Empirical Economic Studies on Colombia

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Submitted to the graduate degree program in Economics and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Date Defended: 17 May 2018

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Date Approved: 17 May 2018

Abstract

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May 2018

This dissertation explores three different but related economic issues in the country of Colombia. The first chapter determines the impacts of the prolonged civil conflict suffered in Colombia on its unemployment rate compared to other similar Latin American economies. The second chapter explores the effect of the presence of illegal leftist and rightist armed groups on municipal investments into education, health, infrastructure and environment. The third chapter determines the effect of the municipal location relative to a border, on the municipal investment decisions into wastewater management.

Chapter I., co-authored with Alexander Alegría Castellanos PhD., assesses the impact of the Colombian conflict on the unemployment rate for the period 1995-2014. Calderon-Mejia and Ibañez (2016) assess the effects of forced displacement on the labor market, specifically on wages. Our study relies on their findings, and additionally explores the effect of the conflict on the unemployment rate in Colombia. To estimate this effect, we use a difference-in-differences regression analysis to establish the average treatment effect relative to similar countries. Similarly, we use the Synthetic control method to estimate the effect of the conflict on the unemployment rate. Using both methods, we find a higher unemployment rate in Colombia relative to a counterfactual formed by Latin American countries, after an increase in the intensity on the conflict in 1995 due to changes in the drug war strategy. We demonstrate the significance of our results using a placebo tests. Overall, our results identify the incidence of the violent conflict on the total unemployment rate.

Chapter II. This study assesses the effects of leftist guerrilla groups and rightist paramilitary groups on investments made by the municipal governments in the country of Colombia between 2000 and 2010. Specifically, how the presence of illegal armed groups affects levels of municipal investments into education, health, infrastructure, environmental protection, and other categories. Limits on political participation and institutional weaknesses were key

elements propagating violence that disrupted Colombia for years. Searching for solutions to these structural problems, Colombia transferred many decision-making responsibilities from the central government to regional and local governments in [years]. Paradoxically this decentralization opened an opportunity for illegal armed groups to play meaningful roles in local political and economic life, eventually taking control over local resources in several municipalities. To assess the importance of these groups, empirical analysis exploits annual budgetary data for municipalities, information on conflict and violence, and community-level socioeconomic data (e.g., income, population). In this analysis, the dependent variables reflect municipal investment measured in three ways: total investment, levels of investment categories, and categorical proportions of total investment. The primary regressors are the presence of rightist paramilitaries and the presence of leftist guerrillas. Results suggest a differentiated impact by leftist and rightist groups. In proportional terms, municipalities affected by leftist guerrillas allocated less of their investments into environment and infrastructure, yet more into health. In contrast, municipalities affected by rightist paramilitaries allocated less of their investments in health, yet more into education.

Chapter III. examines the effect of location on municipal investment into wastewater management. Specifically, it explores whether location, relative to regional and international borders, plays a role in these investment decisions. Intuitively, transboundary aspects of pollution undermine a jurisdictional government's desire to curtail the amount of pollution generated from a source. As the distance between the source and a border falls, the transboundary aspects grow since a greater proportion of the detrimental effects of the pollution are born by neighboring downstream jurisdictions. Empirical studies consider the problem of transboundary pollution by examining various relevant outcomes. Some studies examine pollution levels on two sides of an intra-national border. Other studies assess environmental quality at intra-national or international borders. Additional studies examine the stringency of regulations imposed on and enforcement actions taken against facilities located at or near borders. Our study contributes to this literature in two ways by (1) developing a rich conceptual framework to explain governmental use of policy tools to induce better environmental management by polluters, and (2) exploring the problem of transboundary pollution in the context of a developing economy. Using data for municipalities in the country of Colombia between 2000 and 2013, we find that municipalities located further from an intra-national border

invest more into wastewater management than municipalities located closer to an intra-national border, consistent with the hypothesis that regional governments employ policy tools more strongly against the former set of municipalities. However, distance to international borders does not affect municipal wastewater investment.

Acknowledgements

I thank the Fulbright program and Colciencias for their support during my doctoral studies. These scholarships gave me the opportunity of enhancing my skills, learn from top researchers and professionals, and broadened my view and perspective of the world beyond my experience in my beloved Bogotá.

I'm also thankful toward my dissertation committee members for all their advice, patience, and support. Professor Dietrich Earnhart was always interested in my research, and constantly motivated me in the development of this product. He provided me with research and professional tools that I later implemented and adopted for my own purposes. I have learned from his passion toward applied research, his willingness to discuss different topics, his kindness toward others and his valuable insight. Similarly, Professor Donna Ginther instructed me in the use of relevant tools to study and answer engaging questions. Her courses allowed us to discuss a broad variety of issues and methodologies that we later applied into our own research. As a result, her classes were a great introduction to doctoral research in economics. Professor David Slusky has been an example of passion for applied work in economics. His energy has ignited us with the desire to explore, formulate question, and most importantly to keep learning. Professor Tsvetan Tsvetanov always gave me valuable advice. He took the time to formulate questions, provided solutions, and has been a great example of a thoughtful scholar in economics. All of them succeeded in fostering a learning environment for the students working with them. I have a profound admiration for all of them and will always be thankful for their effort, support and discipline.

Of course, I thank my family and friends. Their support has been fundamental throughout this process. My eternal gratitude goes to my mom, and my sister. Both have endured the road with me, and their love has given me strength to overcome many obstacles. I thank my friends for their cheers and their friendship from the distance, all of them have helped me greatly at different points and stages of my life. I also thank Iris Gándara. She is a constant motivator, and has accompanied me with patience through this process. She has enjoyed all my successes, and suffered with my failures.

To all of those who helped me in this process in one-way or another, thank you.

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Chapter I. How does the Colombian Conflict Affects the Unemployment Rate

(Co-Authored with Alexander Alegría-Castellanos PhD. Candidate)

1. Introduction

This chapter assesses the economic impact of the high intensity conflict in Colombia between 1995 and 2014. After decades of conflict, and years of negotiation, rebels and government finally reached an agreement to end fifty years of war in 2017 (NYT 2016). However, this upcoming post-conflict situation requires a better understanding on the economic legacies of civil conflict, shedding light on possible recovery strategies, and pointing out a case of study for current or upcoming post-conflict situations in different regions.

The constant state of violence in Colombia represented a threat for the political and economic institutions, affecting firm's decisions to stay or to exit the market (Camacho and Rodriguez 2013), that added to the massive forced displacement of civil population toward big urban areas, impacted local investments, and created obstacles for foreign investments. On the other hand, despite these adverse conditions, political and economic institutions did not suffer major transformations, and democracy remains as the form of government (Chacón, Robinson, and Torvik 2011); moreover, for some years within this period of violence, Colombia experienced positive income shocks and reduced poverty levels in urban areas according to official data (World Bank 2017). This context and the recent peace agreements with two of the major illegal armed groups, allow us to inquire if the conflict affected the unemployment rate in Colombia.

Several studies assess the socio-economic impact of conflict in Colombia. Some of them show the incidence of violent actors on the decision process in policy making (Acemoglu, Robinson, and Santos 2013; Chacón, Robinson, and Torvik 2011), and the impact of conflict on political elections, and democratic processes. In particular, Acemoglu et al. (2013) use electoral and legislative data, and find a strong relation between right wing illegal armed groups and electoral outcomes in determined regions in Colombia. Other empirical studies examine the impacts of conflict on health outcomes (Camacho 2008), its consequences on forcibly displaced households (Ana María Ibáñez and Vélez 2008; Ana María Ibáñez and Moya 2010; Ana María Ibáñez and Vélez 2008; Ana María Ibáñez 2009), and its incidence on firms' exit decisions (Camacho and Rodriguez 2013; Rozo 2016). These studies show the welfare losses due to the

forced displacement phenomena, provide evidence regarding policy instruments for preventing displacement, and determine the impact of conflict on firm's exits from the market.

Similarly, unemployment in Colombia is an issue analyzed under several approaches. Some authors estimate the effect of non-salary cost on the unemployment rate (Sánchez, Duque, and Ruíz 2009; Bernal and Cardenas 2004), the impact of the economic cycle (Nuñez and Bernal 1997), and the gap between the supply and demand of high quality workers (Nuñez and Sanchez 1999; Cárdenas and Bernal 1999). Even though most of these studies relate the increase on the unemployment rate strictly to macroeconomic conditions, we encounter a correlation between the intensification of the Colombian conflict in the 1990s decade, and this increase in the unemployment rate for the same period (Figure 3).

Some other academic works examine the relationship between the labor market and forced displacement in Colombia (Ibáñez and Moya 2010; Ibáñez and Vélez 2008; Ibanez 2009; Calderón-Mejía and Ibáñez 2016); however, only one of them, specifically, estimates the impact of forced displacement on wages in Colombia (Calderón-Mejía and Ibáñez 2016). Using instrumental variables to assess the effect of these migrations on the urban labor market, the authors find that this phenomenon reduces wages for urban unskilled workers who compete for jobs with the arriving population. Our study aligns with the examination of Calderon-Mejia and Ibanez (2016), and contributes to the literature analyzing the unemployment rate using a methodology that allows estimating this effect by comparing with a counterfactual, following Abadie and Gardeazabal (2003).

To estimate the effect of the "high intensity conflict" on the unemployment rate, we approach the problem from two similar methods. First, we estimate a difference-in-differences model to establish the average treatment effect of the "high intensity conflict" in Colombia relative to similar countries within the region; and second, we construct a "synthetic Colombia" to estimate the effect of this treatment on the unemployment rate. A main problem is the definition of a treated and untreated region within Colombia, due the geographic uniformity of the violent events and multiplicity of illegal armed groups (Figure 1). Because of this, we choose eight countries in South and Central America, with a relatively low or nonexistent conflict during the period of analysis, as control groups (donor countries).

The untreated countries we choose for the period of study are Argentina, Chile, Ecuador, Uruguay, Paraguay (South America), Costa Rica, Panama, and Honduras (Central America).

Although all Latin American nations had guerrilla movements after 1960, few of them have a history of conflict with the length or intensity of the Colombian conflict. Other countries such as Mexico and Brazil share institutional characteristics with Colombia, in particular Mexico; but they are not comparable given their economic size relative to the Colombian economy.

Using the World Development Indicators data base available at the World Bank, we obtained information on economic variables (GDP per capita, investments, unemployment by sector, population, enrollment, and labor force among others) for all the potential control units and Colombia, between 1977-2014. We also consult public available data from the Center for Social Studies at Universidad de los Andes - CEDE and the Conflict Analysis Resource Center - CERAC to explore measures on conflict and violence.

Considering 1995 as a break point for the treatment period, we estimate our difference-in-differences (DID), and our synthetic control estimated effect. For the DID, we find an average treatment effect of 3.7 percentage points in our preferred estimation relative to the control group. Meanwhile, our synthetic control shows an average estimated effect of 4.9 percentage points relative to the synthetic Colombia. Both estimations represent at least one third of the average unemployment rate for the treatment period (1995-2014); however, the synthetic control suggests an effect larger than the first average effect estimated by DID. We test our DID results through three different standard test, and for the synthetic control method we follow Abadie et al.(2010) implementing a placebo test to validate our results.

The rest of the paper is organized as follows. Section 1 introduces a detailed literature review describing studies examining economic impacts of conflict worldwide and in Colombia. Section 2 offers a brief context on the Colombian conflict pointing out key elements for the period selection. Sections 3 and 4 present the empirical strategy for our analysis and the results obtained. Section 5 contains some conclusions and comments. An Appendix presents results from a series of robustness tests.

2. The Colombian Conflict and Economic Outcomes

For the past fifty years, Colombia has faced a constant threat to its institutional stability, as well as a situation of violence originated from different armed groups representing multiple ideologies, motivations, and tactics. From the mid-sixties communist guerrillas were formed with the remains of former bipartisan self-defense armies (GMH 2013; Palacios 2006; Dube and Vargas 2013), and later on the seventies and eighties, paramilitary groups and drug cartels arise,

both motivated by the control and protection private property of agricultural land, as well as the returns of the drug dealing (GMH 2013). Even though there was a constant state of violence, the political and economic institutions did not suffer major transformation within the country, and democracy has remained as the form of government.

During the past twenty years the Colombian economy experienced a recovery boosted by high prices in commodities such as oil, coal and gold, as well as a persistent reduction in poverty levels in urban areas according to official data (World Bank 2017). Similarly, the state has negotiated peace agreements with two of the major illegal armed groups during the past fifteen years. Given this context, it is valid to question how the armed conflict in Colombia impacted the labor market, and how the unemployment rate was affected by the persistence of violent events that derived in forced displacement toward main urban areas, and obstacles to local and foreign investments.

Several studies have considered the impact of conflict on economic outcomes using different approaches. Most of them examine the impact of political conflict using cross-country level data (Alesina et al. 1996; Alesina and Perotti 1996; Barro 1991; Mauro 1995; Venieris and Gupta 1986); finding a negative effect of conflict on investments, savings, and economic growth. Abadie and Gardeazabal (2003); Grier and Maynard (2016); and Horiuchi and Mayerson (2015) use a synthetic control to estimate the impact of political instability and conflict on economic outcomes. These works conclude that political instability has a negative impact on the economic performance of regions or firms.

Abadie and Gardeazabal (2003) assess the economic impact of conflict, using the terrorist conflict in the Basque Country as a case study. They find that, after the outbreak of terrorism, per capita GDP in the Basque Country decreased around 10 percentage points compared with the synthetic control region. Grier and Maynard (2016) find that political instability affected negatively economic growth while other indicators such as poverty, health and inequality improved, and Bove, Elia, and Smith (2016) find a negative but not significant effect of conflict on economic growth. To do so, this study compares its results with the results of a sample of "cases of studies" using synthetic controls to demonstrate the heterogeneous effects of conflict on economic performance.

Regarding to the effect of conflict within specific countries on microeconomic level Shemyakina (2011), Chamarbagwala and Morán (2011), and Eccleston (2011), consider the

impacts of conflict or exposure to terrorism on education outcomes (human capital accumulation). Eccleston (2011) finds that psychological stress due to exposure to terrorist events has negative impacts on early educational attainment and cognitive ability. Similarly, Chamarbagwala and Morán (2011), and Shemyakina (2011) find a strong negative impact of conflict on educational attainment and schooling, especially among vulnerable populations located on regions with high conflict intensity (Chamarbagwala and Morán 2011; Shemyakina 2011).

Specifically for Colombia and Bosnia Herzegovina, some scholarly works, assess the impact of forced displacement on labor participation and welfare (Ibáñez and Moya 2010; Ibáñez and Vélez 2008; Kondylis 2010; Calderón-Mejía and Ibáñez 2016) . Kondylis 2010 finds that displaced people in Bosnia are less likely to be working compared with those who stayed at the same place; her results reveal a differential effect on men whom experience high unemployment rates, while displaced women are more likely to drop out the labor force). Similarly, Ibáñez and Moya 2010 examine the effect of forced displacement (caused by conflict) on households' welfare after displacement; and Ibáñez and Vélez 2008 estimate the welfare losses due to forced displacement compared to a situation of traditional (unforced or voluntary) migration.

Lastly, we want to reference studies that analyze the impact of the conflict on politics, labor, and human capital specifically for Colombia. Acemoglu et al., (2013), consider the influence of irregular armies on policy decisions, in particular vote shares, finding a strong relation between paramilitaries and electoral outcomes in determined regions of Colombia. Ibáñez and Moya (2010), contribute to the literature of the conflict in Colombia assessing the vulnerability of households through information collected from a representative sample of forcibly displaced households in Colombia. These authors find that victims of forced displacement face difficulties in generate income and significant drops in consumption, revealing the limitation on the effectiveness on the public interventions. Similarly, Ibáñez and Vélez (2008) examine the causes of the forced displacement in Colombia, estimate the welfare losses and provide some evidence regarding policy instruments for preventing displacement.

These previous studies open the opportunity to ask: Did the extended violence in Colombia have an impact on the labor market? Although our analysis is strongly based on the methodology used by Abadie and Gardeazabal (2003), our study focused on the impacts on

unemployment in Colombia, using as a control group a set of Latin American countries which constitutes a regional analysis rather than an analysis focused within Colombia.

3. Context: The Colombian Conflict

This document investigates on the impact of the armed conflict on the Colombian economy during the period 1977-2014[1]. Colombian armed conflict has lasted for more than a half of a century. It has had a multiplicity of internal actors (Colombian Government, Paramilitaries, Guerrilla, and Drug Cartels) which appeared in different moments, and played different roles in the conflict. Former bipartisan self-defense groups remains derived in the formation of communist guerrilla groups after 1964 claiming lack of political representation (Palacios 2006; GMH 2013). As a response to these communist groups, the national government did incentivize the formation of self-defense (paramilitary) groups as a counter-insurgency strategy[2]. Finally, during the decade of 1980s, the boom in the drug trafficking activity became a part of the paramilitary activity and, therefore fueled the rise of violence in the country during the decade of 1990s.

Table 8 in the appendix, presents data collected by the Group of Historical Memory, the Center for Conflict studies – CERAC, and the Victims Unit in Colombia. The violent activity, in terms of victims, was relatively low during the decade of the 1980s; the number of victims of landmines or unexplode ordinance was very low during this decade, and its use increased after 1990 and it reached the peak in 2006. Other indicators of violence such as the number of kidnappings or the number of victims of massacres jumped up after 1988, right after the government declared as illegal any paramilitary activity within the country. Finally, although the communist guerrillas did not expand or confronted aggressively before the 1980s, they did occupy more territory, and structured themselves in a more sophisticated way.

The peak of the conflict in terms of magnitude of terrorist attacks occurred in the period 1996-2005. According to the GMH (2013) this period was marked by the simultaneous

[1] According to the General Report of the Historical Memory Group (GMH) (2013), the civil conflict in Colombia can be divided into four periods. Our analysis includes the second (1982-1996) and third period (1996-2005).

[2] The lack of confidence of the elites in how the government was handling the conflict with the Guerrillas, and the decision of the Guerrilla to reach rural zones, contributed to the emergence and expansion of paramilitary groups to protect the interests of the elites. The Colombian government passed the Law 48 of 1968 to legitimize the creation of these groups[2]. In this sense, the paramilitaries were born as legal groups with the mission to help the Colombian army to fight Guerrillas. The Ordinance 813/1989 declared the paramilitary groups illegal, but they continued operating until peace agreements in 2005.

expansion of the guerrillas and the paramilitaries[3], the war against the drug trafficking, and the change in the organization of the drug cartels. The magnitude of violent events such as kidnappings, massacres, deaths, and landmine victims reached the highest point between years 1995-2002; and the forced displacement worsened between 2000 and 2008.

Although the territorial control was still one of the main objectives among the different armed actors, the reasons why they fought changed (Salazar and Castillo 2001). Popular perception of the leftist guerrillas as defenders of social demands transformed into an image of vandalism and common delinquency; in this sense, all illegal armed groups used intimidation, killed, and forced displacement of population as instruments to instill the fear among the civil population. Thus, the violent groups dominated the population through fear.

The level of the conflict in this period (1996-2005) reached such a big magnitude that according to the GMH (2013), Colombia was ranked second to Sudan in terms of forced displaced people. The massive displacement of the population from different regions in Colombia, especially toward the main populated cities affected the labor market and the welfare of this part of the population. The Colombian labor market suffered negative impacts on wages and employment opportunities (Ana Maria Ibáñez 2009), and the victims of forced displacement faced difficulties to generate income, significant drops in consumption, and significant losses in welfare (Ibáñez and Moya 2010; Ibáñez and Vélez 2008; Ibanez 2009). It took time for displaced people to adjust to a new environment.

At least four elements boosted the high intensity of the conflict in Colombia at this time. First, the 1991 Colombian constitution had the unintended effect of giving illegal armed groups the opportunity to control the resources of regions considered as strategic to continue fighting (Gutiérrez 2010). Second, changes in policies related to the war on drugs motivated a shift in the cultivation and production of coca from Peru and Bolivia to Colombia, bringing an upsurge in the price of coca leaf, and as consequence, a new source of revenue to fight for (Angrist and Kugler 2008; Mejia and Restrepo 2016, 2013). Third, the new illegal group CONVIVIR emerged in 1994 (GMH 2013); this group was created to fight guerrillas in order to control places

[3] Also during this period, through the decree 356 of 1994, the Colombian government allowed the emergence of new-armed groups named "Convivir" (Private Surveillance Companies). These groups defined themselves as anti-subversive Political-Military groups, so they controlled of strategic locations (municipalities) of the country and influenced politicians both at local and national level (Acemoglu, Robinson, and Santos 2013; Gutiérrez 2010; Garay Salamanca and Salcedo-Albarán 2010).

occupied by guerrilla groups. Lastly, during this period the FARC, the ELN and the AUC expanded their members and the territory in which they operated (Arias and Ibáñez 2012). These four elements combined to generate a long period of massacres, extortions, selective deaths and kidnappings.

These tactics of domination over the civil population affected the economic activity in general. The extortion had an impact on firm's decision to stay or to exit the market (Camacho and Rodriguez 2013). Similarly, the level of regional influence and political control of some of these violent groups allowed them to take advantage of public resources, and not be prosecuted by the national authorities given the prominent mutualism among some illegal groups and politicians at the central level of government (Acemoglu, Robinson, and Santos 2013) . These conditions, plus the massive displacement of civil population toward big urban areas, impacted local investments, and created obstacles for foreign investment, as well as generated pressure on the country's production, and therefore on the rate of unemployment.

The violence in Colombia evolved, and took multiple shapes. Many factors contributed to the continuation of the conflict. These factors included the limitation of the political participation of some armed groups like the guerrillas, the beginning of drug trafficking, and its propagation around the country. The poor performance of Colombian institutions, and paradoxically, the decentralization opened an opportunity for the illegal armed actors to get involved in the political and economic life of local and regional governments taking control over some regions and their resources (Acemoglu, Robinson, and Santos 2013; Gutiérrez 2010; Garay Salamanca and Salcedo-Albarán 2010). Although with different levels of impact, the armed conflict spread in one form of violence or another to the whole national territory, as it is shown in the figures from the Group of Historical Memory report (2013).

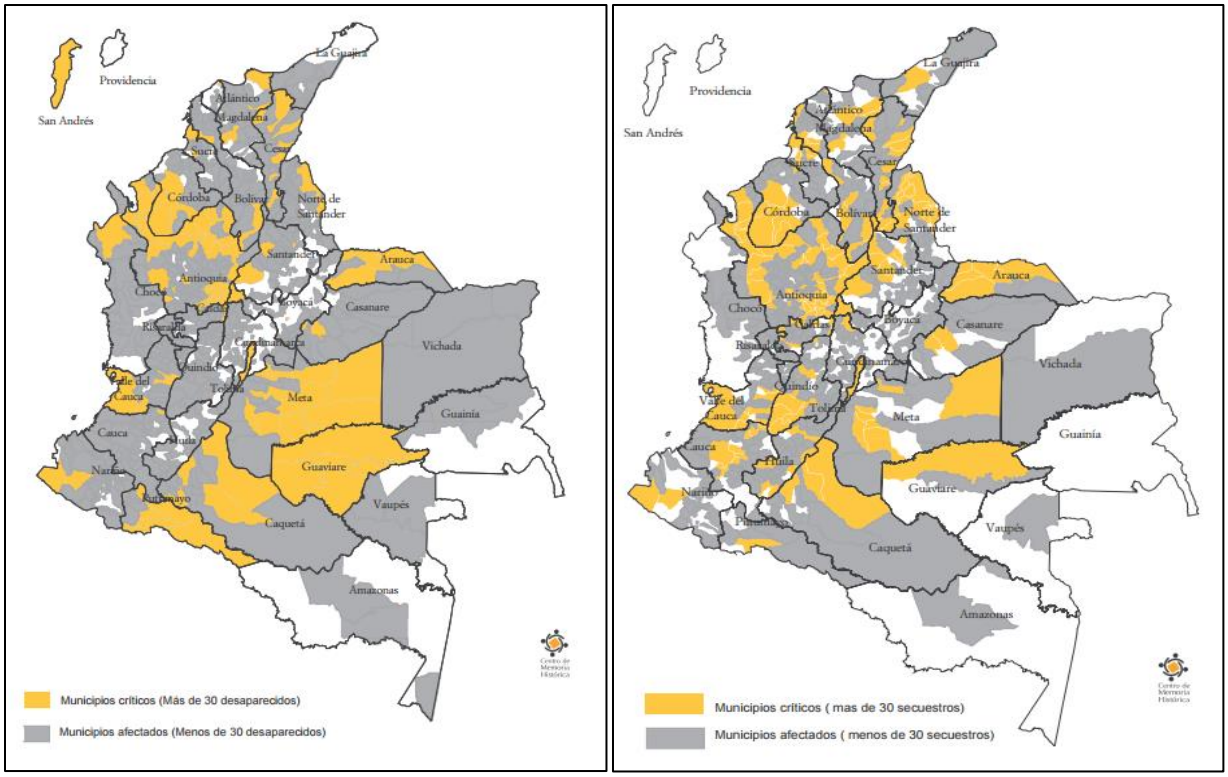


Figure 1. Distribution of violence in Colombia
Source: Group of Historical Memory – Colombia. Report "Basta ya"
Left: Municipalities affected by forced disappearances
Right: Municipalities affected by kidnappings

4. Empirical Strategy

To study the impact of the conflict in the Colombian economy, we focus our analysis on the impact on the unemployment rate. For these we use two strategies. First, using countries in the Latin-American region, which have not been involved in a prolonged and intense armed conflict as Colombia, we construct a difference-in differences model; second, using the synthetic control methodology and the same set of countries we construct a control region that resembles relevant economic characteristics of Colombia before the high level of Colombian armed conflict starts. For both approaches, we think about Colombian conflict as a natural experiment in which, according to the previous description of the armed conflict, Colombia as a whole is the treated unit.

a) Sample Selection and Data

We propose to estimate a difference-in-differences model, and to create the Synthetic control using a set of countries that related to Colombia in terms of institutional framework,

income, and even geographically. Although we follow the study proposed by Abadie and Gardeazabal (2003) in which they explore regions within Spain, our analysis cannot rely on the exploration of the different regions in Colombia. The geographic uniformity of the violent events and the multiplicity of illegal armed actors in Colombia are restrictions for the definition of an untreated (unaffected) "region" within Colombia by the conflict (e.g., Figure 1). Because of this, we choose eight countries in South and Central America as potential control units.

These countries are not treated with a "high intensity conflict' for the period of study. Considering this, we pick a pool of countries formed by Argentina, Chile, Ecuador, Uruguay, Paraguay (South America), Costa Rica, Panama, and Honduras (Central America). Although all Latin American nations had guerrilla movements after 1960, few of them have a history of conflict with the length or intensity of the Colombian conflict. Most of the countries selected do not have any armed conflict for the analyzed period. Other countries such as Mexico and Brazil share institutional characteristics with Colombia, in particular Mexico[4]; but they are not comparable with Colombia given their economic size relative to the Colombian economy. Including countries with predictor values far different from the treated unit may generate problems with the estimation of the synthetic control, and the resulting weights of those countries are not going to be of help to the implementation of the synthetic control. Other countries such as Nicaragua, El Salvador and Peru are excluded since they face high intense armed conflicts for the analysis period.

Similarly, we choose the pre-treatment and treatment based on two criteria. First, the availability of data for Colombia, and the control countries. Even though the Colombian conflict can be traced back from 1950, most of the information regarding the conflict in Colombia is available after 1980 (Table 8); besides, the availability of data for Colombia, and many other Latin American countries is somehow complete or at least available after 1960. Second, the history of the Colombian armed conflict in the recent years that defines the peak of the conflict[5] after 1995 (GHM 2013) as noticed also in Figure 2 and Figure 3. Therefore, the pre-treatment period is 1977-1994, and the treatment period is 1995-2014.

[4] Mexico has suffered from an internal conflict related to the drug cartels. This has triggered a big wave of criminal violence implying events such as massacres, assassination of politician leaders, and regular citizens. The occurrence of these violent events, which include disputes for the political and economic control of some parts of the Mexican territory, excludes this country from our potential control group.

[5] The period between 1995 and 2005 is marked by an increase in violence with drug cartels, guerrillas and paramilitaries being part of it.

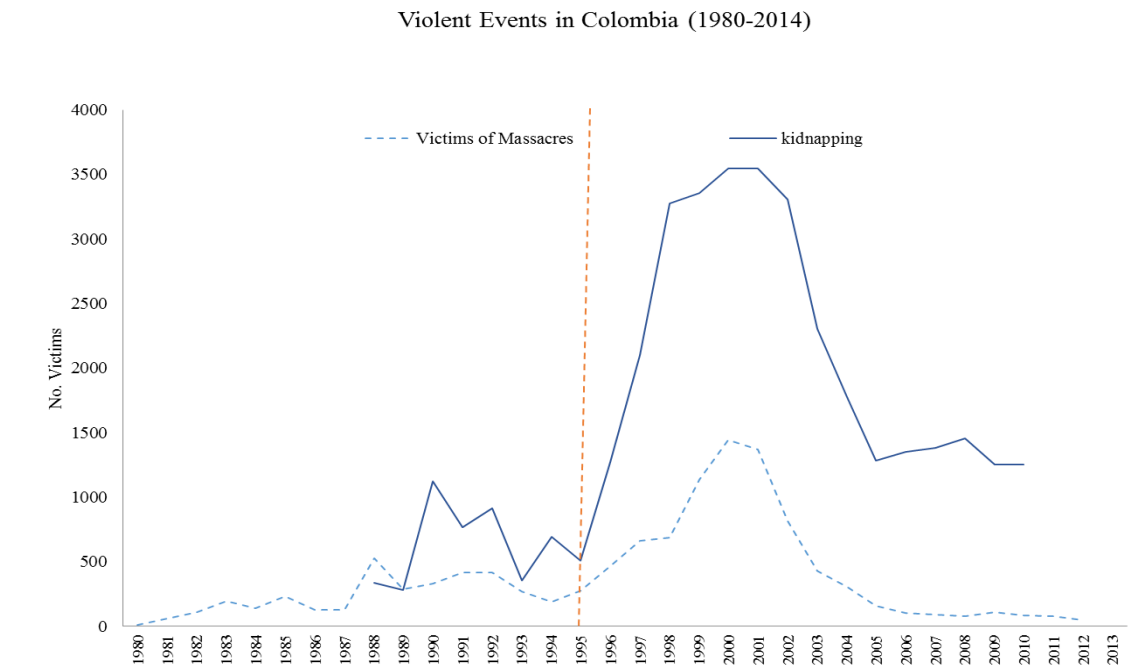


Figure 2. Violent Events in Colombia (1980-2014) Victims of Massacres and Kidnappings

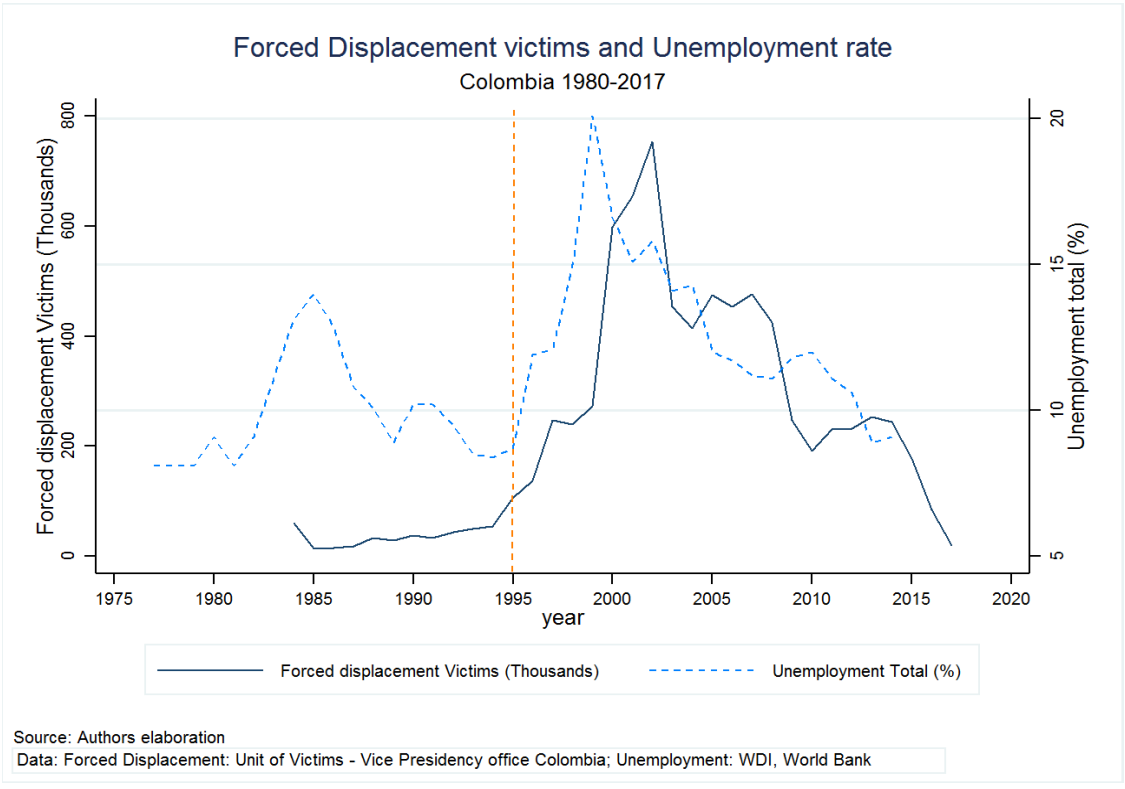


Figure 3. Forced Displacement victims (thousands) and Unemployment rate (1982-2017)

To implement our strategies, we collected data for these countries from two major sources. From the World Development Indicators – WDI platform established by the World Bank, we gather data for economic variables such as GDP, GDP per capita, unemployment rate, labor force, and Gross fixed formation of Capital; as well as other variables such as population, population density, and life expectancy at birth, land area, and gross enrollment for primary, secondary and tertiary education. From the International Labor Organization – ILO, we gathered data on total employment and employment by sectors (agricultural, industry and services). Finally, we also consulted data on conflict variables (i.e., violent events) from the Group of Historical Memory – GHM, the Conflict Analysis Research Center – CERAC, and the Unit of Victims from the Vice-Presidency office in Colombia.

b) Differences-in-Differences

In our first approach we estimate a difference-in-differences (DID) model with the armed conflict as our natural experiment; Colombia as the treated unit, and a set of countries within the region[6] as the untreated or control units (these are countries in the region that have been not treated during the period under analysis). As it was mention before, our treatment period starts after 1995 and last until 2014. This period is characterized by the high levels of intensity of the conflict. Therefore, we have divided the whole period that goes from 1977 to 2014 into a pre-treatment period from 1977 to 1994 and a post-treatment period from 1995 to 2014.

In the case of the DID approach we have two groups indexed by treatment status $T = \{1, 0\}$. Where 0 indicates countries not receiving treatment, i.e. the control group, and 1 indicates the country receiving the treatment, i.e. the treatment group, which in our case is Colombia. Then, every country has two kinds of observations, one pre-treatment and one post-treatment.

The two outcomes our interest can be model through this equation:

$$Y_{it} = \alpha + \beta C_i + \gamma D_t + \delta(C_i . D_t) + \theta X + \epsilon_{it} \quad (1)$$

Where $\alpha, \beta, \gamma, \delta, \theta$ are unknown parameters, and ϵ_{it} is a random, unobserved "error" term which contains all determinants of Y_{it}, which our model omits. It is important to notice that, β is the treatment group specific effect, γ is the time trend common to control and treatment effect,

[6] Chile, Argentina, Ecuador, Uruguay, Paraguay, Costa Rica, Panamá, Dominican Republic, and Honduras.

and δ is the true effect of treatment. Therefore, the purpose of our interest focused on the assessment of δ, for unemployment as outcome variable.

The matrix X includes covariates such as the GDP per capita in constant 2010 US dollars, the gross fixed capital formation as a proportion of the GDP as a measure of investments, and general characteristics such as population density, life expectancy at birth, and gross enrollment in primary and secondary education.

c) Synthetic Control

The second strategy which uses a combination of countries to construct a synthetic region resembling Colombia during the pre-treatment period relies heavily on the Synthetic Control approach proposed by Abadie and Gardeazabal (2003). They find that it would be problematic to assess the impact of the conflict in the Basque Country simply by a comparison between the Basque country and the rest of Spain during terrorism year, since this may not show the true impact and pre-terrorism differences between the Basque Country and the rest of Spain. Therefore, they approach this problem using a weighted combination of other Spanish regions with similar characteristics to the Basque Country before terrorism; they called this weighted average as a "Synthetic Basque Country" not affected by terrorism. In other words, this is an ideal counterfactual to examine the true impact of conflict.

5. Results

a) Difference-in-Differences and Synthetic Control for Unemployment

i. Differences-in-Differences Analysis

Table 1 reflects the results for our DID estimation; presenting two sets of estimations. First, we have the parsimonious model (columns 1-3); second, we include a set of covariates (columns 4-6). In each set, we show the unemployment rate aggregated (total), and disaggregated by gender. For both estimations, the parsimonious and including covariates, the DID coefficient reflects a positive estimated mean difference on the unemployment rate total, and the unemployment rates for females and males. Interestingly, the inclusion of covariates reveals a positive expected mean change in the unemployment rate from before to after the onset of the "high intensity conflict" period among the control group, in other words, the more complete estimation shows a positive effect of time on the unemployment rate in the absence of treatment.

Table 1. Differences in Differences unemployment rate

VARIABLES	(1) Unemployment Total	(2) Unemployment Female	(3) Unemployment Male	(4) Unemployment Total	(5) Unemployment Female	(6) Unemployment Male
Diff-in-Diff	3.229***	3.844***	3.039***	3.711***	3.218***	3.695***
	(1.081)	(1.272)	(0.961)	(0.899)	(1.073)	(0.822)
Controls				X	X	X
Observations	380	380	380	349	349	349
R-squared	0.024	0.025	0.042	0.427	0.397	0.405
Number of id	10	10	10	10	10	10

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In order to identify causal effects, the DID assumes that prior to the intervention, the unemployment rates have identical trends in treatment and control countries. Then, after the intensification of the conflict (treatment), the DID estimates how the unemployment rates change in the treatment (Colombia) compared to the control countries that did not suffer a "high intensity conflict". To test the common trend assumption, we apply two standard falsification tests. Following Talosaga and Vink (2014), we try to estimate directly any difference in trends using the following regression model for the pre-treatment (if year < 1995):

$$Y_{it} = \alpha + \beta_1 trend + \beta_2 (treatment \times trend) + \theta X + \epsilon_{it} \quad (2)$$

If the common trend assumption holds, the coefficient β_2 should not be statistically significant. The second test estimates the model using a "placebo" treatment. We re-estimate the DID for the pre-treatment period assuming that the treatment affected at an earlier date. In this case the DID coefficient should be not significant and close to zero. The first test confirms the common trend assumption for either the parsimonious case, or including covariates (Table 9 Appendix). For the second test we estimate two placebos (Table 10 and Table 11 Appendix), one assuming that the treatment started in 1985 (ten years earlier), and second assuming the treatment started in 1990. For the first placebo we find a not statistically significant DID coefficient for the parsimonious model, but this becomes significant[7] when including covariates.

[7] It becomes significant at 10% significance level

For the second placebo, neither the parsimonious nor the model with covariates reveals a significant DID coefficient.

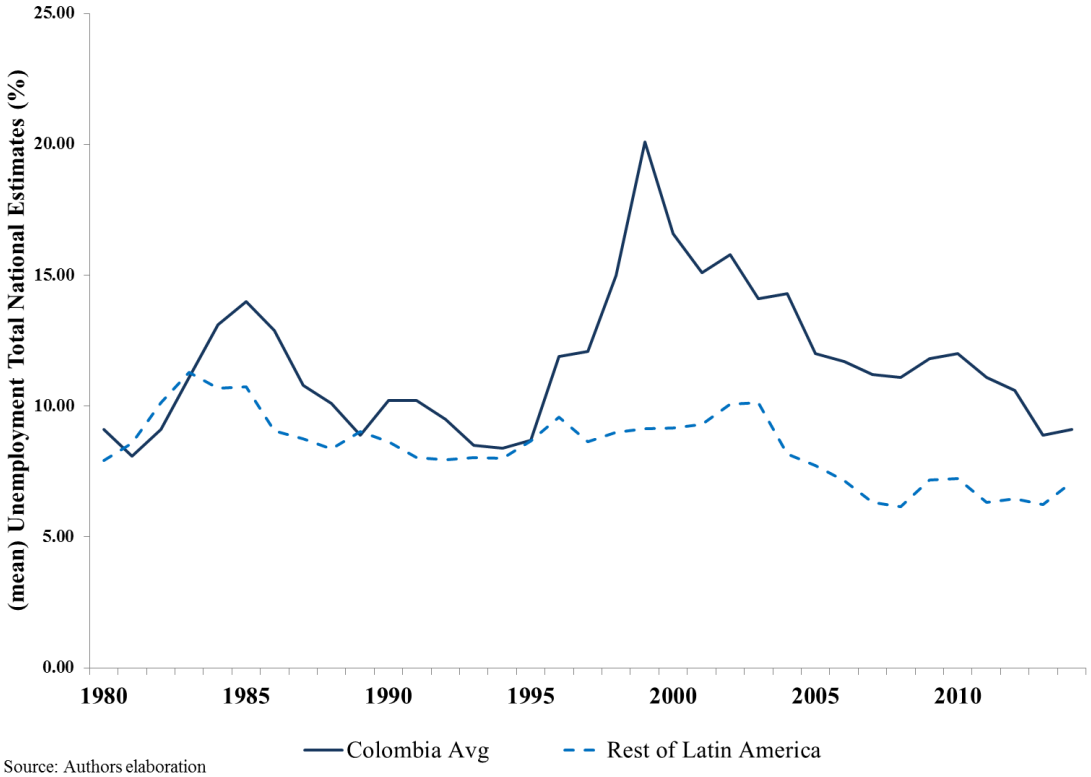
Although we find an effect of the "high intensity conflict" on the unemployment rate in Colombia, as well as on the female and male unemployment rates; these mixed results for the falsification test, do not allow us to draw a conclusion. However, these results do signal the existence of an impact in Colombia with respect to other countries within the region caused by the presence of a "high intensity conflict"; in order to establish a consistent conclusion, we rely on the synthetic control method proposed by Abadie and Gardeazabal (2003) applied for the Colombian case.

ii. Synthetic Control

The key question to evaluate the causal effect in which we are interested is how the unemployment has evolved in Colombia after 1994 in absence of the conflict. Certainly, this question cannot be answered without the help of a counterfactual because we are not able to have both Colombia without and with conflict simultaneously. Therefore, we use the synthetic control method as a procedure to estimate that counterfactual.

Figure 4 shows the trend of the unemployment in Colombia and the rest of countries in Latin America[8]. As we can see, the rest of Latin America does not seem to be a suitable control group for our purposes. Although at the beginning of the pre-treatment period (1977-1994), the unemployment rate in Colombia was slightly similar than the average unemployment rate for the rest of countries in the region, this difference was greater by 1985 when the unemployment rate was about 5% greater in Colombia than the average for Latin America. Moreover, on average, the unemployment rate for Colombia during the pre-treatment period was 14%; meanwhile the average unemployment for Latin America was 9%. Figure 4 suggests that, even before the beginning of the "high intensity conflict" period in Colombia, there is a gap between the unemployment rate in Colombia and the unemployment rate in the rest of Latin America. As suggested by Abadie et al.(2010) and Abadie and Gardeazabal (2003) the synthetic control method help us to estimate a counterfactual for Colombia from a pool of donor countries for the period 1977-1994

[8] The countries included are: Argentina, Bolivia, Brazil, Chile, Costa Rica, Ecuador El Salvador, Honduras, Nicaragua Panama, Paraguay, Peru, Uruguay, Puerto Rico, and Venezuela RB.



Source: Authors elaboration
Data: WDI-World Bank

Figure 4. Trend in Unemployment rate: Colombia vs. rest of donor countries

The Table 2 displays the results of our synthetic control in terms of pre-treatment characteristics between Colombia and the pool of donor countries. These results compare the means of the predictors of unemployment among Colombia, the synthetic Colombia and the average of the 8 donor countries, excluding from our donor pool those countries that do not meet the characteristics to be part of this[9]. We see that the average of countries that did not suffer a "high intensity conflict" after 1994 does not provide a good control group for Colombia. Economic predictors such as the GDP per capita or the investments (Gross fixed capital formation) adjust better for the Synthetic Colombia than the average of donor countries; a similar situation resembles with other predictors (i.e., life expectancy at birth, population density and gross enrollment in secondary education). Notice that it is important to have a donor pool of countries showing a high similarity with Colombia, which is the country exposed to the treatment (high intensity conflict). In this sense, the synthetic Colombia accurately resembles the predictor values for the actual Colombia during the pre-treatment period. According to Abadie et

[9] As we have explained in the empirical framework.

al.(2010), this result assures that we have a counterfactual that falls within the convex hull of the data.

Table 2. Unemployment rate predictor means.

	Colombia		Average of control countries
	Treated	Synthetic	
GDP Per capita (constant 2010 US $)	3969.80	3948.49	4599.337
Gross Enrollment Primary (female and male)	108.07	104.27	107.4469
Gross Enrollment Secondary (female and male)	47.28	52.40	54.34334
Life expectancy at birth (age)	67.12	68.65	69.56216
Population Density (ages 15-64 pop per km sq.)	16.40	16.67	14.94567
Gross fixed capital formation (% of GDP)	17.14	17.49	18.88967

Note: All variables are averaged for 1977-1994 period

The weights of each control country in the synthetic Colombia are reported in Table 3. The unemployment rate in Colombia, before the "high intensity conflict" period, is best resembled by a combination of Panama, Uruguay and Honduras, which are the only countries within our donor pool with positive weights. All other countries within the donor pool have a weight of zero for the synthetic Colombia.

Table 3. Country weights in the Synthetic Colombia

Country	Weight
Chile	0
Costa Rica	0
Ecuador	0
Panamá	0.379
Paraguay	0
Uruguay	0.250
Argentina	0
Honduras	0.371

Figure 5 shows the trend of the unemployment rate of Colombia and the synthetic Colombia for the period 1977-2014. We see that the synthetic Colombia presents a similar trajectory during the pre-treatment period. Altogether, this similarity and the similarity among the unemployment rate predictors reveal that the synthetic Colombia approximates the

unemployment rate that would have occurred in Colombia in the absence of a "high intensity conflict" after 1994.

During the treatment period (1995-2014), there is a gap between the unemployment rate for Colombia and the unemployment rate for the synthetic Colombia. This divergence in Figure 5 suggests a positive effect of the "high intensity conflict" on the unemployment rate in Colombia. The estimated effect of this treatment on the unemployment rate is given by the difference between Colombia and the synthetic Colombia. On average, the "high intensity conflict" contributed with 4.9% of the unemployment rate for the treatment period; in other words, relative to the 12.8% average unemployment rate in Colombia for the period 1995-2014 our results suggest that the "high intensity conflict" explains more than one third of the unemployment rate.

i. Robustness of these results

a) Placebo test

Even though the figures and the computations based on the divergence suggest that the conflict in Colombia has an effect on the variable of our interest we test whether our estimates have real significance or they are obtained by chance following Abadie et al.(2010) and Abadie and Gardeazabal (2003). In this sense, the questions we must respond is what would it happen with our results if we choose a random country besides Colombia? Using the non-treated countries within our donor pool, we apply the synthetic control during the sample period of our study. For each iteration, we reassign the "high intensity conflict" treatment to one of our 8 countries, and include Colombia within the set of donor countries. According to Abadie et al.(2010) the idea behind this placebo is that if the placebo creates gaps of similar magnitude to the gap estimated in our main synthetic, then we can affirm that our results do not provide significant evidence of a positive effect of the treatment on the unemployment rate in Colombia. On the opposite case, if the gap for Colombia is relatively larger than the ones estimated for the non-treated countries, we can say that our results provide significant evidence of a positive effect of the "high intensity conflict" on the unemployment rates.

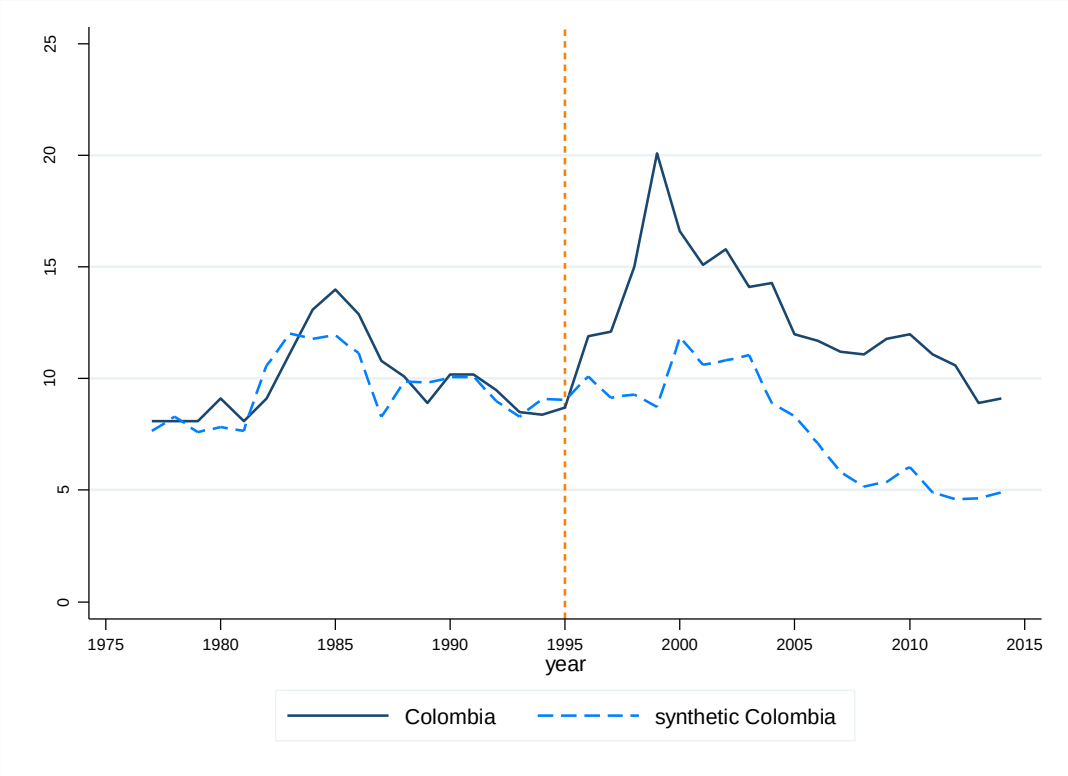


Figure 5. Trends in Unemployment rate: Colombia vs. Synthetic Colombia

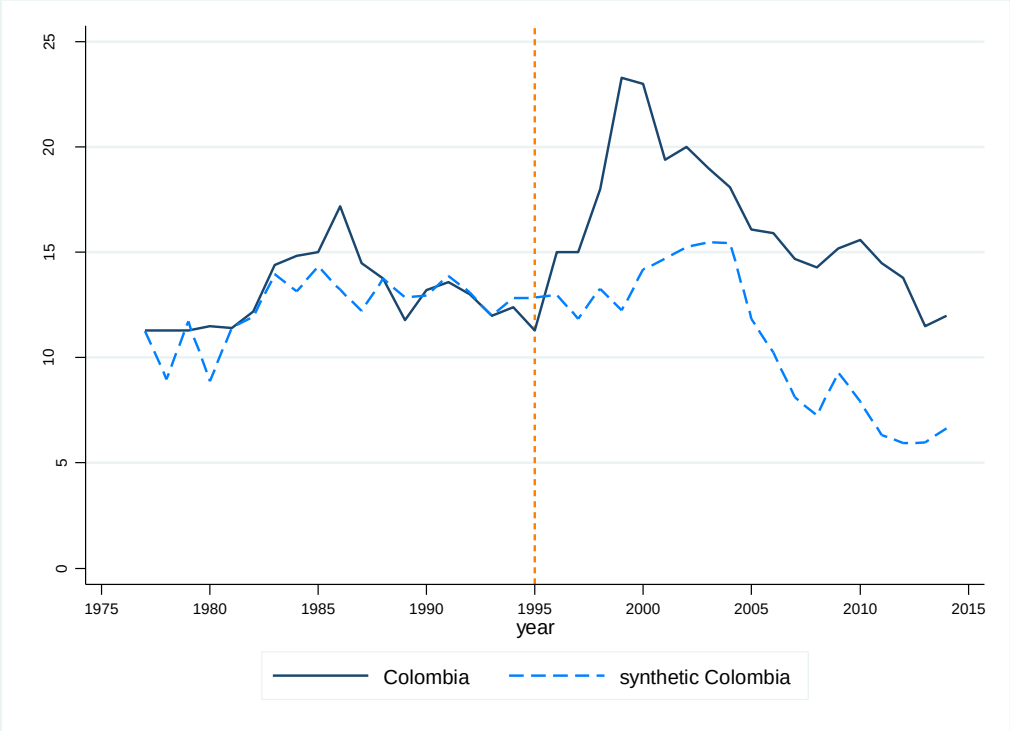


Figure 6. Trends in Unemployment rate Female: Colombia vs. Synthetic Colombia

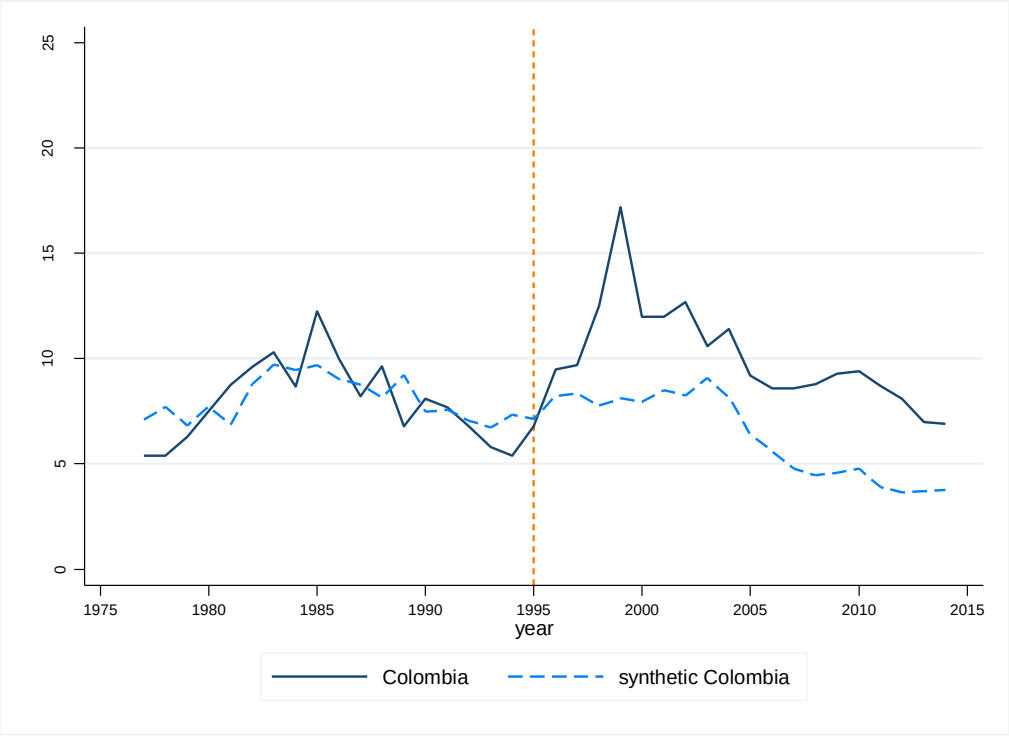


Figure 7. Trends in Unemployment rate Male: Colombia vs. Synthetic Colombia

We do this for each one of the other eight countries, and then we compute the estimated effect associated with each of the placebo run, as well as the distribution of these effects. Thus, we can see where Colombia as the treated unit lies in the distribution; and based on a standard level of rejection we can conclude whether the effect is significant or not. Figure 8 shows the gap in the unemployment rate for the eight placebos, and Colombia. This figure also reveals that Argentina could have fit problems in the pretreatment period; however, its mean squared prediction error (MSPE) is 12.1. Removing Argentina, we can see that the effect of the conflict on the unemployment rate in Colombia is the highest (Figure 9).

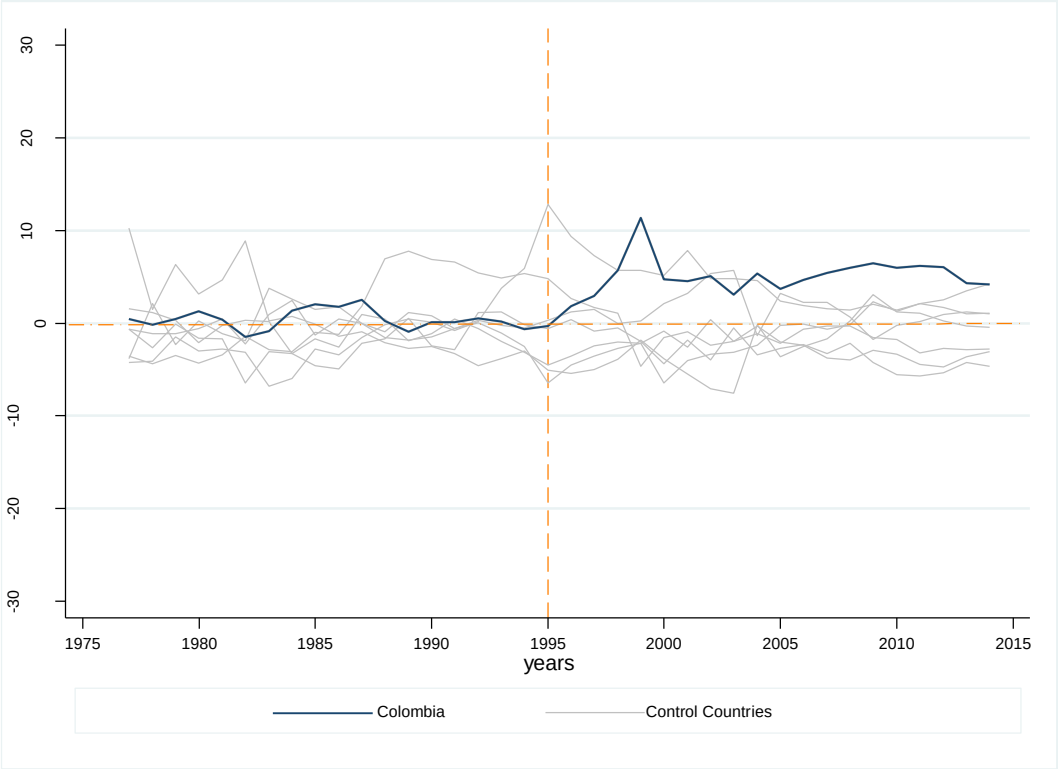


Figure 8. Unemployment rate gaps in Colombia and placebo gaps in all 8 control countries

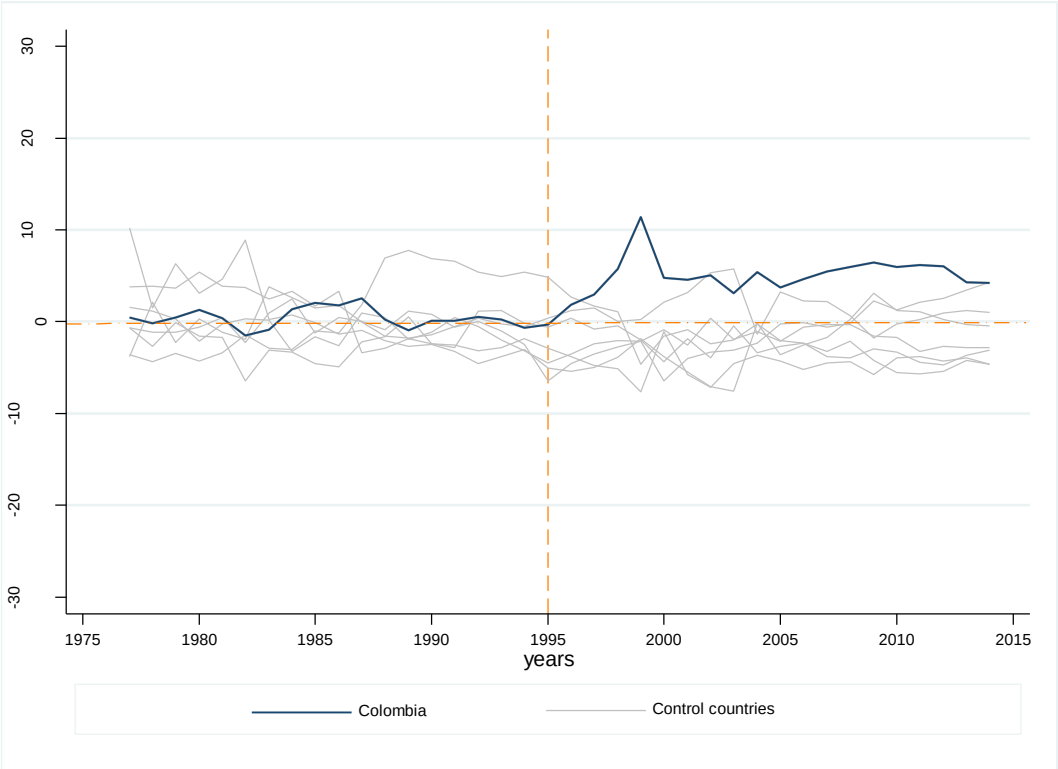


Figure 9. Unemployment rate gaps in Colombia and placebo gaps without Argentina

Even though these graphs give us an idea about how severe is the effect using the placebos, a more accurate way to evaluate the Colombian gap relative to the gaps obtained for the placebos is to analyze the distribution of the effects obtained after running iteratively a synthetic for every country. The idea is to calculate a post/pre-"high intensity conflict" MSPE ratio and constructs its distribution; based on that we assess the probability of having a value of the post/pre-"high intensity conflict" MSPE ratio as large as it is for Colombia. As it can be seen in the Figure 10, the distributions of the post/pre conflict MSPE shows that the value of Colombia falls far from the values of the rest of the countries, meaning that our results are significant. The probability of observing a behavior similar to Colombia is one in nine.

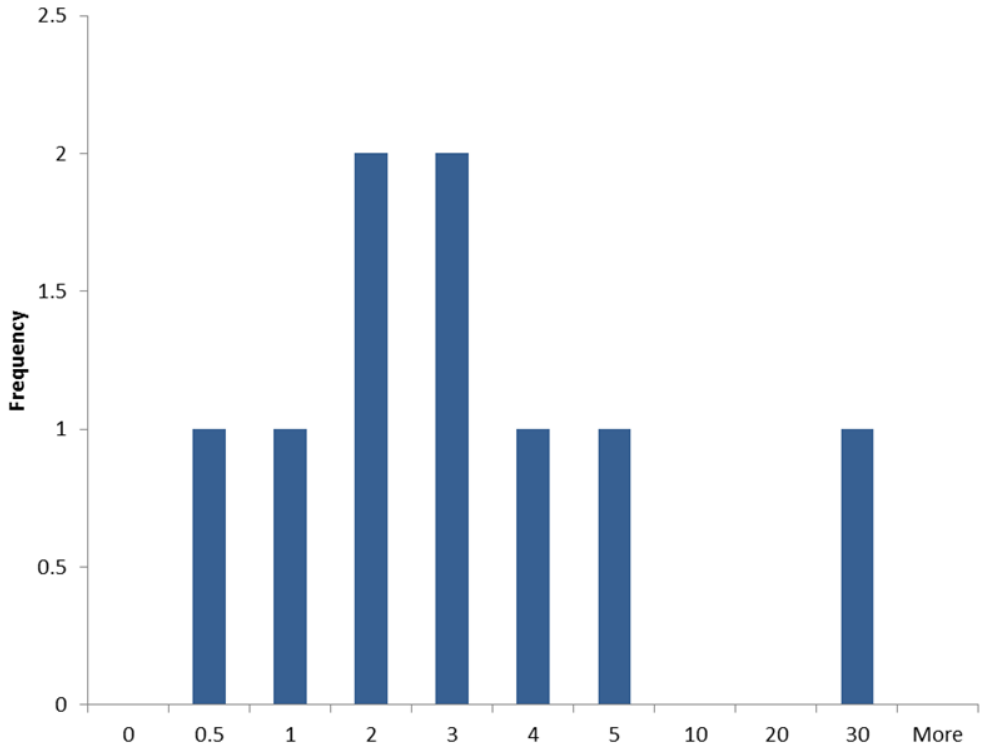


Figure 10. Post/Pre "High intensity conflict" mean square prediction error

The average treatment effect for Colombia compared to its synthetic control is an increase of 5.4% in the unemployment rate. This value is presented in Figure 11 below by the vertical line. That graph shows the cumulative distribution function of average treatment effects from systematically assigning treatment to each potential control country. The average treatment effect for Colombia is larger than the average treatment effect for all other countries, meaning

that the effect of the high intensity of the Colombian conflict on the unemployment rate is highly significant.

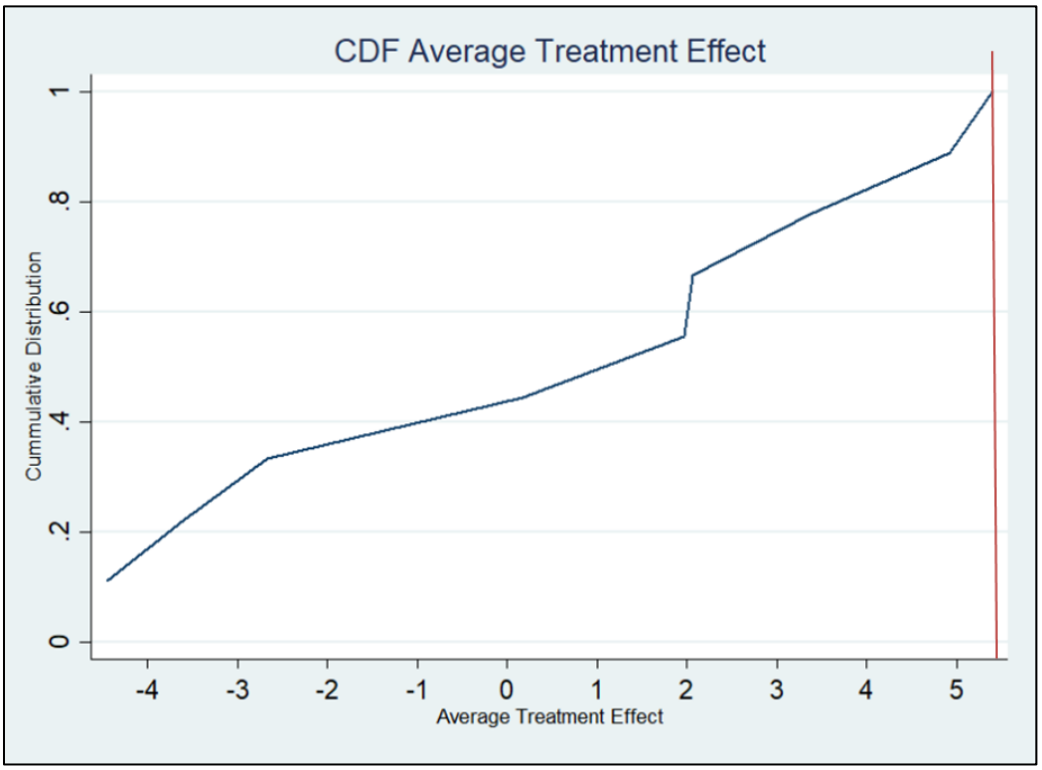


Figure 11. CDF Average Treatment Effect

Similar results are achieved when disaggregating the unemployment rate by gender. However, the effect on the female unemployment rate seems to be higher than the effect on the male unemployment. These results are consistent with other studies on the Colombian labor market that find a greater affectation for unemployment within the female population (Nuñez and Bernal 1997; Sánchez, Duque, and Ruíz 2009); however, these studies do not include the "high intensity conflict" within their analyses (see Figure 6 and Figure 7).

b) Synthetic control analysis including more countries in the donor pool

In the section called "sample selection and data" we have said that even though countries such as such as Mexico and Brazil share institutional characteristics with Colombia, they are not comparable with Colombia given their economic size relative to the Colombian economy. Therefore, including them in the donor pool will not contribute to the implementation of the synthetic given that their weights in the donor pool will probably be zero or close to it. In order to prove what we were saying in that section, we run the synthetic adding Brazil and Mexico to the list of countries that we use as controls. The results in

Table 5 show that the weights assigned to Mexico and Brazil are zero which confirms that these countries are not suitable to construct the synthetic Colombia. The countries that positively contribute to the synthetic Colombia are Panama, Uruguay and Honduras with weights of .38, .25, and .37 respectively which are pretty much the same weights these countries got when we run the synthetic without Brazil and Mexico (See

Table 5).

Table 4. Unemployment rate predictor means

	Colombia		Average of control countries
	Treated	Synthetic	
GDP Per capita (constant 2010 US $)	3969.80	3948.49	5254.263
Gross Enrollment Primary (female and male)	108.07	104.27	109.8345
Gross Enrollment Secondary (female and male)	47.28	52.40	59.63335
Life expectancy at birth (age)	67.12	68.65	68.86283
Population Density (ages 15-64 pop per km sq.)	16.40	16.67	15.1299
Gross fixed capital formation (% of GDP)	17.14	17.49	19.22486

Note: All variables are averaged for 1977-1994 period
These are the predictors including Mexico y Brazil.

Table 5. Country weights in the Synthetic Colombia

Country	Weight
Chile	0
Costa Rica	0
Argentina	0
Ecuador	0
Panama	0.379
Paraguay	0
Uruguay	0.250
Honduras	0.371
Mexico	0
Brazil	0

We have also run a synthetic including the rest of the countries in the regions[10]. The results in the Table 6 below show again Brazil and Mexico with weights zero in the donor pool. However, in addition to Panama, Uruguay and Honduras, which had positive weights under our

[10] We included all countries from which we obtained data to run the synthetic, meaning countries without many missing values.

main specification, now Ecuador, El Salvador, and Bolivia positively contribute to the donor pool with weights of 0.03, 0.01, and 0.08 respectively. However, it is important to notice two things. First, even though these weights are positive the biggest of them represents only eight percent. Second, El Salvador and Bolivia are two countries that faced similar conflicts than those faced by Colombia, and then they should not be included as controls in a model explaining the effect of a conflict on labor market variables.

Table 6. Unemployment rate predictor means

	Colombia		Average of control countries
	Treated	Synthetic	
GDP Per capita (constant 2010 US $)	3969.80	3967.66	4928.259
Gross Enrollment Primary (female and male)	108.07	104.88	106.7154
Gross Enrollment Secondary (female and male)	47.28	55.88	57.19691
Life expectancy at birth (age)	67.12	67.42	66.21285
Population Density (ages 15-64 pop per km sq.)	16.40	16.47	21.77518
Gross fixed capital formation (% of GDP)	17.14	17.14	19.06421

Note: All variables are averaged for 1977-1994 period
These are the predictors including with all countries included.

Table 7. Country weights in the Synthetic Colombia

Country	Weight
Chile	0
Costa Rica	0
Argentina	0
Ecuador	0.034
Panama	0.299
Paraguay	0
Uruguay	0.282
Honduras	0.290
Mexico	0
El Salvador	0.012
Brazil	0
Peru	0
Bolivia	0.083
Venezuela	0
Nicaragua	0

6. Conclusions

Analyzing the effects of the conflict in Colombia requires the consideration of multiple particularities including its duration, the multiplicity of armed actors involved, and the objectives of such armed actors. We overcome the lack of a counterfactual region within Colombia, by using a set of Latin American countries as a control group; and we estimated through two methodologies the effect of the "high intensity conflict" in Colombia over the unemployment rate.

Our first approach using a difference-in-differences revealed an effect on the unemployment rate. For the period 1995-2014, the DID estimated effect was about 3.7% with respect the control countries in our preferred specification (Table 1, columns 4-6); and this magnitude replicated for the unemployment rate for females and males. However, these results only signaled the impact of the conflict; in order to estimate the true impact of the conflict we construct a synthetic Colombia as a counter factual.

In addition, we found an estimated effect after running the Synthetic for the period 1977-2014, and we gathered few interesting conclusions. First, from our pool of donor countries only three countries obtained a positive weight: Panama, Uruguay and Honduras with weights of 0.379, 0.25 and 0.371 respectively. Second, the computation of the synthetic control allowed us to have an estimated impact of the conflict on the unemployment rate of 4.9% above the "Synthetic Colombia", which represents more than one third of the average unemployment rate for the "high intensity conflict" period (1995-2014) in Colombia. It is important to notice that there was a differentiated impact for females and males; consistent with other studies on the Colombian labor market (Nuñez and Bernal 1997; Sánchez, Duque, and Ruíz 2009), we found a greater effect among the female population for the "high intensity conflict" period that the male counterpart. Both, the DID estimated effect and the synthetic control estimate, represent at least roughly one third of the average unemployment rate for the post-treatment period. However, the synthetic control suggests an effect larger than our DID estimate.

The analysis conducted in this paper gives an idea of how the conflict affected one labor variable as it is the unemployment, the next step could be to explore differentiated effects by schooling level and the economy by sectors to identify which segments of the population and which parts of the economy were affected by the conflict. Similarly, this study opens two questions: first, a question regarding the mechanisms through which this "high intensity conflict"

treatment has affected the unemployment rate; one hypothesis may reside in the pressure imposed on the labor market in urban areas due the forced displacement phenomena. However, we do not test such hypothesis in this document. Second, it is valid to ask if there was any effect on the GDP in Colombia given the impact on the unemployment rate; our first approaches to the last question do not reveals conclusive results (Appendix).

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Appendix I

Table 8. Victims of violence in Colombia 1980-2014

Years	Selective Deaths	Forced Displacement	kidnapping	Victims of Massacres	Victims of Landmines
1980	NA	NA	279	10	0
1981	98	NA	92	62	0
1982	178	NA	114	106	1
1983	138	NA	124	193	0
1984	190	60.039	150	138	1
1985	180	13.835	346	229	0
1986	280	15.459	154	125	0
1987	60	19.099	132	125	0
1988	444	33.371	335	526	0
1989	390	29.735	280	290	0
1990	393	37.671	1122	328	22
1991	421	33.233	766	418	69
1992	461	43.935	912	419	151
1993	389	49.579	354	271	84
1994	491	54.066	691	187	85
1995	614	105.466	509	275	130
1996	565	137.364	1269	463	120
1997	811	246.95	2100	662	96
1998	439	239.354	3278	684	58
1999	682	272.792	3354	1134	54
2000	1291	598.026	3547	1441	137
2001	761	653.228	3545	1370	299
2002	1067	753.678	3306	815	634
2003	1495	453.126	2303	427	756
2004	1071	414.909	1773	303	890
2005	702	473.898	1283	160	1182
2006	399	454.267	1350	105	1235
2007	486	476.171	1384	89	978
2008	427	424.856	1455	78	857
2009	518	247.75	1252	106	747
2010	361	191.803	1252	87	552
2011	353	230.316	NA	80	549
2012	183	231.683	NA	45	502

Authors' elaboration

Sources: Group of Historic Memory – Colombia[11]; Victims Unit – President Office Colombia[12]; Center for Conflict Studies – CERAC.

[11] http://www.centrodememoriahistorica.gov.co/micrositios/informeGeneral/basesDatos.html

[12] https://cifras.unidadvictimas.gov.co/Home/Desplazamiento

A. Synthetic Control

This methodology considers the availability of J control "regions" different than the treated region, and W a $J \times 1$ vector of nonnegative weights summing to one. Each scalar in the W vector (i.e., w_j) represents the weight of region j in the synthetic control region. The main idea is to find a vector W in such a way that the synthetic control is the closest to the treated region before the beginning of terrorism. Then, given a vector X_1 $(K \times 1)$ of pre-terrorism values of K economics variables for the treated region, a $K \times J$ matrix X_0 containing the values of the same variables for the J possible control regions, and a diagonal matrix V with nonnegative components reflecting the relative importance of the different economic variables, a vector W^* of weights is chosen to minimize $(X_1 - X_0 W)V'(X_1 - X_0 W)$ subject to $w_i \geq 0$ and $w_j + \cdots + w_J = 1$. The objective is to approximate the outcome variable in the treated region Y_1 to the path this would have in the absence of conflict, so this counterfactual outcome path is calculated as the outcome of the synthetic control region $Y_1^* = Y_0 W^*$.

B. Common trend assumption – Placebo

Table 9. Test for common trend assumption: test in pre-treatment period

VARIABLES	(1) Test Unemployment	(2) Test-controls Unemployment
Trend	-0.074	-0.009
	(0.078)	(0.089)
Test1 ($Treatment \times Trend$)	0.119	0.035
	(0.135)	(0.073)
Covariates		X
Year Dummies	X	X
Constant	9.659***	54.587***
	(1.709)	(8.341)
Observations	180	168
Number of id	10	10

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10. Test for common trend assumption: Placebo treatment (t < 1985)

VARIABLES	(3) Placebo Unemployment	(4) Placebo-controls Unemployment
Time-treat ($t < 1985$)	9.645***	53.668***
	(1.749)	(8.338)
treatment	1.415	0.985
	(4.784)	(1.050)
DID	-1.887	-2.796*
	(1.459)	(1.567)
Covariates		X
Dummy year	X	X
Observations	180	168
Number of id	10	10

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 11. Test for common trend assumption: Placebo treatment (t < 1990)

VARIABLES	(5) Placebo 2 Unemployment	(6) Placebo 2-controls Unemployment
timetreat3($t < 1990$)	1.091	56.056***
	(1.322)	(8.348)
Treatment	0.731	0.052
	(4.884)	(1.470)
DID	-0.215	-0.439
	(1.628)	(1.706)
Covariates		X
Dummy years	X	X
Constant	8.455***	
	(1.753)	
Observations	180	168
Number of id	10	10

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

C. Employment to population ratio

In this paper, our main objective is to analyze the impact of the high intensity of the conflict in Colombia on the unemployment rate. However, now we want to study another measure of the Colombian labor market, which is the employment to population ratio. The 12 below contains the results of a difference in differences model that is similar to the one we have run for the unemployment rate, the only difference is that now the dependent variable is the employment to population ratio. These results show that during the period 1995-2014 the effect of the conflict on the dependent variable for Colombia was approximately 0% (0.0000864) with respect the control countries.

Table 12. Difference in Differences Employment to Population Ratio

	(1)	(2)
VARIABLES	Employment to population ratio Total	Employment to population ratio Total
DID	0.0000864***	0.0000994***
	(0.0000259)	(0.0000254)
controls	X	X
R-squared	0.49	0.43
Observations	316	342

Standard errors in parentheses
***p<0.01, **p<0.05, *p<0.1

We also run the synthetic for the employment to population ratio as our dependent variable. Table 13 and Table 14 show the mean of each predictor used to construct the synthetic and the weight of every country in the donor pool respectively. As it can be seen, the synthetic values for the predictor are closer to the values of Colombia's predictors than the average values. However, in the Figure 12 it is not clear that the year 1995, which is our cutoff point, defines a point in which Colombia and its synthetic diverge. The two lines were different even before our cutoff point. Therefore, in this case we cannot say that the high intensity of the conflict is the cause of any difference in employment to population ratio during the period 1995-2014.

Table 13. Employment to population ratio predictor means

	Colombia		Average of control countries
	Treated	Synthetic	
GDP Per capita (constant 2010 US $)	3969.804	3970.623	4599.337
Gross Enrollment Primary (female and male)	108.0654	108.0721	107.4469
Gross Enrollment Secondary (female and male)	47.27657	47.28624	54.34334
Life expectancy at birth (age)	16.40294	16.40365	14.94567
Population Density (ages 15-64 pop per km sq.)	17.14444	19.03947	18.88967

Note: All variables are averaged for 1977-1994 period

Table 14. Country weights

Country	Weight
Chile	0
Costa Rica	0.177
Argentina	0
Ecuador	0.205
Panama	0
Paraguay	0.233
Uruguay	0.225
Honduras	0.16

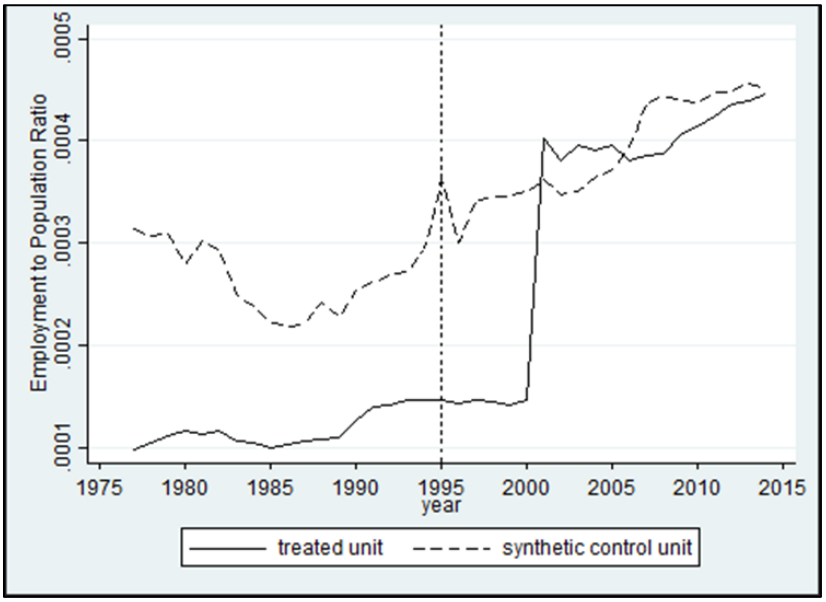


Figure 12. Trends in Employment to population ratio total: Colombia v. Synthetic Colombia

D. Gross Domestic Product – Difference in Differences

Table 15. Difference in Differences GDP per capita (constant 2010 US$)

VARIABLES	(1) GDP per capita Diff-in-Diff	(2) GDP per capita Diff-in-Diff - Controls
Time treatment (t<1995)	2,110.988***	674.737***
	(133.304)	(204.147)
DID	-502.775	-495.879
	(421.544)	(346.072)
Gross enrollment primary education		-56.447***
		(10.344)
Gross enrollment secondary education		33.396***
		(6.157)
Life expectancy at birth (ages)		177.666***
		(33.917)
Population density (pop per kmsq)		-31.701***
		(6.019)
Employment in Agriculture (% of labor force total)		-60.530***
		(8.695)
Employment in Services (% of labor force total)		28.287***
		(9.005)
Employment in Industry (% of labor force total)		4.734
		(17.173)
Gross fixed Capital formation (% GDP)		113.941***
		(12.842)
Constant	4,290.144***	-4,980.046*
	(91.746)	(2,607.693)
Observations	380	313
R-squared	0.420	0.721
Number of Countries (id)	10	10

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Chapter II. The Effects of Illegal Armed Groups on Municipal Investments in Colombia

1. Introduction

This study assesses the effects of leftist guerrillas and rightist paramilitaries on municipal investments in Colombia. Over the past fifty years, violence in Colombia has evolved and taken many shapes. Limits on political participation and institutional weaknesses were key elements propagating violence that disrupted Colombia for years. Searching for solutions to these structural problems, Colombia transferred many decision-making responsibilities from the central government to regional and local governments in [years]. Paradoxically this decentralization opened an opportunity for illegal armed groups to play meaningful roles in local political and economic life, eventually taking control over local resources in several municipalities. (Acemoglu et al., 2013; Gutiérrez, 2010; Garay Salamanca and Salcedo-Albarán, 2010).

After 1991, the central government corrected institutional weaknesses and strengthened regulatory capacity with reasonable success. First, the central government defined the competencies of departmental (regional) and municipal governments regarding their provision of public services, including education, health, and drinking water. Second, the central government established criteria that each departmental government would use to certify whether a municipal government is worthy of receiving resources from the central and departmental governments (Zapata-Cortés 2016). Even though the central and departmental governments give resources to municipalities, each municipal government has the authority to choose the budget amounts allocated to health, education, infrastructure, environmental protection, and other areas ("general purposes"), including ongoing expenditures (e.g., teacher salaries).

Unfortunately, after 1991, illegal armed groups co-opted municipal institutions, gained control over local decisions and resources, and usurped the mantle of the "state" in several locales (General 2014; Gáfaro, et al., 2014). These actions of illegal armed groups may have impacted municipal investment in total and the allocation of investments across key categories, e.g., health, education. This study empirically explores these possible impacts on municipal investments. Thus, rather than exploring the causes behind the conflict in Colombia, this study focuses on the legacy of the civil conflict.

Several studies consider the socio-economic impact of the conflict on Colombia. Some studies show the incidence of violent actors on the decision-making process regarding political elections, democratic processes, and local collective organizations (Acemoglu et al., Robinson, and Santos 2013; Chacón, Robinson, and Torvik 2011; Gáfaro, Ibáñez, and Justino 2014). Acemoglu et al. (2013) use electoral and legislative data by region in Colombia to show a strong relation between right-wing illegal armed groups and electoral outcomes in certain regions. Similarly, Gáfaro et al (2014) assess the impact of non-state armed groups on local collective organizations during the armed conflict in Colombia, revealing an increase in overall participation in local organizations, driven by the coercion exercised by these irregular armies. Other empirical studies examine the consequences of the conflict on forcibly displaced households (Ana María Ibáñez and Vélez 2008; Ana María Ibáñez and Moya 2010; Ana María Ibáñez and Vélez 2008; Ana Maria Ibáñez 2009). These studies help to determine the welfare losses due to forced displacement and provide evidence on the effectiveness of policy instruments for preventing displacement. Additional studies explore the impact of conflict on labor markets and firms' exit decisions (Camacho and Rodriguez 2013; Rozo 2016; Calderón-Mejía and Ibáñez 2016).

Our study contributes to this literature by exploring the economic impact of civil conflict on investments and differentiating these effects by investment type: health, education, environmental protection, infrastructure, and other.

To generate these contributions, our empirical study explores municipal investment in the country of Colombia between 2000 and 2010. Our study exploits variation over time and across space in municipal investment measured in three ways: total investment, levels of investment by category (education, health, infrastructure, environmental protection, and other), and categorical proportions of total investment. Similarly, our empirical analysis exploits variation in the presence of illegal groups over time and across space, as well as variation between leftist and rightist groups. For a given year, leftist guerrilla groups and/or rightist paramilitary groups may be present in a particular municipality. Or neither type of group may be present. To accommodate this pattern, we generate two primary regressors. One captures the presence of at least one guerrilla group in the given year and municipality. The other regressor captures the presence of at least one paramilitary group in the given year and municipality. Thus, we explore

two types of treatment in our difference-in-difference empirical framework.[13] The presence of illegal groups also varies over time. In the sample, some municipalities never host illegal armed groups. Sadly, most municipalities host at least one type of illegal group. Of these municipalities, the temporal pattern varies substantially across municipalities: only the presence of leftist groups over time, only the presence of rightist groups over time, first the presence of only leftist groups but later the presence of only rightist groups, etc. Given this substantial variation in the temporal pattern across municipalities, our difference-in-difference empirical framework does not identify a single treatment period. Instead, we compare various treatment periods to the set of periods lacking treatment.

Using this empirical framework, we estimate separately the effects of leftist and rightist groups on municipal investments, while testing whether the effects of leftist and rightist groups differ. To capture the long run effect of illegal armed groups, our analysis includes three factors measuring the presence of each illegal group based on timing: contemporaneous measure, one-year lagged measure, and two-year lagged measure. We employ fixed effects regression analysis to link the presence of illegal armed groups to municipal investments.

The fixed effects results reveal these relationships. The presence of leftist guerrilla groups lowers environmental investment, as a proportion of total investments, by 1 % at the moment of presence (i.e., contemporaneous effect). Over the subsequent two years, the lagged effects reinforce the contemporaneous effect. The long run effect of the permanent presence is the sum of three coefficient magnitudes or * %. Similarly, the presence of leftist guerrilla groups lowers infrastructure investment, as a proportion of total investments, by 0.6 % with a one-year lag. However, the presence of leftist guerrilla groups raises health investment, as a proportion of total investments, by 1.8 % with a two-year lag. In contrast, the presence of rightist paramilitary groups does not impact environmental investment or infrastructure structure and actually lowers health investment by 4.1 %. Unlike leftist guerrilla groups, the presence of rightist paramilitary groups increases educational investment by 2 % based on each presence measure, implying a long run effect of 6 %. These results are robust to the inclusion of several control factors as

[13] To assess whether the two illegal groups influence the other group's impact on municipal investments, our empirical analysis also includes an interaction term between these two primary regressors as a third regressor. The coefficient of this interaction term never proves statistically significant. Thus, neither positive nor negative synergies prove relevant for these two types of illegal groups.

regressors, including municipal revenues and transfers from other levels of government (central, departmental).

The rest of the study elaborates on these points. Section 2 reviews the related literature. Section 3 describes the context of the empirical analysis. Section 4 describes the gathered data and constructed variables. Section 5 reports and interprets the empirical results. Section 6 concludes.

2. Related Literature

The aim of the political, administrative, and fiscal decentralization in Colombia was to give citizens or their locally elected representatives more power in public decision-making and autonomy to determine investments including those to protect the natural resources, to improve public services such as health and education, and to increase and to maintain infrastructure. However, the situation of violence in Colombia and the presence of illegal armed groups represented an obstacle for the political and economic institutions (Acemoglu, Robinson, and Santos 2013; Gutiérrez 2010; Garay Salamanca and Salcedo-Albarán 2010). As a conflict consequence, the decentralization process in Colombia opened an opportunity for these illegal groups to get involved within the political and economic issues in the regions.

Several studies assess the socio-economic legacy of the conflict using different approaches. Some of them examine the impact of conflict on economic outcomes. Using cross-country level data Alesina et al. (1996); Alesina and Perotti (1996); Barro (1991); Mauro (1995); and Venieris and Gupta (1986) find a negative effect of conflict on investments, savings, and economic growth. Other studies assess the economic impact of conflict on regions or firms. Abadie and Gardeazabal (2003) assess the economic impact of conflict, using the terrorist conflict in the Basque Country as a case study. They find that, after the outbreak of terrorism, per capita GDP in the Basque Country decreased around 10 percentage points compared with the synthetic control region. Grier and Maynard (2016) find that political instability affected negatively economic growth while other indicators such as poverty, health and inequality improved; and Bove, Elia, and Smith (2016) find a negative but not significant effect of conflict on economic growth. To do so, this study compares its results with the results of a sample of "cases of studies" using synthetic controls to demonstrate the heterogeneous effects of conflict on economic performance. Also on the economic outcomes, other studies examine the legacy of conflict on physical capital and investments. Most of these studies consider a scenario of interstate wars and the postwar evolution of investments and physical capital (Davis and

Weinstein 2002; Brakman, Garretsen, and Schramm 2004; Miguel and Roland 2006). Comparing cities and regions, these studies find that cities or regions that were heavily bombed recover quicker than those cities untouched by bombing.

Regarding to the effect of conflict within specific countries on microeconomic level Shemyakina (2011), Chamarbagwala and Morán (2011), and Eccleston (2011), consider the impacts of conflict or exposure to terrorism on education outcomes (human capital accumulation). Eccleston (2011) finds that psychological stress due to exposure to terrorist events has negative impacts on early educational attainment and cognitive ability. Similarly, Chamarbagwala and Morán (2011), and Shemyakina (2011) find a strong negative impact of conflict over educational attainment and schooling, especially among vulnerable populations located on regions with high conflict intensity (Chamarbagwala and Morán 2011; Shemyakina 2011). Specifically for Colombia and Bosnia Herzegovina, some scholarly works, assess the impact of forced displacement on labor participation and welfare (Ana María Ibáñez and Moya 2010; Ibañez and Engel 2007; Ana María Ibáñez and Vélez 2008; Kondylis 2010). Kondylis (2010) finds that displaced people in Bosnia are less likely to be working compared with those who stayed at the same place; her results reveal a differential effect on men whom experience high unemployment rates, while displaced women are more likely to drop out the labor force. Similarly, Ibáñez and Moya (2010) examine the effect of forced displacement (caused by conflict) on households' welfare after displacement; and Ibáñez and Vélez (2008) estimate the welfare losses due to forced displacement compared to a situation of traditional (unforced or voluntary) migration.

Finally, several studies assess the socio-economic impact of conflict in Colombia. Some of them show the incidence of violent actors on the decision process in policy making (Acemoglu, Robinson, and Santos 2013; Chacón, Robinson, and Torvik 2011), studying the impact of conflict on political elections, and democratic processes. In particular, Acemoglu et al.(2013) using electoral data by region and legislative data, find a strong relation between right wing illegal armed groups, and electoral outcomes in determined regions in Colombia. Similarly, Gáfaro et al (2014) investigates the causal impact of non-state armed groups on local institutions during the armed conflict in Colombia, defining institutions as local collective organizations different from the local authorities or public institutions. This study reveals an increase in overall participation in local organization, with a particular strong effect on political organizations,

driven by coercion exercised by the irregular armed groups that capture them for war purposes. Some other studies consider the impact of conflict on forced displaced population (Ana María Ibáñez and Vélez 2008; Ana María Ibáñez and Moya 2010; Ana María Ibáñez and Vélez 2008; Ana María Ibáñez 2009). Meanwhile, others examine impacts on health outcomes, firms decisions, and labor markets (Camacho 2008; Camacho and Rodriguez 2013; Rozo 2016; Calderón-Mejía and Ibáñez 2016). These studies contribute to determine the welfare losses due to the forced displacement phenomena, provide evidence regarding policy instruments for preventing displacement, determine the impact of conflict on firm's exits from the market, and provide evidence on the impact of forced displacement on wages.

2.1. Decentralization process

Colombia is a unitary republic with autonomous regional entities or sub-national governments identified as departments (equivalent to U.S. states) and municipalities. Departments are territorial entities with autonomy to manage, to plan and to promote socio-economic development within their own territory. Similarly, the departments are responsible for (1) coordinating and complementing municipal action and (2) intermediating between the central government and municipalities in able to provide the services determined by the constitution (DANE 2007). A municipality is the basic territorial entity unit with political, fiscal, and administrative autonomies within its boundaries.

In the last three decades of the 20th century, Colombia decentralized its government functions. As one of the first steps, the 1968 constitutional reform transferred responsibilities from the central government to the departments, allowing departmental governors to design and implement development plans and programs, as well as to fulfill other functions that lie below the ministerial capacities at the national level. Colombia reinforced this transfer of competencies in 1971 with the "Situado fiscal", which dedicated a proportion of the national income to local administration for the provision of municipal services. During the same year, the national government crafted a system for sharing sales tax revenues with departments and municipalities, defining these revenues available for all purposes (Moncayo Jimenez 2005).

Decentralization can be horizontal or vertical (Correa and Steiner 1994) . In Colombia, this process was vertical because it transferred decision-making and resources to sub-national levels – departments and municipalities. In particular, the central government delegated a multiplicity of functions to municipalities, including water systems, sewer systems, and

environmental management (Valencia-Tello and Karam De Chueiri 2014; Moncayo Jimenez 2005).[14] This process not only included an increase in delegation of functions and resource decentralization, but also attempted to change access to and the provision of basic services in all the regions of the country. According to González (1994), the decentralized model implemented in Colombia was a copy of the fiscal federalism model, which main objective is to achieve local efficiency and a reduction in the central government expenditure. However, at the beginning of the process some levels of centralization remained, due to institutional weaknesses at the municipal level (Valencia-Tello and Karam De Chueiri 2014). Afterwards, the central government tried to correct the negative effects of the institutional design and to strength its regulatory capacity in two ways: (1) defining clearly departmental and municipal competencies regarding the provision of public services, and (2) conditioning municipal resources to a certification awarded by each department based on criteria established at the national level (Zapata-Cortés 2016). Despite this decentralization, the central government designed a set of rules applicable to the budgetary process at the national and sub-national levels of government (DDT-DNP 2012) that allowed the central government to maintain some control.[15]

By 2000, Colombia had completed its decentralization process. Due to this decentralization, municipal governments have the autonomy to govern their own resource management constrained by the central government's retained authority and authority delegated to departmental governments.

2.2. Illegal armed groups and the decentralization

This document investigates on the impact of the presence of illegal rightist and leftist armed groups on municipal investments in Colombia during the period 2000-2010. Over the past fifty years, violence in Colombia has evolved and taken many shapes. Limitations in political participation and the weaknesses in the institutions are key elements in the propagation

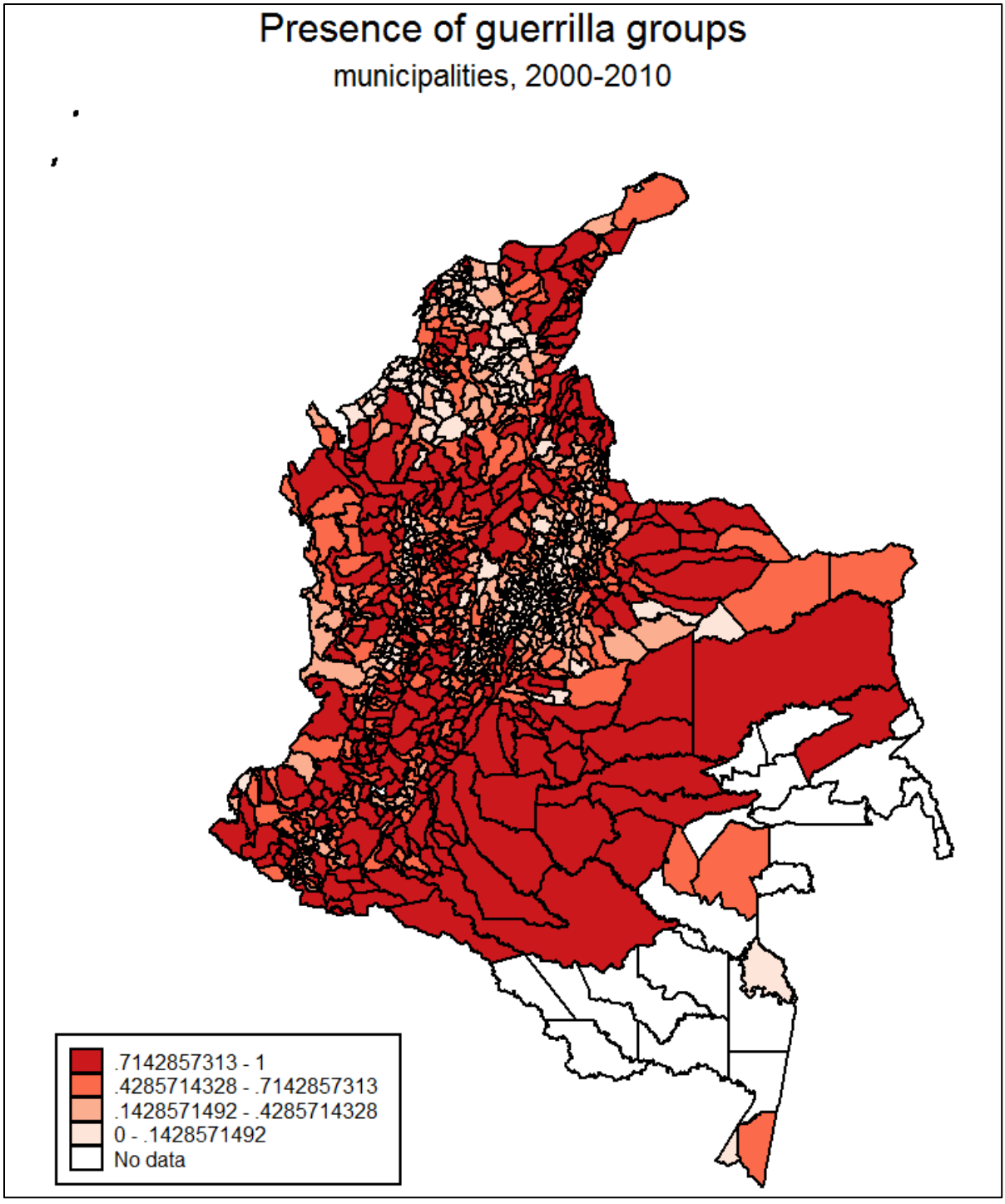
[14] Act 715, 2001. Art. 76.5.4 Identifies these activities: execute decontamination projects of water streams and water deposits affected by wastewater discharges, as well as disposition programs, elimination, and recycling of liquid and solid residuals, and controlling air pollutant emissions.

[15] The central government created the Statue of Budget (Estuto Único de Presupuesto) – EUP, defining the budgetary process in Colombia and its different steps. Two main agents operate at the local level: major and municipal council. The major is responsible for local economic development, including allocating the municipal expenditure and investments according to the approved budget (DDT-DNP, 2012). The municipal council approves and authorizes budgetary revenues and expenditures. Similarly, two agents operate at the department level: governor and department assembly. Governors are responsible for regional economic development, designing plans and programs, and defining revenues and expenditures (DDT-DNP, 2012). The department assembly approves the plans, projects, and budgets proposed by the governor.

of violence within Colombia. Searching for a solution to these structural problems, Colombia has faced a political, administrative, and economic transformation that has transferred decision-making responsibilities from the Central government to regional governments. Paradoxically, the decentralization opened an opportunity for the illegal armed actors to get involved in the regional political and economic life taking control over their resources (Acemoglu, et al, 2013; Gutiérrez, 2010; Garay Salamanca and Salcedo-Albarán, 2010).

The irregular armies co-opted municipal and departmental institutions, and gained control over decisions and resources. According to Gutiérrez-Sanín (2010), this increased capacity of the illegal armed groups to block or co-opt municipal and department councils, turned them into instruments to articulate themselves into the political and administrative system within the regions. On one hand, the leftist guerrilla groups put pressure on municipal resources to gain access to rents through percentages of contracts, and exercising power over governors and majors to get strategic advantages. On the other hand, the rightist paramilitary groups took advantage of the municipalities in the same way as the leftist guerrillas, but also these groups had a greater capacity to co-opt municipal administrations, and possessed a permanent and direct contact with national security agencies, governors, majors, and economic elites within the regions (Gutiérrez-Sanín, 2010).

These alliances among private economic interest (legal and illegals) had an effect on the fiscal and socioeconomic performance at the local administrative level. For instance, the incidence of the rightist paramilitary groups on municipal revenues reflected at both rising new revenues and the provision of public goods. According to Zapata, Acosta and Gonzalez (2013), by the end of the 1990's decade, the main source of revenue for the municipalities was the property tax, along with other minor taxes over commercial or industrial activities, and vehicle taxes. Moreover, the collection of such property tax depended excessively on the coercion capacity of the municipality over landowners that usually protected themselves with heavy armed and trained groups (paramilitaries) (Gutiérrez-Sanín, 2010). The scarce regulatory capacity affected the fiscal decentralization, and originated the eruption of private interest including illegal armed groups, into the decision-making process at the local level in Colombia (Garay & Salcedo-Albarán, 2010).



Source: CEDE – Municipal panel on presence of illegal groups
Authors' elaboration

Figure 13. Presence of Leftist Guerrilla Groups (2000-2010)

3. Data description

Using different data sources, we assemble a panel data including information for 1,088 municipalities in Colombia for the period 2000–2010 (Table 16). We are interested in the proportion of investments allocated to environment, infrastructure, education, health, and general purpose. The Colombian Ministry of Finances and the National Department – DNP, annually collect this data, along with data on municipal revenues. The Center for Development Studies – CEDE affiliated to the Universidad de los Andes builds and update a panel for municipal budgetary information using these inputs. Similarly, CEDE assembles a panel with demographic variables for municipalities using Census data from the National Statistics Department from Colombia – DANE. Finally, we consult conflict and violence data assembled by CEDE and the Conflict Analysis Resource Center – CERAC, based on official sources (National Police, National Army, and Ministry of Defense), and primary information respectively.

Table 16. Data sources

Municipality Budgetary Panel (2000-2010)	Center for Development Studies – CEDE Universidad de los Andes Ministry of Finance Colombia
Municipality Panel – General Characteristics (2000-2010)	CEDE Universidad de los Andes
Data on conflict: (1997-2010)	CEDE Universidad de los Andes CERAC

3.1.Dependent variables:

Given that our main interest is to explore the effect of the presence of illegal armed groups (rightist and leftist) on municipal investments, we consider five investment categories. First, environmental investments that include waste water treatment, natural disasters' prevention, as well as conservation, protection, and restoration of natural resources. Second, we consider infrastructure investments such as transportation, roads, public housing, and equipment (public spaces). Third, we consider education investments, including child protection programs, child nutrition, schools, and related expenses. Fourth, we consider health investments that include public health programs, vaccination programs, hospitals, and related expenses. Finally, we also consider investments in any other concepts called general purposes that account for cultural activities, traditions, communitarian organizations, attention to vulnerable population (e.g., population under poverty line, veterans, and conflict victims).

Table 17. Dependent variables

Type of investments	Description
Environmental	Waste water treatment Natural disasters' prevention Conservation, protection, and restauration
Infrastructure	Transportation Roads Housing Equipment (public spaces)
Education	Child nutrition programs Schools
Health	Public health programs and campaigns Hospitals
General Purpose	Cultural activities Vulnerable Population attention

3.2.Control sets

In addition to the different categories of municipal investments, we have data for municipal general characteristics. We use as initial control group measures of municipal economic activity, and the level of population. These variables are available at aggregated level (i.e., GDP total), or disaggregated by economic sector (i.e., agriculture, services, and industry). Moreover, we use as additional control variables information on municipal revenues (total, tax, and capital revenues) and transfers to the municipalities made by the superior levels of government (departments and central government).

Table 18. Descriptive statistics relevant variables 2000-2010

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent Variables (proportion of total investments)					
Environmental Investments	1,088	0.281	2.528	0.058	83.550
Infrastructure	1,088	0.155	0.058	0.016	0.390
Education	1,088	0.380	1.762	0.052	37.181
Health	1,088	0.602	0.194	0.106	2.880
General Purposes	1,088	0.361	0.393	0.090	8.687
General Characteristics (log)					
GDP Total	1,084	11.224	1.193	7.195	15.138
GDP Services	1,084	10.217	1.437	4.765	14.507
GDP Industry	1,084	9.609	1.546	5.181	14.971
GDP Agriculture	1,084	9.458	1.285	2.673	12.782
Population	1,088	9.508	0.980	6.781	13.035
Budget Variables (log)					
Total revenues	1,088	8.670	0.789	7.157	12.071
Tax Revenues	1,088	6.086	1.478	1.539	11.390
Transfers	1,088	6.191	0.381	2.679	7.938
Capita Revenues	1,088	8.351	0.763	6.769	11.762

4. Methodology and Results

To assess the effect of the presence of irregular armies on municipal investments in Colombia, we estimate a fix-effects model, which allows identifying the impact of presence of irregular armies from within-municipal variation across time. Using fixed-effects, we account for potential specific factors that may be responsible for municipalities to change investments. Similarly, we include year fixed-effects to account for a non-uniform treatment during the period of the study (Figure 14). In other words, we are trying to identify whether the presence of illegal armies (leftist or rightist) had an effect on different municipal investments.

The baseline model is as follows:

$$M_{it} = m_i + \gamma_t + \beta D_{it} + \theta D_{it-j} + X_{it} + \upsilon_{it} \qquad (1)$$

Where M_{it} is the investment on municipality i at a given year t; m_i is a municipal-specific fixed-effect; γ_t is a time fixed-effect; D_{it} denotes the presence of an illegal armed group in a municipality i in a year t; X_{it} is a set of control variables including general characteristics to

account for potential changes in gross domestic product and population. In all the regressions, the standard errors are clustered by municipality to correct for serial correlation.

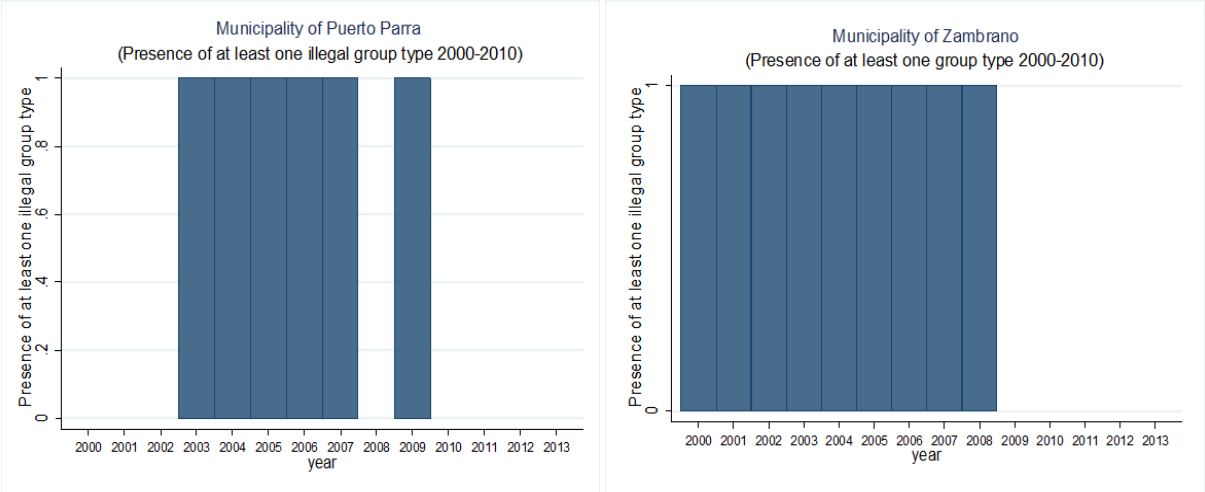


Figure 14. Treatment for at least one illegal group type. Two municipalities

The effect of the presence of illegal armed groups (leftist or rightist) on municipal investments can be estimated using the proposed model, which defines the presence of guerrillas or paramilitaries as the treatment under study and municipalities as the treated units. The model includes a binary treatment (presence or no presence), where the indicator D_{it} , is equal to one if the municipality *i* is treated at year *t* and zero otherwise (Figure 14). The municipal investments used as dependent variables – total investments (log), environmental, infrastructure, education, health, and general purpose – are discussed above in the data section. Using these different types of investments allows us to check whether the presence of illegal armed groups (leftist or rightist) affects investments in different ways.

4.1.Presence of leftist guerrillas

Table 19 presents the results of the fixed-effects regressions for the different types of investments using as a treatment the presence of leftist guerrilla groups in the municipality *i*, at a given year *t*. The results on the first column suggest that environmental investments as a proportion of the total investments was 1% less in a municipality with presence of guerrilla at year *t* than municipalities without presence of guerrilla in the same year. This effect seems to be persistent and statistically significant after two periods of the initial treatment. Column (2) shows the effect of the presence of leftist guerrillas into infrastructure; in this case, municipalities with

the presence of leftist guerrillas have 0.6% less investments into infrastructure as a proportion of total investments relative to those municipalities without presence at moment *t*; this effect takes place a year after the initial treatment. Columns (3) – (5) show the results for the proportion of investments on education, health, and General purposes respectively, for this case the presence of illegal leftist guerrillas does not seem to have an effect.

Table 19 Baseline model – Leftist guerrillas

	Dependent variables				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Environment/ tot. invests	Infrastructure/ tot. invests	Education/ tot. invests	Health/ tot. invests	Gral purposes/ tot. invests
Presence of guerrilla at t	-0.00944***	-0.00123	-0.00076	0.01038	-0.06622
	[0.00747]	[0.72145]	[0.91238]	[0.52327]	(0.49250)
Presence of guerrilla at t-1	-0.00777**	-0.00639*	0.01012	0.01712	-0.08272
	[0.03273]	[0.07491]	[0.10824]	[0.12410]	(0.56725)
Presence of guerrilla at t-2	-0.00668**	-0.00364	-0.00269	0.01732	0.06023
	[0.03381]	[0.29021]	[0.67035]	[0.13589]	(0.19052)
Presence of guerrilla at t-3	-0.00231	-0.00457	0.03905	0.02982	0.10972
	[0.47832]	[0.15799]	[0.23103]	[0.18583]	(0.30742)
General characteristics	X	X	X	X	X
Year fixed-effects	X	X	X	X	X
Observations	4,498	4,498	4,498	4,498	4,498
R-squared	0.02559	0.12422	0.04794	0.01061	0.00382
Municipalities	988	988	988	988	988

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.2.Presence of Rightist paramilitaries

Table 20 shows the effects of the rightist paramilitary presence on municipal investments using the dummy to define the treatment in the municipality *i*, at a given year *t*. Column (1), (2), and (5) suggest no impact on environmental, infrastructure, or general-purpose investments;

meanwhile Column (3) shows that municipalities with the presence of rightist paramilitaries have 2% more investments into education out of total investments than municipalities not treated at year *t*. This treatment seems to affect education investments three periods after the initial treatment. Similarly, column (4) suggests that municipalities treated with paramilitary groups' presence have 4.1% less investments on health as a proportion of total investments than untreated municipalities.

Table 20 Baseline model – Rightist paramilitaries

	Dependent variables				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Environment /tot. invests	Infrastructure/ tot. invests	Education/ tot. invests	Health/ tot. invests	Gral purposes/ tot. invests
Presence of paramilitaries at t	-0.00142	-0.00052	0.02037**	-0.01310	0.00894
	[0.68829]	[0.88544]	[0.02832]	[0.25507]	[0.88382]
Presence of paramilitaries at t-1	0.00266	0.00303	0.00539	-0.07211	-0.07826
	[0.44128]	[0.38644]	[0.33839]	[0.16369]	[0.33738]
Presence of paramilitaries at t-2	0.00249	0.00151	0.00876	-0.04090*	-0.09497
	[0.47295]	[0.65219]	[0.13437]	[0.06140]	[0.36213]
Presence of paramilitaries at t-3	-0.00033	0.00144	0.01538*	-0.02687	0.19036
	[0.91994]	[0.66616]	[0.07570]	[0.24954]	[0.11827]
General characteristics	X	X	X	X	X
Year fixed-effects	X	X	X	X	X
Observations	4,498	4,498	4,498	4,498	4,498
R-squared	0.02116	0.12329	0.04668	0.01592	0.00462
Municipalities	988	988	988	988	988

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.3. Robustness check

To check the robustness of our main estimations, we include additional controls within for each one of the treatments previously defined. Table 21 and Table 22 present the results of a set of regressions in which we account for other factors that may explain changes in the

proportion of municipal investments in the sectors already defined. In particular, we introduce variables that account for municipal revenues (total revenues, tax revenues, no tax revenues), and transfers from other levels of government (departments and central government).

In the case of the leftist guerrilla treatment, the coefficients of the contemporaneous treatment (*t*) are similar once we include these additional controls. First, for the environmental investments the coefficient at t, and its lags remain at the same statistical significance level, and the magnitude of the effect remains around the same levels. Second, for the infrastructure investments, the effect of the leftist guerrilla presence is still significant one period after the initial treatment, and the magnitude of the coefficient are somewhat similar. Finally, after adding these controls, we find a significant effect of the leftist guerrillas on health investments two periods after the initial treatment. Although this constitutes a change with respect the main specification, the coefficient changes from 1.7% to 1.8%, and the level of significance in the main specification is slightly above 10%.

These results suggest a consistent effect of the presence of leftist guerrillas on environmental, and infrastructure investments as a proportion of total investments, and a likely effect on health investments. On the other hand, these also suggest a consistent impact of the rightist paramilitaries on education investments, and health investments.

For the rightist paramilitary treatment, the results do not seem to change dramatically including these additional controls. Table 22 shows that the presence of rightist paramilitary groups does not influence investments such as environment, infrastructure, or general purpose. However, for the case of education, the inclusion of additional controls changes the effect of the rightist paramilitary presence two periods after the initial treatment, and increases the magnitude of the significant coefficients. Finally, for the case of health investments, the inclusion of these controls do not change the effect of the rightist paramilitaries two periods after the initial treatment, but instead increases the magnitude of this coefficient changing from 4% in the baseline result to 4.3% after including additional controls.

Table 21 Leftist guerrillas – additional controls

VARIABLES	Dependent variables (1) Environment/ tot. invests	(2) Infrastructure/ tot. invests	(3) Education/ tot. invests	(4) Health/ tot. invests	(5) Gral purposes/ tot. invests
Presence of guerrilla at t	-0.00999***	-0.00163	-0.00236	0.01145	-0.06479
	[0.00457]	[0.63812]	[0.72858]	[0.48601]	[0.49445]
Presence of guerrilla at t-1	-0.00799**	-0.00653*	0.00962	0.01723	-0.08168
	[0.02781]	[0.06941]	[0.12258]	[0.12409]	[0.56840]
Presence of guerrilla at t-2	-0.00723**	-0.00401	-0.00297	0.01866*	0.06075
	[0.02141]	[0.24637]	[0.63152]	[0.09876]	[0.18573]
Presence of guerrilla at t-3	-0.00293	-0.00495	0.03875	0.03149	0.10935
	[0.36731]	[0.12593]	[0.23751]	[0.16067]	[0.30560]
General characteristics	X	X	X	X	X
Year fixed-effects	X	X	X	X	X
Budget variables	X	X	X	X	X
Observations	4,498	4,498	4,498	4,498	4,498
R-squared	0.02548	0.12446	0.04739	0.01119	0.00385
Municipalities	988	988	988	988	988

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 22 Rightist paramilitaries – additional controls

	Dependent variables				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Environment/ tot. invests	Infrastructure/ tot. invests	Education/ tot. invests	Health/ tot. invests	Gral purposes/ tot. invests
Presence of paramilitaries at t	-0.00114	-0.00034	0.02131**	-0.01392	0.00979
	[0.74628]	[0.92545]	[0.01994]	[0.22676]	[0.87114]
Presence of paramilitaries at t-1	0.00308	0.00342	0.00668	-0.07383	-0.07757
	[0.37213]	[0.32898]	[0.22669]	[0.15574]	[0.33571]
Presence of paramilitaries at t-2	0.00285	0.00207	0.01022*	-0.04359*	-0.09456
	[0.41212]	[0.53753]	[0.08146]	[0.05271]	[0.36096]
Presence of paramilitaries at t-3	-0.00024	0.00187	0.01675*	-0.02912	0.19101
	[0.94348]	[0.57666]	[0.05366]	[0.22667]	[0.11825]
General characteristics	X	X	X	X	X
Year fixed-effects	X	X	X	X	X
Budget variables	X	X	X	X	X
Observations	4,498	4,498	4,498	4,498	4,498
R-squared	0.02094	0.12363	0.04623	0.01709	0.00472
Municipalities	988	988	988	988	988

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Conclusions

The results reveal that those municipalities with presence of leftist guerrilla groups had 1% less environmental investments as a proportion of total investments at the moment of treatment, and then the effect remains after two periods of the initial treatment. Similarly, these municipalities had 0.6% less investment into infrastructure as a proportion of total investments with respect to those municipalities without presence of leftist guerrillas one year after the initial presence of these groups. For the case of health, the effect takes place until two periods after the initial treatment, and shows that municipalities with presence of leftist guerrillas had 1.8% more health investments as a proportion of total investments relative to municipalities without presence at a given year.

For the case of the rightist paramilitary presence, the results suggest no impact on the environmental, infrastructure, or general-purpose investments; however, they suggest an effect a persistent effect on education showing 2% more investments relative to municipalities with no presence of paramilitary groups at a given year. Finally, municipalities with presence of rightist paramilitaries have 4.1% less health investments as a proportion of total investments relative to municipalities with no presence of paramilitaries. These results hold after including additional controls to the base line model, that account for other factors that may explain changes in the proportion of municipal investments; in particular, we include variables accounting for municipal revenues, and transfers from other levels of government toward the municipalities.

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Chapter III Transboundary Pollution and Municipal Investments into Wastewater Management

1. Introduction

This study explores the effect of transboundary pollution on municipal investment into wastewater treatment in the context of a developing country, namely Columbia. Pollution transcends both domestic and international borders separating jurisdictions. Water pollution flows downstream across borders along riverways and streambeds, while air pollution blows across borders based on wind direction. This transboundary dimension of pollution generates negative externalities. In a sub-national setting, a polluting "upstream" jurisdiction imposes some of the detrimental effects of its pollution on its neighboring "downstream" jurisdiction. For example, some of the water pollution from one U.S. state flows into another U.S. state. When authority over environmental protection is decentralized to some extent within a single country, individual regional jurisdictions hold much autonomy over their own governance of pollution control. Thus, the negative externality generally remains unresolved. As important, the presence of a transboundary externality extends to the international setting. In this setting, a polluting upstream country imposes some of the generated detrimental effects on its neighboring downstream pollution. Since no supra-national authority fully controls pollution control, the international externality remains unresolved.

Of course, multiple entities generate pollution within a given jurisdiction or country. Excepting highly centralized economies, the national government and regional governments do not directly control pollution control or environmental management decisions made by the many polluting entities. Instead, the national and regional governments merely influence the polluters' management choices using various policy tools. Our study explores environmental management effort expended by municipal governments to treat household-based wastewater. As in most countries, the national government and regional governments do not directly control even these local government management decisions, relying instead on various policy levers.

Environmental management expended by polluting entities, including local government wastewater treatment plants, helps to reduce pollution. The difference between who bears the cost of the environmental management and who enjoys the benefits in the form of reduced environmental harm leads to inefficiently low environmental management, which implies

excessive pollution. As argued, the inefficiently low level of environmental management reflects inefficiently weak use of policy tools on the part of national and regional governments.

Assessing whether the environmental management level is too low or the policy tool use is too weak is quite challenging. The more straightforward analysis is to exploit variation across space within a given jurisdiction or country. The regional government should employ its policy tools less strongly when the polluting entity lies relatively closer to the regional border and employ its tools more strongly when the polluting entity lies relatively far from the regional border because the transboundary effect grows as distance to the regional border falls. Consequently, the polluting entity expends greater management effort when located further from the regional border. Similarly, the national government should employ its policy tools less strongly when the polluting entity lies relatively closer to the international border and employ its tools more strongly when the polluting entity lies relatively far from the international border. Consequently, the polluting entity expends greater management effort when located further from the international border.

In Colombia, wastewater management decisions regarding household-based wastewater lie with municipal governments. However, the central government offers direct transfers for wastewater management and applies regulatory pressure, while regional governments offer both direct transfers and technical assistance, because concerns about water pollution are prominent in Colombia. Our study gathers data on an array of rivers, municipalities, and departments and defines their position within the country relative to rivers' directional flow. Then our study exploits these data to examine the effect of location on a city's investment into wastewater management. Specifically, it explores whether location, relative to regional and international borders, plays a role in these investment decisions.

Several studies consider the problem of pollution in transboundary settings. Some studies examine the level of emissions generated by polluting sources as the dependent variable. Of these, some studies examine location relative to intra-national borders. These studies mostly capture location by measuring the distance to an intra-national border. The remaining studies contrast pollution levels on two sides of an intra-national border, distinguishing between upstream and downstream regions. All of these studies reveal the expected effect: the closer is a polluting source to an intra-national border, the higher is the pollution level (Cai et al., 2016; Helland and Whitford, 2003). Other studies assess ambient water quality as the dependent

variable. These studies find evidence of a transboundary effect, at both intra-national and international borders, by observing lower quality on the upstream side of a border but higher quality on the downstream side of a border (Sigman, 2002; Sigman, 2005). The last set of studies examines regulatory actions as the dependent variable. These studies reveal that environmental regulation and enforcement are less stringent against facilities located at or near borders.

Our study contributes to this literature by exploring the problem of transboundary pollution in the context of a developing economy. Our study also contributes by developing a rich conceptual framework to explain governmental use of policy tools to induce better environmental management by polluters.

To generate these contributions, we first theoretically analyze the problem by developing a conceptual framework that captures the institutional setting of water quality protection in Colombia. We consider a situation of one country with three different levels of government: central, departmental, and municipal. Departments represent regional government entities. The country includes one central government, multiple departments, and multiple municipalities. Some departments lie within the interior of the country, while other departments lie on the country's border. Similarly, some municipalities lie within the interior of a given department, while other municipalities lie on a given department's border. Municipalities discharge wastewater into rivers that flow from one municipality to the next and from one department to the next until the river crosses an international border or empties into an ocean. The central government employs two policy tools: financial transfers for environmental management and regulatory pressure (e.g., fines for violating pollution limits). The departmental government employs its own policy tools: financial transfers and technical assistance. From our theoretical framework, we derive the following hypotheses: (1) the level of environmental management investment is greater for those municipalities located upstream within a department because the departmental government employs its policy tools more strongly against these interior municipalities, and (2) the level of environmental management investment is greater for those municipalities located in departments that lie upstream within a country because the central government employs its policy tools more strongly against these interior departments.

Second, we use data on municipalities in the country of Colombia between 2000 and 2013. We employ regression analysis to link a municipality's location, relative to domestic and international borders, to the level of municipal wastewater treatment investment. We measure

location in two ways: (1) two binary indicators, one contrasting interior and border municipalities within a department and a second contrasting interior and border departments within the country of Colombia; (2) two distance measures: one capturing the distance to a departmental border and a second capturing the distance to an international border. We further manipulate the distance measures to construct non-linear specifications: (1) quadratic polynomial in distance, and (2) distance splines. Our results reveal that interior municipalities invest more than border municipalities and that the distance to a department border positively affects municipal wastewater management investments, both consistent with our first hypothesis. Results from the quadratic specification demonstrate that the impact of regional border distance falls as this distance grows, consistent with a convex relationship between transboundary pollution and distance, i.e., transboundary pollution becomes disproportionately more important as distance falls.

We do not reach a similar conclusion for the international setting. The binary indicator does not prove significant. The distance measure is significant only in the parsimonious model, which includes no control factors. And the quadratic effect is insignificant.

Collectively, we conclude that intra-national transboundary pollution influences regional governments' policy efforts but international transboundary pollution does not affect the central government's policy efforts.

The rest of the study elaborates on these points. Section 2 reviews the relevant literature. Section 3 describes the context of the empirical analysis. Section 4 constructs a conceptual framework. Section 5 describes the empirical strategy. Section 6 interprets the empirical results. Section 7 concludes.

2. Literature Review

The aim of political decentralization is to give citizens or their locally elected representatives more power in public decision-making and autonomy to determine investments including those to protect the natural resources. However, situations in which different political jurisdictions share natural resources generate negative externalities, which affect the investment decision-making process. According to Olmstead (2014), these negative externalities are particularly common for shared water resources. When two or more political jurisdictions share a natural resource, location relative to jurisdictional borders affects investment into environmental management on the part of polluting entities by influencing the use of policy tools on the part of

jurisdictional governments. The same logic applies to the sharing of a natural resource by multiple countries.

Various studies consider this problem of transboundary pollution. Some studies examine pollution levels (air, water, land) from regulated sources as the dependent variable. Of these, some examine intra-national borders and most examine the internal distance to an intra-national border. All previous studies reveal the expected effect: the closer is a regulated source to an intra-national border, the higher is the pollution level (Cai et al., 2016; Gray and Shadbegian, 2004; Helland and Whitford, 2003). Other study contrasts pollution levels on two sides of the intra-national borders comparing upstream and downstream provinces in China, finding that upstream provinces generate higher levels of pollution (Cai et al., 2016). Other study examines a border effect, assessing the effect of the proximity to intra-national borders, it finds that the pollution levels are lower the closer to an intra-national border (Gray and Shadbegian, 2004).

Another set of studies examines international borders. One study examines the effect of proximity to an international border on pollution levels. This study finds different results for different pollutants when assessing proximity to the Canadian border. The results reveal more biochemical oxygen demand (BOD) pollution discharged into water but less sulfur dioxide (SO_2) pollution emitted into the air (Gray and Shadbegian, 2004).

Similarly, a set of studies examines environmental water quality. Most of these studies examine pollution levels using measurement stations as units of observation (Limpscomb and Mobarak, 2015; Kahn et al., 2015; Sigman, 2002). Some studies examine intra-national borders comparing water quality on two sides of the intra-national border. In particular, Sigman (2005) focuses in the relationship between states in the US with authorization to enforce the Clean Water Act and its neighboring states. To do so, the author tries to identify the impact of an upstream-authorized state on the water quality in a downstream state. The study reveals that being downstream of an authorized state has a negative impact on water quality, which is consistent with the hypothesis of free-riding; however, other result reveals zero effects on water quality for those authorized states (Sigman, 2005). Other studies comparing two-sides of intra-national borders describe expected results, and confirm higher levels of water pollution in upstream jurisdictions closer to an intra-national border than the water pollution in downstream jurisdictions (Limpscomb and Mobarak, 2015; Kahn et al., 2015).

Of these studies, some also examine the internal distance to an intra-national border. Sigman (2005) includes three different location variables indicating whether the measurement stations are located upstream of a state border, downstream of a state border, or located on river when it forms a border between two states. Under the assumption that far downstream of a border, the pollution endowment from upstream free riding diminishes with natural attenuation and far upstream, the polluting state experiences almost all the damage, Sigman (2005) also considers the proximity to an intra-national border to measure the effect of upstream state's authorization on downstream state's water quality. The result of this continuous measure confirms the initial findings with a discrete approach: upstream state's authorization has a negative impact on the water quality measured at downstream stations within 50 miles of the border. The remaining studies reveal similar results examining internal distance to an intra-national border (Limpscomb and Mobarak, 2015, Kahn et al., 2015). Other study examines international borders and compares environmental water quality on two sides of international borders. This study finds that the level of pollution discharged into a waterbody upstream of an international border is higher than other comparable stations (Sigman, 2002).

The last set of studies examines regulatory actions as the dependent variable (e.g. inspections, enforcement, and location permit). Of these, one study examines intra-national borders, comparing regulatory actions on two sides of the intra-national border. This study finds that regulation agencies are more lenient against regulated sources located upstream of a border (Cai et al., 2016). Some other studies examine regulatory actions using the internal distance to an intra-national border as the regressor. These studies find that, within a particular region, the regulation is less stringent at bordering counties, particularly when it comes to the enforcement of pollutant industries or the decision on the location of pollutant industries (Cai et al., 2016; Duvivier and Xiong, 2013). Other study examines the effect of proximity to an intra-national border on regulation actions. The results for plants located nearby to the border of states with a strong environmental regulation show to fewer inspections and more enforcement in the water pollution side, more inspections and enforcement in the air pollution side (Gray and Shadbegian, 2004). Similarly, this study examine the impact international borders on the regulation finding different results for different pollutants; plants located near to the Canadian border face the fewer inspections for water pollution (and more BOD pollution), but more enforcement actions for air pollution (and lower SO_2 emissions) (Gray and Shadbegian, 2004).

3. Context

3.1. Political and Administrative Division

Colombia is a unitary republic with autonomous regional entities or sub-national governments identified as departments (equivalent to U.S. states) and municipalities. Departments are defined as territorial entities with autonomy to manage, to plan and to promote socio-economic development within their own territory. Similarly, the departments are responsible for (1) coordinating and complementing municipal action and (2) intermediating between the central government and municipalities in order to provide the services determined by the constitution (DANE, 2007). A municipality is the basic territorial entity unit with political, fiscal, and administrative autonomies within its boundaries.

3.1.2. Geographical and Population Division

Colombia is a reasonably large country at 1.2 million square kilometers (Murad Rivera et al., 2003). Located in the northern extreme of South America, Colombia shares hydrological basins with five bordering countries -- Ecuador and Peru in the south and Venezuela and Brazil in the east -- and meets the Pacific Ocean in the west and the Caribbean Sea in the north (IDEAM, 2015). Colombia governs coasts along the Pacific Ocean and Caribbean Sea, which has implied a constant process of negotiation with the neighbors to protect shared water resources and marine areas.

Currently, the country has 1,120 municipalities, each embedded within one of the 32 departments (DANE, 2007). Some municipalities are located along departmental borders (hereafter "border municipalities"). Other municipalities are located within the interior of a department (hereafter "interior municipalities"). Similarly, some departments are located along an international border or coast (hereafter "border departments". Other departments are located within the Colombian interior (hereafter "interior departments").

Based on physical features, regional identity, history, and economic characteristics, the National Geographic Institute of Colombia divides the country into four main natural regions: (1) Atlantic, formed by coast plains and the Santa Marta Sierra; (2) Pacific, formed by the Pacific Ocean coast and the western cordillera; (3) Andean, formed by the central and west cordilleras and the valleys of Cauca and Magdalena; and (4) Eastern, formed by plains, the Orinoco basin, and the Amazonas basin. Most of the country's population resides in the Atlantic region. In contrast, the Eastern region houses only 2% of the population yet represents 42 % of the total

territory (Murad Rivera et al., 2003). During the second half of the 20th century, Colombia transformed into a mostly urban country as people migrated to the main four cities. More recent, violent conditions in the rural areas has prompted the migration and forced displacement toward big cities, increasing the pressure on environmental resources.

3.2. Municipal Wastewater Treatment and Water Quality in Colombia

3.2.1. Water Quality Issues

Colombia faces increasing environmental issues related to pollution of water sources. According to the Ministry of Environment, Housing, and Territorial Development (MAVDT) (2004), growing urban areas generate pressure over natural resources, housing and provision of public services due to the constant migration of population toward these areas. Therefore, there is an increased pollution discharged on water resources coming from municipal sewers, with deficient or no treatment. Although Central and local authorities have tried to adopt wastewater treatment programs and projects, following international patterns, these have difficulties.

Besides the pressure over water resources generated by the increase in urban population, Colombia faced other issues. The central Government identifies three major issues: First, there are environmental and health impacts associated with a decrease in water quality availability and restrictions in use. On one hand, ecosystems are affected by the increasing pollution discharged, specially by big urban areas (Bogota, Medellin and Cali), according to the National Inventory of Water, since 1998 around 1300 waterbodies received pollution from municipal wastewater reducing the quality of water sources. On the other hand, there are also effects on public health, the increase in the levels of pollution on water bodies, added to low economic levels, lack of education, and poor sanitation in some communities, configures a high risk setting for diseases with a high economic cost. Along with the pollution generated by domestic agricultural and industrial activities, the inexistent or inefficient wastewater treatment also contributes to generate environmental and health problems.

A second issue relates to the wastewater systems build in Colombia and the institutional capacity to generate programs toward wastewater treatment. By 2004, the MAVDT reported 237 wastewater systems build in 235 municipalities, representing only 21.7% of the municipalities in the country; including Bogotá, capital of the country; the proportion of population covered reached the 64%, and only the 44% excluding Bogotá. Regional environmental authorities - AAR and local authorities (municipalities) did not have enough instruments to develop programs

and projects for wastewater treatment (MADS 2004). By 2013, the proportion of municipalities with wastewater systems in place increased to 43.5% (SSPD 2013), but there is still a deficit in the proportion of pollution treated that follows the trends for the Latin American (SSPD, 2013; Tiempo, 2017) region where around 31% of water is treated before discharge into waterbodies.

A third problem identified is the institutional framework. The level of centralization in the country added to the different number of public institutions involved in the problem of wastewater treatment made difficult the coordination of goals and tasks. At the national level, there was not a definition of a state policy in this regard (MADS 2004). At the regional level (AAR and Departments) struggled with financial and technical restrictions to provide support to the municipalities and to implement the confusing decontamination national policies. Finally, at the local level there were not enough efforts planning toward the development of local systems for environmental recovery and wastewater treatment.

In terms of water quality, two of the major rivers in Colombia show different quality levels across the country. On one hand, the Magdalena stream shows low water quality levels in the municipality of Girardot, department of Cundinamarca, where the Magdalena receives waters coming from the Bogotá stream. In this segment, known as the "High" Magdalena, the low water quality is explained by the high levels of Total Solid Suspended coming from bordering municipalities in Cundinamarca; the "mid" Magdalena also reveals a low water quality condition due to the economic activities in neighboring departments (Santander and Boyacá) that affects multiple tributaries to the Magdalena stream. Finally, the "low" Magdalena is affected due to cattle raising, municipal discharges and gold mining activities (IDEAM**,** 2014). On the other hand, the Cauca stream shows a low water quality index due to the affectation of some of its tributaries at different station points.

3.2.2. Pollutant Discharges and Wastewater Treatment

The Colombian Hydrology and Meteorology Institute (IDEAM) estimates the pollutant net load by discharge points that are discharged into the hydrologic systems coming from industrial, domestic, and agricultural sources (IDEAM, 2014). The highest contribution of pollution discharge into the water bodies in Colombia is made by the domestic sector (80% on average), followed by the industry (19% on average). The urban areas are the major contributors to the pollutant discharge being responsible for about 70% on average for the discharges of pollutants such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD),

Total Solid Suspended (TSS), Nitrogen (N), and Phosphorus (P). Similarly, the IDEAM identifies the hydrographic sub-zones under higher pressure due to loads of BOD and COD, being the Magdalena has the highest pressure; the "high" Magdalena (interior departments) receives 180.781 ton per year from the Bogotá River, being the highest load of BOD in the country.

Table 23 summarizes the amount of pollution removed by the wastewater treatment system in placed in the municipalities. The IDEAM estimates that around a third of BOD and COD is removed, and that around half of the pollutants discharged by the industry is removed while less than 20% of the pollutants discharge by the domestic sector is removed.

Table 23 Pollution removed by the wastewater treatment system in Colombia

Parameter	Domestic and Industry load (kg)	Domestic and Industry discharges (kg)	Quantity removed (kg)	% removed
BOD	1,085,127,286	736,296,107	348,831,179	32.1%
COD	2,411,886,881	1,648,621,034	763,265,847	31.6%
TSS	1,517,405,973	1,119,062,421	398,343,552	26.3%
N	128,890,983	126,345,302	2,545,681	2.0%
P	32,465,812	31,915,345	550,467	1.7%

Source: National Water Study (IDEAM, 2014)

a. Regulatory framework

Due to this context, the country developed an institutional framework to achieve a reduction in the amount of pollution generated and discharged into water sources. First, the central government designed policies guiding the coordination of environmental management among national, regional and local entities, and defined common objectives (SSPD 2013). Second, the central government also made efforts implementing a regulatory framework related to the wastewater treatment including acts to regulate wastewater discharges, and defining instruments (economic, management and institutional) to execute the policies for this sector.

Regarding the institutional framework, the country defined a structure to design, implement and regulate the domestic wastewater treatment. At the national level, there are three entities coordinating efforts. The first institution at the central level is the Ministry of Environment and Sustainable Development – MADS (by its Spanish name), which has traditionally coordinated the environmental policy in Colombia. The MADS dictates the general framework for the preservation and restauration of natural resources through the Natural

Resources National Code (Executive order 2811, 1974)[16]. This defines wastewater treatment plants as instrumental in order to preserve the water resources in Colombia; implements a national system to deal with environmental issues, and defines its own functions, as well as other decentralized entities functions such as Environmental Regional Authorities (Act 99, 1993).

Within its functions, this ministry defined the parameters required for wastewater treatment management plans – PSVM (by its Spanish name) and included these plans as a part of the licensing process for those entities in charge of the wastewater treatment management (Res. 1433, 2004). Similarly, it delegates the approval of the PSVM, and licensing process into the Environmental Regional Authorities, and environmental units within the municipalities[17]. Moreover, the MADS established technical guidelines for wastewater treatment management in Colombia (Res. 1096, 2000), where it describes the minimum requirements that the process of design, construction, technical supervision, operation, and maintenance of wastewater treatment systems in Colombia must follow (MADS 2000).

The MADS also defines the retributive rate for direct and indirect use of water to discharge pollution. In 2011, the central government established: 1.) that retributive rates and compensations apply too for pollution levels above the limits permitted without exclusion of any other preventive or sanction measure, and that the payment of such retributive rates do not legalize the discharges object of sanction; and 2.) that the resources collected by the charge of the retributive rates and compensations will be allocated to wastewater treatment projects, decontamination projects, and water quality monitoring projects (Act 1450, 2011). In this way, the MADS defines the guidelines to establish load pollution limits, the process of control of such limits, and defines the parameters to calculate the retributive rate for discharge points (Executive order 2667, 2012).

Finally, according to the National Social and Economic Policy Council (Conpes 3177, 2002), the MADS prioritizes the municipalities to invest in a two-step process. First, the MADS prioritizes investments in wastewater treatment plants using a set of minimum conditions:

1. Municipalities where the discharges produce a substantial negative impact, considering the receptor water body assimilation capacity and its effects on public health;

[16] Part III, Title VI. Water uses, conservation, and preservation of water bodies. Chapter II Prevention of pollution and pollution control. Art. 134-148.
[17] Municipalities with population greater or equal to 1 million.

2. Municipalities with sewer coverage above 80% and that have built, or have resources guaranteed to build interceptors, collectors and final emissaries of their systems;
3. Municipalities with water supply systems that include potabilization plants;
4. Municipalities that, by Act 142, 1994, guarantee the financial, operational and institutional strength of their systems.

Second, the MADS prioritizes municipalities based on additional criteria:

1. Municipalities where the receptor water body is the water source for water supply systems downstream from the discharge point(s)
2. Municipalities, that from a basin perspective, represent major benefits on the recovery and use of the water resource;
3. Projects with a higher reduction of pollutant load by Peso ($) invested
4. Projects that formulate the re-use of wastewater

The MADS dictates technical norms and regulations in coordination with other ministries. The second entity at the central level is the Ministry of Health and Social Protection – MSPS; this ministry dictates public health and sanitary norms and regulation as well as controls water quality for different uses. The MSPS is responsible to establish what uses, that produce or could produce water pollution, will require its authorization before asking for authorization from the local environmental authority for the use of the resource. Similarly, the MSPS defines the desirable and admissible characteristics for water bodies as a measure of sanitary control (Act 9, 1979). The MSPS defines the water quality criteria, uses and destinations for water bodies, and the rules regarding pollutant discharges into water bodies, establishes minimal requirements for discharge points and gives guidelines for discharge permits, discharge plans, and the record of the discharges (Executive order 1594, 1984).

Finally, the third institution at the central level is the National Planning Department – DNP, which supports the assessment and formulation of policies, plans and projects within multiple sectors including the wastewater treatment sector. Throughout the Social and Economic Policy Council – Conpes, the DNP contributes to the design of the National Plan for Wastewater treatment management looking to make viable the policies within this sector (DNP, MADS, and MDE 2002). The DNP defines funding sources for these projects as well as addressing the financial resources from the General National Budget to investments in wastewater management according to the priorities defined by the MADS.

Similarly, at the regional level there are two entities. The Department (state) participates in the planning process, and gives technical and financial assistance to municipalities and entities in charge of the wastewater treatment (MADS 2004). The environmental regional authority executes the national decontamination policies. As we have mentioned, the MADS delegates into the environmental regional authorities the approval of PVMS, and the designation of licenses for wastewater treatment plants, define regional discharge limits, in its region (Act 99, 1993). At the local level, the municipality must assure provision of efficient sewer systems (directly or through private agent), and invest own resources in water related including wastewater treatment projects.

These entities coordinate actions to achieve the objective of reducing pollution levels on water bodies. The central government, throughout the three entities described above, has designed and enforced regulations related to environmental protection, national sanitary code, and water quality and dumping. The central government has also provided technical norms for the wastewater management sector, has implemented retributive rates for direct and indirect use of water to discharge pollution, and has delegated into the environmental regional authorities and municipalities functions, including the approval of PSMV plans and licensing for wastewater management, while still keeping some controls.

4. Conceptual Framework

This section constructs a conceptual framework assessing the effects of transboundary spillovers on environmental abatement effort. We consider the situation of one country with three different levels of government: central, departmental, and municipal. Departments represent regional government entities. The country includes one central government, multiple departments, and multiple municipalities. Some departments lie within the interior of the country, while other departments lie on the country's border. Similarly, some municipalities lie within the interior of a given department, while other municipalities lie on a given department's border.

Municipalities discharge wastewater into rivers that flow from one municipality to the next and from one department to the next until the river crosses an international border or empties into an ocean (or sea). Given this directional flow, we label certain municipalities as upstream or downstream from others and certain departments as upstream or downstream from others. For simplicity, we consider a single river that flows across the entire country. Moreover,

we consider two categories of departments: (1) upstream, interior department and (2) downstream, border department. Similarly, within each department, we consider two categories of municipalities: (1) upstream, interior municipality, and (2) downstream, border municipality. Combining these two sets of categories, we consider four types of municipalities:

(1) upstream, interior municipality within an upstream, interior department;

(2) downstream, border municipality within an upstream, interior department;

(3) upstream, interior municipality within an upstream, border department; and

(4) downstream, border municipality within an upstream, border department.

Our conclusions generalize to consideration of an array of rivers and arrays of municipalities and departments as defined by their position within the country relative to the rivers' directional flows.

Municipalities are able to engage in abatement to lower their discharges, denoted as a. Each government entity plays its role in promoting these efforts. The municipal government invests its own resources into abatement, denoted as a_m. The central government transfers resources to municipal governments, denoted as a_g. The central government also expends regulatory efforts, denoted as q, to induce greater abatement from municipalities. These regulatory efforts include the provision of permits, imposition of discharge limits, conducting of inspections, and application of fines. Departmental governments also transfer resources to municipalities for wastewater abatement, denoted as a_d. Departmental governments also offer technical assistance to municipalities, denoted as η.

The amount of resources allocated to abatement comes from three sources: municipal government's own investment (a_m), departmental transfers (a_d), and central government transfers (a_g). Total abatement effort is as follows: $a = a_m + a_d + a_g$.

This conceptual framework explores how the central government and departmental governments decide how many resources to transfer, how much regulatory effort to expend, and how much technical assistance to offer.

4.1. Central Government and Municipal Government

For expositional purposes, we first consider the case of two government levels: central government and municipal. Thus, we remove the departmental level. The central government objective is to maximize central net benefits of abatement, denoted Π_c. The benefits of abatement divide into three categories: internal to both the municipality and the central government,

denoted $v(a)$ ("internal-internal"), external to the municipality but internal to the central government in certain cases, denoted $w(a)$ ("external-internal"), and external to both the municipality and the central government, denoted $z(a)$ ("external-external"). The internal-internal benefits differ between the interior municipalities *i* and the border municipality *b*, as described below. The cost of abatement is denoted $k(a)$. We assume that the internal-internal benefits and the abatement costs do not differ between the interior and border municipalities: $v_i(a) = v_b(a)$ and $k_i(a) = k_b(a)$. Based on these definitions, social net benefits are shown in equation (1):

$$\Pi = v(a) + w(a) + z(a) - k(a) \quad (1)$$

Municipalities seek to maximize municipal net benefits, denoted Π_m, which exclude external benefits. Consider interior municipality *i*. The municipality enjoys only one internal benefit, $v(a)$; the other benefits, $w(a)$ and $z(a)$, are external to the municipality. In this case, independent of transfers, the interior municipality identifies its optimal level of abatement effort denoted a_{mi}*, where municipal net benefits are maximized:

$$\frac{d\Pi m}{da} = 0 \Longrightarrow \quad \frac{dv}{da} = \frac{dk}{da} \quad (2)$$

However, the central government's net benefits, Π_c, are broader for the interior municipality because the central government cares about the benefits enjoyed by the downstream border municipality. Thus, central net benefits for the interior municipality are shown as follows:

$$\Pi ci = v(a) + w(a) - k(a) \quad (3)$$

Given this broader set of net benefits, the centrally optimal level of abatement for the interior municipality, denoted a_{ci}*, is based on this condition:

$$\frac{dv}{da} + \frac{dw}{da} = \frac{dk}{da} \quad (4)$$

Now consider border municipality b. Again the municipality enjoys only internal benefits, *v(a).* The municipality identifies the municipally optimal abatement level, denoted a_{mb}*, based on this condition:

$$\frac{d\Pi m}{da} = 0 \Longrightarrow \quad \frac{dv}{da} = \frac{dk}{da} \quad (5)$$

The central government enjoys the same benefits because the other benefits are external to the central government. The central government sets the centrally optimal level of abatement for the border municipality, a_{cb}*, as follows:

$$\frac{dv}{da} + 0 = \frac{dk}{da} \quad (6)$$

As a reference, the social planner seeks to maximize social net benefits. For the interior municipality, the social planner sets the marginal net benefits of abatement to zero. For an interior municipality, this condition identifies the socially optimal abatement, denoted a_i*: $\frac{dv}{da} + \frac{dw}{da} + \frac{dz}{da} - \frac{dk}{da} = 0$. For a border municipality, this condition identifies the socially optimal abatement, denoted a_b*: $\frac{dv}{da} + 0 + \frac{dz}{da} - \frac{dk}{da} = 0$.

In conclusion, for an interior municipality, the municipally optimal abatement level is lower than the centrally optimal abatement level, which is lower than the socially optimal abatement level:

$$a_{mi}^* < a_{ci}^* < a_i^* . \quad (7)$$

For a border municipality, the municipally optimal abatement level equals the centrally optimal abatement level, which is lower than the socially optimal abatement level:

$$a_{mb}^* = a_{cb}^* < a_b^* . \quad (8)$$

Comparing equations (4) and (6) reveals that the central government values differently abatement for the interior municipality and the border municipality. The centrally optimal abatement level for the interior municipality exceeds the centrally optimal abatement level for the border municipality:

$$a_{ci}^* > a_{cb}^* . \quad (9)$$

As important, equation (7) reveals a decision-making conflict for the interior municipality. Left to its own devices, the interior municipality expends less abatement effort than the amount desired by the central government.

Given this decision-making conflict, the central government transfers resources to the interior municipality, denoted a_{gi}, so that abatement effort rises directly, and/or apply regulatory pressure on the interior municipality, denoted, q_i, so that the interior municipality is induced to increase its own abatement effort. We first assume that the central government is only able to transfer funds. Under this assumption, the central government transfers a_{gi}* so that the sum of abatement equals the centrally optimal level, a_{ci}^*:

$$a_{ci}^* = a_{mi}^* + a_{gi}^* . \quad (10)$$

This transfer resolves the discrepancy between a_{ci}* and a_{mi}*.

Now assume some institutional matter constrains direct investments so that the following condition holds:

$$a_g \leq \bar{a}_g \, . \tag{11}$$

This constraint does not bind the central government's transfer unless the following condition holds:

$$a_{gi}^* > \bar{a}_g \, . \tag{12}$$

Given this binding constraint, the central government chooses to expand regulatory efforts q_{ci}* in order to reach a_{ci}^* conditional upon the transfer of a_{gi}*. As long as transfers involve only minimal transactions costs, while regulatory pressure clearly involves real costs, e.g., the central government must hire inspectors. If regulatory pressure were costless, the central government still seeks to obtain the centrally optimal abatement level of a_{ci}^*. Of course, as the costs of regulatory pressure, the centrally optimal abatement level falls below a_{ci}^*. For simplicity, we assume that regulatory pressure is nearly costless.

We next focus on the interior municipality's decision in light of regulatory pressure. Regulatory pressure imposes costs on municipality, denoted *x*. This regulatory cost rises as the central government applies more pressure so *x* is a rising function of *q*. Moreover, the central government applies more pressure when the municipality expends less effort, a_m. Given these connection, we define regulatory costs as this function: $x[q(a_m)]$. Thus, the municipality's net benefits equal the following:

$$\pi_m = v(a) - k(a) - x\big(q(a_m)\big) \tag{13}$$

Knowing that the central government applies more regulatory pressure, which increases the municipality's regulatory costs, when the municipality's abatement investment is lower, the municipality chooses to expend greater abatement effort in order to avoid these regulatory costs. Thus, the chosen extent of abatement is rising in regulatory pressure:

$$\frac{da_{mi}^*}{dq} > 0 \tag{14}$$

The appendix describes the situation where the central government cares about the discharges generated by the municipalities, imposes limits on these discharges, and applies fines for discharges that lie above these limits.

We utilize equation (13) to derive the municipality's privately optimal choice of abatement, a_{mi}*, when facing regulatory costs:

$$\frac{dv}{da} - \frac{dx}{da} = \frac{dk}{da} \tag{15}$$

If $q_i = q_i^*$ then the central government is able to induce the centrally optimal abatement level:

$$a_{mi}^* + \bar{a}_g = a_{ci}^* \quad (16)$$

where a_{mi}^* is a function of regulatory pressure and the constraint on central transfers is binding.

In this case, the central government influences abatement in two ways: transfers resources for abatement equal to the constraint, $a_{gi}^* = \bar{a}_g$ and applies the amount of regulatory effort needed to induce the centrally optimal abatement level, $q_i^* > 0$.

In contrast, for the border municipality, the central government transfers no resources for abatement, $a*_{gb} = 0$ and applies no regulatory pressure, $q_b^* = 0$, because the level of abatement chosen by the border municipality equals the centrally optimal abatement level, $a_{mb}* = a_{cb}*$. Thus, abatement by the interior municipality exceeds abatement by the border municipality:

$$a_i = a_{mi}^* + \bar{a}_g > a_{mb}^* = a_b \quad (17)$$

Moreover, central transfers to the interior municipality exceed central transfers to the border municipality:

$$a_{mi}^* > a_{mb}^* \quad (18)$$

And regulatory pressure against the interior municipality exceeds regulatory pressure against the border municipality: $q_i* > q_b* = 0$.

4.2. Department Government and Municipal Government

For this sub-section, we assume that the central government plays no role. This new situation only involves the department government and two municipalities: one municipality interior to the department (interior municipality *i*) and one municipality on the border of the department (border municipality *b*). We construct a setting in which the departmental government plays a role nearly identical to the central government. The only difference involves the tools available to the departmental government. Bothe the central government and departmental government are able to transfer resources for abatement by the municipality. However, unlike the central government, the departmental government is not able to apply regulatory pressure; instead, the departmental government can only provide technical assistance.

The departmental government maximizes its departmental net benefits, denoted Π_d. this maximization identifies the departmental government's optimal abatement level, denoted $a_{di}*$. In the absence of technical assistance, the department optimally transfers to the interior

municipality resources, denoted a_{ri}*, so that the total amount of abatement equals the departmentally optimal amount:

$$a^*_{mi} + a_{ri} * = a^*_{di} \quad (19)$$

In contrast, the department government transfers no resources to the border municipality, a_{rb}*, since the chosen level abatement equals the departmentally optimal level: a_{mb}* = a_{db}*.

Thus, within a department, the interior municipality's chosen abatement level lies below the departmentally optimal abatement level, which lies below the socially optimal abatement level:

$$a^*_{mi} < a^*_{di} < a^*_i \quad (20)$$

More important, the interior municipality's departmentally optimal abatement level lies below the border municipality's departmentally optimal abatement level:

$$a^*_{db} < a^*_{di} \quad (21)$$

However, institutional arrangements may constraint the amount of transfers from the departmental government to the two municipalities: $ar =< ar\sim$. This constraint binds for the interior municipality if this condition holds:

$$a^*_{di} > \overline{a}_r \quad (22)$$

Obviously, this constraint cannot bind the transfer to the border municipality.

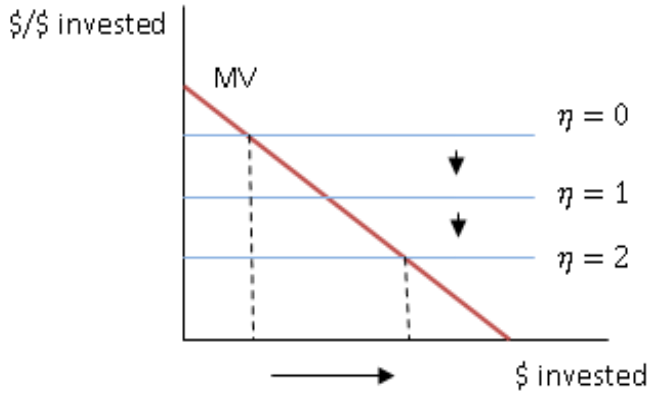
Given this constraint, the department chooses also to offer technical assistance, denoted η. This technical assistance facilitates the municipalities' abatement efforts. To demonstrate this point, we modify the abatement cost function so that it depends on technical assistance: *k(a,η)*. Abatement costs are still increasing in a but now decreasing in η. More important, *marginal* abatement costs, denoted as *MAC* and captured by *∂k/∂a*, are decreasing in technical assistance, i.e., $\frac{\frac{\partial k}{\partial a}}{\partial \eta} < 0$.

We modify the municipality's objective function to reflect the modified abatement cost function:

$$\pi_m = v(a) - k(a, \eta) \quad (23)$$

In order to demonstrate the role of technical assistance, we capture the marginal value of abatement to the municipality as MV = dv/da. The municipality identifies its privately optimal choice of abatement, a_m*, by setting MV = MAC. As technical assistance increases, MAC falls; consequently, the privately optimal amount of abatement rises, i.e., as η rises, a_m* increases. Figure 15 captures this relationship between technical assistance and the municipality's chosen abatement level.

Figure 15. Investment and Technical Assistance



To accommodate the department's use of technical assistance, we modify the department's net benefits of abatement:

$$\pi d = v(a) + w(a) + z(a) - k(a,\eta) \qquad (24)$$

If η is nearly costless, the department government still wishes to reach the previously identified optimal abatement level, a_{di}*, by offering the necessary technical assistance, denoted η_i*. If technical assistance is costly, then the departmentally optimal abatement level when technical assistance is costly, denoted $a_{di}^{*\prime}$, exceeds the departmentally optimal abatement level when technical assistance is costless, a_{di}^{*}. Consequently, the departmental government offers less technical assistance than η_i*, which implies the interior municipality chooses to employ less abatement, denoted $a_{mi}^{*\prime}$, so that $a_{mi}^{*\prime} + \bar{a}_r = a_{di}^{*\prime} < a_{di}^{*}$. Regardless of the costs of technical assistance, we can safely conclude that the departmental government offers some positive amount of technical assistance to the interior municipality, which clearly exceeds the amount of technical assistance offered to the border municipality, which equals zero.

4.3. Interaction between Central Government and Departmental Government

For this sub-section the three level of government interact. First, the municipality chooses $a_{m;}$ second, the department chooses a_d, and the level of technical assistant to municipalities (η); and third, the central government chooses a_g and the level of regulatory efforts (q).

As mentioned above, within a department the interior municipality's chosen abatement level lies below the departmentally optimal abatement level ($a_{mi}^* < a_{di}^* < a_i^*$). This regardless its location relative to the international border. Therefore, for any department $a_{db}^* < a_{di}^*$ holds. Moreover, considering the technical assistance choice by the department we concluded that the departmental government offers some positive amount of technical assistance to the interior municipality, exceeding the amount of technical assistance offered to the border municipality.

Meanwhile, the central government optimal abatement level is greater than the optimal abatement level of an interior municipality, regardless its department location relative to an international border ($a_{mi}^* < a_{ci}^* < a_i^*$), even when it comes to regulatory pressure the central government decision favors the abatement levels of interior municipalities relative to border municipalities ($q_i^* > q_b^*$ and $a_{mi}^* > a_{mb}^*$).

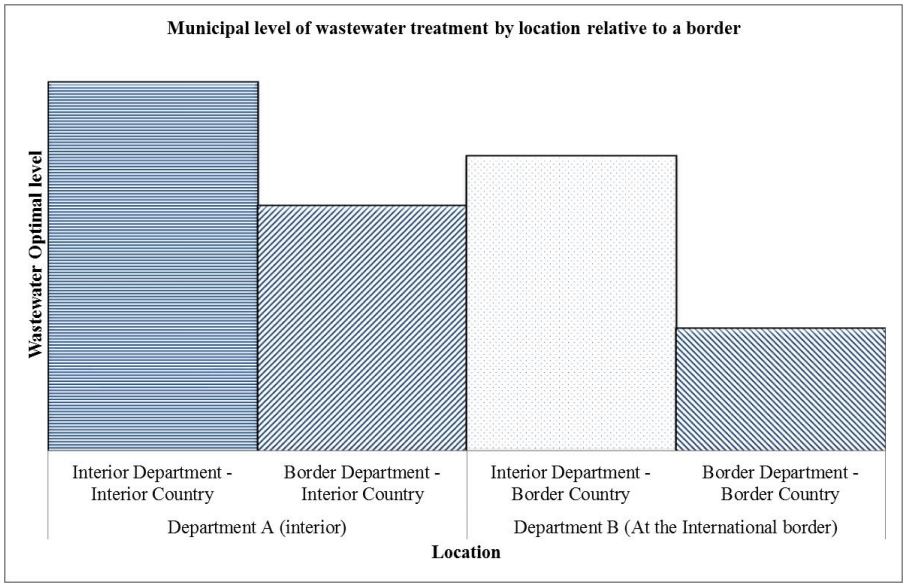
Focus on a particular interior department. We have that $a_{db}^* < a_{di}^*$. In this case, the central government optimal abatement level for the border municipalities equals the department optimal abatement level ($a_{db}^* = a_{cb}^* = a_{mb}^*$). A similar situation occurs with the optimal abatement level in interior municipalities within this interior department. Then, ($a_{ci}^* > a_{mi}^* > a_{mb}^* = a_{cb}^*$).

Focus next on a particular border department. We know that $a_{db}^* < a_{di}^*$. The central government optimal abatement level for the border municipalities equals the optimal abatement level ($a_{db}^* = a_{cb}^*$). Now, for the case of the interior municipalities the central government optimal abatement level may not follow the same pattern, considering that these interior municipalities are located at a border department. Assuming the central government favors interior locations more than border locations, in terms of abatement levels and regulatory efforts; then for a border department we have $a_{mi}^* < a_{ci}^* < a_{di}^*$. In other words, optimal abatement levels and optimal regulatory effort levels are greater for interior departments than the optimal abatement, and optimal regulatory efforts in at a border department.

Hence, given that the central government prioritizes interior location over closeness to an international border and considering that departments optimize both the abatement level

(a_{di}^{*}, a_{db}^{*}), and the technical assistance provided to the municipalities, regardless of their location relative to international borders, we have a relationship summarized in Figure 16 .

Figure 16. Hypotheses on Wastewater Treatment level



5. Empirical Strategy

This study analyzes the effect of location relative to borders on municipal investments into wastewater treatment management. To do so, we assess the water related investments at the municipal level in 1,120 municipalities in Colombia from 2000 to 2013. First, we identify municipalities located at the border or at the interior of a department (state), as a discrete explanatory variable to identify differences in the amount of water related investments. Second, we use a continuous measure of distance to explain differences on investment levels. For both cases, we expect that the location of the municipality relative to a border have an impact on the amount of investments on wastewater treatment management.

5.1. Sample Selection and Data

Using different data sources, we assemble a panel data including information for municipalities 1120 in Colombia for the period 2000–2013. We are interested in the investments allocated to water related issues by municipality. The Colombian Ministry of Finances and the National Department – DNP, annually collect this data, along with data on municipal revenues. The Center for Development Studies – CEDE affiliated to the Universidad de los Andes built a panel for municipal budgetary information using these inputs. Similarly, CEDE assembles a panel with demographic variables for municipalities using Census data from the National Statistics Department from Colombia – DANE. Finally, we consult conflict and violence data

assembled by CEDE and the Conflict Analysis Resource Center – CERAC, based on official sources (National Police, National Army, and Ministry of Defense), and primary information respectively.

We also use data from the Hydrology and Meteorology Institute (IDEAM) and the Geographic Institute (IGAC), to gather geographic information on Water bodies (water streams, rivers, basins), and municipal and departmental boundaries. These are the inputs to define the location of each municipality with respect to a department border or an international border.

First, we define the set of main rivers that we include within our sample. Based on the criteria, and information publicly provided by IGAC, we use a set of 124 rivers, joining two sets of water streams information: double drainage and simple drainage.[18] Second, using IGAC and IDEAM definitions on the main hydrological regions and minor basins in Colombia, we identify flow direction. Third, using the water flow direction we identify a border for each department as a reference point to measure a distance from the municipality until the point where the main river abandons the department toward the next. Similarly, we identify an international border for each hydrological region where the river abandons the country toward other country or the oceans.

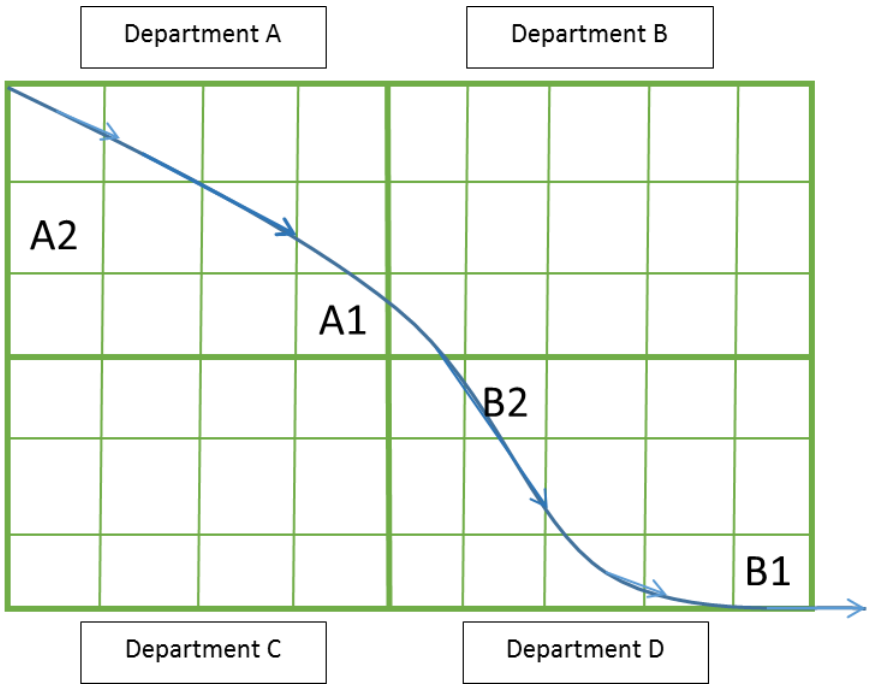
After defining the set of rivers and joining this information with the municipal and department boundaries, we propose to use a concept of distance that relates the municipal border to the departmental border, as well as an international border. At this step, we seek to answer these three questions: (1) does the municipality lies along a departmental border?, (2) is the municipality located upstream or downstream of a waterway? and (3) does this municipality lie along an international border?

Figure 17 shows our categorization of each municipality within these definitions. We consider not only their location relative to the department border, but also the river flow direction. Consider a country formed by four departments, and several municipalities within each of these, and consider a river flowing left to right crossing the country from northwest to southeast. Under these conditions, a municipality located in the Department A is upstream of any municipality located at Department B and Department D. Within a Department A, municipality A2 is upstream and interior, meanwhile municipality A1 is downstream A2, and at the border of Department A. In this case, the benefit of allocating wastewater treatment resources within department A is higher at the interior of the department, in other words in municipalities like A2,

[18] See Table 31 in the Appendix.

than at the border in A1 and similar municipalities. Department B faces a similar situation regarding their own municipalities. In this case, B2 is likely to receive more support from the Department government than B1.

Figure 17. Categorization of Municipalities regarding Location



These definitions are helpful to understand the hypotheses previously stated in the conceptual framework. First, from the department A and B examples, we see that departmental governments send greater amount of resources when the municipality is located upstream (in-department) relative to municipalities downstream (on-border); Second, the central government earmarks for investments in wastewater treatment increases when the municipality is located upstream (in-country). In general, we argue that the amount of environmental investments, in other words wastewater treatment, is greater as the distance from the municipality to the department border or to the international border increases.

5.2. Empirical Specification

This study examines the effect of location, relative to a border, on the municipal wastewater management investments in Colombia. Let y_{it} denote the environmental investment made by a municipality i at time t. Let Di and I_i represents distance measurements relative to a department border and an international border respectively. First, we estimate the effect of distance on municipal investments, but then, there are additional covariates that we assume can

affect municipal environmental investments X_{it}, as well as regional characteristics (r_i), municipal categories (c_i) and time specific characteristics (t_t). Therefore, the more general specification for our model is given by the following equation:

$$y_{it} = \alpha + \beta_1 D_i + \beta_c I_i + \gamma X_{it} + \sigma r_i + \delta t_t + c_{it} + \varepsilon_{it} \,. \quad (25)$$

Our set of estimations include all wastewater related municipal investments, and include as controls general municipal characteristics (Gross Domestic Product, Population, Land area and altitude), budget variables (tax revenues, transfer revenues and capital revenues), and includes dummies for presence of minorities within the municipality, and presence of conflict in the municipality.

As alternative specifications, we assess a non-linear effect of the distance on the wastewater management investments. First, we include a quadratic term for both the department and the international distance.

$$y_{it} = \alpha + \beta_1 D_i + \beta_2 D_i^2 + \beta_3 I_i + \beta_4 I_i^2 + \gamma X_{it} + \sigma r_i + \delta t_t + c_{it} + \varepsilon_{it} \quad (26)$$

Likewise, we create splines for the distance measures to check whether the effect of distance differs across splines. Therefore, the effect of distance for those municipalities located at a distance in the first spline (D^*_i) is given by β_1, the effect for those municipalities located within the second spline (D^{**}_i) is given by $\beta_1+\beta_2$, and the effect for those municipalities located in the third spline (D^{***}_i) is given by $\beta_1+\beta_2+\beta_3$. A similar logic follows for the international distance splines:

$$y_{it} = \alpha + \beta_1 D_i^* + \beta_2 D_i^{**} + \beta_3 D_i^{***} + \beta_4 I_i^* + \beta_5 I_i^{**} + \beta_6 I_i^{***} + \gamma X_{it} + \sigma r_i + \delta t_t + c_{it} + \varepsilon_{it} \,. \quad (27)$$

6. Empirical Results

To understand how the relative location of a municipality can affect the amount of investments on wastewater management, we estimate a set of models assessing the effect of distance relative to a domestic or to an international border. We present first different estimations including as explanatory variable the distance to a department border. Second, we estimate adding a distance to an international border within these estimations; and finally, we create splines to check for non-linear effects of the distance on municipal investments.

a) Location relative to a Department border (domestic border)

Table 24 show that the distance with respect to a Department border has an effect on the investments in wastewater treatment on the municipalities. Column 1 does not include controls

for general characteristics, budget variables or any dummy for region or time effects, and indicates that an increase in 1 km in the distance relative to the border reduces the investments by 9.6%. Column 2 adds measure for general characteristics such as Gross Domestic Product, population, land area and altitude, as well as fixed effects for region and time, and the effect of distance changes to an increase in 4.1% the investments on wastewater treatment management. Column 3 includes budget variables (tax revenues, transfer revenues, and capital revenues) and drops to 3.0%. Columns 4 and 5 include a variable for municipal category, which is an indicator summarizing population and total revenue, and shows on average an effect of 2.2% increase in the municipal investments as the distance increases. The OLS estimates in Table 24 are therefore consistent with the hypothesis that the wastewater management investments in a municipality are positively affected by the location (distance) relative to a department (domestic) border.

Table 24. Log-Log Distance to Department border

OLS Estimates of the Effect of Location on Wastewater related municipal investments Dependent variable: Log of Municipal water related investments					
	(1)	(2)	(3)	(4)	(5)
Distance to Dept. Border (log)	-0.09647***	0.04174***	0.03033***	0.02254***	0.02221**
	[0.00000]	[0.00011]	[0.00048]	[0.00937]	[0.01425]
General characteristics		X	X	X	X
Budget variables			X	X	X
Other variables					X
Region Dummies		X	X	X	X
Year Dummies		X	X	X	X
Municipal Category Dummy				X	X
Observations	14,622	10,333	9,940	9,940	9,940
R-squared	0.00491	0.51850	0.67481	0.65278	0.65341

Robust pval in brackets
*** p<0.01, ** p<0.05, *p<0.1

Table 25**Error! Not a valid bookmark self-reference.** shows that the location at a department border has an effect on the investments in wastewater treatment on the municipalities. Similar to the continuous case, column 1 indicates that a municipality located at

the border of a department has a positive and significant effect on the municipal investments on wastewater treatment management. However, Columns 3, 4, and 5 reveal a negative effect for those municipalities located at the department border on the wastewater investment.

Table 25. Log-Log Dept. Border Indicator

OLS Estimates of the Effect of Location on Wastewater related municipal investments Dependent variable: Log of Municipal wastewater related investments					
	(1)	(2)	(3)	(4)	(5)
Dept. Border indicator	0.18967***	-0.00791	-0.03544***	-0.03052**	-0.03279***
	[0.00000]	[0.59026]	[0.00320]	[0.01118]	[0.00746]
General characteristics		X	X	X	X
Budget variables			X	X	X
Other variables					X
Region Dummies		X	X	X	X
Year Dummies		X	X	X	X
Municipal Category Dummies				X	X
Observations	15,014	10,605	10,195	10,195	10,195
R-squared	0.00838	0.51271	0.64486	0.64613	0.64680

Robust pval in brackets
*** p<0.01, ** p<0.05, *p<0.1

b) Location relative to a Domestic and an international border

Table 26 shows that when including the distance to the department border (domestic) and the distance to the international border (international), the distance to the department border influences the investments in wastewater treatment on the municipalities, but the effect of the international border vanishes. Column 1 shows a first estimation that does not include any control, and indicates that the effects of both distances are negative on the municipal investments on wastewater treatment. Column 2 includes general characteristics, regional dummies, and year dummies as controls, and shows that both distances have a statistically significant effect, however, when including additional controls the effect of the international distance vanishes, and the effect of the domestic distance remains positive meaning greater investments on wastewater treatment as the distance relative to the international border increases (columns 3-5). This OLS estimates in Table 26 test the hypothesis that distance with respect to a department border (domestic) affects positively the wastewater management investments in a municipality.

Table 26. Log-Log Department and International Distances

OLS Estimates of the Effect of Location on Wastewater related municipal investments Dependent variable: Log of Municipal wastewater investments					
	(1)	(2)	(3)	(4)	(5)
Distance to Intl. Border (log)	-0.17672***	0.10859***	0.02311	0.02310	0.01481
	[0.00000]	[0.00001]	[0.24592]	[0.25295]	[0.54970]
Distance to Dept. Border (log)	-0.08116***	0.05574***	0.04686***	0.03724***	0.03624***
	[0.00000]	[0.00000]	[0.00000]	[0.00019]	[0.00025]
General characteristics		X	X	X	X
Budget variables			X	X	X
Other variables					X
Region dummies		X	X	X	X
Year dummies		X	X	X	X
Municipal category dummies				X	X
Observations	12,330	8,722	8,404	8,404	8,404
R-squared	0.01685	0.52278	0.66927	0.66911	0.66983

Robust pval in brackets

*** p<0.01, ** p<0.05, * p<0.1

c) Department and international border: quadratic form

As a robustness check, we estimate the effect of domestic and international distance on the investments in wastewater treatment on municipalities including a quadratic form. Table 27 Column 1 does not include any control, and indicates that both distances, domestic and international, have a positive effect on the municipal investments on wastewater treatment management until a turning point where the effect becomes negative, supporting the hypothesis of decreasing investments at the margin. Column 2 includes general characteristics for the municipalities, as well as region and year dummies, and indicates that the effect of the international distance on the wastewater treatment management investments is positive and decreasing, similarly for the domestic distance. Columns 3-5 includes controls related to budget variables, and shows that domestic distances have a positive and decreasing effect on the municipal investments on wastewater treatment, meanwhile the international distance have a negative effect and increasing.

Table 27. Log-Log Department and International Distances (including quadratic term)

OLS Estimates of the Effect of Location on Wastewater related municipal investments Dependent variable: Log of Municipal water related investments					
	(1)	(2)	(3)	(4)	(5)
Distance to Intl. Border	0.30919*	0.58412***	-0.75004***	-0.59207***	-0.78039***
	[0.06718]	[0.00053]	[0.00000]	[0.00002]	[0.00000]
Distance to Intl. Border Sqr.	-0.04463***	-0.04646***	0.06697***	0.05249***	0.07281***
	[0.00350]	[0.00157]	[0.00000]	[0.00001]	[0.00000]
Distance to Dept. Border	0.46307***	0.59476***	0.48125***	0.49871***	0.50731***
	[0.00001]	[0.00000]	[0.00000]	[0.00000]	[0.00000]
Distance to Dept. Border Sqr	-0.06433***	-0.06457***	-0.05054***	-0.05391***	-0.05560***
	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]
General characteristics		X	X	X	X
Budget variables			X	X	X
Other variables					X
Region dummies		X	X	X	X
Year dummies		X	X	X	X
Municipal category dummies				X	X
Observations	12,330	8,722	8,404	8,404	8,404
R-squared	0.01956	0.52533	0.67197	0.67140	0.67238

Robust pval in brackets

*** p<0.01, ** p<0.05, * p<0.1

d) Domestic and international border: Splines

As a second robustness check, we create splines using the measures of distance to both the domestic and the international border. To verify the nonlinear effect of distance on the municipal investments, we divide the distance measures into three knots using a linear spline, so we can estimate the effect of different distances on the municipal investments on wastewater treatment.

Regarding the distance with respect to the department border, we define three knots. First, municipalities located in a distance lower than 50 kms from the department border; second municipalities located within 50-100 kms; and third, municipalities located farther than 100 kms

from the department border. Similarly, we define three knots for the international distance, starting with departments located within a distance lower than 200 kms, following departments with a distance within 200-300 kms, and finally, departments located at a distance greater than 300 kms.

Table 28 show the results for the domestic distance, column 1 indicates a negative effect for those municipalities located at less than 50 kms (0.42%), meanwhile the effect of the distance for municipalities within 50-100 km is still negative (-0.28%), and those municipalities located at a distance greater than 100 kms is positive (0.12%). Column 2 includes controls for general characteristics, and region and year dummies, and indicates no effect of the distance for the municipalities located at a distance less than 50 km of the department border, but a positive effect for the other two knots. Columns 3-5 add budgetary variables as controls, and indicate a negative effect on those municipalities located more than 100 km from the department border.

Meanwhile for the international distance (Table 28), column 1 indicates that those municipalities located less than 200 kms experiment a positive effect on municipal investments on wastewater management investments, but the sign of the effect reverses as for those located between 200 and 300 km, and those located more than 300 kms. Column 2 includes controls for general characteristics, region and year dummies, and indicates no statistically significant effect of the international distances on the municipal investments on wastewater management. Columns 3-5 add budgetary variables, other variables, and municipal categories as controls, and they indicate a negative effect on those municipalities located more than 100 km from the department border; however, for the international distances they indicate a negative effect for those located less than 200 km from the international border, but a positive effect for those located within 200-300 km, and those located more than 300 km from the international border.

In sum, distances have an effect on wastewater management investment at the municipal level. This impact is consistent when it comes to distance relative to the department border, using a continuous measure, as well as it confirms the expected effect a binary measure for the location (interior or border). If we include the international distance measure, the effect of the distance to a departmental border remains significantly positive. Similarly, the significantly positive effect of the distance to a departmental border remains with the inclusion of quadratic terms. These results are consistent with the notion that intra-national governments induce municipalities located at an intra-national border to invest less in environmental management (Cai et al., 2016;

Duvivier and Xiong, 2013). We do not reach the same conclusion for the measure of international distance. Although the effect proves significantly positive in the parsimonious model, significance vanishes once we include more control factors.

Table 28. Log-Log Splines

OLS Estimates of the Effect of Location on Wastewater related municipal investments Dependent variable: Log of Municipal water related investments	(1)	(2)	(3)	(4)	(5)
Dist. Dept. Border (<50)	-0.00417***	-0.00098	0.00057	0.00050	0.00052
	[0.00030]	[0.34481]	[0.52944]	[0.58436]	[0.57115]
Dist. Dept. Border (50-100)	0.00142	0.00413***	0.00164	0.00166	0.00159
	[0.37529]	[0.00364]	[0.18797]	[0.19017]	[0.21021]
Dist. Dept. Border (>100)	0.00269***	-0.00404***	-0.00278***	-0.00283***	-0.00283***
	[0.00009]	[0.00000]	[0.00000]	[0.00000]	[0.00000]
Dist. Intl. Border (<200)	0.00206***	0.00031	-0.00098***	-0.00083***	-0.00081***
	[0.00000]	[0.32516]	[0.00008]	[0.00100]	[0.00133]
Dist. Intl. Border (200-300)	-0.00658***	-0.00067	0.00244***	0.00252***	0.00187**
	[0.00000]	[0.50853]	[0.00269]	[0.00204]	[0.02461]
Dist. Intl. Border (>300)	0.00434***	0.00027	-0.00130**	-0.00158***	-0.00081
	[0.00000]	[0.71597]	[0.02949]	[0.00845]	[0.19628]
General characteristics		X	X	X	X
Budget variables			X	X	X
Other variables					X
Department dummies					
Region dummies		X	X	X	X
Year dummies		X	X	X	X
Municipal category dummies				X	X
Observations	15,014	10,605	10,195	10,195	10,195
R-squared	0.02733	0.51551	0.64752	0.64858	0.64951

Robust pval in brackets

*** p<0.01, ** p<0.05, * p<0.1

7. Conclusions

This study analyzes the effects of location relative to a border on the municipal investments on wastewater management. In particular, it examines both the effect of domestic

distances, and international distances at the municipal level in the country of Colombia. The analysis controls for municipal characteristics, such as GDP, population, land area and municipal altitude; budget variables including municipal tax revenues, transfer from other government levels, and municipal capital revenues; geographic regional effects and time effects. This empirical analysis examines municipal investments on wastewater management in the country of Colombia for the years 2000 to 2013.

Estimation of the effect of distances on municipal investments on wastewater management generates the following results. First, considering solely the measure of distance to a department border we find a positive and statistically significant effect. This means that for an increase in 1 standard deviation in the distance relative to a department border, the municipal investments increase on average 0.02 standard deviation. The positive effect of the distance to a department distance remains consistent after various specifications, and the inclusion of the international distance measure.

Second, considering the distance to an international border, the results are inconclusive. Although we expect a consistent and monotone relation between the distance to an international border and the investments on wastewater management, the significance of this measure vanishes when including additional controls such as municipal categories and budget variables.

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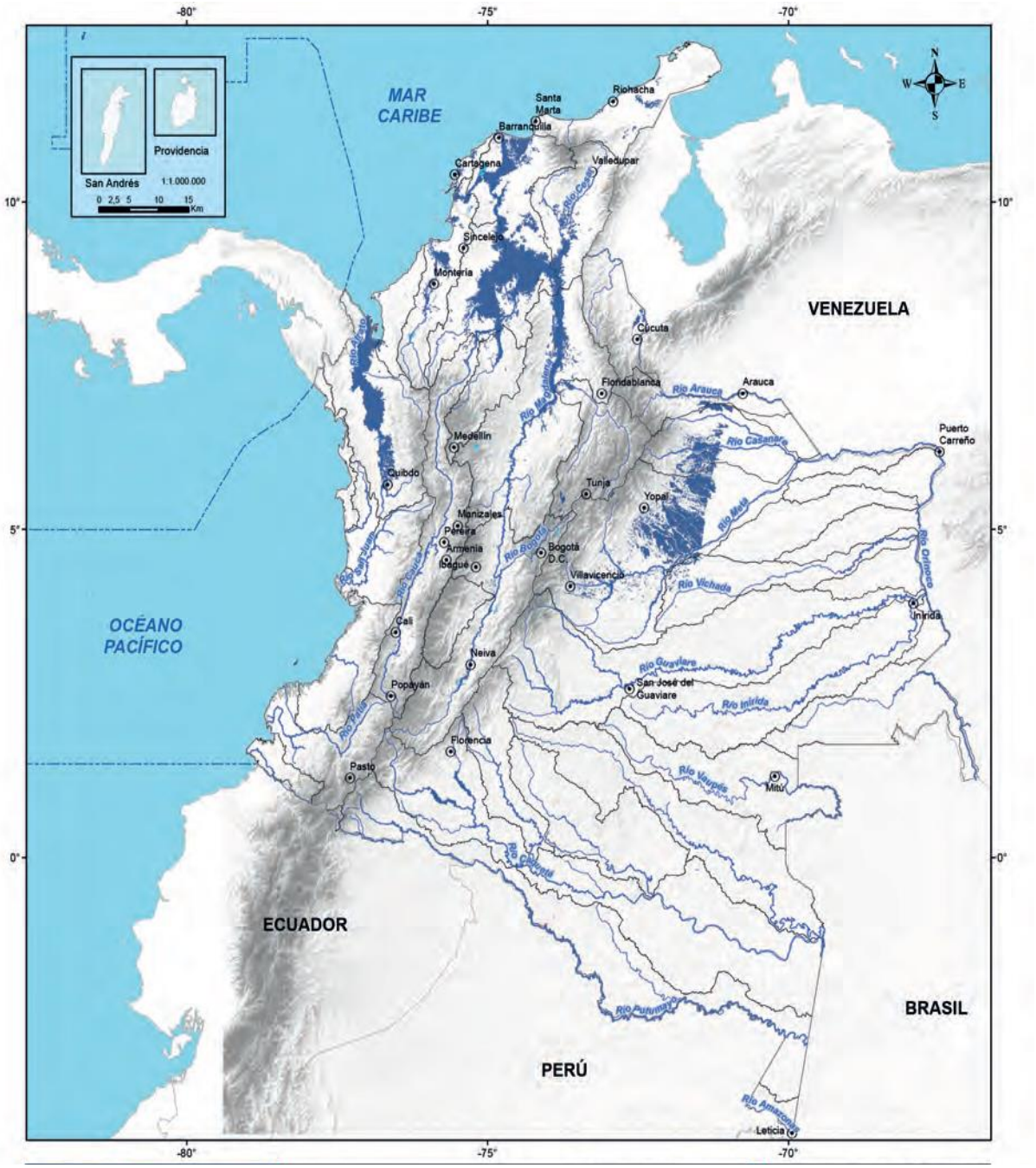
Figure 18. Mayor Rivers in Colombia

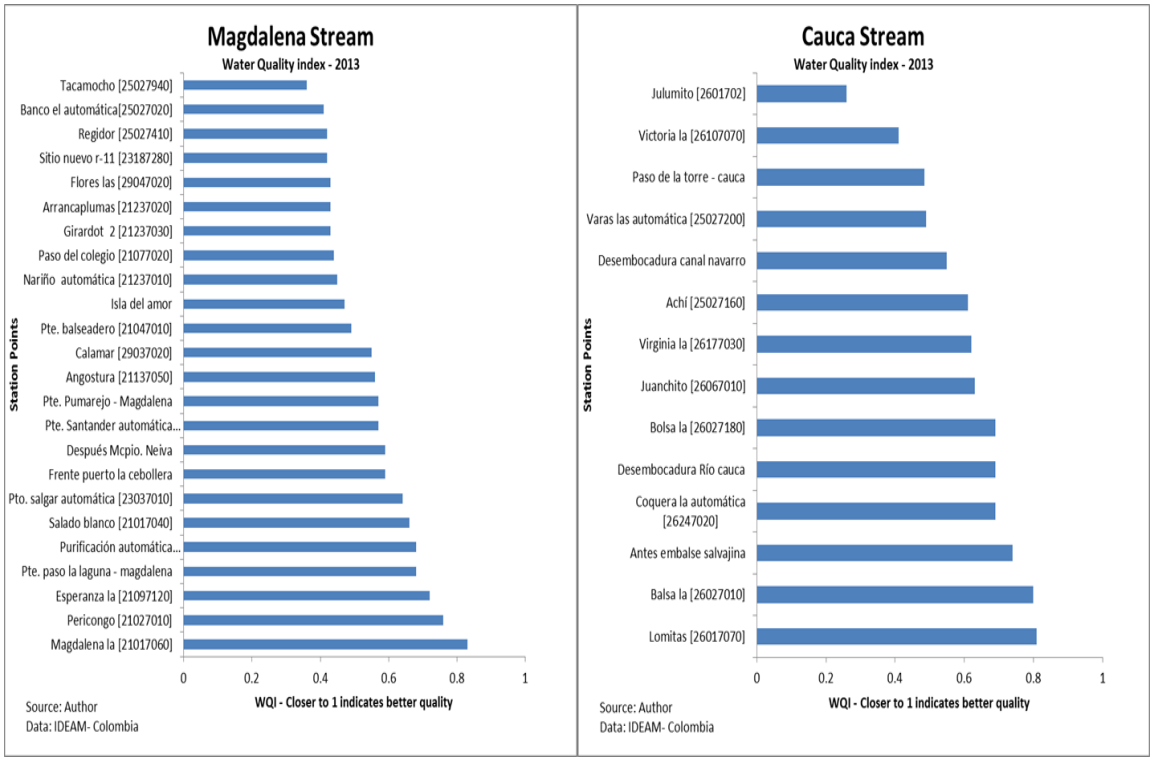


Source: IDEAM (2014)

Appendix III.

a) Appendix A. Figures

Figure 19. Water Quality Index - Magdalena and Cauca Streams



b) Appendix A. Conceptual framework

The central government imposes a lower legal limit on the amount of abatement offered by the municipality, denoted *L*. If the municipality is caught falling below this legal minimum, the central government imposes a fine, denoted *F*, that represents a linear transformation of the difference between the municipal investment in abatement, a_m, and the legal abatement limit, L: $F = \alpha (L - a_m)$, where α is a positive constant. The municipality lowers the magnitude of this fine by investing more into abatement.

c) Appendix B. Decentralization and Regulatory framework

In the last three decades of the 20th century, Colombia decentralized its government functions. As one of the first steps, the 1968 constitutional reform transferred responsibilities from the central government to the departments, allowing departmental governors to design and implement development plans and programs, as well as to fulfill other functions that lie below the ministerial capacities at the national level. Colombia reinforced this transfer of competencies in 1971 with the "Situado fiscal", which dedicated a proportion of the national income to local administration for the provision of municipal services. During the same year, the national government crafted a system for sharing sales tax revenues with departments and municipalities, defining these revenues available for all purposes (Moncayo Jimenez, 2005).

Decentralization can be horizontal or vertical (Steiner and Correa, 1994). In Colombia, this process was vertical because it transferred decision-making and resources to sub-national

levels – departments and municipalities. In particular, the central government delegated a multiplicity of functions to municipalities, including water systems, sewer systems, and environmental management (Valencia-Tello and Karam De Chueiri, 2014; Moncayo Jimenez, 2005).[19] This process not only included an increase in delegation of functions and resource decentralization, but also attempted to change access to and the provision of basic services in all the regions of the country. According to González (1994), the decentralized model implemented in Colombia was a copy of the fiscal federalism model, which main objective is to achieve local efficiency and a reduction in the central government expenditure. However, at the beginning of the process, some levels of centralization remained, due to institutional weaknesses at the municipal level (Valencia-Tello and Karam De Chueiri, 2014). Afterwards, the central government tried to correct the negative effects of the institutional design and to strength its regulatory capacity in two ways: (1) defining clearly departmental and municipal competencies regarding the provision of public services; and (2) conditioning municipal resources to a certification awarded by each department based on criteria established at the national level (Zapata-Cortés, 2016). Despite this decentralization, the central government designed a set of rules applicable to the budgetary process at the national and sub-national levels of government (DDT-DNP 2012) that allowed the central government to maintain some control.[20]

By 2000, Colombia had completed its decentralization process. Due to this decentralization, municipal governments have the autonomy to govern their own environmental management constrained by the central government's retained authority and authority delegated to departmental governments.

Table 29 Regulatory Framework

Executive Order 2811/1974	Natural Resources and Environment Protection National Code
Act 99, 1993	National Environmental System – SINA
Act 9, 1979	Sanitary National Code
Executive Order 1594, 1984	Water use and Dumping
Res. 1433, 2004	Wastewater treatment management plans – PSVM
Res. 1096, 2000	Technical Regulations Water Supply and Sanitation Sector
Executive order 2667, 2012	Retributive rates and contributions
Act 142, 1994	Public Utilities National Regime
Executive Order 3100, 2003	Stablish redistributive rates for environmental use
Res. 372, 1998	Stablishes the minimum for redistributive env. Rates
Executive Order 1180, 2003	Environmental licenses and permits

Source: National Plan for Municipal wastewater treatment – MVADT (2004)

[19] Act 715, 2001. Art. 76.5.4 Identifies these activities: execute decontamination projects of water streams and water deposits affected by wastewater discharges, as well as disposition programs, elimination, and recycling of liquid and solid residuals, and controlling air pollutant emissions.

[20] The central government created the Statue of Budget (Estuto Único de Presupuesto) – EUP, defining the budgetary process in Colombia and its different steps. Two main agents operate at the local level: major and municipal council. The major is responsible for local economic development, including allocating the municipal expenditure and investments according to the approved budget (DDT-DNP, 2012). The municipal council approves and authorizes budgetary revenues and expenditures. Similarly, two agents operate at the department level: governor and department assembly. Governors are responsible for regional economic development, designing plans and programs, and defining revenues and expenditures (DDT-DNP, 2012). The department assembly approves the plans, projects, and budgets proposed by the governor.

d) Appendix C. Data:

Table 30. Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
All wastewater related municipal investments (log)	15,014	13.5984	1.00838	8.39309	21.5289
Distance to international border	15,400	422.196	277.73	0	872.202
Distance to department border	15,400	127.785	77.7554	0	428.956
Distance to international border (log)	12,936	6.05318	0.67949	4.02019	6.77102
Distance to department border (log)	14,980	4.6654	0.72676	1.79123	6.06136
GDP total (Log)	10,960	11.2735	1.28223	6.93638	18.4443
Population (Log)	15,364	9.56382	1.08291	6.63857	15.8534
Land area (Log)	15,400	5.76932	1.21467	2.70805	11.0925
Altitude (Log)	15,400	6.23188	1.76994	0.69315	10.1354
Tax revenues (log)	15,021	6.31476	1.67874	-3.5582	15.2227
Transfer revenues (log)	14,705	6.27394	0.63122	-5.7617	11.2627
Capital revenues (log)	15,038	8.49289	0.96884	3.17327	14.9111

Table 31. Main Colombian Rivers defined by official sources

Colombian Rivers Considered			
RÍO USARAGA	RÍO CUSAY	RÍO MICAY	RÍO SAN JUAN
RÍO USARAGÁ	RÍO CUSIANA	RÍO MIRA	RÍO SAN LOPE
RÍO ABAQUÍA	RÍO DOCAMPADÓ	RÍO MULATOS	RÍO SAN LORENZO
RÍO AGUACATAL	RÍO DUDA	RÍO MURINDÓ	RÍO SAN MIGUEL
RÍO AMAZONAS	RÍO GAUAGUAQUÍ	RÍO MURRÍ	RÍO SAN PABLO
RÍO APAPORIS	RÍO GAZAUNTA	RÍO NARE	RÍO SANQUIANGA
RÍO ARAUCA	RÍO GIVIRU	RÍO NAYA	RÍO SATOCA
RÍO ARIARI	RÍO GUACAVÍA	RÍO NECHÍ	RÍO SEQUIHONDA
RÍO ATABAPO	RÍO GUAINÍA	RÍO NEGRO	RÍO SINÚ
RÍO ATRATO	RÍO GUAJUÍ	RÍO NULPE	RÍO SOGAMOSO
RÍO BAUDO	RÍO GUAMAL	RÍO OPÓN	RÍO SUCIO
RÍO BOJABÁ	RÍO GUAPE	RÍO ORDO	RÍO TAMANA
RÍO BONGO	RÍO GUAPI	RÍO ORINOCO	RÍO TAMBOR
RÍO BUBUEY	RÍO GUATIQUÍA	RÍO ORPUA	RÍO TAME
RÍO CAGUÁN	RÍO GUAVIARE	RÍO ORTEGUAZA	RÍO TANANDÓ
RÍO CAJAMBRE	RÍO GUAYABERO	RÍO PATÍA	RÍO TAPAJE
RÍO CALAFITA	RÍO GUAYAS	RÍO PATÍA VIEJO	RÍO TAPAJE VIEJO
RÍO CAQUETÁ	RÍO GUAYURIBA	RÍO PICHIMA	RÍO TARAIRÁ
RÍO CARARE	RÍO GUIZA	RÍO PORCE	RÍO TARAZA
RÍO CASANARE	RÍO HUMADEA	RÍO PURARE	RÍO TELEMBI
RÍO CATRIPE	RÍO HUMEA	RÍO PURRICHA	RÍO TIMBA GRANDE
RÍO CAUCA	Río IJUA	RÍO QUIPARADÓ	RÍO TIMBIQUÍ
RÍO CERTEGUI	RÍO ISCUANDÉ	RÍO QUITO	RÍO TIMBITA
RÍO CIMITARRA	RÍO LA CAL	RÍO RAPOSO	RÍO TOCARAGUA
RÍO COBARÍA	RÍO LA MIEL	RÍO ROSARÍO	RÍO TOLA
RÍO CRAVO NORTE	RÍO LA SIERPE	RÍO ROTAYA	RÍO TRAIRÁ (TARAIRÁ)
RÍO CRAVO SUR	RÍO LIMONES	RÍO SAIJA	RÍO TUA
RÍO CUBUGÓN	RÍO LOS URUIMES	RÍO SALDAÑA	RÍO UPÍA
RÍO CUCUANA	RÍO MAGDALENA	RÍO SAMANÁ	RÍO VAUPÉS
RÍO CUCUNA	RÍO META	RÍO SAN JORGE	RÍO VICHADA
Río CURBARADÓ	RÍO METICA	RIO SAN JUAN	RÍO YURUMANGUÍ

Source: National Geographic Institute- Colombia
Simple and Double drainage- Shape files
Recovered from: http://sigotn.igac.gov.co/sigotn/default.aspx

e) Appendix D. Additional Results

Table 32. Log-Log Department and International border Indicator

OLS Estimates of the Effect of Location on Wastewater related municipal investments Dependent variable: Log of Municipal wastewater investments					
	(1)	(2)	(3)	(4)	(5)
International Border Ind.	0.01145	0.33409***	0.33617***	0.39168***	0.53047***
	[0.94114]	[0.00003]	[0.00001]	[0.00000]	[0.00185]
Dept. Border indicator	0.01434	0.05174**	-0.01836	-0.01825	-0.01831
	[0.60254]	[0.02380]	[0.31767]	[0.31990]	[0.31798]
0b.dwborder#1.exterior	-0.15142***	0.06646**	0.01287	0.00741	0.00850
	[0.00001]	[0.02810]	[0.60396]	[0.76522]	[0.73211]
General characteristics		X	X	X	X
Budget variables			X	X	X
Other variables					X
Department dummies	X	X	X	X	X
Region dummies					
Year dummies		X	X	X	X
Municipal category dummies				X	X
Observations	15,014	10,605	10,195	10,195	10,195
R-squared	0.13465	0.56199	0.66231	0.66537	0.66586

Robust pval in brackets

*** p<0.01, ** p<0.05, * p<0.1

Note to Table 32. P-values are in brackets. Data are from the Municipal Panel created by the Center for Development Studies – CEDE at Universidad de los Andes, using publicly available information from official sources, and include municipalities in Colombia between 2000 and 2013. General characteristics includes variables such as GDP, Population, land area and altitude; Budget variables includes tax revenues, capital revenues, and transfer revenues; and other variables include a dummy variable for the presence of land belonging to minorities within the municipality and a dummy variable for the presence of at least one irregular army.

Table 33. Log-Log Distance to International Border

OLS Estimates of the Effect of Location on Wastewater related municipal investments Dependent variable: Log of Municipal water related investments					
	(1)	(2)	(3)	(4)	(5)
Distance to Intl. Border (log)	-0.12003***	0.02922	0.00532	0.03320**	0.02968*
	[0.00000]	[0.15142]	[0.73918]	[0.03935]	[0.06611]
General characteristics		X	X	X	X
Budget variables			X	X	X
Other variables					X
Department dummies	X	X	X	X	X
Region Dummies					
Year Dummies		X	X	X	X
Municipal category dummies				X	X
Observations	14,902	10,529	10,124	10,124	10,124
R-squared	0.13378	0.56218	0.68336	0.66629	0.66681

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note to Table 33. P-values are in brackets. Data are from the Municipal Panel created by the Center for Development Studies – CEDE at Universidad de los Andes, using publicly available information from official sources, and include municipalities in Colombia between 2000 and 2013. General characteristics includes variables such as GDP, Population, land area and altitude; Budget variables includes tax revenues, capital revenues, and transfer revenues; and other variables include a dummy variable for the presence of land belonging to minorities within the municipality and a dummy variable for the presence of at least one irregular army.