More public goods, more violence? The effect of rural roads on armed conflict and illegal economies in Colombia

Author: Laura Elizabeth Moreno Gama

Advisors: Jorge Andrés Gallego & Juan Fernando Vargas

Master's degree in Economics

Department of Economics
Universidad del Rosario

Bogotá, Colombia
September, 2019

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Abstract

This paper estimates the impact of rural roads on armed conflict and illicit crops in Colombia over a fourteen year period of rapid growth of road investments. I estimate the causal impact of these interventions using micro-data of the royalties revenues to the transport sector at the municipal level, and implement a strategy of Difference-in-Differences with staggered adoption. The results show that new rural roads, in particular small projects known as *placa-huella*, have a positive causal effect on armed conflict and on coca crops. These unintended effects of road provision are mainly driven by the intensification of violence in wealthier municipalities. In these municipalities, I find that the new connectivity leads to an increase in the production of legal crops. Hence, wealthier municipalities are more attractive to armed groups and more vulnerable to attacks that seek to expropriate these new rents. Similarly, the institutional background seems to be determinant in the sign of the effect: in municipalities with qualified and stable institutions, public good provision mitigates the development of illegal activity. I argue that these results highlight the importance to provide public goods in parallel with strengthening the local state capacity through reliable institutions.

Keywords: Roads; Public Goods; Armed Conflict; Illegal Economies; Royalties.

JEL codes: D2; D74, H41; O11; O4; R4

I especially thank my advisors, Jorge and Juan, for their invaluable guidance, motivation and patience. I gratefully acknowledge extraordinary support from Mounu Prem, Luis R. Martínez and Darwin Cortés. Special thanks to Elliot Motte. For helpful comments, I thank the audience at the *Micro Applied Workshop* and at the *Brown Bag Seminar* at *Universidad del Rosario*. For my lovely grandma. All remaining errors are my own.

*Department of Economics, *Universidad del Rosario*. e-mail: laurae.moreno@urosario.edu.co

"If it weren't for the armed groups, I think we could reach a consensus on what the region needs to progress. But all the armed groups want is to control the economic question and all are willing to massacre or murder or force people from their homes to win" - Gloria Cuartas, ex-major of Apartadó (quoted in Kirk, 2003)

1 Introduction

Investment in road infrastructure has increased significantly in the last years around the world. According to the World Bank, 14% of its investment projects were aimed at improving road infrastructure in 2017. Making roads a larger sector of World Bank investments than other historically important sectors such as education or health (World Bank, 2018). Several studies agree that roads reduce transportation, consumption and production costs of goods and services (BIDS, 2004; UNCTAD, 2007; Donaldson, 2010). Others claim that with easier access to markets and technology, better roads can also expand farm and non-farm production through increased availability of relevant inputs and lower input costs (Binswanger *et al.*, 1993; Levy, 1996; BIDS, 2004). Greater earnings opportunities from road development can also contribute to higher productivity and demand for labor at the household level (Leinbach, 1983; Benziger, 1996; Jacoby, 2000; Rammelt and Leung, 2017). Therefore, increases in households income may also boost household consumption, reduce poverty (Fan *et al.*, 2000; BIDS, 2004), and households would benefit in improved education and health (Bryceson and Howe, 1993; Levy, 1996).

The importance of roads for economic growth has been of policy interest and vastly studied, but there is little systematic evidence about the causal link and the channels through which road investments affect armed conflict and illicit crops. This paper studies the effect of a common type of road in Colombia known as *placa-huella* on armed conflict and on illegal economies. Theoretically, in countries with high state capacity and law enforcement, more roads would lead to high levels of security and less proliferation of illegal economies (Donladson, 2010). Positive impacts on these outcomes may arise due to the heightened perception of the state's capacity to intervene with improved road infrastructure (D'Arcy and Nistotskaya, 2017). Alternatively, in states with weak institutions, the results are an open question. Recent literature has found negative short-term impacts on security outcomes[1] (Baires and Dinarte, 2017); unintended effects would be mainly driven by the arrival of unlawful groups to newly connected and more prosperous municipalities. The construction of these roads may bring higher visibility to the economic resources available in such municipalities. As a result, armed groups may wish to expropriate citizens in these municipalities thus leading to increased risks of attacks.

Overall, this limited literature emphasizes the importance played by state capabilities and law enforcement on the impact of public goods on illegal activity. This represents one aspect of what Mann (1986, 1993) calls the *infrastructural power* of the state (see also Soifer, 2008). Principally, new connectivity could help armed groups to expand their capacity in

[1] In the case of illegal crops, to the best of my knowledge, there are no documented causal results.

municipalities with weak institutions. In these places, committing more crimes becomes more profitable and attractive while the cost of illegal activities is null or very low. There is no entity that regulates these activities and once a crime is committed, the law does not apply. In particular, Besley and Persson (2009, 2011) emphasize the importance of state capacity and suggest that state-building will be encourage when illegal groups are afraid that state capabilities will be used against them. However, if the state does not have the capacity to ensure security for the population, illegal groups would take advantage of these limitations in the local offices. Moreover, armed groups increase the profits obtained from illegal activities such as illegal crop production thanks to better connectivity of the road network and may continue to use these profits to improve their power.

Considering the particular context of Colombia, I study the effects of road provision on armed groups' attacks and on the number of hectares dedicated to coca cultivation. From 2011, the most common project to improve tertiary roads is known as *placa-huella*. These interventions are conducted in rural localities – areas which were particularly ravaged by the Colombian conflict. Using a Difference-in-Differences with staggered adoption strategy, I provide evidence that supports the hypothesis that public goods do not necessarily lead to better armed conflict outcomes. The sign of the impact involves other relevant variables such as state capacity, law enforcement, and economic activity. The results indicate that municipalities that invested royalty revenues in *placa-huella* projects display an increase in attacks by illegal groups such as the Armed Revolutionary Forces of Colombia (FARC), the National Liberation Army (ELN), and paramilitary groups. I also find positive and significant impacts of road construction on illegal crop production. These increases represent 4.8% (for FARC), 10.5% (for ELN), and 0.76% (for paramilitary) more attacks with respect to the average attacks. Additionally, this strategy allows me also to explore the dynamic effect of roads on conflict and potential explanatory mechanisms.

After documenting the effect, I evaluate two mechanisms to better understand these findings: economic activity and institutional background. On the one hand, I argue that illegal activity increases because roads promote economic activity and, subsequently, agricultural earnings. Therefore, the benefit of committing extortions and expropriating these new resources also increase. Using measures of economic activity, I find that the increase of attacks is more important in municipalities with higher agricultural gross domestic product, in line with the rapacity effect found in Dube and Vargas, 2013. On the other hand, the institutional framework focuses on studying how different actors react to public good provision (D'Arcy and Nistotskaya, 2017). I argue that the sign of the effect of public goods provision depends on the state's capacity, namely the importance of law enforcement forces, and, in general, the institutional background of local offices. The results indicate that in municipalities with better institutional background, public goods mitigate illegal activity. Conversely, in municipalities with worse institutions, new roads are related to a larger number of attacks and a greater cultivation of coca.

This article contributes to the vast literature of the impacts of road investments on development outcomes (Rigg and Wittayapack, 2007; MacKinnon *et al.*, 2008; Banerjee, Duflo and Qian, 2012, among others). More specifically, I contribute to this literature in three different ways. First, I provide additional knowledge on the indirect and dynamic impact of roads on internal conflict and illegal economies. In particular, results suggest that after the construction of a rural road the life-quality of citizens deteriorates due to an increase in illegal activity. Second, I contribute to the literature that highlights how changes in the expected rents of armed groups can exacerbate internal conflict (Angrist and Kugler, 2008; Dube and Vargas, 2013). In this case, agricultural earnings increase due to the connectivity provided by these new roads. As a result, the incentives to intimidate the population through attacks to expropriate these rents also increase. Hence, prosperous places become more attractive to armed groups. Third, I consider state capacity as a potential mechanism and the results indicate that in places where the state develops better capabilities, public goods attenuate conflict. Therefore, this study is related to the literature examining the local administration's capability to mitigate the unintended results of development projects in rural areas (Donladson, 2010; Prem *et al.*, 2018).

The rest of the paper is organized as follows. In the next section, I provide a background on the Colombian armed conflict and on road policies. Section 3 presents the data sources and descriptive analysis, while Section 4 details the empirical strategy. In Section 5, I study the impact of new roads on armed conflict and illicit crops both in a non-parametric and parametric event study model. In Section 6, I study the potential mechanisms that drive the results and Section 7 examines two alternative explanations. Section 8 presents robustness checks and Section 9 concludes. Other relevant information is available in the Appendix.

2 Background: internal conflict and roads in Colombia

2.1 The Colombian internal conflict

The internal armed conflict in Colombia is a continuous period since 1960 opposing the State and guerrillas of the extreme left. Decades later, right-wing paramilitary groups, drug cartels, and criminal gangs joined the war. Some of the reasons why violence arose in Colombia include the weakness of the State, the conflict over land possession, the existence of significative economic inequalities, the polarization and persecution of the civilian population due to its political orientation (Bergquist, 1992; Thomson, 2007). During the 1980s, the conflict brutally escalated with armed groups conducting intimidation actions in several of the country's regions, paramilitary groups selectively assassinating leftist civilians and violent drug gangs developing a toxic atmosphere in the underground world.

The highest peak of violence occurred between 1997 and 2003, but it is in the second half of the 1990s when the conflict enters its wildest phase. Armed interventions, enforced disappearances, indiscriminate massacres of civilians, mass forced displacement, and collective kidnappings of civilians, military and politicians were the most common in Colombia. The highest point comes under the presidency of Andrés Pastrana and the government of Álvaro Uribe, during which the Colombian Army, armed groups, drug cartels, and paramilitaries faced each other. During this period, the country also underwent economic transformations. Colombia transited from a coffee-growing state to a mining and coca-growing country, with the dynamism of new sectors of agribusiness, as well as coal, oil and gold mining.

Given the nature of the conflict, rural areas were most affected by the war as the presence of the State was more fragile than in urban areas. Illegal groups such as FARC caused large forced displacements in the countryside. The Colombian conflict is an important driver of the economic lag rural areas face today as it impeded economic actors to fully exploit the resources of these regions and prevented the rural population from escaping poverty (Thomson, 2007; Arias *et al.,* 2014). Productive decisions are based on minimizing the likelihood of being attacked by armed groups or mitigating their consequences, instead of maximizing the profitability and production of their (legal) crops (Arias and Ibañez, 2012).

After the outbreak of brutal violence in the 2000s, different governments made efforts to put a definite end to the armed conflict. The government of Juan Manuel Santos (2010-2018) enacted the most promising peace process. In 2012, the Santos government formally began peace talks with FARC that took place in Havana, Cuba. After almost four years of negotiations on August 28, 2016, the last of the six points on the negotiation agenda was signed. It declares a bilateral cessation of hostilities, disarmament, demobilization, and reinstatement to public life of the members of the insurgent group.

Within the six agreed points, the Programs of Substitution of Illicit Crops play a fundamental role, due to the importance illicit crops have in illegal group's financial resources. During years, the relationship between illicit crops and armed conflict has existed; they present a positive correlation. Therefore, coca growing regions are more likely to suffer a high risk of violence. Indeed, the empirical evidence presented by Mejia and Restrepo (2015) indicates that between 1994 and 2008 a 10 percent increase in the value of coca cultivated produced a rise of 1.25 percent in the homicide rate of a municipality. However, as Garzón (2017) showed, between 2012 and 2016, the homicide rate decreased in municipalities that produced coca. Although the rate is still higher in these municipalities, its fall is more marked there than in the non-coca growing municipalities. Unfortunately, this trend seems to be changing in 2017. During the first seven months of 2017, the number of homicides increased in municipalities with coca crops.

2.2 Road projects in Colombia

The current lag in Colombian road infrastructure has become a limitation to achieve adequate growth in various economic activities. In order to promote growth, the Government and the private sector implemented several projects that seek to provide high quality roads to carry out foreign trade operations, and thus connect all areas of the country with its main economic hubs. The National Institute of Roads (INVIAS, 2017) points out that investment in this sector has been growing faster in recent years, going from 2% in 2012 to 2.7% in 2016, as a percentage of GDP. As such, in 2015 Colombia came in third place in Latin America regarding road infrastructure investment.

Recently, state actors have integrated the critical role roads play on the Colombian conflict within their political agenda. According to INVIAS (2017), conflict zones are territories that suffer from a lack of public goods provision (schools, roads, public services, etc). This indicates that these zones face considerable challenges and their citizens live with basic unsatisfied needs, in part because of the lack of the state's presence. Several scholars and institutions of the country agree that it is indispensable to improve connectivity of the road network. More specifically, they advocate the state to endow fragile areas with tertiary roads, namely the 281 municipalities that are most affected by the conflict and in which the road system is destroyed or disfunctional. To this end, some of the recent policies related to road provision aim at filing this gap in these areas. For instance, the *Corredores de la Paz* program, *Plan Bicentenario*, among other initiatives, are a case in point.

Lately, *placa-huellas* represent a popular type of tertiary road policy.[2] The main difference between these projects and other initiatives of road provision mentioned above, is that these roads do not have an explicit goal of reducing the effects of conflict. Hence, these are useful to measure the impact of roads, constructed without a specific objective on conflict. These projects are carried out in rural zones that present a low volume of traffic with very few buses and trucks. Automobiles, campers, and motorcycles are the main components of the vehicular flow on these roads (INVIAS, 2017). Projects that fall under the *placa-huella* initiative are financed with royalty revenues and the popularity of these roads occurred in 2011.

According to the National Planning Department (2018) each proponent[3] decides whether to construct a *placa-huella* or not. Then, she goes to the *Órganos Colegiados de Administración y Decisión* (OCAD, by its acronym in Spanish) to get the approval for her project. The role of the OCADs is to evaluate, make viable, approve, and prioritize the programs and projects that will be funded with resources from the General Royalties System. The OCADs meet frequently to make this type of project viable, thus at any moment resources for *placa-huellas* can be authorized. If the *placa-huella* is approved, the construction begins using royalties revenues. On average, the cost of a *placa-huella* kilometer is US$156.657, which is the most economical and time-efficient mechanism to construct the 20 kilometers needed to connect a municipality (INVIAS, 2017). This guarantees suitable roads for just over five years and, with small maintenance, roads can sustain longer. These projects are part of the rehabilitation plan of tertiary roads. Its role is to improve the terrestrial intercommunication of the rural population, as well as to reduce transportation costs of people and goods.

3 Data and Descriptive Analysis

The main dataset used in the analysis is constructed from the combination of three sources that allows me to have annual data at the municipal level between 2000-2014. First, to

[2] Figure A.1 shows an image of a *placa-huella*.

[3] It could be the municipality Mayor, the Governor, or any other person interested in the project.

obtain information on road constructions in Colombia, I used the royalty database from the National Planning Department (DNP, by its acronym in Spanish). It contains detailed information about how municipalities allocate the revenues from royalties to different sectors. I focus only on the transport sector, which includes road provision. In particular, I have information about the specific destination of the revenues, the starting and ending date of the road, type of road, among other useful variables for this study. In that sense, for this analysis, I define one main treatment: rural roads done under the form of *placa-huella* projects. Additionally, all the specifications include an indicator variable for all the other road project available in the database (tertiary, not *placa-huella*, secondary and primary roads). Moreover, a crucial point in the empirical strategy used to measure the causal impact is that all roads were constructed at different points in time. The construction of the *placa-huellas* starts and ends in different years among municipalities.

Correspondingly, all municipalities did not receive the same amount of money, neither all of them constructed a *placa-huella* between 2000 and 2014. These heterogeneities can be seen in Figures A.2 and A.3. The first presents the geographical distribution and the physical advance of the *placa-huellas*. In all regions of Colombia, it is possible to find one or more *placa-huella* construction, which places these projects in a different position from other road provision initiatives that have focused their efforts on filling the gap only in specific places of the country. Figure A.2 presents the comparison between the municipalities that received revenues for these projects and the physical advance of each project. Almost all the projects in the sample have a 100% of physical completion and only three projects that received revenues for *placa-huellas* have less than 100% of physical completion. Thus, these three municipalities are part of the control group.[4]

Conversely, there are 448 municipalities that did not construct a *placa-huella* using royalty revenues.[5] These municipalities are assigned to the control group. In particular, these municipalities are known as *never treated*. Meanwhile, Figure A.3 shows the average amount of royalty revenues invested in the transport sector between 2000-2015, and equally, it varies across municipalities. Figure A.4 presents the number of *placa-huellas* constructed between 2000 to 2015. It is divided by the starting and ending year of the road. It is clear that before 2011, there were only a few cases of completed *placa-huellas*. Hence, I defined the pre-treatment period as years spanning from 2000 to 2010.

Concerning armed conflict outcomes, I use the Conflict and Violence database of *Universidad del Rosario*. This database contains information about the dynamics of the Colombian Armed Conflict between 1996-2014. The primary outcomes are four measures of conflict intensity: the total number of attacks, the number of attacks by FARC, ELN, and paramilitary groups. Other important measures of conflict are the number

[4] The results, explained below, are robust to including these municipalities as part of the treatment group and to exclude them from the sample.

[5] Within the sources of road financing are the General System of participations, public-private partnerships and foreign investment. That is, not only with royalty resources is it possible to find a *placa-huella* construction. Being this a constraint of this document that in future versions it is tried to correct thanks to the consolidation of a panel that contains all these sources of financing.

of civilians kidnapped, confrontations, etc. Finally, I used the SIMCI-UNDOC database to gather information on illegal economies such as the number of hectares dedicated to coca cultivation. This dataset includes all sizes of land: small (less than 0,25 hectares) and abundant, in several municipalities. Overall, I consolidated a panel that contains information on 1.121 municipalities from 2000 to 2014. Likewise, all of the specifications include controls that come from different sources: DNP, Center for Study of Economic Development (CEDE), and the Colombian Statistical Agency. These controls are discussed below in this Section.

Table A.1 shows basic statistics for the main variables of interest in pre-treatment periods. It is divided into three panels. Panel A contains statistics of all the 1.121 municipalities between 2000 and 2010. For all the sample, FARC committed 1.4 attacks on average, while ELN committed 0.52 attacks and paramilitaries 0.08 attacks. It shows the significant presence of FARC in the conflict during the period of analysis. Likewise, Panel A shows that 60% of municipalities allocated resources in *placa-huella* road constructions and 85% of the sample assigned resources to any other road project. On average, municipalities received US$1.48M from investing in new roads, and there is enormous variance. However, this is normal, since, before 2011 only a few municipalities received royalties revenues, and the amounts received varied a lot across municipalities.[6]

Panels B and C, contain the same statistics as Panel A with a breakdown between treated and never treated municipalities. In the pre-treatment period, both groups had presence of illegal groups and crops. This suggests that if the attacks of armed groups (or the hectares cultivated of coca) present any change after the road completion it is not explained because they arrive by the first time to those municipalities. Correspondingly, on average, both groups received royalty revenues to develop road projects. At the same time, it is useful to assess the balance between treated and controls units in their pre-treatment characteristics. That is, it is convinient that control units are *good* counterfactuals to compare to the treatment units which will enable me to estimate the causal impact. Thus, to evaluate if I am comparing *similar* control and treated units, I implement a t-test to have statistical evidence about the null hypothesis in which the difference in mean for control and treated units is statistically equal to zero.

Table A.2 shows the results and the p-values associated with this null-hypothesis. Panel A provides the results of the test for the primary outcomes. It shows that all the p-values are greater than 0.05, and therefore, I can conclude that the outcomes of control and treated units are equal in means. Panel B shows the results of the t-test for municipal characteristics. For the majority of the variables, treated and control units are statistically equal in means. In particular, it is interesting to note that municipalities that invest in *placa-huella* projects are not more likely to have more rural population. In addition, their economic progress, understood as GDP, as well as their agricultural GDP, seem to be equal, on average, to that of municipalities that do not invest in *placa-huella* projects.

[6] In 2011, a reform of the Royalties System was carried out in order to distribute resources better across municipalities.

Furthermore, treated and controls are not statistically equal in means only along three dimensions: their index of basic unsatisfied needs, the number of users with electric power and natural gas. More precisely, control municipalities present more users with those services, and the index of basic unsatisfied needs is higher. This implies that, to rule-out the possibility that these pre-existing differences are the cause of changes in the outcomes, I include the corresponding three variables as controls in all the specifications I estimate. Moreover, I include the values of these covariates in 2000 (pre-treatment period) interacted by year dummies, to have dynamic controls and isolate any possible endogeneity in the equations. In addition, I also include other covariates such as municipalities' population to control for size effects.

4 Empirical Strategy

The main methodological problem when estimating the impact of the *placa-huellas* is that these interventions are not conducted randomly in municipalities. Therefore, the critical identification concern is that unobserved confounding factors may be correlated with both armed conflict and illegal crops. The ideal experiment to estimate the effects of road construction would be to allocate roads randomly to some municipalities and not to others and then to compare conflict levels and hectares of illicit crops. However, this is not possible. Thus, it is necessary to estimate the causal impact implementing a methodology that once the identification assumptions are fulfilled, the effect can be measured. In this section, I describe how I determined the causal effect using a quasi-experimental design, the identification assumptions behind it, and the main estimated equations.

The provision of *placa-huellas* in Colombia locates this analysis, under a setting in which treatment adoption by municipalities occurs at different points in time. This paper implements a Difference-in-Differences with Staggered Adoption strategy (Athey and Imbens, 2018). Under this framework, observational units (i.e. municipalities in this study) can adopt the treatment at any of the time periods I study.[7] Municipalities can also *choose* not to take the treatment throughout the whole time period. In the latter case, units are part of the never treated group. Similarly, once a unit adopts the treatment, it remains exposed to it for all the subsequent periods. Then, I observe for each municipality the adoption date (i.e. the year of road completion) and the sequence of realized outcomes for every *pre* and *post* adoption period. Consequently, the main equation I estimate writes as:

$$Y_{it} = \alpha_i + \gamma_t + \sum_{j=k}^{n} I(j=k)\theta_j + (\mathbf{X'}_{i,2000} \times Year_t)\phi + \varepsilon_{it} \tag{1}$$

Where i stand for municipality and t for year. α_i and γ_t are municipal and year fixed effects, respectively. These terms account for year and municipalities hetereogeneities that may bias/influence the estimated coefficients if they are not taken into account in this panel setting. ε_{it} are standard errors clustered at the municipality level, the level at

[7] Here, I take one year as a time period.

which the treatment is assigned (Bertrand *et al.*, 2004). As mentioned before, I control for a series of covariates[8] interacted by each *year*, to obtain the differential effect over time of cross-section covariates. These covariates are captured by the X vector.

Finally, the main component of the equation: $I(j = k)$, is an indicator variable for the timing of the construction year. The value of this variable indicates the difference in years between the *current* year and the end year of the *placa-huella*. Positive values of this variable indicate periods *after* the road was built. Conversely, negative values imply years *before* the road was built. For instance, if the value of this variable is 1 (-1), it means that construction of the *placa-huella* was completed one year ago (will be completed in one year). Due to the availability of information related to illegal attacks, this variable can only take values between -4 and 4.

Following common practices in the Difference-in-Differences with staggered adoption strategy, I normalize the $I(j = k)$ indicator to 0 for the year in which municipality i finished the *placa-huella*. For the never treated municipalities, these indicator variables are always 0. Therefore, θ_j captures the dynamics of road investments relative to the reference year. In all specifications, the reference year is the year just before the road completion, $t - 1$. Accordingly, within the same calendar years, I compare the outcomes of municipalities that constructed a *placa-huella* in year t to those treated in year $t + j$ and the never treated municipalities.

Additionally, to isolate the causal effect of road construction on the studied outcomes, the timing of the road construction must be uncorrelated with municipal attacks and illicit crops hectares, conditional on the set of control variables I consider as well as municipal and year fixed effects. Particularly, if the construction of a *placa-huella* is preceded by a significative reduction (increase) in armed conflict and/or illicit crops hectares, this important identifying assumption would be violated. This assumption is known as *no anticipation*. By analyzing the dynamics of θ_j, I can provide evidence to support or reject this assumption. More formally, the pre-period θ_j indicators should not be statistically different from zero. Furthermore, in the general Difference-in-Differences scenario, this assumption is known as the *common trends assumption* and can be *validated* by plotting the patterns of the outcomes for both groups: treated and control units. This assumption requires that, in the absence of treatment, the difference between the treatment and control group is constant over time. As a complement, I present the patterns of both groups using the raw data and discuss this assumption in the next section.

Athey and Imbens (2018) consider an additional assumption in this scenario known as the *design assumption*. This concerns the assignment process for the adoption date which is, in this case, the end year of the road's construction. It is an assumption that requires that the adoption date is random. This assumption is extreme and can only be guaranteed by design. Moreover, it has no testable implications. However, they argue that it is possible to relax this assumption if the adoption date is completely random

[8] Index of basic unsatisfied needs, the number of users with electric power and natural gas.

within subpopulations with the same values for the pre-treatment variables. I show that it is reliable to think that these outcomes do not present anticipatory effects even if the adoption date is not (entirely) random.[9] Hence, the θ_j estimators can be read as causal effects.

Moreover, in order to gauge the magnitude of dynamic effects, I consider the parametric version of the Difference-in-Differences strategy. Following Colonnelli and Prem (2017), after implementing the Difference-in-Differences with Staggered Adoption, I continue to explore the relationship between rural roads, armed conflict, and illicit crops by estimating the following equation:

$$Y_{it} = \alpha_i + \gamma_t + \theta(Post \times Treat)_{it} + (\mathbf{X'}_{i,2000} \times Year_t)\phi + \varepsilon_{it} \quad (2)$$

This specification allows me to analyze the statistical significance and magnitude of the estimates. This corresponds to a Difference-in-Differences specification, in which $Post \times Treat$ is an indicator variable taking a value of one for all years after the road was built, zero otherwise. This indicator is always 0 for never treated municipalities. As discussed in Section 3, treatment is defined as a *placa-huella* completion. Thus, θ captures the impact of new roads on outcomes linked to the conflict. In other words, it measures the difference in the change in the outcome variable in municipalities with *placa-huellas* and in municipalities that never received one of these interventions, conditional on the set of municipality and year fixed effects and controls.

In the same way, in the following sections I use variations of this specification to analyze the mechanisms through which rural roads affect illegal activity. In particular, I use triple interactions to explore potential heterogeneous effects of my main result according municipal-level variation in state capacity, law enforcement and economic activity. I estimate then, the following equation for test for heterogeneous effect in the economic activity:

$$\begin{aligned} Y_{it} = {} & \alpha_i + \gamma_t + \theta_1(Post \times Treat)_{it} + \theta_2(Post \times Treat \times AgriculturalGDP_{i,2000}) + \\ & (\mathbf{X'}_{i,2000} \times Year_t)\phi + \varepsilon_{it} \end{aligned} \quad (3)$$

Equation 3 also includes the constitutive terms of the triple interaction. Under this specification, the coefficient of interest is the one associated with the triple interaction. In another specification I interact the $Post \times Treat$ with measures of state capacity and law enforcement capabilities. These potential mechanisms are fixed in a pre-treatment year (2000), to exclude any source of endogeneity. The other components of the equation are the same as before: municipalities and year fixed effects and controls.

[9] Figure A.5 plots the density of the periods between the start and end year of road construction, that is the years that take to construct a *placa-huella*. This indicates that there is some variability in the years needed to finish a *placa-huella*. Some of these roads are built in two or three years, but others take four or more years to be completed. Hence, this Figure presents some suggestive evidence in favor of the *design assumption* by showing that the adoption date of treatment is not completely sure -not all roads have the same construction period length-.

5 Results

The first part of the analysis investigates the dynamics of *placa-huellas* on armed conflict and on illegal crops. To that end, I estimate Equation 1, and the results are plotted in Figures 1 and 2.[10] It displays the point estimates over a window of [-4, 4] together with the confidence intervals.[11] As mentioned previously, in a Difference-in-Differences with Staggered Adoption framework, we should not observe differential trends in the pre-treatment periods between treated and control municipalities. This implies that the pre-treatment point estimates should not be statistically different from zero.

These figures show that the pre-treatment point estimates are statistically equal to zero. It allows me to consider the post-periods coefficients as the causal effect of roads on illegal activity. In addition, Figure A.6 presents the same analysis using the raw data (i.e. the mean attacks per year) and a window of [-4, 4]. The raw data indicates the same pattern: in the initial period of treatment t, it is clear that the trends followed by treated and control municipalities take a divergent path. Conversely, in pre-treatment periods, the difference in trends between treated and control units seems to be constant over time.

These figures also illustrate the positive impact of roads on armed conflict and illicit crops. Figure 1 presents the effect of the *placa-huellas* on the total number of attacks and on the hectares dedicated to coca cultivation. Meanwhile, Figure 2 shows the heterogeneous effect of roads on three different types of armed groups in Colombia. The results present that the number of attacks and the hectares of coca boost after the *placa-huella* construction. Similarly, municipalities in which *placa-huellas* were built suffered an increase in the number of FARC, ELN, and paramilitary attacks. A note-worthy point is that these effects do not take place immediately. For instance, significant effects on the number of FARC attacks arise only two periods after a road is built.

In addition, the magnitude of this effect increases over time. Municipalities in which a *placa-huella* road was built show an increase of about 0.17 attacks two years after road completion compared to municipalities without a *placa-huella*. Four years after construction, municipalities where a road was built display an increase of 0.35 attacks compared to municipalities without *placa-huellas*. For ELN and paramilitary attacks, positive and significant effects appear in periods two and three after the road construction. For ELN, the increase in illegal attacks is around 0.11 and 0.019 more attacks for paramilitary groups. The magnitude of these effects is lower than the magnitude of *placa-huellas* on the number of FARC attacks. This is consistent with previous literature on the subject and highlights the role played by the size of the armed group on the effects of public good provision on conflict (Cortés and Montolio, 2013).

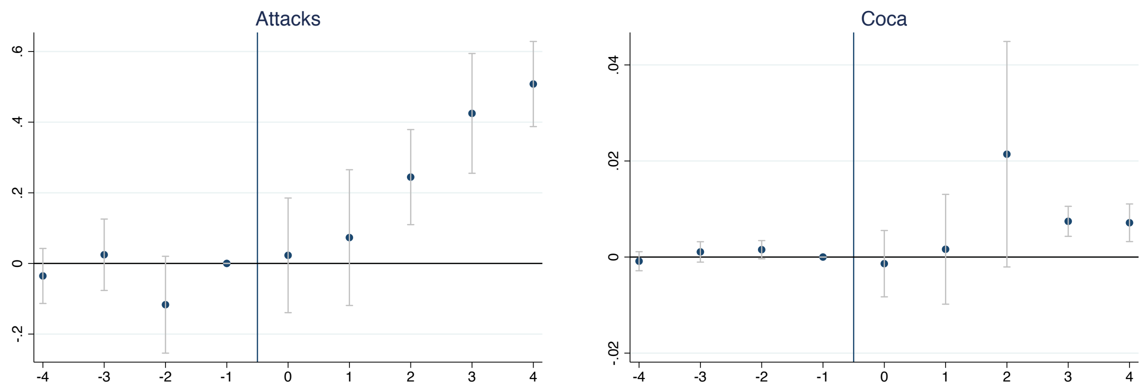
Concerning the effect of *placa-huella* road on the number of hectares dedicated to coca cultivation, the point estimates behave similarly as the armed conflict outcomes. New

[10] Figure A.7 presents the results of the estimations without controls. It shows the same conclusions as in the case of including controls in Equation 1.

[11] C.I with a confidence level of 95% is plotted.

roads respresent an increase in the size of land destined to coca cultivation. The increase in this crop's growth displays its highest point three years after the road completion and reaches about 0.01 hectares more compared to municipalities without *placa-huella*. Given that municipalities with *placa-huella* are localities which were already affected by the conflict, these results suggest that *placa-huella* road construction exacerbates the conflict.[12] That is, new rural roads are not related to the arrival of armed groups to newly connected municipalities. Rather, new rural roads intensify the violence associated to the conflict as measured by the outcomes I study.

Figure 1: Dynamic point estimates for *placa-huella* projects.



Notes: Attacks represent the total number of attacks in each municipality and Coca represents the hectares (in hundreds) dedicated to coca cultivation. The X axis presents years since the *placa-huella* construction. Own calculations.

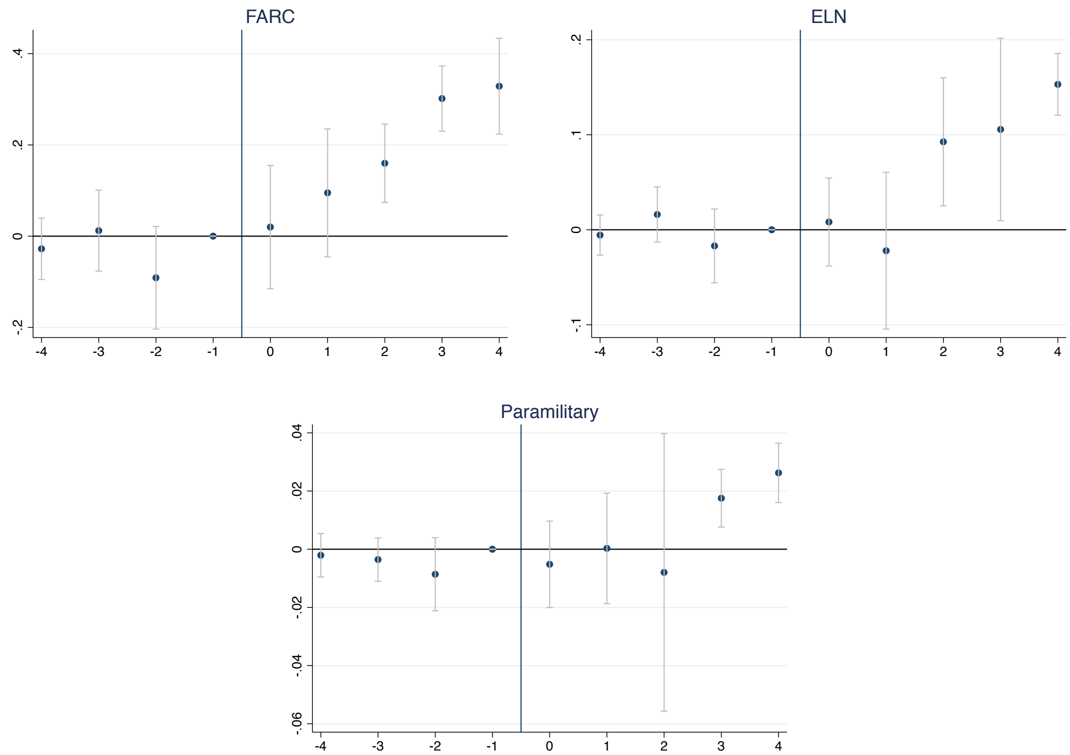
On the other side, Table 1 shows the results of Equation 2. Similarly to the dynamic case, I find positive impacts of *placa-huellas* on the number of attacks perpetrated by armed groups and at the aggregate number of attacks. The magnitude of this effect varies according to the identity of the armed group conducting the attack. Again, road provision has a greater effect on the number of attacks conducted by the largest armed group under study, i.e. FARC, compared to the less sizeable ELN or paramilitary groups. For FARC, a *placa-huella* is related to an average increase of 0.0687 attacks, for ELN 0.0561 attacks and paramilitary 0.0062 attacks each year.

Finally, it is interesting to compare these increases to mean violence levels. These increases are 4.8% (for FARC), 10.5% (for ELN), and 0.76% (for paramilitary) more attacks with respect to the average attacks. Similarly, concerning increases in standard deviations, for FARC, ELN, and paramilitary attacks, the increase is less than half of a standard deviation in each outcome. However, for the number of hectares dedicated to coca cultivation, it seems that there are no significant differences between treated and control municipalities. These results indicate that *placa-huella* roads lead to an increase in the number of illegal attacks but that there is no sizeable effect on coca crops.[13]

[12] As documented in Section 3, illegal groups were previously located in municipalities that invested in *placa-huella* projects.

[13] Table A.3 shows that using three different approaches of the coca cultivation measure the results remain the same. There are no sizeable effects after the construction of a *placa-huella*.

Figure 2: Dynamic point estimates by type of armed group.



Notes: These figures show the effect of the *placa-huellas* on FARC, ELN and Paramilitary attacks. The X axis presents years since the *placa-huella* construction. Own calculations.

Table 1: Parametric Difference-in-Differences

VARIABLES	(1) Attacks	(2) FARC	(3) ELN	(4) Paramilitary	(5) Coca hectares
Post × *Placa-Huella*	0.0703***	0.0687**	0.0561***	0.0981***	0.0017
	(0.00387)	(0.0307)	(0.0171)	(0.0048)	(0.0019)
Observations	16,315	16,315	16,315	16,315	16,315
Mean Dep. Var	1.99	1.42	0.534	0,81	1.16
S.D Dep. Var	1.64	1.21	0.85	0.21	2.30
Time/Mun. F.E	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓	✓
Number of Mun.	1,121	1,121	1,121	1,121	1,121

Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. Attacks represents the total number of attacks in each municipality. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are measured in hundreds of hectares. Robust standard errors are clustered at the municipality level and are shown in parentheses. In columns 1-5, variables that are not shown include municipality and year fixed effects, log of population, users with natural gas, with electric power, and an index of unsatisfied needs. All specifications include the term *Post × other roads*.

6 How do rural roads affect armed conflict and illicit crops?

The analysis in Section 5 concludes that *placa-huella* road provision increases the number of attacks that are conducted by armed groups as well as the growth of illegal crops. In this section, I aim to study how these roads are related to illegal activity. I investigate two potential mechanisms that drive the relationship between road provision and illegal activities. First, I hypothesize that *placa-huella* roads enhance illegal activity because they boost economic production in rural areas. As a result, armed groups have greater economic incentives to assault rural municipalities in order to expropriate or to extract rents from new sources of wealth in these areas.

Second, following the work of D'Arcy and Nistotskaya (2017), public goods such as roads are related to state capacity. However, in areas with weak institutions and low levels of law enforcement, it remains uncertain whether road provision reduces conflict. The role played by institutions determines how different actors react to public goods provision. Namely, they change the economic incentives carried by public good provision. Thus, I test if the institutional background is determinant in the sign of the effect of public goods on conflict. These mechanisms are discussed in the next subsections.

6.1 Economic activity, public goods and illegal activity

I argue that *placa-huella* road provision leads to an increase in illegal activity because such roads foster higher levels of economic activity in newly interconnected areas. This makes such localities more attractive to armed groups as new economic resources create incentives for these groups to violently assault municipalities and capture these resources. Thus, armed groups can finance their activity by expropriating this wealth. To test this hypothesis, I use two measures of economic activity: the agricultural gross domestic product and the *legal* mining of gold.[14]

The motivation to use agricultural GDP is straightforward. Because newly built *placa-huellas* roads are constructed mainly in rural zones, such interventions have a large economic impact on farm production. This makes agricultural GDP a natural causal variable worth investigating. Similarly, the reason why I study gold mining is that it is an important source of income for armed groups. Note should be taken that I focus on production in *legal* mines, as opposed to illegal mines, the latter being mostly related to armed groups.[15] Therefore, I chose the study of gold production as it is commodity specificly related to the Colombian armed conflict.

[14] I use information provided by the *Unidad de Planeación Minero Energética* on both legal and illegal mines. I focus only on legal mines for each of the municipalities in the sample because information on illegal mining activities is approximative and incomplete which could add unnecessary noise to my estimations.

[15] Peasants, who for years have lived on gold and have no mining title to extract it, have been forcedly expropriated by armed groups. This is one of the main mechanisms that lie behind illegal mining activites (Sarmiento et al., 2013).

I use the parametric version of the Difference-in-Differences strategy to test whether road provision increases illegal activities (attacks and illegal crops) through this mechanism. More specifically, I am interested in the sign of the triple interaction of the *post* and *treatment* indicators and agricultural GDP of Equation 3. For each municipality, the value of agricultural GDP is fixed to what it was in the latest pre-treatment year (2000). This is done to exclude any source of endogeneity. In these specifications, I compare the outcomes of the never treated municipalities and municipalities with *placa-huellas*. On the other hand, I also use the time-varying version of the agricultural GDP to show if effectively after the *placa-huella*, there is a production boost.

Moreover, I centered agricultural GDP to compare municipalities above the mean and the ones below the mean value of this variable. Hence, θ_1 measures the effect of these roads in municipalities below the mean value of agricultural GDP and θ_2 reflects the impact on municipalities with levels of agricultural GDP above the mean. As such, if θ_2 is significant and positive, then road provision leads to an increase in illegal activities in municipalities with higher agricultural GDP. This would support my claim that armed groups expropriate new economic resources created by the new *placa-huellas* roads. Additionally, when I use agricultural GDP as an outcome, I would expect the sign of the coefficient of the *post* and *treatment* indicators would be positive and significant as well.

Table 2 presents the results of Equation 3. Columns 1-4 show the effect on the usual outcomes, and Column 5 shows the results when I use the time-varying version of the agricultural GDP as an outcome. Columns 1-4 show a heterogeneous effect. In municipalities where the level of agricultural GDP is below the mean, the construction of a *placa-huella* is related to an increase in 0.069 attacks by FARC. Meanwhile, in places above the mean, the increase is greater: these roads lead to an increase of 0.234 FARC attacks. Significant increases in attacks are also found for other armed groups. In the case of illicit crop growth, road provision has a significant effect only in richer municipalities. Indeed, the number of hectares dedicated to coca cultivation decreases by 0.130 hectares after the *placa-huella* construction in wealthy municipalities. Finally, Column 5 illustrates another interesting result: after the construction of a *placa-huella* in a given municipality, the value of agricultural production increases by 0.514 points from its mean, compared to municipalities without *placa-huellas*.[16]

Overall, Table 2 presents evidence in favor of the hypothesis in which prosperous municipalities are more likely to perceive increases in illegal activity in two directions. First, these new roads effectively boost agricultural GDP compared to places without *placa-huellas*. This suggests that these interventions improve legal economic activities. Furthermore, in municipalities with levels of agrarian production above the average, the increase in attacks is more considerable. Second, in such municipalities, it seems that there is evidence of a substitution effect between legal and illegal economic activities. In prosperous municipalities, new roads boost GDP while the number of hectares of

[16] Table A.4 presents results using some of the main crops produced in the Colombian countryside separately such as potatoes, and cocoa trees. It shows that roads increase these specific economic activities, not only aggregate production.

illicit crops decreases. This suggests that armed groups have two motivations to commit attacks: (i) the expropriation of new economic resources which is in line with the rapacity effect found in Dube and Vargas, 2013), and (ii) the fall in coca leaf production which directly translates in a decrease of armed groups' financial revenues. Consequently, these two effects make wealthy municipalities increasingly vulnerable and more prone to attacks.

On the other hand, Table 3 presents the results when I use gold production to test for a potential heterogeneous effect.[17] As with agricultural GDP, I fix the value of gold production to its value in a pre-treatment year for each municipality, and I center it on its mean value. Columns 1-4 control for the triple interaction to evaluate possible heterogeneous effects in places where the production of gold is superior to the mean value. The coefficient of 0.0598 in Column 5 indicates that after the *placa-huella* construction, the output of gold increases. Meanwhile, Column 4 shows that once I control for gold production, the number of hectares dedicated to coca cultivation experienced a significant reduction of 0.0648 hectares after construction of the *placa-huella*.

Table 2: Illegal Activity and Agricultural GDP (legal economic activity)

VARIABLES	(1) Attacks	(2) FARC	(3) ELN	(4) Paramilitary	(5) Coca hectares	(6) Agric. GDP
Post × *Placa-Huella*	0.0805**	0.0693***	0.0599**	0.00724**	0.00729	0.5142***
	(0.0139)	(0.0238)	(0.0243)	(0.0029)	(0.00644)	(0.0058)
Post × *Placa-Huella*	0.307*	0.234***	0.061***	0.098***	-0.130***	-
× Agr. GDP_{2000}	(0.0736)	(0.0294)	(0.0078)	(0.012)	(0.0178)	-
Observations	16,315	16,315	16,315	16,315	16,315	16,315
Mean Dep. Var	1.99	1.42	0.534	0,81	1.16	0
S.D Dep. Var	1.64	1.21	0.85	0.21	2.30	289.167
Time/Mun. F.E	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓	✓	✓
Number of Mun.	1,121	1,121	1,121	1,121	1,121	1,121

Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. Agricultural GDP is centered on its mean. Attacks represents the total number of attacks in each municipality. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are measured in hundreds of hectares. Robust standard errors are clustered at the municipality level and are shown in parentheses. In columns 1-5, variables that are not shown include municipality and year fixed effects, log of population, users with natural gas, with electric power, and an index of unsatisfied needs. Column 5 only includes municipality and year fixed effects, and log of population. All specifications include the term *Post* × *other roads* and the terms of the triple interaction: Post × *Placa-Huella*× Agricultural GDP_{2000}.

Additionally, Column 1 shows that there is an increase in FARC attacks both for municipalities with values of gold production below the mean and for municipalities with

[17] In particular, the following equation is estimated:

$$Y_{it} = \alpha_i + \gamma_t + \theta_1(Post_t \times Treat_i) + \theta_2(Post_t \times Treat_i \times Gold_{i,2007}) + (\mathbf{X'}_{i,2000} \times Year_t)\phi + \varepsilon_{it} \quad (4)$$

It also includes the terms of the triple interaction.

higher production levels. However, in municipalities with higher gold production levels, the magnitude of the effect of the *placa-huellas* on conflict is greater. Correspondingly, the number of hectares of coca decreases significantly in these places. Again, this supports the claim that there is a substitution effect between legal and illegal economic activities. Nevertheless, for ELN and paramilitary attacks, there are no significant changes in most gold productive municipalities. Presumably this may be explained by the fact that, historically, these groups have not been related to gold mining.

To sum up, I present evidence in favor of the claim under which roads boost the production of legal commodities, encouraging peasants to shift their production from illegal crops to licit economic activities in more productive places. As a result, these municipalities experienced an intensification of the conflict given that armed groups had fewer resources to fund their activity with illegal crops which incites them to attack more. Given that these municipalities are wealthier after road construction, the benefit to intimidate citizens and expropriate their resources increases because armed groups can extract more of these new rents.

Table 3: The case of gold

VARIABLES	(1) Attacks	(2) FARC	(3) ELN	(4) Paramilitary	(5) Coca hectares	(6) Gold
Post × *placa-huella*	0.0922**	0.0629***	0.0451***	0.127***	-0.0004	0.0598***
	(0.0156)	(0.00935)	(0.00842)	(0.0389)	(0.0310)	(0.00947)
Post × *placa-huella*	0.209***	0.191***	-0.0373	0.0481	-0.0648**	-
× $Gold_{i,2007}$	(0.0128)	(0.0693)	(0.0979)	(0.0502)	(0.359)	-
Observations	16,315	16,315	16,315	16,315	16,315	16,315
Mean Dep. Var	1.99	1.42	0.534	0,81	1.16	0
S.D Dep. Var	1.64	1.21	0.85	0.21	2.30	0.0181
Time/Mun. F.E	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓	✓	✓
Number of Mun.	1,121	1,121	1,121	1,121	1,121	1,121

Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. Agricultural GDP is centered on its mean. Attacks represents the total number of attacks in each municipality. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are measured in hundreds of hectares. Robust standard errors are clustered at the municipality level and are shown in parentheses. In columns 1-5, variables that are not shown include municipality and year fixed effects, log of population, users with natural gas, with electric power, and an index of unsatisfied needs. Column 5 only includes municipality and year fixed effects, and log of population. All specifications include the term *Post* × *other roads* and the terms of the triple interaction: Post × *Placa-Huella* × $Gold_{i,2007}$.

6.2 State capacity, public goods and illegal activity

Besides the mechanism I have pointed out in the previous subsection, there is another channel through which road provision leads to increased illegal activities. As D'Arcy and Nistotskaya (2017) explain, state capacity is highly correlated with the provision of public goods. States that display extensive enforcement capacities also exhibit better provision of essential public goods and are less corrupt than states with weaker institutions. Following this account, I present evidence of a second mechanism explaining the increase of illegal activities after *placa-huellas* road completion. I argue that the sign of the effect of public goods provision on illegal activities depends on the strength of local institutions. As I will detail later, the strength of local institutions can be understood as both the level of state capacity, and the importance of law enforcement in local offices.

The case of the Colombian conflict is an ideal setting to study how the effect of public goods provision on illegal activity is intrinsically linked to the presence, nature and quality of state institutions (Acemoglu and Robinson, 2012). Indeed, both armed conflict and *placa-huellas* road construction take place in rural areas where state presence is low and local institutional capacities are limited. Thus, an increase in the number of attacks may arise because armed groups take advantage of the lack of law enforcement in rural areas in two ways. First, and most intuitively, it is easier for armed groups to extract rents or appropriate agricultural wealth to fund their activities in the case where state regulations that protect land rights are absent. Second, armed groups may take advantage of the constraints faced by some municipalities, such as failures in the police force and local judiciary system amongst other limits, to commit more attacks and intimidate the local population.[18]

State capacity can be proxied by military strength or by the efficiency of other branches of government, such as the judiciary. Hence, I use two proxies of state capacity: the proximity to a military brigade and two measures of judicial capabilities. Proximity to a military brigade approximates the strength of state presence in the sense that security levels are higher around brigades given the presence of soldiers and military equipment they entail. Hence, it can be argued that incentives for armed groups to commit attacks nearby military brigades is lower than further away from them. The two judicial measures I use summarize data on the number of judges, attorneys and general prosecutors stationed in each municipality used in Prem *et al.,* (2018).[19] The ability to timely resolve judicial processes reveals that judicial institutions are prepared to ensure the rights of citizens. In addition, the size of judicial institutions indicates the power they have to promptly resolve processes within the jurisdictional system. A greater number of judges can result in faster judicial proceedings and their corresponding sanction. Furthermore, the number of police and judges in the municipality are decided by the national state. These measures allow me to shed light on the role of national state presence at the local level.

The results of the estimations are presented in Table 4. Panel A shows that the proximity to a military brigade is crucial when analyzing the effect of new *placa-huellas* roads on conflict. Indeed, the more remote municipalities are relatively to military brigades, the more they experience increases in attacks and the more land they have dedicated to coca crops. When comparing the two coefficients in Panel A, for each of these two

[18] This is consistent with what Fiszbein (1997) describes in his account of the limits of Colombian state capacities in rural areas. Colombian municipalities face critical challenges of capacity, skillful public workers, and social services provision. He also argues that these challenges can be enhanced through local governors' commitment.

[19] More information related to these measures can be found in Prem *et al.,* (2018).

outcomes, the effect of a *placa-huella* is nine, six and two times lower than the impact in municipalities further away from a brigade for FARC, ELN, and paramilitary attacks, respectively. In this sense, it seems that the presence and capacity of the state can be reinforced through military brigades, and the unintended consequences of road provision could be attenuated by greater military presence in these areas.[20]

On the other hand, Panel B presents results when interacting the *Post* $\times$ *placa-huella* indicator with two measures of judicial efficiency at the municipality level. The results show that in places where the judiciary system acts faster, condemning criminals and punishining them with relevant convictions according to the charges, *placa-huella* road construction leads to a decrease in illegal activity, in line with what was expected. In these places, after the *placa-huella* construction, the number of attacks of armed groups decreases considerably. The coefficient of the triple interaction indicates that in municipalities with better judicial institutions, road provision would result in about 0.25 or 0.14 fewer FARC attacks. In other words, this translates in a reduction of 17% and 9% below the mean number of attacks. For ELN and paramilitary attacks, the decrease is also significant and negative, but the magnitude is not as high as FARC attacks. As such, these results suggest it is important for the state to strengthen local institutions in remote areas as they are capable of protecting citizens.

Following these findings, I continue to explore the relationship between state capacity and public good provision by studying the effect of three different road types on illegal activity. More precisely, I exploit three binary variables of the DNP's royalties' dataset each of them indicating whether a primary, secondary or tertiary (non *placa-huella*) road was built. I interact each variable with the *post* indicator variable in order to use this as the main regressor I study. Importantly, I estimate the following equation:

$$
\begin{aligned}
Y_{it} = \alpha_i + \gamma_t + \theta_1(Post_t \times Placa - Huella_i) + \theta_2(Post_t \times Tertiary_i) + \\
\theta_3(Post_t \times Secondary_i) + \theta_4(Post_t \times Primary_i) + (\mathbf{X'}_{i,2000} \times Year_t)\phi + \varepsilon_{it}
\end{aligned}
\tag{5}
$$

This equation also includes the constitutive terms of the interactions. Under this specification, I compare municipalities with some of these four road types and the never-treated municipalities. Table 5 presents the results showing that armed groups take advantage of the lack of law enforcement and state capacity in two main ways. Several remarks are in order. First, the coefficients of the impact of roads on conflict decrease as road size increases meaning that the effect of road provision is non-monotonic. For instance, after the construction of a *placa-huella*, the attacks by FARC increase in 0.0684 attacks. Conversely, after an intervention of a primary road, the increase of FARC attacks is 0.000538 attacks which is an order of magnitude lower - and it is not significant at any of the usual levels of confidence.

[20] Table A.6 shows the results when I evaluate a potential heterogeneous effect coming from the distance to the department capital of each municipality. However, the results show that the distance to the department capital is not related to any significant change in the armed conflict outcomes.

Table 4: State Capacity and Public Goods

VARIABLES	(1) Attacks	(2) FARC	(3) ELN	(4) Paramilitary	(5) Coca hectares
	Panel A: Military Brigade				
Post × *placa-huella*	0.0368	0.0548***	0.0304***	0.0156**	0.0190
	(0.0241)	(0.00170)	(0.000687)	(0.00351)	(0.734)
Post × *placa-huella*	-0.736	0.523***	0.186***	0.0275***	0.433***
× Distance Brigade$_i$	(0.827)	(0.0579)	(0.0215)	(0.00337)	(0.123)
	Panel B: Efficiency				
Post × *placa-huella*	0.0244***	0.0708***	0.0519***	0.0791***	0.00712
	(0.000152)	(0.00104)	(0.000433)	(0.000660)	(0.00808)
Post × *placa-huella*	-0.207**	-0.144**	-0.0535**	-0.00950***	-0.0193***
× Speed Efficiency$_{i,2008}$	(0.0888)	(0.0619)	(0.0233)	(0.00367)	(0.00638)
Post × *placa-huella*	-0.0039**	-0.253**	-0.0948**	-0.0166***	0.00884
× Judicial Institution Size$_{i,2008}$	(0.0019)	(0.109)	(0.0408)	(0.00625)	(0.0111)
Observations	16,315	16,315	16,315	16,315	16,315
Mean Dep. Var	1.99	1.42	0.53	0,81	1.16
S.D Dep. Var	1.64	1.21	0.85	0.21	2.30
Time/Mun. F.E	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓	✓
Number of Mun.	1,121	1,121	1,121	1,121	1,121

Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. Attacks represents the total number of attacks in each municipality. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are measured in hundreds of hectares. Distance Brigade$_i$ is the log of distance from each municipality to the nearest military brigade. Judicial Institution Size$_{i,2008}$ is the number of judges, attorneys and general prosecutors in each municipality in 2008. Robust standard errors are clustered at the municipality level and are shown in parentheses. In columns 1-4, variables that are not shown include municipality and year fixed effects, log of population, users with natural gas, with electric power, and an index of unsatisfied needs. All specifications include the term *Post × other roads*.

Second, these results also evidence the fact that the importance of state capacity varies across the country. Indeed, if state capacity in terms of road provision was similar across municipalities, then road size would not matter on the level of illegal activity in each municipality. Table A.5 indicates there is a differential effect of a *placa-huella* and a primary road. It shows a t-test in which the null hypothesis is that the point estimate of a *placa-huella* and a primary road on the four main outcomes I study is the same. Based on these results, it is safe to conclude that the effect of a primary road on conflict is different from the effect of a *placa-huella*. Meanwhile, the effect of a tertiary road (non *placa-huella*) is the same as the impact of a *placa-huella*. This suggests that in areas with tertiary roads (which are mostly rural areas) such projects lead to stronger increases in the levels of conflict. Relatedly, the construction of primary roads that come with the building of tolls and the presence of military checkpoints presumably create an environment of security, resulting in less proliferation of illegal activity.

Finally, as primary routes are likely to be built in areas where the state has higher incentives to guarantee security (connecting important economic hubs for instance), rural areas are made vulnerable to threats and attacks perpetrated by armed groups. They are also more likely to serve armed groups by financing them through illegal crop production. Rural areas can be used by armed groups to commit their illegal activities, and thus, can be used to facilitate war actions, expropriate rents of the peasants and boost illegal economies (consistent with the findings of *Fundación Gaia Amazonas (NGO)*, 2018).

Table 5: Road size and State Capacity

VARIABLES	(1) Attacks	(2) FARC	(3) ELN	(4) Paramilitary	(5) Coca hectares
Post × *Placa-huella*	0.157***	0.0684**	0.0528***	0.0058*	0.0010
	(0.0438)	(0.0324)	(0.0198)	(0.0032)	(0.0018)
Post × Tertiary	0.0936*	0.0127***	0.0259*	0.000142*	0.00110
	(0.0541)	(0.0041)	(0.00150)	(0.0007)	(0.0284)
Post × Secondary	0.0627	0.0118***	0.0099***	0.0034	0.0043
	(0.0669)	(0.00388)	(0.0003)	(0.0812)	(0.00327)
Post × Primary	0.0708*	0.000538	-0.0429	-0.0219	-0.00398
	(0.0409)	(0.104)	(0.0460)	(0.0139)	(0.00320)
Observations	16,315	16,315	16,315	16,315	16,315
Mean Dep. Var	1.99	1.42	0.534	0,81	1.16
S.D Dep. Var	1.64	1.21	0.85	0.21	2.30
Time/Mun. F.E	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓	✓
Number of Mun.	1,121	1,121	1,121	1,121	1,121

Notes: See Table 1.

7 Alternative accounts

In this section, I consider two alternative mechanisms that could explain the results found in Section 5. I present evidence showing that these mechanisms do not hold.

7.1 Rentier effects

One set of alternative accounts posits that rentier effects are at play. More precisely, the increase in attacks could be viewed as expropriation attempts led by armed groups aimed at capturing new revenues that each municipality receives for the construction of the *placa-huella*. Indeed, it is possible that armed groups are interested in financing their activities with public revenues. This could lead to increases in attacks on bridges, public infrastructure, and pipelines to intimidate public stakeholders managing these infrastructures in order to capture this wealth. Hence, to test this possible explanation, I estimate the following equation:

$$\begin{aligned} Y_{it} = \alpha_i + \gamma_t + \theta_1(Post_t \times Placa - Huella_i) + \theta_2(During_t \times Placa - Huella_t) + \\ (\mathbf{X'}_{i,2000} \times Year_t)\phi + \varepsilon_{it} \end{aligned} \tag{6}$$

In this equation, I use both the start and end dates road construction to create a variable that corresponds to one to the construction period of the road, zero otherwise. Throughout this period, each municipality receives the revenues to develop the project, and hence, if rentier effects are at play, I would expect that the coefficient θ_2 is positive and significant. It would suggest that armed groups are responding to this positive income shock and increase the attacks to financing their activity using these revenues. Moreover, once I control for the *during* indicator, I would also expect that the θ_1 coefficient loses significance because royalty transfers stop.

Table A.7 presents the results when Equation 6 is estimated. It shows that the effects of the *placa-huellas* after the construction remains positive and significant. Furthermore, the magnitude of the effect shown in these estimations remains similar to what was found in previous sections, suggesting that the effect of the *placa-huella* completion on the outcomes is robust to this new specification. The effect of the during period of road building is statistically equal to zero. These results present evidence against the hypothesis of rentier effects.[21] It reveals that while municipalities receive royalties revenues, the change in the number of attacks is not statistically significant. This means that the effect is driven by the economic opportunities produced by the *placa-huella*, not the money received to build it.

7.2 Effectiveness in the execution of royalty projects

Another alternative mechanism is related to the execution of this type of road projects. This second account is aligned with a source of corruption on the adjudication of *placa-huella* projects and highly related to the first alternative account I examine. Armed groups could take advantage of projects which are poorly executed to extract rents and use this as a financial resource for their activities. Poor execution encompasses delays in the delivery of the road, going over-budget or other irregularities in the project's execution (warnings or sanctions issued by the DNP who monitors the projects'execution).

To test this account, I use three measures provided by the DNP for each of the projects funded with royalties revenues. The first variable is an indicator variable for critical projects. This variable takes into account characteristics as unjustified delays of more than 100 days, large imbalances between the fiscal and financial completion of the project, among other irregularities. Second, I consider an continuous measure of transparency that covers consistency on the reported information, the execution of the project, etc.

[21] Up to a point, in Section 5 I already presented some suggestive evidence against rentier effects. The significant effect of the *placa-huella* appears two or three periods after the road completion, not immediately. Hence, if rentier effects were at play, immediate effects would arise in the dynamic case.

Finally, I use a continuous measure of a project's efficacy which encompasses whether a project meets its initial budget, whether it complies with deadlines set by the DNP, and the ratio between the physical and financial completion of the project. Thus, these three variables seek to measure the performance of each project. For these measures, I collapse the information at the municipality level since these variables come at the project level.

As such, I estimate the following equation:

$$Y_{it} = \alpha_i + \gamma_t + \theta_1(Post_t \times Placa - Huella_i) + \theta_2(Post_t \times Placa - Huella_i \times Performance_{it}) \\ + (\mathbf{X'}_{i,2000} \times Year_t)\phi + \varepsilon_{it} \tag{7}$$

Where $performance$ is each of the previous indicators (these three measures are included in the same regression). I use the inverse of these performance measures (except for the dummy variable of critical projects) to analyze what happened on the worse-ranked municipalities. If this account is true, then θ_2 should be positive and significant for the efficiency and transparency measures, suggesting that in municipalities where the project performed worse, the number of attacks increases after the road completion. Table A.8 displays the results. It shows that the performance of the project does not drive the effect of roads on illegal activity. Moreover, for municipalities with the worst project's management, illegal activity seems not to respond with increases. Hence, these findings suggest that project performance is not driving increases in illegal activity after a *placa-huella* road completion.

8 Robustness checks

In this section, I subject the estimates to several robustness checks. In the first check, I aim to provide evidence that all the effect on armed conflict and illicit crops is driven by the *placa-huellas* and other roads are not leading to any changes in these outcomes. Thus, I estimate Equation 1 without the municipalities that between 2000-2014 constructed a *placa-huella*. In this case, the treatment is all other types of roads. In this specification, I compare the outcomes of the never treated municipalities and the municipalities that constructed primary, secondary, or tertiary, not *placa-huellas*, roads. The results are plotted in Figure A.8. It shows the dynamic point estimates for each of the outcomes, together with the 95% confidence interval. These figures show that there is not any significant change in the outcomes for municipalities that constructed other roads compare to the never treated municipalities.

The second check is a complement of the previous. I estimate Equation 1 when treatment is other roads with the full sample. The aim is the same as above: to verify that all the effect is driven by the municipalities with *placa-huellas*. In this specification, I compare the outcomes of the never treated, municipalities with *placa-huellas* and the municipalities that constructed any of the other roads. Figure A.9 plots the coefficients and the C.I. Again, these point estimates are statistically equal to zero, and hence, it seems that primary, secondary, and tertiary roads are not affecting these outcomes in the same way as the *placa-huellas*. The dynamic effect on these outcomes comes from the construction of a *placa-huella* in a given municipality.

On the other hand, the third check aims to subject the estimates to a *strict* specification of Equation 2. In this case, I include the interaction of year fixed effects and department and region trends. Table A.9 presents the results of estimating Equation 2 controlling for regional and department trends. Panel A presents the results when I include regional trends and Panel B when controlling for department trends. In the first case, the results are the difference in the outcomes of treated and control municipalities inside the same regions and the second, inside the same department. In this case, the treatment is *placa-huellas* roads. I would expect that the results hold up even if I add these interacted terms, and hence, the results are consistent with different department and regional trends. The results indicate that the magnitude and the sign of the point estimates are not changing dramatically when I add regional trends. Hence, municipalities with *placa-huellas* experienced an increase in the illegal attacks and crops after the road construction compared to the municipalities that did not receive a *placa-huella* at any point in time (the never treated group) within the same region.

However, in the case of department trends, the effects on these outcomes change, and the significance as well. The coefficient of FARC attacks remains the same in magnitude and significance, but the other point estimates of attacks are not significant at any level. While the ones for illegal crops seem to acquire significance. For these outcomes, after the construction of a *placa-huella*, the hectares of coca increase in about 0.0062 hectares, compared with the never treated municipalities, within the same department. In spite of these results, it seems that, even if this last specification is highly *strict*, the *placa-huella* are boosting both illegal crops and attacks after its construction.

Another concern is related to the spillover effects that may arise in this context. It could be the case that the illegal activity of a given municipality due to the *placa-huella* affects outcomes of the other nearest municipalities. Thus, treated conflict-zones potentially will affect conflict levels and hectares of illicit crops of the treated municipalities at later points in time (control group for treated in t). Under this scenario, these municipalities may not represent a valid counterfactual for municipalities treated *today* (in t). Then, the results of the Difference-in-Differences with Staggered Adoption will be biased upwards, as the same forces affecting treated municipalities may affect counterfactual municipalities leading increases in their conflict levels and harvested illicit crops as well. I, therefore, show that the results are robust to different control groups.

Hence, following Colonnelli and Prem (2017) I estimate Equation 1 with smaller windows to compare municipalities treated in t with municipalities treated near t (and the never treated group). That is, I restrict attention to a control group of municipalities that are far away from treated ones. Table A.10 presents the results when I use three different small windows, [-1, 1], [-2, 2] and [-3, 3]. This table shows that only significant effects arise two and three periods after the road construction. Hence, the findings are robust to different control groups. Similarly, the magnitude of the point estimates remain similar to the case in which the window used was [-4, 4].

On the other hand, Table A.11 shows the relationship between municipal characteristics and the timing of treatment adoption. The aim of this regressions is to determine whether these characteristics are correlated to the timing of the treatment. I divided the sample into five groups or cohorts of municipalities. I constructed a dummy so that each municipality is assigned to one of these groups. For example, if certain municipality is assigned to the first cohort, it means that this municipality received in the first *wave* the treatment (*placa-huella*). I use these variables as outcomes and a set of municipal characteristics as covariates. Hence, in Column (1) I am comparing the first cohort with respect to adopters in latter points in time (i.e. municipalities that received the treatment after - cohorts 2 to 5-). I omitted the *last takers* or cohort five.

The ideal scenario is one in which these characteristics were not be good predictors of the timing of the treatment adoption. Thus, I could argue that the timing is uncorrelated with observable characteristics and it is more reliable to assume that the timing is random. In this case, the results indicate that there are some characteristics that potentially could explain the timing of the treatment adoption. For instance, it seems that the index of unsatisfied needs is positively correlated with municipalities that in the first *wave* finished the *placa-huella*. However, when I use the main outcomes of this study as covariates, these variables are not correlated to the adoption timing. Thereby, the conflict levels of each municipality are not correlated to any changes in the adoption date of the *placa-huellas*.

As I have pointed out in previous sections, these results also show that the construction of the *placa-huellas* is not random and this means that the adoption timing is not random neither. The implications of this result goes beyond of what potentially, using econometrics methods, I could correct. Nevertheless, some of the covariates that explain the timing of treatment adoption, are included as covariates in Equation 1. A note-worthy point to remark is that as Athey and Imbens (2018) explain, the timing of the adoption date is random only by experimental design, which is not the case of the *placa-huella* construction.

Recently, Abraham and Sun (2019) show that the regressions that include leads and lags of the treatment could produce causally uninterpretable results as they assign non-convex weights to cohort specific treatment effects. They proposed an alternative method to determine the causal impact of a dynamic treatment. It consists of a weighted averages of the underlying treatment effects with weights representative of cohort share (i.e. Interaction Weighted (IW) estimator). In particular, these estimators could be useful when the *treatment effect homogeneity* assumption is unlikely to be met. This assumption could be violated when different cohorts have different profiles of dynamic treatment effect. For example, if cohorts differ in their covariates, the way they respond to treatment potentially could be different.

In order to see how the violation of this assumption could bias the results, I use their approach to compare with my findings. The results of estimating the effect of *placa-huellas* applying the IW method are plotted in Figures A.10, A.11 and A.12. It shows, for each outcome, the estimations of the Difference-in-Differences with staggered adoption and the IW estimates joint with the 95% confidence intervals. It shows that both of these models differ on the point estimates and the confidence intervals. However, *(i.)* again it is possible to present evidence in favor of the pre-trends assumption that requires that the pre-treatment point estimates are statistically equal to zero. *(ii.)* even if the magnitude of the estimations change slightly, the sign of the effect remains the same. The aggregate number of attacks increase, and also, the number of attacks by each of the armed groups in the sample. The magnitude of the estimators for the hectares dedicated to coca cultivation is the one that changes more considerably. Two periods after the construction, the hectares of coca increases in about 0.12 hundred of hectares. While in the case of the Fixed Effect model, the increase was 0.01 hundred of hectares. In addition, for all conflict outcomes, significant effects only arise two periods after the *placa-huella* construction, as in the FE model.

9 Conclusion

In this paper, I investigate the impacts of road provision on armed conflict and illegal economies in Colombia. I find that building a *placa-huella*, a common type of rural road in Colombia, leads to an increase in the number of attacks in the municipalities where the roads are built. The number of hectares dedicated to coca cultivation also increases once the road is completed. These results are consistent with the literature that argues that building roads or even motorable tracks in remote areas boosts illegal activities in those areas (Jain and Singh, 2003; Etter *et al.,* 2006; Armenteras *et al.,* 2006).

I examine two mechanisms that potentially drive these unintended results. First, I show that in prosperous municipalities, the effects of road provision on illegal activities are higher than in medium or lower-income municipalities. Roads improve economic performance (understood as agricultural resources), and hence, the armed groups can extract more rents of this new wealth. Second, in places with strong institutions, public goods reduce illegal activities. Conversely, armed groups can take advantage of the lack of local justice and police services to commit more crimes in areas where the state's presence is weaker.

These results should not discourage those who believe that investments in transportation infrastructure can foster higher levels of security, and promote a safer lifestyle for the citizens, which can ultimately translate into higher economic well-being. Instead, they highlight the importance of other factors that influence the effects of public goods on illegal activity. It is crucial to consider ways to both provide public services and increase local state capacity in rural areas. Providing high-quality training for public sector workers in conflict-affected areas, and guaranteeing the sustainability of reputable institutions represent promising actions to achieve this goal.

The results I present also have important policy implications on the crop voluntary substitution effort in post-conflict Colombia. I show that rural roads foster legal economic activity and in places with a history of better economic performance illegal economic activity is substituted by legal production after road construction. However, this implies an increase in the attacks of armed groups thus highlighting armed groups' incentives to finance their activity through illegal sources. It also evidences the impossibility of rural farmers to shift their production from illegal to legal crops even if the production of legal crops is more profitable once new roads are built (Owen, 1987; Nijkamp and Blaas, 1994; Leinbach, 1995; Hoyle and Knowles, 1998). Further research can focus on exploring how to promote crop substitution initiatives that cancel out these unfavorable effects while increasing local state capacity.

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Appendix

Figure A.1: *Placa-huellas* in Colombia. Source: Santa Marta's mayoralty.

Table A.1: Basic Statistics for pre-treatment periods

Variable	Obs.	Mean	S.D	Min.	Max.
		PANEL A: ALL SAMPLE			
FARC	11.210	1,43	1,34	0	30
ELN	11.210	0,52	0,91	0	34
Paramilitar	11.210	0,08	0,24	0	11
Hectares of coca	11.210	636,87	522,31	0	23.147,95
Placa-Huella Proj.	11.210	0,60	0,44	0	1
All road Proj.	11.210	0,85	0,28	0	1
Amount of Royalties	10.463	4.710	12.700	0	200
		PANEL B: TREATED MUNICIPALITIES			
FARC	6.730	1,39	1,16	0	24
ELN	6.730	0,50	0,56	0	13
Paramilitar	6.730	0,08	0,19	0	5
Hectares of coca	6.730	639,42	289,43	0	10.564,73
Amount of Royalties	5.983	8.720	9.760	170	42.000
		PANEL C: NEVER TREATED MUNICIPALITIES			
FARC	4.480	1,45	1,29	0	30
ELN	4.480	0,56	1,09	0	34
Paramilitar	4.480	0,09	0,26	0	11
Hectares of coca	4.480	651,84	485,61	0	16.523,88
Amount of Royalties	3.733	10.753	13.733	0	36.000

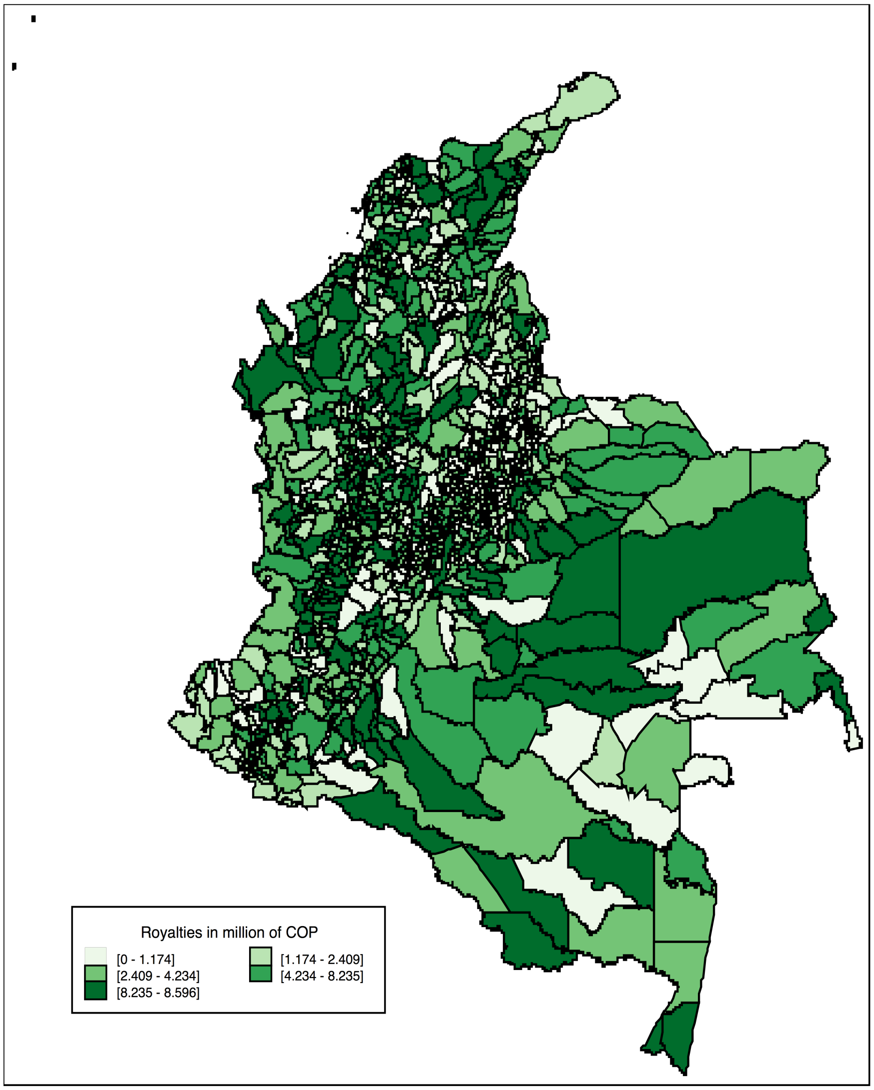
Note: The amount of Royalties is in million of Colombian pesos.

Table A.2: Difference in means test for outcomes and covariates in pre-treatment periods.

Variable	**Control** *(S.D)*	**Treatment** *(S.D)*	**Difference** (p-value)
	Panel A: T-Test for Outcomes		
FARC	1.493	1.4079	0.086
	(1.645)	(1.229)	(0.514)
ELN	0.532	0.473	0.058
	(1.122)	(0.585)	(0.37)
Paramilitary	0.093	0.081	0.01
	(0.32)	(0.22)	(0.40)
Hectares of coca	636.30	620.71	15.59
	(545.24)	(307.27)	(0.11)
	Panel B: T-Test for municipality characteristics		
Coverage of aqueduct	63.11	62.69	0.42
	(31.98)	(30.50)	(0.23)
Coverage of waste disposal unit	48.63	46.05	2.58
	(33.99)	(31.45)	(0.34)
Coverage of sewerage	44.38	45.72	-1.34
	(32.79)	(30.48)	(0.45)
Users with electric power	17.08	7.03	10.05***
	(75747.61)	(16451.52)	(0.00)
Users with natural gas	19.403	8.087	11.315***
	(57254.13)	(38247.55)	(0.00)
Basic Unsatisfied Needs	45.26	45.30	-0.04***
	(25.96)	(21.02)	(0.00)
Births	956.74	976.20	-19.46
	(3994.56)	(1388.95)	(0.67)
Deaths	291.08	228.38	62.70
	(1344.43)	(414.92)	(0,78)
Rurality Index	24.78	23.88	0.90
	(14.21)	(9.20)	(0.54)
Total Population	59.46	58.77	0.68
	(245321.33)	(80514.58)	(0.67)
Rural Population	8.04	9.00	-0.96
	(7733.41)	(10170.37)	(0.74)
Mortality Infant Rate	0.59	0.59	0.00
	(0.29)	(0.23)	(0.52)
Capital Dep. Distance (km)	81.13	81.60	-0.47
	(67.46)	(59.74)	(0.73)
Distance to Bogota	335.15	329.45	5.70
	(244.14)	(188.40)	(0.54)
GDP	255041.9	235561	19480.9
	(1041586)	(58906.8)	(0.23)
Agricultural GDP	24100.47	22853.53	1246.941
	(29996.53)	(31029.71)	(0.35)
Municipalities	4.480	6.730	-

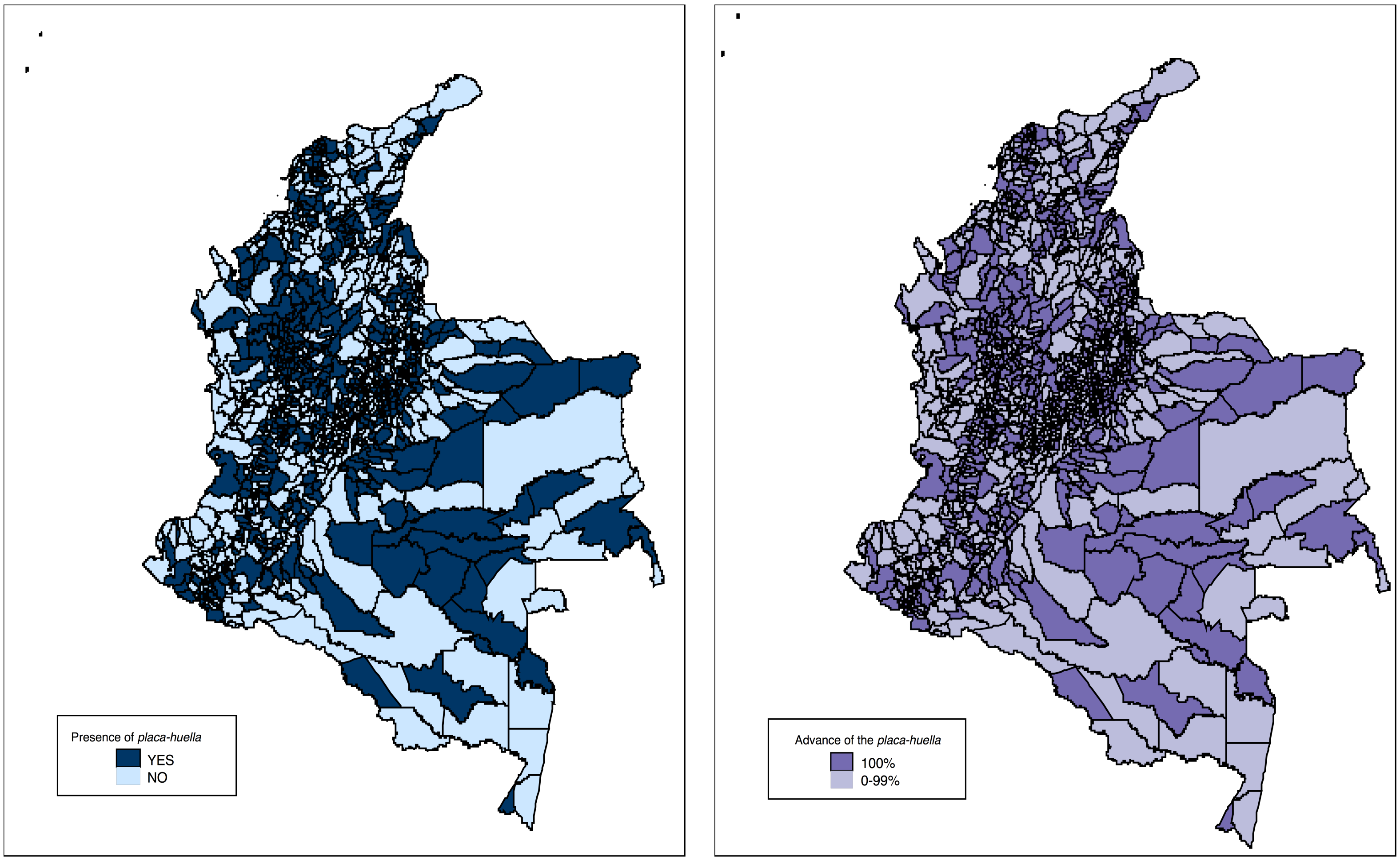
Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Hectares of coca is in hundreds of hectares.

Figure A.3: Amount received of Royalties in Municipalities for the transport sector.



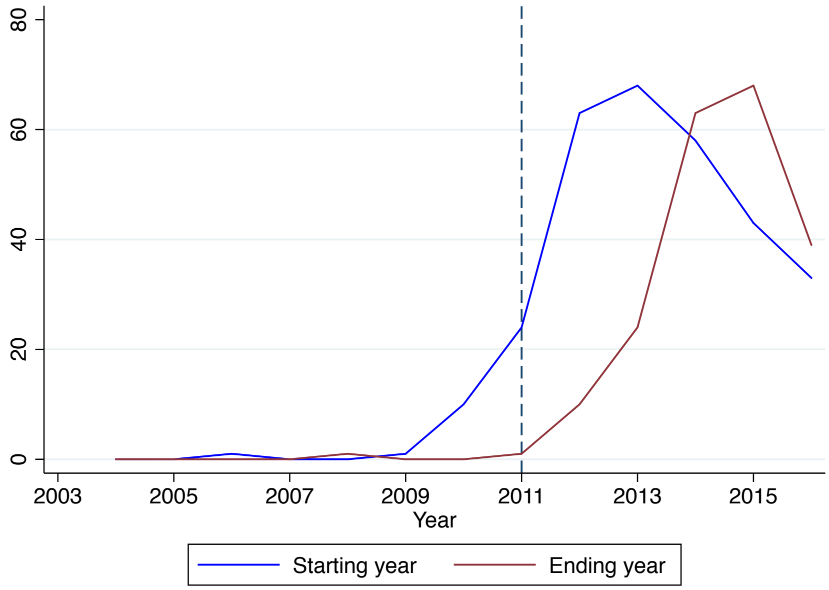
Notes: This map presents the geographical distribution of the royalties to the transport sector in Colombia. The greener, the more royalties the municipality receives. Own calculations.

Figure A.2: Geographical distribution and physical advance of the *placa-huellas* in Colombia



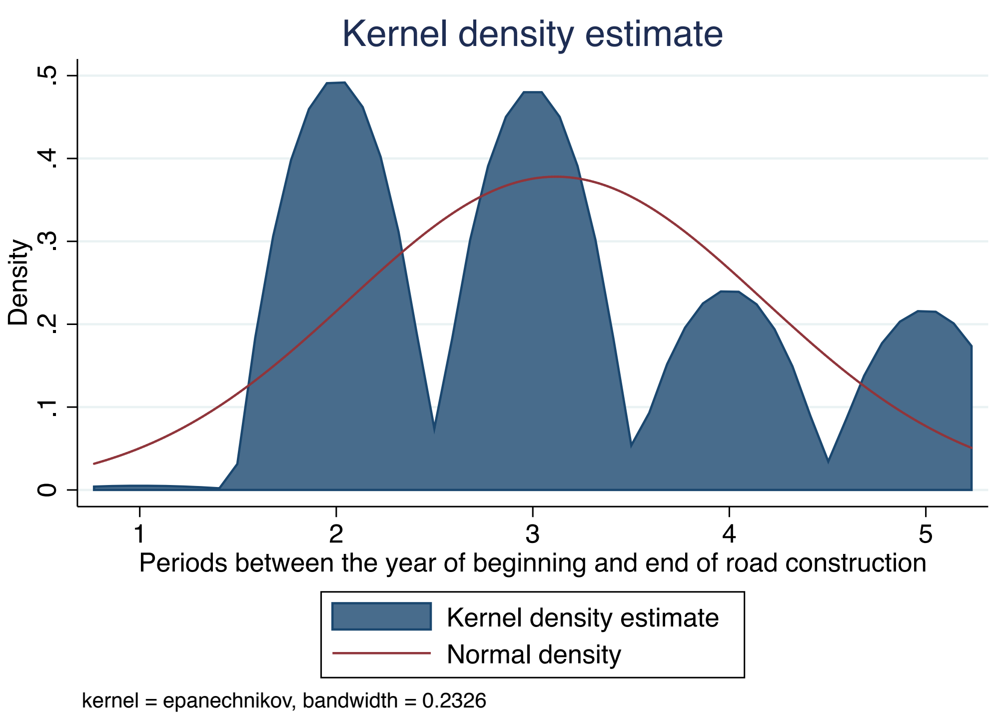
Notes: These maps show the geographical distribution of the *placa-huellas* (left map) and the physical status of the *placa-huellas* (right map) in each municipality. Own calculations.

Figure A.4: Number of *placa-huella* roads per year.



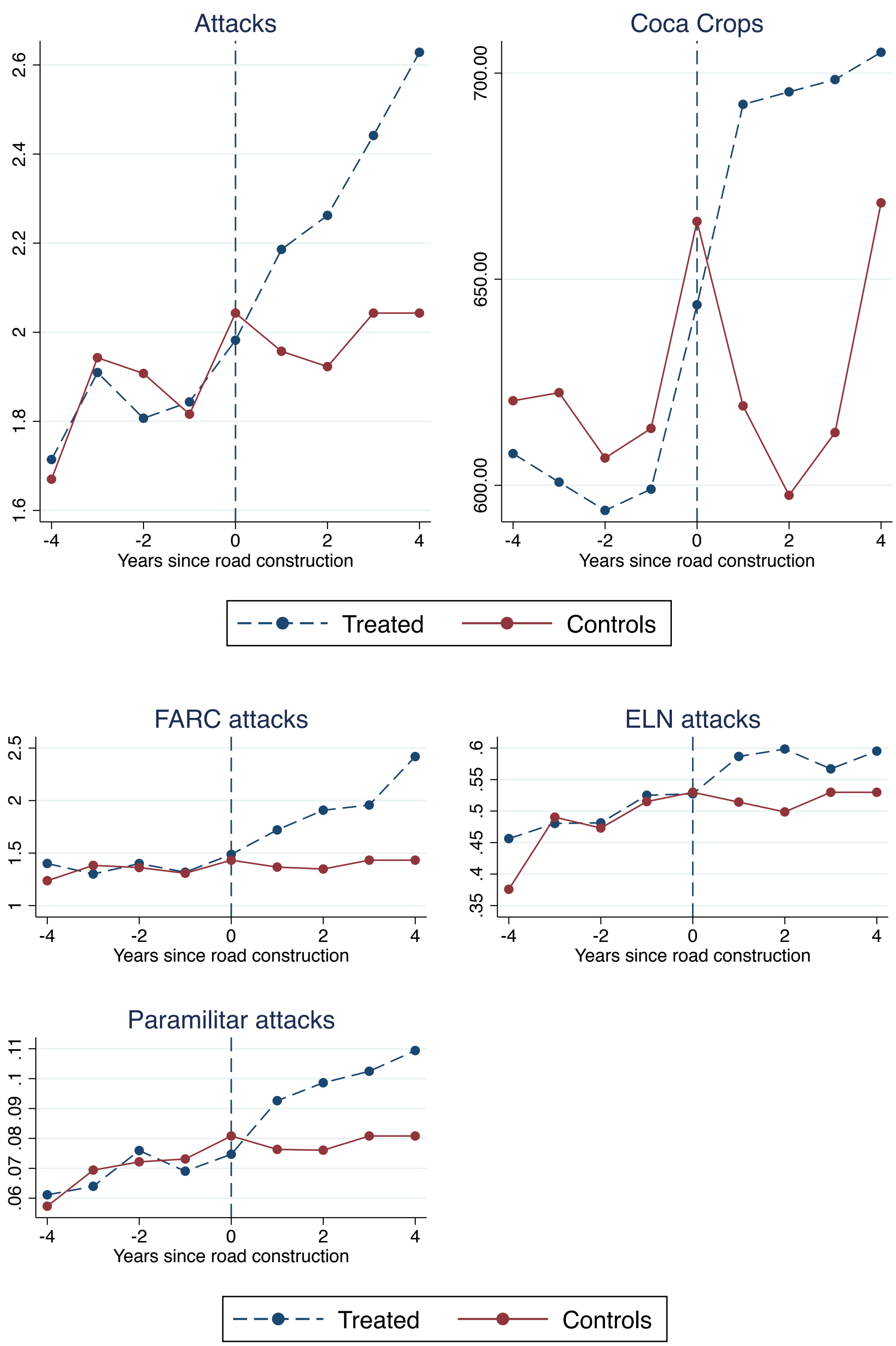
Notes: This Figure plots the starting and ending year of the contruction of the *placa-huellas* in Colombia. It shows the number of roads per year. Own calculations.

Figure A.5: Years since the beginning of the roads



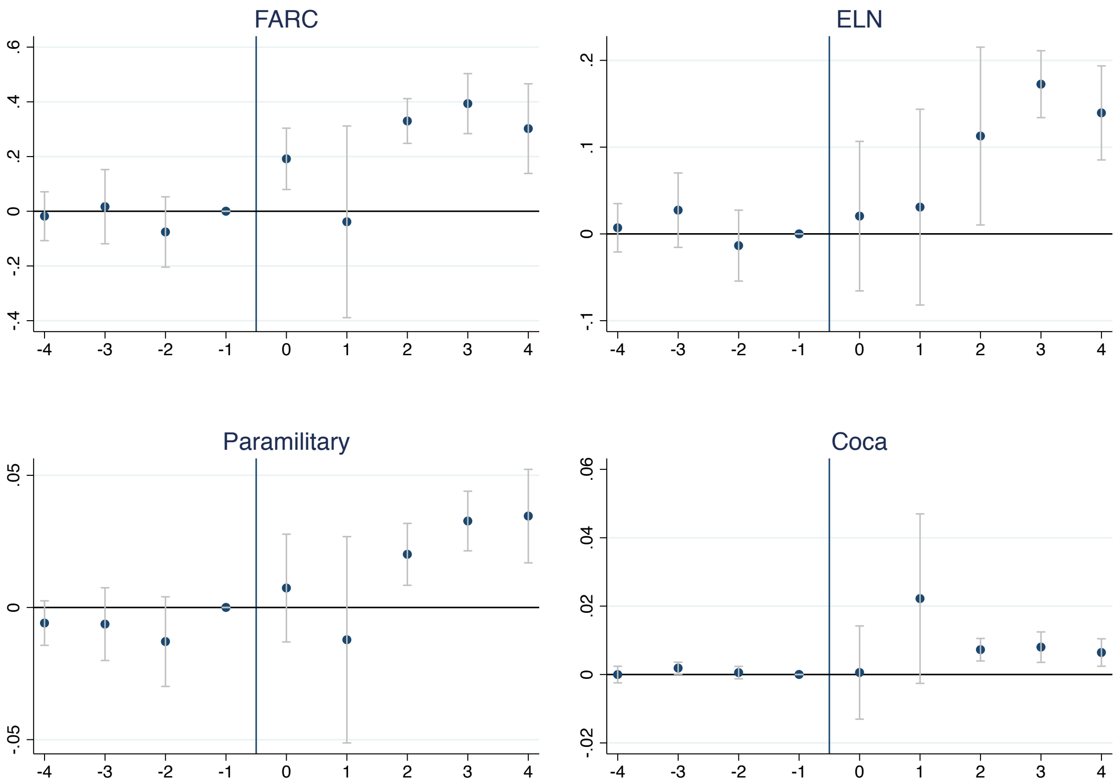
Notes: This kernel estimate presents the density of the variable that indicates how many years it takes to build a *placa-huella* based on the starting and ending year variables. Own calculations.

Figure A.6: Treated and Control Municipalities: raw data (mean values per year)



Notes: These figures show the average values of the main outcomes both for the municipalities that constructed a *placa-huellas* and the ones that did not. These values are plotted over a window of [-4.4]. Zero indicates the starting date of the road construction. Own calculations.

Figure A.7: Dynamic effect of roads on conflict without controls.



Notes: These figures show the effect of the *placa-huellas* on FARC, ELN and Paramilitary attacks and the hectares dedicated to coca cultivation without controls. The X axis presents years since the *placa-huella* construction. Own calculations.

Table A.3: Transformations of the coca crop measure.

VARIABLES	(1) Share of Coca	(2) log(Share of Coca)	(3) Share of Coca (hyperbolic)
Post × *placa-huella*	0.623	0.00864	0.0952
	(0.398)	(0.0125)	(0.453)
Observations	16,315	16,315	16,315
Mean Dep. Var	1.18	0.357	0.459
S.D Dep. Var	24.57	0.483	0.553
Time/Mun. F.E	✓	✓	✓
Controls	✓	✓	✓
Clustered errors	✓	✓	✓
Number of Mun.	1,121	1,121	1,121

Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. Share of Coca represents the ratio between the hectares dedicated to coca cultivation and the total of hectares used to any cultivation in each municipality. Log(Share of Coca) is the natural logarithm (+1) of Share of Coca and Share of Coca (hyperbolic sine) represents the hyperbolic transformation of the share of coca.

Table A.4: Roads and Agricultural Commodities.

VARIABLES	(1) Hect. Cocoa	(2) Hect. Potato	(3) Prod. Cocoa	(4) Prod. Potato
Post × *placa-huella*	0.513**	0.245***	0.327***	0.207***
	(0.023)	(0.00729)	(0.0125)	(0.0225)
Observations	16,315	16,315	16,315	16,315
Mean Dep. Var	0.247	0.802	0.121	0.499
S.D Dep. Var	0.045	0.067	0.098	0.035
Time/Mun. F.E	✓	✓	✓	✓
Controls	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓
Number of Mun.	1,121	1,121	1,121	1,121

Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level.

Table A.5: Effects by type of road: t-test for estimated values.

VARIABLES	(1) Attacks	(2) FARC	(3) ELN	(4) Paramilitary	(5) Hectares of coca
	H_0: $\beta_{Post \times Placa\text{-}huella} = \beta_{Post \times Tertiary}$				
p-value	0.298	0.389	0.490	0.382	0.284
	H_0: $\beta_{Post \times Placa\text{-}huella} = \beta_{Post \times Secondary}$				
p-value	0.00	0.00	0.00	0.02	0.00
	H_0: $\beta_{Post \times Placa\text{-}huella} = \beta_{Post \times Primary}$				
p-value	0.0015	0.009	0.00	0.0032	0.00

Table A.6: Heterogeneous effect using the capital department distance.

VARIABLES	(1) Attacks	(2) FARC	(3) ELN	(4) Paramilitary	(5) Hectares of Coca
Post × *Placa-Huella*	0.0821**	0.0241***	0.0502**	0.0780**	0.136
	(0.0252)	(0.00176)	(0.00227)	(0.0119)	(0.000123)
Post × *Placa-Huella*	-0.186	-0.117	0.0818	0.0129	-0.608
× $CapitalDepart.Distance_i$	(0.265)	(0.184)	(0.717)	(0.111)	(0.447)
Observations	16,315	16,315	16,315	16,315	16,315
Mean Dep. Var	1.99	1.42	0.534	0,81	1.16
S.D Dep. Var	1.64	1.21	0.85	0.21	2.30
Time/Mun. F.E	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓	✓
Number of Mun.	1,121	1,121	1,121	1,121	1,121

Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. Attacks represents the total number of attacks in each municipality. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are in hundreds of hectares. Robust standard errors clustered at the municipality level are shown in parentheses. In columns 1-5, variables not shown include municipality and year fixed effects, log of population, users with natural gas, with electric power and an index of unsatisfied needs. All specifications include the term *Post* × *other roads*.

Table A.7: Parametric Difference-in-Differences: during VS post construction

VARIABLES	(1) Attacks	(2) FARC	(3) ELN	(4) Paramilitary	(5) Hectares of coca
Post × *Placa-Huella*	0.0975***	0.0405*	0.0518***	0.00517**	0.00178
	(0.0316)	(0.0239)	(0.0154)	(0.00235)	(0.00189)
During × *Placa-Huella*	-0.0191	-0.0201	-0.00143	0.00241	-0.00117
	(0.0507)	(0.0436)	(0.0197)	(0.00398)	(0.00467)
Observations	16,315	16,315	16,315	16,315	16,315
Mean Dep. Var	1.99	1.42	0.534	0,81	1.16
S.D Dep. Var	1.64	1.21	0.85	0.21	2.30
Time/Mun. F.E	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓	✓
Number of Mun.	1,121	1,121	1,121	1,121	1,121

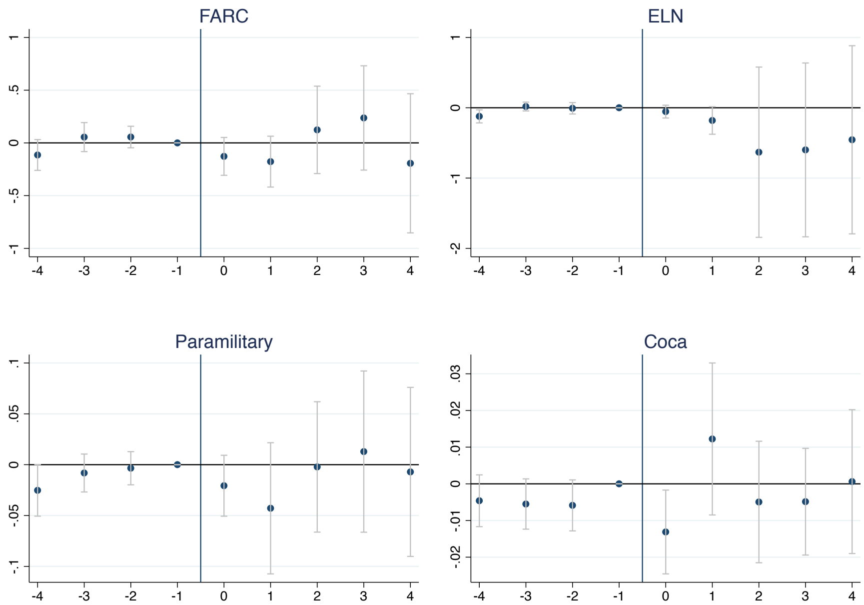
Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. Attacks represents the total number of attacks in each municipality. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are in hundreds of hectares. Robust standard errors clustered at the municipality level are shown in parentheses. In columns 1-6, variables not shown include municipality and year fixed effects, log of population, users with natural gas, with electric power and an index of unsatisfied needs. All specifications include the term *Post* × *other roads*.

Table A.8: Management of road projects.

VARIABLES	(1) Attacks	(2) FARC	(3) ELN	(4) Paramilitary	(5) Hect. Coca
Post × *Placa-Huella*	0.0786***	0.0405*	0.0518***	0.00517**	0.00178
	(0.000846)	(0.0239)	(0.0154)	(0.00235)	(0.00189)
Post × *Placa-Huella*	-0.0227	-0.0162	-0.00528	-0.00123	0.000503
× Transparency	(0.0319)	(0.0226)	(0.00830)	(0.00129)	(0.000389)
Post × *Placa-Huella*	-0.0126	-0.0105	-0.00217	7.77e-05	-0.000132
× Efficacy	(0.0213)	(0.0146)	(0.00618)	(0.000944)	(0.000187)
Post × *Placa-Huella*	0.00309	0.00230	0.000641	0.000155	-0.000745
× Critic. Proj.	(0.00549)	(0.00382)	(0.00151)	(0.000222)	(0.0588)
Observations	16,315	16,315	16,315	16,315	16,315
Mean Dep. Var	1.99	1.42	0.534	0,81	1.16
S.D Dep. Var	1.64	1.21	0.85	0.21	2.30
Time/Mun. F.E	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓	✓
Number of Mun.	1,121	1,121	1,121	1,121	1,121

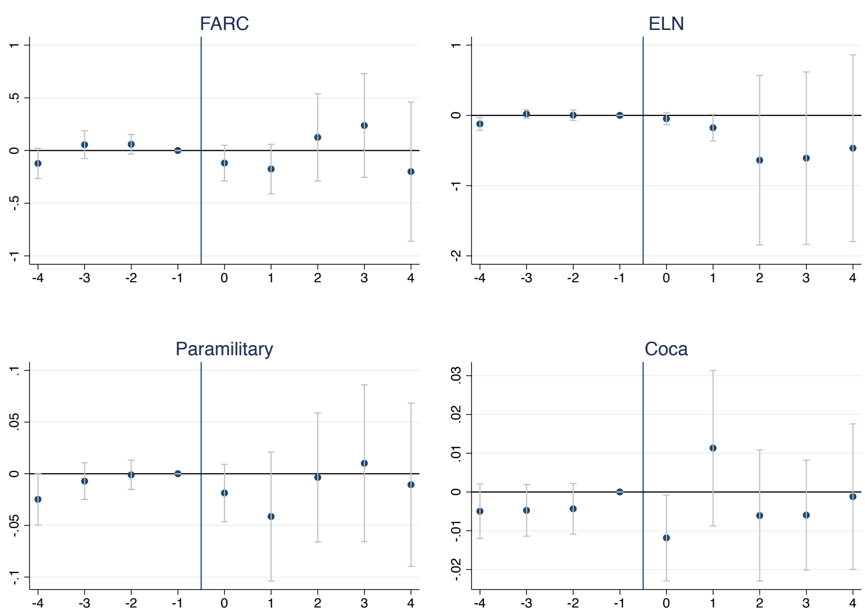
Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. Attacks represents the total number of attacks in each municipality. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are in hundreds of hectares. Robust standard errors clustered at the municipality level are shown in parentheses. In columns 1-4, variables not shown include municipality and year fixed effects, log of population, users with natural gas, with electric power and an index of unsatisfied needs. These specifications also include *Post × other roads* and the constitutive terms of the triple interactions.

Figure A.8: Dynamic coefficients of main outcomes without municipalities with *placa-huellas*.



Notes: These figures show the effect of *other roads -not placa-huellas-* on FARC, ELN and Paramilitary attacks. Coca represents the number of hectares dedicated to coca cultivation. The X axis presents years since the *placa-huella* construction. Own calculations.

Figure A.9: Dynamic Coefficient with the full sample.



Notes: These figures show the effect of the of *other roads -not placa-huellas-* on FARC, ELN and Paramilitary attacks. Coca represents the number of hectares dedicated to coca cultivation. The X axis presents years since the *placa-huella* construction. Own calculations.

Table A.9: Other specifications of the parametric Difference-in-Differences.

VARIABLES	(1) FARC	(2) ELN	(3) Paramilitary	(4) Hectares of coca
Panel A: Including the interaction between Year FE and Region				
Post × *Placa-huella*	0.0612***	0.0743***	0.00470***	0.00152
	(0.0073)	(0.0186)	(0.00062)	(0.00157)
Panel B: Including the interaction between Year FE and Department				
Post × *Placa-huella*	0.0547***	-0.309	-0.0914	0.00620***
	(0.00621)	(0.487)	(0.0912)	(0.00232)
Observations	16,315	16,315	16,315	16,315
Mean Dep. Var	1.42	0.534	0,81	1.16
S.D Dep. Var	1.21	0.85	0.21	2.30
Time/Mun. F.E	✓	✓	✓	✓
Controls	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓
Number of Mun.	1,121	1,121	1,121	1,121

Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are in hundreds of hectares. Robust standard errors clustered at the municipality level are shown in parentheses. Variables not shown include municipality and year fixed effects, log of population, users with natural gas, with electric power and an index of unsatisfied needs.

Table A.10: Dynamic Coefficients when treatment is *placa-huella* projects. Small windows.

VARIABLES	(1) FARC	(2) ELN	(3) Paramilitary	(4) Hectares of coca
	Panel A: Window [-3, 3]			
$t-3$	0.0265	0.00395	-0.000692	0.000221
	(0.0314)	(0.0380)	(0.00279)	(0.00100)
$t-2$	-0.0573	0.0137	-0.00125	0.000763
	(0.0367)	(0.0134)	(0.00337)	(0.00114)
t	0.0315	0.0218	-0.00334	-0.000504
	(0.0453)	(0.0145)	(0.00653)	(0.00181)
$t+1$	0.0213	0.00694	-0.00368	-0.00114
	(0.0568)	(0.0227)	(0.00573)	(0.00310)
$t+2$	0.166***	0.0212*	0.00569	0.00165
	(0.0340)	(0.0109)	(0.00783)	(0.00544)
$t+3$	0.128***	0.0680**	0.00957**	0.0205*
	(0.0381)	(0.0265)	(0.0209)	(0.00114)
	Panel B: Window [-2, 2]			
$t-2$	-0.00425	0.206	0.000130	-0.000243
	(0.0247)	(0.00979)	(0.00246)	(0.00109)
t	0.00476	0.0213	-0.000499	0.000691
	(0.0403)	(0.0142)	(0.00488)	(0.00144)
$t+1$	0.0488	0.0206	-0.00222	-0.000394
	(0.0381)	(0.0199)	(0.00555)	(0.00170)
$t+2$	0.0636***	0.025*	-0.00130	-0.000730
	(0.0227)	(0.0132)	(0.00526)	(0.00307)
	Panel C: Window [-1, 1]			
t	0.00679	0.00341	0.00201	0.00120
	(0.0270)	(0.0102)	(0.00292)	(0.00155)
$t+1$	0.0190	0.00259	0.000194	0.000578
	(0.0370)	(0.0134)	(0.00443)	(0.00155)
Mean Dep. Var	1.42	0.534	0,81	1.16
S.D Dep. Var	1.21	0.85	0.21	2.30
Time/Mun. F.E	✓	✓	✓	✓
Controls	✓	✓	✓	✓
Clustered errors	✓	✓	✓	✓

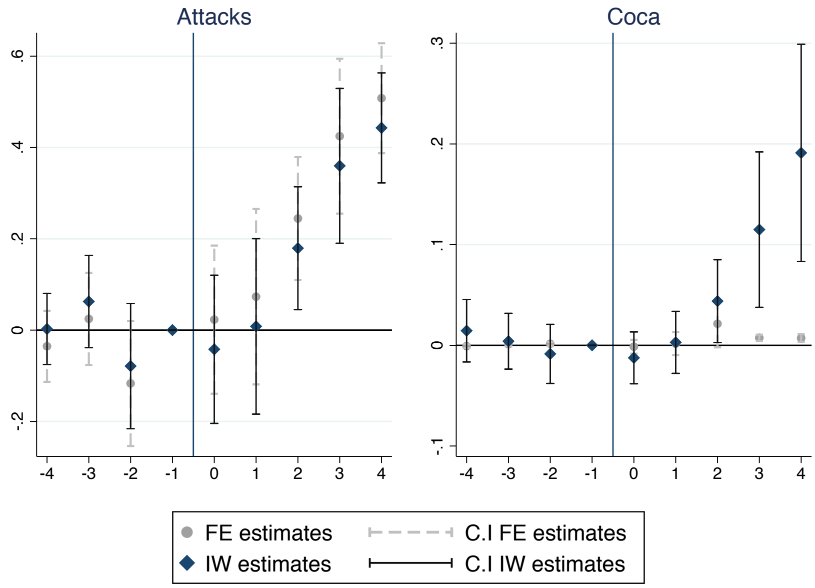
Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are in hundreds of hectares. Robust standard errors clustered at the municipality level are shown in parentheses. In columns 1-5, variables not shown include municipality and year fixed effects, log of population, users with natural gas, with electric power and an index of unsatisfied needs.

Table A.11: Municipal characteristics as predictors of the treatment timing.

VARIABLES	(1) 1st treated cohort	(2) 2nd treated cohort	(3) 3rd treated cohort	(4) 4rd treated cohort
Attacks	-0.0559	0.00306	-0.00922	-0.0737
	(0.0378)	(0.0413)	(0.0499)	(0.0551)
FARC	0.0431	-0.00982	0.0864	0.0501
	(0.0383)	(0.0418)	(0.505)	(0.0557)
ELN	0.0459	-0.0259	0.0110	0.0541
	(0.0404)	(0.0441)	(0.0529)	(0.0611)
Hectares of coca	4.04e-06	-2.68e-06	-2.68e-06	-3.07e-06
	(1.04e-05)	(1.15e-05)	(0.0000132)	(1.46e-05)
Subsidized Regime	1.99e-07	3.33e-07	4.35e-07*	7.53e-07**
	(1.94e-07)	(2.21e-07)	(0.00257)	(2.98e-07)
Births	-1.07e-05	8.83e-07	0.00085	-1.31e-05
	(8.24e-06)	(9.12e-06)	(0.0000104)	(1.17e-05)
Deads	2.51e-05	-2.05e-05	-0.0000454	1.52e-05
	(2.61e-05)	(2.89e-05)	(0.0000332)	(3.73e-05)
BUN	0.00197***	0.00127**	-0.000402	-0.00321***
	(0.000491)	(0.000557)	(0.000654)	(0.000761)
Aqueduct	-6.95e-05	7.50e-05	-0.000420*	-8.96e-05
	(0.000165)	(0.000187)	(0.000219)	(0.000255)
Waste service	-0.000273	-0.000545**	-0.0000323	8.60e-05
	(0.000212)	(0.000239)	(0.000279)	(0.000322)
Users with natural gas	0.000225	0.000230	-0.0000792	-0.000352
	(0.000206)	(0.000232)	(0.00027)	(0.000312)
Users with electricity	0.584	-1.44e-06**	-1.45e-06*	-9.10e-07
	(0.749)	(6.40e-07)	(7.84e-07)	(8.92e-07)
GDP	0.693	-4.76e-06***	-4.85e-06***	-6.07e-06***
	(0.485)	(1.15e-06)	(1.78e-06)	(2.22e-06)
Total population	1.68e-06***	1.70e-06***	1.52e-06***	1.66e-06***
	(3.99e-07)	(5.10e-07)	(4.38e-07)	(5.42e-07)
Rural population	-1.24e-06	-1.63e-06	-1.13e-06	-1.64e-06
	(8.03e-07)	(1.02e-06)	(8.46e-07)	(1.06e-06)
Rurality index	0.00785	-0.0814***	-0.0909**	-0.0834*
	(0.06423)	(0.0305)	(0.0388)	(0.0492)
Capital distance (km)	0.04832	-0.000121	-5.13e-05	1.02e-05
	(0.6747)	(0.000134)	(0.000170)	(0.000217)
Distance to Bogota	0.0794	7.27e-06	5.03e-06	5.74e-05
(0.3896)	(3.48e-05)	(4.49e-05)	(5.76e-05)	
Observations	15,662	14,357	8,647	2,447
Number of Mun.	1,076	986	594	168
% Munic. treated (per wave)	8	35	38	15

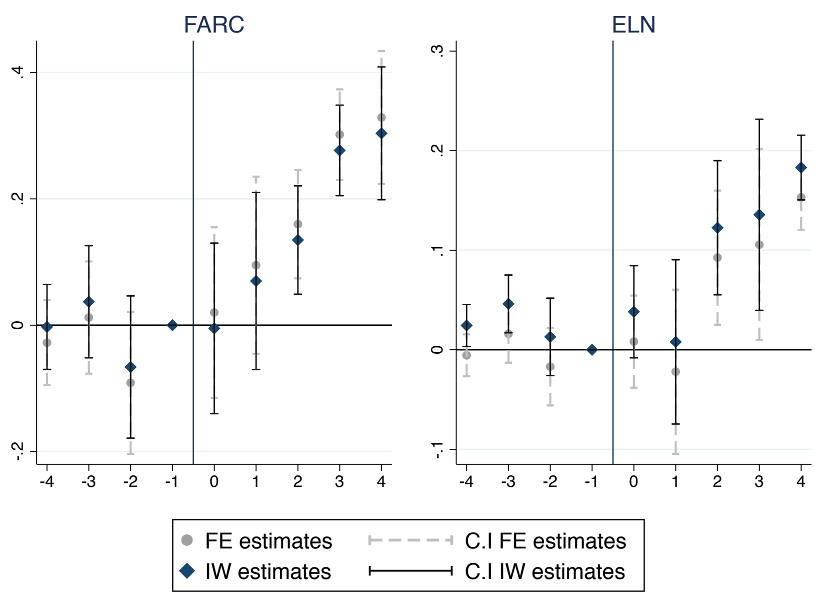
Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. BUN is the index of basic unsatisfied needs. % Mun. treated (per wave) represents the percentage of municipalities treated in each cohort.

Figure A.10: Fixed Effects versus IW estimates of the effects of the *placa-huellas*



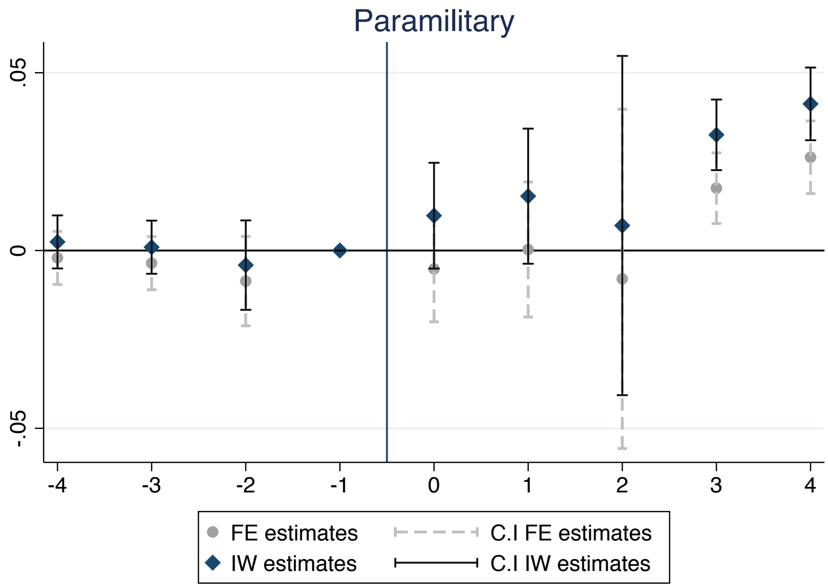
Notes: These figures show the point estimates and 95% confidence intervals of the effect of the *placa-huellas* on the total number of attacks and on the hectares of coca cultivation using the DD with staggered adoption strategy and the Interaction-weighted estimation. Own calculations.

Figure A.11: Fixed Effects versus IW estimates of the effects of the *placa-huellas*



Notes: These figures show the point estimates and 95% confidence intervals of the effect of *placa-huellas* on the total number of FARC and ELN attacks using the DD with staggered adoption strategy and the Interaction-weighted estimation. Own calculations.

Figure A.12: Fixed Effects versus IW estimates of the effects of the *placa-huellas*



Notes: These figures show the point estimates and 95% confidence intervals of the effect of *placa-huellas* on the total number of paramilitary attacks using the DD with staggered adoption strategy and the Interaction-weighted estimation. Own calculations.