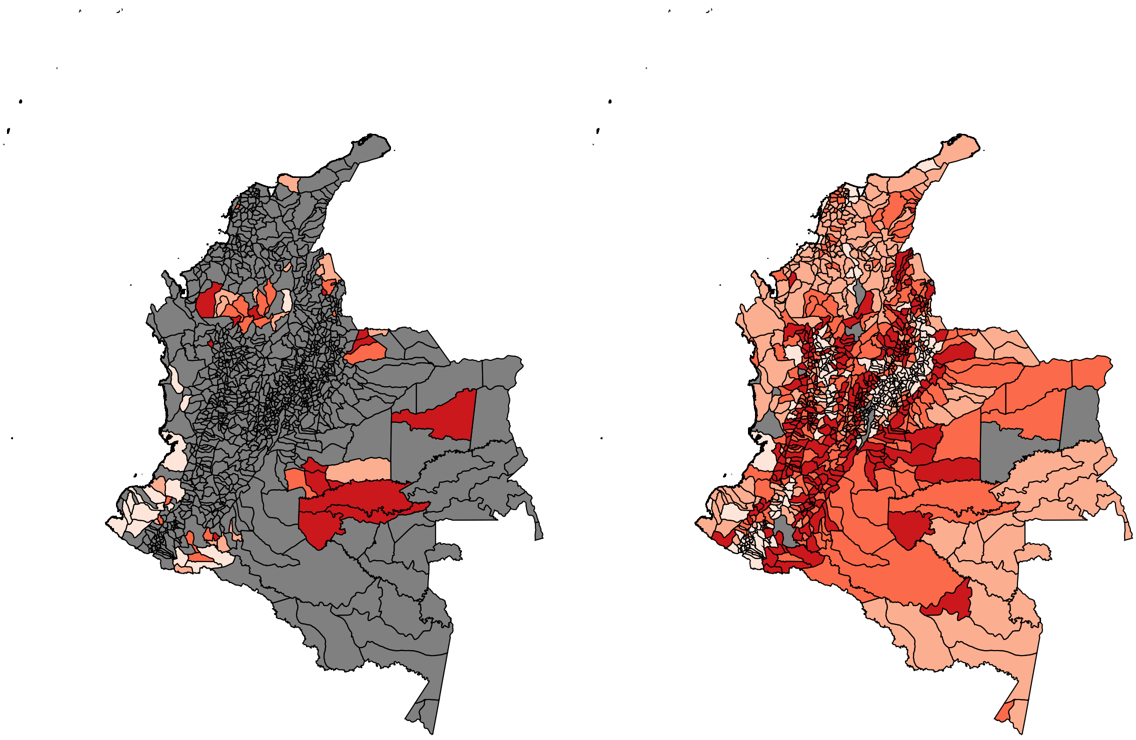


Figure 2: Homicide rate in coca-growing municipalities (solid line) and non growers (dotted line) from 1990 to 2011.



Productivity from UNODC surveys. Estimated suitability index.

Figure 3: Cocaine productivity in Colombia and our suitability measure.

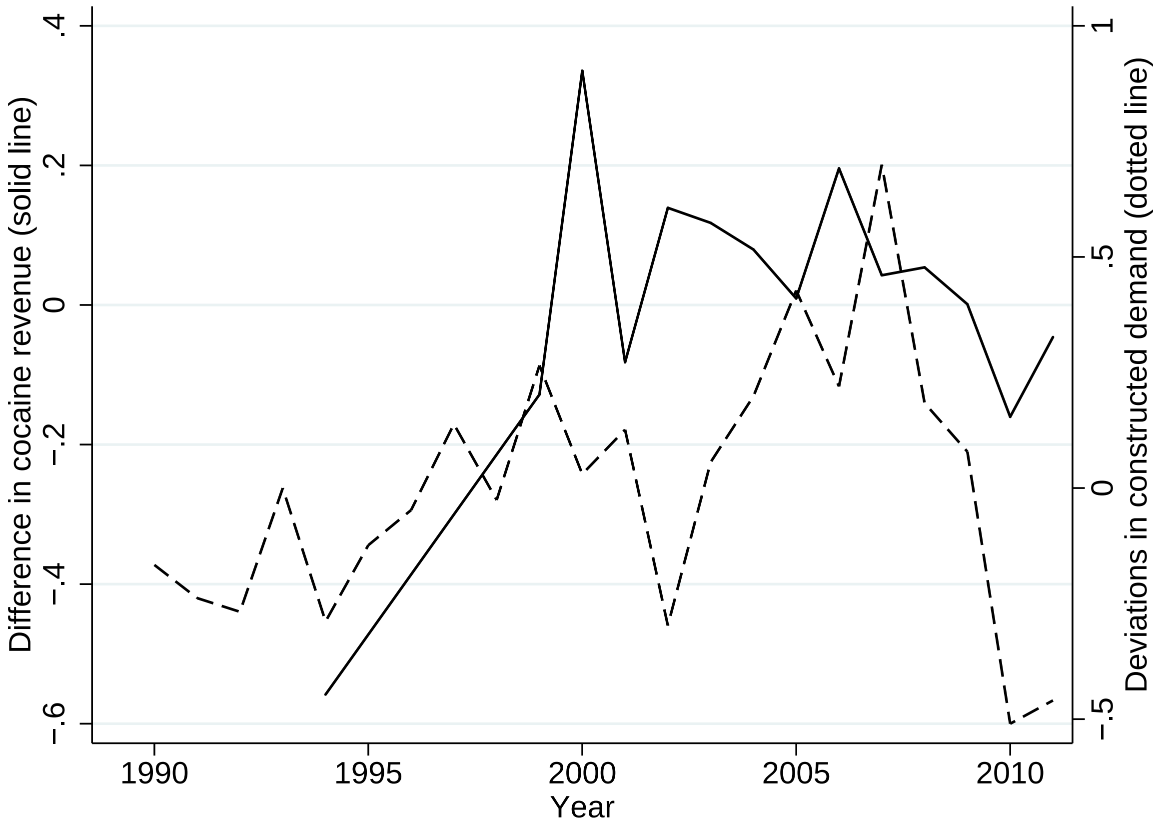


Figure 4: Relationship between differential cocaine revenue in high suitability municipalities and demand. The figure plots both series relative to their mean.

Figure 5: Differential changes in the homicide rate for every additional standard deviation in the suitability index from 1983 to 1998. The year 1994 is chosen as the base year, and all estimates are to be interpreted as changes relative to this year. We plot a 95% confidence interval in dotted lines around the main estimates in solid lines.

Table 1: Descriptive statistics for the main variables used in our empirical exercise

	Suitability terciles		
	Lower tercile	Middle tercile	Higher tercile
Conflict-related outcomes:			
Homicide rate (1990-2011)	31.87 (49.67) **N= 7666**	51.35 (69.26) **N= 7738**	69.88 (80.29) **N= 7696**
AUC presence (1993-2008)	0.07 (0.26) **N= 5568**	0.14 (0.35) **N= 5616**	0.15 (0.36) **N= 5600**
FARC presence (1993-2008)	0.25 (0.43) **N= 5568**	0.37 (0.48) **N= 5616**	0.45 (0.50) **N= 5600**
AUC attacks' rate (1993-2008)	0.25 (2.85) **N= 5480**	0.71 (4.75) **N= 5575**	0.71 (4.62) **N= 5583**
FARC attacks' rate (1993-2008)	3.05 (14.73) **N= 5481**	4.99 (19.02) **N= 5579**	7.11 (24.36) **N= 5583**
ELN attacks' rate (1993-2008)	0.76 (3.92) **N= 5481**	1.85 (10.81) **N= 5579**	1.64 (9.13) **N= 5583**
Total attacks' rate (1993-2007)	69.15 (320.53) **N= 5063**	101.81 (391.88) **N= 5139**	142.74 (830.48) **N= 5220**
Forced displacement rate (1997-2009)	608.76 (3019.91) **N= 4550**	1542.29 (4826.56) **N= 4574**	1275.21 (3695.21) **N= 4550**
Civilian incidents with mines rate (1990-2009)	0.33 (3.86) **N= 7684**	0.99 (8.73) **N= 7699**	0.82 (6.82) **N= 7696**
Military incidents with mines rate (1990-2009)	0.61 (7.91) **N= 7684**	1.44 (11.19) **N= 7699**	2.02 (15.10) **N= 7696**
Kidnap rate (1996-2008)	5.35 (21.36) **N= 4550**	7.51 (23.11) **N= 4576**	8.90 (27.98) **N= 4550**
Acts of terrorism rate (1998-2008)	1.06 (4.75) **N= 3850**	2.24 (7.96) **N= 3872**	2.78 (9.23) **N= 3850**
Robbery rate (2003-2011)	61.92 (97.32) **N= 3150**	62.33 (109.81) **N= 3168**	92.74 (127.99) **N= 3150**
Cocaine-related outcomes:			
Hectares with coca crops (1994, 1999-2011)	30.39 (387.13) **N= 4900**	119.04 (611.13) **N= 4928**	100.31 (652.45) **N= 4900**
Hectares eradicated (1994-2008)	39.79 (680.47) **N= 5250**	149.76 (1005.25) **N= 5280**	128.26 (995.45) **N= 5250**
Drug-related captures' rate (1993-2008)	3.79 (12.03) **N= 6643**	6.35 (18.95) **N= 6660**	8.43 (24.80) **N= 6646**
Drug-related operations' rate (1993-2008)	1.15 (12.30) **N= 5593**	2.70 (29.25) **N= 5604**	3.28 (22.82) **N= 5596**
Geographic characteristics:			
Altitude above sea level	1828.10 (1036.26) **N= 350**	748.61 (762.59) **N= 352**	918.79 (410.79) **N= 350**
Water availability index	3.1e+06 (6.0e+05) **N= 350**	3.4e+06 (5.4e+05) **N= 352**	3.4e+06 (4.3e+05) **N= 350**
Erosion index	1.49 (1.12) **N= 350**	1.91 (1.00) **N= 352**	2.38 (0.86) **N= 350**
Soil aptitude index	2.63 (1.18) **N= 350**	2.88 (1.26) **N= 352**	2.53 (1.16) **N= 350**
Suitability for palm trees	-0.11 (0.77) **N= 350**	0.17 (1.28) **N= 352**	-0.08 (0.79) **N= 350**
Suitability for sugar cane	-0.25 (0.84) **N= 350**	0.00 (1.05) **N= 352**	0.31 (1.07) **N= 350**
Suitability for cocoa	-0.37 (0.61) **N= 350**	0.10 (1.05) **N= 352**	0.28 (1.13) **N= 350**

Notes: The table presents summary statistics for the main variables used in our empirical analysis. See the text for a description of the variables and sources. For each variable we present its mean, standard deviation (in parenthesis), and number of observations. Each column contains the data for municipalities in a given suitability tercile.

Table 2: Descriptive statistics for accessory variables used in our empirical exercise

	Suitability terciles		
	Lower tercile	Middle tercile	Higher tercile
Commodities (dummies for presence in late 90s):			
Banana production	0.06 (0.24) **N= 10150**	0.15 (0.36) **N= 10208**	0.18 (0.38) **N= 10150**
Coffee production	0.33 (0.47) **N= 10150**	0.47 (0.50) **N= 10208**	0.77 (0.42) **N= 10150**
Flower production	0.12 (0.33) **N= 10150**	0.05 (0.22) **N= 10208**	0.09 (0.29) **N= 10150**
Gold production	0.10 (0.30) **N= 10150**	0.16 (0.37) **N= 10208**	0.17 (0.38) **N= 10150**
Palm-tree production	0.03 (0.18) **N= 10150**	0.12 (0.33) **N= 10208**	0.07 (0.25) **N= 10150**
Cattle production	0.81 (0.39) **N= 9889**	0.80 (0.40) **N= 10063**	0.84 (0.36) **N= 10121**
Oil production	0.03 (0.17) **N= 10150**	0.07 (0.26) **N= 10208**	0.13 (0.33) **N= 10150**
Oil port	0.05 (0.21) **N= 10150**	0.11 (0.31) **N= 10208**	0.01 (0.08) **N= 10150**
Emerald production	0.01 (0.12) **N= 10150**	0.01 (0.11) **N= 10208**	0.03 (0.17) **N= 10150**
Coal production	0.18 (0.38) **N= 10150**	0.06 (0.23) **N= 10208**	0.06 (0.23) **N= 10150**
Institutional quality and state presence:			
Year of foundation	1840.65 (113.18) **N= 10150**	1891.21 (90.90) **N= 10208**	1860.82 (115.14) **N= 10150**
Judicial institutions per 10.000 pop. (late 90s)	1.51 (1.23) **N= 9889**	1.23 (1.10) **N= 9918**	1.43 (1.14) **N= 10121**
Existence of police station (late 90s)	0.82 (0.39) **N= 9889**	0.90 (0.30) **N= 10063**	0.90 (0.30) **N= 10121**
Index of distance to nearest army brigade (late 90s)	2.14 (0.74) **N= 9889**	2.39 (0.68) **N= 10063**	2.26 (0.69) **N= 10121**
Total number of state institutions (early 90s)	174.69 (127.51) **N= 9193**	147.78 (128.96) **N= 9193**	153.39 (117.23) **N= 9454**
Public employees per 100.000 pop (early 90s)	2828.94 (2450.92) **N= 9599**	2902.72 (3059.97) **N= 9541**	2883.26 (2329.54) **N= 10005**
Population and development:			
Population in 1993	41162.72 (3.0e+05) **N= 10063**	22911.80 (29254.50) **N= 9976**	38501.49 (1.5e+05) **N= 10121**
Share of rural population in 1993	0.69 (0.23) **N= 10063**	0.61 (0.23) **N= 9976**	0.61 (0.23) **N= 10121**
Fraction of population from ethnic groups (late 90s)	0.03 (0.12) **N= 9889**	0.02 (0.08) **N= 10063**	0.02 (0.07) **N= 10121**
Gini coefficient by province in 1993	0.44 (0.11) **N= 10150**	0.41 (0.13) **N= 10208**	0.43 (0.12) **N= 10150**
Presence of Dengue (late 90s)	0.31 (0.46) **N= 9889**	0.15 (0.36) **N= 10063**	0.22 (0.41) **N= 10121**
Acqueduct coverage (late 90s)	0.65 (0.24) **N= 10150**	0.64 (0.22) **N= 10150**	0.69 (0.21) **N= 10150**
Seawage coverage (late 90s)	0.35 (0.25) **N= 10150**	0.39 (0.27) **N= 10150**	0.52 (0.24) **N= 10150**
Density of paved primary roads in 1995	21.53 (38.81) **N= 9599**	18.88 (32.80) **N= 9222**	17.67 (35.76) **N= 9889**
Density of paved secondary roads in 1995	14.50 (36.90) **N= 9599**	11.45 (29.07) **N= 9222**	14.82 (35.15) **N= 9889**
Location and remoteness:			
Presence of a national main road (early 90s)	0.11 (0.32) **N= 9889**	0.13 (0.34) **N= 10063**	0.15 (0.36) **N= 10121**
Distance to state capital (km)	76.91 (55.53) **N= 10150**	86.63 (68.81) **N= 10208**	75.59 (45.32) **N= 10150**
Distance to Bogota (km)	318.64 (201.44) **N= 10150**	382.31 (200.96) **N= 10208**	245.02 (126.28) **N= 10150**
Distance to main markets (km)	148.18 (120.82) **N= 10150**	141.47 (114.25) **N= 10208**	91.22 (70.14) **N= 10150**
Extension (squared km)	758.45 (2094.02) **N= 10150**	1481.65 (4836.40) **N= 10208**	811.62 (1910.30) **N= 10150**
Historical violence and conflict:			
Historical violence dummy from 1901 to 1917	0.07 (0.26) **N= 10063**	0.10 (0.30) **N= 9976**	0.12 (0.32) **N= 10121**
Historical violence dummy from 1918 to 1931	0.09 (0.29) **N= 10063**	0.13 (0.33) **N= 9976**	0.16 (0.37) **N= 10121**
Historical violence dummy from 1948 to 1953	0.07 (0.26) **N= 10063**	0.12 (0.33) **N= 9976**	0.22 (0.41) **N= 10121**
Homicide rate in 1990	2.61 (1.76) **N= 10150**	2.89 (1.91) **N= 10208**	3.60 (1.72) **N= 10150**
Dummy for tactical position in conflict	0.32 (0.47) **N= 10150**	0.49 (0.50) **N= 10208**	0.53 (0.50) **N= 10150**
Dummy for strategic position in conflict	0.11 (0.31) **N= 10150**	0.19 (0.39) **N= 10208**	0.22 (0.42) **N= 10150**

Notes: The table presents summary statistics for the main variables used in our empirical analysis. See the text for a description of the variables and sources. For each variable we present its mean, standard deviation (in parenthesis), and number of observations. Each column contains the data for municipalities in a given suitability tercile.

Table 3: Geographic determinants of coca crops' productivity.

	In levels			In logs		
Coca leaf per area:	Planted	In prime age	Harvested	Planted	In prime age	Harvested
	(1)	(2)	(3)	(4)	(5)	(6)
	Adjusting for number of harvests					
Altitude (in 100 mts)	0.190***	60.590**	60.646**	0.190***	0.191***	0.191***
	(0.068)	(23.097)	(23.169)	(0.068)	(0.068)	(0.068)
Altitude squared	-0.011***	-3.537***	-3.544***	-0.011***	-0.011***	-0.011***
	(0.004)	(1.313)	(1.320)	(0.004)	(0.004)	(0.004)
Yearly precipitation (in mm)	0.079	63.171	61.192	0.079	0.080	0.078
	(0.148)	(49.667)	(49.900)	(0.148)	(0.148)	(0.147)
Precipitation squared	-0.001	-0.745	-0.715	-0.001	-0.001	-0.001
	(0.002)	(0.724)	(0.728)	(0.002)	(0.002)	(0.002)
Erosion index	0.506*	163.501	162.012	0.506*	0.504*	0.495*
	(0.257)	(100.626)	(101.425)	(0.257)	(0.257)	(0.256)
Erosion squared	-0.099	-34.457	-33.432	-0.099	-0.099	-0.095
	(0.073)	(28.959)	(29.228)	(0.073)	(0.073)	(0.073)
Soil aptitud	-0.370***	-124.201**	-123.571**	-0.370***	-0.369***	-0.368***
	(0.127)	(50.516)	(50.969)	(0.127)	(0.127)	(0.127)
Soil aptitude squared	0.043**	14.886**	14.808*	0.043**	0.043**	0.043**
	(0.018)	(7.379)	(7.497)	(0.018)	(0.018)	(0.018)
Observations	13493	13493	13493	13493	13493	13493
Municipalities	64	64	64	64	64	64
	Ignoring variation in number of harvests					
Altitude (in 100 mts)	7.049**	7.086**	7.057**	0.104***	0.104***	0.104***
	(3.191)	(3.199)	(3.194)	(0.038)	(0.038)	(0.038)
Altitude squared	-0.388**	-0.387**	-0.386**	-0.006***	-0.006***	-0.006***
	(0.170)	(0.170)	(0.170)	(0.002)	(0.002)	(0.002)
Yearly precipitation (in mm)	1.163	1.205	0.835	-0.019	-0.018	-0.020
	(6.135)	(6.128)	(6.167)	(0.082)	(0.082)	(0.082)
Precipitation squared	-0.011	-0.012	-0.006	0.000	0.000	0.000
	(0.085)	(0.085)	(0.085)	(0.001)	(0.001)	(0.001)
Erosion index	21.546	21.397	21.044	0.324*	0.323*	0.314*
	(13.859)	(13.888)	(14.070)	(0.172)	(0.172)	(0.173)
Erosion squared	-4.157	-4.149	-3.932	-0.063	-0.063	-0.059
	(4.109)	(4.112)	(4.195)	(0.052)	(0.052)	(0.053)
Soil aptitud	-21.565***	-21.458***	-21.387***	-0.300***	-0.299***	-0.298***
	(7.130)	(7.168)	(7.213)	(0.083)	(0.084)	(0.084)
Soil aptitude squared	3.054***	3.032***	3.021***	0.040***	0.040***	0.040***
	(1.111)	(1.119)	(1.131)	(0.013)	(0.013)	(0.013)
Observations	13493	13493	13493	13493	13493	13493
Municipalities	64	64	64	64	64	64

Notes: The table presents estimates of the geographic determinants of coca crops' productivity. Each observation corresponds to a coca field, for which the UNODC collects self-reported productivity data, used as dependent variable in levels (left panel) or logs (right panel). Standard errors robust against heteroskedasticity and arbitrary correlation patterns within municipalities are presented below each estimate in parenthesis. Stars indicate significance in the usual way.

Table 4: Effect of demand shocks on coca-related activities in municipalities with different suitabilities.

Outcome:	log coca crops (1)	Dummy coca crops (2)	Dummy eradication (3)	log drug captures (4)	log drug operations (5)
Suitability × Demand shock	0.170***	0.012***	0.060***	0.163***	0.228***
	(0.048)	(0.005)	(0.012)	(0.030)	(0.039)
Observations	14728	14728	15780	19956	16800
			Controls for Suitability × Year		
Suitability × Demand shock	0.175***	0.013***	0.014	0.170***	0.193***
	(0.049)	(0.005)	(0.010)	(0.029)	(0.032)
Observations	14728	14728	15780	19956	16800

Notes: The table presents estimates of the effect of the interaction between our external demand proxy and the suitability index, $s_m \times \ln D_t$, on several measures related to the extent of the cocaine trade in a municipality. In the bottom panel we include differential trends, $s_m \times t$, as controls. All models include a full set of municipality fixed effects and year effects. Standard errors robust against heteroskedasticity and arbitrary correlation patterns within municipalities are presented below each estimate in parenthesis. Stars indicate significance in the usual way.

Table 5: Effect of demand shocks on homicides and coca revenue in municipalities with different suitabilities.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Homicide rate.			
Suitability × Demand shock	0.105***	0.098**	0.089**	0.099**	0.082**	0.091**	0.098***
	(0.035)	(0.041)	(0.042)	(0.046)	(0.040)	(0.041)	(0.034)
Observations	23100	23100	23100	23100	23100	23100	23100
				Homicide rate. Controls for Suitability × Year			
Suitability × Demand shock	0.084***	0.070**	0.083*	0.098**	0.082*	0.076**	0.080***
	(0.030)	(0.032)	(0.043)	(0.044)	(0.042)	(0.033)	(0.030)
Observations	23100	23100	23100	23100	23100	23100	23100
				Coca revenue.			
Suitability × Demand shock	0.199***	0.265***	0.189**	0.306***	0.285***	0.279***	0.207***
	(0.056)	(0.076)	(0.095)	(0.107)	(0.108)	(0.083)	(0.056)
Observations	14728	14728	14728	14728	14728	14728	14728
				Coca revenue. Controls for Suitability × Year			
Suitability × Demand shock	0.206***	0.264***	0.086	0.248***	0.232**	0.251***	0.226***
	(0.057)	(0.076)	(0.072)	(0.090)	(0.093)	(0.062)	(0.058)
Observations	14728	14728	14728	14728	14728	14728	14728
Construction of demand shock:							
Consumption:	TEDS	TEDS	TEDS	TEDS	TEDS	TEDS	TEDS
Seizures transit:	MEX	MEX	MEX	MEX	CA	MEX	MEX
		US	CA	CA, US	US	(rate)	
Seizure sources:	PERU	PERU	PERU	PERU	PERU	PERU	PERU
	BOL	BOL	BOL	BOL	BOL	BOL (rate)	

Notes: The table presents estimates of the effect of the interaction between our external demand proxy and the suitability index, $s_m \times \ln D_t$, on the log of the homicide rade (top two panels) and coca revenue (bottom panels) in a municipality. In the second and fourth panels we include differential trends, $s_m \times t$, as controls. Each model uses a different construction of the external demand proxy by changing our initial choice of data required to construct it. The bottom rows indicate the exact choice of data used to construct the external demand proxy. All models include a full set of municipality fixed effects and year effects. Standard errors robust against heteroskedasticity and arbitrary correlation patterns within municipalities are presented below each estimate in parenthesis. Stars indicate significance in the usual way.

Table 6: Effect of demand shocks on homicides and coca revenue in municipalities with different suitabilities.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Homicide rate.			
Suitability × Demand shock	0.122***	0.088***	0.099***	0.092***	0.093***	0.063**	0.131***
	(0.040)	(0.030)	(0.033)	(0.032)	(0.030)	(0.026)	(0.047)
Observations	23100	23100	23100	23100	23100	23100	23100
				Homicide rate. Controls for Suitability × Year			
Suitability × Demand shock	0.093***	0.075***	0.077***	0.072***	0.077***	0.046*	0.097***
	(0.033)	(0.028)	(0.027)	(0.025)	(0.027)	(0.024)	(0.036)
Observations	23100	23100	23100	23100	23100	23100	23100
				Coca revenue.			
Suitability × Demand shock	0.234***	0.166***	0.212***	0.208***	0.204***	0.211***	0.282***
	(0.064)	(0.050)	(0.067)	(0.060)	(0.066)	(0.048)	(0.075)
Observations	14728	14728	14728	14728	14728	14728	14728
				Coca revenue. Controls for Suitability × Year			
Suitability × Demand shock	0.218***	0.192***	0.174***	0.179***	0.172***	0.243***	0.238***
	(0.062)	(0.052)	(0.060)	(0.054)	(0.060)	(0.049)	(0.067)
Observations	14728	14728	14728	14728	14728	14728	14728
Construction of demand shock:							
Consumption:	0.5TEDS	1.5TEDS	Last year consumers	Last month consumers	Annual prev.	Annual prev. 2	Harm perc.
Seizures transit:	MEX	MEX	MEX	MEX	MEX	MEX	MEX
Seizure sources:	PERU BOL	PERU BOL	PERU BOL	PERU BOL	PERU BOL	PERU BOL	PERU BOL

Notes: The table presents estimates of the effect of the interaction between our external demand proxy and the suitability index, $s_m \times \ln D_t$, on the log of the homicide rate (top two panels) and coca revenue (bottom panels) in a municipality. In the second and fourth panels we include differential trends, $s_m \times t$, as controls. Each model uses a different construction of the external demand proxy by changing our initial choice of data required to construct it. The bottom rows indicate the exact choice of data used to construct the external demand proxy. All models include a full set of municipality fixed effects and year effects. Standard errors robust against heteroskedasticity and arbitrary correlation patterns within municipalities are presented below each estimate in parenthesis. Stars indicate significance in the usual way.

Table 7: Effect of demand shocks on homicides and coca revenue in municipalities with different suitabilities. Controls for fixed characteristics related to our suitability index and their influence over time.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Homicide rate. Controls for Covariates× Demand shock							
Suitability × Demand shock	0.105***	0.100**	0.126***	0.100***	0.126***	0.189***	0.072*	0.139***
	(0.035)	(0.042)	(0.040)	(0.038)	(0.038)	(0.034)	(0.041)	(0.047)
Observations	23100	22790	18540	21758	22790	22842	23100	18254
	Homicide rate. Controls for Covariates× Demand shock and Suitability × Year							
Suitability × Demand shock	0.084***	0.078**	0.105***	0.076**	0.104***	0.167***	0.052	0.116**
	(0.030)	(0.039)	(0.037)	(0.035)	(0.034)	(0.035)	(0.039)	(0.048)
Observations	23100	22790	18540	21758	22790	22842	23100	18254
	Coca revenue. Controls for Covariates× Demand shock							
Suitability × Demand shock	0.199***	0.237***	0.181***	0.184***	0.214***	0.209***	0.223***	0.199**
	(0.056)	(0.066)	(0.068)	(0.059)	(0.059)	(0.066)	(0.070)	(0.081)
Observations	14728	14518	11802	13860	14518	14560	14728	11620
	Coca revenue. Controls for Covariates× Demand shock and Suitability × Year							
Suitability × Demand shock	0.206***	0.244***	0.188***	0.192***	0.222***	0.216***	0.230***	0.206**
	(0.057)	(0.067)	(0.068)	(0.060)	(0.060)	(0.067)	(0.070)	(0.082)
Observations	14728	14518	11802	13860	14518	14560	14728	11620
Covariates:	None	Main products	State presence	Level of Dev.	Remote areas	Hist. violence	Region dummies	All

Notes: The table presents estimates of the effect of the interaction between our external demand proxy and the suitability index, $s_m \times \ln D_t$, on the log of the homicide rate (top two panels) and coca revenue (bottom panels) in a municipality. In the second and fourth panels we include differential trends, $s_m \times t$, as controls. In columns 2 to 8 we control for a full set of interactions between our external demand proxy, $\ln D_t$, and groups of fixed municipal characteristics described in the bottom row. All models include a full set of municipality fixed effects and year effects. Standard errors robust against heteroskedasticity and arbitrary correlation patterns within municipalities are presented below each estimate in parenthesis. Stars indicate significance in the usual way.

Table 8: Effect of demand shocks on homicides in municipalities with different suitabilities. Controls for changes in government enforcement and the deployment of Plan Colombia.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Suitability × Demand shock	0.100**	0.099***	0.081***	0.117**	0.113***	0.153**	0.121***
	(0.049)	(0.031)	(0.031)	(0.051)	(0.040)	(0.064)	(0.040)
Eradication campaigns	0.035***						
	(0.005)						
Drug related captures	0.108***						
	(0.013)						
Drug-related operations	0.091***						
	(0.019)						
Reinforcements during Uribe		0.354**					
		(0.142)					
Suitability × Aggregate enforcement			0.054*	0.006			
			(0.032)	(0.009)			
Military bases × Aggregate enforcement					-0.306***	-0.050***	-0.149**
					(0.060)	(0.016)	(0.068)
Army brigade × Aggregate enforcement					-0.028	-0.012	-0.007
					(0.054)	(0.014)	(0.057)
Police station × Aggregate enforcement					-0.302**	-0.026	-0.302**
					(0.148)	(0.034)	(0.149)
Observations	15755	19912	23100	19988	19268	16644	19268
Aggregate enforcement:			Plan Col.	Nat. Erad.	Plan Col	Nat Erad.	Demand Shock

Notes: The table presents estimates of the effect of the interaction between our external demand proxy and the suitability index, $s_m \times \ln D_t$, on the log of the homicide rate in a municipality. In columns 5 to 7 we add interactions between aggregate variables and the proximity to a military base or armed brigade, and a dummy for the presence of a police station. In column 5, we use a dummy for the Plan Colombia years (after 2000) as a proxy for aggregate enforcement. In column 6 we use the aggregate level of coca crops' eradication. Finally, in column 7 we use our external demand for cocaine, with the intuition that the government may be responding to changes in demand near its military deployments. The results controlling for differential trends by suitability are similar, and available upon request, as well as the effects on coca revenue. All models include a full set of municipality fixed effects and year effects. Standard errors robust against heteroskedasticity and arbitrary correlation patterns within municipalities are presented below each estimate in parenthesis. Stars indicate significance in the usual way.

Table 9: Heterogeneous effects of demand shocks on homicides and coca revenue in municipalities with different suitabilities depending on institutional quality.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Homicide rate.			
Suitability × Demand shock	0.119***	0.110***	0.107***	0.124***	0.075**	0.106***	0.115***
	(0.033)	(0.040)	(0.036)	(0.035)	(0.038)	(0.036)	(0.037)
State presence × Demand shock	-0.141***	-0.043	0.006	-0.089**	-0.155***	-0.147***	-0.075
	(0.051)	(0.036)	(0.043)	(0.035)	(0.033)	(0.047)	(0.050)
Suitability × State presence × Demand shock	-0.059	-0.022	-0.063	-0.041	0.050*	-0.033	0.007
	(0.048)	(0.039)	(0.054)	(0.032)	(0.028)	(0.062)	(0.051)
Observations	21186	18672	21098	21054	23100	22790	18254
				Homicide rate. Controls for Suitability × Year			
Suitability × Demand shock	0.095***	0.091**	0.083**	0.100***	0.054	0.084***	0.093***
	(0.029)	(0.036)	(0.032)	(0.031)	(0.034)	(0.032)	(0.032)
State presence × Demand shock	-0.141***	-0.043	0.007	-0.089**	-0.154***	-0.146***	-0.075
	(0.051)	(0.036)	(0.043)	(0.035)	(0.033)	(0.047)	(0.050)
Suitability × State presence × Demand shock	-0.060	-0.022	-0.065	-0.041	0.050*	-0.033	0.008
	(0.048)	(0.039)	(0.054)	(0.032)	(0.028)	(0.062)	(0.051)
Observations	21186	18672	21098	21054	23100	22790	18254
				Coca revenue.			
Suitability × Demand shock	0.207***	0.227***	0.191***	0.205***	0.227***	0.224***	0.213***
	(0.061)	(0.067)	(0.057)	(0.058)	(0.063)	(0.064)	(0.068)
State presence × Demand shock	-0.116***	-0.201**	0.014	-0.133**	-0.092	-0.141**	-0.103*
	(0.043)	(0.085)	(0.061)	(0.057)	(0.056)	(0.069)	(0.055)
Suitability × State presence × Demand shock	-0.087**	-0.071	-0.078	-0.100*	-0.128***	-0.246**	-0.047
	(0.036)	(0.078)	(0.056)	(0.054)	(0.044)	(0.108)	(0.045)
Observations	13496	11886	13440	13412	14728	14518	11620
				Coca revenue. Controls for Suitability × Year			
Suitability × Demand shock	0.216***	0.234***	0.201***	0.214***	0.235***	0.232***	0.220***
	(0.061)	(0.068)	(0.058)	(0.059)	(0.064)	(0.065)	(0.069)
State presence × Demand shock	-0.116***	-0.201**	0.014	-0.133**	-0.092	-0.141**	-0.103*
	(0.043)	(0.085)	(0.061)	(0.057)	(0.056)	(0.069)	(0.055)
Suitability × State presence × Demand shock	-0.087**	-0.071	-0.078	-0.100*	-0.128***	-0.246**	-0.047
	(0.036)	(0.078)	(0.056)	(0.054)	(0.044)	(0.108)	(0.045)
Observations	13496	11886	13440	13412	14728	14518	11620
Proxies of state presence:	Judicial	Military	Capacity	Public goods	Age	Proximity	All

Notes: The table presents estimates of the effect of the interaction between our external demand proxy and the suitability index, $s_m \times \ln D_t$, on the log of the homicide rate (top two panels) and coca revenue (bottom panels) in a municipality. In the second and fourth panels we include differential trends, $s_m \times t$, as controls. In each column we add an interaction between an indicator of institutional quality, I_m, and our variable of interest, $s_m \times \ln D_t$. The interaction between I_m and our demand measure is included but not reported to save space. We construct I_m as the principal component of several measures of institutional quality, divided in groups and described in the bottom row. All effects are evaluated at the mean. All models include a full set of municipality fixed effects and year effects. Standard errors robust against heteroskedasticity and arbitrary correlation patterns within municipalities are presented below each estimate in parenthesis. Stars indicate significance in the usual way.

Table 10: Effect of demand shocks for several agricultural commodities on homicides in municipalities with different suitabilities.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sugar cane suit. × International price	-0.025	0.001	-0.033				
	(0.032)	(0.032)	(0.032)				
Oil palm suit. × International price	0.034	0.023	-0.015				
	(0.034)	(0.033)	(0.031)				
Cocoa suit. × International price	0.064	0.037	-0.109***				
	(0.046)	(0.042)	(0.042)				
Pooled bundle × International price				0.021	-0.046***	0.037**	-0.044**
				(0.017)	(0.017)	(0.018)	(0.019)
Pooled bundle × International price × Institutional quality						-0.045**	-0.045**
						(0.022)	(0.022)
Coca suitability × Demand shock		0.106***	0.065**	0.108***	0.071**	0.122***	0.085***
		(0.035)	(0.031)	(0.035)	(0.031)	(0.037)	(0.033)
Coca suitability × Demand shock× Institutional quality						0.002	0.006
						(0.052)	(0.050)
Observations	24542	23100	23100	23100	23100	18254	18254
Controls for trends by suitability:	No	No	Yes	No	Yes	No	Yes

Notes: The table presents estimates of the effect of the interaction between our external demand proxy and the suitability index, $s_m \times \ln D_t$, on the log of the homicide rate in a municipality, and similar interactions for other crops, including sugar cane, palm trees and cocoa. In some columns we control for differential trends by crops' suitabilities, and this is communicated in the bottom row. In columns 4 to 7 we pool all legal commodities together. In columns 6 and 7 we add a triple interaction with a measure of institutional quality computed as the principal factor of all our measures of state presence and institutions. All models include a full set of municipality fixed effects and year effects. Standard errors robust against heteroskedasticity and arbitrary correlation patterns within municipalities are presented below each estimate in parenthesis. Stars indicate significance in the usual way.

Table 11: Effect of demand shocks on conflict-related outcomes in municipalities with different suitabilities.

	No trend				Controlling for differential trends			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: Violence by FARC and AUC							
Outcome:	AUC presence	FARC presence	AUC attacks	FARC attacks	AUC presence	FARC presence	AUC attacks	FARC attacks
Suitability × Demand shock	0.040***	0.036**	0.040***	0.036**	-0.011	0.041***	-0.011	0.041***
	(0.009)	(0.014)	(0.009)	(0.014)	(0.012)	(0.015)	(0.012)	(0.015)
Observations	16784	16784	16784	16784	16784	16784	16784	16784
	Panel B: Other conflict outcomes							
Outcome:	Total attacks	Forced displacement	Mil. incidents with mines	Civ incidents with mines	Total attacks	Forced displacement	Mil. incidents with mines	Civ incidents with mines
Suitability × Demand shock	0.196***	0.063	0.126***	0.053***	0.020	-0.041	0.106***	0.042***
	(0.068)	(0.057)	(0.022)	(0.014)	(0.090)	(0.055)	(0.020)	(0.012)
Observations	15422	13674	23079	23079	15422	13674	23079	23079
	Panel C: Violence unrelated to cocaine							
Outcome:	Kidnapps	Terrorism	Robberies	ELN actions	Kidnapps	Terrorism	Robberies	ELN actions
Suitability × Demand shock	-0.131***	-0.102***	-0.024	-0.016	-0.089*	-0.086**	-0.124***	0.006
	(0.047)	(0.035)	(0.043)	(0.023)	(0.051)	(0.037)	(0.046)	(0.023)
Observations	13676	11572	9468	16643	13676	11572	9468	16643

Notes: The table presents estimates of the effect of the interaction between our external demand proxy and the suitability index, $s_m \times \ln D_t$, on several conflict-related outcomes in a municipality. In the right panel we include differential trends, $s_m \times t$, as controls. All models include a full set of municipality fixed effects and year effects. Standard errors robust against heteroskedasticity and arbitrary correlation patterns within municipalities are presented below each estimate in parenthesis. Stars indicate significance in the usual way.

Table 12: 2SLS and OLS estimates of the effect of cocaine revenue in a municipality on homicides.

				Correcting for errors in variables		
	TS2SLS	2SLS	OLS	Long difs.	IV with lag	IV with erad.
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: Base model			
log of Cocaine Revenue in municipality	0.526**	0.423**	0.031***	0.080***	0.134***	0.204***
	(0.240)	(0.188)	(0.005)	(0.010)	(0.022)	(0.026)
Observations	23100	14684	15523	1061	13344	12227
F-statistic		12			152	156
			Panel B: Adds differential trends by suitability.			
log of Cocaine Revenue in municipality	0.408**	0.419**	0.032***	0.077***	0.144***	0.197***
	(0.193)	(0.183)	(0.005)	(0.010)	(0.025)	(0.026)
Observations	23100	14684	14684	1052	12580	11572
F-statistic		13			124	147

Notes: The table presents 2SLS and OLS estimates of the effect of the log of our measure of cocaine revenue on the log of the homicide rate in a municipality. In the second panel we include differential trends, $s_m \times t$, as controls. Column 1 presents a two-sample 2SLS estimator that exploits the reduced form over the whole 1990-2011 period. Column 2 presents the traditional 2SLS estimates. Column 3 presents traditional OLS estimates and column 4 presents a long difference estimator taking changes between 1994 and 2007. Columns 5 and 6 instrument the log of cocaine revenue using its lag or the log of eradication in a municipality. All models include a full set of municipality fixed effects and year effects. Standard errors robust against heteroskedasticity and arbitrary correlation patterns within municipalities are presented below each estimate in parenthesis. Stars indicate significance in the usual way.