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Laura E. Moreno

Jorge A. Gallego

Juan F. Vargas

Universidad del Rosario, Facultad de Economía
Cl. 12c #4-59. Bogotá, D. C., Colombia
PBX: (031) 2970200 ext. 4163

facultadeconomia@urosario.edu.co
https://www.urosario.edu.co/Facultad-de-Economia/Inicio/
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More roads, more conflict? The effect of rural roads on armed conflict and illegal economies in Colombia*

Laura E. Moreno† Jorge A. Gallego‡ Juan F. Vargas§

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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. We 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 places, we 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. In addition, the institutional background seems to be determinant in the sign of the effect: in municipalities with qualified and stable institutions, road provision mitigates the development of illegal activity. These results highlight the importance of providing 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

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†New York University Abu Dhabi

‡Universidad del Rosario

§Universidad del Rosario

1 Introduction

Investment in road infrastructure has increased significantly in the last years around the world. In 2017, according to the World Bank, 14% of its investment projects were aimed at improving road infrastructure. Consequently, roads became a larger sector of the Bank's investments, compared to other historically important sectors such as education or health (World Bank, 2018). Roads are crucial for development. 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 the proliferation of 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. (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. Moreover, in the case of illegal crops, to the best of our knowledge, there are no documented causal results.

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 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 encouraged 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, we study the effects of road provision on armed groups' attacks and on 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 (Athey and Imbens, 2018), we provide evidence that supports the hypothesis that public goods do not necessarily lead to better armed conflict outcomes. The sign of the impact is mediated by 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 a higher increase in attacks by illegal groups such as the Armed Revolutionary Forces of Colombia (FARC), the National Liberation Army (ELN), and paramilitary groups after these projects were completed. These increases represent 4.8% (for FARC), 10.5% (for ELN), and 0.76% (for paramilitary) more attacks with respect to the average attacks. We also find positive and significant impacts of road construction on illegal crop production.

After documenting the main effects, we evaluate two potential mechanisms to better understand our findings: economic activity and institutional background. On the one hand, we argue that criminal activity increases because roads enhance economic activity and, consequently, agricultural earnings. Therefore, the benefit of committing extortions and expropriating these new resources also increases. Using measures of economic activity, we 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 the reaction of the different actors to public good provision is context-dependent (D'Arcy and Nistotskaya, 2017). We argue that the sign of the effect of public goods provision depends on state capacity, namely the importance of law enforcement forces, and, in general, the institutional background of local offices. Our 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, we contribute to this literature in three different ways. First, we 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, we 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, we 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 administrations' 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, we provide a background on the Colombian armed conflict and on road policies in the country. Section 3 presents the data sources and the descriptive analysis, while Section 4 details the empirical strategy. In Section 5, we 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, we 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 dates from 1960, opposing the State and left-wing guerrilla groups. Decades later, right-wing paramilitary groups, drug cartels, and criminal gangs joined the war. Some of the reasons explaining why violence arose in Colombia include the weakness of the State, conflict over land possession, the existence of considerable economic inequalities, the polarization and persecution of the civilian population due to its political orientation, among others (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 exerting terrorism in major cities.

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 very common in Colombia. The highest point comes under the governments of Andrés Pastrana and Álvaro Uribe, during which the Colombian Army, guerrilla groups, drug cartels, and paramilitaries faced each other. During this period, the country also underwent economic transformations. Colombia transitioned 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 the

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, while it prevented the rural population from escaping poverty (Thomson, 2007; Arias *et al.*, 2014). Productive decisions were, in many cases, 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, Santos' government formally began peace talks with the FARC, negotiations 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 declared 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 Substitution of Illicit Crops Program plays a fundamental role, due to the importance that illicit crops have in the financing of illegal groups. For years, the correlation between illicit crops and armed conflict has been positive. Coca growing regions have exhibited higher risks 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 greater than in the non-coca growing municipalities. Unfortunately, this trend seems to have changed since 2017.

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, recent governments and the private sector have 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 in Colombia.[1] One of the main differences between these projects and the other initiatives of road provision mentioned above, is that these roads do not have the explicit goal of reducing the effects of conflict. Hence, these are useful to measure the impact of roads, as they are constructed without the specific objective of reducing 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 peaked after 2011 (Gallego et. al., 2019).

According to the National Planning Department (2018) each proponent[2] 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 this analysis is constructed from the combination of three sources that allows us to analyze annual data at the municipal level between 2000 and 2014. First, to obtain information on road constructions in Colombia, we 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 oil and mining royalties to different sectors. We strictly focus on the transport sector, which includes road provision. In particular, we have information about the specific destination of the revenues, the starting and ending dates of each project, the type of road constructed, among other useful variables. In that sense, for this analysis, the main treatment is defined as follows: rural roads constructed in a particular year under the form of *placa-huella*

[1] Figure A.1 in the Appendix shows an image of a *placa-huella*.
[2] It could be the municipality Mayor, the Governor, or any other person interested in the project.

projects. Additionally, all the specifications include an indicator variable for whether another road project was constructed (tertiary, not *placa-huella*, secondary and primary roads). One of the most important aspects of the empirical strategy used to identify the causal impact on conflict and coca production is that roads were constructed at different points in time. The construction of the *placa-huellas* start and end in different years across 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 figure presents the geographical distribution and the physical progress of the *placa-huellas*. The Figure shows that *placa-huellas* are spread across all regions in Colombia, which contrasts with other road provision programs that have focused on specific places of the country—mainly the most affected by the war. 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.[3]

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

Concerning armed conflict outcomes, we use the Conflict and Violence database of *Universidad del Rosario*. This database contains information about the dynamics of the Colombian Armed Conflict between 1996 and 2014. The primary outcomes are four measures of conflict intensity: the total number of attacks and the number of attacks perpetrated by the FARC, the ELN, and paramilitary groups, respectively. Other important measures of conflict are the number of civilians kidnapped, confrontations between groups, among others. Finally, we used the SIMCI-UNODC database to gather information on illegal economies such as the number of hectares dedicated to coca cultivation. Overall, we consolidated a panel dataset that contains information on 1121 municipalities from 2000 to 2014. Likewise, all of the specifications include controls that come from different sources including DNP, the Center for Study of Economic Development (CEDE), and the Colombian Statistical Agency (DANE).

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

[4] Other sources of road financing include the General System of Participations (SGP), public-private partnerships and foreign investment.

Table A.1 reports basic descriptive statistics for the main variables of interest in the pre-treatment periods. It is divided into three panels. Panel A contains statistics for all the 1121 municipalities between 2000 and 2010. For all the sample, FARC committed 1.4 attacks on average, while ELN committed 0.52 attacks and the paramilitaries 0.08 attacks. This information depicts the important role played by the FARC in the conflict during the period of analysis. Likewise, Panel A shows that 60% of municipalities allocated resources to *placa-huella* projects and that 85% of the sample assigned resources to any other road project. On average, municipalities received US$1.48M for investments in new roads, and there is an enormous variance across municipalities. However, this result is normal, since, before 2011 only a few municipalities received royalties revenues, and the amounts received varied a lot across municipalities.[5]

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 illicit crops. Additionally, on average, both groups received royalty revenues to develop road projects. It is also useful to assess the balance between treated and controls units in their pre-treatment characteristic to get a sense of whether control units are *good* counterfactuals to compare to the treatment units. Thus, to evaluate if we are comparing *similar* treated and control units, we conduct *t*-tests of differences in means to corroborate whether such differences are statistically equal to zero.

Table A.2 shows the results and the p-values associated with these tests. Panel A provides the results of the test for our primary outcomes. It shows that all the p-values are greater than 0.05, and therefore, we fail to reject the null hypotheses that the outcomes of control and treated units are equal in means. Panel B shows the results of the *t*-tests 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, measured through their 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.

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

[5] In 2011, a reform of the Royalties System was carried out in order to distribute resources better across municipalities. See Gallego et. al., (2019).

and to enhance the precision of our estimations.

4 Empirical Strategy

The main methodological challenge upon 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 intensity and illegal crops prevalence. In this section, we describe the quasi-experimental design utilized to estimate the causal impact of road provision, the identification assumptions behind it, and the main estimated equations.

The construction of *placa-huellas* in Colombia locates this analysis under a setting in which treatment adoption by municipalities occurs at different points in time. Hence, this paper implements a Difference-in-Differences with Staggered Adoption strategy (Athey and Imbens, 2018). Under this framework, observational units—municipalities in this case—can adopt the treatment at any of the time periods under study.[6] 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. We 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 we 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 stands 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' heterogeneities that may bias/ the estimated coefficients if they are not taken into account in this panel setting. ε_{it} is the error term, while standard errors are clustered at the municipality level, the level at which the treatment is assigned (Bertrand *et al.*, 2004). As mentioned above, we control for a series of covariates,[7] by fixing them in a pre-treatment year (2000) and interacting them by each *year*, to obtain the differential effect over time of these variables. These covariates are captured by the X vector in the previous expression.

The main component of the equation is $I(j = k)$, 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

[6] Here, we take one year as a time period.

[7] Covariates include population, the index of basic unsatisfied needs, and the number of users with electric power and natural gas.

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, we 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, we 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 outcomes of interest, the timing of the road construction must be uncorrelated with municipal attacks and illicit crops hectares, conditional on the set of control variables we consider, as well as with 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* effect. By analyzing the dynamics of θ_j, we can provide evidence to support or reject this assumption. More formally, the pre-treatment 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 differences between the treatment and control groups are constant over time. To explore this issue, we 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*. It relates to the assignment process for the adoption date which is, in this case, the end year of the road's construction. Under this assumption, the adoption date should be random. This is an extreme assumption that can only be guaranteed by design. Moreover, it has no testable implications. However, Athey and Imbens (2018) argue that it is possible to relax it if the adoption date is completely random within subpopulations with the same values for the pre-treatment variables. We provide evidence showing that it is reliable to think that these outcomes do not exhibit anticipatory effects even if the adoption date is not (entirely) random.[8] Hence, the $\hat{\theta}_j$ estimators that we report below can be read as causal effects.

Moreover, in order to gauge the magnitude of the dynamic effects, we consider the

[8] 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-.

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

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

This specification allows us to analyze the statistical significance and the magnitude of the estimated coefficients. 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 civil 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 we use variations of this specification to analyze the potential mechanisms through which rural roads affect illegal activity. In particular, we use triple interactions to explore potential heterogeneous treatment effects, in terms of municipal-level variations in state capacity, law enforcement and economic activity. For instance, to test for heterogeneous effects in terms of the economic activity, we estimate equations of the following form:

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

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 other specifications we interact the $Post \times Treat$ variable with measures of state capacity and law enforcement capabilities. These potential mechanisms are fixed in a pre-treatment year (2000), to prevent any source of endogeneity. The other components of the equation are the same as before: municipalities and year fixed effects and covariates.

5 Results

The first part of the analysis investigates the dynamics of *placa-huellas* on armed conflict and illegal crops. To that end, we estimate Equation 1, and the results are plotted in

Figures 1 and 2.[9] The figures display the point estimates over a window of [-4, 4] together with the confidence intervals.[10] 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 in all cases. This result allows us to consider the post-treatment 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 attacks by the 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 in the case 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).

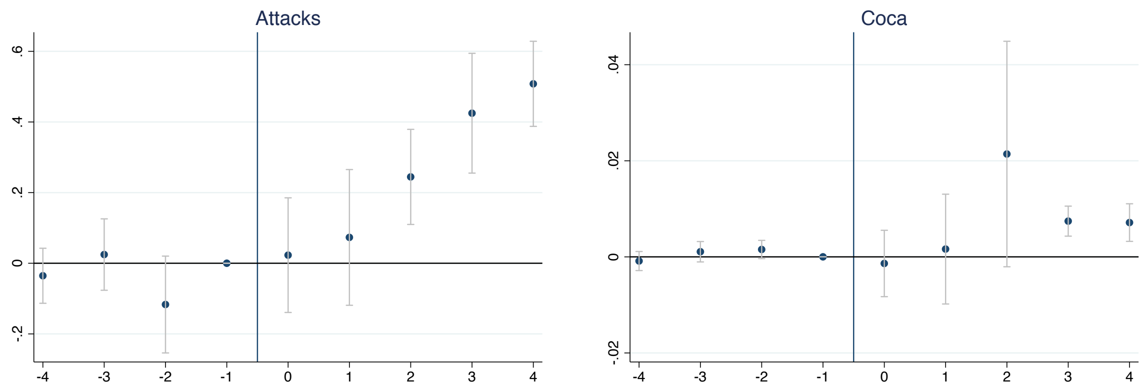
Concerning the effect of *placa-huella* roads on the number of hectares dedicated to coca cultivation, the point estimates behave similarly as in the case of armed conflict outcomes. New roads generate an increase in the size of land destined to coca cultivation. The effect on this outcome reaches its highest point three years after the road completion and is of about 0.01 cultivate hectares more compared to municipalities without a *placa-huella*.

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

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

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.[11] 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 under 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.

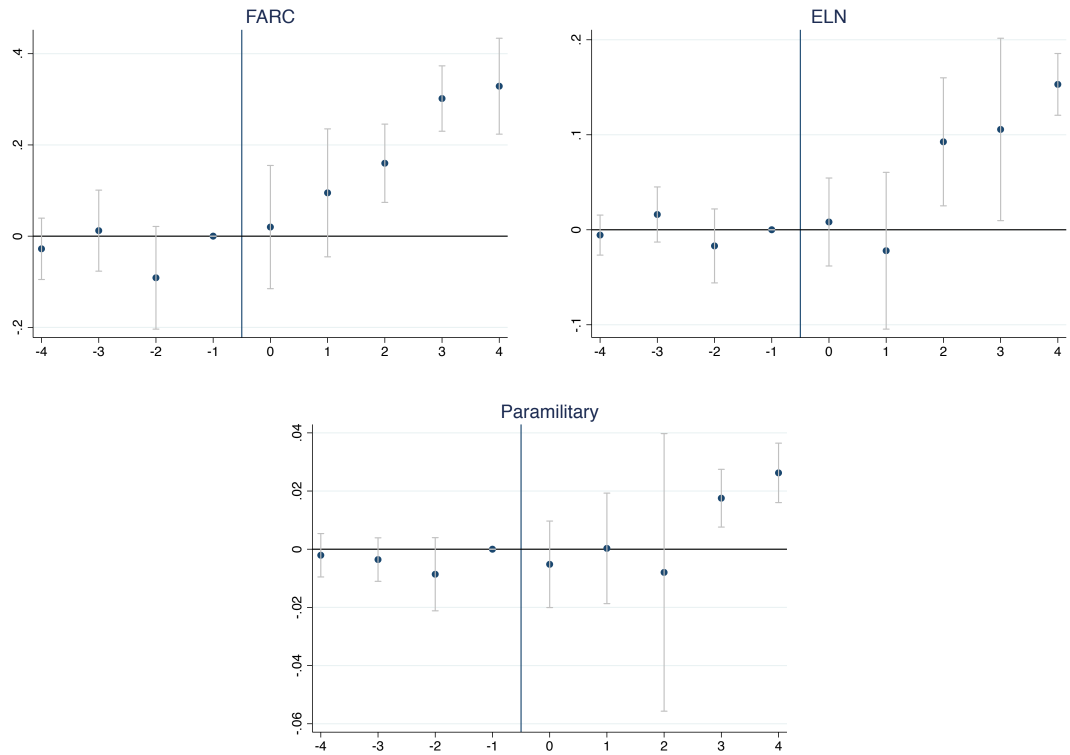
On the other side, Table 1 shows the results of Equation 2. Similarly to the dynamic case, we find positive impacts of *placa-huellas* on the number of attacks perpetrated by armed groups and on the aggregate number of attacks. The magnitude of this effect varies according to the identity of the armed group perpetrating 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 for paramilitaries 0.0062 attacks each year.

Finally, it is interesting to compare these increases to mean levels of violence. These increases are 4.8% (for FARC), 10.5% (for ELN), and 0.76% (for paramilitaries) more attacks with respect to the average levels of attacks. Similarly, concerning increases in standard deviations, for FARC, ELN, and paramilitary attacks, the increase is less than half of a standard deviation for 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 sizable effect on coca crops.[12]

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

[12] Table A.3 shows that using three different approaches for the coca cultivation measure, the results remain the same. There are no sizable 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.

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, we aim to study how these roads are related to illegal activity. We investigate two potential mechanisms that may drive the relationship between road provision and illegal activities. First, we 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 the provision of public goods. Thus, we test if the institutional background is determinant in the sign of the effect of road provision on conflict. These mechanisms are discussed in the next subsections.

6.1 Economic activity, public goods and illegal activity

We 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, we use two measures of economic activity: the agricultural gross domestic product and the *legal* mining of gold.[13]

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 we study gold mining is that it is an important source of income for armed groups. Note should be taken that we focus on production in *legal* mines, as opposed to illegal mines, the latter being mostly related to armed groups.[14] Therefore, we chose the study of gold production as it is a commodity specifically related to the Colombian armed conflict.

[13] We use information provided by the *Unidad de Planeación Minero Energética* on both legal and illegal mines. We 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 our estimations.

[14] 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).

We 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, we are interested in the sign of the triple interaction of the *post* and *treatment* indicators and agricultural GDP in 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 potential source of endogeneity. In these specifications, we compare the outcomes of the never-treated municipalities and municipalities with *placa-huellas*. Additionally, we also estimate a model that uses the time-varying version of the agricultural GDP as an outcome variable, to corroborate whether it is the case that after the provision of the *placa-huella*, a production boost takes place.

Moreover, we centered agricultural GDP to compare municipalities above the mean with those 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 the claim that one of the goals of armed groups is to expropriate new economic resources created by the new *placa-huellas* roads. Additionally, when we use agricultural GDP as an outcome, we would expect the sign of the coefficient of the *post* and *treatment* indicators to be positive and significant as well.

Table 2 presents the results of models based on Equation 3. Columns 1-4 show the effect on the usual outcomes, and Column 5 shows the results when we use the time-varying version of the agricultural GDP as an outcome. Columns 1-4 provide evidence for the existence of heterogeneous treatment effects. 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*.[15]

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

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

increase in attacks is higher. 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 illicit crops decreases. This suggests that armed groups have two motivations to commit attacks: (i) the expropriation of new economic resources which goes 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 we use gold production to test for potential heterogeneous effects at this level.[16] As with agricultural GDP, we fix the value of gold production to its value in a pre-treatment year, and center it on its mean value. Columns 1-4 control for the triple interaction to test for 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 we control for gold production, the number of hectares dedicated to coca cultivation experienced a significant reduction of 0.0648 hectares after the construction of a *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}.

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

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

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 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, we 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 activities with illegal crops, which incited 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: Illegal Activity and Gold Production

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 the 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 we have pointed out in the previous subsection, there is another channel through which road provision may lead 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, we present evidence of a second mechanism explaining the increase of illegal activities after *placa-huellas* road completion. We argue that the sign of the effect of public goods provision on illegal activities depends on the strength of local institutions. As we 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.[17]

State capacity can be proxied by military strength or by the efficiency of other branches of government, such as the judiciary. Hence, we 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 we use summarize data on the number of judges, attorneys and general prosecutors stationed in each municipality used in Prem *et al.,* (2018). 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 us 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,

[17] 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.

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 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.[18]

On the other hand, Panel B presents results when interacting the *Post* × *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, we 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, we 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. We interact each variable with the *post* indicator variable in order to use this as the main regressor under study. Importantly, we estimate the following equation:

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

This equation also includes the constitutive terms of the interactions. Under this specification, we 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

[18] Table A.6 shows the results when we 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.

is 0.000538 attacks which is an order of magnitude lower and it is not significant at any of the usual levels of confidence.

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* × Distance Brigade$_i$	-0.736	0.523***	0.186***	0.0275***	0.433***
	(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* × Speed Efficiency$_{i,2008}$	-0.207**	-0.144**	-0.0535**	-0.00950***	-0.0193***
	(0.0888)	(0.0619)	(0.0233)	(0.00367)	(0.00638)
Post × *placa-huella* × Judicial Institution Size$_{i,2008}$	-0.0039**	-0.253**	-0.0948**	-0.0166***	0.00884
	(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 the 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 that 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 we 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, we consider two alternative mechanisms that could explain the results found in Section 5. Namely, we corroborate whether the effects of roads on conflict are driven by rentier effects and/or project execution effectiveness. We 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, we estimate the following equation:

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

In this equation, we use both the start and end dates of road construction to create a variable that equals one for the construction period of the road and zero otherwise. When the variable activates, municipalities start receiving the money to construct the road, and hence, if rentier effects are at play, we would expect the coefficient θ_2 to be positive and significant. Such result would suggest that armed groups strategically respond to these positive income shocks by increasing their attacks, with the aim of expropriating these revenues. Moreover, once we control for the *during* indicator, we would expect a reduction in the θ_1 coefficient, as part of the effect would be absorbed by the construction period.

Table A.7 reports the results of these models. It shows that the effects of *placa-huellas* on conflict, once construction has been completed, remains positive and significant. Furthermore, the magnitude of the effect remains similar to what we found in previous sections, proving that the effect of the *placa-huella* completion on the outcomes is robust to this alternative specification. The effect of the construction period is statistically equal to zero. All in all, these results represent evidence against rentier-effects hypothesis.[19] They reveal that the effects are not driven by the allocation of money to build the roads, but rather by the economic opportunities generated by the *placa-huellas* once they start to operate.

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 associated with a source of corruption on the adjudication of *placa-huella* projects and highly related to the first alternative account we examined. Armed groups could take advantage of projects which are poorly executed to extract rents and use them to finance their activities. Poor execution manifests in the form of delays in the

[19] In fact, in Section 5 we had already presented some suggestive evidence against the rentier-effects hypothesis. The significant effect of *placa-huellas* appears two or three periods after the road completion and not immediately. Hence, if rentier effects were at play, immediate effects would be evident in the dynamic case.

delivery of the road, going over-budget, among other signs of inefficiencies and irregularities in the execution of a project. All this translates into warnings and/or sanctions issued by the DNP, who is in charge of monitoring the projects' execution.

To test for this alternative account, we use three measures provided by the DNP for each of the projects funded through royalties revenues. The first one is an indicator variable for what DNP calls "critical projects". A critical project has traits as unjustified delays of more than 100 days, large imbalances between the fiscal and financial completion of the project, among other irregularities. Second, we consider a continuous measure of transparency that captures consistency on the reported information, the execution of the project, among other characteristics. Finally, we use a continuous measure of a projects' efficacy which encompasses whether a project meets its initial budget, whether it complies with the 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, we collapse the information at the municipality level since these variables come at the project level.

As such, we estimate models of the following form:

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

In these models, $performance$ represents each of the previous indicators (the three measures are included in the same regression). We use the inverse of these performance measures (except for the dummy variable of critical projects) to interpret the results in terms of the worse-ranked municipalities. If the alternative account holds, then θ_2 should be positive and significant for these efficiency and transparency measures, suggesting that in municipalities where projects performed worse, the positive effect of road provision on conflict is higher. Table A.8 displays the results of these models. It shows that the performance of a project does not mediate on the effect of roads on illegal activity. Moreover, for municipalities with the worst levels of management, illegal activity seems not to respond to treatment. Hence, these findings suggest that project performance is not driving the increase in illegal activity after a *placa-huella* road completion.

8 Robustness checks

In this section, we conduct several tests to check the robustness of our results. In the first check, we aim to provide evidence that all the effects on armed conflict and illicit crops are driven by the *placa-huellas* and that other roads are not leading to any changes in these outcomes. Thus, we estimate Equation 1 without the municipalities that between 2000-2014 constructed a *placa-huella*. In this case, the treatment is the provision of any of the other types of roads. In this specification, we compare the outcomes of the never-treated municipalities and the municipalities that constructed primary, secondary, or tertiary—not *placa-huella*—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 intervals. These figures show that there are no significant changes in the outcomes for municipalities that constructed other roads, compared to the never-treated municipalities.

The second check complements the previous one. We estimate Equation 1, defining treatment as the provision of other roads, but this time using the full sample of municipalities. The aim is the same as above: to verify whether the effect is driven by the municipalities with *placa-huellas*. In this specification, we compare the outcomes of the never-treated municipalities, places with *placa-huellas* and municipalities that constructed any of the other roads. Figure A.9 plots the coefficients and the confidence intervals for these estimations. Again, these point estimates are statistically equal to zero, and hence, it seems that primary, secondary, and tertiary roads are not affecting our outcomes in the same way as the *placa-huellas* do. The dynamic effects on illegal activities come from the provision of a *placa-huella* in a given municipality.

Our third robustness check restricts the estimations to a stricter version of Equation 2. In this case, we include departmental and regional linear time trends. Table A.9 reports the results of these models. Panel A reports the results when we include regional trends and Panel B when we control for departmental trends. In the first case, the results report the difference in the outcomes for treated and control municipalities inside the same region and the second, inside the same department. In this case, treatment is defined as the provision of *placa-huella* roads. The results indicate that the magnitude and the sign of the point estimates do not change dramatically when we add regional trends. Hence, municipalities with *placa-huellas* experienced an increase in illegal attacks and coca cultivation after the road completion compared to municipalities that did not receive a *placa-huella* within the same region. However, in the case of departmental trends results are not totally robust. 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.

An additional concern that may arise in this context is related to the potential spillover effects that may take place. It could be the case that the increase illegal activity in a given municipality generated by the provision of a *placa-huella* has an effect on outcomes for neighboring municipalities. Thus, conflict-zones treated in t may potentially affect the levels of conflict and the number of hectares of illicit crops cultivated in municipalities treated in the future—which belong to the control group in t. Under this scenario, these municipalities may not represent a valid counterfactual for municipalities treated in t. In such case, the results of our estimations may be biased, as the same forces affecting treated municipalities may affect counterfactual municipalities by leading to increases in their measures of illicit activity. To attenuate this concern, we report the results of models in which we use alternative control groups.

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

In terms of the identification strategy followed throughout this study, it is important to corroborate whether the timing of treatment adoption is correlated with municipality characteristics. Table A.11 shows the relationship between a set of municipality traits and the timing of treatment adoption. We have divided the sample into five groups or cohorts of municipalities, depending on timing. Municipalities in the first cohort, for instance, received treatment in the first *wave*. Dummies for these cohorts are used as outcomes in regressions against municipality characteristics. Hence, in Column (1), for instance, we are comparing the first cohort with respect to adopters at later points in time (i.e. municipalities that received the treatment afterwards—cohorts 2 to 5). We omitted the last set of takers (cohort five).

We would expect no correlation between these traits and the timing of treatment adoption. However, the results indicate that there are some characteristics that correlate with the outcomes. For instance, the index of unsatisfied needs is positively correlated with the indicator for municipalities in the first wave. Hence, it is important to control for these characteristics in our main specifications. Nonetheless, it is noteworthy that in the case of our outcome variables (attacks and hectares of coca), these variables are not correlated with the adoption timing.

A final caveat. Abraham and Sun (2019) show that regressions that include leads and lags of the treatment can produce causally uninterpretable results as they assign non-convex weights to cohort specific treatment effects. The authors propose an alternative method to determine the causal impact of a dynamic treatment. It consists of a weighted average of the underlying treatment effects, where weights represent cohorts' shares—the Interaction Weighted (IW) estimator. Moreover, these estimators are useful when the *treatment effect homogeneity* assumption is unlikely to be met. This assumption may be violated when different cohorts have different profiles of dynamic treatment effects. For example, if cohorts differ in certain important covariates, the way they respond to the treatment could potentially be different.

In order to see how the violation of this assumption could bias the results, we use Abraham and Sun's approach and compare it to our main 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. These figures show, for each outcome, the estimations of the Difference-in-Differences with Staggered Adoption and the IW estimates, joint with their respective 95% confidence intervals. The graphs show that, in general, the point estimates and the confidence intervals slightly differ under both approaches. In fact, the substantive findings of the paper remain unchanged.

9 Conclusion

In this paper, we investigate the impacts of road provision on armed conflict and illegal economies in Colombia. We 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).

We examine two mechanisms that potentially drive these unintended results. First, we 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 states' 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 we present also have important policy implications on the crop voluntary substitution effort in post-conflict Colombia. We 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

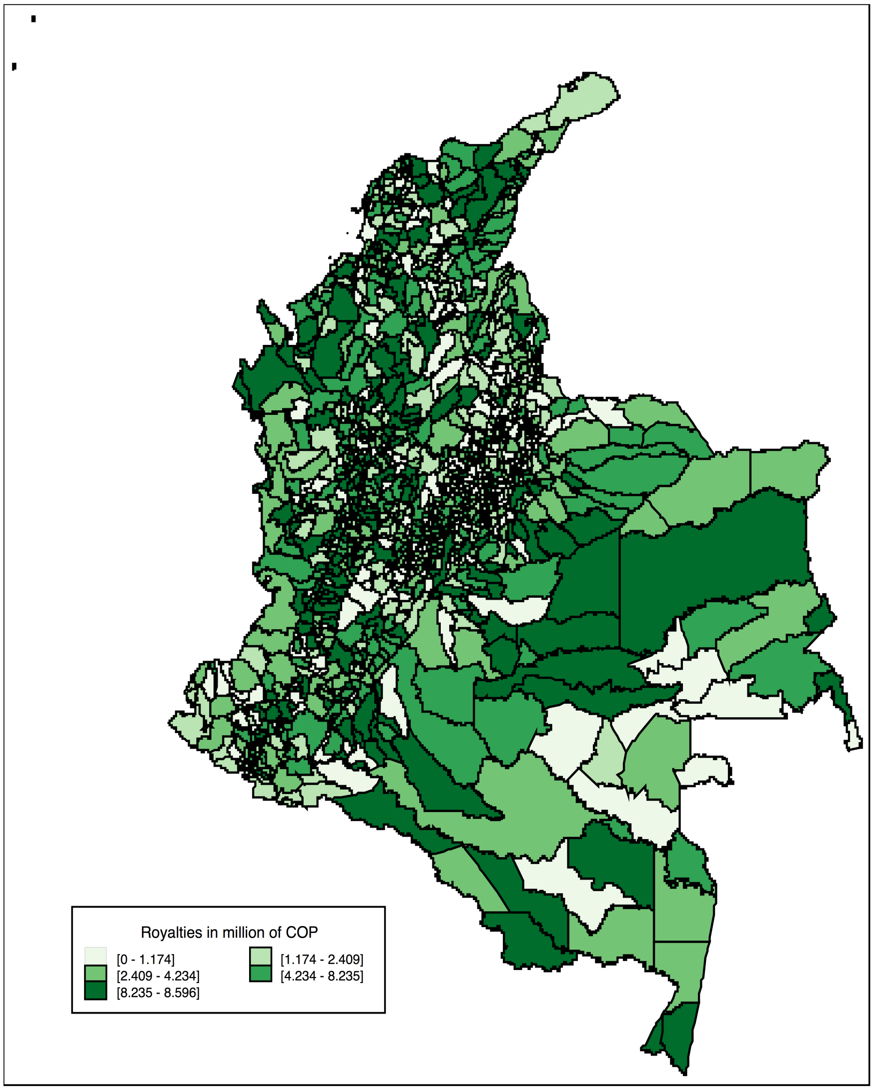
Note: The amount of Royalties is in million of Colombian pesos.

Table A.2: Test of differences in means for outcomes and covariates in pre-treatment periods.

Variable	**Control** *(S.D)*	**Treatment** *(S.D)*	**Difference** (p-value)
Panel A: T-Tests 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-Tests 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	-

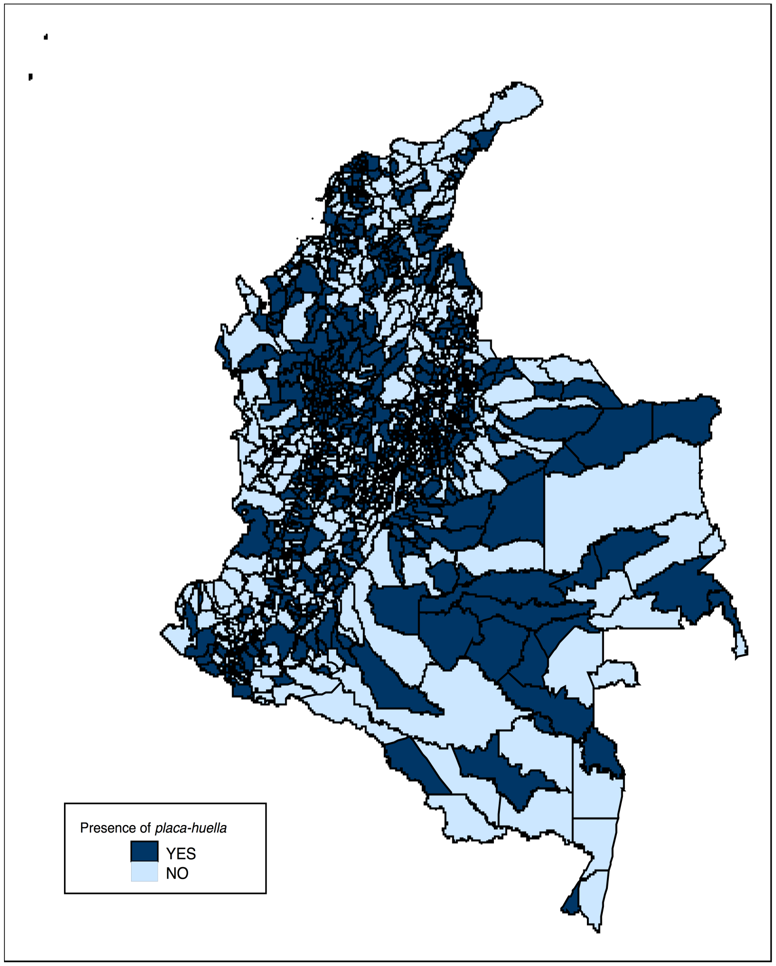
Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Hectares of coca is in hundreds of hectares.

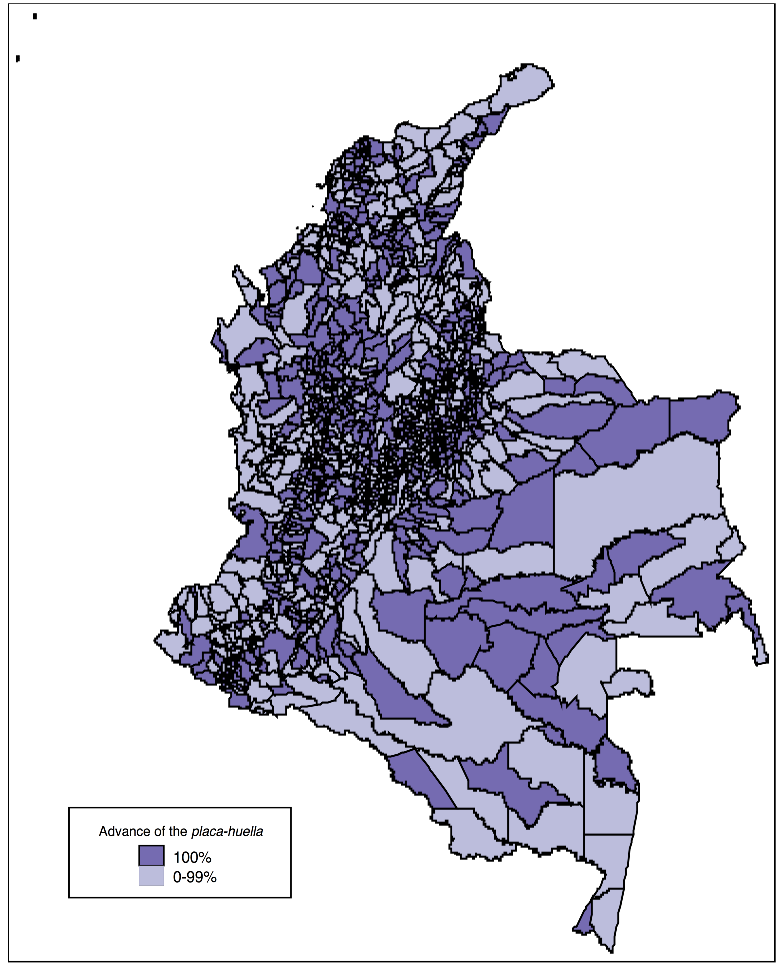
Figure A.3: Allocation of Royalties for the transport sector across Colombian municipalities .



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

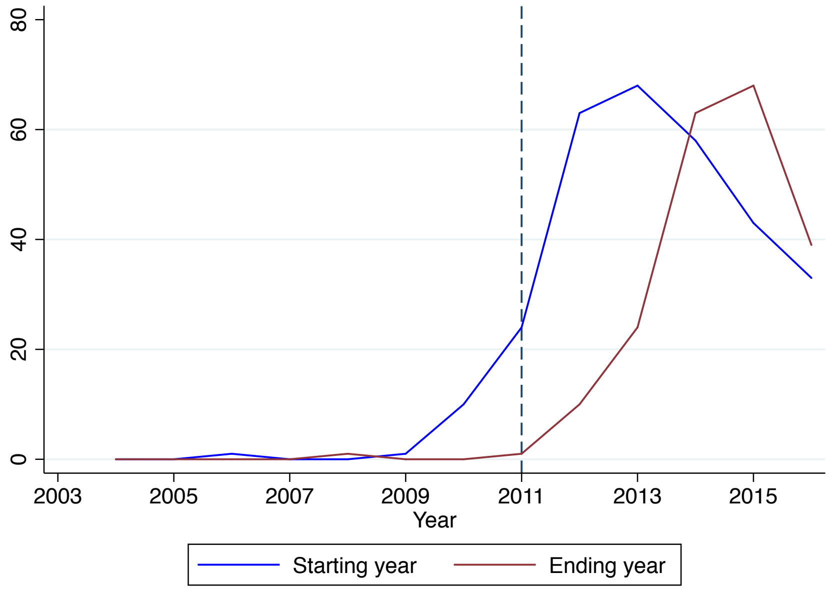
Figure A.2: Geographical distribution and physical advance of *placa-huellas* in Colombia





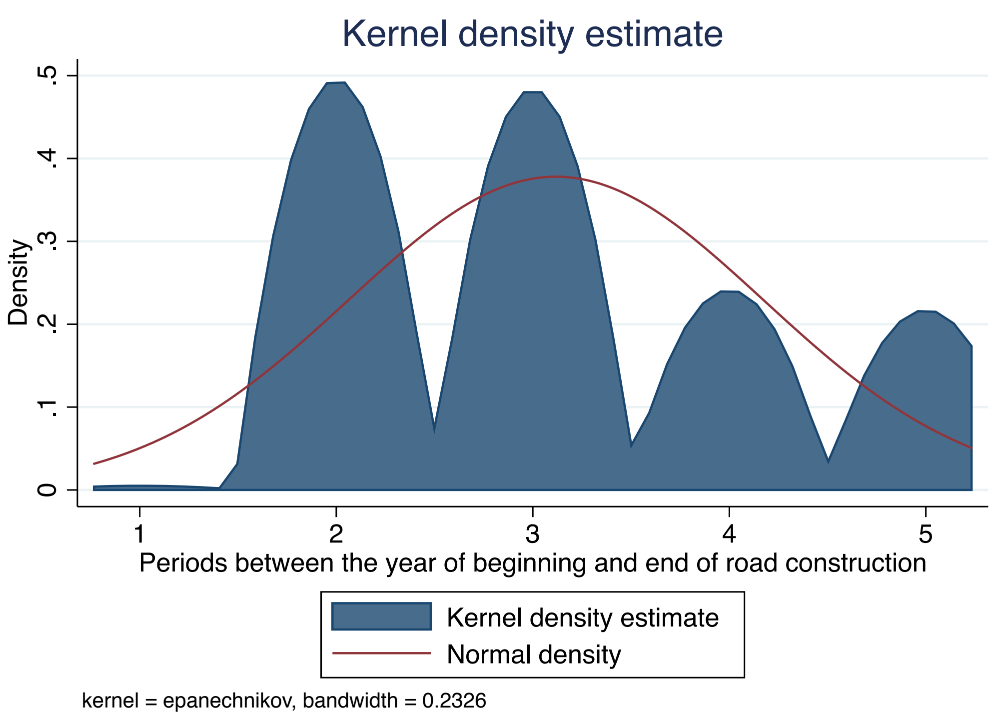
Notes: These maps show the geographical distribution of *placa-huellas* (left map) and the physical status of *placa-huellas* (right map) in each municipality. Own calculations.

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



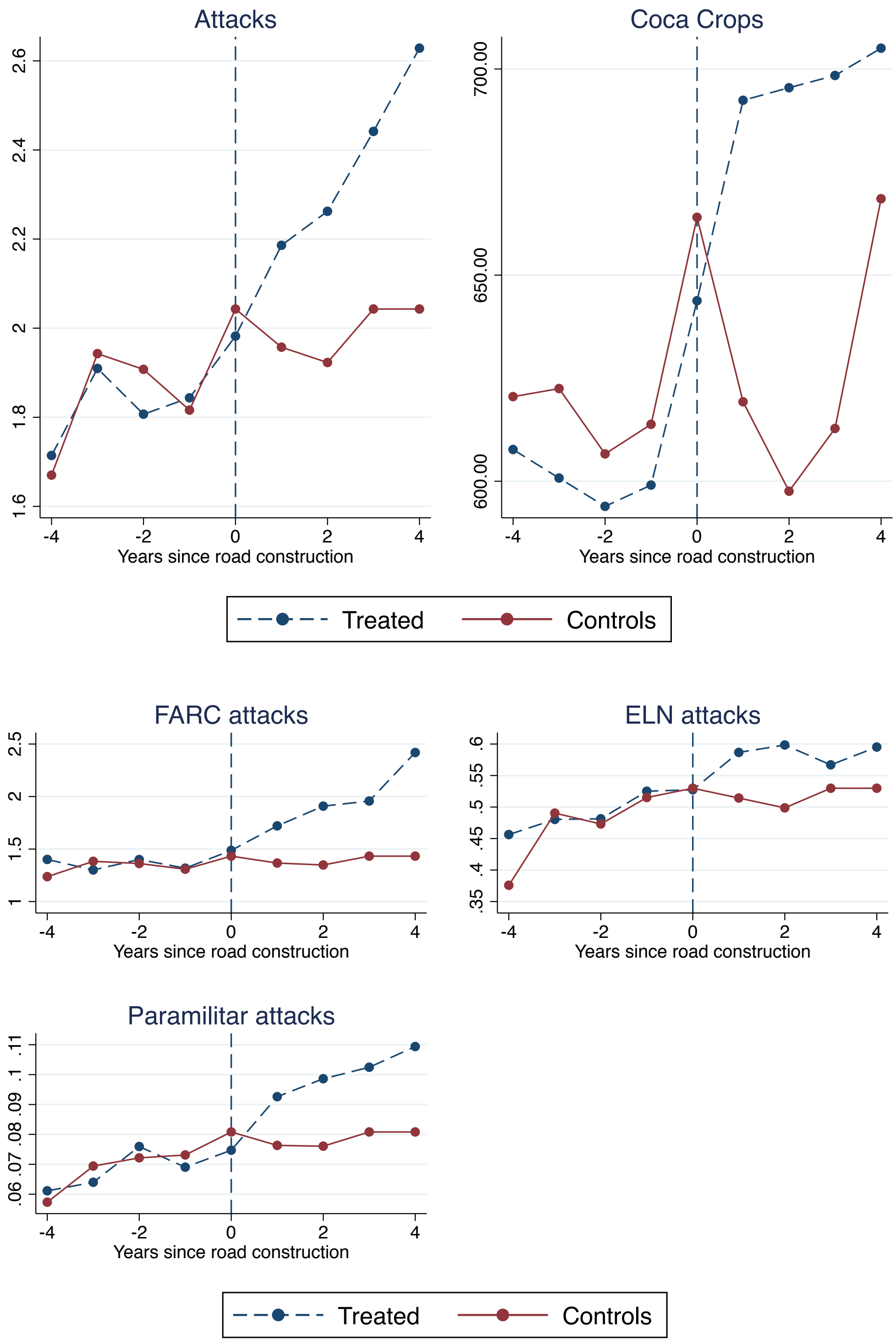
Notes: This Figure plots the starting and ending year of the construction of *placa-huellas* in Colombia. It shows the number of roads per year. Own calculations.

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



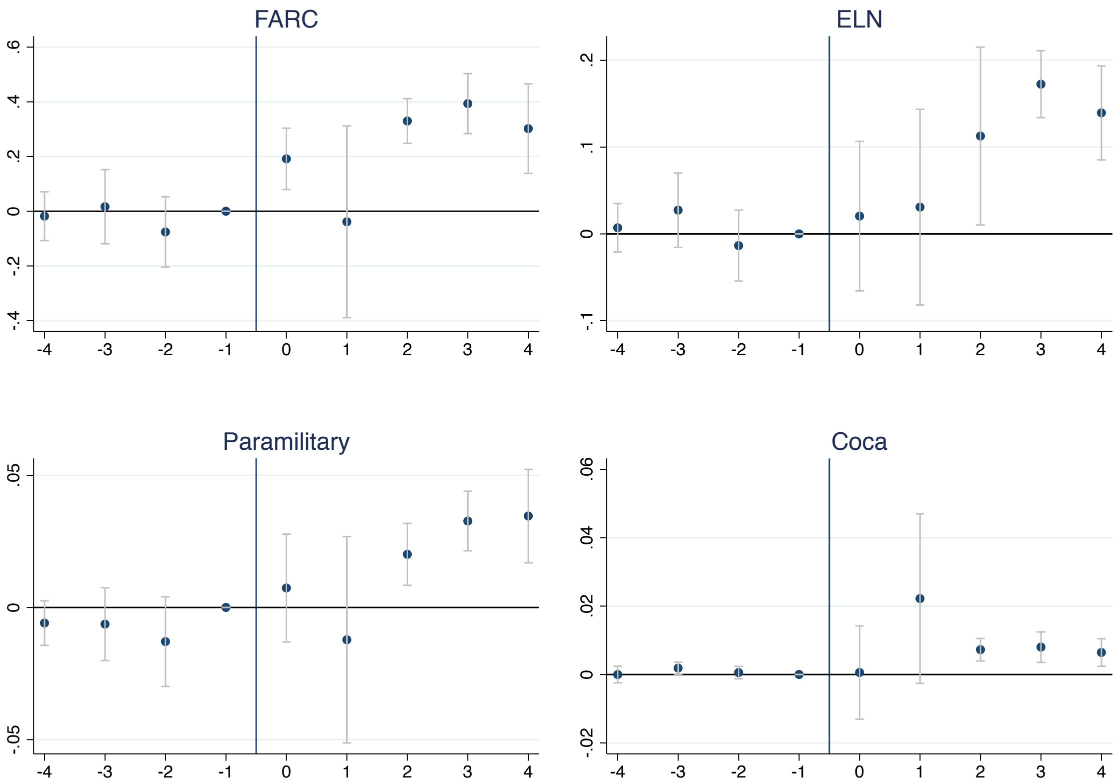
Notes: This kernel estimate presents the density of the variable that indicates how many years it takes to build a *placa-huella* based on the starting and ending year variables. Own calculations.

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-huella* and those 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 *placa-huellas* on FARC, ELN and Paramilitary attacks and the hectares dedicated to coca cultivation without controls. The X axis represents 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 $\times$ *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-tests 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 effects using the department capital 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* × $CapitalDepart.Distance_i$	-0.186	-0.117	0.0818	0.0129	-0.608
	(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

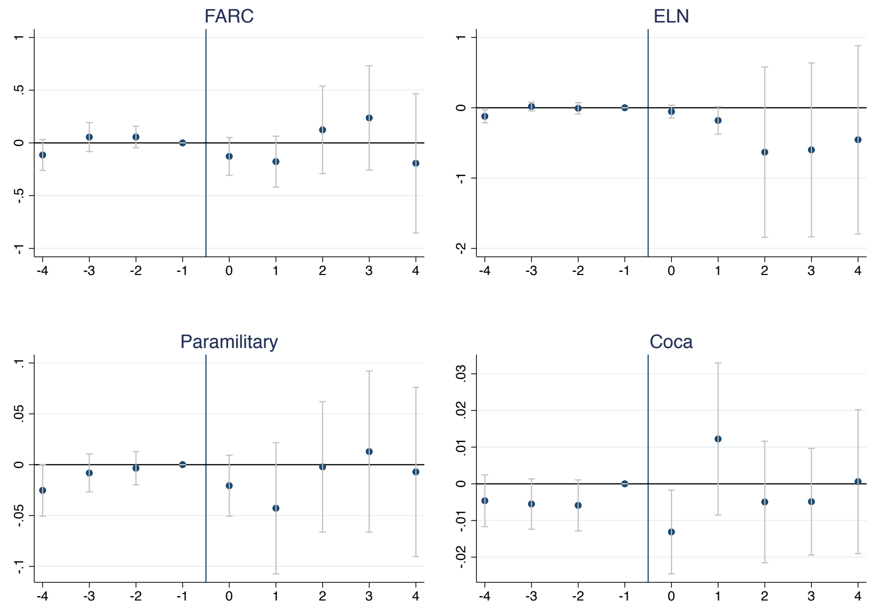
Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. Attacks represents the total number of attacks in each municipality. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are in hundreds of hectares. 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* × Transparency	-0.0227	-0.0162	-0.00528	-0.00123	0.000503
	(0.0319)	(0.0226)	(0.00830)	(0.00129)	(0.000389)
Post × *Placa-Huella* × Efficacy	-0.0126	-0.0105	-0.00217	7.77e-05	-0.000132
	(0.0213)	(0.0146)	(0.00618)	(0.000944)	(0.000187)
Post × *Placa-Huella* × Critic. Proj.	0.00309	0.00230	0.000641	0.000155	-0.000745
	(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

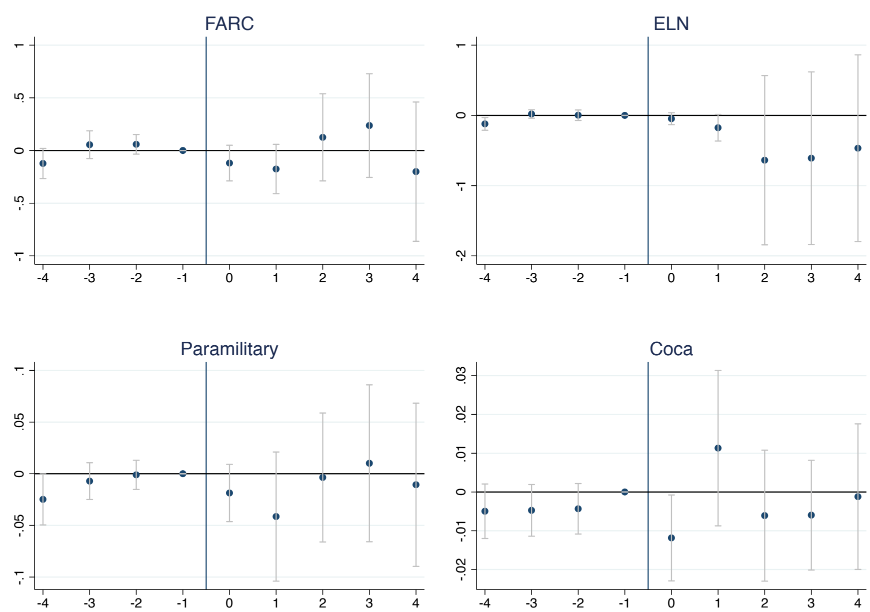
Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. Attacks represents the total number of attacks in each municipality. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are in hundreds of hectares. 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 Coefficients 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: Inclusion Regional Time Trends			
Post × *Placa-huella*	0.0612***	0.0743***	0.00470***	0.00152
	(0.0073)	(0.0186)	(0.00062)	(0.00157)
	Panel B: Inclusion of Departamental Time Trends			
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	✓	✓	✓	✓

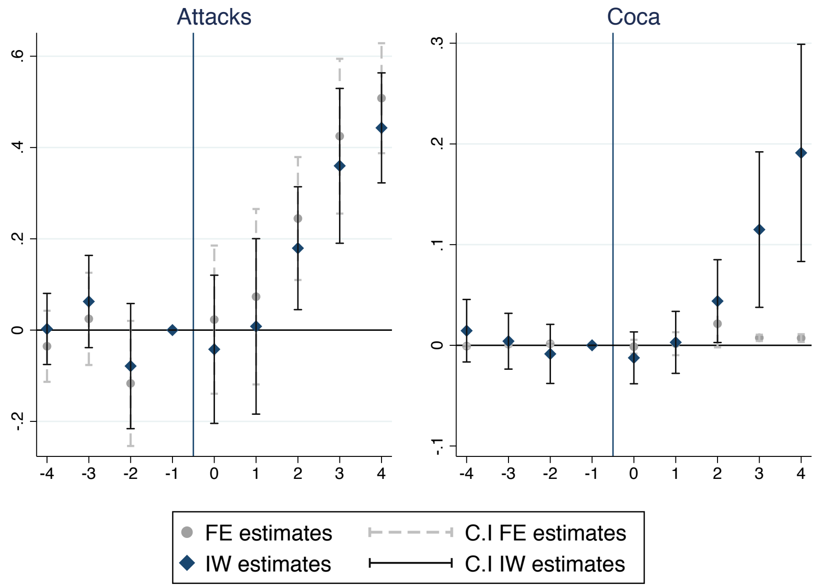
Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. FARC, ELN and Paramilitary represent the total number of attacks by each armed group. Coca crops are in hundreds of hectares. Robust standard errors clustered at the municipality level are 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

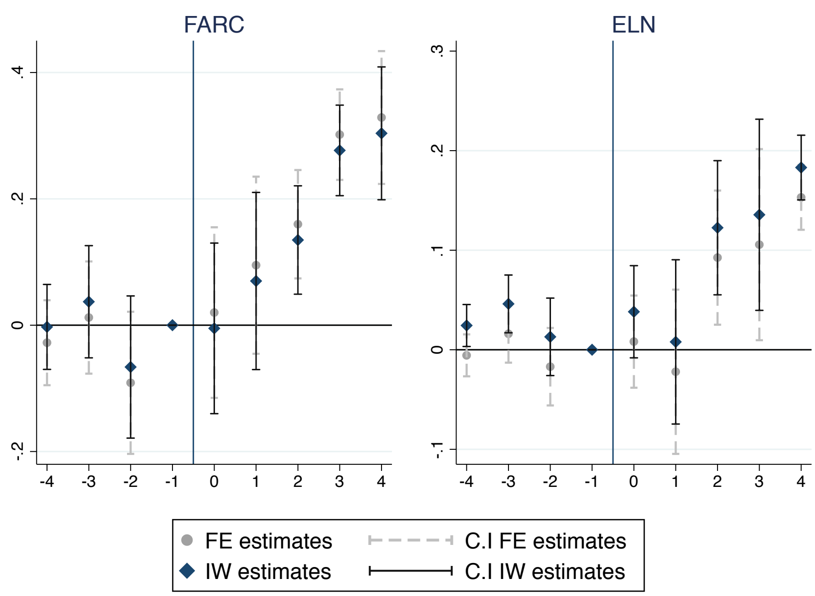
Notes: *** is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level. BUN is the index of basic unsatisfied needs. % Mun. treated (per wave) represents the percentage of municipalities treated in each cohort.

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



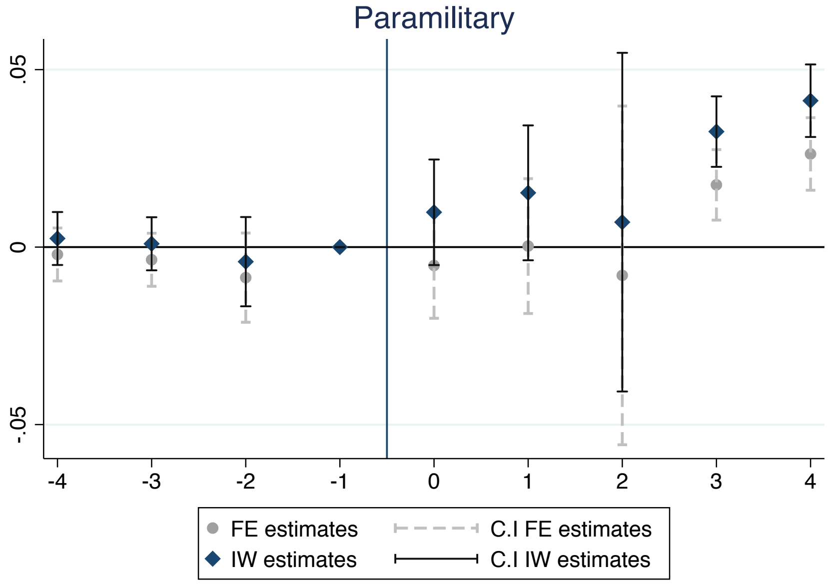
Notes: These figures show the point estimates and 95% confidence intervals of the effect of the *placa-huellas* on the total number of attacks and on the hectares of coca cultivation using the DD with staggered adoption strategy and the Interaction-weighted estimation. Own calculations.

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