

Agricultural Tariffs and Coca Crops: The Colombia-US Free Trade Agreement Case

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Abstract

Trade liberalization generates benefits in various aspects of an economy. Nevertheless, sectors like agriculture present difficulties in liberalization because of the need to adapt to the new competition. Consequently, trade policy may affect economic conditions and derive in incentives for illegal activities. Using municipal level data for Colombia, this research study the effect of trade liberalization in the agricultural sector on the dynamic of coca crops. Using a *difference-in-differences* strategy in the Colombia-US Free Trade Agreement framework, I find that municipalities that depend highly on the cultivation of the most sensitive crops present a differential decrease in the area covered with coca after the agreement implementation. The effect is consistent with incentives for agriculture from more market access and more imports of lower-price inputs. Exploring potential heterogeneities, I find that credit access drives the decrease in coca crops. Nonetheless, municipalities with more exposure to small farming have a lower impact. The results highlight the importance of trade, complemented with other policies, as a tool for development.

JEL classification: K42, O13, Q1

KeyWords: Agriculture; Illegal Markets; Coca; Colombia; Free Trade; Trade Policy

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Aranceles Agrícolas y Cultivos de Coca: El Caso del Tratado de Libre Comercio Colombia-Estados Unidos*

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Resumen

La liberalización comercial genera beneficios en varios aspectos de una economía. Sin embargo, sectores como el agrícola presentan dificultades en este proceso por la necesidad de adaptarse a la nueva competencia. En consecuencia, la política comercial puede generar afectaciones sobre condiciones económicas y derivar en incentivos para actividades ilegales. Utilizando datos a nivel municipal para Colombia, esta investigación estudia el efecto de la liberalización comercial del sector agrícola sobre la dinámica de los cultivos de coca. Usando una estrategia de *diferencias en diferencias* en el marco del Tratado de Libre Comercio Colombia-Estados Unidos, encuentro que los municipios que dependen en gran medida de los cultivos más sensibles, presentan una disminución diferencial en el área con coca después de la implementación del acuerdo. El efecto es coherente con los incentivos para la agricultura derivados de un mayor acceso al mercado y de mayor cantidad de importaciones de insumos a menor precio. Explorando posibles heterogeneidades, encuentro que el acceso al crédito impulsa la disminución de los cultivos de coca. No obstante, los municipios con mayor exposición a la pequeña agricultura tienen un impacto menor. Los resultados destacan la importancia del comercio, complementado con otras políticas, como herramienta para el desarrollo.

Clasificación JEL: K42, O13, Q1

Palabras Clave: Agricultura; Mercados Ilegales; Coca; Colombia; Libre Comercio; Política Comercial

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1 Introduction

There is the general idea that trade liberalization generates benefits in terms of economic growth, access to markets, improvement of efficiency and innovation, and competitiveness (Boudreaux & Ghei, 2017). Nevertheless, sensitive sectors like agriculture, have conditions that make the process of liberalization more difficult, mainly between developed and developing countries. Thus, trade policy decisions may have impacts on agricultural production and affect, for better or worse, aspects such as economic growth, poverty reduction, and food security, especially in developing countries (Byerlee, De Janvry, & Sadoulet, 2009; Dethier & Effenberger, 2011).

Although there may be significant benefits from agricultural liberalization (Zamroni, 2006; Fabiosa, 2008), there is a need for adjustment mechanisms that allow for better competition between countries to avoid potential adverse effects for agricultural production (Levy & Van Wijnbergen, 1995). Consequently, in developing countries where illegal activities are possible substitutes for legal markets, if liberalization negatively affects agriculture, there may arise incentives for the increase of illicit activities, which serve to cover farmers' losses. On the other hand, if liberalization generates better conditions for agriculture, illegal activities might decrease.

This paper studies the effect of agricultural liberalization on the dynamic of illegal activities. Specifically, I exploit the Free Trade Agreement (FTA) between Colombia and the United States (US) to find the effect of the agricultural tariff reduction scheme in the dynamic of coca cultivation in Colombia. I consider the most sensitive crops that remain highly protected for more extended periods so farmers can adjust to external competition. Using a *difference-in-differences* strategy, I find that municipalities that are sensitive to the production of the most sensitive crops in the FTA framework had a decrease in coca crops relative to municipalities with low sensitivity. Although desired, the effect is unexpected as long as the FTA did not have the direct objective of impacting illegal activities.

The results are consistent with trade benefits related to market access (Romalis, 2007; Zahonogo, 2016) and more imports of lower-price agricultural inputs (Boudreaux & Ghei, 2017), that can incentivize agrarian production instead of illegal activities. Besides, given that the tariff elimination for the most sensitive crops was not immediate, but designed for a long term reduction to allow for adaptation of farmers to the new market conditions, the FTA presented an opportunity to strengthen agricultural development.

Exploring potential drivers, I find that the effect was more negative in municipalities with higher access to credit, consistent with the welfare effects generated by financing opportunities in the agricultural sector (Hartarska, Nadolnyak, & Shen, 2015). Nevertheless, the decrease in coca crops was smaller in municipalities with a higher share of small farming, which is in line with literature stating that the main affected in a liberalization setting might be small farmers (Abbott, 2003; Zamroni, 2006). Surprisingly, variables related to illegal armed actors or state capacity do not drive the effects.

The previous results show that there are heterogeneous effects on how producers perceive the benefits of free trade. Additionally, I find that after the announcement of a substitution program in 2014 that led to an increase in coca crops (Mejía, Prem, & Vargas, 2019; Ladino, Saavedra, & Wiesner, 2019; Lopez, Guarín Núñez, Medina, & Zuleta, 2019), the effect of the FTA implementation disappears. This result shows that even if the FTA generated a differential decrease in coca crops, there is a need for more robust conditions to improve the agricultural sector to ensure that incentives for illegal activities will not surpass legal markets.

Policy implications from the results suggest the need for more trade as an instrument to promote development, as long as it can have unexpected but desired impacts in outcomes beyond the direct scope of trade policy. Nevertheless, liberalization must be accompanied by other complementary policies that seek to strengthen the context, conditions, and institutions around producers to obtain adequate benefits from trade policy (Zahonogo, 2016), and avoid affectations for specific groups of the population.

Colombia is a relevant country for this research. Agriculture accounts for 6.3% of the added value of Colombian GDP. Still, it represents 15.8% of the total occupied labor force, making it the second most important economic sector in terms of employment only after the retail industry (DANE, 2019). Moreover, agriculture generates employment for approximately 60% of the population in rural areas (DNP, 2019). On the other hand, 67% of the world's coca crops cultivated are in Colombia. Coca crops are the primary input for the production of cocaine. Consequently, Colombia is the leading producer of cocaine in the world (UNODC, 2018).

Furthermore, academic literature proves the relationship between agricultural aspects and illegal activities. Dube and Vargas (2013) find that negative price shocks in labor-intensive activities (including agricultural production) may generate an increase in conflict.¹ Also,

¹See also Bazzi and Blattman (2014) and Corvalan and Pazzona (2019).

Dube, García-Ponce, and Thom (2016) finds that price shocks in important crops can increase the area cultivated with illegal crops. This paper is more related to Dube et al. (2016) but contributes to the literature in the use of a permanent change given by the FTA and the tariff reduction scheme, rather than temporary price shocks.

The article also contributes to the literature about the effects of trade liberalization in developing countries, focusing on unexpected outcomes, with a special case of analysis from the FTA implementation and its effect on illegal crops. For the Colombian case, Bonilla and Munoz (2019) explores the effect of the import competition (exploiting the FTA implementation) on workers and firms. Also, previous research of the Colombia-US FTA has focused on the expected consequences of the agreement. Light, Rutherford, et al. (2003) and Gracia, Zuleta, et al. (2004) uses General Equilibrium Models to predict potential consequences from the FTA implementation. They find that given that Colombia already has preferential access to the US market, FTA benefits are small.

Finally, the document seeks to contribute to the literature on the risk factors that affect coca cultivation. Coca has a direct relation with conflict given that is assumed to serve as a financing source for illegal armed groups (Ross, 2004; Angrist & Kugler, 2008). The relationship between illicit crops, drug trafficking, and violence, maintains coca to be a problem for the Colombian government. Forced eradication efforts have not been effective in reducing coca (Moreno-Sanchez, Kraybill, & Thompson, 2003; Reyes, 2014), and the implementation of substitution programs have shown to decrease coca crops (Ladino et al., 2019).

The remainder of the document is divided as follows: the next section presents a review of the context of the Colombia-US FTA, illicit crops in Colombia, and how trade policy might affect illegal cultivations. The third section presents and describes the data, the fourth explains the empirical strategy, the fifth section presents the results, and the last section concludes.

2 Context

2.1 Colombia-US Free Trade Agreement

In the 90s decade, Colombia began an economic opening process. The first approach in terms of trade between the US and Colombia was the Andean Trade Preference Drug Eradication

Act (ATPDEA). The US eliminated tariffs for several products to incentivize exports and strengthen drug fighting in Latin America.² The second approach to trade between Colombia and the US was the negotiation of a Free Trade Agreement (FTA), which is assumed to be the most important of Colombian history (Cano-Sánchez, 2013) as the US has been the leading trade partner of the country (Romero, 2006).

The FTA was approved in 2006 and implemented by the Colombian government in November of 2010.³ While tariffs were reduced for manufacturing, services, and mining sectors (Bonilla & Munoz, 2019), agriculture had a special treatment that consisted of longer stages for tariff reduction for the most sensitive crops, considering the need for farmers to adapt to US import competition. Colombia asked for more extended tariff elimination periods for rice, maize, bean, and sorghum ("sensitive crops" from now on), all of which have more than ten years of tariff elimination. The crops were selected, taking into account the importance they have for the national agricultural production and the lack of competition capacity against US imports.

Table A.1 describes the ad-valorem tariffs and the period for which it will be zero. The tariffs used for the agreement are based on the previous year's duties. All of the sensitive crops had high levels of protection even before the FTA implementation. For maize and sorghum, the elimination consists of yearly reductions for 12 years. For bean, the removal has a period of 10 years. In the case of rice, the tariff value remains invariant until year 6 of the implementation. Since then, the tariff begins to decrease for 13 years. Given the reduction mechanism, in the short term, the sensitive crops remain highly protected.

2.2 Illegal Crops in Colombia

The second half of the twentieth century in Colombia saw the birth of left-wing guerillas such as Fuerzas Armadas Revolucionarias de Colombia (FARC) and Ejército de Liberación Nacional (ELN); and right-wing paramilitary groups such as Autodefensas Unidas de Colombia (AUC). For these armed actors, illicit crops represent the primary input for drug fabrication and traffic, which serve as one of their most important income sources. In the Colombian case, the main illegal plantation is coca, which is the primary input in the creation of co-

²Apart from Colombia, countries included in ATPDEA were Bolivia, Peru, and Ecuador, all of which also had drug trafficking problems.

³The US effectively implemented the agreement in 2012, after Colombia. Nevertheless, given previous trade agreements such as ATPDEA, the US already had lowered (or eliminated) tariffs. Then, no changes in trade are expected due to US implementation. See (Bonilla & Munoz, 2019).

caine hydro-chloride. Thereby, coca crops strengthen existing conflicts, since they serve as a funding source for insurgent groups (Ross, 2004; Angrist & Kugler, 2008).

Colombia became the leading coca leaf grower in the world (UNODC, 2018) after the sudden decline of coca in Peru and Bolivia due to state interventions (Laserna, 2009; Thoumi, 2009) and the expansion of the armed conflict (Torres, Díaz, et al., 2005; Mejía & Posada, 2008). Although the government developed actions to reduce coca crops such as forced eradication (Mejia, Restrepo, & Rozo, 2015) or substitution programs (Mejía et al., 2019; Ladino et al., 2019), coca remains to be a prevalent problem for Colombia.

Moreover, coca is an alternative for replacing legal crops as can be cultivated with relative ease. Coca can grow in low-quality soil; it is resistant to weather and pests; it can be harvested from three to six times a year; and requires little infrastructure for transport to different parts of the territory (Mansfield, 1999; Dion & Russler, 2008). Also, the economic structures of farmers in coca regions depend on both coca crops and traditional cultivations (UNODC, 2008; ODC, 2010).⁴ Given the dependence of farmers on both coca and legal crops, the Colombian government asked for the special treatment in tariff reduction for the most sensitive crops to reduce the risk of coca cultivation (Villarreal, 2012).

2.3 From Free Trade to Illegal Crops

Depending on the benefits obtained from trade, liberalization can shape the incentives of the production of an economy. How trade affects output in a particular sector, would also impact the production decisions of potentially substitute activities. Consequently, although the FTA implementation with the US does not have the objective of directly impact coca cultivation, to the extent that legal and coca crops can be substitutes, how the FTA affects agriculture might also generate impacts on the dynamic of coca crops.

It can be expected that free trade allows for access to new markets, which leads to higher rates of economic growth for developing countries (Romalis, 2007; Zahonogo, 2016). On the other hand, free trade can generate lower costs on imports (Boudreaux & Ghei, 2017), lower prices in necessary inputs for domestic production, and enhance productivity levels for the users of the imported goods (Amiti & Konings, 2007). As long as the fulfillment of these mechanisms can shape the incentives for production, it implies that the FTA implementation might not affect agricultural conditions.

⁴Panels in Figure A.1 maps the geographic location of coca and the sensitive crops.

Nevertheless, while the consequences of the FTA's implementation are favorable for the US, in terms of more access to markets (Jurenas, 2010), benefits for Colombia are not clear. Light et al. (2003) document that the FTA can generate gains in welfare for consumers in Colombia, however, Gracia et al. (2004) recognizes that with the welfare gains, the FTA may increase income inequality, and negative consequences may arise for production in sensitive sectors such as agriculture, generating higher poverty and unemployment (Romero, 2006).

Salamanca, Gómez, and Landínez (2009) highlight the sensitivity for the agricultural sector, as previous FTA kept protected crops, then, there has no been an improvement process in agriculture; and, considering that a condition for the agreement consist in the elimination of tariffs for sensitive products.⁵ Then, following the literature, liberalization might also have negative consequences in terms of lower crop cultivation and production, especially for those that directly compete with US crops (Suárez Montoya & Barberi Gómez, 2015).

Depending on how the FTA impacted agriculture, one can expect positive or negative effects on coca crops. Figure 1 presents the dynamic of variables related to the agricultural sector that might react to the implementation of the FTA. Panel 1a shows the evolution of the agricultural production in Colombia. It can be observed that it presents an increasing trend after the FTA implementation. Although it might not be significant, there has no been great affectations for the aggregate production after the FTA implementation.

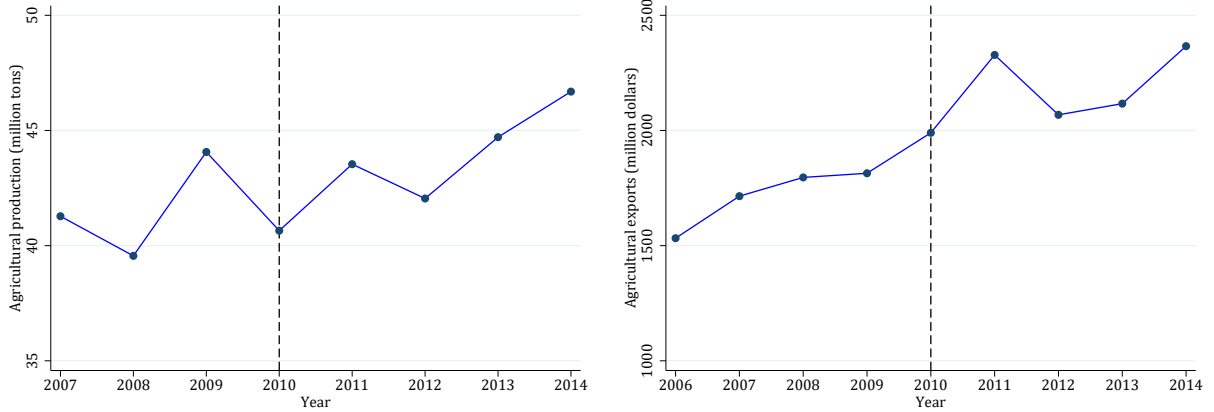
In terms of market access, Panel 1b shows the evolution of agricultural exports to the US. Given previous agreements, Colombia already had significant access to the US markets (Bonilla & Munoz, 2019). Nevertheless, the FTA implementation did not affect the increasing trend in the value of agricultural exports. Then, descriptively, the FTA did not appear to affect Colombian agricultural exports negatively. Even more, given the increasing export value trend, it can be assumed that there has been increasing market access for the Colombian agrarian sector.

Panel 1c presents the evolution of fertilizer imports from the US, which are essential inputs for agricultural production. The figure shows that after the FTA implementation, there was a significant increase in the total imported value. This increase is consistent with the mechanism mentioned by (Amiti & Konings, 2007), in which lower tariffs promote imports of lower-price inputs, which can be an incentive for farmers to improve their production. Effec-

⁵Salamanca et al. (2009) also include in the reasons for potential adverse effects that the US is a trade partner that exceeds Colombian trade capacity; and the danger of distortions on prices and production, since the US supports exports with subsidies.

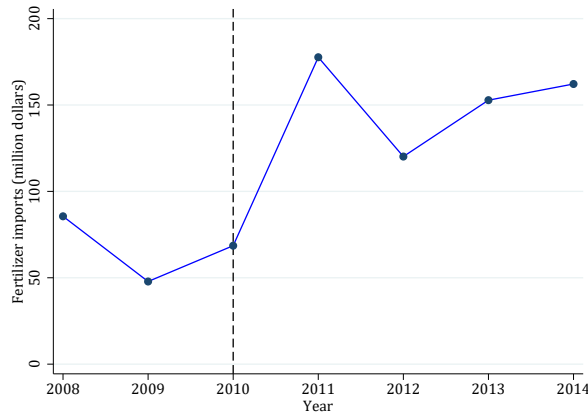
tively, the FTA implementation immediately reduced the tariff values for chemical fertilizers to 0.⁶

Figure 1: Evolution agricultural variables - Free Trade Agreement



(a) Agricultural production
(million tons)

(b) Agricultural exports value
(million dollars)



(c) Fertilizer imports value
(million dollars)

Notes: agricultural production information was obtained from the Ministry of Agriculture of Colombia. Data on agricultural exports come from the information system of the World Integrated Trade Solution (WITS) of the World Bank. Fertilizer import values come from the Colombian Agropecuarian Institute (ICA). The black dashed line indicates the year of FTA implementation.

⁶National media mentioned that the reduction of tariffs for fertilizers might end with a "fertilizer import monopoly". <https://www.dinero.com/negocios/articulo/frenan-monopolio-importacion-insumos-agricolas/146137>. Also, the decrease in the trade cost would allow for more persons to import fertilizer and might decrease the perceived price for farmers. <https://www.portafolio.co/negocios/empresas/persona-podra-importar-insumos-agro-108690>.

Although the evolution of the variables' described can not be directly attributed to the FTA implementation (and their exploration goes beyond the scope of this article), the data show that there have been no critical affectations for the country's agricultural conditions after the agreement implementation. Thus, consistent with the trade mechanisms not affecting agriculture, it is expected that the FTA implementation generates a negative effect on coca crops. In any case, the existence of an impact on coca might be unexpected, as it was not the primary objective of the FTA.

Though, the literature that states adverse effects from the FTA is not necessarily opposed to this hypothesis, as trade is not necessarily a "win-win" relationship.⁷ Given the Colombian context, there might still exist heterogeneous effects that can influence the benefits perceived by farmers. Zamroni (2006) argues that the potentially affected in an FTA framework may be the small producers rather than medium and big producers. Zahonogo (2016) specifies that the FTA benefits can be perceived if the implementation is complemented with policies for the strength of public institutions and financial capacity. Finally, (Arias, Ibáñez, & Zambrano, 2014) finds that rural areas exposed to armed conflict can change farmers' incentives for cultivation.

3 Data

Data from different sources were collected to build a municipal level panel for 1.117 municipalities.⁸ The main analysis has its focus on the period between 2006 (that is the first period for which agricultural production data is available) and 2014, as previous research demonstrated that since 2014, coca crops increased in response to the announcement of a substitution program.⁹ The research is looking primarily for short-term effects, but I will also present results extending the study period to 2018, to check if the substitution program vanishes any effect. The dependent variable is a measure of coca crops, and the main estimations include municipal level control variables to isolate potential confounders. Table 1 present summary statistics for the variables.

Information on coca crops come from the *Integrated System for Illicit Crops Monitoring* (SIMCI) of the UNODC. SIMCI annually produces information in coca cultivation through

⁷Kudos to Paul Krugman on trade (for the most part). <https://www.aei.org/economics/international-economics/kudos-to-paul-krugman-on-trade-for-the-most-part/>.

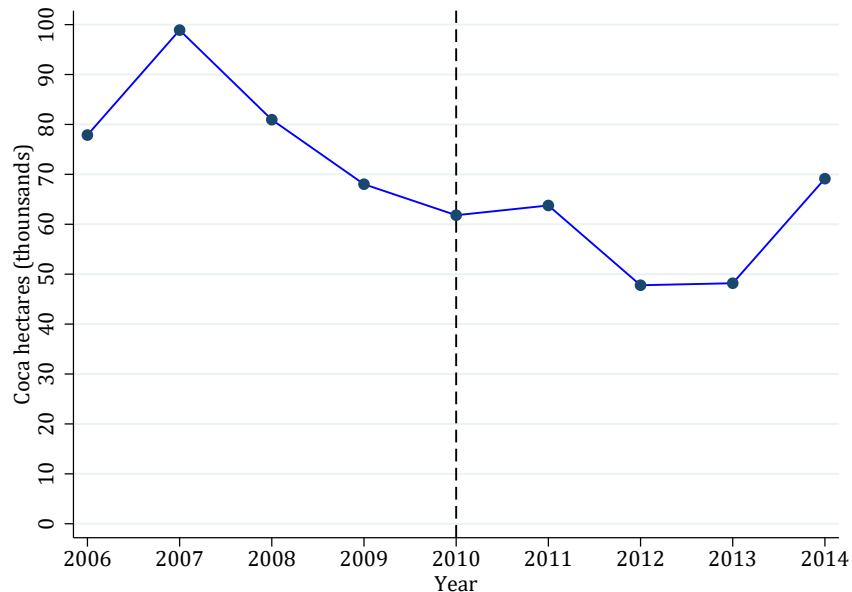
⁸Colombia has a total of 1.121 municipalities. Areas without agricultural production information are not considered for the analysis.

⁹See Mejía et al. (2019), Ladino et al. (2019) and Lopez et al. (2019)

satellite imagery, from which coca hectares are estimated and aggregated at the municipal level. The dependent variable is the percentage of the municipal area with coca crops, to account for municipal size, given that larger areas can have more hectares of coca crops.

Figure 2 describes the evolution of coca crops throughout the study period.¹⁰ Panel A in Table 1 presents summary statistics for the coca related variables. 24% of the municipalities cultivated coca ever before the FTA implementation. Once implemented, the municipalities that had coca at some point increase to 25%. In terms of the municipal area, the average area covered with coca crops is 0.035% in 2006. When limiting the sample to the municipalities that had coca ever before the FTA implementation, the average municipal area covered with coca crops increases to 0.15%.

Figure 2: Evolution of coca crops hectares



Notes: the black dashed line indicates the year of the FTA implementation.

Information about agricultural production in Colombia comes from three different sources. Data on agricultural production in tons for several crops were obtained from the *National Ministry of Agriculture*. To make production between crops comparable, data on current prices were obtained from the *Agricultural Prices Information System*, of the National Department of Statistics (DANE) and the *Information System on Producer Prices* of the Food

¹⁰Figure A.2 extends the evolution of coca crops to 2018.

and Agriculture Organization of the United Nations (FAO).¹¹ I calculate the production value in pesos for each crop from the data on quantities and prices.

The treatment variable is a dummy that divides municipalities between high/low sensitivity base on the median of a measure of agricultural importance in the FTA framework. I calculate it for 2006, which is the first period of the study. Using a pre-treatment period for treatment definition avoids potential endogeneity if there is a change in production resulting from the FTA implementation. Also, using 2006 avoids possible anticipation effects due to FTA signing. The agreement was signed on November 22. The final production in 2006 would not be significantly affected by anticipation effects. The treatment is based on the following equation:

$$WeightedShare_m = \sum_{s=1}^4 \frac{ProdValue_{sm}}{TotalProdValue_m} \times Tariff_s \quad (1)$$

Where s , m represents sensitive crop and municipality, respectively. s goes from 1 to 4 for each of the sensitive crops (rice, bean, maize, sorghum). $ProdValue_{sm}$ corresponds to the production value for each of the sensitive crops in the municipality m , $TotalProdValue_m$ is the total agricultural production value for municipality m , and $Tariff_s$ is the ad-valorem base tariff for each of the sensitive crops. The formula corresponds to a weighted average in which the tariff value weights for the most sensitive crops. The variable considers the importance of the sensitive crops in each municipality's agricultural production and the trade importance given by the tariff value for each sensitive crop. The variable might be interpreted as a sensitivity measure of agricultural production in the FTA framework.

The treatment variable is based in $WeightedShare_m$ and is a dummy that equals 1 for municipalities above the median (0 otherwise).¹²

¹¹FAO collects information from a variety of national sources to build a dataset of prices for several crops. DANE gathers data directly from producers to approximate the price that the producer receives from crops. FAO prices were used if DANE had not reported information for specific products. For example, for sensitive crops such as sorghum, given that DANE had not reported prices, FAO data were used. All the prices were adjusted deflating by the 2006 price index.

¹²Iacobucci, Posavac, Kardes, Schneider, and Popovich (2015a, 2015b); McClelland, Lynch Jr, Irwin, Spiller, and Fitzsimons (2015), and Rucker, McShane, and Preacher (2015) discuss the statistical implications of the median split of a continuous variable. While Iacobucci et al. (2015a, 2015b) argues in favor, McClelland et al. (2015); Rucker et al. (2015) argues against. In any case, the authors ask for caution when using a median split. Concerns arise due to potential type I and II errors. The Results section present robustness to ensure the strength of the main results.

$$Sensitive_m = \begin{cases} 1 & , \text{ if } WeightedShare_m > Median(WeightedShare) \\ 0 & , \text{ Otherwise} \end{cases} \quad (2)$$

The production can be differentiated between transitory and permanent crops. According to Argüello (2012), permanent plantations require higher levels of investment, land size, and more extended periods for harvest and production. Besides, they are harder to substitute. Transitory crops require less investment and are easier to replace, consequently, affordable for more farmers. The sensitive crops considered for the analysis are all transitory. Then, only transitory production is considered for the treatment definition.¹³

Figure 3 present the evolution of coca crops differentiating between municipalities with high sensitivity ($Sensitive_m = 1$) and low sensitivity ($Sensitive_m = 0$).¹⁴ After the FTA implementation, the gap between municipalities with high/low sensitivity seems to decrease. A simple regression framework show a negative correlation of the coca crops area after the FTA implementation.¹⁵ Then, a negative effect can be interpreted as a differential decrease of coca crops in the highly sensitive municipalities relative to low sensitive municipalities. For periods before the FTA implementation, trends appear to evolve similarly, except for 2007, where a coca area shift appears for the treated municipalities. The estimations include control variables to account for differences in the pre-trends between both groups.

Panel B in Table 1 presents descriptive statistics for the agricultural variables. Rice, Bean, Maize, and Sorghum Ever are dummy variables that indicate if the municipality had cultivations of the mentioned crops ever in the period. 95% of the municipalities had maize ever in the study period, which makes maize the most prevalent crop. It is followed by bean, for which 70% of municipalities had cultivation ever. Maize represents, on average, the 30% of the transitory agricultural production, while bean and rice represent both 12 %. Sorghum is the less prevalent crop between the sensitive crops considered for the analysis. When aggregating and weighting by tariff values, the average weighted share is 25%.

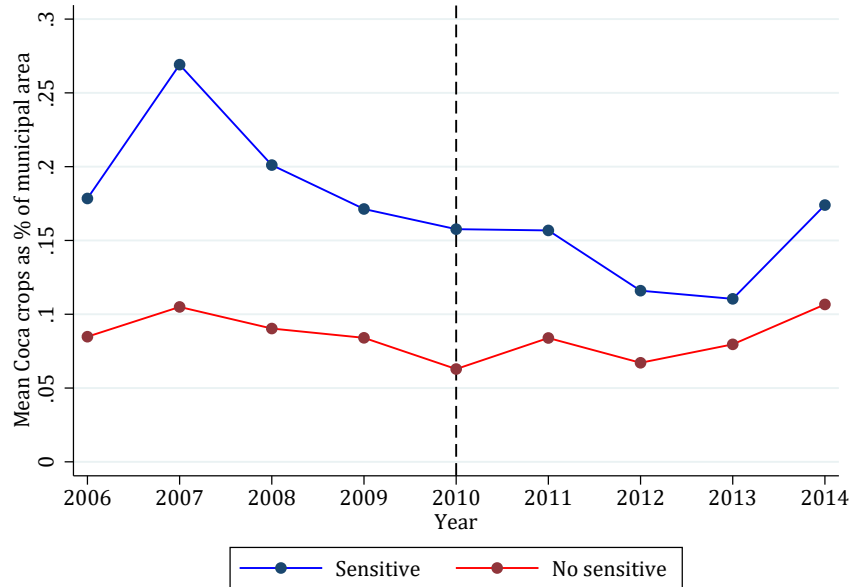
Other variables that may be related to coca production or agricultural production should be considered to isolate potential confounders for a correct causal estimation. Aerial and manual eradication are measured at the beginning of the study period to control for approximations

¹³I present robustness results when including all the crops for the treatment calculation and using only permanent crops as a placebo test.

¹⁴Figure A.3 extends the comparative evolution of coca crops to 2018.

¹⁵See Table A.2. The regression is used only for interpretation purposes.

Figure 3: Evolution of area with coca crops by high/low sensitivity



Notes: the black dashed line indicates the year of the FTA implementation.

to interdiction capacities¹⁶, considering that interdiction may generate differential trends between the treatment and control groups. The *National Ministry of Justice* reports data on eradication.

A set of socio-economic variables include the logarithm of the population living in rural areas and a poverty measure based on unmet basic needs, all measured before the FTA implementation. Geographical variables include an index of soil erosion and water sources to control by conditions that affect the production of legal and illegal crops. The previous data were obtained from the Municipal Panel of *Universidad de Los Andes*. Finally, conflict variables include paramilitary and FARC actions measured as the average actions for the periods before the FTA implementation. The events were obtained from Osorio, Mohamed, Pavon, and Brewer-Osorio (2019). Panel C in Table 1 present summary statistics for the control variables.¹⁷

¹⁶See Moreno-Sanchez et al. (2003); Bagley (2012); Reyes (2014) or Mejia et al. (2015) for discussion between eradication efforts and coca crops.

¹⁷Table A.3 present the differences in means for the control variables.

Table 1: Main variables - Summary statistics

	Mean	Median	Std. Dev.	Min	Max	Obs
Panel A. Coca variables						
Coca before FTA	.24	0	.42	0	1	1,117
Coca ever	.25	0	.43	0	1	1,117
Coca crops 2006 (% area)	.035	0	.16	0	2.2	1,117
Coca crops 2006 (% area Coca before FTA)	.15	.029	.3	0	2.2	263
Panel B. Interest variables						
Weighted Share	.25	.23	.24	0	.8	1,117
Sensitive	.5	0	.5	0	1	1,117
Rice ever	.3	0	.46	0	1	1,117
Bean ever	.7	1	.46	0	1	1,117
Maize ever	.95	1	.23	0	1	1,117
Sorghum ever	.11	0	.31	0	1	1,117
Rice share	12	0	29	0	100	1,117
Bean share	12	0	22	0	100	1,117
Maize share	30	13	36	0	100	1,117
Sorghum share	1.2	0	6.5	0	100	1,117
Panel C. Other variables						
Aerial erad. (% municipal area)	.11	0	.7	0	13	1,117
Manual erad. (% municipal area)	.063	0	.45	0	10	1,117
Rural population (log)	8.8	8.9	.86	5.4	11	1,113
Unmet basic needs	45	43	21	5.4	100	1,109
Soil erosion	1.9	2	1.1	0	5	1,057
Water sources	3.3	3.3	.55	0	5.6	1,057
FARC presence	.38	0	2.4	0	71	1,117
Paramilitary presence	.75	0	5.4	0	165	1,117

Notes: an observation is a municipality. Coca ever is equal to 1 if the municipality had coca ever in the study period. Coca bef equals 1 if the municipality had coca ever before the FTA implementation. Rice, bean, maize, and sorghum ever are equal to 1 if the municipality had the corresponding crop ever in the study period. Share for each crop correspond to the share of the production value measured in 2006. All *Other variables* are measured before the FTA implementation.

4 Empirical Strategy

The identification relies on a *difference-in-differences* strategy, that interacts with the time variable the measure of sensitivity. The estimation compares municipalities with a high/low sensitivity, before/after the FTA implementation. The equation is the following:

$$PctgCoca_{mt} = \alpha_t + \mu_m + \beta(Post_t \times Sensitive_m) + \gamma X_{mt} + \epsilon_{mt} \quad (3)$$

Subscripts m and t represent municipality and year, respectively. α_t and μ_m are year and municipality fixed effects. $Sensitive_m$ represents the dummy variable that equals one above the median of the municipal measure of the weighted share of the sensitive crops (as described in Data section), and $Post_t$ is the dummy variable for periods after the FTA implementation. The coefficient of interest is β , which captures the differential change of coca crops in municipalities with a high share of sensitive crops, relative to municipalities with a low share of sensitive crops after the FTA implementation.

X_{mt} is a vector of pre-treatment control variables that are interacted with time dummies to control for differential trends in the municipal attributes flexibly. The included control variables are measures of aerial and manual eradication, rural population, unmet basic needs (poverty), soil erosion, access to water sources and, FARC and paramilitary presence. All control variables are measured before the FTA implementation, as described in the Data section. ϵ_{mt} is the error term correlated by municipality and time and clustered at the municipal level.

Given that the *difference-in-differences* is a quasi-experimental approach, assumptions must be met to interpret the results as causal. For this setting, the assumption to be fulfilled is the "parallel trends". In the absence of the FTA implementation, coca crops would have evolved similarly for all the municipalities. To test for parallel trends, I estimate the following dynamic equation:

$$PctgCoca_{mt} = \alpha_t + \mu_m + \sum_{t \in T} \beta(t \times Sensitive_m) + \gamma X_{mt} + \epsilon_{mt} \quad (4)$$

The dummy variable for sensitive crops interacts with the time dummies for each period, using 2010 as the base year. If no pre-treatment coefficient is significant, it can be assumed that after controlling for several covariates, the difference in the outcome between municipalities with high/low sensitivity was evolving similarly before the FTA implementation. If the previous statement is fulfilled, and assuming nothing else happened that affected differentially sensitive municipalities, the parallel trends assumption can be presumed to be met. Thus, results can be interpreted as causal.

I also estimate a variation of the main equation, where the third term of interaction is included to explore heterogeneous effects as an approximation to potential drivers of the effect. The equation is the following:

$$\begin{aligned}
PctgCoca_{mt} = & \alpha_t + \mu_m + \delta(Post_t \times Sensitive_m \times Z_m) \\
& + \beta_1(Post_t \times Sensitive_m) + \beta_2(Post_t \times Z_m) + \gamma X_{mt} + \epsilon_{mt}
\end{aligned}
\tag{5}$$

The term Z_m corresponds to municipal measures of variables that I argue can generate heterogeneous effects. The coefficient of interest is δ , which accounts for the triple interaction between municipalities with high/low sensitivity, before/after the FTA implementation, and the covariate Z_m .

Specifically, I explore four groups of variables as potential explanations for the main effects. First, variables related to farm size and land distribution, as production capacity may affect the incentives to change to illegal crops in a free trade framework (Zamroni, 2006). Second, variables related to credit access, as fewer financial barriers may ease the development of agricultural production (Hartarska et al., 2015). Third, state capacity, as is related to coca crops, but is also a condition for effectively get benefits from trade liberalization (Zahonogo, 2016), and the presence of illegal armed actors, as is connected to the dynamics of coca crops, but also with the incentives related to the decision of cultivation (Arias et al., 2014).

5 Results

5.1 Main Results

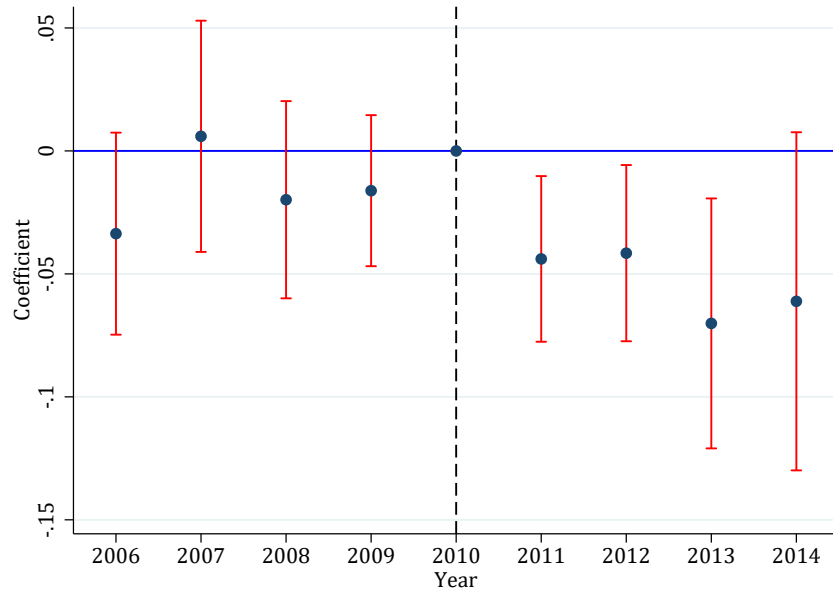
The main finding shows a negative effect on coca crops after the FTA implementation. Then, municipalities that depend more on the sensitive crops had a differential decrease in the municipal area with coca crops. The effect is unexpected, as the FTA did not have the direct objective of impacting illegal crops. However, the result is consistent with trade theory in which access to markets and cheaper imports of inputs incentivizes agricultural production instead of illicit cultivations. Moreover, given that the tariff reduction was not immediate, but in longer stages, it presents evidence that the tariff reduction mechanism has accomplished its objective to avoid the displacement of farmers to illegal crops, and might even be an opportunity for agricultural development.

To assess the validity of the parallel trends assumption, Figure 4 shows the results from equation 4 using 2010 as the base year. The regression results only consider municipalities

that had coca ever before the study period.¹⁸ The sample is limited to prevent potential bias from selecting municipalities that start cultivating coca after the FTA implementation. Each coefficient point represents the differential change (in percentage points) in municipalities with high sensitivity compared to those with low sensitivity.

After controlling for several covariates, there are no significant coefficients for periods before the FTA implementation. I conclude that the main assumption is fulfilled, and if no other event differentially affected sensitive municipalities, the results can be interpreted as causal. The post-treatment coefficients show that there are significant negative effects after 2010.

Figure 4: Event study differential coca cultivation by sensitivity - coca before treatment sample



Notes: the figure illustrates the event study for coca cultivation in municipalities with high/low sensitivity, using 2010 as the base year. The x-axis plots years and the y-axis plots the coefficients of each year interacted with the sensitive measure. The segment containing each point corresponds to the 95% confidence interval. The regression includes the set of control variables interacted with time dummies. Errors are clustered at the municipal level.

Table 2 present the results from the estimation of equation 3. All the specifications include time and municipality fixed effects, but they vary in the inclusion of control variables and the sample considered. The columns in the table report negative and significant effects.

¹⁸The graph correspond to the event study of column 6 in Table 2. Figure A.4 present the event study for the other specifications.

The estimation is robust to changes in the sample and the exclusion of control variables.¹⁹ Nevertheless, the preferred setup is in column (6), which shows a decrease in coca crops of 0.041 percentage points in municipalities with high sensitivity.

Then, in municipalities that depend highly on the production of sensitive crops, the FTA implementation generates a differential decrease of coca crops. I conclude that consistent with higher access to markets and more imports of agricultural inputs, the scheme of more extended periods for tariff reduction encourages a decrease in coca crops. The effect is significant and considerable in magnitude, given that it accounts for approximately 24% of the mean of coca crops before the FTA implementation.

Table 2: Difference-in-differences - main specification

Dependent variable:	Pctg of coca hectares					
	(1)	(2)	(3)	(4)	(5)	(6)
Sensitive X Post	-0.018*** (0.0045)	-0.0082** (0.0039)	-0.053*** (0.017)	-0.039** (0.018)	-0.055*** (0.019)	-0.041** (0.019)
Sample	All	All	Coca ever	Coca ever	Coca before	Coca before
N. of obs.	10,053	9,486	2,538	2,322	2,367	2,223
Municipalities	1117	1054	282	258	263	247
Mean of Dep. Var. before	0.038	0.039	0.15	0.16	0.16	0.17
R^2	0.77	0.84	0.74	0.82	0.74	0.81
Controls		x		x		x

Notes: all the regressions include municipality and year fixed effects. Standard errors, clustered by municipality, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Additionally, Table 3 shows the results using a sensitivity measure that weights the sensitive crops by the tariff values for the years after the FTA implementation, to explore if the reduction in the tariffs affects the results. Considering that the agreement defines the conditions for tariff reductions before the implementation, the use of tariff values after 2010 is exogenous to changes in the municipal area with coca crops.

It can be seen that the coefficients are similar to the one in the preferred set-up, and present small changes with the use of tariff values for years after the FTA implementation. The results are consistent with the slow process of liberalization and the high rate of protection in

¹⁹Iacobucci et al. (2015a) argues that the median split may cause misleading effects if independent variables are highly correlated, leading to a higher probability of type I error. See that even without including control variables, considering that *Post* is uncorrelated with *Sensitive*, the effects are robust, then type I error should not be a concern in this setting.

the short term. The results also reinforce the evidence about the importance of liberalization processes that allow farmers to adapt to new competition.

Table 3: Difference-in-differences - share of sensitive crops weighted by tariffs after FTA implementation

Dependent variable:	Pctg of coca hectares			
	(1)	(2)	(3)	(4)
Sensitive X Post	-0.0447** (0.0201)	-0.0447** (0.0201)	-0.0446** (0.0202)	-0.0382* (0.0203)
Tariffs year	2011	2012	2013	2014
N. of obs.	2,223	2,223	2,223	2,223
Municipalities	247	247	247	247
Mean of Dep. Var. Before	0.17	0.17	0.17	0.17
R^2	0.81	0.81	0.81	0.81

Notes: all the regressions use Coca Before sample, include municipality and year fixed effects, and control variables interacted with time dummies. Standard errors, clustered by municipality, are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.2 Additional Robustness

Table A.4 include a municipal/time-varying measure for aerial and manual eradication of coca crops. Although it might be endogenous to the area with coca crops, the results remain negative and significant, showing that the effects are not driven by the evolution of the government efforts for coca eradication. Table A.5 present the results using department/year fixed effects to explore a more saturated model, and account for department-level shocks in a given year. Although the effects in general stop to be significant, the coefficients are still negative. Moreover, it can suggest that the effects of the FTA respond individually at the municipal level.

Further robustness for the preferred specification are presented in Table A.6. Column (1) limits the sample to municipalities that had sensitive crops ever. This additional sample reduction eliminates municipalities that never had sensitive crops. Following Gelman and Park (2009), column (2) drops the sample between the 30th and 70th percentiles of the (continuous) treatment distribution, and compare the groups above the 70th percentile and below the 30th percentile, considering that extreme groups can be more comparable in categories.²⁰ The results are robust to changes in the sample.

²⁰Gelman and Park (2009) argues that dropping the sample is not as efficient. Still, it can be used as a supplementary result.

Column (3) uses the continuous form of the treatment variable. The result shows a differential decrease in coca crops of 0.09 percentage points as sensitivity increases after the FTA implementation. The result is higher in magnitude compared to the main result. Then, dichotomization leads to more conservative estimates in this setting.²¹

Column (4) uses the average weighted share for the periods before the FTA to establish the categorization between high/low sensitivity. Column (5) does the same, but including in the aggregate production value the permanent crops. Both are negative and significant. The previous results show that the main findings are robust to changes in the periods used for the treatment definition. Column (6) uses the same treatment as (5) without control variables and using the sample for which all the controls have the full set of observations, as there might be the concern of a sample exclusion effect. The results are robust and are not driven by sample exclusion.

Column (7) presents a treatment based on agricultural production as quantity instead of value. The result is robust to this specification. Column (8) uses a placebo treatment variable that considers only permanent crops²², as a test to check if permanent crop production has a relationship with coca crops after the FTA implementation. As expected, given the characteristics of permanent crop production, there is a non-significant effect. The result presents additional arguments for the use of a treatment variable based on transitory crop production.

On the other hand, following [Kahn-Lang and Lang \(2019\)](#), the functional form of the estimation is essential, especially when testing for parallel trends. Changes in the specification of the outcome may generate different results if there are important differences in the treatment and control groups' trends. Although the estimations include covariates to control differential trends, I re-estimate using a different functional form of the outcome as an additional robustness check.

²¹[Rucker et al. \(2015\)](#) ask for caution when using median splits, given the loss of power that may lead to type II error. Considering that the main result is smaller in magnitude than the continuous treatment effect, but still significant, it can be interpreted as a more conservative effect, and type II error should not be a concern in this setting.

²²Crops used for the permanent crop treatment are coffee (10% tariff reduction), banana (15% tariff reduction), cane (10% tariff reduction), and cocoa (10% tariff reduction), which are the most widely cultivated permanent crops along the study period. The treatment is constructed as described in the Data section. All of them had an immediate elimination of tariffs.

Figure A.5 replicates the dynamic estimation of equation 4, using as dependent variable the logarithm of the coca hectares.²³ Pre-treatment periods are still no statistically significant. Table A.7 present the average results using as the dependent variable, the logarithm of coca crops. The results are also robust on average and account for a change of approximately 29%. Equivalently, the effect accounts for a reduction of 0.05 percentage points of the municipal area with coca crops.

5.3 Heterogeneous effects

I find that the FTA implementation generates a decrease of coca crops in municipalities with a high sensitivity relative to municipalities with low sensitivity. Although consistent with benefits from trade, there still might exist conditions under which the farmers perceive different levels of benefits. To explore potential drivers for the results, I estimate heterogeneous effects using equation 5.

Farmer size and land distribution. According to Abbott (2003) and Zamroni (2006), small farmers might be the most affected by agricultural liberalization even if it generates benefits on average. It might be expected that municipalities with a high share of small farmers may present a smaller reduction in coca crops. To measure the exposure of small farming, I use the share of the municipal area used for small farming and the share of productive units for small farming (units of less than 10 hectares).²⁴

Land distribution is another concern for small farmers. Flores (2014) argues that for the Colombian case, the disputes over the land present vertical inequalities in which the dominant groups push the subordinate group to suboptimal conditions. It can be expected that variables associated with the distribution of land may also be related to a lower decrease in coca crops. To measure land distribution, I use the land Gini coefficient.

Table 4 present the results using the variables described. Column (1) and Column (2) show heterogeneous effects for a higher share of small farming areas and small productive units. Both present a significant and positive coefficient for the triple interaction, which shows that municipalities with high sensitivity and higher shares of small farming had a lower decrease in coca crops. Column (3) shows no significance for the triple interaction with the Gini

²³Logarithm + 1 to include observations for which the number of coca hectares is 0. A covariate of municipal size is included to account for municipalities that, given their size, can cultivate more coca.

²⁴The data were obtained from the *National Agricultural Census* from the Ministry of Agriculture. Although the information was collected ex-post the FTA implementation, it still shows trend and relationship with coca crops dynamics.

coefficient. Nevertheless, the result from column (3) is similar in magnitude to column (1) and (2). The results show that the size of the farm and production affect the benefits of the FTA implementation.

Table 4: Heterogeneous effects - Land distribution and farm size

Dependent variable:	Pctg of coca hectares		
	(1)	(2)	(3)
Sensitive X Post	-0.056** (0.024)	-0.14*** (0.047)	-0.17* (0.10)
Sensitive X Post X Small farming area (%)	0.19* (0.12)		
Sensitive X Post X Small farming unit (%)		0.17** (0.066)	
Sensitive X Post X Land gini			0.21 (0.16)
N. of obs.	2,223	2,223	1,719
Municipalities	247	247	191
Mean of Dep. Var. Before	0.17	0.17	0.18
R^2	0.81	0.82	0.83

Notes: small farming area is defined as the share of the municipal area used for small farming. Small farming unit is the share from the total number of productive units hat has less than 10 hectares. The interaction term between the mechanism and the time variable is used but omitted. All the regressions use the Coca Before sample, include municipality and year fixed effects, and control variables interacted with time dummies. Standard errors, clustered by municipality, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Credit access. Higher access to credit is associated with higher growth rates in the agricultural sector (Hartarska et al., 2015). For the Colombian case, Echavarría, Villamizar, Restrepo, and Hernandez (2017) found that access to credit has significant effects on agricultural production and poverty reduction. Then, municipalities with more access to credit might report a higher (more negative) decrease in coca crops due to more investment capacity. To measure credit access, I build variables indicating the number of credits per farmer and the credit value per farmer based on information of credits granted and the number of farmers per municipality.²⁵

Table 5 present the results. Column (1) and (2) estimates the triple interaction for the number of credits per farmer and the credit value per farmer. While the number of credits granted is not significant, the credits' value has a significant and negative coefficient.

²⁵Data from *National Ministry of Agriculture*.

Columns (3) and (4) present the results of using the number of credits per small farmer and credit value per small farmer, respectively. Both variables are negative and significant. The results are consistent with the situation in which higher access to credit incentivize agricultural production and discourages coca crops. Additionally, the results are in line with (Zahonogo, 2016), as better financial opportunities complement the FTA implementation in obtaining benefits from trade.

To further explore the importance of credit access, I estimate equation 3 using the credit variables as outcomes, to understand if high sensitive municipalities, after the FTA implementation are positively correlated with credit access. Table A.8 present the results. Columns (1) and (2) use as dependent variables the number of credits per farmer/small farmer, and columns (3) and (4) the credit value. The results show that high-sensitive municipalities have significantly more credit access levels than low-sensitive municipalities. The correlations are not significant (but are positive) for the overall of farmers. The results show that although financial capacities are important in general for agricultural strengthening, the need for financing is more important for small farmers, which are also the ones with lower capacity for adaptation to the new market conditions in a free trade setting.

Illegal armed groups presence and state capacity. The presence of illegal armed actors may have different effects on coca in this setting. Angrist and Kugler (2008) describes that the presence of illicit armed actors may contribute to the increase in coca cultivation as it is a financial source. On the other hand, Arias et al. (2014) found that violent shocks induced households to reduce investment in permanent crops and use more land for transitory. Depending on the case, positive or negative effects can be found from illegal armed groups' presence. I use the average number of events in which Paramilitary or FARC groups were involved from 2006 to 2010.

Related, Dion and Russler (2008) describes a higher probability of finding coca cultivations in places with lower state capacity. Municipalities in which the state is less capable of enforcing legal actions may be more prone to cultivate coca. In terms of trade, Zahonogo (2016) argues that for a correct perception of free trade benefits, there is a need for improvement in institutional capacity. If institutions affect how agriculture perceives the gains from trade, there might be incentives for coca cultivation even in the presence of market access and more import of inputs. Following Acemoglu, García-Jimeno, and Robinson (2015) I use the average number of public offices in a municipality as an approximation to state presence.

Table 5: Heterogeneous effects - Credit access

Dependent variable:	Pctg of coca hectares			
	(1)	(2)	(3)	(4)
Sensitive X Post	-0.036*	-0.033*	-0.035*	-0.035*
	(0.019)	(0.019)	(0.019)	(0.019)
Sensitive X Post X Cred/farmer	-0.011			
	(0.011)			
Sensitive X Post X Cred val/farmer		-0.0036***		
		(0.00089)		
Sensitive X Post X Cred/small farmer			-0.013***	
			(0.0047)	
Sensitive X Post X Cred val/small farmer				-0.0022***
				(0.00082)
N. of obs.	2,223	2,223	2,223	2,223
Mean of Dep. Var. Before	247	247	247	247
Municipalities	0.17	0.17	0.17	0.17
R^2	0.82	0.82	0.82	0.82

Notes: Cred/farmer is defined as the fraction between all the credits granted and the number of farmers in a municipality. Cred val/farmer is defined as the fraction of the aggregated value of the credits granted and the number of farmers in the municipality. Cred/small farmer and Cred val/small farmer corresponds to the same variables but for small farmers, defined as the productive units of size below 10 hectares. The interaction term between the mechanism and the time variable is used but omitted. All the regressions use the Coca Before sample, include municipality and year fixed effects, and control variables interacted with time dummies. Standard errors, clustered by municipality, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6 present the results using the variables described above. Column (1) and (2) consider the measures of FARC and Paramilitary presence, respectively, and Column (3) measures state capacity. The results show that the triple interactions for all the variables are not significant. The results are consistent with a situation in which neither the illegal armed actors nor the state presence has participation in the dynamic of coca after the FTA implementation. Nevertheless, the lack of significant effects for state capacity also relates to the need for stronger institutions for agricultural development.

5.4 Substitution Program Announcement

The main study period was limited to 2014, considering a substitution program's announcement, which led to an increase in coca crops. In this section, I briefly explore the results for the extended study period to discuss if the announcement may have affected the results after

Table 6: Heterogeneous effects - Illegal armed actors and state capacity

Dependent variable:	Pctg of coca hectares		
	FARC (1)	Paramilitary (2)	State presence (3)
Sensitive X Post	-0.047*** (0.017)	-0.047*** (0.016)	-0.032 (0.024)
Sensitive X Post X FARC	0.016 (0.021)		
Sensitive X Post X Paramilitary		0.0071 (0.012)	
Sensitive X Post X State presence			-0.025 (0.039)
N. of obs.	2,223	2,223	2,223
Municipalities	247	247	247
Mean of Dep. Var. Before	0.17	0.17	0.17
R^2	0.81	0.81	0.81

Notes: FARC and Paramilitary are measured as the average number of events in which each group was involved before the FTA implementation. State presence is a dummy that equals 1 if the municipality is above the median of the average number of public offices. The interaction term between the mechanism and the time variable used but omitted. All the regressions use Coca Before sample, include municipality and year fixed effects, and control variables interacted with time dummies. Standard errors, clustered by municipality, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

2014. The program consists of benefits for farmers in exchange to voluntarily eradicate their coca crops. The benefits include cash transfers, in-kind transfers, and technical assistance for agricultural projects. Recent literature about the program announcement has proved that farmers increase coca crops in response to the announcement, in expectation to have the benefits from the program.²⁶

Figure A.6 extends the periods of analysis to 2018. It can be seen that after 2014, the effect stops to be significant. Table 7 present the average results from equation 3. Columns (1) and (2) estimate the average effect for all the periods. None of the columns present significant results. Columns (3) and (4) present a variation of equation 3, in which the effects are estimated separately for the periods between the FTA implementation and the substitution program announcement (*PostFTA*), and the periods after the announcement (*PostAnnouncement*). The effect for periods after the FTA implementation but before the announcement showed significance, as in the preferred estimations. Nevertheless, the significance disappears after the program's announcement.

²⁶See Mejía et al. (2019), Ladino et al. (2019) or Lopez et al. (2019).

Table 7: Difference-in-differences - extended analysis

Dependent variable:	Pctg of coca hectares			
	(1)	(2)	(3)	(4)
Sensitive X Post	0.0082 (0.048)	-0.039 (0.050)		
Sensitive X Post FTA			-0.057*** (0.019)	-0.043** (0.020)
Sensitive X Post Announcement			0.073 (0.086)	-0.035 (0.084)
N. of obs.	3,419	3,211	3,419	3,211
Municipalities	263	247	263	247
Mean of Dep. Var. before	0.16	0.17	0.16	0.17
R^2	0.58	0.73	0.58	0.73
Controls		x		x

Notes: all the regressions use the Coca Before sample, and include municipality and year fixed effects. Standard errors, clustered by municipality, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results show that farmers of sensitive crops might be incentivized to react to the program's announcement to expect future benefits. This intuition might explain the disappearance of the results after 2014, even if the FTA showed to decrease coca crops differentially. Moreover, it suggests that incentives from the program announcement surpassed the opportunities for agriculture generated by the FTA.

Given the sensitivity of the agricultural sector in the face of US import competition (Salamanca et al., 2009), the results also suggest the need for more robust conditions to strengthen agriculture. This need takes more importance as the tariff reduction mechanisms that keep protected the sensitive crops for more extended periods will decrease after several years. If agriculture has not been strengthened enough once the tariffs are eliminated, there may arise negative consequences.

6 Conclusion

Exploiting the FTA implementation between Colombia and the US, I explore the effect of the tariff reduction scheme on the most sensitive crops on coca crops' dynamic. I find that there was a differential coca reduction in municipalities with high sensitivity to the crops affected by the FTA, relative to municipalities with low sensitivity. The result is consistent with the benefits of free trade, such as higher market access and more imports of agricultural inputs.

The result is still an unexpected benefit, as the FTA does not directly intend to impact coca cultivation.

There are heterogeneous effects for higher access to credit, which decreases exposure to illegal activities and enhances the benefits of free trade. Nevertheless, municipalities with more exposure to small farming have lower effects, consistent with literature stating that not all kinds of producers perceive the same benefits from trade. Illegal armed actors and state capacity play no role in driving the results. Finally, I find that a coca substitution program's announcement surpassed the incentives from trade and made the FTA implementation effect disappear.

The results described above present evidence that the FTA was beneficial in decreasing the area affected by coca cultivations. It shows that agriculture is an important aspect to consider when adopting policies aiming to reduce illegal activities. Nevertheless, there are also important policy implications beyond the "war on drugs". First, the existence of an effect on coca crops shows that free trade can generate unexpected (but desired) effects on outcomes not directly considered by trade and liberalization. Second, trade policy must consider other aspects such as the size of the producers, financial capacity, and institutional development to obtain aggregate benefits from more liberalization.

From the results, I conclude that trade liberalization is still a tool to foster development. But, in addition to more market openness, trade policy must also consider complementary policies. In this way, governments can ensure that a liberalization process will be accompanied by the correct conditions, contexts, and institutions to allow producers to adapt to new competition and ensure that the country will perceive adequate benefits from free trade. Further research is needed to understand other unexpected effects from the FTA and correctly understand how the trade mechanisms work to transmit the impact on the economy.

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A Additional tables and figures

Table A.1: Sensitive crops - tariff reduction conditions

Crop	Ad valorem tariff value	Reduction period	Reduction mechanism
Rice	80%	19 years	Invariant base value until year 6. Reduction in equal annual stages from year 7
Maize	25%	12 years	Equal annual stages
Bean	60%	10 years	33% reduction in base value on year 1. Reduction in equal annual stages from year 2
Sorghum	25%	12 years	Equal annual stages

Source: Colombian - US Governments (2012). Agricultural tariff schedule

Table A.2: Correlation coca area ater the FTA implementation

Dependent variable:	Pctg of coca hectares (1)
Post FTA implementation	-0.0088*** (0.0031)
N. of obs.	10,053

Notes: this regressions is used only to check the correlation of the area with coca crops after the FTA implementation for interpretation purposes. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.3: Control variables - differences in means high sensitive/low sensitive

Variable	(1)	(2)	T-test
	Low sensitive Mean/SE	High sensitive Mean/SE	Difference (1)-(2)
Aerial erad. (% municipal area)	.028 (.0091)	.19 (.041)	-.16***
Manual erad. (% municipal area)	.06 (.022)	.065 (.015)	-.0049
Rural population (log)	8.7 (.036)	8.9 (.036)	-.21***
Unmet basic needs (poverty)	40 (.91)	50 (.81)	-10***
Soil erosion	1.9 (.048)	1.9 (.045)	-.019
Water sources	3.2 (.024)	3.5 (.022)	-.26***
FARC presence	.26 (.054)	.5 (.14)	-.24*
Paramilitary presence	.53 (.11)	.98 (.31)	-.45

Notes: t-tests are the differences in the means across the groups. Standard errors are clustered at municipal level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.4: Difference-in-differences - municipality/time varying eradication controls

Dependent variable:	Pctg of coca hectares					
	(1)	(2)	(3)	(4)	(5)	(6)
Sensitive X Post	-0.012*** (0.0041)	-0.0068 (0.0042)	-0.040** (0.016)	-0.032* (0.017)	-0.042** (0.017)	-0.034* (0.018)
Aerial erad. (% municipal area)	0.11*** (0.012)	0.11*** (0.012)	0.11*** (0.012)	0.11*** (0.012)	0.11*** (0.012)	0.11*** (0.012)
Manual erad. (% municipal area)	0.024*** (0.0057)	0.024*** (0.0056)	0.026*** (0.0050)	0.026*** (0.0046)	0.025*** (0.0050)	0.026*** (0.0046)
Sample	All	All	Coca ever	Coca ever	Coca before	Coca before
N. of obs.	10,053	9,486	2,538	2,322	2,367	2,223
Municipalities	1117	1054	282	258	263	247
Mean of Dep. Var. before	0.038	0.039	0.15	0.16	0.16	0.17
R^2	0.81	0.82	0.79	0.80	0.78	0.80
Other controls		x		x		x

Notes: all the regressions include municipality and year fixed effects. Standard errors, clustered by municipality, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.5: Difference-in-differences - department/year fixed effects

Dependent variable:	Pctg of coca hectares					
	(1)	(2)	(3)	(4)	(5)	(6)
Sensitive X Post	-0.016*** (0.0050)	-0.0058 (0.0043)	-0.031* (0.019)	-0.0093 (0.019)	-0.026 (0.020)	-0.013 (0.020)
Sample	All	All	Coca ever	Coca ever	Coca before	Coca before
N. of obs.	10,053	9,486	2,538	2,322	2,358	2,214
Municipalities	1117	1054	282	258	262	246
Mean of Dep. Var. before	0.038	0.039	0.15	0.16	0.16	0.17
R^2	0.80	0.85	0.80	0.85	0.80	0.85
Controls		x		x		x

Notes: all the regressions include municipality and department/year fixed effects. Standard errors, clustered by municipality, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: Difference-in-differences - treatment definition robustness

Dependent variable:	Pctg of coca hectares								
	Sample		Continuous	Mean pre-treatment period		Agr. Prod	Placebo		Main specification
	Treated ever	70/30 pctile	Sensitive	Sensitive	Sensitive w/ permanent crops	(5) w/ no missing obs	Agric. Prod.	Treatment permanent crops	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
Sensitive X Post	-0.056** (0.022)	-0.075*** (0.025)	-0.099** (0.047)	-0.050** (0.024)	-0.034** (0.017)	-0.076*** (0.022)	-0.046** (0.020)	0.011 (0.017)	-0.041** (0.019)
N. of obs.	1,683	954	2,223	2,223	2,223	2,223	2,223	2,223	2,223
Municipalities	187	106	247	247	247	247	247	247	247
Mean of Dep. Var. before	0.18	0.21	0.17	0.17	0.17	0.17	0.17	0.17	0.17
R^2	0.83	0.85	0.81	0.81	0.81	0.74	0.81	0.81	0.81
Controls	x	x	x	x	x		x	x	x

Notes: column (1) use the sample of coca before municipalities that have ever had sensitive crops. Column (2) drops sample between the 30th and 70th percentile. Column (3) considers the continuous version of the treatment. Column (4) calculate the median over the share of sensitive crops between 2006 and 2010. Column (5) calculate the median for the share of sensitive crops including permanent crops. Column (6) uses the same treatment as in (5), using only observations that have the complete set of variables (no missing data). Column (7) use only permanent crop production for treatment. Column (8) shows the preferred estimates. All the regressions use the Coca Before sample. Standard errors, clustered by municipality, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.7: Difference-in-differences - dependent variable robustness

Dependent variable:	Logarithm of coca hectares (log + 1)					
	(1)	(2)	(3)	(4)	(5)	(6)
Sensitive X Post	-0.13*** (0.038)	-0.075* (0.039)	-0.29* (0.16)	-0.28* (0.16)	-0.17 (0.16)	-0.29* (0.17)
Sample	All	All	Coca ever	Coca ever	Coca before	Coca before
N. of obs.	10,053	9,486	2,538	2,322	2,367	2,223
Municipalities	1117	1054	282	258	263	247
Mean of Dep. Var. Before	0.038	0.039	0.15	0.16	0.16	0.17
R^2	0.92	0.93	0.84	0.86	0.84	0.86
Controls		x		x		x

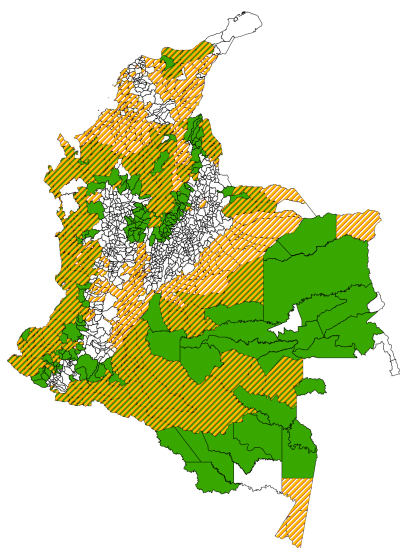
Notes: apart from the general control variables described in Data section, the size of the municipality in hectares is also included. All the regressions include municipality and year fixed effects. Standard errors, clustered by municipality, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.8: Heterogeneous effects - Credit access as dependent variable

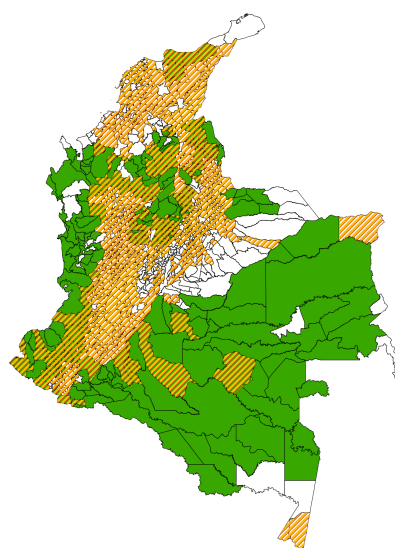
Dependent variable:	Number credits		Credit value	
	Farmer (1)	Small farmer (2)	Farmer (3)	Small farmer (4)
Sensitive X Post	0.026 (0.017)	0.047* (0.026)	0.050 (0.046)	0.18*** (0.060)
N. of obs.	2,223	2,223	2,223	2,223
Mean of Dep. Var. Before	247	247	247	247
Municipalities	0.17	0.17	0.17	0.17
R^2	0.79	0.87	0.89	0.86

Notes: the dependent variables of credit are measured as log + 1. All the regressions use the Coca Before sample, include municipality and year fixed effects, and control variables interacted with time dummies. Standard errors, clustered by municipality, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

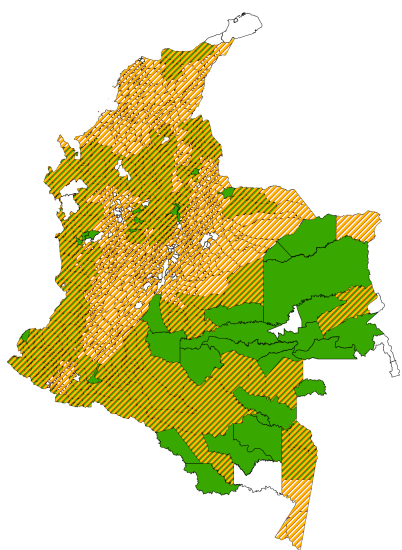
Figure A.1: Geographic distribution - coca and sensitive crops



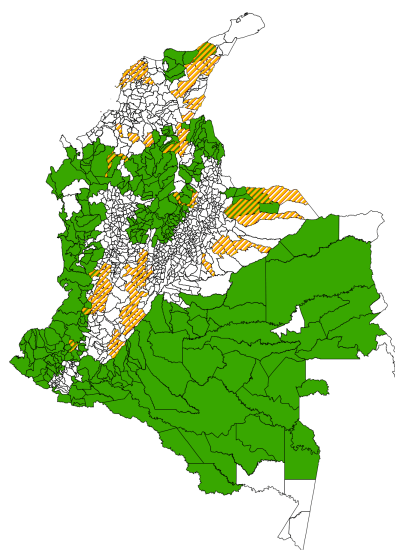
(a) Rice



(b) Bean



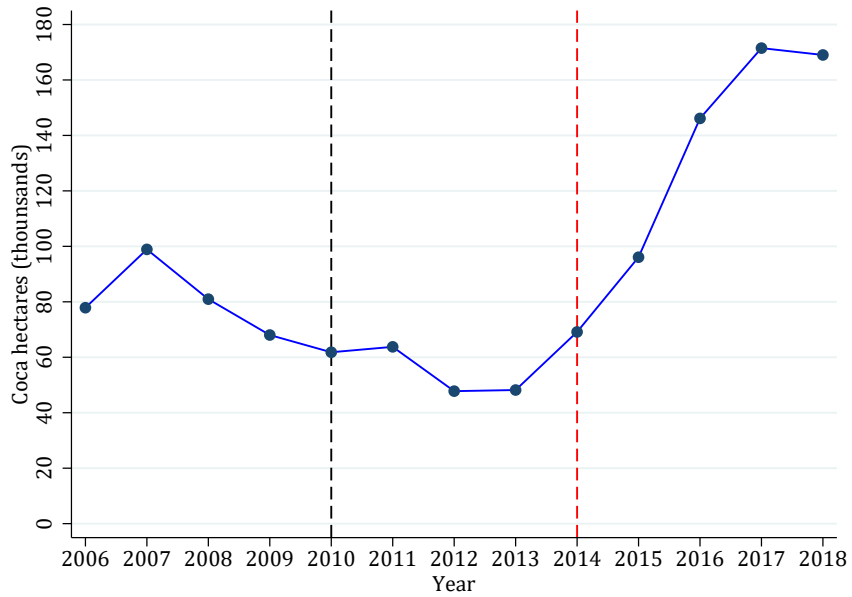
(c) Maize



(d) Sorghum

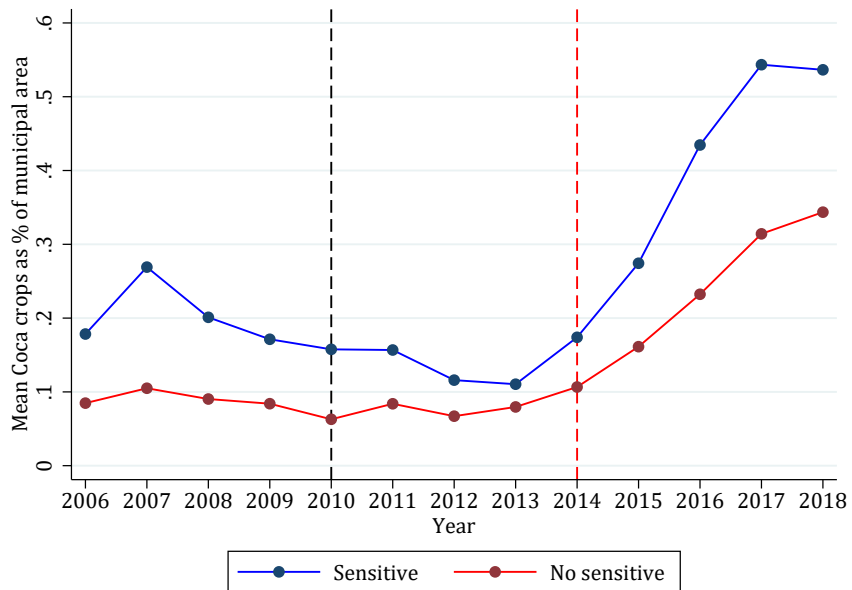
Notes: green represent municipalities that had coca ever before the FTA implementation. Orange stripes represent municipalities that had cultivation in 2006 of sensitive crops.

Figure A.2: Evolution of coca crops hectares



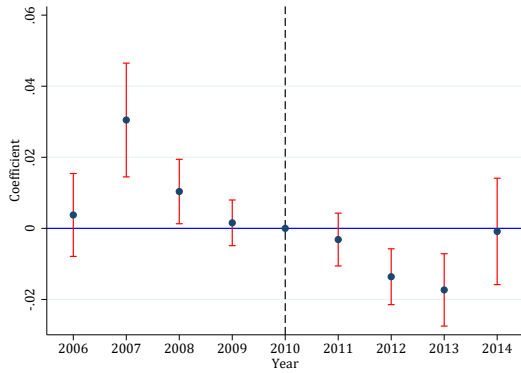
Notes: the black dashed line indicates the year of FTA implementation. Red dashed line indicates the year of PNIS implementation.

Figure A.3: Evolution of area with coca crops by high/low sensitivity

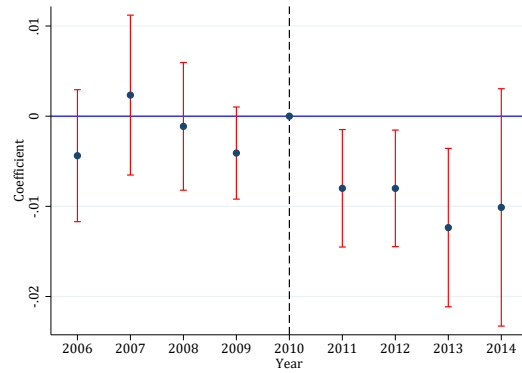


Notes: the black dashed line indicates the year of the FTA implementation. Red dashed line indicates the year of PNIS implementation.

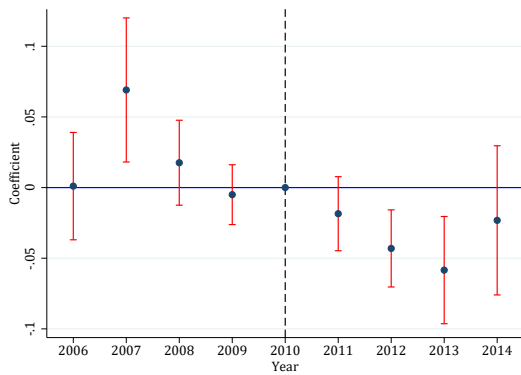
Figure A.4: Event study differential coca cultivation by sensitivity - other specifications



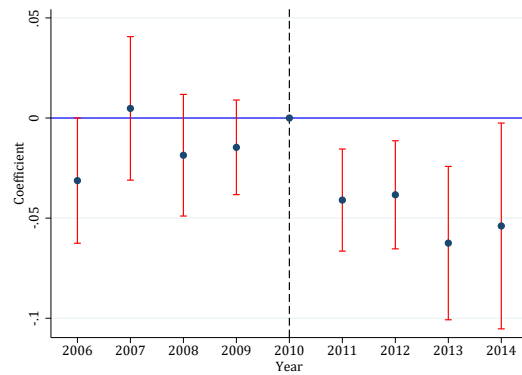
(a) All sample



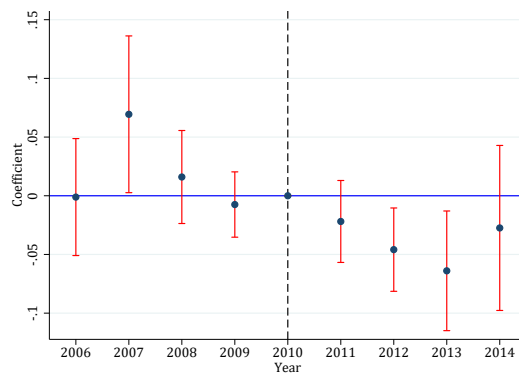
(b) All sample - controls



(c) Coca ever



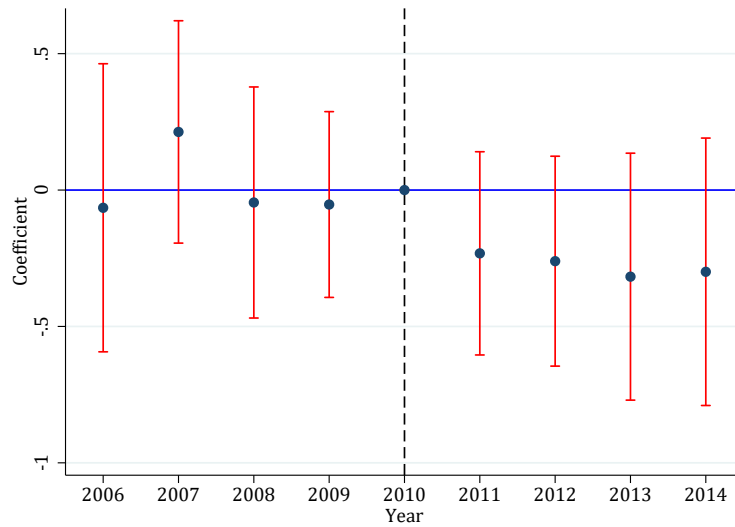
(d) Coca ever - controls



(e) Coca before

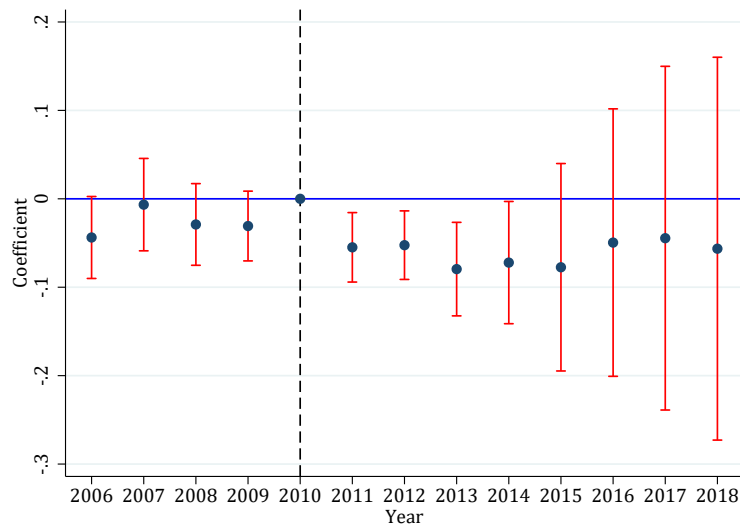
Notes: the figures illustrate the event study for coca cultivation in municipalities with high/low sensitivity, using 2010 as base year, varying the sample considered and the inclusion of control variables following the specifications of columns 1-5 of Table 2. The x-axis plots years and the y-axis plots the coefficients of each year interacted with the sensitive measure. The segment containing each point correspond to the 95% confidence interval. Errors are clustered at the municipal level.

Figure A.5: Event study differential coca cultivation by sensitivity - logarithm of coca crops (log + 1)



Notes: the figure illustrate the event study for coca cultivation in municipalities with high/low sensitivity. The x-axis plots years and the y-axis plots the coefficients of each year interacted with the sensitive measure. The segment containing each point correspond to the 95% confidence interval. Errors are clustered at the municipal level.

Figure A.6: Event study differential coca cultivation by sensitivity - period extended to 2018



Notes: the figure illustrate the event study for coca cultivation in municipalities with high/low sensitivity. The x-axis plots years and the y-axis plots the coefficients of each year interacted with the sensitive measure. The segment containing each point correspond to the 95% confidence interval. Errors are clustered at the municipal level. The regression includes the set of control variables interacted with time dummies. Errors are clustered at the municipal level.