Books and Bushes: Schooling Decisions and Coca Production in Colombia

Juan C. Angulo*

Abstract

This paper explores the relation between agricultural shocks in illegal crops and schooling decisions. I focus on the case of Colombia where coca leaf fields were increasing at an average annual rate of 25 percent. The country's main strategy to eradicate coca crops was aerial spraying of herbicide until 2015, when the policy was suspended. I exploit the removal of the policy and use it as an instrument for the presence of coca fields, which lead to a Difference-in-Differences strategy. However, I show that my setting does not meet all the assumptions to use the strategy but it fits those of Fuzzy Difference-in-Differences. My findings suggest that a one percent increase in the area cultivated with coca crops increases the high-school dropout rate by 0.3 standard deviations. This effect represents an increase of almost 30% relative to the 3.15% mean high-school dropout rate. On the other hand, I do not find a significant effect on the primary- or middle-school dropout rate. Moreover, among the high-school students that decide to stay in school, there is a decrease in the share of students that fulfill the requirement for their grade in areas with coca presence. I also find some evidence that mathematics test scores in primary-school improve in such areas. Finally, I rule out the possibility that coca presence affects the area cultivated or harvested of any other crop in the municipality. Taken together, I interpret these results as suggestive evidence that high school-age individuals are leaving school to work on coca related activities.

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*University of Maryland, Department of Agricultural and Resource Economics, 2200 Symons Hall, College Park, MD, 20742. E-mail: jcangulo@umd.edu.

1 Introduction

This paper explores the relation between agricultural shocks and schooling decisions. There are many papers that relate booms in legal markets with schooling decisions. Examples abound such as the coffee boom in Brazil, where poorer children were withdrawn from school.[1] Yet, there are less papers that relate booms in illegal markets with schooling decisions. In particular, there are just a handful of papers that related the presence of coca leaves with schooling decisions (Angrist and Kugler, 2008; Dammert, 2008; Sviatschi, 2018).

In this paper I look at the effect of coca crops presence on school participation. I focus on the case of Colombia where coca fields were increasing at an average annual rate of 25 percent, from 2013 to 2017. I take advantage of the 2015 suspension of aerial spraying of herbicide as a strategy to eradicate coca crops to test whether school-age individuals decide to remain in school. To do so, I first explore whether there is a significant change on school outcomes; in particular, I look at the effect of coca presence on enrollment and dropout rate. Then, I focus the attention on what happen to school-age individual that decide to remain and to leave school. I look at school attainment and school efficiency measures to document the changes in the patterns of individuals that decide to remain in school and, finally, I look at (legal) agricultural activities to shed light on whether the students that decide to leave the school due to the presence of coca crops are joining the legal labor market. I interpret these results as suggestive evidence that school-age individuals are leaving school to work on coca related activities as the higher dropout rates are present in areas with higher presence of coca fields, while there is no change in the presence of legal crops.

The ideal experiment would compare school outcomes in municipalities that are identical in all respects except exposure to coca fields. To approximate such an experimental ideal, I use municipal variation on the share of area cultivated with coca fields. I take advantage of the spike in the presence of coca fields starting 2013, which can be characterized as a boom in coca leaf production and whose production is labor intensive. Harvesting coca crops demands time and physical effort, but it does not require a different set of skills than the ones needed to harvest licit crops.[2] Either children or adults can work on the harvesting activities of coca where a plot is harvested a minimum of 4 times a year. Previous studies have related coca production with children and teenage work, both in Colombia (Angrist and Kugler, 2008; Rodríguez, 2020) and in Peru (Sviatschi, 2018).

[1] See for instance Kruger (2007).

[2] Note, coca leaf is the primary input in the production of cocaine. Turning coca leaves into coca paste and then into cocaine is less labor intensive and require from additional inputs, mostly chemicals.

As part of the 'war on drugs', the United States and the Colombian government launched *Plan Colombia* in late 1999, a policy-package aimed at reducing the country cocaine supply. The strategies implemented included the forced eradication of coca crops through the aerial spraying campaigns of herbicide. However, after the World Health Organization found that the active component of the herbicide sprayed (namely glyphosate) is "probably carcinogenic to humans," the Colombian government under the then-President Santos suspended the aerial spraying of coca fields in late 2015.

I use the suspension of the fumigation policy as an exogenous source of variation to empirically test the relation between the presence of coca crops and the schooling decisions. Spraying of herbicide only occurred in areas affected with coca presence yet not all the areas affected are indeed sprayed. Therefore, I look at exogenous variation in the policy using both cross-sectional and longitudinal variation. I calculate the share of area affected with coca presence in a given year, and I instrument it using a dummy variable for whether the area was fumigated or not in that year. Notice, the value of the dummy is 0 for all the areas after 2015 as the fumigation policy was suspended that year.

Intuitively, my instrument pick two consecutive periods and compare an area that was not sprayed with an area that was sprayed. Using the policy suspension I exploit the temporal variation as in a difference-in-differences framework. On the other hand, I exploit the cross-sectional variation as not all the areas with coca presence are sprayed which lead to a fuzzy design. Notice, spraying missions are centrally planned and administered by the Anti-Narcotic Police after aerial recognition of cultivated areas, then I can hardly claim that fumigation is random. Nonetheless, I present some evidence suggesting that the missions are determined by geographic rather than coca presence and therefore, I could assume that the spraying mission are decided quasi-randomly.

Both the temporal and cross-sectional variation lead to a difference-in-difference framework, however my setting differ from that of the 'classical' difference-in-differences so I borrow from the literature the Fuzzy Difference-in-Differences methodology (de Chaisemartin and D'Haultfœuille, 2017). First, there are areas were the government stop spraying before the suspension of the fumigation campaigns, which could be interpreted as staggered adoption of the 'treatment', and then the aerial spraying missions did not have a permanent effect as municipalities do not remain exposed to the treatment at all times afterwards; in particular, the effect of the fumigation last less than a year. These challenges are tackled by the fuzzy difference-in-difference design by comparing groups that adopt and remove the treatment while controlling for the timing of the adoption/removal of the policy.

In addition to the presence of coca and the eradication data, I use data from the Colombian Ministry of Education to test the effect of the presence of coca on school outcomes. Particularly, I use the dropout, enrollment, and retention rates in primary, middle, and high school, separately. Even though the outcomes come from individual decision, my treatment and data are at the municipal level. My results are consistent with the expected values of a negative effect of coca presence on school outcomes. I find that increasing presence of coca crops is significantly correlated with more students dropping out from high school, while I do not find any effect on the other grades nor in the enrollment rate. I find that on average dropout rate increases by 0.33 standard deviations in areas with presence of coca crops, which represent a decrease of almost 30% relative to the 3.15% mean high school dropout rate. In addition, I find that the retention rate decreases, although its magnitude is much smaller (0.1 percentage points).

I further explore school efficiency by looking at the performance of the students that decided to stay in school. To do this I use the grade pass, rate, and repetition rates in primary, middle, and high school as measures of school efficiency. My results suggests that the increasing presence of coca fields it has almost no effect on the students that remained in school, except for those in high school, where there is a negative effect on the grade pass rate. This means that students that did not drop out from school are not fulfilling the requirements of their grades. Moreover, I use information from the standardized tests—Saber5, Saber9, and Saber11 that students take at the end of primary, middle, and high school respectively—to asses the effect of coca presence on school attainment. I do not find any effect on the tests scores except for the mathematics component in primary school which present a positive effect. Even though this results is consistent with previous studies that show that students that remain in school tend to perform better, it is unexpected as there was no reported effect in primary school enrollment nor dropout.

Finally, to shed light on an outside option for the school-age students, I explore changes in the production of other legal crops. I use data on the area cultivated and harvested in each municipality, as well as its ratio. These measures allow me to test whether coca crops crowd out legal crops. My results suggests that the coca presence has no effect neither on the area sown nor in the area harvested, which implies that the agricultural labor market is in equilibrium. Since there is only change in the area cultivated with illegal crops and not on the area with legal ones, I interpret these results as suggestive evidence that, on the one hand, there is not a crowd out effect of the coca crops on the legal crops, and on the other hand, that school-age individuals that decide to drop out are working on coca related activities. Notice, I can not claim that this is in fact the case, as I do not have data to support it, but I can not rule it out either.

A limitation of my analysis is the level of aggregation of the school outcome variables. They are at the year-municipal level while the decision of enrolling or dropping out of school is at the individual level. Moreover, tests are also taken by individual students and the level of aggregation could mix top-performing schools with bottom-performing in the same municipality. Similarly, both the coca presence and the spraying data are at the year-municipal level, which do not allow me to capture short-term dynamics nor find a more precise effect. For instance, the presence of coca crops could increase at the end of the year and the student might dropout in the middle of it because families decide to migrate from the rural area to the urban area or to a different municipality. On the other hand, I can not distinguish the effect by grades, or within school levels, where the positive enrollment in one grade is averaged with the negative enrollment in another grade within the same school level.

This study connects with the literature considering the eradication of coca crops through aerial spraying. Some of these studies have found evidence of small but positive effects of the aerial spraying campaigns aimed at reducing coca cultivation (Abadie et al., 2015; Cote, 2019; Ibanez and Carlsson, 2010; Mejía et al., 2019, 2017; Reyes, 2014), although there is one study that suggests that an increase in forced eradication leads to an increase in the area cultivated (Reyes, 2014). Some studies have found that the presence of coca fields is related to children and teenager work, both in Colombia (Angrist and Kugler, 2008; Rodríguez, 2020) and in Peru (Sviatschi, 2018). Other studies have also related aerial spraying with more displacement (Espinosa, 2010), and with increasing number of medical consultations related to dermatological and respiratory illnesses, as well as the number of miscarriages (Camacho and Mejía, 2017)

On the other hand, this study contributes to the studies that explore the relation between exposure to illegal markets and education and labor decisions (Dammert, 2008; Dávalos and Dávalos, 2019; Ibáñez, 2010). There is one paper that exploits the boom in Colombian illegal gold mining, finding that school attendance decreases as well as the probability of child work increases (Santos, 2018). There are two papers that uses the presence of coca fields in Peru and relate it with child work and schooling decisions; one uses the shift of production from Peru to Colombia (Angrist and Kugler, 2008) while the other exploit the exposure to illegal labor markets (Sviatschi, 2018).

The studies closer to mine are those of Rodríguez (2020) and of Mejía et al. (2019). The former investigates the effect of the aerial spraying policy on education decisions using survey data in areas affected with coca presence; although, their study cover the period before the boom in coca fields. On the other hand, the latter study exploit the unintended consequences of a policy announcement where the coca growing farmers would receive incentives for voluntarily crop substitution. Their results suggests that the surge in coca fields is differentially higher in areas with presence of illegal armed groups.

To the best of my knowledge, this is the first paper that studies the consequences of the coca boom of the beginning of the 2010s. In addition, this is the first paper that studies the removal of the aerial spraying strategy and that uses the standardized test scores Saber 5 and Saber 9 to show heterogeneous effects of school attainment across grades while relating them to coca presence.

The rest of the paper is organized as follows. Section 2 provides some background on the Colombian case. Section 3 summarize the data sources and describe the research design. Section 4 describes the empirical strategy to estimate the effect of coca presence on school outcomes. Section 5 reports the main findings on school outcomes, school efficiency, and school attainment. Finally, Section 6 concludes.

2 Institutional Context and Background

2.1 Coca fields in Colombia

Coca leaf is the main component of cocaine, a powerful addictive drug whose mayor producer is Colombia with 70 percent of the world supply (Semana, 2019) and approximately 89 percent of the cocaine seized and subjected to laboratory analysis in the United States in 2019.[3] The main ingredient to produce cocaine is the cocaine alkaloid, a chemical compound that can be extracted from the leaves of coca plants. The coca plant is a native plant from Latin America and particularly from the Andean Region. It was grown in the Andes long before the arrival of European settlers. The leaves of the coca plant are chewed by local indigenous tribes even today in Bolivia and Peru, who use coca leaves in religious and social ceremonies (DIRAN, 2014; Mejía and Posada, 2008; Tobón, 2013).

Coca crops are a permanent or multi-annual crop, therefore the cost of producing coca leaves decreases over time. One hectare[4] (ha) of coca bushes produces on average 1,217 kg of fresh coca leaves per harvest. Each plot is harvested a minimum of 4 times a year and 4.6 times on average.

[3] https://www.state.gov/bureau-of-international-narcotics-and-law-enforcement-affairs-work-by-country/colombia-summary/.

[4] One hectare (ha) is equivalent to approximately 2.5 acres.

Between 1.1 and 1.4 grams of cocaine can be produced from 1 kg of coca leaf, which implies a production estimate between 5 and 6 kg of cocaine per hectare per year. Depending on multiple factors, such as the density of sowing, soil nutrients, the weather conditions, and the care of the plantation, it can present higher yields (DIRAN, 2014; Mejía and Posada, 2008).

Coca crops are labor intensive. Workers are needed for plow the earth, plantation, fumigation, and harvest, where the latter is the one that demands more work force (Dammert, 2008; Rodríguez, 2020). Harvesting demands time and physical effort, however it does not need a different set of skills than the ones needed to harvest licit crops, that is unskilled labor (Riley, 1993). One hectare of coca requires in sum 51 day's work and it can be harvested in 10 work's day. Around 122 kg of coca leaves can be harvested in one day (DIRAN, 2014). Previous studies have related coca production with children and teenager work, both in Colombia (Angrist and Kugler, 2008; Rodríguez, 2020) and in Peru (Sviatschi, 2018).

According to DIRAN (2014), the revenue from harvesting comes from the amount of kilograms one person harvest. The price for one kilogram of coca leaves is approximately $500 Colombian pesos (roughly[5] $0.16 US dollars), although the price varies between regions. For each hectare harvested in one day the revenue is $ 608,500 Colombian pesos (roughly $190 US dollars). The total revenue will depend on how much they can harvest and on how many kilograms of coca leaves they can carry. For a farmer harvesting its own plot, the National Police has estimated an income between 2 and 3 monthly minimum wages which is slightly above the region's median income. Moreover, Ibáñez (2010) suggests that farmers grow coca as there is no possibility of making a living from legal forms of agriculture.

Areas where there is presence of coca fields are less connected with the rest of the country, far from city centers, and with higher poverty levels. In particular, Dávalos and Dávalos (2019) find that extremely poor farmers are more likely to grow coca than non-poor farmers in the same area. Similarly, their study suggests that households with access to credit or receiving cash payments for their licit crops are less likely to grow coca. School coverage and quality in areas affected with coca crops are lower than other country regions (Espinosa, 2010; Zuleta, 2019). Even though the number of municipalities affected with coca presence has been declining over time, the ones that are still affected present more coca crops than before. For instance, 82 percent of the lots identified in 2018 had already been previously detected, sprayed or eradicated (UNODC, 2019).

[5] $1 US dollar is equivalent to $3,300 Colombian pesos using 2018 exchange rate.

Increase in coca fields and peace talks

In 2012, the government of Colombia and the FARC[6] guerrilla started dialogues with a five-point thematic agenda[7] to terminated a five-decade long internal conflict. In 2016, negotiators announced and signed the final agreement to end a five decade-long civil conflict. One of the points in the agenda included the problem of illicit crops, suggesting a non-trivial relation between the illicit crops and the FARC.

Figure 1 presents the dynamics of the coca crops in Colombia, showing an increasing trends since 2013, one year after the peace negotiation dialogue started. The area under coca bush cultivation went from 48,000 hectares in 2013 to 146,000 in 2016. Previous studies have suggested that the increase in coca cultivation was higher in municipalities where FARC had continuous presence during the peace dialogues (López et al., 2019; Mejía et al., 2019; Zuleta, 2019). However, the study by Mejía et al. (2019) presents evidence suggesting that the increase in the area cultivated with coca was an anticipation effect generated by the announcement made in 2014 of an agreement on the point of illicit drugs on the peace talks agenda. The parts agreed on an incentive policy for crop substitution aimed at reducing the area cultivated with coca by replacing it with licit crop. Notice that their evidence suggests that the increase in area cultivated comes from both increasing the plot size affected and from displacement to new plots.

2.2 Aerial spraying of coca fields

Colombia has aggressively pursued forced coca eradication to reduce the amount of land that households devote to illegal crops (Reyes, 2014). In 1999 an important change in Colombia's strategy toward the war on drugs took place. The *Plan Colombia*, a policy-package co-financed by the American and the Colombian governments, was launched with the goal of reducing 50 percent the cultivation over a period of six years. *Plan Colombia* strategy against coca crop cultivation, including aerial spraying, forced and manual eradication, although the main instrument used was the aerial spraying of herbicides over coca fields (Abadie et al., 2015; Zuleta, 2019). Colombia is the only country that allowed aerial spraying for counter-drug purposes (Isacson, 2019). According to Ibanez and Carlsson (2010), from 1997 to 2005, 5,200 millions US dollars were invested to reduce

[6] The Revolutionary Armed Forces of Colombia, FARC by its Spanish acronym, is a left-wing guerrilla founded in the mid 1960s.

[7] The peace negotiation took place mostly in Havana, Cuba, where the five-point thematic agenda included rural development, political participation, end of the conflict (ceasefire and surrender of weapons), illicit drugs, and victims.

cocaine production in Colombia.

The Colombian government through the Anti-Narcotic division (DIRAN by its Spanish acronym) of the National Police is in charge of the forced eradication using aerial spraying. The spraying events are administered and planned centrally by the Anti-Narcotic Police after aerial reconnaissance of cultivation areas. Eradication is made through small aircrafts spraying glyphosate, the active ingredient in the herbicide RoundUp (Isacson, 2019). Aerial spraying allows operating in remote and insecure areas where manual eradication is cost prohibitive or too dangerous (Abadie et al., 2015). Spraying aircrafts are protected and escorted by the National Police with armed helicopters to protect the fumigation planes from armed attacks from the ground. In the event of long flights where helicopters do no reach, missions are not canceled, but fumigation planes must go unprotected (Reyes, 2014).

According to Reyes (2014), there is a strong link between distance from an airport used for fumigation and the amount of coca eradication. The modified military planes (fumigation equipment instead of weapons) used for spraying are small aircrafts that can flight to every region of the country. The escorting helicopters from the police have a range of 80 miles from the airport. Beyond the 80-mile range, fumigation planes must go unprotected increasing the expected cost of eradication missions. The data for spraying campaigns is recorded by geo-coding devices that are built into the aircrafts used for the aerial spraying campaigns. Information on the location and number of hectares sprayed is recorded during the flight and then collected by the national authorities when the plane lands. These records include the exact date and time of the spraying event, the municipality of occurrence, the number of hectares sprayed, and the type of illicit crop sprayed.[8]

Effectiveness of the spraying

According to DIRAN, spraying is 90 percent effective.[9] A survival rate of a sprayed crop of 8.8 percent was used by SIMCI to estimate the area affected with coca fields presence (UNODC, 2017). The ideal conditions for the campaigns include no rain on the targeted fields from two hours before to four hours after the spraying. Once a coca field is sprayed, the land takes six to eight months to regenerate to a point in which coca can be grown again there. However, if it rains or if growers wash the crops immediately after the spraying, the effect of the spraying is mitigated and the land recovers much faster. These plots are likely to be re-sprayed. If done right, the herbicide can be

[8] For security reasons, due to the precision of the data, it is not available for public consultation.

[9] Personal communication with official from DIRAN, July 2019

"washed out" from plants, as long as this is done right after the spraying has taken place. Measures of coca cultivation are available only annually and are aggregated at the municipal level, therefore it is impossible to know for certain which fields are sprayed more than once.

In October 2015, the Colombian government, under then-President Santos, suspended the aerial spraying of coca crops after the World Health Organization literature review found that glyohosate is "probably carcinogenic to humans".This evidence holds for the case of Colombia, as suggested by Camacho and Mejía (2017) that documented the effect of the aerial spraying of herbicides (glyphosate) on short-term health related outcomes. After the suspension, Colombia's Constitutional Court (one of the three highest judicial review authorities) placed restrictions on any use of glyphosate from aircraft, but did not ban the practice (Isacson, 2019).

Previous studies have documented a small (or negligible) effect of the aerial spraying campaigns aimed at reducing coca cultivation (Abadie et al., 2015; Cote, 2019; Mejía et al., 2019, 2017; Reyes, 2014), and one has found that aerial spraying is not a cost-effective strategy to eradicate coca from a supply-reduction perspective (Mejía et al., 2017). Their results are contradictory to the survival rate reported by the police, however, it can be explained by the strategies adopted by coca growing farmers to mitigate the effects of the fumigation campaigns. In particular, they alternate coca with legal crops; reduce the plot size (UNODC, 2014); or reallocate the coca crops to areas less likely to be sprayed (Mejía et al., 2017), among others. Figure 1 presents suggestive evidence of this, as for various years during the 2010s the area eradicated by aerial spraying was larger than the previous year or the current year area affected.

2.3 Colombia's education system

Colombia's education system is regulated by the Ministry of Education (MEN by its Spanish acronym) however, the 32 *departamentos* are in charge of administering education in accordance with MEN's regulations.[10] It comprises 5 education levels: early education, preschool, primary, secondary, and tertiary (MEN, 2013). All children between five and fifteen years old are legally required to attend one year of preschool, 5 years of primary school, and 4 years of middle school (lower secondary education), the only compulsory levels, yet from 7 to 13 years is the age range at

[10]The *departamentos* are the equivalent to the USA States. Colombia is administratively divided into 32 *departamentos* plus the capital district of Bogotá, and each *departamento* is divided into municipalities. There are cases where a municipality is in charge of administering education. These administrative figures are called ETC and there are 95 in the country.

which over 90 percent of the school age population is enrolled (OECD, 2016). In order to access tertiary education, students must finish the 2 years of high school (upper secondary education) and take the SABER 11 standardized test.[11] Children usually enroll into preschool (grade 0) at age 5 and require 12 consecutive years of schooling to finish high school, at age 17.

According to MEN (nd), using data from 2009, the dropout rate vary across the country, from 2.19% in Bogotá to a 14.09% in Guanía, where the national dropout rate is 5.15%. Similarly, the dropout rate also vary across grades, where the higher rates are presented at higher grades. In 2014, 87 percent of the schools in Colombia were public and out of those, 78 percent were located in rural areas (OECD, 2016). Both the dropout and enrollment rates in urban areas outperform the ones in the rural areas. For instance, the percentage of students who remain enrolled in grade 11 in the rural area is 48%, while for the urban area is 82%. Figure 2 shows this percentage for the two areas and the 11 school grades using data from 2008. The average education years in 2016 was 5.5 years in the rural area and 9.6 years in the urban area (Hernández, 2018).

Notice that the presence of illegal crops in the territory has had an impact on education. The school coverage and quality are lower in areas where there is presence of coca relative to other country regions (Zuleta, 2019). Therefore, the presence of such illegal crops is associated with more children joining the labor force and leaving school (Hamdan, 2013; Rodríguez, 2020). The children that join the labor force in coca-related activities are payed by work's day and by the amount of coca leaves they can harvest and carry (DIRAN, 2014). Because of this it is common for the children to skip school during harvesting time in certain regions of the country (Forero, 2019). Nonetheless, according to a recent survey among farmers in the voluntarily substitution program, the farmers who grow coca use the revenue to invest in their children education. As noted above, the revenue made by these farmers is more profitable than cultivating legal crops, but it is as high as the region's median income (DIRAN, 2014).

On the other hand, education is affected by the civil conflict related to areas with coca production. For instance, Mejía and Restrepo (2013) document the effect of illegal cocaine markets on violence while Angrist and Kugler (2008) show that the rural areas that saw accelerated coca production subsequently became considerable more violent. The nearly five-decade long internal conflict also had an impact on education. Different studies have found that the presence of armed groups

[11]The SABER 11 test is administered prior to graduation in Colombian high schools (grade 11th). It is similar to the SAT in the United States but it is administered by the government through the Colombian Institute for the Promotion of Higher Education, ICFES by its Spanish acronym, a organization that manages and evaluates the education and Institutes in the country.

and the exposure to violence is associated with early school dropouts (Rodríguez and Sánchez, 2012; Vargas et al., 2014), with lower academic achievement (Rodríguez and Sánchez, 2010), and with children entering the labor market at early ages (Angrist and Kugler, 2008; Rodríguez and Sánchez, 2012; Rodríguez, 2020). Furthermore, there is one study that documents a positive effect of conflict termination, using the ceasefire declared by FARC during peace negotiations, on educational outcomes (Namen et al., 2019).

3 Data and Research Design

3.1 Data

I build a municipality-year level panel data to study the effect of coca presence on school participation. In particular, I use the boom in the area affected with coca crops to study its effect on school dropout, enrollment, and retention. I focus on the period from 2012 to 2017, during the President Santos term only, who initiated peace negotiations with FARC guerrilla in 2012. Notice that the period of the peace process overlaps with that of constant growth of the area effected with coca bushes, and contains the year of the suspension of the aerial spraying strategy (see Figure 1).[12] My sample consist of all 1,120 municipalities of Colombia, except for the 2 island municipalities that form the departamento of San Andrés, Providencia and Santa Catalina.[13] I describe the main variables and the data sources below.

3.1.1 Education data

The main dependent variables are school-related outcomes that come from the MEN. This data has information aggregated at the municipal level each year over the period 2012-2017. It has the enrollment, dropout, grade pass, grade fail, and grade repetition rates for primary, middle and high school, separately. Note that, students enrolled either pass, fail, or dropout, and among those that

[12]It is important to take into account the complex dynamics of the peace negotiations, such as the 2014 ceasefire, which have an impact on the dropout rate, as suggested by Namen et al. (2019). Furthermore, a previous study by Rodríguez (2020) analyses the effects of aerial spraying on education decisions limiting her study period to 2012 to avoid the dynamics of the peace negotiations. In addition, Mejía et al. (2019) and López et al. (2019) suggest that the growth of the area affected with coca was a results of the announcement of the incentives for coca growing producers during the peace talks, with differential effects in FARC-controlled municipalities.

[13]The state of San Andrés, Providencia and Santa Catalina is located in the Caribbean Sea, approximately 482 miles northwest of mainland Colombia. I drop them from the sample due to their location and because the presence of coca crops is not monitored.

fail, some students repeat the grade while other also dropout or change of school. My analysis is focused on the enrollment, dropout, and retention rates. A limitation, however, is that it does not have an attendance variable that captures short term dynamics of students and it does not have information on neither households' nor students' migration decisions to study. It is important to clarify that, even though the outcome comes from a decision from the individual, my treatment and data is at the municipal level.

The dropout rate captures yearly dynamics as it is measured as the share of students that leave school at any point during the academic year relative to the initial enrollment. Under this methodology, for instance, a student that changes school during the academic year will be counted as if she has dropped school. On the other hand, the enrollment rate is measured as the number of students of an age group that enrolled school at the beginning of the academic year relative to the size of the population of that age group (MEN, 2013). Notice that the latter rate can take values greater than one because of overage students outside the reference age group or student attending school from neighboring municipality. It is not possible to distinguish between these two however, the latter is more likely to happen in more urban municipalities where students from surrounding areas come to study, while the former is more likely to happen in the more rural municipalities as the access to school is more limited (Forero, 2019).[14] The grade pass and grade fail rates capture the share of students that fulfill the academic requirements of their grade, and the ones that do not fulfill them, respectively. These two rates are aggregated into the retention rate that speaks of the share of students that did not dropout from school. The grade repetition is a efficiency measure and it reports the share of students that have to repeat or go through an academic grade again (MEN, 2013).

3.1.2 Illegal crops and spraying data

Data on illicit crops comes from the Integrated Monitoring System of Illicit Crops (SIMCI by its Spanish acronym) of the United Nations Office on Drugs and Crime (UNODC). It has information on the municipal area (measured in hectares) cultivated with coca bushes each year over the period 2001-2018.[15] SIMCI is a satellite-based monitoring system that uses imagery of the entire territory of Colombia's mainland to estimate the extension of the coca crops annually, as of December 31 of

[14] The rural areas of Colombia have flexible schools known as *Escuela Nueva* or "New School". This program encourage students to come back to school where children of various ages and grade levels work in small groups (Hamdan, 2013).

[15] Data availability goes back to 1999, although starting 2001 the data evaluates the entirety of the country.

each year. 70 percent of the satellite images are obtained within two months range (two months before or after the cut-off date), while of the remaining 30 percent, about half is obtained from August to November of the estimate year, and half between March and April of the following year (Abadie et al., 2015). Coca plot identification is based on visual interpretation of satellite images, including three stages: (1) preliminary visual interpretation includes an analysis of the historical coca series and georeferenced photographs taken in overflights by the National Police, (2) verification overflights based on visual inspection from an aircraft on the territories affected by coca crops, and (3) edition using the verification overflights information to adjust the preliminary interpretation (UNODC, 2017). Note that, using this methodology, an area that was affected during a particular year can be reported as not having coca if eradication was effective in the territory.[16]

Reports on illicit crops eradicated using aerial spraying are produced by DIRAN reporting the area of illicit crops sprayed by the National Police. This information is available from 1999 to 2015, when aerial spraying was suspended. Note, multiple spraying of the same area is possible; furthermore, the reported area eradicated by aerial spraying in a given year could be larger than the area cultivated in the same year. This can happen due to both replanting and plant protection (Abadie et al., 2015). The aerial spraying of coca crops was the most important strategy during the *Plan Colombia* however, it was less used in its last years. This can be seen in Figure 1 that shows the area eradicated by aerial spraying present a downward trend since 2006 until its suspension in 2015. There is no information on what municipalities were sprayed or how many times, however following the previous discussion on effectiveness, I assume that all the municipalities that report positive values of eradication in a given year were sprayed in that year. Using this definition, it exists the possibility of labeling some areas as "non-sprayed" where in fact those areas were sprayed. However, had this be the case, the impact of the intervention would be effective.

3.2 Evaluation design

The ideal experiment would compare school outcomes in municipalities that are identical in all respects except exposure to coca fields. To approximate such an experimental ideal I use municipality-level variation on the share of area affected with coca fields. However, the municipalities that have presence of coca bushes could be systematically different the ones that do not have such presence leading to a selection bias problem.

[16] Abadie et al. (2015) discuss the advantages of using this methodology relative to alternative ways of measuring coca cultivation at the municipal level.

I take advantage of the increasing trend in coca cultivation and use the exposure to aerial spraying of herbicide as a source of exogenous variation. Notice that only some of the areas affected with coca presence are sprayed. The areas sprayed are dynamically determined by changes over time and over municipalities, although they present a persistent location pattern (UNODC, 2017, 2019). Figure 3 and Figure 4 show this pattern using 3-years of data. The implementation of the policy—the removal of the aerial spraying—can be seen in panel (d) of Figure 4 where any of the municipalities is shown to be sprayed, even though there were still areas affected with coca. Notice that the areas affected are persistent in time, but it is important to highlight that this figures do not allow me to separate whether the existing fields affected were increasing in plot size or moving within the municipality.[17]

I exploit the temporal variation created by the suspension of the aerial spraying strategy in 2015 to instrument the presence of coca crops. Furthermore, I use the cross-sectional variation of the fumigation strategy as not all the municipalities affected with coca presence are effectively sprayed. Notice, spraying missions are administered and centrally planned, then I can hardly claim that fumigation is random; however, if the missions take place in an area where there is coca presence and all areas are equally accessible, then I can test whether the probability of spraying is given by the presence of coca crops and by geographic characteristics.

To determine the probability of a municipality being sprayed, I use geographic characteristics at the municipal level that help explain the presence of coca crops (Acevedo and Bornacelly, 2014; Mejía and Restrepo, 2013), and information on the area cultivated. Notice that the former set of characteristics do not vary over time while the share of area cultivated does vary. Assuming, for simplicity, that I define an area as fumigated as

$$D_{mt} = \mathbb{1}\{Spray_{mt} > 0\}$$

where $\mathbb{1}\{\cdot\}$ is the treatment indicator function and D is an indicator variable that takes the value of 1 when the municipality m in year t reports a positive area eradicated through an aerial spraying mission, $Spray_{mt}$; and 0 otherwise. Then, I estimate the following linear probability model

$$D_{mt} = \beta coca_{mt} + X_m\delta + e_{mt} \tag{3.1}$$

where $coca_{mt}$ is a measure of coca presence in municipality m and year t normalized by the area

[17] Mejía et al. (2019) findings suggest that the increase in coca fields comes from a growth in pre-existing plots as well as in plots detached from pre-existing ones.

of the municipality, and X_m is a vector of geographical characteristics that do not vary over time. In particular, it includes the distance to the closest airport from where spraying missions depart, the number of airport within the 80 miles radius, the distance to the Department's capital and closest market, the share of rural population and area, and the characteristics used to create the coca suitability index (Mejía and Restrepo, 2013).

Table 1 report the estimates. Column (1) presents the results using the full sample of municipalities showing a positive relation between the presence of coca crops and the probability of spraying as well as a very small relation with some geographic characteristics. However, further examination of the data revealed that this results is driven mainly by the municipalities that do not have coca crops and are not sprayed. Column (2) results explore the results only for the subset of municipalities that have been sprayed at least one time, ruling out the ones that either do not have presence of coca or have never been sprayed for other reasons. Interestingly, the results suggests that the share of area cultivated marginally and negatively explains the probability of the spraying mission. Furthermore, some of the geographic conditions explain the probability. For instance, the distance to the principal market and to Department's capital is positively estimated as expected as coca is grown in more remote areas. In addition, water disposability—which captures areas with more precipitation—is also positively correlated with the probability of spraying. This result is less expected as spraying missions need to have 'optimal' weather conditions that includes less rain so as the glyphosate is not wash out from the crops, but on the other hand, more rains could affect positively the production of the crop (Rodríguez, 2020). Finally, the soil erosion and elevation are negatively correlated with the probability, which is unexpected as these two characteristics are related to the presence of coca crops (Mejía and Restrepo, 2013).

Columns (3), (4), and (5) further explore the dynamics of the spraying campaigns on the municipalities that have been sprayed. Since spraying campaigns could be decided the prior year based on the information available at the time, the results of Column (3) include the lagged value of the cultivated area while those of Column (4) include both the contemporaneous and the lagged values of the cultivated area. These two results go in line suggesting no relation. Finally, in Column (5) instead of the current and the lagged value, I include the variation between to two as the government could focus on the areas that present a higher increase. Similarly to previous results, there seems to be no relation between the presence of coca and the spraying campaigns except for the growth in area cultivated (Column (5)) that presents a negative relation but marginally significant. I take these results as suggesting evidence that the decision to spray is quasi-randomly determined based on observable geographic characteristics and not decided deterministically.

4 Empirical strategy

To uncover the relation between coca presence and school participation, I am interested in the following relation

$$school_{mt} = \alpha_m + \beta coca_{mt} + \varepsilon_{mt} \tag{4.1}$$

however, the estimates will be biased given that the presence of coca fields is not random. To tackle this, I use the aerial spraying missions of coca fields and their suspension in 2015 as a source of exogenous variation. The unexpected announcement allows me to exploit the longitudinal variation; while the quasi-randomness of the spraying missions, the cross-sectional variation. Formally, this relation can be written as

$$coca_{mt} = \tau_m + \gamma \left(spray_{mt} \times \mathbb{1}[t > 2015] \right) + \upsilon_{mt} \tag{4.2}$$

which lead to a difference-in-difference framework. However, notice my setting differs from that of the 'classical' difference-in-difference so I borrow from the literature the Fuzzy Difference-in-Difference methodology (de Chaisemartin and D'Haultfœuille, 2017) that allows me to include the fuzzy design by comparing groups that adopt and remove the treatment while controlling for the timing of the adoption/removal of the policy, and to recover the Wald estimand of the difference-in-difference.

This comparison deal with (*i*) the staggered adoption of the treatment—in the sense of Athey and Imbens (2018); Callaway and Sant'Anna (2019)—as there were some municipalities that had been sprayed in the past but were not being sprayed before 2015. It relaxes the assumption of units exposed to treatment remain treated thereafter as (*ii*) fumigation has no permanent effect given than a coca field that was sprayed takes six to eight months to regenerate to a point in which coca can be grown again. This implies that municipalities switch from being sprayed one year to not sprayed the next one (or vice versa); moreover, (*iii*) part of the fuzzy design comes because not of all the areas affected with coca presence are being sprayed every year and some areas being sprayed report zero area affected due to the effectiveness of the fumigation, i.e. they report control areas as being treated. Finally, (*iv*) the control group before 2015, the year the fumigation strategy is suspended, is comprised of municipalities that are not being sprayed so it is possible to interpret them as being 'treated.'

The last point is counter intuitive in two sense: first, it is easier to understand the 'treatment' as being fumigated instead of suspending fumigation. Second, labeling as treated the municipalities that are not being sprayed will create before the suspension a treated and a control group and two treated groups after the suspension, which is not the standard presentation of a difference-in-difference. I re-label as treated those municipalities that are being sprayed and as control those not being sprayed, making this setting a reverse difference-in-difference where I will be exploiting the 'adoption' of the fumigation strategy. Notice that this is more intuitive and pose no challenges to the estimation procedure but will present the estimates with the sign flipped and therefore the coefficients should be interpreted accordingly (Kim and Lee, 2019). Finally, the fuzzy difference-in-difference allows to recover the Wald estimand of the difference-in-difference with the sign pointing in the correct direction of the effect.

To simplify, I label as treated those municipalities that reported positive eradication through an aerial spraying. So the dummy variable D_{mt} that indicates fumigation also serves as my treatment indication variable. Additionally, given that the probability of being sprayed does not change with the presence of coca fields, as Table 1 results suggests, then one could think of spraying missions as the excluded instrument of an IV regression. Then, de Chaisemartin and D'Haultfœuille (2017) shows that the Fuzzy Difference-in-Difference recover the Wald-DID estimand defined by $W_{DID} = DID_Y/DID_D$, where for any random variable R_{GT} that belong to the treatment group G and period T

$$DID_R = E(R_{11}) - E(R_{10}) - (E(R_{01}) - E(R_{00}))$$

based on pair-wise comparisons of the switchers. Notice, under certain conditions, the previous expression recover the weighted difference between the LATEs of treatment and control group switchers. I use the stata package `fuzzydid` (de Chaisemartin et al., 2019) to recover and present the Wald estimands, where standard errors are bootstrapped and allowed to be correlated across time for the same municipality in all regressions (Abadie et al., 2017).

Intuitively, I expect the suspension of the aerial spraying to reduce the uncertainty of coca growing farmers and then increase the production of coca leaves. At its turn, this increase in production should lead to an increase in the demand for unskilled labor force. This excess in demand is accompanied by an increase in the labor supply through more children joining the labor force, specially from the upper grade level. This implies that I expect a negative sign for the enrollment and retention rates and a positive sign for the dropout rates.

5 Results

5.1 Coca presence and school outcomes

Table 2 presents the Wald estimate for the main outcome variables using the Fuzzy Difference-in-Differences strategy and the Stata package `fuzzydid`. Each column of the table uses a different outcome and it is reported in the column header. The outcome variables are standardized to have zero mean and unit variance in the sample. As expected, the estimates for dropout rate for the three school levels are positive and for enrollment rates are negative, although only the high school dropout rate is the only estimate statistically different from zero at the 5 percent level. This results goes in line with the idea that teenage students are more likely to join the labor force in areas sprayed (Rodríguez, 2020). In particular, a one percent increase in the area affected with coca crops cause an increase in 0.3 standard deviations in high-school dropout rate. This implies that, on average, the high school dropout out rate increase by almost 0.9 percentage points. Given that the average rate is 3.15, this results suggest an effect of an increase in almost 30%.

On the other hand, the results in the retention rate are the complement to those of dropout rate but they need not to be exact opposites. As in the case of the dropout rate, both retention rates for primary and middle school are not statistically different from zero, while the one for high school is statistically significant at the 5 percent. In terms of size, they are much smaller with only a decrease in about 0.1 percentage point, however given that the students that remain in school are the ones that either fail or pass the academic year, the results are less obvious. I further explore these results in section 5.2.

5.2 Retention rate and school efficiency

In this section I explore the retention rate as it speaks about academic achievement. Recall that the retention rate is calculated as the share of students who do not dropout from school but finish the academic year either fulfilling the academic requirement of their grade (pass) or not fulfilling them (fail). Finally, among those who do not fulfill the requirements, there exist those who have to repeat the grade by academic reasons. This is a concern in Colombia's education system as the proportion of grade repeaters of 15-years-old having to repeat at least one year is

41 percent (OECD, 2016). A possible explanation for the low academic performance of students is that they skip school, for instance, during harvesting time. Note that, had the students decide to skip school, their academic achievement would be affected. Therefore, the share of students who fulfill the academic requirements will decrease, and the share of students who do not fulfill them will increase. The expected sign for the grade repetition rate is not obvious because students who fail a grade might have incentives to retire themselves from the education system, and not to repeat the academic grade. However, if this is not the case, the expected increase in the share of students that fail might lead to more students repeating a grade.

I follow the same empirical strategy using as outcomes the school efficiency measures, i.e. grade pass, grade fail, and grade repetition rates, and report the results in Table 3. Note that all the estimates are statistically not different than zero, except for the high school grade pass rate that present a negative sign and significance only at the 10 percent. This result is expected for primary and middle school as the presence of coca fields seems to not be related to students leaving school. In addition, the students that are not dropping out are performing worse than they counterparts in places without coca presence. Therefore, this results goes in line with the hypothesis that students miss school during harvesting seasons although they do not dropout school completely. Yet, there is no finer data to test this hypothesis.

5.3 School attainment

Data on school attainment come from the ICFES, a Colombian governmental agency in charge of measuring the quality of education. I am using information on the high school exit standardized test (namely, Saber 11),and from the end of primary and middle school test (Saber 5 and Saber 9, respectively). These exams are used to measure the quality of the education institutions and the high school exit exam is also used by the students to access higher education. The data cover the period 2012-2017, however due to comparability of test, the year 2012 and 2013 results for Saber 11 are excluded from the sample. Outcomes are standardize to have zero mean and unit variance in the sample.

I use the same strategy using the test scores averaged at the municipal level as outcome and present the results in Table 4 for the mathematics and language components of the Saber 5, 9, and 11 exams. Surprisingly, most of the estimates are not different than zero, except for the mathematic results in primary school students. The results suggests that students that stayed in primary school perform better. This idea goes in line with the opportunity cost of students staying in school and with heterogeneity of unobserved preferences. That is, students that decide to stay in school are those whose opportunity cost of leave is higher because they are potentially better students, but also they are receiving a more personalized education.[18] Nonetheless, given that there are no more students dropping out from school, as the previous results showed, this is somewhat surprising. The rest of the coefficients present a positive point estimate, which is consistent with the hypothesis, except for the high school language exam. The point estimate does not have the expected sign, although it is not statistically different than zero. Note that this results might be driven by other factors like the presence of civil conflict, as suggested by Rodríguez and Sánchez (2010). The relation between presence of coca fields and civil conflict has been proven in previous studies, as well as the relation between civil conflict and school attainment. However, if this were the case, then the presence of both coca crops and civil conflict should have a bigger impact on test scores as both effects go in the same direction.

5.4 Legal crops

So far, my results suggests that there are larger dropout rates among school-age students in the areas that are more affected by coca fields, in particular for high-school students. Similarly, these students are also not fulfilling the requirement to advance to their subsequent grade yet, those that finish high-school have not differential effects on their exit exam. There is no evidence that students are joining the labor market or coca related activities. Since school-age students may have more difficulties joining the formal labor market, I can explore whether there are changes in the production of other agricultural crops.

I shed light on this mechanism by using data from the Ministry of Agriculture, gathered by Universidad de los Andes (Acevedo and Bornacelly, 2014), that report for a variety of agricultural products that area devoted to sown and the area harvested. Using this two measures, I create the ratio of area sown to area harvested to explore the possibility that there are less crops being harvested relative to what is sown. In addition, I calculate the share of area sown and harvested relative to the municipality area to explore the possibility independently as the presence of coca crops could be affecting both variables. These measures will allow me to test whether there is a crowd out effect of the coca crops on the legal crops.

I use the same strategy as before and report the estimates in Table 5. My results suggests that the presence of coca crops have no effect on the legal crops, neither in the area sown nor in the area

[18] Vargas et al. (2014) found a similar results using the municipalities in Colombia that faced civil conflict.

harvested meaning that there is no crowd out effect. In addition, one could interpret these results as the agricultural labor market being in equilibrium despite the coca surge, i.e. the coca crops are not replacing the legal crops and the labor force is fully allocated. If this were the case, it opens the possibility to school-age students to fill the excess in labor demand on coca-related activities. Overall, these results go in line with the hypothesis that school-age students are joining the labor force to work on coca related activities (Rodríguez, 2020; Sviatschi, 2018). However, I can not claim that this is in fact the case, as I do not have data to support it, but I can not rule it out either.

6 Conclusion

This paper provide evidence that school-age students exposure to agricultural shocks lead to less human capital accumulation. I focus on the case of the illegal market of coca leaves, the primary input in cocaine production. I use the case of Colombia as it carry out missions where coca fields are aerially sprayed with herbicide as part strategy to force eradicate coca crops. I exploit the suspension of the aerial spraying campaigns in 2015 to empirically test my hypothesis. This suspension lead me to an instrumental variable difference-in-difference setting. However, since not all the assumption where met, I borrow from the literature the Fuzzy Difference-in-Differences methodology to tackle the challenges in the assumptions.

I find that the increasing presence of coca crops is associated with more students dropping out of high school, while I do not find any effect on the other grades nor in the enrollment rate. My results also suggests that high school students are less likely to fulfill the requirement to advance to the next grade. Finally, I explore school attainment and find that only primary school students mathematics test score is positively affected, a results consistent with previous studies. I rule out the possibility that school-age students are dropping school for working in legal agricultural activities which—along the other results— I interpret as suggestive evidence that school-age students that drop out from school are working in coca related activities.

Overall , this paper provide an additional step at understanding the role of illegal markets in schooling decisions and school efficiency in the presence of external shocks.

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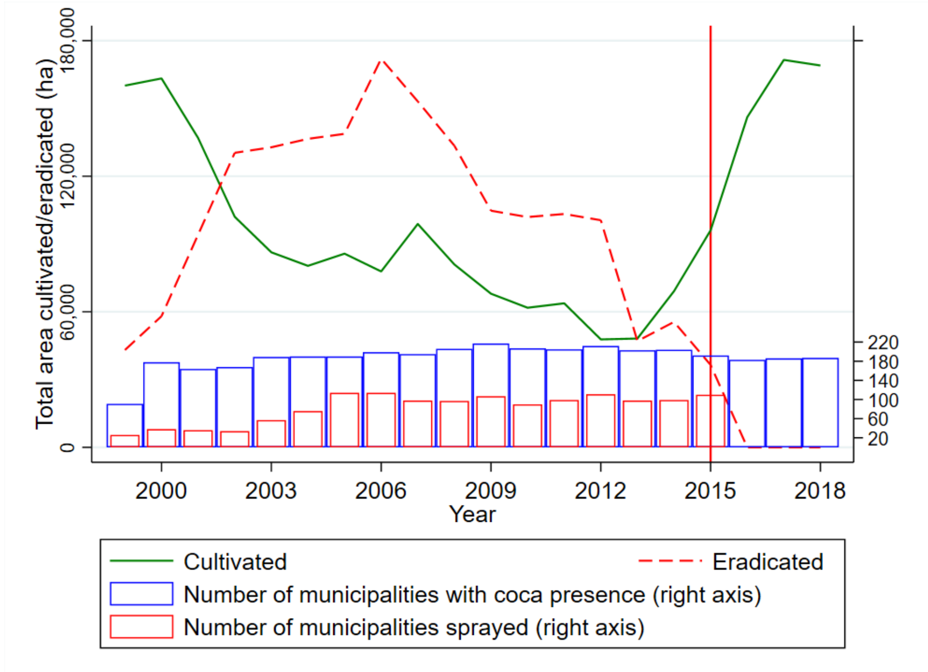
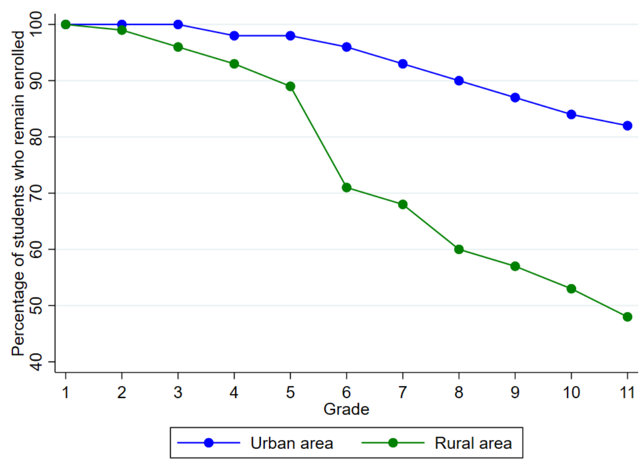
Figure 1: Dynamics of the coca cultivation and eradication in Colombia, 1999-2018



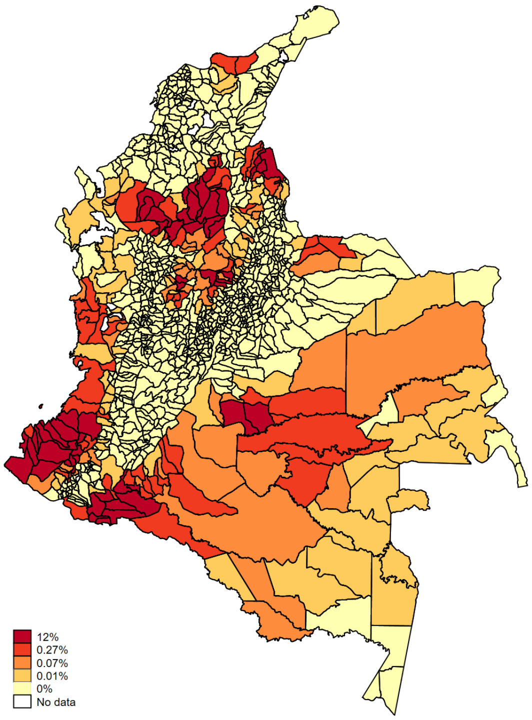
Note: Data from UNODC-SIMCI and DIRAN. Over the period, there has been 327 municipalities that have had presence of coca at least in one year, and 235 that have been sprayed at least once. There are 208 that have had presence of coca and have been sprayed at least once. The total area in hectares is reported in the left axis, while the number of municipalities affected and sprayed is reported in the right axis.

Figure 2: Percentage of students who remain enrolled by grade

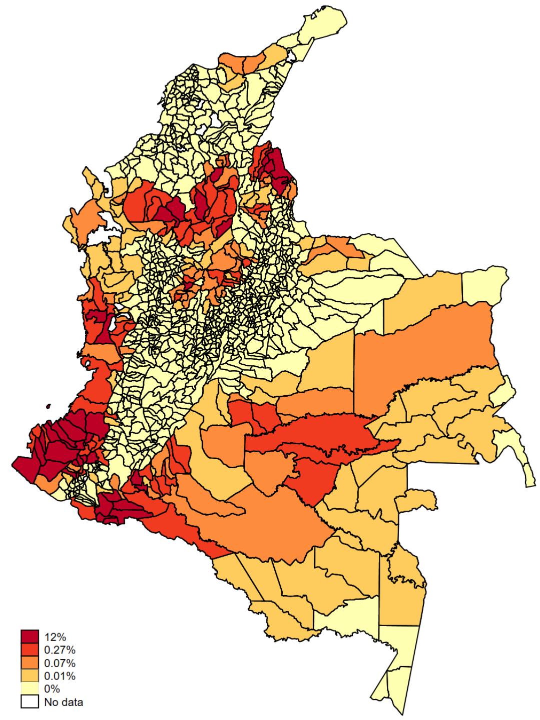


Source: Taken from MEN (nd). Data from 2008 Quality of Life Survey.

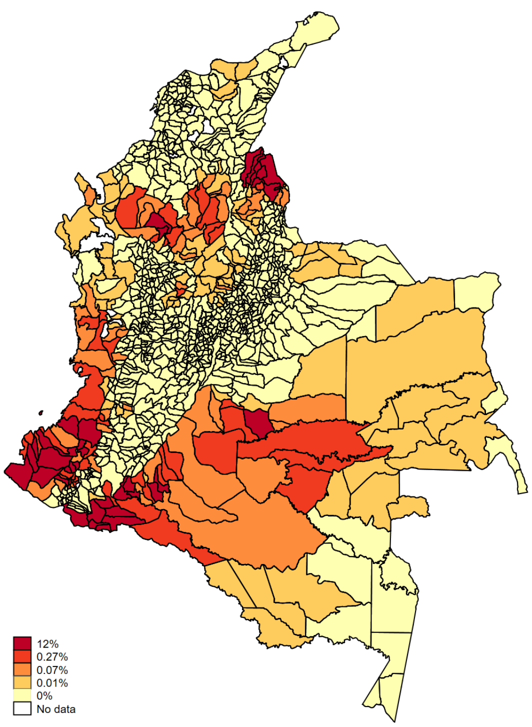
Figure 3: Areas affected by coca presence, 2007-2018



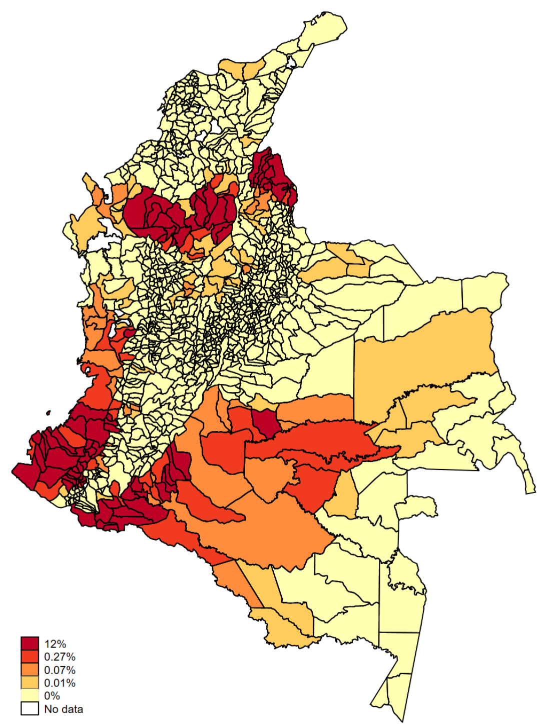
(a) 2007 to 2009



(b) 2010 to 2012



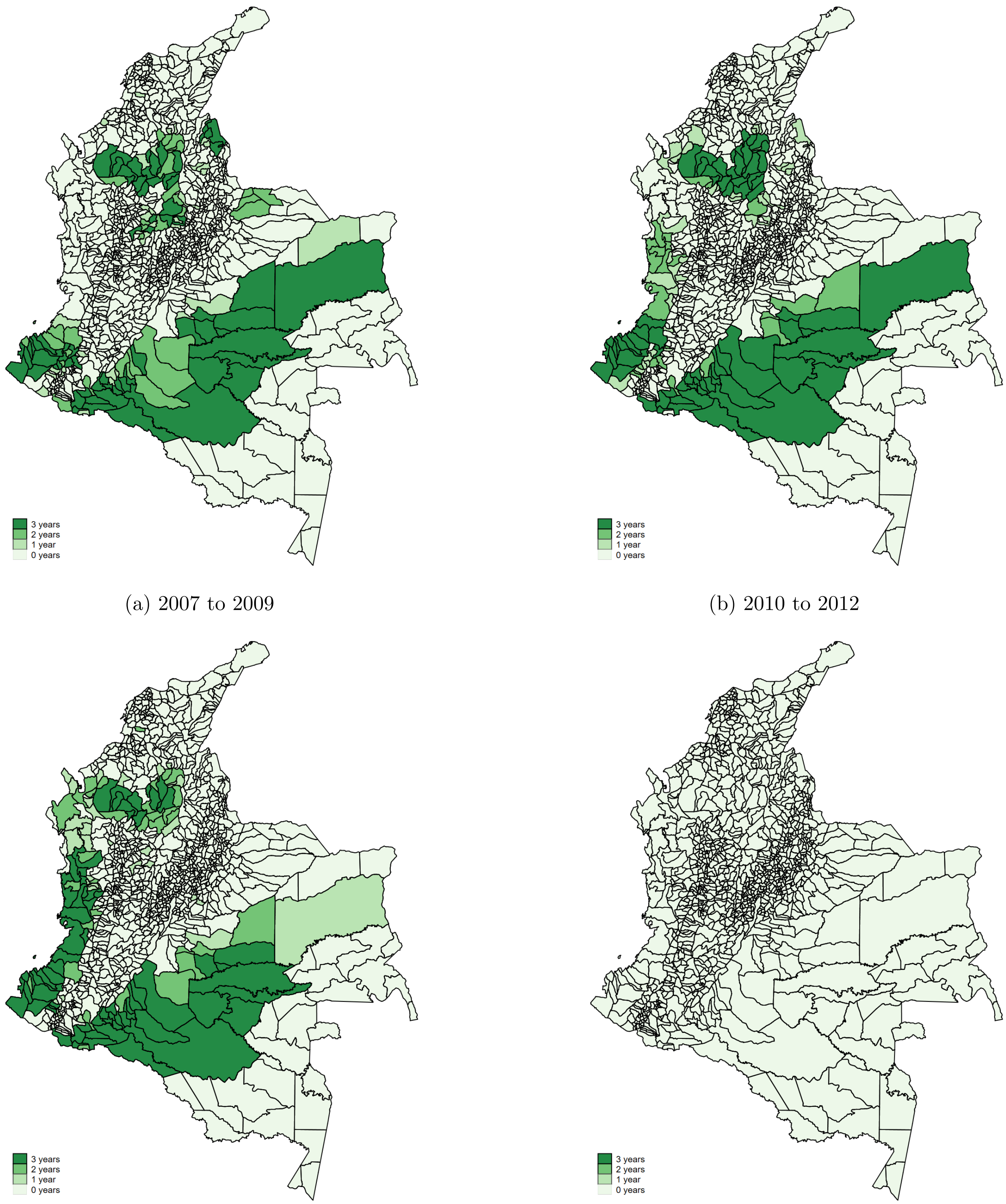
(c) 2013 to 2015



(d) 2016 to 2018

Note: Data from UNODC-SIMCI. The area affected is measured as the share of area with presence of coca crops, relative to the total area of the municipality. Panels (a) to (d) show the three-years average of the area affected from 2007 to 2018 using the same scale. Darker areas represent more affected municipalities.

Figure 4: Territories sprayed, 2007-2018



(a) 2007 to 2009

(b) 2010 to 2012

(c) 2013 to 2015

(d) 2016 to 2018

Note: Data from DIRAN. A municipality is considered sprayed if the area eradicated by aerial spraying is positive. Panels (a) to (d) show the three-years sum of the area affected from 2007 to 2018. Darker areas represent municipalities that were sprayed more times.

Table 1: Probability of sparying

VARIABLES	(1) Prob=1	(2) Prob=1	(3) Prob=1	(4) Prob=1	(5) Prob=1
Share of cultivated area	0.005***	-0.002*		-0.007	
	(0.001)	(0.001)		(0.005)	
Lag. Share of cultivated area			-0.002	0.007	
			(0.002)	(0.006)	
Δ Share of cultivated area					-0.007*
					(0.004)
Number of airports in radius	-0.002	0.030	0.030	0.030	0.030
	(0.009)	(0.034)	(0.033)	(0.034)	(0.034)
Distance to closest fumigation airport	-0.056***	-0.010	-0.009	-0.009	-0.009
	(0.014)	(0.034)	(0.034)	(0.034)	(0.033)
Distance to Department's capital	0.009*	0.022*	0.021*	0.021*	0.021*
	(0.005)	(0.013)	(0.013)	(0.013)	(0.013)
Distance to closest principal market	0.094***	0.218***	0.215***	0.216***	0.216***
	(0.016)	(0.052)	(0.052)	(0.052)	(0.050)
Elevation x 100 mts (MASL)	-0.002***	-0.006*	-0.006*	-0.006*	-0.006*
	(0.001)	(0.003)	(0.003)	(0.003)	(0.003)
Water disposability index	0.045***	0.100***	0.100***	0.100***	0.100***
	(0.006)	(0.020)	(0.020)	(0.020)	(0.020)
Soil erosion index	-0.016***	-0.044**	-0.044**	-0.043**	-0.043**
	(0.004)	(0.020)	(0.020)	(0.020)	(0.020)
Soil aptitud index	-0.018***	-0.017	-0.016	-0.017	-0.017
	(0.005)	(0.019)	(0.019)	(0.019)	(0.019)
Share of rural population	0.003	-0.036	-0.037	-0.037	-0.037
	(0.022)	(0.096)	(0.096)	(0.096)	(0.096)
Observations	6,348	1,308	1,308	1,308	1,308
R-squared	0.125	0.132	0.131	0.133	0.133

Notes: This table presents the probability of a municipality being sprayed. Column (1) include all the municipalities while Column (2) to (5) results restrict the sample to municipalities that have been sprayed at least once since 2001. Standard errors reported are clustered at the municipality level and presented in parenthesis. * is significant at the 10% level, ** is significant at the 5% level, *** is significant at the 1% level. .

Table 2: Main results of the effects of the coca presence

Dependent variable:	Dropout rate			Enrollment rate			Retention rate		
	Primary	Middle	High	Primary	Middle	High	Primary	Middle	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Area affected coca	0.109	0.136	0.328**	-0.028	-0.004	-0.022	-0.118	-0.104	-0.259**
	(0.133)	(0.128)	(0.157)	(0.021)	(0.032)	(0.046)	(0.124)	(0.169)	(0.105)
Observations	7,653	7,627	7,520	5,521	5,521	5,521	7,653	7,631	7,570
Dep. Var. Mean	2.73	4.57	3.15	86.93	90.15	73.35	97.27	95.43	96.84
Dep. Var. S.D.	2.12	3.20	2.71	22.78	23.81	22.78	2.09	3.18	2.70

Notes: This table presents the Wald estimad using the stata `fuzzydid` package. Each entry in the table comes from a different estimation. Outcomes are reported in the header of the column and each one is standardized to have zero mean and unit variance in the sample. Standard errors are clustered at the municipality level and bootstraped using 50 repetitions. They are reported in parenthesis. * is significant at the 10% level, ** is significant at the 5% level, *** is significant at the 1% level.

Table 3: School efficiency measures and coca presence

Dependent variable:	Grade pass rate			Grade fail rate			Grade repetition rate		
	Primary	Middle	High	Primary	Middle	High	Primary	Middle	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Predicted Area affected coca	0.098	0.024	-0.179*	-0.234	-0.152	0.026	0.126	0.027	-0.178
	(0.127)	(0.125)	(0.095)	(0.167)	(0.107)	(0.145)	(0.115)	(0.114)	(0.128)
Observations	7,721	7,699	7,661	7,653	7,648	7,618	7,599	7,595	
Dep. Var. mean	94.01	89.97	93.46	3.11	5.28	3.18	1.72	2.36	0.97
Dep. Var. S.D.	4.58	7.08	5.13	3.40	5.78	3.73	2.01	2.72	1.43

Notes: This table presents the Wald estimad using the stata `fuzzydid` package. Each entry in the table comes from a different estimation. Outcomes are reported in the header of the column and each one is standardized to have zero mean and unit variance in the sample. Standard errors are clustered at the municipality level and bootstraped using 50 repetitions. They are reported in parenthesis. * is significant at the 10% level, ** is significant at the 5% level, *** is significant at the 1% level.

Table 4: School attainment and coca presence

	Language			Mathematics		
	Primary	Middle	High	Primary	Middle	High
Dependent variable:	Saber5	Saber9	Saber11	Saber5	Saber9	Saber11
	(1)	(2)	(3)	(4)	(5)	(6)
Area affected coca	0.143	0.121	-0.036	0.174**	0.072	0.012
	(0.089)	(0.082)	(0.034)	(0.086)	(0.085)	(0.039)
Observations	6,555	6,536	4,366	6,553	6,534	4,366
Dep. Var. mean	295.51	284.33	48.78	294.78	290.51	47.86
Dep. Var. S.D.	30.79	31.95	3.68	33.30	33.8	4.28

Notes: This table presents the Wald estimad using the stata `fuzzydid` package. Each entry in the table comes from a different estimation. Outcomes are reported in the header of the column and each one is standardized to have zero mean and unit variance in the sample. For primary and middle school, estimates uses data from 2012 to 2017, while for high school, from 2014 to 2017. Standard errors are clustered at the municipality level and bootstraped using 50 repetitions. They are reported in parenthesis. * is significant at the 10% level, ** is significant at the 5% level, *** is significant at the 1% level.

Table 5: Legal crops and coca presence

Dependent variable:	Ratio harvest-sown	Share area sown	Share area harvested
	(1)	(2)	(3)
Area affected coca	0.004	0.004	0.005
	(0.012)	(0.004)	(0.005)
Observations	5,403	5,459	5,459
Dep. Var. mean	0.850	0.141	0.121
Dev. Var. S.D.	0.124	0.166	0.145

Notes: This table presents the Wald estimad using the stata `fuzzydid` package. Each entry in the table comes from a different estimation. Outcomes are reported in the header of the column. Standard errors are clustered at the municipality level and bootstraped using 50 repetitions. They are reported in parenthesis. * is significant at the 10% level, ** is significant at the 5% level, *** is significant at the 1% level.