The effects on the value of legal agriculture of a US-funded policy aimed at fighting the war on drugs in Colombia

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Abstract

Colombia is among the three largest coca leaf producers and the world's leading supplier of cocaine to the US (UNODC, 2009). The US and Colombia have aggressively pursued forced coca eradication and introduced an anti-drug policy named Plan Colombia (PC) to combat cocaine production. This paper examines the effects of the strategies for controlling coca supply in Colombia on the value of the agricultural output. For this purpose, the study exploits the main changes in the policy used by the Colombian government under PC to reduce cocaine supply as an exogenous variation in coca cultivation to the value of legal agricultural production. The empirical strategy follows a (triple) difference-in-differences (DID) estimator by assessing whether changes in the PC strategy to reduce coca cultivation affect the value of agricultural production disproportionately in coca-growing areas. The results indicate an increase in the legal agricultural GDP due mainly to the interdiction of cocaine and cocaine-processing facilities policy in Colombia since 2007. Coca-growing areas of Colombia saw substantial drops in cultivation from 2007 to 2013 and benefited from such policy compared to agriculture in non-coca-growing regions. The results also indicate that the value of agricultural production in the coca-growing areas gained a monetary benefit from the cocaine labs' dismantling policy of about US$284.2 million. These estimates can be considered the first linking the value of agricultural products to the effect of policies at curbing coca cultivation and cocaine supply. Based on the findings, efforts to reduce coca cultivation should emphasize anti-drug strategies on production stages and trafficking with the highest value-added. This empirical evidence is crucial for strengthening legal agriculture, at least in terms of the value of agricultural production.

2.1. Introduction

Colombia is among the three largest coca leaf producers and the world's leading supplier of cocaine to the US (UNODC, 2009). Because of the socio-economic costs resulting from this, both nations have aggressively pursued forced coca eradication and introduced a robust anti-drug policy named *Plan Colombia* (PC)[1] to combat cocaine production. The policy has used three primary strategies in practice for this: (i) eradication of coca cultivation by aerial spraying with pesticides over planted fields and manual coca crops destruction; (ii) alternative livelihood programs for coca-producing regions aimed at increasing the relative profit of non-coca agricultural activities by providing monetary subsidies in exchange for not cultivating coca; and (iii) interdiction of cocaine-producing laboratories and related facilities.[2]

Although the cost of the anti-drug policy was around 5.5 billion US dollars from 2000 to 2007 (ONDCP, 2006; GAO, 2008), its effectiveness in reducing coca cultivation is still controversial.[3] The literature has focused on quantifying the policy effects on the population of areas with coca production.[4] No empirical studies have assessed their effects on the value of agricultural production in the areas growing coca. This chapter

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[1] Launched bilaterally in 2000, *Plan Colombia* (PC) was a US foreign-military aid and diplomatic initiative. The policy aimed to combat Colombian illegal drug production, organized crime, and drug trafficking organizations. In the first phase of PC (2000-2006), aid resources reached USD$4.8 billion, mainly invested in the defense industry (National Planning Department-DNP-, 2016). The second phase (2007-2009), called the "Strategy for Strengthening Democracy and Social Development," was focused on institutional strengthening in areas affected by violence and with investments of USD$2.1 billion aimed at improving the population's socio-economic conditions in municipalities with the presence of either demobilized or active illegal armed groups. The last phase of the Plan (2010-2015) implied USD$2.7 billion for supporting the socio-economic development of the most vulnerable populations to both the violent confrontations between drug trafficking organizations and the Colombian government and the adverse effects of coca crops eradication campaigns.

[2] An interdiction strategy (*interdiction policy*) is defined here as the set of Colombian government operations and direct interventions to dismantle or destroy cocaine processing facilities (or laboratories) and increase coca base, coca leaves, and cocaine seizures. The government invested in these strategies to reduce the cocaine supply by targeting its intermediate and final production stages (Cote, 2019).

[3] There is still little empirical work assessing the efficacy of drug control policies under Plan Colombia. This gap is particularly evident in the case of coca eradication, which targets the farmers that produce coca leaf, the primary input of cocaine (Reyes, 2014). Only Moreno-Sanchez *et al.* (2003), Dion and Russler (2008), and Reyes (2014) have attempted to estimate the effectiveness of coca eradication in Colombia at the national, departmental, and municipal levels, respectively. Nevertheless, there is no research relating the effectiveness of Plan Colombia to the agricultural production value of licit or conventional crops.

[4] The main alternative crops that directly compete for land allocation with coca are coffee and cocoa.

uses a 21-year panel covering almost 97% of the entire country in the 1995–2015 period to estimate these effects. More specifically, this study examines the effects of the policies controlling coca supply in Colombia on the value of legal agricultural production.

The cultivation of coca leaves in Colombia links to cocaine processing, given that coca leaf is the essential input in cocaine production. The other leading coca leaf growing countries (i.e., Bolivia and Peru) clearly distinguish coca for cocaine production and its use for culturally tied consumption such as chewing, tea, and medicine (Koops, 2009; UNODC, 2014). Although there has been a remarkable decline in the total area under coca cultivation[5] , little of this reduction has been attributed to successful eradication campaigns alone, which have been the dominant anti-drug policy in the last three decades in Colombia (Vargas, 2005; Reyes, 2014; Mejía et al., 2017). Some studies have argued that indiscriminate aerial spraying of glyphosate destroys legal agriculture proximate to coca plantations. (Bishop 2003; Ibañez and Martinsson, 2013; Camacho and Mejía, 2015; Relyea, 2005; Rozo 2014;). Other studies assert that such aerial spraying campaigns generate negative economic, social, environmental, political, and health consequences (Moreno-Sanchez et al., 2003; Vargas, 2005; Dion and Russler, 2008).

Previous literature has documented diverse responses of coca farmers to the risk of eradication. Some farmers plant coca more extensively (Moreno-Sanchez *et al.*, 2003), while others either reduce or abandon coca production such that coca supply declines and the international coca price increases. This increase in coca price may incentivize farmers to expand coca cultivation in other locations (Dion and Russler, 2008; Robledo, 2015). The Colombian government has sporadically and not consistently carried out some social programs to encourage farmers to abandon coca cultivation by identifying alternative legal crops that could replace coca labor and income. However, these strategies have historically received less support than eradication efforts (Vargas, 2005). Empirical evidence suggests that alternative crops to coca production are generally more effective than eradication campaigns in reducing coca supply in the short and long run (Moreno-

[5] The area under coca cultivation decreased by almost a half: falling from 248,189 hectares (ha) in 2007 to 98,899 ha in 2013 (UNODC Coca Cultivation Survey, 2014). More generally, Plan Colombia reduced coca cultivation from 160,000 ha in 2000 to 48,000 ha in 2013, and the estimated value of Colombia's drug-related economy shrank from US$7.5 billion in 2008 to US$4.5 billion in 2013 (Mejía, 2016).

Sanchez *et al.*, 2003; Ibañez and Carlsson, 2010; Tabares and Rosales, 2005; Ibañez and Martinsson, 2013). Also, a higher presence of governmental institutions and public forces in coca-growing regions links to a significant coca cultivation reduction (Dion and Russler, 2008). The lack of governance and the presence of insurgent groups, in turn, promote an illegal environment that induces farmers to grow and supply coca leaves to the cocaine production system (Holmes *et al.*, 2006; Angrist and Kugler, 2008; Dube and Varga, 2013; Ibañez *et al.*, 2013; UNODC, 2014). Therefore, alternative crops alone appear not to provide farmers with enough incentives to abandon coca cultivation. Suggestive evidence has shown that the threat of violence, economic risks, and the fall in the prices of legal crops increases the incentives for farmers to switch to illicit crops (Moreno-Sanchez *et al.*, 2003; Dube and Vargas, 2013; Ibañez *et al.*, 2013).

According to Robledo (2015), the eradication of coca cultivation has produced little real impact and, in some cases, the opposite effect by increasing the area under coca cultivation. Alternative crop policy and livelihood programs for coca-producing regions implemented by the Colombian government have not even been significantly more effective than the eradication policy (Robledo, 2015; Mejía, 2016). By contrast, Mejía (2016), Mejía and Restrepo (2016), Mejía *et al.* (2017), and Cote (2019) show that the interdiction of coca-and-cocaine-producing laboratories and related facilities, especially since 2007, has proven to be the most effective and even cost-effective counternarcotics strategy used by Colombia.

The US Government Accountability Office has reported that the annual US funding for the military component of PC was, on average, 540 million USD per year between 2000 and 2008. This funding added to the 812 million USD invested by the Colombian government per year in the war on illegal drug production and trafficking, representing around 1.2% of Colombia's average annual GDP during the 2000-2008 period. The results on PC effectiveness are considered mixed despite such substantial investments. Figure A.2.1 in Appendix A displays the number of hectares of coca grown, the number of hectares sprayed in aerial eradication campaigns, and the number of hectares subjected to manual eradication between 1995 and 2014. The figure shows that despite the efforts to reduce coca plantations through intensive eradication campaigns, the annual number of hectares devoted to coca cultivation did not significantly fall, especially between 2005 and 2008, when both strategies were at their peaks. Although the area under coca cultivation fell rapidly from about 140,000 hectares in 2000 to 80,000 in 2002, areas planted with coca were relatively stable at an average of about 85,000 hectares in 2003-2006.[6] However, coca cultivation decreased again from 2007 to 2013, declining to about 48,000 hectares even when coca eradication efforts were substantially reduced (see Figure A.2.1).

The remainder of the chapter is as follows. Section 1.1 provides a background of the interdiction policy under the PC since 2007. Section 2 presents the data used and describes the empirical strategy implemented in the chapter. Section 3 presents and discusses the main results. Finally, Section 4 concludes the chapter.

2.1.1. Interdiction Strategies

During former President Álvaro Uribe's second term, Ex-President Juan Manuel Santos became defense minister in 2006. The emphasis of Colombia's anti-drug strategies shifted radically since Santos and his team decided to reduce eradication

[6] In 1978, the Colombian government launched aerial fumigation to eradicate cannabis crops with the herbicide Paraquat (Vargas, 2002). Because of the ecological risks associated with this herbicide, the Colombian government replaced it with glyphosate, known commercially as Roundup, around the mid-1980s. Since then, aerial spraying of glyphosate-based defoliants has been the most common anti-drug policy followed by Colombian governments (Davalos, 2016). The aerial fumigation program began officially in the 1990s continuing then for 21 years until the Colombian government halted it in 2014 because of the devastating health or environmental impacts caused by glyphosate (For more details on these aspects, see the World Health Organization report, 1994; Fritschi *et al.*, 2015; and Camacho and Mejía, 2015). Manual eradication is not associated with environmental or health risks, but it is a more expensive policy because it is a labor-intensive activity. According to Davalos (2016), the Colombian government also carried out manual eradication campaigns when and where aerial spraying was restricted or in easy-access areas without armed conflict (less than 10% of total eradication actions). However, manual eradication was only an official anti-drug policy in 2004. It became a national program with a budget from the Colombian government in 2004, and Plan Colombia was allocated exclusively to this activity (DNP, 2010; Davalos. 2016).

campaigns of coca cultivation and put more effort toward dismantling cocaine production and trafficking. Figure 2.1 shows that the number of hectares under aerial spraying declined from about 152,000 in 2006 to 80,000 in 2009 (a reduction of 48%). Figure A.2.2 illustrates that the number of laboratories destroyed increased from around 2,100 in 2006 to 3,000 in 2008 (an increase of 43%). This new anti-drug strategy reduced the net supply of cocaine by more than 50%, a supply shock that impacted the entire region and the street price of cocaine in the United States (see Figure A.2.3 in Appendix A of this chapter). Figure A.2.4 in Appendix A displays coca base and cocaine seizures series and coca crop cultivation from 1999 to 2014. These seizures derived from three policies designed for reducing the cocaine supply. (1) interdictions of the labs and facilities where cocaine is processed; (2) disruption of cocaine shipments en route to consumption markets; and (3) imposition of stricter state controls on the sales of chemicals used to turn coca leaves into coca base. We can observe that cocaine hydrochloride seizures increased from 127 kilograms in 2006 to almost 200 in 2009 (an increase of 57%).

The interdiction of coca base and cocaine-processing facilities seems to have had much higher effects—not only on cocaine trafficking but also on coca cultivation— than eradication and other policies. Empirical evidence suggests that the sharp decline in Colombia's cocaine supply from 2007 to 2009 induced by such an anti-drug strategy pushed drug trafficking organizations' bases away from Colombia while embraced by other locations such as Central America and Mexico (Castillo *et al.*, 2020). Mejía and Restrepo (2013) find that for every cocaine-laboratory interdiction (detected and destroyed by the authorities), the area under coca cultivation decreases by approximately three hectares. The systematic elimination of cocaine-processing facilities could have represented a negative shock to the demand for coca leaves, at least in the short run, and thus coca cultivation declined.

A simple demand and supply representation of the markets for cocaine and coca can illustrate the essential hypothesis of the present research. This conjecture can be associated with a Production Possibilities Frontier (PPF) relationship between coca and alternative conventional crops with and without anti-drug policies (see Figures B.2.1-B.2.3 in Appendix B of this chapter). Intuitively, the 2008 negative shock in the net cocaine supply of Colombia (displayed in Figure A.2.3) can be represented in Figure B.2.1 as a leftward (or an upward) shift of the worldwide cocaine supply curve so that the international price of cocaine will be higher. As Figure B.2.2 illustrates, this shock would imply that the demand for coca leaves in Colombia shifts to the left (or downwardly) to a lower price level when the cocaine production decreases because of the interdiction policy (making more costly the processing and sale of cocaine). Figure B.2.3 exemplifies through a PPF scheme that the shock could ultimately affect the relative prices of illicit crops (coca) to licit crops, ceteris paribus. This association perhaps implied that a significant decline in coca cultivation could increase the value of legal agricultural production to the extent that licit crops divert resources from producing coca.

This chapter uses department-level data to assess the effect of the policies implemented under PC for reducing illicit crop cultivation on the value of agricultural production in areas identified as coca-growing. This study examines the hypothesis that the production value of licit crops in Colombia is mostly negatively related to cocaine production in those areas with coca plantations. Figure 2.1 shows the intensity of coca cultivation among Colombian departments. Figure 2.3 illustrates the evolution of the agricultural GDP of coca-growing and non-coca growing departments and their difference across years. We can roughly observe that both groups follow a similar trend before PC. Their trend difference has increasingly augmented over the years during PC, notably during the official interdiction policy period.

2.2. Methodology and Data

This chapter examines a potential induced effect of interdiction anti-drug policy on the value of legal agricultural production. This link implies that the higher the relative returns from conventional crops such as coffee and cocoa, the more likely the area under coca farming to be lower. Alternatively, an effective anti-drug policy generating a systematic reduction of coca cultivation may induce many farmers to switch from coca cultivation to conventional crops. Given this reverse causality, we might need at least a plausibly exogenous source of variation in either coca cultivation or legal crops to identify any impact of the change in one on the other. This study exploits the three main strategies used by the Colombian government under PC to reduce cocaine supply as an exogenous variation in coca cultivation to the value of legal agricultural production. The two first strategies focused on illicit crop controls through forced eradication campaigns directly targeting coca farming in two different ways, i.e., aerial spraying and manual eradication. The third strategy consists of redirecting interdiction efforts to target the intermediate and final stages of cocaine production.

Total hectares with coca leaves may not be by itself a proxy for the economic relevance of coca production in most regions since it may not reflect the benefit associated with growing coca. Thus, we use the plausibly exogenous changes in coca cultivation induced by the policies for reducing the illegal drug trade, which increases the cost of drug production. The primary mechanism explaining such variation relies on the effectiveness of these interventions to increase costs associated with coca farming, limiting its profitability, discouraging farmers from growing coca, and leading them to adopt alternative production activities.

2.3. Data

2.3.1. Coca Related Variables

To measure coca cultivation, we constructed a 21-year panel of 31 Colombian departments (24 of which grew coca at some point during the 1995–2015 period). We use data from the United Nations Office on Drug and Crime (UNODC). The UNODC has conducted satellite surveys of coca crops in every municipality of the country since 1999[7]. These surveys use satellite photography to measure the number of hectares with coca plantations in a given area\municipality on December 31st of each year.

The UNODC and the Colombian government use satellite imagery and verification flights over coca-growing areas to monitor the location and spread of coca

[7] Although there is no data on the exact amount of coca cultivated and cocaine produced and subsequently exported, both the UNODC and the US State Department make annual estimates of the size of the illicit industry. The present study uses such estimates.

cultivation. Although the UNODC and the Colombian government achieved full national coverage in the year 2001, the information on coca leaves cultivation for the period 1995-1998 was estimated based on Angrist and Kugler (2007), "*Cuadro 1*." in Ramírez (2002), and Uribe (1997). In 2005, for example, the area within each department with active coca cultivation was between 28 and 17,305 hectares, with seven departments having no reportable levels of coca cultivation.

We identified the departments with coca-growing areas and their participation in the national total coca cultivation with the variable on coca crops. The variable captures the cross-sectional variation of coca cultivation (see Figure 2.1) and time-variation of coca crops in Colombia (see Figure 2.2). We also obtain the ratio between the area planted with coca in each department/year to the total (national) area cultivated with coca in the corresponding year to measure coca farming intensity.

Regarding the coca-eradication-interdiction policy variables, we use direct indicators for each policy that capture variations in the profitability from coca-growing for the various departments of Colombia. These indicators are the number of hectares with coca subjected to aerial spraying and manual eradication and the number of cocaine processing facilities destroyed. Alternatively, the interdiction policy is proxied as the amount (in kilograms) of coca base, coca leaves, and cocaine seized each year. Based on this information, we create a variable indicating the department level of exposition to each of the three annual indicators before 2000 (the year of PC's implementation). These indicators have been available only since 1999. Thus, we use this year's information for the pre-intervention analysis in some specifications.

2.3.2. Agricultural Production Variables

We use the available annual data on the value added by the department and economic activity series with the base year 2005 over the 1995–2015 period from the National Administrative Department of Statistics (DANE). The departmental GDP measures the productive activity of different country departments, and it defines the behavior, development, and economic structure for analysis and regional decisionmaking. We also use the information at the department level available for the period of study from the statistics per department and municipality agricultural evaluations (EVA)[8] from the Ministry of Agriculture and Rural Development (MADR) related to the area planted, production, and yields of permanent and transitory crops. The final sample consists of 651 observations (31 departments × 21 years).

Information about the population in rural areas is from the DANE's departmental estimates of population projections by urban/rural area and age groups of 0-80 and more years for the 1985-2020 period. The Colombian rural working-age population was calculated here as the people aged ten years and over in rural areas of each department. The variables on legal agricultural output used in the estimation are the output variable (agricultural GDP), given by the value of agricultural production in 2005 US million dollars; agricultural land defined as thousands of hectares of arable and permanent cropland and permanent pastures; rural population and the number of participants in the working-age population in rural zones. We also calculate departmental GDP per capita and the value-added in the agricultural sector as percent of GDP (or GDP share of agriculture).

2.3.3. Other variables

We use data also on the internal displacement of people from the Colombian government's Unique Registration System. We used consolidated statistical information from CODHES-SISDES (Information System on Human Rights and Displacement) on the number of forced internally displaced persons corresponding to each municipality (that we aggregate to the department level) from year to year. This database defines internally displaced persons as those forced to abandon their physical residences and employment activity because of armed conflict, generalized violence, massive human rights violations, or other circumstances that threaten or drastically alter public order. We

[8] The agricultural evaluations of municipalities are investigations that have been carried out since 1970 by the Ministry of Agriculture and record the productive activity related to agriculture, livestock, forestry, and aquaculture throughout Colombia's territory.

specify the variable as the ratio of the annual number of displaced persons to the total population in the department of origin per 100 thousand inhabitants.

Other variables include measures of weather variables, i.e., temperature and rainfall. The construction of these variables uses data regarding the Agrometeorological Indicators produced on behalf of the Copernicus Climate Change Service. This dataset covers the world time series daily surface meteorological data from 1979 to 2020. The dataset consists of the hourly ECMWF-ERA5 data geo-localized and available at a spatial (horizontal) resolution of 0.1° x 0.1° (10km2). More specifically, we use the information on (1) *precipitation flux*, defined as the total volume of liquid water (mm3) precipitated over the period 00h-24h local time per unit of area (mm2), per day; and (2) *2m temperature* indicating the daily air temperature at 2 meters above the surface. We then aggregated the data to the monthly/municipality level. Finally, temperature and rainfall represent the annual department means of the municipality\monthly values of *2m temperature* and *precipitation flux* variables, respectively. We use these variables considering that weather shocks can lead to more prolific or lean harvests directly associated with changes in profits from rural activities, potentially affecting incentives to invest in legal agricultural activities.[9] Thus, the focus is on rural areas in Colombia. Weather shocks are among the most relevant risk factors faced by rural households because of the potentially harmful effects of weather shocks on the agricultural activities on which rural populations generally rely (Giné *et al.*, 2008; Andalón *et al.*, 2016).

2.4. Empirical Implementation

Our empirical strategy follows a *difference-in-differences* (DID) estimator by assessing whether changes in the PC policies to reduce coca cultivation affect the value of agricultural production disproportionately in coca-growing departments. In this

[9] Colombia has been particularly affected by rainfall and temperature shocks. According to the Global Climate Risk Index (Harmeling, 2011), the country ranked third (after Pakistan and Guatemala) in 2010 among the countries more affected by weather-related events such as droughts, floods, and heatwaves. Moreover, the number of disaster events registered in Colombia in the first decade of the 2000s increased by more than 60% from 1970–to 99 (Campos *et al.*, 2011; Andalón *et al.*, 2016).

approach, time variation depends on the official year each policy started under the PC (2000-15). Aerial spraying of glyphosate is assumed to start at the beginning of the PC in 2000. As stated before, manual eradication started as a national program in 2004. Finally, as the Colombian government redefined its anti-drug strategy in 2006, emphasizing the interdiction of drug shipments and the detection and destruction of cocaine processing labs over the eradication of coca crops, the interdiction policy is thus considered official under the PC since 2007.

The variation we explore to identify the effect of these strategies on the value of agricultural production or agricultural GDP (AGDP) thus combines the timing of the policy changes and a direct measure of their implementation under the PC across different areas. With this empirical strategy, we test if the AGDP increase after each of these policies is higher in coca-growing departments and to what extent that increase results from such policies. The interventions' timing is unique for the entire country, so the effect identification comes mainly from the heterogeneous response of different areas to the policies.

We create a dummy variable equal to 1 for the interval between 2000 and 2003, capturing the first illicit coca crops control strategy used under the PC (aerial spraying of glyphosate). Then, we create a second dummy variable equal to 1 between 2004 and 2006, corresponding to the manual eradication program implemented in 2004. Furthermore, we include a third dummy equal to 1 starting in 2007, identifying the years of increased interdiction policies from the Colombian government. Our baseline specification follows the difference-in-differences regression:

$$\begin{aligned} AGDP_{it} = \alpha &+ \beta_1 \cdot (D_{2000 \leq t \leq 2003} \times \text{Coca}_{1i}) \\ &+ \beta_2 \cdot (D_{2004 \leq t \leq 2006} \times \text{Coca}_{2i}) \\ &+ \beta_3 \cdot (D_{t \geq 2007} \times \text{Coca}_{3i}) + \mathbf{X}_{it}\phi + \alpha_i + \beta_{rt} + \varepsilon_{it}, \end{aligned} \tag{1}$$

where $AGDP_{it}$ is the (real-valued) agricultural production in millions of 2005 US dollars. for department i in the year t; $D_{2000 \leq t \leq 2003}$ is a dummy variable equal to 1 for years between 2000 and 2003; $D_{2004 \leq t \leq 2006}$ is a dummy variable equal to 1 between 2004 and 2006; $D_{t \geq 2007}$ is a dummy equal to 1 for 2007 and all following years; Coca_{ji} for $j = 1,2,3$ is a variable indicating the number of hectares (aerially) sprayed with glyphosate, the number of hectares manually eradicated, and the number of coca base and cocaine processing labs destroyed, respectively[10] [11]; $\mathbf{X}_{it}$ is a vector of time-varying control variables; α_i are department-fixed effects; β_{rt} is a region-specific year dummy for Colombia's five major regions (Amazon, Andean, Caribbean, Orinoco, and Pacific); ε_{it} indicates a random term; and α_0, β_1, β_2, β_3, and ϕ are parameters. OLS estimation of equation (1) would produce unbiased estimates of the βs under the usual assumptions that:

$$E[\varepsilon_{it}|D_{2000\leq t\leq 2003}, D_{2004\leq t\leq 2006}, D_{t\geq 2007}, \text{Coca}_{1i}, \text{Coca}_{2i}, \text{Coca}_{3i}, \mathbf{X}_{it}, \alpha_i, \beta_{rt}] = 0 \quad (2)$$

In some robustness exercises, we also use the information on the indicators before PC. This information is available only for 1999, so we create two sets of variables: one related to the level of each policy indicator for 1999 (before PC) and another indicating the annual variation of each policy indicator after PC. The former set provides a proxy for the initial level of constraint on the coca production in the local economies before the policies under PC. The latter corresponds to a direct measure of losses to the cocaine production sector, constraining coca cultivation during the PC period. As the second set of variables differs by department, when they interact with the dummies for the timing of each policy implementation, a sort of triple differences estimator is created like in Chimeli and Soares (2007). This triple-differences estimation compares coca-growing departments to the other departments and evaluates whether the policy changes affect the outcome variable disproportionally in departments with coca cultivation.

It is noteworthy to mention some potential concerns with this difference-in-differences (DID) strategy, such as omitted variables and differential dynamic behavior of the value of agricultural production. There may be changes happening simultaneously to the implementation and effectiveness of the policies. Because a fraction of the

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[10] Each indicator is equal to zero for the departments identified as non-coca-growing in our sample (i.e., they did not grow coca from 1995 to 2015). This framework aims to identify the primary treatment and control groups. These departments are considered the primary control group consisting of the departments of Atlántico, Casanare, Huila, Quindío, Risaralda, Sucre, and Tolima (see Figure 1.2).

[11] Coca_{ji} with $j = 1,2$, and 3 are variables indicating coca and cocaine production constraints, increasing the costs associated with coca cultivation. They could also reflect the relative economic relevance (or perhaps relative profitability) of coca production for a given area. Coca_{3i} is alternatively specified in some specifications like the amount (in kilograms) of coca base, coca leaves, and cocaine seized each year at the department level.

government's budget accrues to implement the policies, such a fraction is a part of the GDP that equivalently has the agricultural GDP of each department as a component. Moreover, the policies' effectiveness may also depend on the heterogeneous institutional/geographic environment within Colombia that could have significant economic impacts that may affect the evolution of the value of legal agricultural production. Agricultural inputs endowments (quality and availability) and the prices of commodities from legal agriculture and coca-related products could also be strong predictors of $AGDP$ and the effectiveness of the policy. Another important caveat would be the incidence of violence due to the armed conflict in rural Colombia that may be highly associated with legal agricultural activities and illicit crop production. More generally, worsened environmental and socioeconomic conditions can also debilitate legal agriculture by pushing many farmers toward illegal crop production. This relationship can further constrain the intensity of each policy's execution and effectiveness. Some pervasive side effects of such policies (e.g., aerial spraying) may cause detrimental consequences to the profitability of agriculture. Farmers can also migrate to areas where they can cultivate coca. This migration would significantly change the sample composition of the treated group (and\or comparison group) by generating attrition effects. All these aspects can represent relevant driving factors changing the pattern of legal agricultural activity and illicit crops simultaneously in the production possibilities frontier of agriculture. We allow for regional-specific time dummies that immediately account for any systematic difference across regions due to the policy, environment, or socioeconomic changes to mitigate these concerns.

Some specifications also allow for flexible time trends as functions of departments' initial characteristics. Given that most of the control variables observed at the department level could be technically endogenous to the restrictions on coca cultivation, we include the interactions of the baseline values (in 1995 or 1996 according to the availability of data) of such controls with time dummies. The control variables are at the department level. These variables are agricultural land (measured as thousands of hectares of arable and permanent cropland and permanent pastures); the working-age population in rural zones; GDP per capita (in logs); the share of GDP in agriculture; the rural conflict-related number of internally displaced persons (from rural to urban zones) and casualties; the ratio between the area planted with coca of each department to the total (national) area cultivated with coca; and the average levels of temperature and precipitation. This specification also includes an interaction between the baseline value of agricultural production (in constant prices) and time dummies to allow for differential dynamics of legal agriculture.

It is also worth mentioning that, by construction, the variance of $AGDP$ is directly related to agricultural production. Thus, we weighted all regressions by the departmental total crop production in metric tons. The DID analysis may also underestimate standard errors because of autocorrelation in the residuals. Therefore, following Bertrand *et al.* (2004) and Chimeli and Soares (2017), the standard errors are clustered at the department level to account for any arbitrary structural correlation over time.

2.5. Empirical Results

2.5.1. Baseline Results

Table 2.1 presents descriptive statistics for coca and non-coca-growing departments for the sample. The table shows the average agricultural GDP ($AGDP$), GDP per capita, the fraction of GDP in agriculture, agricultural land, rural population, and annual average temperature and rainfall between 1995 and 2015. The pre-2000 period refers to the years before PC, and the post-2000 indicates the PC period in which the analyzed policies occurred. The objective of the table is to characterize the differences between departments with coca cultivation and those without coca crops.

The table shows that coca and non-coca-producing departments were not much different in their GDP per capita, agricultural land, or weather characteristics. However, non-coca departments have smaller average agricultural GDP, departmental GDP, and population, and they are also more dependent on agriculture relative to coca-producing departments. Although these differences, it is imperative to note that we are mainly interested in looking at the changes in such differences during the analyzed period.

Regarding the comparison in this way, we can infer from Table 2.1 that the differences between coca and non-coca departments in terms of agricultural GDP, departmental GDP, GDP per capita, temperature, and population increased by approximately 21%, 34%, 35%, 13.0%, and 28%, respectively. These differences do not necessarily imply a methodological issue because the DID method allows comparison groups to start at different outcome levels (DID focuses on changes rather than absolute levels). The differences between the two groups regarding the importance of agriculture in the departmental economy (GDP share of agriculture), land for agricultural activities, and mean precipitation reduced by approximately 2%, 33.4%, and 5%, respectively. To estimate any impact of the policies on curbing coca/cocaine supply under PC, we rely mainly on the three assumptions for the internal validity of the empirical strategy or DID approach. The first assumption is that comparison groups follow a parallel outcome trend before treatment (Parallel Trend Assumption). Second, the composition of groups pre/post-change is stable (Stable Unit Treatment Value Assumption). Finally, the intervention is unrelated to the outcome at baseline (allocation of the intervention was undetermined by outcome variable). We verify if these assumptions hold later in section 2.5.2.

The main results for the sample of all coca-growing departments are in Table 2.2. Column 1 does not include any control. In col-umn 2, we incorporate region-specific time dummies. Column 3 adds interactions of time dummies with baseline values for all the control variables used. These variables are the ratio of coca planted area to the national area under coca cultivation, agricultural land, GDP per capita, and share of GDP in agriculture; the working-age population in rural zones, rate of internally displaced persons (from rural to urban areas), and the rate of rural conflict-associated casualties; the average levels of temperature and precipitation; the proportions of permanent and transitory crops production relative to the total crops production plus the value of legal agricultural production.

Columns 1 to 3 reveal significant effects of the variables manual eradication ($Manual\ 2004$) and interdiction policy ($Interdiction\ 2007$) on legal agricultural production's (real) value. The estimated coefficient for the variable indicating aerial spraying ($Aerial\ 2000$) is nonsignificant in column 1 and significant but much smaller than those related to the other policies in columns 2 and 3. Overall, the estimated coefficient on the first policy change ($Aerial\ 2000$) is always smaller than those on those other policies ($Manual\ 2004$ and $Interdiction\ 2007$), considering that the three coefficients are estimated precisely, except in column 1, which does not include control variables. Therefore, coca-growing departments exhibit a relative increase in the (real) value of their legal agricultural production during the PC period. This increase was particularly significant between 2004 and 2006, and more intense after 2007.

Note that when we introduce the region-specific time dummies in column 2, the magnitude and the statistical significance of the coefficients for all the policies turn into more sizable ones. The coefficients on the first and the third policy become statistically more statistically significant when we included the set of interactions of initial conditions and the time dummies. With this same inclusion, the point estimates of the first and the second policy become somewhat bigger. However, the coefficient estimated on the third policy is still the strongest in terms of magnitude and statistical significance. Thus, it is possible to infer that the difference in the evolution of the (real) value of legal agricultural production across coca-growing and non-coca-growing departments does not seem to be driven by differential trends across regions or even departments.

These estimations are somewhat consistent with the evolution of the agricultural GDP displayed in Figure 2.3. As stated before, the figure depicts that the difference in the agricultural GDP of coca-growing departments relative to non-coca ones has increased across the years of PC, especially during the official interdiction policy period, even though they mostly follow a similar trend. Given that the difference in the AGDP across coca-growing and non-growing departments starts at a high level even before PC, we should interpret with caution the relatively large point estimate for the coefficient on the last treatment variable. To mitigate concerns about this initial difference and to analyze this pat-tern more rigorously, column 4 of Table 2.2 allows treatments to affect both the trend and the level of the outcome variable. We thus interact each treatment variable with a linear time trend that equals zero in the first year of the policy. The estimates suggest at least three relevant aspects. First, the aerial spraying policy cannot be significantly associated with a persistent increase in the agricultural GDP but with a significant increase in its trend. Second, the manual eradication program further increased the level of AGDP without significantly affecting the previous AGDP trend. Third, the interdiction policies since 2007 substantially increased the previous AGDP level. However, the interdictions can only be associated with a mild increase in the agricultural GDP trend during the following years (about USD 26 million or 2.5% in the AGDP per year afterward).

Columns 5 and 6 of Table 2.2 present the results of the triple difference esti-mates. The results in column 5 suggest that increases in AGDP were mainly due to the manual eradication, particularly in departments that had sort of eradication campaigns before PC. However, the estimates in column 6 reveal more consistently that the increases in AGDP were primarily because of the interdiction policies, especially in those departments with more coca base and cocaine processing facilities dismantled after 2007.[12]

To conclude the discussion of the baseline results, we analyze the quantitative interpretations and implications of the numbers in Table 2.2. One can directly read these estimates as changes in the (real) value of agricultural production in US million dollars after the corresponding intervention under PC. For instance, the estimates in column 3 of Table 2.2 indicate that the AGDP of coca-growing departments increased, on average, 192.9 million USD from 2000 to 2003, 224.9 between 2004 and 2006, and 384.2 after 2007 compared to non-coca-growing departments. When we compare these increases to the pre-2000 average AGDP of coca-growing departments, the estimated coefficients correspond to increases ranging from 1% to 2% or even slightly more, considering the estimates in column 2. Although these numbers could seem sizable, they are somehow consistent with and comparable to the potential total annual value of coca production estimated by the UNODC from 2002 to 2015. Figure 2.4 displays the evolution of that value in millions of USD during most of the PC years. It is worthy to note that the annual

[12] The coefficients presented in columns 5 and 6 of Table 2.2 are the cumulative effect of each policy on coca-growing departments, and they are in the measurement units of those policies. It is also important to note that the estimated coefficients from columns 5 and 6 are not directly comparable to those in other columns because the scales of the treatment variables are different.

values calculated by the UNODC come from the factor of production quantities available in the market (minus seizures as product loss) and estimated farmgate prices. The UNODC also converts the values to USD based on the annual exchange market rate average, as Colombia's Central Bank reported. Thus, it is very likely that these values are very low respective to the actual ones. It is also possible to infer from Figure 2.4 that the average value of coca production during most of the years of PC was approximately US$551 million per year, which represents around 2.5% of the annual average GDP in the agricultural sector of coca-growing departments in 2002-2015.[13] Furthermore, the total value of coca was, on average, US$421, $US614, and US$496 per year in 2002-03, 2004-06, and 2007-15, respectively. These values are somewhat reasonably comparable to the estimates in columns 1 to 4 in Table 2.2.

Figure 2.5 shows the gross average annual income per person of coca leaf production and paste/base together with the number of farms (households) involved in coca cultivation.[14] We can observe that after 2007 the gross average annual income per person of coca production decreased substantially from approximately US$2,600 in 2008 to about US$1,000 in 2013. It is also possible to see that the number of households involved in coca cultivation declined significantly.

Thus, the baseline results are consistent with the experience of the coca-growing departments during the PC period, where the overall increase in the value of agricultural production was slightly above 100% (Coefficient of Variation$-\mathrm{CV}-\approx$ 104%) compared to the non-coca-departments of about 50% ($\mathrm{CV}\approx$ 51%) percent. The cumulative percentage increase in the difference between the value of legal agricultural production of coca-growing departments to those non-coca departments reached almost 40% in 2015.

[13] The UNODC Surveys estimate that the total coca production value from 2005 to 2015 was between 0.2% and 0.6% of Colombia's GDP and between 3% and 5% of the Colombian agricultural GDP. Moreover, the total value of coca leaves traded from 2000 to 2013 was US$200 million per year, while the expected return from coca leaves sales was around US$360 million per year, once subtracting the costs of production (mainly labor and agricultural inputs) from the total revenues (Mejía and Rico, 2011; Mejía, 2016). Using the average estimated number of households involved in coca cultivation from the UNOCD, the expected annual return from the sale of coca leaves would be about US$2,250 per household.

[14] The UNODC estimates the growth of households involved in coca cultivation based on: (1) a multivariate indicator (built considering the behavior of the affected area; (2) the population projection (from the DANE) of the municipalities affected by coca; and (3) the growth trend as reported in each phase of the coca productivity studies of UNODC. This information is available only starting in 2005.

Our estimated coefficients explain roughly at least 77.7% and 87.5% of the differential increase in the value of legal agricultural production across departments with and without coca cultivation when averaged over the entire period between 1999 and 2015. The interdiction policy itself contributed around 68% to this average increase. These estimates can be considered the first ones linking the value of legal agricultural products directly to the effect of PC's policies aimed at curbing coca cultivation and cocaine supply.

2.5.2. Differential Trends and Other Contemporary Variations

Although the results across the different specifications in Table 2.2 are somehow consistent, it is also reasonable to believe that treatment variables capture heterogeneous and preexisting dynamics of the AGDP in coca-growing departments. To be this the case, remarkable differences in the trends of AGDP in coca-growing versus non-coca-growing departments should be present already before implementing anti-drug policies under PC. Moreover, this would have to be the case conditional on the region-specific time dummies and interactions of initial conditions that must add the value of legal agricultural production and the time dummies already included in previous specifications.

To test such conjecture, we incorporate some relevant control variables to account for preintervention trends (or a placebo intervention) in the value of legal agricultural production. We insert a dummy for 1995–1999 interacted with a dummy variable indicating coca-growing departments. This exercise aims to identify if the value of legal agricultural production in the coca-growing departments was already differently increasing some years before the anti-drug policies under PC. The results are in column 1 of Table 2.3. We can observe that the corresponding "preintervention placebo" is relatively small and not statistically significant. Nonetheless, we can see that the estimated coefficient for the variable $Aerial\ 2000$ is not statistically significant, and its magnitude has reduced substantially.

Thus, the estimates do not provide evidence that the treatment variables $Aerial\ 2000$, $Manual\ 2004$, and $Interdiction\ 2007$ capture a differential dynamic behavior of the AGDP before the respective policies during PC. Column 2 of Table 2.2

estimates an additional specification that includes department-specific linear trends. Although this specification is rather data demanding, the results show a low impact on the estimated coefficient for $Interdiction\ 2007$. By contrast, all the point estimates increased significantly, but they turned into less significant and not statistically significant estimates for $Aerial\ 2000$ and $Manual\ 2004$).

It is important to note that the direct measures for the treatment policies used in the triple difference regressions in Table 2.2 are only consistently available since 1999. The sample is restricted to the period 1999-2015 in columns 3 and 4, presenting analogous estimations to columns 1 and 2, respectively. The results for the AGDP do not dramatically change with $Interdiction\ 2007$. Thus, the estimates for the effect of the interdiction policy are qualitatively like those obtained in columns 1 and 2.

Naturally, significant alternative driving factors arise for the relative increase in the value of agricultural production in coca-growing departments. To mitigate concerns related to these competing explanations, we analyze how economic conditions represented by the GDP per capita and the legal agricultural activity itself were evolving in these departments during the study period. This analysis could help shed light on whether the increase in the value of agricultural production was practically explained only by macroeconomic conditions and the economic growth of Colombia, creating socioeconomic opportunities for the rural population, or due to endogenous expansions of the Colombian agricultural sector. The last four columns in Table 2.2 attempt to explore these relevant driving forces. There seems to be a direct effect on coca-growing departments for GDP per capita. However, this effect loses overall statistical strength, and it concentrates mainly in the mid-2000s as we include department-specific trends in column 6. Regarding the share of legal agriculture in the total GDP, the estimates indicate a statistically insignificant difference between coca-growing and non-coca-growing departments. In general, the results suggest that it seems not likely that significant structural changes in economic conditions or trajectory in the agricultural sector itself could explain the relative increase in the value of agricultural production here observed in coca-growing departments during the period of analysis.

As final tests to the parallel trends' assumption, we conduct parametric and non-parametric tests for comparing the two types of departments. First, we run specifications that include only the initial and final periods, where the initial period is 1995, and the final varies from 1996 to 2015. This exercise allows us to detect the specific timing of the differential behavior of the value of legal agricultural production across coca and non-coca-growing departments. In Figure 2.6, the 20 coefficients estimated sequentially in this procedure, with their respective standard errors, are plotted against the final period included in each regression. The dynamics of the value of legal agricultural production across the two types of departments seem very similar up to 1999 (when there was a not statistically significant decline until 2000). The legal agricultural production value starts increasing afterward in coca-growing departments. The difference in the value of legal agricultural production across coca and non-coca-producing departments started being statistically significant in 2006 and remained so until 2015. Since 2007, the difference in the AGDP across the two groups remains relatively stable until 2010. However, it starts to rise again from 2010 until 2015, when our dataset ends.

Second, we do a more rigorous visual inspection of the pre-treatment trends or non-parametric parallel-trends tests (before PC) for the control group (non-coca departments) and treatment group (coca-growing departments). The data are initially restricted to the pre-interventions period (1995-1999) and plotted using a linear fitted trends comparison graphical form that distinguishes the coca-growing and non-coca-growing departments (See Figure A.2.5 in Appendix A). However, this test could be somewhat misleading because it forces the data into linear time trends, which might obscure differences between them. We use a subset-plot method developed by Cox (2010). This graphical display has the advantage of showing all the data (not fitted values or just averages), so if there are differences in outliers or in the variance that are inapparent in other methods, this exercise can help to identify them. Panel A of Figure A.2.6 in the Appendix shows that most of the non-coca-growing departments follow practically a parallel trend compared to most of the coca-growing departments during the period of analysis. Note that almost all the blue points corresponding to the non-coca departments in Panel A of Figure A.2.6 overlap the orange dots of the treatment group before 1999. Panel B of Figure A.2.6 displays that despite a few coca-growing departments (blue points) followed a similar trend to those in the control group (orange points) even after 2000, most coca-growing departments exhibited notable observational changes during the years of PC. Note that most blue dots there cease overlapping the orange ones indicating significant changes in their trajectory after 1999. Furthermore, the differences by construction in the composition of the treatment group validate the triple difference approach we have used to compare within the coca-growing producing departments.

Finally, a third way to analyze the parallel trend assumption is to squash the data into the annual means in each group and then plot each group's trend line separately. This exercise is similar to that fitted trends comparison we used in Figure A.2.5, except that this third approach does not impose a linear model on the changes in the value of legal agricultural production over time. Figure A.2.7 shows that the parallel trend assumption reasonably fits in the context of the present study, which is perhaps the most critical assumption to ensure the internal validity of DID models. Therefore, this study provides some statistical evidence that, in the absence of the anti-drug policies under PC, the difference in the legal agricultural production value between coca-growing departments and non-coca-growing departments would have been relatively constant over time.

2.6. Conclusions

This paper presents evidence of the increase in the value of agricultural production in Colombian areas with coca cultivation following the introduction of a series of anti-drug and anti-illicit crop production policies under Plan Colombia. The popular press and academic literature have investigated the relationship between coca crop eradication and anti-drug governmental strategies to reduce Colombian coca cultivation and cocaine supply. Still, there is practically no empirical or direct quantitative evi-dence on the link between such policies and their impact on the value of legal agricultural production in the coca-growing areas. This research presents unique evidence of the increase in the legal agricultural GDP mainly because of the interdiction of coca base/paste and cocaine-processing facilities policy in Colombia (circa 2007). The increase in the value of legal agricultural production documented here is undriven by notable changes in the economic, geographical, or environmental conditions, nor preexisting trends in the GDP from agriculture or the agricultural sector itself. Instead, the interdiction policy of coca paste and cocaine-processing facilities in Colombia (circa 2007) has driven such an increase. More specifically, this study points out that the interdiction policy since 2007 in Colombia has boosted the value of producing conventional licit crops in the coca-producing departments. Previous studies have documented the counternarcotics policy of 2007 as the most effective strategy for reducing cocaine production and coca cultivation, which mitigates concerns about reverse causality. Coca-growing areas saw substantial drops in coca cultivation consistently from 2007 until 2013. The licit crop production or, more generally, legal agriculture of departments with areas under coca cultivation seems to have benefited from such policy, while legal agriculture in departments without coca cultivation was not. The estimates suggest that the agricultural GDP grew approximately 2.5% more per year in coca-growing departments since 2007 due to the interdiction policy. The results also indicate that the value of agricultural production in the coca-growing departments gained a monetary benefit from that policy of about US$284.2 million. Overall, our estimates roughly explain between 77% and 87% of the averaged differential increase in the value of legal agricultural production across coca and non-coca-growing departments over the 1999-2015 period. Most of this increase is driven by the interdiction policy, which explains about 68% of the total average differential increase among the two types of departments. These estimates can be considered the first ones linking the value of legal agricultural products directly to the effect of Plan Colombia’s policies aimed at curbing coca cultivation and cocaine supply. Based on the findings, efforts to reduce coca cultivation should emphasize anti-drug strategies in the stages of production and trafficking that generate the highest value-added. This assertion is particularly relevant for strengthening legal agriculture, at least in terms of its production value.

Table 2.1–Descriptive Statistics for Selected Variables in the 1995–1999 and 2000–2015 Periods

	Agricultural GDP	Real GDP	GDP per capita	% GDP in agriculture	Agricultural land	Rural Pop.	Mean Temp.	Mean Rainfall
Non-Coca-Growing Departments (*N*= 7)								
Pre-2000	901.2	5,809.6	6,321.7	15.9	128.2	919.0	292.9	10.5
	(112.9)	(437.2)	(6,049)	(0.91)	(20.90)	(72.3)	(0.45)	(1.21)
Post-2000	952.8	7,012.4	7,209.5	14.0	138.2	972.7	293.8	9.1
	(52.3)	(257.7)	(5,969)	(0.40)	(9.86)	(43.2)	(0.26)	(0.54)
Coca-Growing Departments (*N*= 24)								
Pre-2000	1,678.1	21,747	7,825.2	10.7	192.9	2,779.1	291.7	16.0
	(107.9)	(2,475)	(10,050)	(1.10)	(12.9)	(246.3)	(0.23)	(1.43)
Post-2000	1,891.3	28,390	9,236.1	8.9	181.2	3,073.8	292.2	14.3
	(76.4)	(2,011)	(12,546)	(0.48)	(5.75)	(160.3)	(0.13)	(0.75)

Notes: Averages are weighted by department total crop production in metric tons (standard errors are in parentheses). Variables are agricultural GDP in million 2005 USD, real GDP in million 2005 USD, GDP per capita in 2005 USD (in thousands), percentage of GDP in agriculture, agricultural land in thousand hectares, rural population thousand inhabitants, and the annual mean temperature and rainfall. Pre-2000 is the average between 1995 and 1999 for each variable; post-2000 is the average from 2000 to 2015 for each variable.

Table 2.2–PC's Policies and Value of Agricultural Production, 1995-2015, DID Benchmark Results

	Departments with coca cultivation					
					Triple-difference	
				Treatments interacted with linear trends	Indicators (Before PC) 1999	Indicators (During PC) 2000-15
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Aerial 2000	-0.0872	127.3*	192.9**	64.11	0.0423	0.00337
	[84.53]	[75.01]	[74.38]	[84.60]	[0.0269]	[0.00243]
Aerial 2000 × *trend*				42.14**		
				[19.89]		
Manual 2004	123.3*	219.0*	224.9*	189.1*	0.901***	0.0102
	[68.08]	[117.6]	[115.1]	[99.20]	[0.302]	[0.0104]
Manual 2004 × *trend*				29.87		
				[29.50]		
Interdiction 2007	295.3***	428.1**	384.2***	323.8**	0.149***	0.0132***
	[98.90]	[180.0]	[138.5]	[149.2]	[0.0219]	[0.00352]
Interdic. 2007 × *trend*				26.08**		
				[12.61]		
Region FE × year FE		✓	✓	✓	✓	✓
Baseline charact. × year FE			✓			
Observations	651	651	651	651	651	651
R-squared	0.874	0.882	0.896	0.882	0.889	0.883

Notes: Robust standard errors are in brackets (clustering at the department). The dependent variable is the real value of agricultural production (in 2005 USD). All regressions include a constant, department, and year dummies, and are weighted by total crop production (in metric tons). Treatment variables are dummies = 1 between 2000–2003, between 2004–2006, and after 2007 interacted with: dummy = 1 for coca-growing departments and = 0 otherwise (columns 1– 4); level of the corresponding indicator pre-PC (1999) × dummy = 1 for coca-growing departments and = 0 otherwise (column 5); annual level of the corresponding indicator × dummy = 1 for coca-growing departments and = 0 otherwise (column 6). Columns 2 to 6 control for region-specific time dummies. Column 3 controls for interactions of year dummies with baseline (1995) values of the following department characteristics: agricultural land, working-age population in rural zones, rate of internally displaced persons, rate of casualties, ratio of coca planted area to the national area under coca cultivation, per capita GDP (ln), the fraction of GDP in agriculture, the average level of temperature, the average level of precipitation, the proportion of permanent crops, the proportion of transitory crops, and the value of agricultural production.

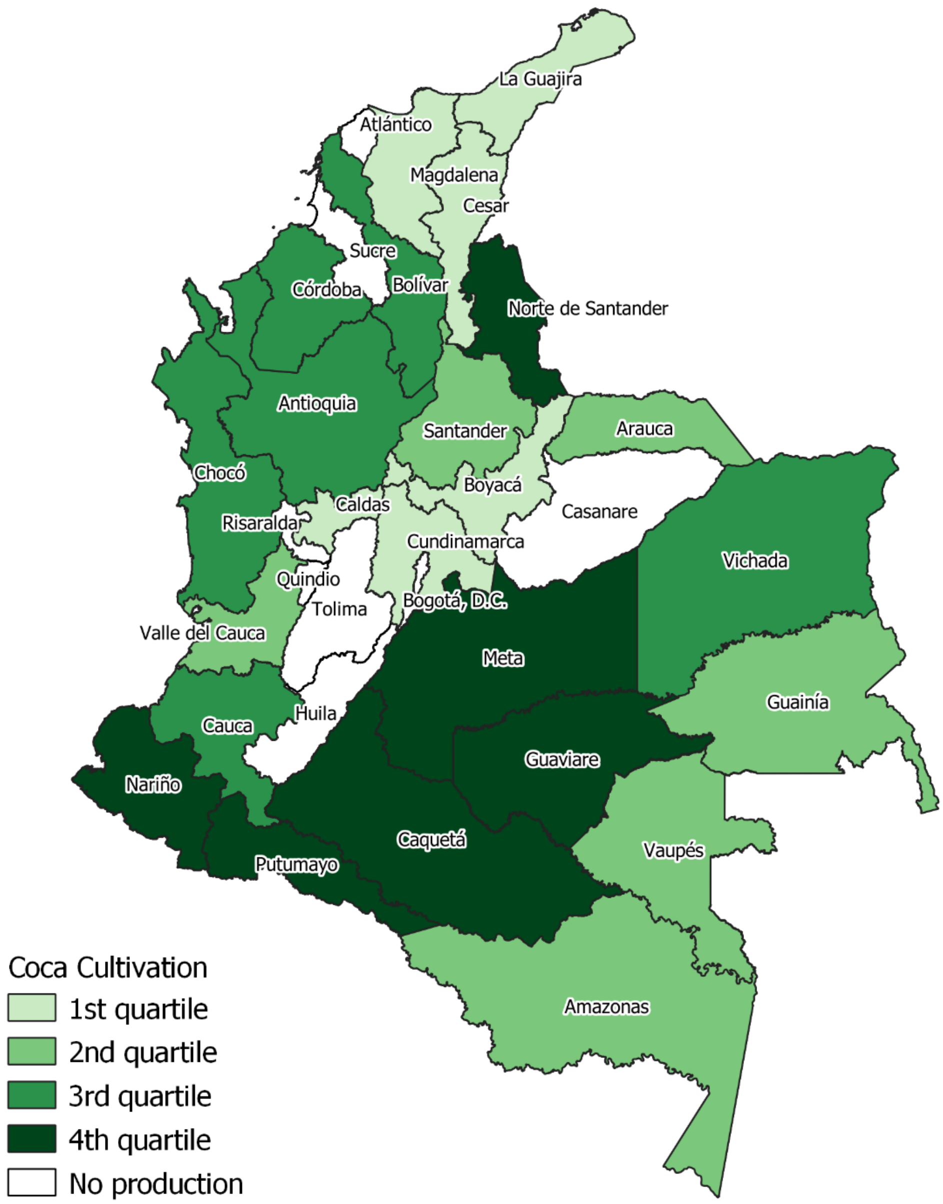
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 2.3—PC's Policies and AGDP, Testing Parametrically for Parallel Trends and Some Other Effects

	Effects on AGDP and parallel trends, 1995-2015				Other economic changes explaining the results, 1995-2015			
	Testing for pre-trend	Department linear trend	Dependent variable: AGDP		Dependent variable: GDP per capita		Dependent variable: Percent GDP in agriculture	
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Aerial$ 2000	8.159	33.67	-4.775	7.778	0.0551*	0.0557**	-0.00146	0.000551
	[75.46]	[108.3]	[96.22]	[110.2]	[0.0309]	[0.0259]	[0.00784]	[0.00974]
$Manual$ 2004	131.5**	183.3	118.6	148.7	0.115*	0.116*	-0.00597	-0.00240
	[61.60]	[117.8]	[82.83]	[119.6]	[0.0567]	[0.0663]	[0.00752]	[0.00946]
$Interdiction$ 2007	303.5***	400.3**	290.6**	350.8*	0.167*	0.169	-0.00414	0.00211
	[90.19]	[168.4]	[125.0]	[176.4]	[0.0894]	[0.118]	[0.0161]	[0.0190]
Placebo	20.62							
	[50.09]							
Department specific trend		✓		✓		✓		✓
Observations	651	651	527	527	651	651	651	651
R-squared	0.974	0.978	0.978	0.982	0.959	0.988	0.914	0.971

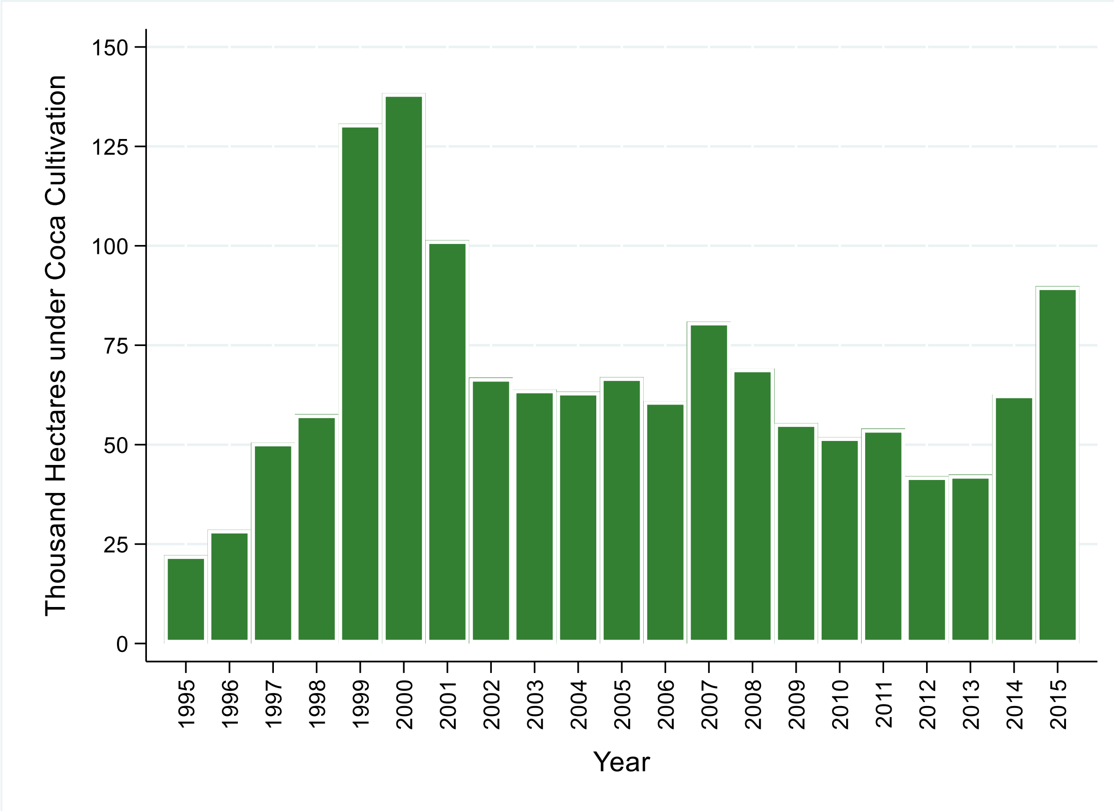
Notes: Robust standard errors are in brackets (clustering at the department). The dependent variable is the value of agricultural production (in million 2005 USD) in columns 1– 4, the log of GDP per capita in columns 5–6, and the share of GDP in agriculture in columns 7–8. All regressions include a constant, department, and year dummies, and are weighted by total crop output in metric tons. Treatment variables are dummies = 1 between 2000–2003, between 2004–2006, and after 2007 interacted with the dummy of the coca-growing department. Pre-2000 placebo is a dummy for 1995–1999 interacted with the coca-growing department dummy. Columns 2, 4, 6, and 8 include, as additional controls, interactions of department dummies with a linear time trend.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Figure 2.1−Coca Plantation Intensity in Colombian Coca-Growing Departments



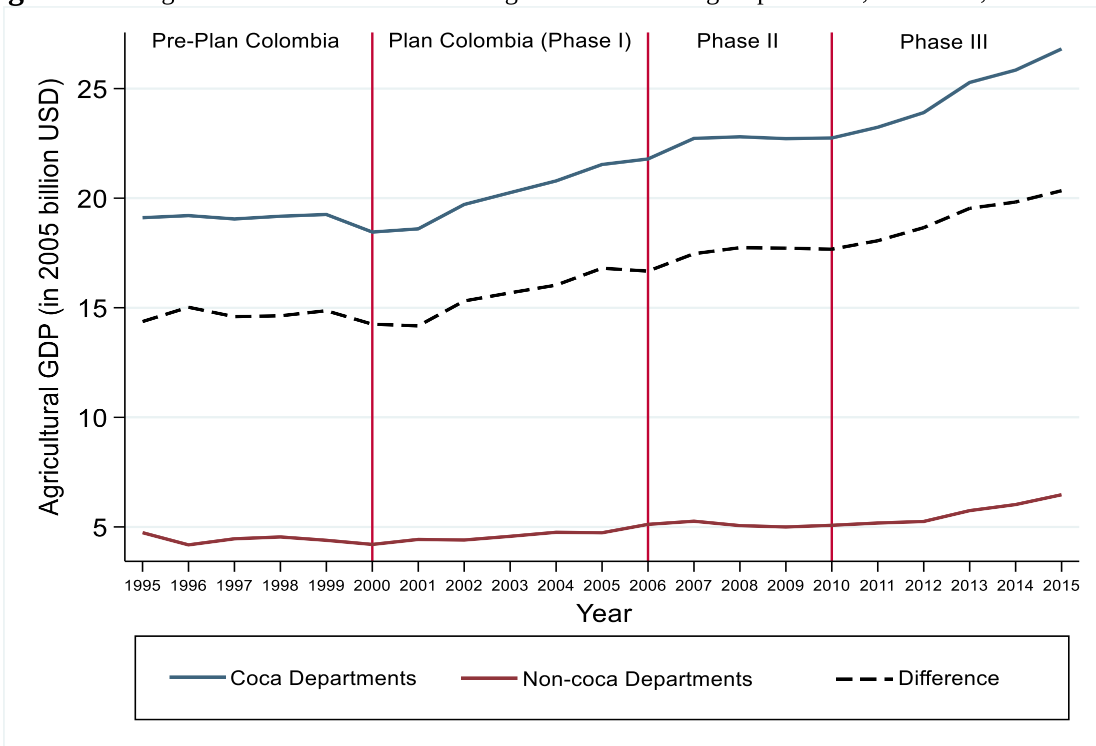
Source: Own calculations based on data from UNODC.

Figure 2.2−Annual Coca Crops in Coca-Growing Departments of Colombia, 1995-2015



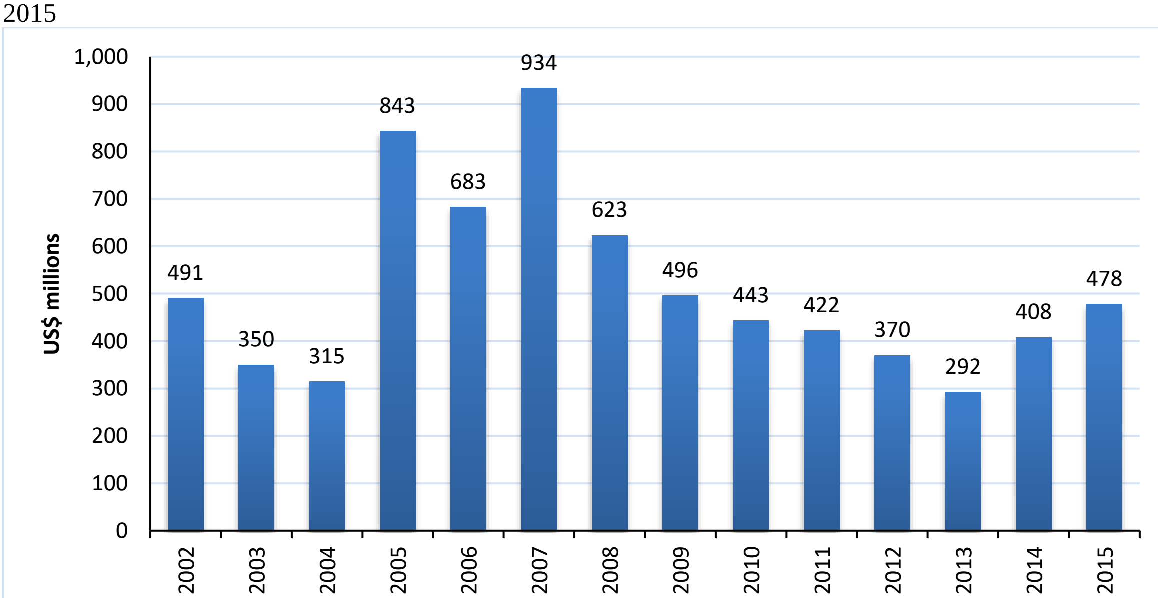
Source: Own calculations based on data from UNODC.

Figure 2.3—Agriculture GDP in Coca-Growing and Non-Growing Departments, Colombia, 1995-2015



Source: Own calculations based on data from DANE.

Figure 2.4—Total Estimated Value of Coca Leaf Production and Coca Derived Farm Products, 2002-2015

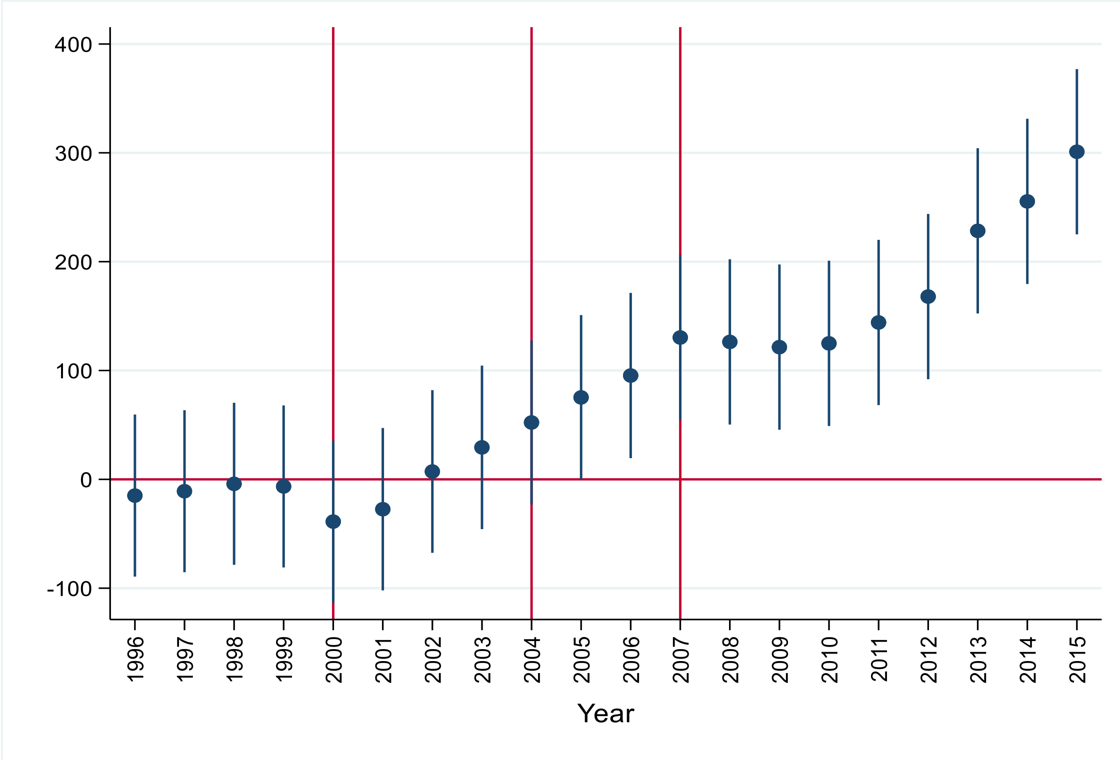


Source: Own elaboration based on data from UNODC.

Figure 2.5—Per Capita Gross Income from Coca Production and Farmers Involved in Coca Cultivation

Source: Own calculations based on data from UNODC.

Figure 2.6—Timing of the Effects under Plan Colombia, All Coca-growing Departments, 1996-2015



Source: Own calculations based on data from EVA.

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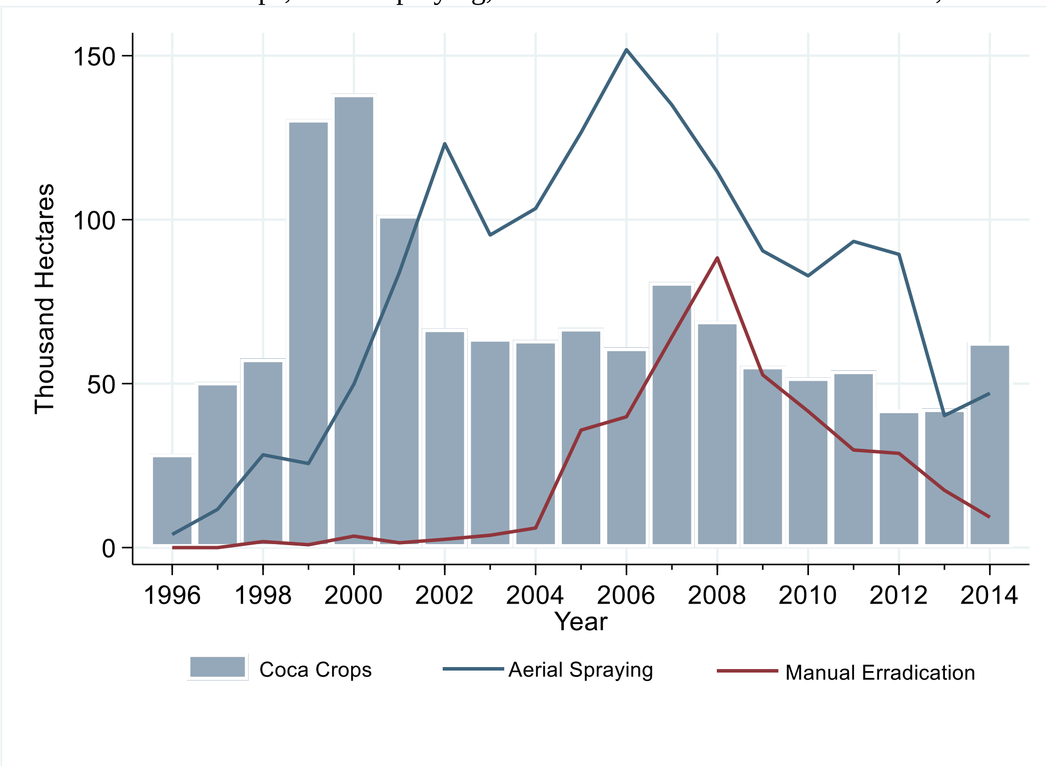
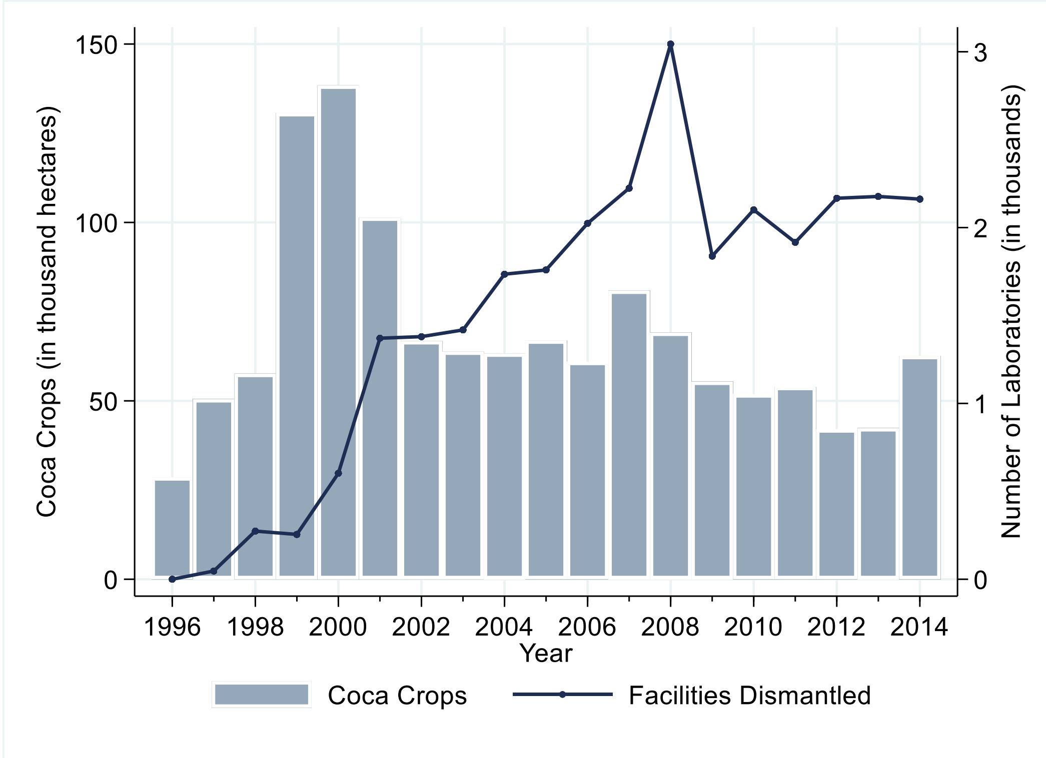
APPENDIX A

Figure A.2.1−Coca Crops, Aerial Spraying, and Manual Eradication in Colombia, 1996-2014



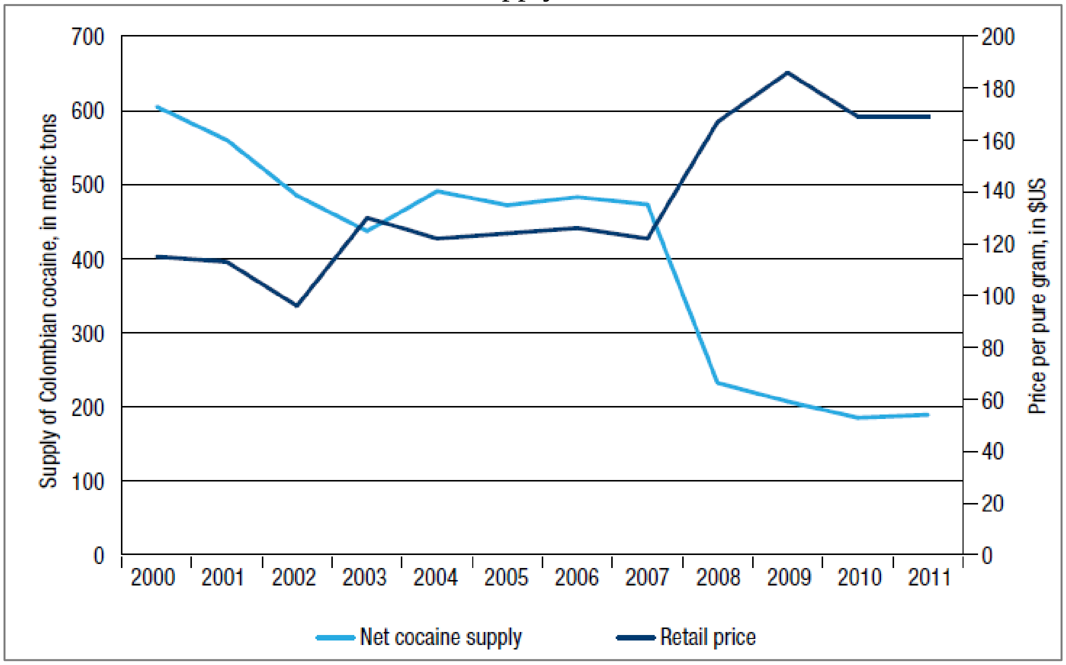
Source: Own calculations, based on data from UNODC and ODC.

Figure A.2.2−Number of Cocaine Processing Facilities Destroyed in Colombia, 1996-2014



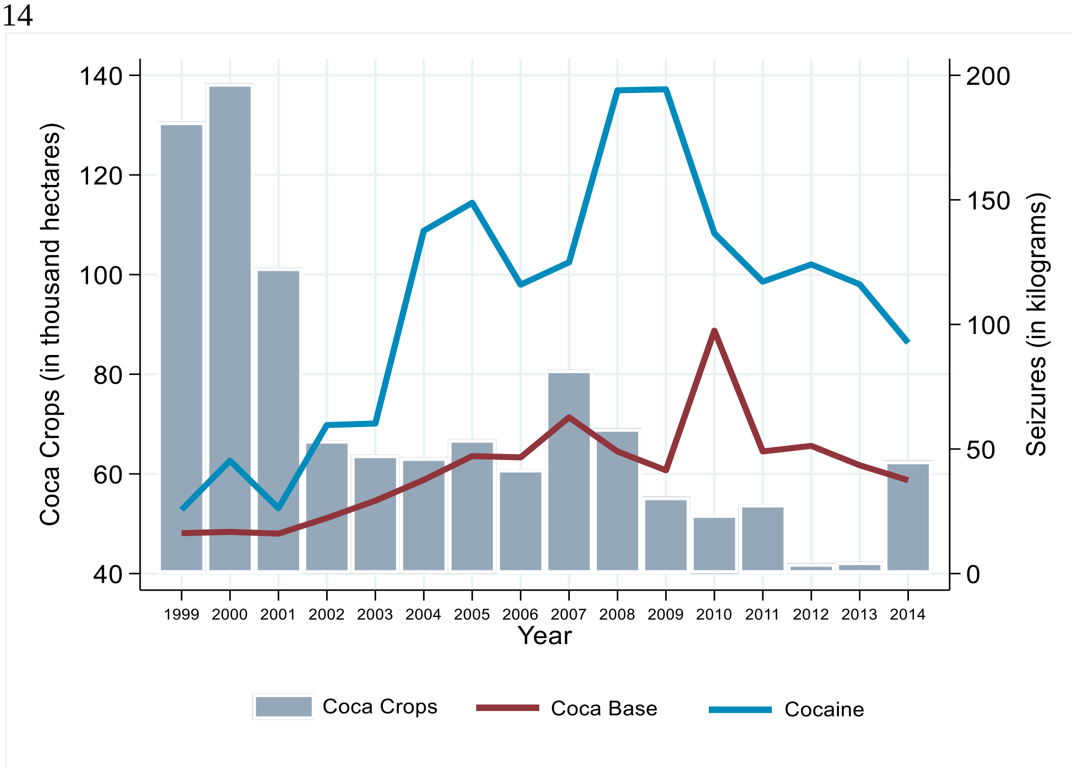
Source: Own calculations, based on data from UNODC censuses and surveys and ODC.

Figure A.2.3–Colombian Net Cocaine Supply and Cocaine Street Prices in the U.S.



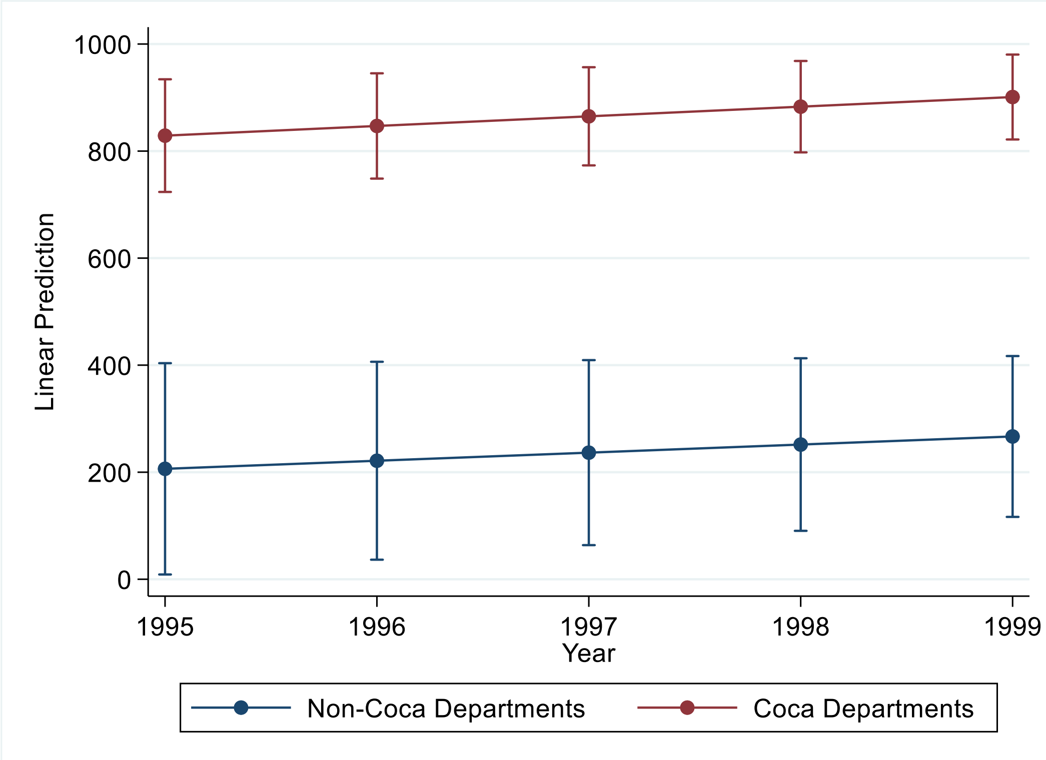
Source: Mejía (2015)'s calculations, based on data from UNODC and the government of Colombia.

Figure A.2.4–Coca Crops, and Coca Base and Cocaine Seizures in Colombia, 1999-2014



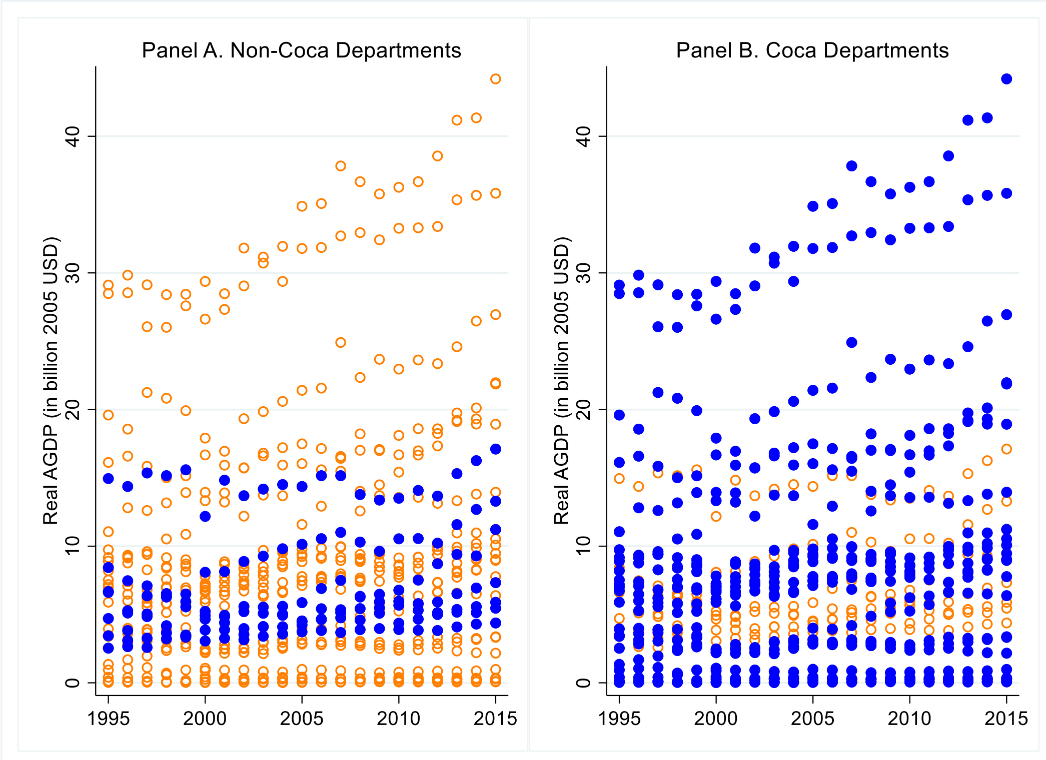
Source: Own calculations, based on data from UNODC and ODC.

Figure A.2.5−Predict Margins of Coca and Non-Coca Departments with 95% CIs, 1995-1999



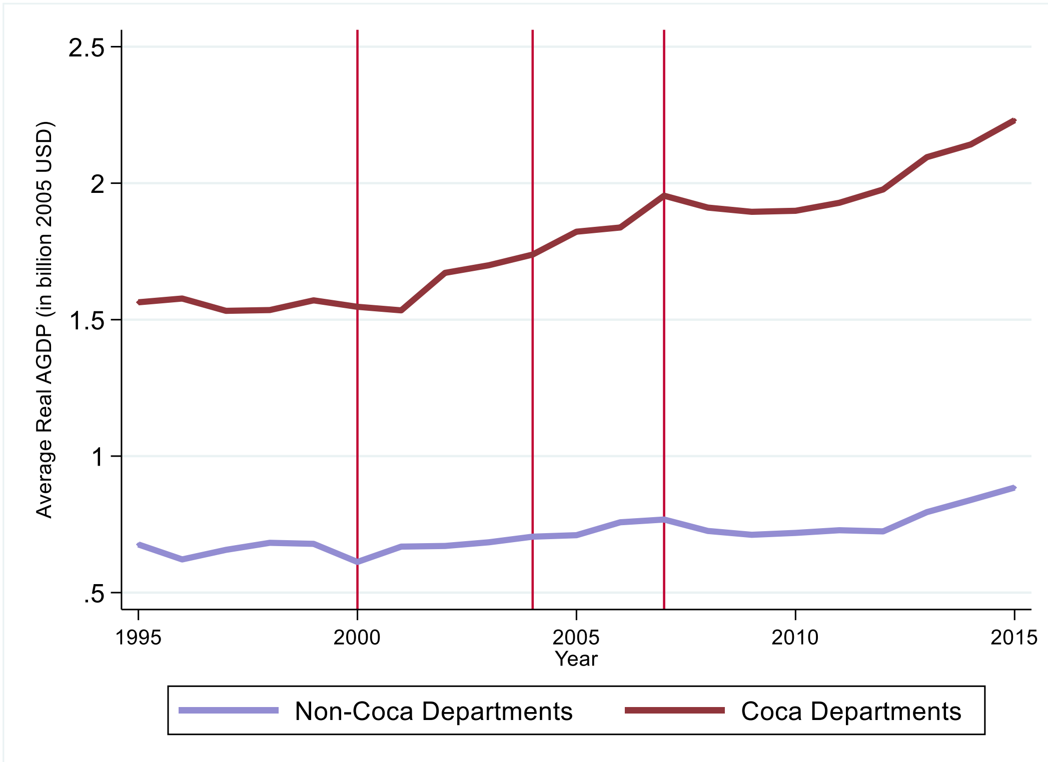
Source: Own calculations based on data from EVA.

Figure A.2.6– Real AGDP Comparison of Coca and Non-Coca Departments, 1995-2015



Source: Own calculations based on data from EVA.

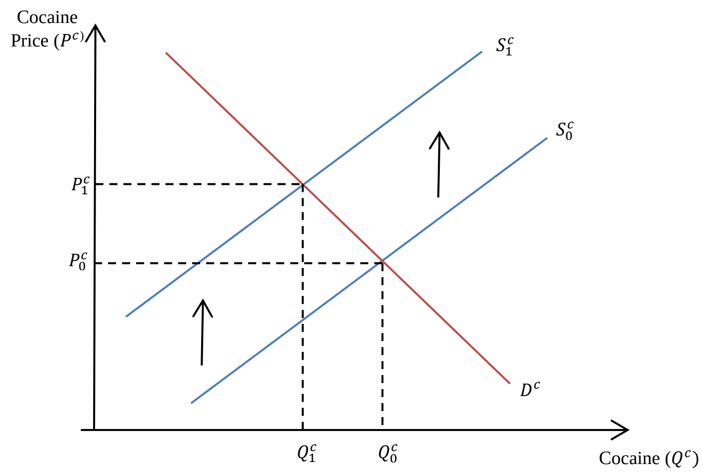
Figure A.2.7−Plot of Real AGDP of Coca and Non-Coca Departments, 1995-2015



Source: Own calculations based on data from EVA.

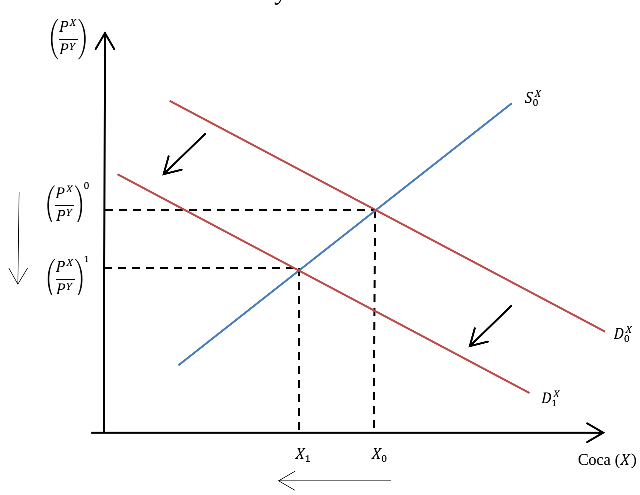
APPENDIX B

Figure B.2.1–Effect of Cocaine-Laboratory Interdiction-Supply-Reduction Policy on Market for Cocaine



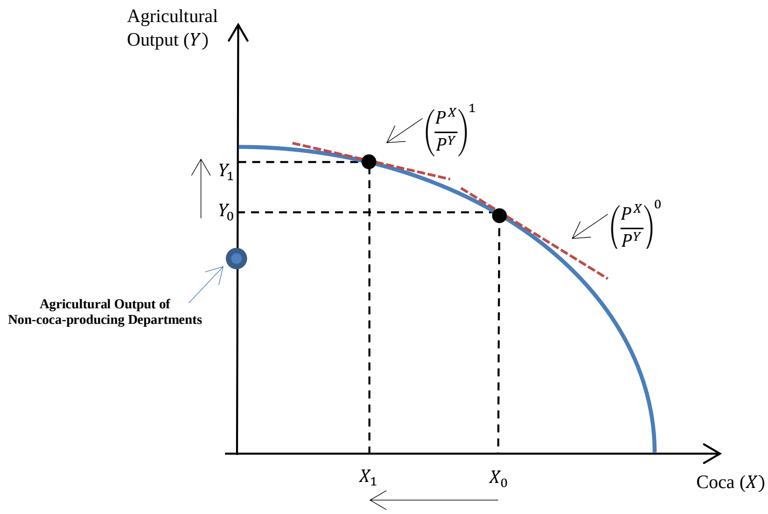
Source: Own elaboration.

Figure B.2.2–Effect of Cocaine-Laboratory Interdiction on Market for Coca Leaves in Colombia



Source: Own elaboration.

Figure B.2.3–Effects of Interdiction on Coca and Agricultural Production in Coca-Growing Departments



Source: Own elaboration.