The London School of Economics
and Political Science

Essays on the Political Economy of Development

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I declare that my thesis consists of approximately 47,301 words.

Statement of Conjoint Work

I confirm that Chapter 2 was jointly co-authored with Juan Camilo Cárdenas, Nicolás De Roux and Christian Jaramillo. I contributed 25 % of this work.

Abstract

The present collection of essays studies some of the ways in which the interaction of economic and political forces affects a country's development path. The focus of the thesis is on Colombia, which is a fertile setting for the study of the political economy of development given its long-lasting internal conflict, the multiple reforms to the functioning of the state that have taken place in the last decades and the availability of high quality sub-national data.

The first two chapters explore people's tendency to use resources differently depending on their source. The first chapter shows how the source of public revenue affects a government's incentives to provide public goods and services, while the second one studies people's propensity to make risky choices when playing a game with easily-gotten house money. The third chapter contributes to our understanding of the international dimension of civil conflict by analyzing the effects of access to territory in a neighboring country on the intensity of an insurgent group's activities.

The idea that governments perform better when they are funded with tax revenue has a long history and surfaces often in debates regarding the origin of the natural resource curse, the effectiveness of foreign aid and the benefits from decentralization. However, the empirical evidence backing this claim is somewhat limited. In the first chapter, I try to fill this gap by comparing the effects of increases in internally-raised tax revenue and in royalties from the extraction of oil on local public good provision in a panel of Colombian municipalities. I find that tax revenue leads to an improvement in public services while oil royalties have no effect. Furthermore, I document a negative effect of royalties on the quality of government, as measured by the disciplinary prosecution of local public officials.

One possible explanation for the results in chapter 1 is that taxation leads to greater accountability because voters value tax revenue more than revenue from an external source. The idea that people assign greater value to resources over which they have some sense of ownership is further explored in the second chapter. In that chapter, which is the result of joint work with Juan Camilo Cárdenas, Nicolás De Roux and Christian Jaramillo, we show that the risk aversion displayed by participants in a lab experiment varies depending on whether they received the endowment on the same day of the session or one month in advance. We interpret this finding as evidence of people's reduced risk aversion when allocating easily-gotten resources, also known as the 'house-money' effect.

In the third chapter, I turn my attention to Colombia's internal armed conflict and I study the allegation that the administration of Hugo Chávez provided access to territory in neighboring Venezuela to Colombian insurgent groups FARC and ELN. I document a disproportionate increase in the intensity of insurgent activity (mainly by FARC) in Colombian municipalities next to the border with Venezuela after Chávez comes to power in 1999. This finding is consistent with the idea that the rebels had access to a safe haven across the border during the Chávez administration, but that the strategic advantage provided by this sanctuary decreased with distance to the border. This chapter contributes to our understanding of foreign support for insurgent groups by developing a novel data-driven method for the detection of the usually secretive activities of trans-national rebel groups. It additionally provides credible estimates of the causal effect of access to foreign territory on insurgent activities.

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This thesis is dedicated to my grandparents, Gilma, Graciela, Roberto and Pedro, who seem to have understood the fundamental causes of development in ways that perhaps I never will.

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Chapter 1

Sources of Revenue and Government Performance: Evidence from Colombia

If government revenue is not coming out of their pockets, voters may be uninformed about it or uninterested in what happens to it, contributing to low accountability and poor governance. This chapter provides empirical evidence on the positive relationship between taxation and governance by comparing the effects of increases in internally-raised tax revenue and in royalties from the extraction of oil on local public good provision in a panel of Colombian municipalities. I find that an increase in property tax revenue, occurring as a result of an exogenous cadastral update, has a positive effect on several basic public services in the areas of education, health and water. These effects are at least ten times larger than the effects of an equivalent increase in oil royalties, obtained as a consequence of exogenous fluctuations in the world price of oil. I find no evidence that oil royalties contribute to improvements in public service provision, despite being earmarked for this purpose. Differences in the timing and in the sectoral allocation of spending across sources are unable to explain the results. I use novel data on disciplinary prosecutions to show that additional oil royalties increase the probability that the mayor and other local public officials are prosecuted, found guilty, and removed from office. I also provide suggestive evidence on the positive effect of taxation on citizen demands regarding public services. These results indicate that accountability is crucial for the responsible management of public funds and that taxation is an effective way of achieving the necessary citizen involvement in public affairs.

1.1. Introduction

Inadequate provision of public goods is an obstacle to development in most low-income countries (World Bank, 2004; Besley and Ghatak, 2006). A frequent way of addressing this problem in recent decades has been through the devolution of expenditure responsibilities to local governments (Gadenne and Singhal, 2014). These reforms have tried to exploit the increased accountability of local public officials and they have had widespread support from international organizations such as the World Bank (2000).[1] However, despite the strong incentives that local democracy appears to provide for good governance, this recent wave of decentralization has met with only limited success so far.[2]

It is true, though, that local governments in developing countries depend to a large extent on external sources of revenue, such as transfers from higher levels of government and natural resource rents. Several well-identified studies have documented how increases in revenue from these sources appear to have a very low impact on public good provision, often leading to a worsening of corruption instead.[3] It thus seems plausible that the way in which local public finances are organized is contributing to the suboptimal provision of public goods across the developing world. If revenue is not coming out of their pockets, voters may be uninformed about it or uninterested in what happens to it, failing to hold the government accountable as a result. However, without the benchmark provided by tax revenue, we cannot rule out that the poor governance associated with additional resources is simply indicating that these governments have low technical capacity or are the victims of widespread corruption, no matter what the source of revenue is.

In this chapter, I test the hypothesis that internally-raised tax revenue has a larger effect on the provision of public goods than revenue from an external or unearned source. For this purpose, I compare the effects of increases in local tax revenue and in royalties from the extraction of oil on the provision of public goods in a panel of Colombian municipalities. I show that local tax revenue has a much larger impact than oil royalties on several indicators of public good provision. I argue that this difference is driven by the opposite effects of tax

[1] In the words of Bardhan (2002, p.185), "In matters of governance, decentralization is the rage."

[2] See Faguet (2014) and Mookherjee (2015) for recent reviews on decentralization. For evidence on local democracy in developing countries, see Ferraz and Finan (2011); De Janvry et al. (2012); Martínez-Bravo et al. (2014); Fujiwara (2015).

[3] See Fisman and Gatti (2002); Reinikka and Svensson (2004); Vicente (2010); Caselli and Michaels (2013); Brollo et al. (2013); Litschig and Morrison (2013); Maldonado (2014); Olsson and Valsecchi (2014).

revenue and external revenue on the misbehavior of local politicians and I use novel data on disciplinary prosecutions to provide supporting evidence.

A comparison of this nature faces several challenges. We must first find a setting where local governments have access to both tax and non-tax sources of revenue and are responsible for the provision of public goods. We must also have access to plausible sources of variation not only in external revenue, which the previous literature has accomplished with some success, but also in internally-raised tax revenue, which is a more daunting task and has seldom been done before. Finally, our comparison must account for the fact that revenue can be used for many different purposes, so a careful choice of outcomes is needed. Colombia meets all these conditions.

Colombian municipalities are responsible for the provision of basic public services and finance them with a mix of local taxes, transfers from the central government and royalties from the extraction of natural resources. The royalties received by resource-producing municipalities are formula-determined and amount to a fixed share of the market value (at world prices) of the extracted resources. Oil is the most important source of royalties in Colombia but the country is a small player in the oil market and is unable to affect world prices.[4] Hence, I exploit time variation in the world price of oil between 2005 and 2011, together with cross-sectional variation in oil intensity (using average municipal oil royalties between 2000 and 2004) to estimate the effect of royalties on local public goods.

The municipal expenditure of natural resource royalties is heavily regulated. Royalties must be spent on public services in the areas of education, health and water until targets are met for five specific indicators. I show that target achievement is low among oil royalty recipients at the start of the sample period and that the earmarking rules were followed, making these indicators the best place to look for the impact of royalties on public goods and services. The four indicators for which yearly data is available are my main outcomes of interest: the net enrolment rate in basic education, the infant mortality rate, the percentage of poor population with subsidized health insurance and a water quality index.

I compare the effect of oil royalties on the indicators above to that of property tax revenue, the main local tax in Colombia. The base of the property tax is the value of the properties in the municipality's official property register

[4]In the appendix I provide very similar results for coal, which is the second most important source of royalties. Together, oil and coal account for over 90 % of royalties in the period 2005-2011.

or cadastre. Each year the national geography institute run by the central government updates the cadastre of some municipalities and reassesses the value of the included properties, which leads to a sharp increase in property tax revenue. I argue that the timing of these updates is plausibly exogenous. For this purpose, I provide evidence on the municipalities' limited ability to manipulate the timing of their update and I show that it is mainly determined by the supply of updates from the geography institute. Furthermore, given that municipalities have discretion over the expenditure of tax revenue, a comparison based on the outcomes for which natural resource royalties are earmarked is likely to be biased in favor of this latter source.

The estimates from an instrumental variables model with municipality and department-year fixed effects indicate that an increase in property tax revenue has a positive and statistically significant effect on educational enrolment and on a water quality index. Additional property tax revenue also increases the probability of achieving universal coverage of poor population with subsidized health insurance. These effects are at least one order of magnitude greater than (and statistically different from) the effects of an increase in oil royalties of the same size. In fact, I find a striking result: the effect of additional royalties is basically zero for all outcomes and the point estimates are negative in several cases.

One potential concern regarding these findings is that different types of municipality may raise revenue from different sources. However, I show that the positive effects of cadastral updating and property tax revenue extend to oil-royalty recipients. Another potential problem is that differences in expenditure could arise because cadastral updates lead to a stable increase in tax revenue while oil price shocks lead to temporary fluctuations in royalties. To address this concern, I show that differences in the propensity to spend out of the two sources (based on a higher cautiousness when spending oil windfalls) cannot explain the results. I also show that there is no evidence of improvement in any indicator in the medium-run (seven years) for oil-royalty recipients, which indicates that royalties are not being spent on projects of a larger scale whose returns require more time to materialize. I find that additional revenue from either source is channeled almost exclusively into investment in fixed capital but that only tax revenue leads to an increase in the number of schools in the municipality.

I argue that the heterogeneous effects of tax revenue and oil royalties on public goods are driven by harder-to-observe differences in the quality

of expenditure, and more generally in the competence of local governments, according to the source of funding. Using newly collected data on the disciplinary prosecution of local public officials in Colombia I find that an increase in oil royalties leads to a statistically significant increase in the probability that the municipal mayor and top members of staff are prosecuted, found guilty and removed from office and barred from politics by a national watchdog agency. Increases in property tax revenue, on the other hand, appear to reduce the probability of these events, although the difference is not statistically significant.

The findings of this chapter are consistent with the idea that taxation makes voters either more able or more willing to hold the government accountable (Paler, 2013). In the theoretical appendix, I provide a model of political agency with career concerns that illustrates how both information-based and preference-based mechanisms can explain the results from the empirical exercise. I provide suggestive evidence on the heterogeneous response of residents to increases in taxation relative to external revenue using data on social mobilizations. I find that property tax revenue has a positive effect on the probability that a protest related to local public services takes place in the municipality, while oil royalties have a negative effect. Again, the difference is not statistically significant.

The idea that taxation improves governance is not new. It can be found in comparative papers on the development of modern Europe (North and Weingast, 1989) or on the 'rentier states' of the Middle East (Mahdavy, 1970; Beblawi, 1990; Ross, 2001). In development economics, this idea is present in discussions on foreign aid (Bauer, 1972; Easterly, 2006; Collier, 2006; Deaton, 2013) and on state capacity (Besley and Persson, 2011, 2013, 2014). In public economics, it is at the core of the 'second generation' approach to fiscal federalism (Oates, 2005; Weingast, 2009) and it is related to the idea of 'fiscal illusion' (Dollery and Worthington, 1996). However, there is only limited empirical evidence on this topic.

Two recent papers have studied the heterogeneous effects of tax revenue and external revenue on public good provision, with mixed findings. Borge et al. (2015) show that additional rents from hydro-power production reduce the efficiency of public expenditure less than increases in other revenue in Norwegian municipalities. In the most closely related contribution to this work, Gadenne (2015) reports improvements in educational infrastructure for Brazilian municipalities that enroll in a tax modernization program, while higher transfers have no effect. The main challenge that this line of research still faces is coming up with plausibly exogenous sources of variation in tax

revenue, as changes in tax bases and tax rates are likely to be endogenous to political and economic factors that can potentially affect outcomes of interest.

In this chapter I introduce cadastral updates as a plausibly exogenous source of variation in local tax revenue.[5] These updates lead to an increase in tax revenue that is not correlated to changes in political or economic conditions, nor in tax administration or structure. I observe cadastral updates for 60 % of municipalities over a five-year period, which ensures the representativeness of the results among Colombian municipalities and allows for a common support with oil-royalty recipients. I exploit the earmarking of natural resource royalties to target the comparison across sources of revenue and I look not only at educational infrastructure, but also at policy outcomes in the areas of education, health and water. This study also contributes to the existing literature by using novel data on disciplinary prosecutions to illustrate the heterogeneous effects of tax revenue and external revenue on local politicians' misbehavior.

The present investigation's main contribution is to the empirical literature studying the relationship between public finance and governance.[6] It is also related to to the empirical literature that uses sub-national data to study the effects of natural resource rents.[7] The theoretical model I develop also complements previous contributions on the political resource curse by exploring the heterogeneous political effects of resource rents relative to tax revenue.[8] This study contributes as well to the 'second generation' literature on fiscal federalism by providing evidence on the importance of local fiscal incentives.[9]

The rest of this chapter is organized as follows. Section 2 provides background

[5]Sánchez and Pachón (2013) use an IV strategy based on cadastral depreciation and find that educational enrolment and water quality improve in Colombian municipalities that collect more taxes. I build on their work by providing the necessary evidence on the exogeneity of the timing of cadastral updates. Additionally, while Sánchez and Pachón (2013) focus exclusively on tax revenue, I answer a different question related to the heterogeneous effects of tax revenue and external revenue.

[6]Zhuravskaya (2000) documents the negative effects of transfer offsets to increases in tax revenue in Russian cities. Ross (2004) reports cross-country evidence on the link between taxation and democracy. Paler (2013) and Martin (2014) provide experimental evidence on people's higher willingness to hold the government accountable when they are taxed. Borge and Rattsø (2008) and Sánchez and Pachón (2013) show that property taxes improve the efficiency and amount of public services in Norway and Colombia, respectively. Casaburi and Troiano (2015) find that cadastral registration has positive effects on local governance in Italian municipalities.

[7]See Caselli and Michaels (2013); Maldonado (2014); Ferraz and Monteiro (2014); Olsson and Valsecchi (2014); Herrera (2014); Carreri and Dube (2015).

[8]See Caselli (2006); Mehlum et al. (2006); Robinson et al. (2006); Caselli and Cunningham (2009); Brollo et al. (2013); Matsen et al. (2015)

[9]See Bardhan (2002); Oates (2005); Bardhan and Mookherjee (2006); Faguet and Sánchez (2008, 2014); Weingast (2009). Glaeser (1996) and Hoxby (1999) explore the potential of the property tax to act as a disciplining device for local governments.

information on the setting for the empirical exercise. Section 3 presents the data and discusses the empirical strategy. The main results on public goods and the robustness checks are shown in section 4. Evidence from disciplinary prosecutions is provided in section 5. In Section 6 I discuss the findings and the underlying mechanisms. Section 7 concludes.

1.2. Local Public Finance and Public Service Provision in Colombia

There are two levels of sub-national government in Colombia: 1100 municipalities are grouped into 32 departments (similarly to US states and counties). The top municipal authority is the mayor, who serves a four-year term without the possibility of re-election. The municipal council, which is elected at the same time as the mayor, must approve the mayor's plan of government as well as the annual budget and must also supervise their execution.

Following a decentralization reform in the early 1990s, municipalities and departments became jointly responsible for the provision of basic public services in the areas of education, health, drinking water and sanitation. The main source of funding for related expenditures is a system of earmarked and formula-determined transfers from the central government called "Sistema General de Participaciones" (SGP), which accounts on average for 63 % of municipal total revenue.[10]

Taxes are the second most important source of revenue and contribute on average with 44 % of current receipts and 13 % of total revenue. The main local taxes (and their average shares of tax revenue) are the property tax (34 %), the business tax (17 %) and the petrol surcharge (22 %).[11] The property tax is the most important source of tax revenue for slightly more than one half

[10]SGP transfers must be kept in a separate account from other sources of revenue. Municipal autonomy over the expenditure of these transfers and over the administration of public services varies across municipalities and across sectors, with the specific responsibilities of each level of government being somewhat blurry (Alesina et al., 2005). After an additional reform in 2001, municipalities "certified" by the Ministries of Education or Health started to directly manage the transfers earmarked for these areas (Cortés, 2010; Brutti, 2015). Otherwise, transfers are managed by the departmental government. Certified municipalities also have greater autonomy in the management of the local education and health systems. However, the provision of health services is highly regulated, even for certified municipalities, and must take place through special firms called "Empresas Sociales del Estado" (ESE). In the case of water and sanitation, municipalities manage the share of transfers earmarked for this purpose unless they are "de-certified" by the Superintendent for Public Services.

[11]Other local taxes include those for car registration and for the display of billboards and banners.

of municipalities, but its relative importance decreases with population size (Núñez, 2005).[12] Aggregate property tax revenue has been relatively stable since 2000 at around 0.5 % of GDP (Sánchez and España, 2013).

Municipalities have discretion over the expenditure of property tax revenue, except for a fixed share that they are required to transfer to an environmental agency.[13] Municipalities can use own revenues (including tax revenue) for the provision of various public services. Any municipality can supply funding for the provision of education and can also invest in educational infrastructure or school equipment. Regarding health-related expenses, municipalities can provide subsidized health insurance to the population classified as poor by the national government's proxy-means-testing targeting system (SISBEN). Municipal governments can also use own revenues for public health initiatives such as vaccination campaigns (vaccines are provided at zero cost by the central government). In the case of water and sanitation, municipalities can invest their own resources in infrastructure or can provide subsidized access to the poor.

The property tax is levied on the cadastral value of all real estate in the municipality. The cadastre or land register is the official record of the physical and economic characteristics of all properties in a municipality. The cadastre of all municipalities in the country (except for Bogotá, Medellín, Cali and the department of Antioquia) is managed by the National geography institute, *Instituto Geográfico Agustín Codazzi* (IGAC), an agency run by the central government. As part of its duties, IGAC periodically updates the cadastres under its control. Cadastral updates mainly involve reassessing existing properties but also, to a much lesser extent, incorporating previously unregistered properties to the cadastre.[14]

The third most important source of local revenue is royalties from the extraction of natural resources. The main source of royalties between 2005 and 2011 was the extraction of oil (69 % of the total), followed by coal (23 %).[15] Royalties are paid by firms to the central government according to a set of

[12] Glaeser (2013) reports that local public finances in the US are not very different, with intra-government transfers and property taxes being the most important sources of revenue for all but the largest cities. Gadenne and Singhal (2014) show that dependence on external revenue is greater for local governments in developing countries.

[13] There are 34 such agencies in the country. Some cover a handful of municipalities while others cover multiple departments. The percentage transferred must be between 15 % and 25 % of property tax revenue.

[14] Iregui et al. (2003, 2004) and Sánchez and España (2013) provide further information on the property tax and on cadastral updating in Colombia.

[15] Royalties are also paid for the extraction of precious metals, gemstones, iron, copper, nickel and salt.

fixed resource-specific formulae of the form

$$\text{royalties} = \text{output} \times \text{world price (USD)} \times \text{exchange rate (COP/USD)} \times \text{royalty rate (\%)}$$

In the case of oil, between 60 % and 84 % of these royalty payments are transferred by the central government to the municipalities and departments where oil is extracted, with the marginal royalty transfer rate decreasing in output. Another 8 % of the total is distributed among the port municipalities from where oil is shipped and the remaining share (between 8 % and 32 %) is allocated to investment projects in non-producing areas.[16] The total amount of royalties received by oil-producing and port municipalities (18 % of the country) between 2005 and 2011 amounted to 3.5 billion USD. On average, royalties represent 23 % of total revenue for this set of municipalities. A reform in 2012 significantly modified the way in which royalties are distributed, but data availability prevents me from exploiting this source of variation.

By law, at least 75 % of royalties must be spent on education, health, drinking water and sanitation until specific targets are met for the specific set of indicators listed in Table 1.1. These indicators are the net enrolment rate in basic education (years 1-9, ages 6-14), the infant mortality rate, the percentage of poor population with subsidized health insurance and the percentages of population with access to clean water and sewerage, where water is only considered suitable for human consumption if it scores less than 5 in a water quality index ranging from 0 to 100. Columns 2 and 3 of Table 1.1 show that target achievement among oil-royalty recipients was low for all indicators at the start of the sample period. The rules governing the distribution and expenditure of royalties do not disincentivize target achievement, as municipalities keep receiving royalties once targets are met and can spend them on priority projects from the mayor's government plan.

In order to achieve the education target, royalties can be spent on education infrastructure, school equipment or transportation. They can only be used to directly finance the provision of education if SGP transfers are shown to be insufficient. Royalty recipients can reduce infant mortality through public health policies or by setting up emergency health posts for common infant diseases. Royalties can also be used for expenditures related to water and sewerage projects, such as initial studies, designs and construction.

[16] The allocation rules are roughly similar for other natural resources.

Table 1.1: Achievement of targets by oil-royalty recipients

Indicator	(1) Target[1]	(2) Mean (2005)	(3) Target met (% in 2005)
Net enrolment rate in basic education (%)	100	91.8	30.0
Infant mortality rate (‰)	16.5	26.8	7.1
Poor population with subsidized health insurance (%)	100	72.7	14.3
Water quality index (0-100)[2]	5	32.2	17.9
Population with access to drinking water (%)[3]	70	63.0	62.1
Population with access to sewerage (%)[3]	70	41.1	26.4

Notes: The table shows the indicators on which at least 75% of royalties have to be spent and the targets that royalty recipients must meet. It also shows the average of each indicator in 2005 for the 140 municipalities with positive oil royalties between 2000 and 2004, as well as the percentage of these municipalities meeting the target. [1] Targets from Decree 1747/1995, modified by Law 1151/2007, Resolution 4911/2008 (Education) and Decree 1447/2010 (Water). [2] Information from 2007, which is the first year for which data on the IRCA water quality index is available. [3] Data on access to drinking water and sewerage is only available from the 2005 population census.

1.3. Empirical Strategy

I use panel data for 969 Colombian municipalities between 2005 and 2011 to test the hypothesis that tax revenue has a larger effect on public good provision than revenue from an external source. I exploit the timing of cadastral updates and the fluctuations in the world price of oil as sources of exogenous variation in local property tax revenue and in royalties from the extraction of oil, respectively, and I compare the effect that revenue from these two sources has on the local public goods for which royalties are earmarked. In the following sub-sections I explain the details of this empirical exercise. First, I introduce the data employed. Secondly, I present the outcomes of interest. Finally, I discuss the identification strategy.

1.3.1. Data

Data on municipal public finance comes from the yearly balance sheets reported by each municipality to the Office of the Comptroller General for the purpose of fiscal control. These balance sheets have disaggregated information on all sources of revenue, including tax revenue (by type of tax), transfers and royalties. Information on expenditure is also available in these balance sheets, disaggregated between current expenditure (operating costs) and investment. I express all money values in tens of thousands of 2004 Colombian Pesos (COP) per capita (unless otherwise stated), using the Consumer Price Index and population estimates from the National Statistical Agency, *Departamento Administrativo Nacional de Estadística* (DANE).

Data on the local public goods for which royalties are earmarked (Table 1.1)

comes from various sources: the net enrolment rate in basic education and the infant mortality rate are provided by the Ministry of Education and DANE, respectively.[17] The source for the yearly percentage of poor population with access to subsidized health insurance is the Ministry of Health.[18] The water quality index, *Indice de Riesgo de la Calidad del Agua* (IRCA), is calculated by the National Health Institute, *Instituto Nacional de Salud* (INS). All indicators are available at the municipality-year level for the period 2005-2011, except for the water quality index, which is only available since 2007. In the following section I explain why I choose these indicators as the main outcomes of interest.

IGAC has yearly data on the number of properties, the total property value and the year of the last cadastral update for both the urban and rural areas of each municipality under its supervision. Municipalities with their own cadastral agencies (Bogotá, Medellín, Cali and Antioquia department) are dropped from the sample. This leaves me with 969 municipalities (86 % of the total). In the empirical exercise I do not distinguish between urban and rural updates, but the results are robust to the exclusion of rural updates (available upon request).

Data on oil royalties comes from the state-owned Colombian oil company, *Ecopetrol*, for the period 2000-2003 and from the National Hydrocarbons Agency, *Agencia Nacional de Hidrocarburos* (ANH), for the period 2004-2011. I use the average petroleum spot price from the IMF's International Financial Statistics (IFS).

I provide summary statistics for the main variables that I employ in Table 1.2. The average municipality has 30,000 inhabitants (the median is 13,000), of which 60 % live in rural areas.[19] The average levels of total revenue, property tax revenue and natural resource royalties are 540,000, 21,000 and 55,000 COP per capita, respectively. On average, municipalities experience fiscal deficits during the sample period, with total expenditure at 580,000 COP per capita. Most expenditure (almost 500,000 COP per capita) goes to investment.

[17] The net enrolment rate is calculated by dividing the number of children with ages 6 to 14 enrolled in school years 1 to 9 by the number of children in this age group. Since data on enrolment and data on population come from different sources, the resulting figure can actually exceed 100 %. I censor enrolment rates above 100 % but the results are robust to using the original data.

[18] Poor is defined as belonging to categories 1 or 2 of the Colombian proxy-means-testing system SISBEN.

[19] However, Colombia is a predominantly urban country. In 2005, 45 % of the country's population lived in the 20 largest cities, where only 7 % of the population is considered rural.

Table 1.2: Summary statistics of main variables

Variable	Mean	Std. Dev.	Min.	Max.	N
A. demographics					
Population (thousands)	30.03	75.55	0.88	1193.67	6,704
Rural share of population	0.58	0.24	0	0.98	6,704
B. cadastral updating					
Cadastral update (dummy)	0.13	0.34	0	1	6,704
Cadastral valuation (millions)	3.59	4.19	0	83.16	6,704
Number of properties (thousands)	9.10	20.26	0	304.51	6,704
C. oil price and royalties					
Oil royalties 2000-2004	2.36	16.4	0	348.47	969
Oil price (per barrel)	12.8	1.70	10.5	15.3	7
D. public finance					
Total revenue	54.35	43.21	8.88	637.52	6,704
Current revenue	13.93	11.97	1.59	212.96	6,704
Tax revenue	6.52	8.67	0.04	169.94	6,704
Property tax revenue	2.08	2.76	0	60.52	6,704
Capital revenue	40.42	35.61	3.29	567.87	6,704
Natural resource royalties	5.45	26.28	0	506.55	6,704
Transfers	35.89	23.26	5.02	553.46	6,704
Total expenditure	58.23	49.74	1.14	972.04	6,704
Current expenditure	8.46	10.98	0.08	776.33	6,704
Investment	49.78	45.02	0.66	931.36	6,704
E. development indicators					
Net enrolment rate in basic education (%)	88	17.18	18.7	244.4	6,704
Infant mortality rate (‰)	22.81	8.51	9.24	64.09	6,704
Poor population with subsidized health insurance (%)	87.15	15.66	0	100	6,704
IRCA water quality index (0-100)	29.38	23.82	0	100	4,472
F. disciplinary processes					
Mayor prosecuted (dummy)	0.19	0.39	0	1	2,985
Mayor found guilty (dummy)	0.14	0.34	0	1	2,985
Mayor banned from office (dummy)	0.08	0.28	0	1	2,985
Top staff prosecuted (dummy)	0.06	0.24	0	1	2,985
Top staff found guilty (dummy)	0.04	0.2	0	1	2,985
Top staff banned from office (dummy)	0.03	0.17	0	1	2,985
Council member prosecuted (dummy)	0.05	0.22	0	1	2,985
Council member found guilty (dummy)	0.04	0.2	0	1	2,985
Council member banned from office (dummy)	0.03	0.17	0	1	2,985

Notes: The sample includes 969 municipalities for the period 2005-2011. Political characteristics in panel F are calculated using results from local elections in 2000, 2003 and 2007 and from national elections in 2002, 2006 and 2010. The variables related to disciplinary processes in panel E contain information from the local political periods 2001-2003, 2004-2007 and 2008-2011. All money variables are expressed in tens of thousands of 2004 Colombian pesos per capita, unless specified otherwise.

1.3.2. Indicators of Local Public Good Provision

As mentioned above, Colombian law stipulates that at least 75 % of royalties must be spent on the improvement of basic public services until targets are met for the set of indicators listed in Table 1.1. The targets are displayed in column 1, while column 2 shows the average value of each indicator in 2005 (the first year for which data is available) among oil-royalty recipients. At the start of the sample, the average municipality receiving oil royalties does not meet any of the targets. Column 3 further shows that the percentage of oil-royalty recipients reaching each target is less than or equal to 30 % for all indicators except access to drinking water (62 %).

The low levels of compliance imply that the targets were binding constraints during the sample period and that royalties had to be spent on the improvement of the indicators in Table 1.1. Figure 1.1, which is based on administrative data on the expenditure of royalties for 2010 and 2011, shows that almost 80 % of royalties were allocated to the attainment of the targets, mainly in education and water. Even though royalties could crowd out own expenditure in the earmarked sectors, total investment in these sectors must rise with royalties (though not necessarily at the margin) since the ratio of royalties to own revenues among oil-royalty recipients is 1.58 on average during the sample period.

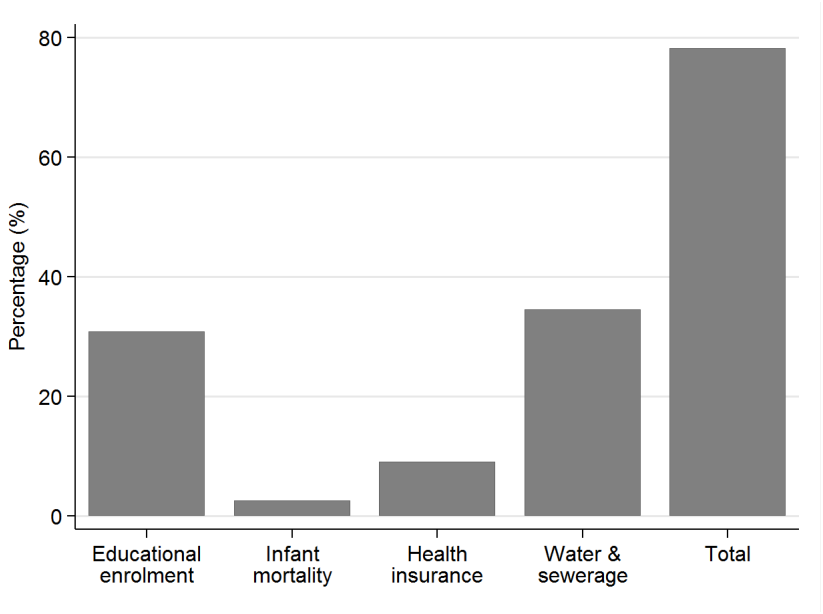
Hence, the indicators in Table 1.1 are the best place to look for the impact of natural resource royalties on public goods and I use them as the main outcomes of interest for the empirical exercise. Yearly municipality-level data is not available on the percentages of population with access to drinking water and sewerage, forcing me to leave these two indicators out of the analysis.[20] Therefore, the four main outcomes of interest are the net basic education enrolment rate, the infant mortality rate, the percentage of poor population with subsidized health insurance and the IRCA water quality index. Nevertheless, there is a strong cross-sectional correlation between the baseline score of the water quality index in 2007 and the values of the two omitted indicators from the 2005 population census, which suggests that the water quality index could potentially capture improvements in access to drinking water and sanitation.[21]

My choice of indicators of local public goods leads to a particularly stringent

[20] Sánchez and Pachón (2013) find a positive cross-sectional effect of local taxation on access to drinking water using data from the population census of 2005.

[21] Sánchez and Vega (2014) report for Colombian departments a strong positive correlation between access to drinking water on infant mortality, so this latter indicator could also capture improvements in access to water and sanitation.

Figure 1.1: Royalties spent on targets for public services



Note: The graph shows the percentage of royalties spent on the attainment of each target (and the total) among 94 oil-royalty recipient municipalities in 2010 and 2011 (unbalanced panel). The graph shows percentages of the total expenditure but the results are very similar for average expenditure across municipalities.

test because municipalities have full discretion over tax revenue while they are required to spend the vast majority of natural resource royalties on the outcomes of interest. The higher required propensity to spend revenue from royalties on these outcomes should lead to the effect of natural resource royalties being mechanically larger than the effect of tax revenue. Therefore, the comparison I carry out is biased, but the bias works against the hypothesis that I want to test.

An additional reason to study the four chosen indicators of local public good provision is because they are a valuable source of information on local living conditions. In fact, the specified targets are closely related to the attainment of some of the United Nations' Millenium Development Goals (MDG), such as achieving universal primary education, reducing under-five mortality by two thirds and halving the share of people without access to clean water and sanitation.

Panel E. in Table 1.2 provides summary statistics for the four main outcome variables, while Table A1 in the appendix uses data from the World Development Indicators (WDI) to compare Colombia's social indicators with those of eleven other Latin American countries around the start of the sample period.[22]

[22]The countries I consider are Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador,

This comparison reveals that the country was lagging in primary educational enrolment and had intermediate results in health and water.

Table 1.2 shows that the net enrolment rate in basic education (five years of primary plus four years of secondary) is 88 % on average in the sample. According to the WDI from 2004 (column 2 in Table A1), Colombia ranked last in net primary enrolment (tied at 92 % with Bolivia and Venezuela). However, column 3 in Table A1 shows that net secondary enrolment was tied for third place at 63 %, outperforming Ecuador, Panama, Paraguay and Venezuela.

Regarding health, Table 1.2 shows that the average infant mortality rate in the sample is 22.8 per 1,000. Column 4 in Table A1 reveals that for this same indicator Colombia ranked sixth out of the twelve countries considered with 19 deaths per 1,000 infants in 2004. Going back to Table 1.2, 87 % of the poor population is covered by subsidized health insurance on average. Although there is no comparable data in the WDI, female life expectancy can provide us with a sense of where Colombia stands in terms of health within Latin America (without being biased due to the negative effects of internal armed conflict). Female life expectancy in Colombia is the seventh highest in the region (tied with Venezuela) at 76 years.

Finally, the average value of the IRCA water quality index in the sample is 29.38 (where less is better and below 5 is considered suitable for human consumption). Looking at the percentage of urban population with access to improved water sources in column 6 of Table A1, Colombia was sixth with 97 %. The country also ranked sixth (tied with Brazil and Mexico) in the percentage of urban population with improved sanitation facilities. However, data from the 2005 population census indicates that there is a substantial urban-rural disparity in water provision, with 91 % of the urban population having access to drinking water but only 46 % of the rural population having so, on average.

1.3.3. Identification Strategy

The objective of the empirical exercise is to estimate the causal effect of property tax revenue and oil royalties on the indicators of public good provision discussed above. I exploit the availability of panel data to estimate a series of models that include as controls both municipality and department-year fixed effects. I am thus able to control for persistent heterogeneity across municipalities as well as for common shocks affecting all municipalities simultaneously, allowing for these time effects to be potentially heterogeneous

Mexico, Panama, Paraguay, Peru, Uruguay and Venezuela.

across departments.

Still, OLS estimates of the parameters of interest could be affected by reverse causality or omitted variable bias. For example, an increase in the demand for social services within a municipality over time may induce the local government to raise more taxes in order to be able to finance them. Similarly, the observed variation in oil royalties may reflect changes in other factors that can potentially affect the outcomes of interest, such as the discovery of new oil fields or an improvement in security conditions.

To address these concerns, I employ a source of plausibly exogenous variation for each source of revenue and I obtain instrumental variables (IV) estimates of the parameters of interest. More specifically, I exploit the timing of cadastral updates and the fluctuations in the world price of oil as sources of plausibly exogenous variation in property tax revenue and in oil royalties, respectively.

The following two sub-sections discuss the choice of instrumental variable for each source of revenue. The third sub-section presents the regression specifications for both the reduced form and the IV models.

Cadastral Updates and Property Tax Revenue

I use the timing of cadastral updates by IGAC as a source of exogenous variation in property tax revenue. Colombian law requires municipal cadastres to be updated every five years, but this condition is rarely satisfied. During the sample period, the average urban update takes place 11.4 years after the previous one, while the average rural update occurs 12.7 years after the last one. I address potential concerns about the endogenous timing of cadastral updates in several ways. I provide evidence against selection on observables and unobservables and I show that the timing of updates is driven for the most part by IGAC's supply, whose main criterion is the age of the current cadastre. I also provide suggestive evidence on an exogenous shock to the supply of updates, which led to a significant increase in the number of updates during the sample period. Furthermore, I provide evidence on municipalities' limited ability to manipulate property tax revenue following a cadastral update.

As a first validation exercise I check that the timing of a cadastral update is not correlated with changes in other observable municipal characteristics. I do this by estimating a series of bivariate regressions:

$$\left\{ \mathrm{D}(\text{update})_{i,j,t+1} = \alpha_i + \delta_{j,t} + \beta_k X^k_{i,t} + \epsilon_{i,j,t} \right\}_{k=1}^{K} \tag{1.1}$$

where $X_{i,t}^k$ is a time-varying characteristic indexed by k and D(update) is a dummy equal to one the year before the update comes into effect. I define the dependent variable in this way to account for the fact that updates that take place in year t only come into effect on January 1st of year $t+1$. I include municipality (α_i) and department-year ($\delta_{j,t}$) fixed effects to ensure that I look at the variation that I will exploit in the main regressions.

I study thirty observable characteristics, which are listed in the left-most column of Table 1.3. I test for disproportionate increases in births, migration and urbanization around the time of an update using the natural log of population and the share of rural population. I look at other sources of revenue (other taxes, transfers, royalties) to check whether cadastral updates try to offset or to complement other changes in revenue. For instance, if municipalities were updating the cadastre to be able to exploit a good investment opportunity in social services, we would expect them to also try to raise more revenue from other sources. Similarly, if cadastral updates were caused by an unobserved improvement in public administration, we would also expect to observe increases in revenue from other local taxes.

I also check whether cadastral updates coincide with observable changes in local political characteristics using data from elections across all levels of government: municipal (mayor, council), departmental (governor) and national (president, congress). I construct indicators for political competition, such as the number of candidates for mayor, the number of parties running for council (per seat) and the vote shares of the winning mayor, departmental governor and president. I also construct Herfindahl–Hirschman concentration indices for mayor, council and congress elections. I study the party affiliation of the mayor, including whether it is different from that of the previous incumbent, whether it is the same as that of the departmental governor and the share of council members that belong to the mayor's party.

I consider the possibility that update years coincide with changes in the implementation of some national policies, such as the number of families enrolled in the conditional cash-transfer program *Familias en Acción* and the value of new loans made by the central government's agricultural bank, *Banco Agrario*. I also examine if cadastral updates are correlated with visits to the municipality by President Alvaro Uribe. During his eight years in office, President Uribe held a government meeting in a different municipality every week and these visits led to significant policy commitments (Tribín, 2014). Finally, I look at indicators on crime, illegal armed group presence and cultivation of narcotics

to test for the possibility that conflict intensity or criminality improve around the time of an update.

Estimates of equation (1.1) for each of the variables mentioned above are presented in columns 1 and 2 of Table 1.3. Only one of the thirty variables considered, the number of parties participating in council elections, has a statistically significant correlation with the timing of cadastral updating.[23] Although this correlation can be explained as a result of sampling error, I verify that the results below are robust to including this or any other variable as a control (available upon request). Columns 3 and 4 show results from an expanded specification that includes dummy variables for the first five years after urban and rural updates as controls. The results are essentially unchanged, which indicates that the point estimates are not attenuated by the very low probability of a new update in the years right after the last one.

Although I am unable to definitely rule out that variation in unobservables is affecting the decision to update, it is not easy to think of changes in unobserved characteristics that would not be picked up by the observable characteristics studied in Table 1.3. Additionally, I show below that the main results are robust to the substitution of municipality fixed effects for the more stringent municipality-term fixed effects, which capture any unobserved within-municipality heterogeneity across local political terms.

One potential driver of cadastral updating is growth in the housing market. As property values increase, municipal governments may find it more attractive to update the cadastre in order to capture some of these higher values in the form of property tax revenue. I test for this possibility by comparing the implied yearly growth rates of property values of updates that occur close to the previous one, which are unusual and more suspicious of selection, to those that occur later.

[23] Sánchez and Pachón (2013) and Sánchez and España (2013) report results from similar regressions using a logit model. Although these authors find significant correlations with transfers, income and some political characteristics, the difference is probably driven by the lack of municipality fixed effects in those estimations.

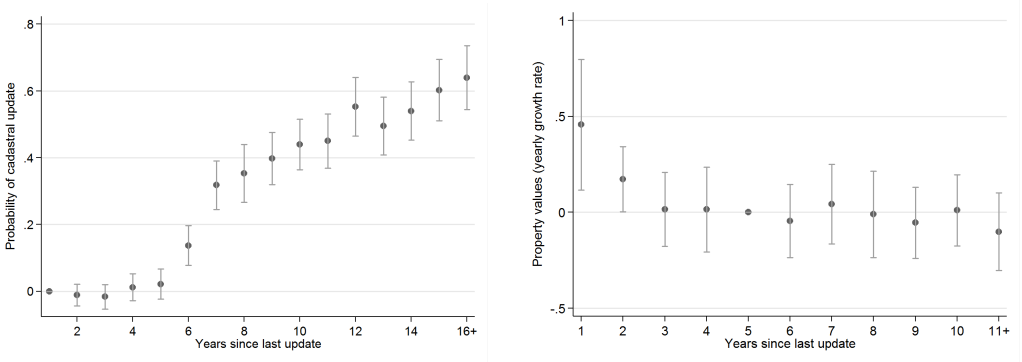
Table 1.3: Predicting a cadastral update

	No controls		Controls for recent updates			
Variable	Coefficient	Standard error	Coefficient	Standard error	Municipalities	Observations
	(1)	(2)	(3)	(4)	(5)	(6)
ln population	0.279	(0.178)	0.0190	(0.195)	969	6,704
rural share of population	-0.764	(0.707)	-0.156	(0.617)	969	6,704
ln non-property tax revenue	0.00215	(0.00990)	0.0105	(0.00975)	969	6,704
ln total transfers	-0.0135	(0.0235)	0.0143	(0.0225)	969	6,704
natural resource royalties	3.79e-06	(2.70e-05)	-2.00e-06	(3.36e-05)	969	6,704
ln capital revenue	-0.0148	(0.0173)	-0.00397	(0.0166)	969	6,704
# candidates last mayor election	0.00407	(0.00413)	-0.00143	(0.00450)	968	6,160
vote share for winning mayor	0.0284	(0.0588)	0.0732	(0.0558)	968	6,160
HHI last mayor election (votes)	0.0231	(0.0608)	0.0436	(0.0582)	968	6,160
D(left-wing mayor)	0.0270	(0.0313)	0.0146	(0.0331)	968	6,160
D(Liberal mayor)	-0.00530	(0.0185)	0.00487	(0.0182)	968	6,160
D(Conservative mayor)	0.0220	(0.0179)	0.0272	(0.0167)	968	6,160
D(change of mayor's party)	-0.00149	(0.0200)	-0.000459	(0.0195)	790	5,432
parties/seat last council election	-0.0644*	(0.0391)	-0.0845**	(0.0367)	969	6,624
HHI last council election (seats)	-0.0638	(0.0648)	-0.0145	(0.0715)	969	6,624
share of council from mayor's party	-0.0548	(0.0375)	-0.0474	(0.0370)	965	6,136
share of council from left-wing parties	0.0148	(0.0710)	0.0270	(0.0731)	969	6,624
vote share for winning governor	0.0208	(0.0453)	0.0102	(0.0438)	969	6,678
D(mayor and governor from same party)	-0.0153	(0.0198)	0.00640	(0.0208)	968	6,154
vote share for winning president	0.00457	(0.0588)	0.0152	(0.0585)	969	6,670
HHI last House election (votes)	0.0549	(0.0617)	0.0229	(0.0586)	968	6,678
HHI last Senate election (votes)	0.0157	(0.0493)	0.00896	(0.0462)	968	6,678
D(Uribe visit)	0.0387	(0.0417)	0.0354	(0.0357)	969	6,704
new families in CCT program	0.000191	(0.000276)	0.000147	(0.000254)	969	6,704
value of new agricultural loans	2.72e-05	(8.88e-05)	6.73e-05	(9.40e-05)	969	6,704
D(municipality certified in education)	0.0320	(0.0750)	0.0370	(0.0823)	969	6,704
homicide rate	-0.000120	(0.000159)	-9.62e-05	(0.000160)	969	6,704
FARC events	-0.000452	(0.00168)	0.000264	(0.00151)	966	5,743
ELN events	-0.00375	(0.00324)	-0.00486	(0.00351)	966	5,743
D(coca crops)	-0.00913	(0.0316)	0.0192	(0.0309)	969	4,797

Notes: Each row corresponds to a different regression of a dummy equal to one the year before a cadastral update comes into effect on the respective variable. All regressions include municipality fixed effects and department-year fixed effects. Columns 3 and 4 show estimates from an enlarged specification that also includes as controls separate dummy variables for the first five years after an urban or rural update. Standard errors clustered two-way by municipality and by department-year. The number of observations varies due to data availability. *** p<0.01, ** p<0.05, * p<0.1

I first illustrate the time path of cadastral updates by regressing an update year dummy on a full set of indicators for the number of years since the previous update, leaving the year immediately after an update as the omitted category. The results from this regression (which includes municipality and department-year fixed effects) are shown in panel (a) of Figure 1.2. The probability of a new cadastral update is very low in the five years following the last one, it then jumps by more than thirty percentage points between the fifth and seventh year and it rises smoothly from the eight year onwards.

Figure 1.2: Probability of cadastral updating and growth in property values



(a) Probability of Update **(b)** Growth in Property Values

Note: Panel (a) shows results from a regression of the cadastral update dummy on a full set of indicators for the number of years since the previous update. The regression includes municipality and department-year fixed effects. Standard errors clustered two-way by municipality and department-year. Omitted category is one year after last update. Panel (b) shows results of a cross-sectional regression including only observations with a cadastral update. The implied growth rate in property values (based on the last update or year 2000) is regressed on a full set of the number of years since the last update. The regression includes department-year fixed effects. The standard errors are clustered by province. The omitted category is five years after last update.

I use the total property values revealed by the cadastral updates for each municipality to construct the implied yearly growth rate in property values.[24] I then use the cross-sectional sample of cadastral updates and regress the growth rate on the dummies for the different number of years since the previous update, leaving the fifth year after an update as the omitted category for ease of interpretation. The results from this regression are shown in panel (b) of Figure 1.2. The estimates indicate that with the exception of updates occurring one or two years after the last one, which are truly exceptional, the growth rate

[24]For municipalities for which I do not observe at least two updates after 2000, which is the first year for which I have data on property values, I use the property values from 2000 as baseline.

in property values is not heterogeneous by the number of years since the last update, despite the large underlying differences in the probability of updating. In other words, a cadastral update that takes place four years after the last one, which is very unusual and hence suspicious of selection bias, reveals the same yearly growth rate in property values as a much more likely update that takes place ten years after the last update.

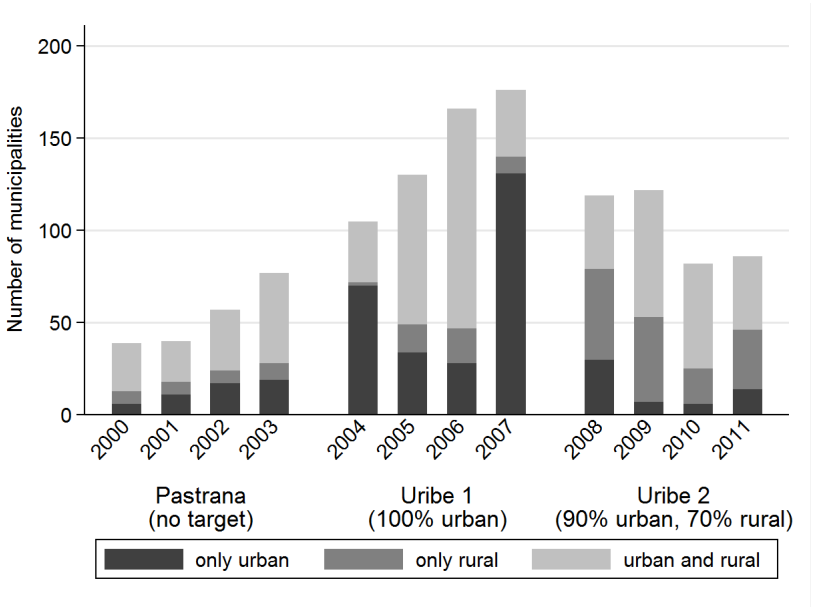
The previous exercises suggest that municipalities have a limited ability to manipulate the timing of cadastral updates. I now provide additional evidence that indicates that cadastral updating is mainly determined by the supply of updates from IGAC. The first piece of evidence comes from the pre-selection of municipalities for cadastral updating that is done by IGAC at the start of every year. This information is not publicly available but I had access to the lists of municipalities prioritized by IGAC in 2011 and 2012. Matching these lists with the actual updates that took place each year, I find that 80 % of updaters were in IGAC's initial list and that 68 % of those pre-selected actually updated. These numbers indicate that although there is room for selection into and out of updating at the margin, the bulk of updates are determined by IGAC. Furthermore, when I estimate equation (1.1) with a dummy for inclusion in the list as dependent variable, I find that the only robust predictors of inclusion are the number of years since the last urban and rural updates (results available upon request). This is consistent with IGAC's objective of keeping the cadastres as up-to-date as possible.

The second piece of evidence on IGAC's authority over the timing of cadastral updates is based on the effect that the incentives provided to IGAC by the central government during the sample period had on the number of updates and their type. Alvaro Uribe included as part of his official government goals for his first term as President (2002-2006) to have the urban cadastres of all municipalities up to date (updated in the last five years). For his second administration (2006-2010), Uribe set as goals for IGAC to have 90 % of urban cadastres and 70 % of rural cadastres up to date. As Figure A1 shows, these targets were binding constraints for IGAC throughout the sample period. Additionally to these incentives, the central government used an IDB loan to provide funding for the cadastral updates of the urban areas of 145 municipalities in 2007.

Figure 1.3 shows the number of updates per year and their type. The graph indicates the president in office each year, bearing in mind once again that there is a one-year lag in the validity of updated cadastres. The graph shows

that the number of updates, particularly urban ones, increased dramatically between 2004 and 2007, which coincides with the introduction of incentives for this type of update by the first Uribe administration. After 2007, the number of updates per year remains relatively high, but we observe a shift towards rural updates, which coincides with the introduction of incentives for this type of update by the second Uribe administration.

Figure 1.3: Cadastral updates per year and presidential term



Note: I assign to each administration its first full calendar year (since presidential terms always start on August 7th) and the three following ones. Each term is then pushed back by one year to account for the fact that updated cadastres only come into effect the 1st of January of the following year.

As a result of the increased supply of updates, 60 % of the municipalities in the sample had a cadastral update between the years 2006 and 2010. These are the update cohorts that I employ for the estimations below. The map in Figure 1.4b shows that the municipalities belonging to these update cohorts are evenly distributed throughout the country.

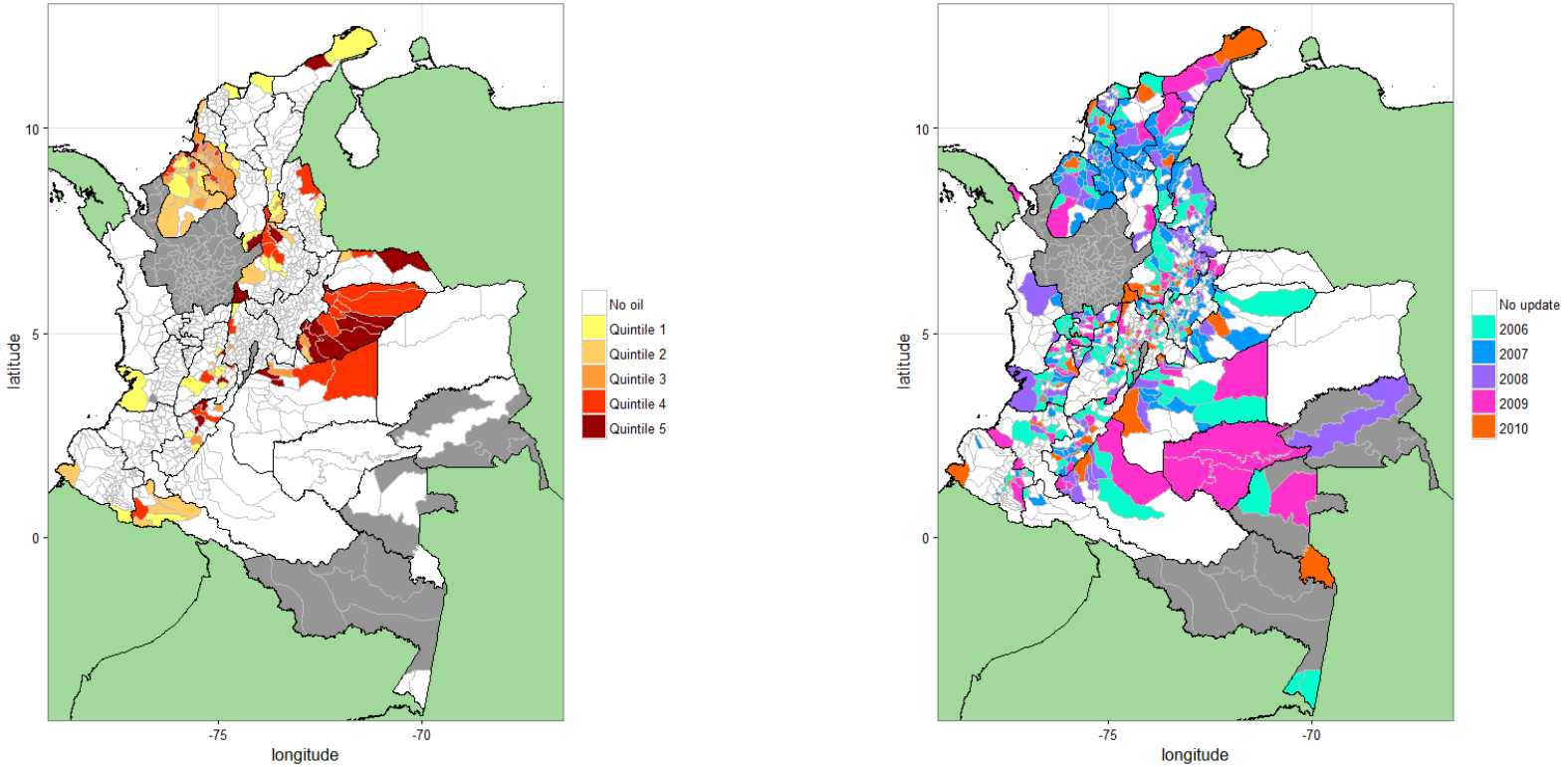
I further use the yearly variation in the supply of updates to look for evidence on selection into cadastral updating. I consider the possibility that municipalities are intentionally updating to collect more tax revenue and I try to get a sense of the size of this selection effect by comparing the effect of updating on tax revenue across update cohorts. This exercise is motivated by the large variation in number and type of updates shown in Figure 1.3, which potentially reflects large differences in the composition of the update pool. For this purpose, I regress property tax revenue on a set of separate post-update dummies for each cohort between 2002 and 2011 (including municipality and

department-year fixed effects). The results, shown in Figure 1.5, indicate that cadastral updating leads to a 25 % increase in property tax revenue, with the return being very homogeneous across cohorts. More specifically, I am unable to reject the null hypothesis that the return in tax revenue is the same for all cohorts between 2002 and 2011, despite the large differences in the number and type of updates across cohorts illustrated in Figure 1.3.

Taken together, the available evidence indicates that municipalities have a limited ability to manipulate the timing of the cadastral updates and that this timing is mainly driven by the supply from IGAC. However, municipalities have discretion over how much taxes to collect. Autonomy over tax collection could be a problem if, for instance, only the municipalities with good investment opportunities collect more taxes after a cadastral update. Figure 1.5 already suggests that municipal governments do not enjoy large discretion over tax collection conditional on updating the cadastre. I provide additional evidence on the limited ability of municipalities to manipulate statutory tax rates using data from Iregui et al. (2003) for 211 municipalities between 1999 and 2002. I regress the statutory property tax rate on a dummy for the years after a cadastral update, including municipality and year fixed effects. The estimates in Table A2 are very small and statistically insignificant, indicating that municipalities do not adjust statutory rates in response to cadastral updates.[25] Finally, in Figure 1.6 I plot the average change in property tax revenue after a cadastral update for the 2006-2010 update cohorts (relative to the year before the update). The graph shows that the number of "compliers" is fairly large, as roughly 75 % of updates lead to an increase in property tax revenue.

[25]Sánchez and España (2013) provide additional evidence from interviews with public officials from several Colombian municipalities on the stickiness of statutory property tax rates.

Figure 1.4: Municipalities with cadastral update and oil-royalty recipients

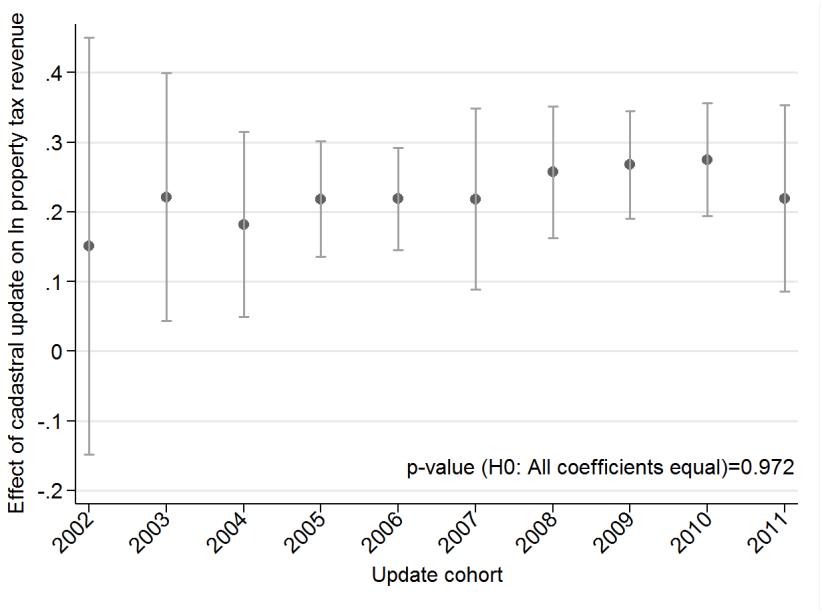


(a) Average oil royalties between 2000 and 2004

(b) Cadastral updates between 2006 and 2010

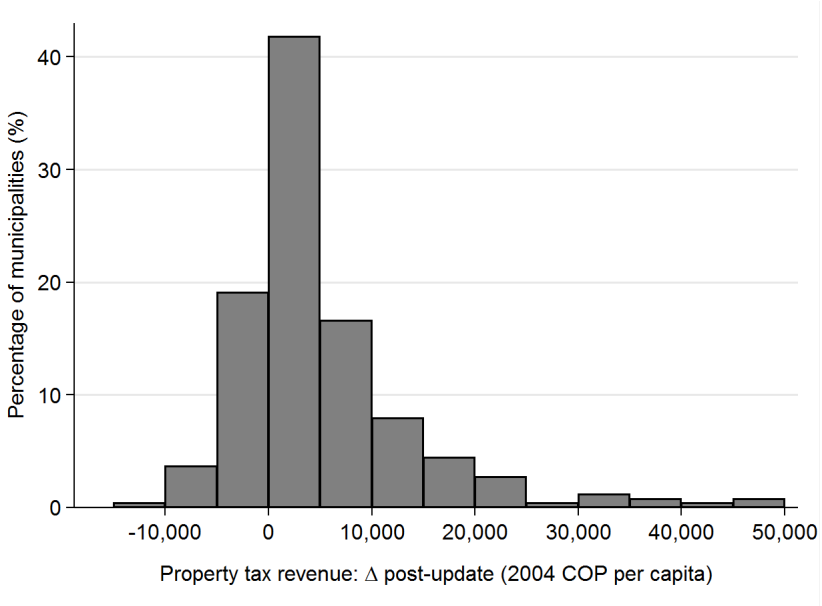
Note: Panel (a) shows average oil royalties between 2000-2004. Municipalities in white did not receive oil royalties in this period while the darker shades correspond to quintiles of the average oil-royalty distribution among royalty recipients. Panel (b) indicates the year in which municipalities had their first cadastral update in the period 2006-2010. In both maps, areas in grey correspond to municipalities that are excluded from the sample. This includes municipalities with their own cadastral agencies (Bogota, Medellin, Cali, Antioquia) and non-municipalized territories.

Figure 1.5: Cadastral updating and property tax revenue



The graph shows point estimates and 95 % confidence intervals for a regression of ln property tax revenue per capita (2004 COP) on a set of dummies equal to one from year t onward if the municipality has a cadastral update on year t, weighted by the share of the cadastre that was updated (depending on whether the update was urban, rural or both). I use property values from 2000 to determine the shares. The regression includes municipality and department-year fixed effects. Standard errors clustered two-way by municipality and department-year.

Figure 1.6: Change in property tax revenue after a cadastral update



The graph shows the histogram for the difference between the average property tax revenue collected after a cadastral update and the amount for the year before the update. Top and bottom 1 % removed for ease of visualization. Property tax revenue in 2004 COP per capita. Update cohorts from 2006 to 2010. Pre-year corresponds to the first one in the case of multiple updates.

Oil Price Shocks and Natural Resource Royalties

The second part of the identification strategy exploits plausibly exogenous variation in the world price of oil, the heterogeneous distribution of this resource across Colombian municipalities and the royalty allocation formula discussed in the background section.[26] In this case, identification is based on two assumptions. The first one is that the world price of oil is exogenous to local conditions in Colombian municipalities. This is a plausible assumption because Colombia is a relatively small exporter of oil. According to the US Energy Information Administration, Colombia is the 18th largest exporter of oil with less than 1 % of world exports.

As a measure of oil abundance I use the average amount of oil royalties received by the municipality between 2000 and 2004 ($\text{royalties}^{\text{oil}}_{i,00-04}$). I use this five-year average to address potential concerns related to regression to the mean in oil royalties. The second assumption necessary for identification is that any systematic differences between municipalities with different levels of oil abundance are time-invariant and thus captured by the municipality fixed effects.

By interacting the average 2000-2004 oil royalties with the world oil price index for a given year I obtain an indicator of predicted royalties if oil output stays at the average pre-sample period level and the only variation is that coming from world price fluctuations. The variation resulting from oil discoveries, for example, is not exploited by this research design. What I exploit is the differential impact of variation in the price of oil in municipalities with varying levels of average oil extraction in the previous years.

Figure 1.7a provides an illustration of the identification strategy for royalties. The black line in the graph corresponds to the world oil price index (right axis). The price of oil increased up to 2008, crashed in 2009 as a result of the global financial crisis and recovered in the last two years of the sample period. The figure also shows point estimates and 95 % confidence intervals (left axis) from the following regression:

$$\text{royalties}_{i,j,t} = \alpha_i + \delta_{j,t} + \sum_{k=2006}^{2011} \beta_k \left[D(\text{year} = k)_t \times D(\text{oil royalties} > 0)_{i,00-04} \right] + \epsilon_{i,j,t} \tag{1.2}$$

where the dependent variable is royalties per capita in municipality i from department j in year t. α_i and $\delta_{j,t}$ are municipality and department-year fixed

[26] This type of difference-in-differences methodology has been widely used in recent studies on Colombia. See, for example, Dube and Vargas (2013); Carreri and Dube (2015); Santos (2014); Idrobo et al. (2014).

effects, respectively. The coefficients of interest β_k capture the average yearly royalties among the set of oil-rich municipalities (positive oil royalties between 2000 and 2004) relative to 2005, which is the omitted year. The graph shows that royalties in these oil-producing municipalities track the yearly variation in the price of oil: higher oil prices lead to more royalties. The results also illustrate the large amount of revenue provided by oil royalties to these municipalities. For example, when the price of oil was at its peak in 2008, the average oil-rich municipality received 100,000 COP per capita of royalties above of what it had received in 2005. This corresponds to 20 % of the total yearly revenue per capita of the average municipality in the sample, according to Table 1.2.

The map in Figure 1.4a shows sextiles of the distribution of (positive) average oil royalties between 2000 and 2004. Even though oil royalties are geographically clustered in areas where there is oil, there is still substantial within-region variation in oil intensity. The inclusion of department-year fixed effects in all regressions ensures that I only exploit within-department variation in oil intensity. A comparison with the map in Figure 1.4b additionally shows that there is substantial overlap between oil-royalty recipients and municipalities with a cadastral update. This allows me to verify that any differential effects across sources of revenue are not driven by systematic differences in the use of revenue across municipalities irrespective of the source.

Reduced Form and Instrumental Variables Specifications

In what follows I use two main specifications. I show reduced-form effects of cadastral updating and predicted oil royalties using the following model:

$$\mathrm{y}_{i,j,t} = \alpha_i + \delta_{j,t} + \gamma_T \mathrm{D}(\text{post-update})_{i,t} + \gamma_R \left[\text{price}_t^{\text{oil}} \times \text{royalties}_{i,00-04}^{\text{oil}}\right] + \epsilon_{i,j,t} \tag{1.3}$$

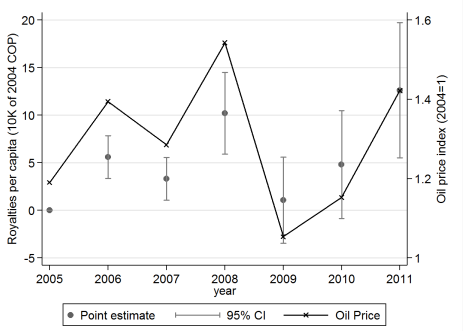
where $\mathrm{y}_{i,j,t}$ is an outcome of interest and α_i and $\delta_{j,t}$ are municipality and department-year fixed effects, respectively. The standard errors are clustered two-way by municipality and department-year following Cameron et al. (2011).

I estimate the effects of tax revenue and royalties on the outcomes of interest using an instrumental variables model:

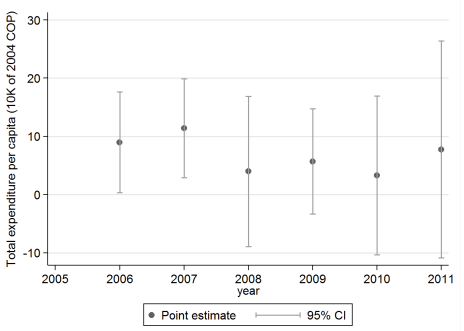
$$\mathrm{y}_{i,j,t} = \alpha_i + \delta_{j,t} + \beta_T \text{property } \widehat{\text{tax}} \text{ revenue}_{i,t} + \beta_R \text{natural } \widehat{\text{resource}} \text{ royalties}_{i,t} + u_{i,j,t} \tag{1.4}$$

where the cadastral update dummy and the predicted oil royalties are used as instruments for tax revenue and natural resource royalties, respectively.

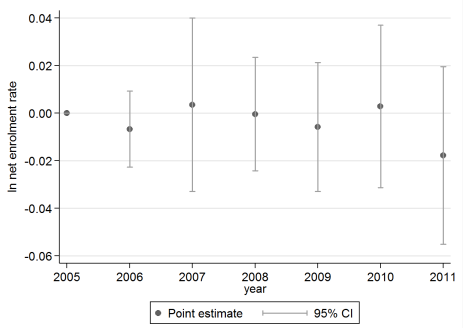
Figure 1.7: Medium-run impact of oil price shocks



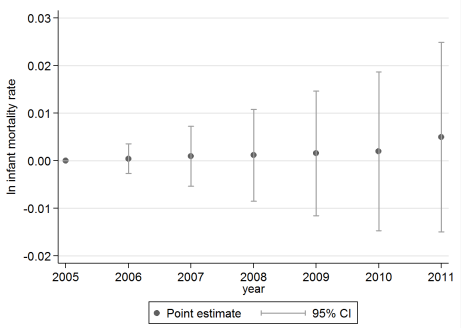
(a) Royalties



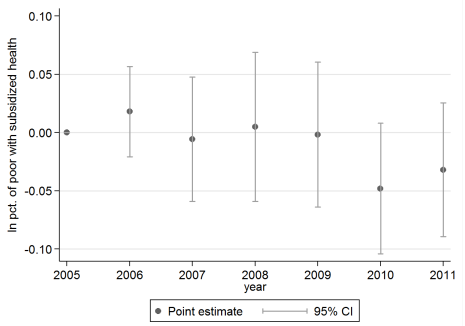
(b) Expenditure



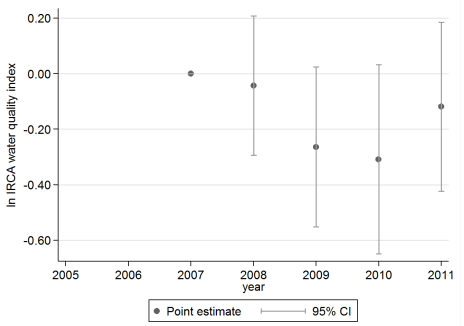
(c) Educational enrolment



(d) Infant mortality



(e) Health insurance



(f) Water quality

Note: Each graph shows point estimates and 95 % confidence intervals from a regression of the variable in the caption on a set of year interactions (2006-2011) with a dummy for municipalities with positive oil royalties between 2000 and 2004. The sample period is 2005-2011. All regressions include municipality and department-year fixed effects. Standard errors are clustered by province. In panel (a), the dark line shows the oil price index (2004=1), constructed with the average petroleum spot price (IMF/IFS), the exchange rate from Banco de la República and the Consumer Price Index from DANE.

To account for the fact that there may be a lag in the expenditure of royalties, I also show estimates of modified versions of equations 1.3 and 1.4 that include cumulative royalties ($\sum_{k=2006}^{t} \text{royalties}_{i,k}$) instead of its contemporary value. This is a more flexible specification as it allows for the effect of royalties to manifest at a later date than when they are collected. Since the municipality fixed effect absorbs all royalties up to 2005, the cumulative is actually a partial one since 2005. As an instrument for cumulative royalties I use the cumulative of predicted royalties: $\sum_{k=2006}^{t} \text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{k}$.

Table 1.4 shows the results from the first-stage regressions. Column 1 shows that cadastral updating leads on average to an increase of 6,000 COP per capita in property tax revenue. Column 2 shows that a one COP per capita increase in predicted oil royalties leads to a 0.85 COP per capita increase in royalties. The results for cumulative royalties, shown in column 3, are very similar. One extra peso of predicted cumulative royalties leads to 0.8 extra pesos of actual cumulative royalties. The three estimates are statistically different from zero at the 1 % level.

Table 1.4: First-stage results

VARIABLES	(1) Property Tax	(2) Royalties	(3) Royalties (cumulative)
D(post-cadastral-update)$_{i,t}$	0.629***		
	[0.126]		
$\text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{t}$		0.851***	
		[0.184]	
$\sum_{k=2006}^{t} \text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{k}$			0.806***
			[0.0584]
Dependent variable mean	2.075	5.449	34.233
- if oil-royalty recipient (00-04)	-	24.861	166.768
Observations	6,704	6,704	6,704
Number of municipalities	969	969	969

Notes: Dependent variable in the header. Money variables in tens of thousands of 2004 COP per capita. All regressions include municipality and department-year fixed effects. Sample period: 2005-2011. Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

1.4. Results on Public Good Provision

1.4.1. Main Results

Table 1.5 shows the main results of the chapter. Panel A shows reduced-form estimates of the effect of the instruments on the outcomes of interest. The dependent variable is specified in the header of each column. Columns 1-4 look at the continuous variables (in logs), while columns 5-8 look at dummy variables for the achievement of the targets from Table 1.1. Panel B shows the corresponding IV estimates.

The results in columns 1-4 of panel A indicate that cadastral updating leads to a 0.8 % increase in educational enrolment and to a 12 % increase in water quality, with both effects statistically significant at the 5 % level. The effect on the percentage of the poor with subsidized health insurance is also positive (1.2 % increase), but not statistically significant. In the case of infant mortality, the point estimate for tax revenue is positive, but the effect is very small and statistically insignificant. The results in the second row show that a 10,000 COP per capita increase in predicted royalties leads to a 1 % increase in the water quality index. This effect is significant at the 10 % level. The estimates for the other indicators are all very small and statistically insignificant.

According to the IV estimates in columns 1-4 of panel B, which scale the reduced-form estimates by the corresponding change in revenue, a $10,000 COP per capita increase in property tax revenue leads to a 1.4 % increase in educational enrolment and to a 14 % increase in the water quality index. These effects are larger than those of an equivalent increase in royalties by more than one order of magnitude and the difference is statistically significant at the 5 % and 10 % levels, respectively. The results for subsidized health insurance point in the same direction but the difference is not statistically significant. Overall, there is no evidence that natural resource royalties have a positive effect on any of the outcomes.

Table 1.5: Sources of revenue and public good provision

	natural log [columns 1-4]				D(target achievement) [columns 5-8]			
VARIABLES	(1) Educational enrolment	(2) Infant mortality	(3) Health insurance	(4) Water quality	(5) Educational enrolment	(6) Infant mortality	(7) Health insurance	(8) Water quality
				PANEL A: REDUCED FORM				
D(post-cadastral-update)$_{i,t}$	0.00886***	0.00295	0.0120	0.123**	0.0133	-0.000557	0.0313*	0.0760***
	[0.00334]	[0.00210]	[0.00850]	[0.0560]	[0.0134]	[0.0109]	[0.0174]	[0.0219]
royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$	0.000119	1.87e-05	-0.000419	0.0112*	0.00136*	7.26e-05	-0.00178	0.00275
	[0.000101]	[2.27e-05]	[0.000751]	[0.00626]	[0.000820]	[7.75e-05]	[0.00142]	[0.00356]
				PANEL B: IV				
property tax revenue$_{i,t}$	0.0142**	0.00472	0.0189	0.145*	0.0220	-0.000855	0.0491*	0.0897***
	[0.00616]	[0.00357]	[0.0136]	[0.0778]	[0.0209]	[0.0174]	[0.0288]	[0.0285]
natural resource royalties$_{i,t}$	0.000231	5.23e-05	-0.000372	0.0113	0.00175	7.99e-05	-0.00177	0.00317
	[0.000162]	[3.93e-05]	[0.000851]	[0.00805]	[0.00118]	[0.000164]	[0.00189]	[0.00376]
1st stage F-statistic	14.604	14.604	14.604	8.126	14.604	14.604	14.604	8.126
p-value H0:tax=royalties	0.022	0.187	0.156	0.086	0.325	0.957	0.074	0.0002
Dependent variable mean in 2005 (level)	86.1	24.2	74.3	30.5	0.15	0.16	0.15	0.18
Observations	6,704	6,704	6,704	4,467	6,704	6,704	6,704	4,467
Number of municipalities	969	969	969	937	969	969	969	937

Notes: Dependent variable in the header: in columns 1-4 the dependent variable is in natural log, while in columns 5-8 it is a dummy for target achievement. Money variables in tens of thousands of 2004 COP per capita. In panel B, D(post-cadastral-update) and royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$ are used as instruments for property tax revenue and natural resource royalties, respectively. All regressions include municipality-term and department-year fixed effects (sample period: 2005-2011, except column 4: 2007-2011). Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

The results on target achievement in columns 5-8 of Table 1.5 paint a similar picture. The reduced-form estimates in panel A indicate that a cadastral update increases the probability of having universal coverage of poor population with subsidized health insurance by 3 percentage points. This is a relatively large effect, given that only 15 % of municipalities met this target in 2005, and it is also statistically significant at the 10 % level. Column 4 additionally shows that a cadastral update leads to an increase of 7.6 percentage points in the probability that water in the municipality is suitable for human consumption. The IV results in panel B indicate that these positive effects of tax revenue on target achievement in the areas of health and water are significantly different from those of natural resource royalties at the 10 % and 1 % levels, respectively. None of the point estimates for royalties in panel B are statistically different from zero and they are all very small.

These results indicate that locally-raised property tax revenue has a positive effect on public service provision in the areas of education, health and water. I find a positive effect of property tax revenue on educational enrolment but not on the probability of full enrolment, which indicates that the increases in enrolment are taking place in municipalities farther away from the target. Property tax revenue has a positive effect on the percentage of poor population with subsidized health insurance and on the probability of universal coverage, but the estimate is only statistically significant for the latter. This suggests that the increases in coverage are coming from municipalities that are close to meeting the target. The lack of an effect on infant mortality should not surprise us, as this is a complex indicator that only partially depends on the supply of health services by public authorities. For instance, only 1 % of deaths during the first five months of life in 2001 were due to diseases preventable through vaccination (MPS, 2005).

The reported effects of property tax revenue on public goods are at least ten times larger than and statistically different from those of an equivalent increase in royalties from the extraction of natural resources. These differences are particularly striking as natural resource royalties are earmarked for expenditure on the specific set of public goods that I study. Despite the resulting bias in favour of royalties, I find no robust evidence of an effect on the indicators of public service provision.

1.4.2. Robustness Checks and Alternative Explanations

In this section I explore several alternative explanations for the previous findings. The first one is that the effect of revenue on public goods is different in municipalities that update the cadastre and in those that receive natural resource royalties, irrespective of the source. To address this possibility, in Table 1.6 I explore whether the reduced-form effect of cadastral updating is heterogeneous by average 2000-2004 oil royalties. I find no evidence of such a heterogeneity. In all specifications the point estimates for the interaction between cadastral updating and oil intensity are very small and never statistically different from zero. Furthermore, I can reject the null hypothesis that cadastral updating has no effect on educational enrolment, water quality and subsidized health insurance for the poor at the median and mean levels of positive oil royalties.

Table 1.6: The effect of cadastral updates in oil-royalty recipients

VARIABLES	(1) Educational enrolment	(2) Infant mortality	(3) Health insurance	(4) Water quality
PANEL A: NATURAL LOG				
D(post-cadastral-update)$_{i,t}$	0.00897***	0.00318	0.0127	0.122**
	[0.00333]	[0.00211]	[0.00863]	[0.0558]
D(post-cadastral-update)$_{i,t}$ × royalties$^{oil}_{i,00-04}$	-4.48e-05	-7.61e-05	-0.000185	-0.00140
	[0.00109]	[0.000873]	[0.00284]	[0.0312]
p-value H0: effect for median non-zero oil royalties=0	0.009	0.174	0.163	0.040
p-value H0: effect for mean non-zero oil royalties=0	0.021	0.375	0.259	0.126
PANEL B: D(TARGET ACHIEVEMENT)				
D(post-cadastral-update)$_{i,t}$	0.0149	-0.000777	0.0309*	0.0751***
	[0.0133]	[0.0110]	[0.0174]	[0.0221]
D(post-cadastral-update)$_{i,t}$ × royalties$^{oil}_{i,00-04}$	-0.000611	6.54e-05	0.000257	-0.000145
	[0.000837]	[0.000111]	[0.000515]	[0.00113]
p-value H0: effect for median non-zero oil royalties=0	0.365	0.964	0.064	0.001
p-value H0: effect for mean non-zero oil royalties=0	0.792	0.978	0.057	0.008
Observations	6,704	6,704	6,704	4,467
Number of municipalities	969	969	969	937

Notes: Dependent variable in the header. The mean of non-zero 2000-2004 average oil royalties is 16.45, the median is 4.39 (tens of thousands of 2004 COP). All regressions include municipality and department-year fixed effects (sample period: 2005-2011 except column 4: 2007-2011). Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

I explore the possibility that the results on cadastral updates are driven by unobservable changes in local government by checking whether the results are robust to the inclusion of municipality-term fixed effects. The results in Table A4 show that even with this more stringent specification there is still a statistically significant difference between the two sources of revenue for

educational enrolment and for the probability of having water suitable for human consumption.

I also consider the possibility that the extremely low return of natural resource royalties is specific to royalties from the extraction of oil. I use data on the royalties from the extraction of coal in 2004 and on the world price of this resource to construct an indicator of predicted coal royalties. Table A7 shows estimates of equations (1.3) and (1.4) for coal royalties. The results are qualitatively and quantitatively similar to the ones for oil.

Another alternative explanation is that the effect of natural resource royalties takes more time to materialize than the effect of tax revenue. One reason why this might happen is if royalties are not spent in the same year in which they are received. Another reason is if royalties are spent on large-scale projects that require more time to be completed. This latter explanation seems feasible given the large amount of revenue that royalties represent.

Cumulative royalties allow for a lag in the effect of revenue from this source and thus provide a solution to the problem. Table A3 replicates the analysis from Table 1.5 using cumulative royalties instead of their contemporary value. The results on tax revenue are unchanged while the results on royalties deteriorate significantly. The IV estimates in panel B indicate that cumulative royalties lead to a worsening of all the outcomes considered, except infant mortality, and the point estimates are statistically significant in the cases of subsidized health insurance and water quality.

I provide additional evidence against the higher return of royalties in the medium run based on regressions similar to equation (1.2), but using the outcomes of interest as dependent variables. The results are shown in panels (c)-(f) of Figure 1.7. As already discussed, panel (a) shows that these oil-endowed municipalities never receive less royalties than in 2005, and actually receive more between 2006 and 2008. Panel (b) shows that they never spend less than in 2005, but they do spend significantly more in 2006 and 2007. However, the results in panels (c)-(f) are consistent with the previous findings: despite the extra revenue and the extra expenditure there is no observable improvement for any indicator. If anything, they seem to worsen.

I turn next to the possibility that changes in the price of oil may affect the outcomes of interest in the municipalities where oil is extracted through other channels besides royalties. As mentioned above, the research design only uses variation in royalties from municipalities where oil was already being extracted in the period 2000-2004, so the results cannot be explained by the structural

transformation associated with oil discoveries (Michaels, 2011). Nevertheless, panel A of Table 1.7 shows that contemporary oil-price shocks are positively correlated with activity by the guerrilla group FARC and they are negatively correlated with the homicide rate. These two correlations suggest that FARC may be exercising control over other criminal activities. The results in panel B show that cumulative royalties, on the other hand, are positively correlated with population and with business tax revenue, which has been used before as a proxy for municipal GDP (Sánchez and Núñez, 2000). These results are consistent with the idea that a series of positive oil-price shocks lead to an economic boom in the municipality and that better economic conditions generate immigration.[27]

Table 1.7: Additional effects of oil price shocks

VARIABLES	(1) ln population	(2) Business tax	(3) Murder rate	(4) FARC events
PANEL A: REDUCED FORM (t)				
$\text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{t}$	-8.76e-06	0.0268	-0.146**	0.0277***
	[8.93e-05]	[0.0226]	[0.0664]	[0.00669]
PANEL B: REDUCED FORM (cumulative)				
$\sum_{k=2006}^{t} \text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{k}$	6.42e-05***	0.00943***	-0.00354	0.00143
	[1.53e-05]	[0.00261]	[0.0122]	[0.00134]
Observations	6,704	6,704	6,704	5,743
Number of municipalities	969	969	969	966
Dependent var. mean	30,026.40	1.60	33.87	1.37

Notes: Dependent variable in the header. Money variables in tens of thousands of 2004 COP per capita. All regressions include municipality and department-year fixed effects (sample period: 2005-2011, except column 4: 2005-2010). Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

The results in Table 1.7 suggest that increased population and armed group presence at the time of higher oil prices may be biasing the estimates for royalties from the previous section. I provide a first piece of evidence against this alternative explanation by showing that the results are unaffected by the inclusion of the variables from Table 1.7 as controls. Figure 1.8 shows point estimates and 95 % confidence intervals for royalties from equation 1.3, next to

[27] Several previous studies have exploited commodity-price shocks as a source of variation in local income (Miller and Urdinola, 2010; Dube and Vargas, 2013; Acemoglu et al., 2013a; Asher and Novosad, 2014).

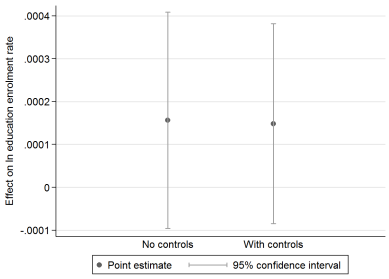
the ones from an enlarged specification that includes controls for population (natural log), business tax revenue, murder rate and FARC activity. The figure shows that the estimates are remarkably robust to the inclusion of these control variables. Although they are 'bad controls' in the sense of Angrist and Pischke (2009), the robustness of the estimates indicates that these variables are not driving the estimated effects.

I further explore the violations of the exclusion restriction for royalties by looking at the cross-sectional variation in oil intensity, measured again as average oil royalties between 2000 and 2004. Figure 1.9 shows yearly average total revenue (panel A) and royalties (panel B) for each quartile of the distribution of average positive 2000-2004 royalties, as well as for municipalities that did not receive oil royalties in this period. The takeaway from these graphs is that municipalities in the top quartile are much richer than all other municipalities and that this extra revenue is clearly coming from natural resource royalties. Municipalities in the third quartile, on the other hand, appear to be much more comparable to the rest of the country.

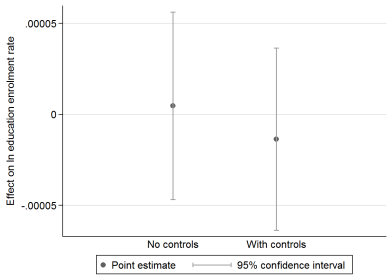
In Table A5 I look at the effect of oil price shocks separately for municipalities in the third and fourth quartiles. Column 1 of the different panels shows a positive effect of predicted royalties on actual royalties (contemporary and cumulative) for both quartiles. This is confirmed by panel (a) in Figure A2, which shows results from separate estimations of equation (1.3) for each of the top two quartiles. However, columns 2-5 provide evidence of heterogeneous non-fiscal effects across these quartiles. The correlation with business tax revenue and FARC activity is only present for the top quartile and the effect on population is much stronger for this group of municipalities. Overall, the non-fiscal effects of oil-price shocks appear to be much weaker in municipalities belonging to the third quartile. However, the results in columns 6-9 provide no robust evidence of a reduced-form effect on the outcomes of interest in either quartile. The yearly averages for each outcome shown in panels (c)-(f) of Figure A2 point in the same direction: municipalities in the third quartile of the oil intensity distribution receive more royalties when the price of oil is high but show no improvement in public service provision despite the weaker non-fiscal effects.

I next exploit the geographic concentration of FARC activity to better understand the extent to which illegal armed group presence may be driving the very low impact of natural resource royalties on the outcomes of interest. I calculate for each municipality the average number of FARC events per capita

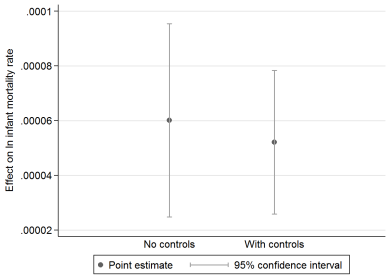
Figure 1.8: Impact of royalties with and without controls



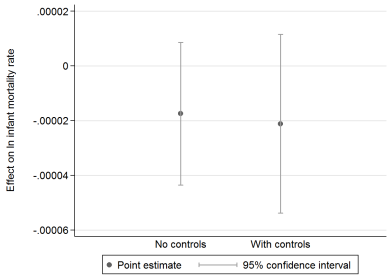
(a) Educational enrolment (t)



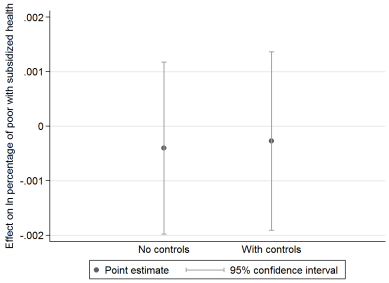
(b) Educational enrolment (cum.)



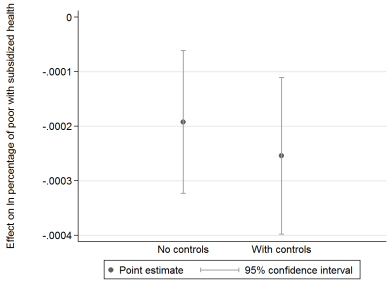
(c) Infant mortality (t)



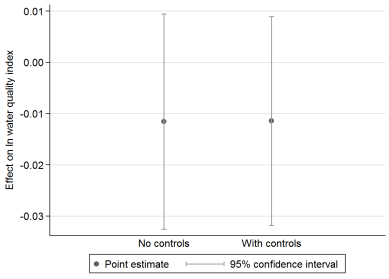
(d) Infant mortality (cum.)



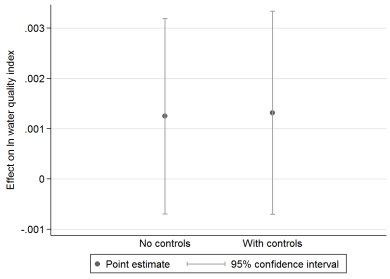
(e) Health insurance (t)



(f) Health insurance (cum.)



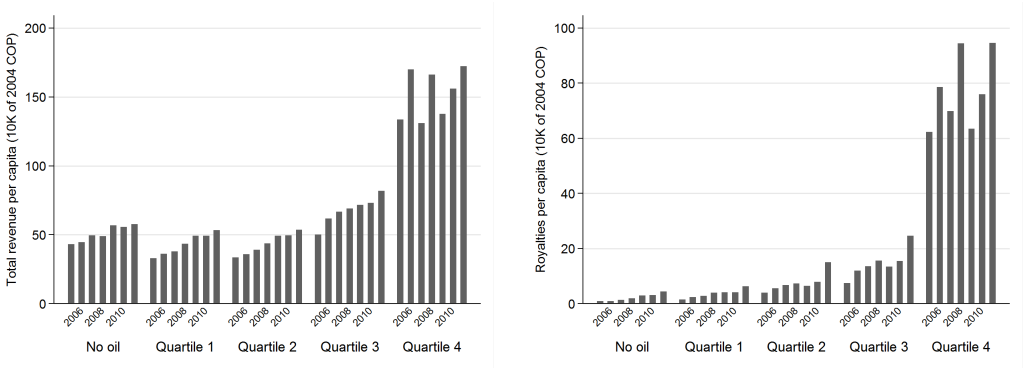
(g) Water quality (t)



(h) Water quality (cum.)

Note: Each graph shows point estimates and 95 % confidence intervals from a regression of the variable in the caption on natural resource royalties (tens of thousands of 2004 COP per capita). Panels on the left show IV results for contemporary royalties, where the instrumental variable is $\text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{t}$. Panels on the right show the results for cumulative royalties, instrumented using $\sum_{k=2006}^{t} \text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{k}$. All regressions use data from the period 2005-2010 and they all include municipality and department-year fixed effects. Standard errors are clustered two-way by municipality and department-year.

Figure 1.9: Total revenue and royalties by oil intensity



(a) Total revenue **(b)** Natural resource royalties

Note: The figures shows yearly averages of total revenue (panel A) and royalties (panel B) for each quartile of the 2000-2004 positive oil royalties distribution. It also shows this information for municipalities with no oil royalties between 2000 and 2004. All money values in tens of thousands of 2004 COP per capita.

between 2005 and 2010, the last year for which data is available, and I estimate an expanded version of equation (1.3) that includes the interaction between the predicted royalties measure and this time-invariant indicator of FARC activity.[28] The results are shown in Table A6 of the appendix. Column 1 shows that additional predicted royalties lead to more actual royalties, irrespective of FARC presence. Columns 2-5 look at the main outcomes of interest. The results provide two main lessons. First, there is evidence that FARC presence attenuates the impact of additional predicted royalties on educational enrolment and water quality in columns 2 and 5. Secondly, the estimates in the second row of each panel indicate that even in those municipalities that receive oil royalties but that did not have any FARC presence during the sample period (roughly 1/3) the effect of additional predicted royalties remains very close to zero and is always at least one order of magnitude smaller than that of a cadastral update.

The final alternative explanation that I consider is that the results are driven by differences in the variability of revenue across the two sources. After all, cadastral updates lead to a stable increase in tax revenue while oil price shocks lead to unpredictable and potentially large variation in oil royalties. The higher variance of royalties may induce local governments to be more prudent in the way they spend these occasional resource windfalls. If this is the case, we should observe that the propensity to spend the marginal peso of royalties

[28] As before, this is most likely a 'bad control', so my main interest is the robustness of the estimates of the parameters of interest to its inclusion.

is smaller than the propensity to spend the marginal peso of taxes.

Panel A in Table 1.8 shows results from estimating equation 1.4 using total expenditure per capita as dependent variable. I introduce a one-year lag in royalties to account for the delay in expenditure. Separate regressions for each source of revenue in columns 1 and 2 reveal that one extra COP of tax revenue leads to approximately 1.3 extra COP of expenditure, while one extra COP of royalties leads to 0.6 extra COP of expenditure. Although the point estimate for tax revenue is more than twice as large as that for royalties, the standard errors are quite large and I fail to reject the null hypothesis that the coefficients are equal to 1. The results are similar if I look at both sources in the same regression: even though the point estimate for tax revenue increases to 1.8, which is three times the propensity to spend royalties, I still fail to reject the null that the coefficients are both equal to 1. Even with this larger difference, it would take some very high returns to scale in expenditure for total spending patterns to explain the results on public goods. Furthermore, column 4 shows that by using cumulative royalties instead, which impose less structure on the timing of expenditure than the lag, the coefficient for royalties rises to 1.2. This coefficient is much closer to the estimates for tax revenue and is, once again, not statistically different from 1.

Panels B and C replicate the previous analysis for the two main sub-categories of expenditure, operating expenses and investment (gross fixed capital formation, more specifically). The estimates for investment in panel B are very similar to the ones for total expenditure and I cannot reject the null hypothesis that the propensity to invest out of both sources is the same and is equal to 1. The point estimates for operating costs in panel C are much smaller and still statistically equivalent across sources. Taken together, these results indicate that tax revenue and royalties are almost exclusively spent on infrastructure investment. They also suggest that revenue from neither source is being systematically employed for patronage and job creation, as this would be reflected in higher wages and higher operating costs.

The similar spending patterns of tax revenue and natural resource royalties, together with the heterogeneous effects of revenue from these two sources on public service provision, suggest that the unobservable quality of spending might be higher for projects financed with tax revenue than for those funded through natural resource royalties. I use data on two indicators of educational infrastructure provided by the Ministry of Education, the number of schools and the teaching area (sq. metres), to provide evidence on the heterogeneous

Table 1.8: Sources of revenue and public expenditure

VARIABLES	(1)	(2)	(3)	(4)
	Contemporary expenditure			Expenditure (cumulative)
PANEL A: TOTAL EXPENDITURE				
property tax revenue$_{i,t}$	1.335		1.779	
	[2.266]		[2.014]	
natural resource royalties$_{i,t-1}$		0.629	0.646	
		[0.529]	[0.544]	
natural resource royalties (cum.)$_{i,t}$				1.179***
				[0.117]
p-value H0: coefficient = 1	0.882	0.482		0.127
p-value H0: tax=royalties = 1			0.645	
PANEL B: INVESTMENT				
property tax revenue$_{i,t}$	1.165		1.593	
	[2.172]		[1.924]	
natural resource royalties$_{i,t-1}$		0.608	0.623	
		[0.516]	[0.530]	
natural resource royalties (cum.)$_{i,t}$				1.125***
				[0.113]
p-value H0: coefficient = 1	0.939	0.447		0.272
p-value H0: tax=royalties = 1			0.647	
PANEL C: OPERATING EXPENSES				
property tax revenue$_{i,t}$	0.157		0.174	
	[0.252]		[0.254]	
natural resource royalties$_{i,t-1}$		0.0229	0.0246	
		[0.0206]	[0.0218]	
natural resource royalties (cum.)$_{i,t}$				0.0535***
				[0.00639]
p-value H0: coefficient = 1	0.001	0.000		0.000
p-value H0: tax=royalties = 1			0.000	
Observations	6,704	6,704	6,704	6,704
Number of municipalities	969	969	969	969
1st stage F-statistic	23.999	22.725	14.047	184.161

Notes: Dependent variable is total expenditure per capita in panel A, investment in panel B and operating expenses in panel C. Contemporary values of expenditure in columns 1-3, cumulative in column 4. Money variables in tens of thousands of 2004 COP per capita. All regressions include municipality and department-year fixed effects. The instrument for lagged royalties is $\text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{t-1}$ (columns 2,3), and for cumulative royalties it is $\sum_{k=2006}^{t} \text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{k}$ (column 4). D(post-cadastral-update) is the instrument for property tax revenue. Sample period: 2005-2011. Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

returns to investment across sources of revenue.

Table 1.9 shows estimates of equations (1.3) and (1.4) using these two indicators (and their normalized version by population) as dependent variables. The results in column 1 show that a 10,000 COP increase in property tax revenue leads to 1.4 more schools in the municipality, while an equivalent increase in natural resource royalties leads to a negligible 0.007 increase. The difference between the two IV coefficients is statistically significant at the 10 % level. Similarly, the estimates in column 3 indicate that the effect of tax revenue on teaching area is much larger than that of natural resource royalties, although the difference is not statistically significant. There is also no statistically significant difference for the population-adjusted indicators in columns 2 and 4, which suggests that the improvements in educational infrastructure brought about by additional tax revenue are not proportional to population.

Table 1.9: Sources of revenue and educational infrastructure

	(1)	(2)	(3)	(4)
	Schools	Schools	Teaching area	Teaching area
VARIABLES		per 10,000 inh.		per 10,000 inh.
		PANEL A: REDUCED FORM		
D(post-cadastral-update)$_{i,t}$	0.904**	0.198	995.3	74.22
	[0.439]	[0.147]	[1,133]	[236.9]
royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$	-0.00184	0.00156	53.91	61.64
	[0.00509]	[0.00143]	[56.12]	[65.63]
		PANEL B: IV		
property tax revenue$_{i,t}$	1.44*	0.317	1,210	166.2
	[0.744]	[0.252]	[1,332]	[282.1]
natural resource royalties$_{i,t}$	0.00710	0.00387	69.28	77.21
	[0.0106]	[0.00364]	[63.81]	[66.75]
1st stage F-statistic	14.604	14.604	5.944	5.944
p-value H0:tax=royalties	0.051	0.210	0.393	0.747
Observations	6,704	6,704	3,882	3,882
Number of municipalities	969	969	871	871
Dependent variable mean	47.69	27.93	10,010.2	4,852.09

Notes: Dependent variable in the header. Money variables in tens of thousands of 2004 COP per capita. In panel B, D(post-cadastral-update) and royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$ are used as instruments for property tax revenue and natural resource royalties, respectively. All regressions include municipality and department-year fixed effects. Sample period: 2005-2011 (columns 1 and 2), 2006-2011 (columns 3 and 4). Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

1.5. Evidence from Disciplinary Prosecutions

In this section I provide evidence on the heterogeneous effect of increases in tax revenue and natural resource royalties on the disciplinary prosecution of local public officials. All else equal, more prosecutions imply more misbehavior, so I take this as proxy evidence on the heterogeneous responses of local public officials to increases in revenue from the two sources.

The watchdog agency *Procuraduría General de la Nación* (PGN) oversees public employees' compliance with a general disciplinary code. This includes local public officials, such as the mayor, top members of staff (e.g. secretary of education) and municipal council members. PGN may start an investigation based on news reports, tip-offs, audit results and reports from other government agencies such as the fiscal watchdog *Contraloría General de la República* (CGR). PGN can hand out sanctions ranging from fines and short suspensions for small offences to the removal from office and a ban from future public employment and public office. These latter sanctions are reserved for serious offences, including gross mismanagement of public funds, corruption and violations of procurement and contracting laws.

I collected a new dataset on disciplinary prosecutions by PGN using publicly available news reports from the agency's website for the years 2004-2015.[29] For each case, I recorded the names of the accused, their roles in the public administration, the nature of the charges, the timing of the events, the stage of the process and the outcome. Based on these characteristics I was able to link multiple reports related to the same case. I have data on 1381 cases taking place in 516 municipalities.

I construct a series of indicators at the municipality-term level based on the disaggregate prosecution data and I estimate modified versions of equations (1.3) and (1.4). I use these broader time periods because it is not always possible to pin down the specific year in which the alleged misconduct took place. To increase the sample size, I use data from the local political periods 2001-2003, 2004-2007 and 2008-2011. I use oil royalties in 2000 from *Ecopetrol* as the cross-sectional indicator of oil intensity to construct the predicted royalties and I also substitute the post-update dummy for the cumulative number of cadastral updates.

The reduced-form estimates in panel A of Table 1.10 and the corresponding IV estimates in panel B indicate that higher natural resource royalties lead

[29] `http://www.procuraduria.gov.co`

to an increase in the probability that the mayor and top members of staff are prosecuted, found guilty and removed from office. According to columns 1-3 in panel B, a 10,000 COP increase in royalties increases the probability that the local mayor is prosecuted (1 pp. increase), found guilty (0.8 pp. increase) and removed from office (0.5 pp. increase). These are not negligible effects given that 19 % of mayors are prosecuted, 14 % are found guilty and 8 % are removed from office. They are also statistically significant at conventional levels. The results for top members of staff in columns 4-6 are qualitatively similar. Additional tax revenue, on the other hand, appears to have a negative effect on the likelihood of these events, although the estimates are very imprecisely estimated and I fail to reject the hypothesis that the effect of tax revenue is the same as that of natural resource royalties.

Table 1.10: Sources of revenue and disciplinary processes

VARIABLES	(1) D(Mayor prosecuted)	(2) D(Mayor guilty)	(3) D(Mayor discharged)	(4) D(Top staff prosecuted)	(5) D(Top staff guilty)	(6) D(Top staff discharged)
			PANEL A: REDUCED FORM			
number of updates	-0.000634	-0.00253	-0.00707	0.00512	-0.00247	-0.00883
	[0.0370]	[0.0336]	[0.0258]	[0.0232]	[0.0178]	[0.0148]
$\text{royalties}_{i,2000} \times \text{price}^{\text{oil}}_{i,t}$	0.0254**	0.0220*	0.0144**	0.0151***	0.00971	0.0109
	[0.0116]	[0.0119]	[0.00699]	[0.00576]	[0.00597]	[0.00663]
			PANEL B: IV			
total property tax revenue	-0.0110	-0.0156	-0.0267	0.0102	-0.0110	-0.0309
	[0.115]	[0.104]	[0.0789]	[0.0710]	[0.0544]	[0.0446]
total royalties	0.0103**	0.00895*	0.00584**	0.00616***	0.00394*	0.00439*
	[0.00511]	[0.00516]	[0.00260]	[0.00185]	[0.00221]	[0.00227]
p-value H0:tax=royalties	0.853	0.815	0.678	0.955	0.785	0.432
Observations	2,888	2,888	2,888	2,888	2,888	2,888
Number of municipalities	964	964	964	964	964	964
Dependent variable mean	0.19	0.14	0.08	0.06	0.04	0.03

Notes: Dependent variable in the header. The dependent variables are dummies indicating if a disciplinary process involving the official was opened, whether the official was found guilty and whether the official was discharged from office. Columns 1-3 look at mayors, while columns 4-6 look at top executive staff. Panel A shows reduced form results, while panel B shows IV estimates, where predicted royalties (oil royalties in 2000 x oil price index) and the cumulative number of cadastral updates (weighted by share of cadastre updated) are used as instruments for total royalties and total property tax revenue (Hundreds of thousands of 2004 COP per capita). The first stage F-statistic is 16.35. All regressions include municipality and department-term fixed effects (2004-2007, 2008-2011). Robust standard errors clustered by municipality and department-term in brackets. *** p<0.01, ** p<0.05, * p<0.1

The findings in columns 3 and 6 are very telling, as they indicate that the offences for which local public officials are prosecuted during periods of high royalties are serious ones, such as corruption and embezzlement. Table A8 summarizes some of the processes that resulted in the removal from office of the mayor of an oil-rich municipality. Most of these cases are clear instances of mismanagement of public funds, such as the provision of spa treatments for

city hall workers by the mayor of Yopal. Many of the cases are related to the management and expenditure of natural resource royalties, such as the loss of 5 million USD worth of royalties in Arauca after they were given to an informal firm to manage and it went bankrupt. Table A9 looks at the most frequent keywords for the processes involving mayors of oil-rich municipalities. 36 % of cases are related to irregularities in investment and procurement and 12 % of processes are related to natural resource royalties. These are the modal keywords for the type of misconduct and the sector among this group of municipalities.

1.6. Discussion

I have provided evidence on the larger effect of tax revenue on public goods relative to natural resource royalties and I have shown that additional royalties lead to a worsening of the misbehavior of local politicians. In this section, I discuss these findings and I establish a relationship between them. I argue that accountability underlies the relationship between taxation and governance and I provide some suggestive evidence.

One straightforward reason why taxation may be positively related to accountability is because voters are better informed about changes in taxation than about changes in external revenue. This informational asymmetry across sources of revenue arises because taxation is in itself informative about government revenue, while information on revenue from other sources must be acquired at a cost. In consequence, if voters do not know that the government has more resources they have no reason to expect or demand an improvement in public services.

In the theoretical appendix I explore this mechanism in the context of a political agency model with career concerns.[30] In the model, voters receive a noisy signal on public revenue, the precision of which is improved by the share of taxes in total revenue. As the revenue signal becomes more precise, voters are more able to infer the incumbent's ability after observing public good provision. Hence, taxation makes the voters' posterior beliefs on the incumbent's ability more sensitive to observed public goods and this leads to higher effort by the incumbent and to more public goods. As external revenue increases, on the other hand, voters become less well informed about revenue and this has a

[30]The model is an extension of the canonical career concerns model of Persson and Tabellini (2000) that incorporates 'signal-jamming' à la Holmström (1999). Alesina and Tabellini (2007) and Matsen et al. (2015) use similar extensions to answer very different questions.

negative effect on the incumbent's effort. Thus, external revenue has a smaller effect on public goods than tax revenue.

This informational explanation is consistent with various findings from the empirical literature. Recent studies provide evidence in support of the idea that voters find it difficult to establish the contribution of government to observed outcomes (Leigh, 2009; De la O, 2013; Guiteras and Mobarak, 2014). Recent research also indicates that voters are relatively uninformed about changes in external revenue (Reinikka and Svensson, 2004; Ferraz and Monteiro, 2014; Gadenne, 2015). Additionally, there is a large literature showing that governments are generally more accountable to voters that are better informed.[31]

One may still wonder how can residents of resource-rich areas not be aware of the flow of resource rents to their government. The point here is that even if voters in these areas know about the abundance of natural resource rents, they must still pay close attention to fluctuations in prices and output to be well informed about the change in these rents. This is important because the empirical exercise above was concerned with changes in revenue from different sources, rather than with their average level, which was absorbed by the municipality fixed effects.

One could also wonder how informative it is to pay your own taxes in a world with significant heterogeneity in tax liabilities. Although this does raise the question about which are the taxes that matter, it is not a major concern for the empirical exercise on Colombia as the cadastral updates that I study lead to a municipality-wide simultaneous increase in tax liabilities. A related question is whether increases to taxation simply make voters, who are already well informed about revenue, more aware of the public purse and its use (increased salience). An explanation along these lines seems particularly plausible for the current setting because the property tax stands out in this respect, as it is a yearly out-of-pocket tax payment on an illiquid asset (Cabral and Hoxby, 2015). Additionally, there is evidence that people's response to taxation is affected by the salience of taxes (Chetty et al., 2009; Finkelstein, 2009).

The other main channel through which the relationship between taxation and accountability may arise is citizens' preferences. It is possible, for instance, that voters simply dislike taxation and punish the incumbent for it unless he compensates them with improved public services. Martin (2014) develops a

[31] See Besley and Burgess (2002); Reinikka and Svensson (2005); Ferraz and Finan (2008); Björkman and Svensson (2009); Snyder and Strömberg (2010); Banerjee et al. (2011); Fergusson et al. (2013); Chong et al. (2015).

model along these lines in which loss-averse voters derive utility from punishing a corrupt government.[32]

In the appendix, I present an alternative version of the theoretical model described above in which the marginal utility of public goods is decreasing in private consumption and voters can acquire costly information on public revenue. I show that taxation may improve incumbent effort and public good provision, even if it is not by itself directly informative, because it induces the acquisition of costly information on government revenue due to its negative effect on disposable income.

There is some empirical evidence supporting these preference-based channels. Both Paler (2013) and Martin (2014) find that participants in lab experiments are more willing to engage in costly punishment of a misbehaving government when the source of revenue is taxation than when it is external, even when information is held constant across treatments. There is also a large literature on reciprocity that has found that people are willing to incur in costly punishment of what they consider to be unfair behavior (Fehr and Gächter, 2000).

Overall, taxation may either increase citizens' willingness to hold the government accountable or their ability to do so (Paler, 2013). Although the available data does not allow me to distinguish between these explanations, all of them predict that tax revenue leads to higher accountability and to better governance. I use data on social mobilizations from the Colombian think-tank CINEP to provide suggestive evidence on the heterogeneous effects of tax revenue and natural resource royalties on accountability and the demand for better government.

Table 1.11 shows reduced-form and IV estimates of the effects of property tax revenue and natural resource royalties on various indicators of citizen involvement in public affairs. The results indicate that property tax revenue appears to have a positive effect on the probability of social mobilizations of any kind (column 1), but more specifically on the probability of demonstrations (column 2), especially those related to public services (column 3). These are not negligible effects. For example, I find that a 10,000 COP increase in property tax revenue leads to a 1 percentage point increase in the probability of demonstrations related to public services, relative to a sample mean of 2.8 %. The effect of tax revenue on worker strikes (column 4) is negative and much smaller, which acts as a placebo test. The effects of natural resource royalties

[32]In the model in the appendix, forward-looking voters cannot credibly commit to vote against the incumbent if they believe him to be of higher ability than his opponent in the election.

are negative but very small for all indicators. Unfortunately, the standard errors are large for all estimates and the difference across sources of revenue is not statistically significant for any indicator.

Table 1.11: Sources of revenue and social mobilizations

VARIABLES	(1) Social Mobilization	(2) Demonstration	(3) Demonstration (Pub. Services)	(4) Strike
		PANEL A: REDUCED FORM		
D(post-cadastral-update)$_{i,t}$	0.0118	0.00686	0.0101	-0.000223
	[0.0138]	[0.0113]	[0.00882]	[0.00453]
royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$	-0.000739	-0.000344	-2.34e-05	-0.000845
	[0.000845]	[0.000285]	[0.000116]	[0.000532]
		PANEL B: IV		
property tax revenue$_{i,t}$	0.0185	0.0108	0.0161	-0.000784
	[0.0225]	[0.0183]	[0.0146]	[0.00738]
natural resource royalties$_{i,t}$	-0.000751	-0.000336	7.58e-05	-0.000999
	[0.000949]	[0.000354]	[0.000199]	[0.000615]
p-value H0:tax=royalties	0.389	0.541	0.268	0.976
Dependent variable mean	0.078	0.048	0.028	0.005
Observations	6,704	6,704	6,704	6,704
Number of municipalities	969	969	969	969

Notes: Dependent variable in the header. Money variables in tens of thousands of 2004 COP per capita. In panel B, D(post-cadastral-update) and royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$ are used as instruments for property tax revenue and natural resource royalties, respectively. The first stage F-statistic is 14.6. All regressions include municipality and department-year fixed effects. Sample period: 2005-2011. Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

1.7. Conclusion

In this chapter I estimated the effect of locally-raised property tax revenue on several indicators of public service provision in Colombian municipalities and I used these estimates as a benchmark to compare the effect of revenue from an external source, the rents from the extraction of oil. I showed that property tax revenue has a positive impact on public services in the areas of education, health and water, while oil royalties have no effect on local public services, despite being earmarked for this purpose. I provided suggestive evidence on the positive relationship between taxation and the demand for good government, as measured by social mobilizations and protests, and on the negative relationship between external revenue and the supply of good government, as measured by

disciplinary prosecutions.

These results confirm previous findings regarding the very low impact of revenue from external or unearned sources - such as natural resource rents, intra-government transfers and foreign aid - on public good provision. But they go further than that, as they allow us to see that this very small effect is indeed specific to external revenue and that tax revenue has a very different and much larger impact. Additionally, this study illustrates how the heterogeneous response of local politicians to increases in revenue from the two sources, as well as that of the citizens to whom they are accountable, is what drives the heterogeneity in returns. Hence, the case for the 'political' nature of the curse of 'external' resources is strengthened.

The findings in this chapter, insofar as they provide evidence on the positive relationship between taxation, accountability and governance, have important implications for policies related to the design of decentralized systems of government, the management of natural resource wealth and the disbursement of foreign aid. Mainly, they invite policymakers to reconsider the effectiveness of resources that are transferred to governments, both across countries and within countries, for projects or services that lack a locally-financed counterpart. More specifically, the evidence in this chapter suggests that citizen involvement is crucial for the responsible management of public funds and that taxation is an effective way of achieving such involvement.

At present developing countries tax too little, both at the national and sub-national levels (Gadenne and Singhal, 2014). The results in this chapter also suggest that there may be high returns to investments in fiscal capacity in terms of improved public service provision and higher living standards.

Future research must try to better understand the relative importance of information and preferences as the driving forces behind taxation's ability to improve government performance. Another avenue for future research is related to the study of different tax instruments with the objective of establishing whether certain characteristics, such as salience, are particularly important for the accountability-enhancing effect of taxation.

Chapter 2

Is It my Money or Not? An Experiment on Risk Aversion and the House-Money Effect

with Juan Camilo Cárdenas, Nicolás De Roux & Christian Jaramillo. *Published as Cárdenas et al. (2014)*[1]

The house-money effect, understood as people's tendency to be more daring with easily-gotten money, is a behavioral pattern that poses questions about the external validity of experiments in economics. We ran an economic experiment with 122 students, who received an amount of money with which they made risky decisions involving losses and gains; a randomly selected treatment group received the money 21 days in advance and a control group got it the day of the experiment. With our preferred specification, we find a mean CRRA risk aversion coefficient of 0.34, with a standard deviation of 0.09. Furthermore, if subjects in the treatment group spent 35 % of the endowment (as they did, on average) their CRRA risk aversion coefficient is higher than that of the control group by approximately 0.3 standard deviations. We interpret this result as evidence of a small and indirect house money effect operating though the amount of the cash in advance that was actually spent. We conclude that the house money effect may play a small role in decisions under uncertainty, especially when involving losses.

[1]We thank Glenn Harrison who commented on a previous version and greatly enriched the analysis. Also we thank two anonymous reviewers and the editor of *Experimental Economics* for their comments.

2.1. Introduction

The house-money effect, understood as people's tendency to be more daring with easily-gotten money, is a behavioral pattern which finds support in incentivized experiments using real money by Thaler and Johnson (1990). Since experiments in economics usually start by handing out money to the subjects so that they never stand to suffer any net monetary losses, the participants' behavior could be modified as a result of the house-money effect. This poses questions about the external validity of experiments in economics (Guala, 2005, p. 231), and particular questions about the incentives used: to what extent do people behave in the experiment like they would have in a real-life situation, given that they play with easily-gotten house money (Levitt and List, 2007)?

The experimental literature has addressed this question in the context of altruism ((Cherry et al., 2002), public goods (Clark, 2002), auctions (Ackert et al., 2006) and capital expenditure (Keasey and Moon, 1996). The general idea of windfall gains has been also explored in the psychology and economics literature (Arkes et al., 1994; Keeler et al., 1985). Most of these papers deal with the issues arising from having people play with their own money by having participants earn money in an initial stage and then making choices with their earnings.

This chapter studies the effect of house money on the risk preferences of a group of 122 undergraduate students within an age range of 16 to 28. The students were randomly assigned to a control or a treatment group and given money to participate in the experiment, which they were told involved risky choices and possibly losses. As usual, the money handed out for participating was enough to cover the potential losses. However, while the control group received this initial money just before they made their choices, the treatment group received the money three weeks in advance so that they had time to spend it before making their choices. (A back-of-the-envelope calculation suggests that on average 35 % of the cash in advance was spent.) This experimental design, inspired by (Bosch-Domènech and Silvestre, 2010), is as close as we can get to having them gamble with their own money.

We find evidence of an indirect house money effect operating through the money that participants had with them at the time of choosing between lotteries. More specifically, we find that for the treatment group, each additional thousand Colombian pesos (COP) spent (USD$0.50) leads to an increase of 0.0019 in their CRRA risk aversion coefficient. We interpret this finding as evidence of a house money effect on those subjects of the treatment group who actually spent

some of the cash provided to them in advance. In our preferred specification, the mean relative risk aversion coefficient equals 0.34 with a standard deviation of 0.09. Therefore, our estimated 35 % expenditure of the endowment would lead to a reduction of 0.3 standard deviations in the risk aversion coefficient. This interpretation rests on two assumptions. First, that the money participants had with them at the time of the experiment is a good proxy for endowment not spent, if compared to the same measure in the control group. Second, and more importantly, we assume that the house money effect only operates for those people who actually spent some of their endowment. We will have more to say about this assumption below.

The results that we report here add to a vast literature documenting risk aversion and suggest that it would be advisable to include credible controls for the house-money effect in experimental work in economics.[2]

2.2. The Experiment

Our experimental design is based on dividing the subject pool randomly in half and giving the treatment group an endowment of cash three weeks in advance of the actual decision-making experiment. The control group receives the same amount of money but on the day of the experiment as is usually done in lab experiments that involve potential losses. With that time period in between we expect to balance between giving sufficient time for them to incorporate the cash as part of their pocket money and not allowing for some discounting of the endowment between the treatment and control groups. (In the appendix we have included the translated version of the instructions to the subjects.)

The subjects were volunteers from an undergraduate psychology course at the Universidad de los Andes in Bogotá (Colombia), recruited in two different semesters of the same course (one in 2009 and another in 2012). The students in the class were randomly assigned to a treatment (cash in advance) or control group (cash experiment day) and then asked to consent to participate in an

[2]Although only partially comparable, empirical evidence from survey work from a developing country suggests risk aversion coefficients between 0 and 5 (Azam et al., 2002). Meanwhile, a survey on experimental studies in developed and developing countries reports estimated coefficients for the CRRA that range from the lowest estimate of 0.05 in Ethiopia to 2.57 in Paraguay (Cárdenas and Carpenter, 2008); Harrison et al. (2010) also report coefficients of these magnitudes. However, Harrison and Rutström (2008) use a method quite similar to ours on the data of Hey and Orme (1994) and find a CRRA of 0.66 with a standard error of 0.04. In general, the estimated ranges found show also a non-negligible sensitivity to the type of experimental procedure used.

economic experiment that involved risky choices. Of a total of 122 students who accepted to participate in the two sessions, 61 were assigned to the control group and 61 to the treatment group. Within each session the random splits between treatment and controls were 51/49 and 48/52. Students in the sessions belonged to more than 20 different minors and majors from social, medical, natural sciences, medicine and engineering (no more than 14 % of the participants in any of the groups belonged to any particular major). Table 2.1 shows the average characteristics of each group.

Table 2.1: Demographic characteristics of treatment and control groups

Variable	Mean Value		p-value	
	Control	Treatment	Rank-sum test	t-test
Female	0.361	0.574	0.019	0.018
Age	19.6	18.8	0.170	0.034
Single	0.967	1.00	0.156	0.156
Siblings	1.4	1.5	0.405	0.291
Semesters at university	3.3	3.0	0.261	0.371
Monthly expenses	445,080	443,440	0.840	0.968
Housing stratum	4.72	4.8	0.898	0.671
Money in pocket	41,132	67,098	0.000	0.001
Adj. Money in pocket	81,132	67,098	0.014	0.057

Notes: All money variables in Colombian pesos (COP) (1) Only two participants (both in the control group) reported "other" as marital status. (2) Using mid-point of reported range. (3) Housing strata in Colombia range from 1 (lowest) to 6 (highest). (4) Amount of money at time of making decisions (pocket + 40,000 for participants in control group).

Treatment subjects were then given COP 40 000 in small change (roughly USD 20 given an exchange rate of COP 1 971 on the initial day of the first round. The minimum monthly wage in Colombia at the time was COP 497 000). Three weeks later, again in class, the decision-making session took place. The control group was given their respective COP 40,000 and everybody proceeded then to make their choices under uncertainty.

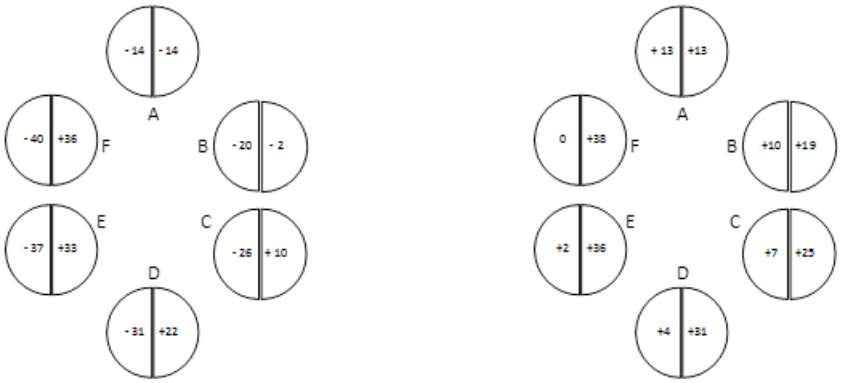
Notice in particular the averages for the available pocket money of the subjects in the treatment and control groups. We asked everyone at the entrance to the room and before the control group received their endowment, how much money they had in their pockets. Our treatment group had significantly more cash in their pockets than the control, as expected, but the difference was smaller than the endowment of 40 000 COP (67 000 COP — 41 000 COP $\approx$ 26 000 COP).[3] If we assume that the money brought to the session by the

[3]A word of caution is due at this point. As suggested by an anonymous referee, in

control group is representative of what members of this student community carry in their pockets, we can think that the treatment group spent on average 14 000 COP (or 35 %) of their cash in advance. For those in the control group, we added the 40 000 COP to their pocket money and therefore we have now a comparable variable, Adjusted pocket money, which will turn out to be an important part of our analysis.[4]

Following Binswanger (1980) Ordered Lottery Selection (OLS) design (Harrison and Rutström, 2008, pp. 52-56), all participants were handed a piece of paper with six different uniform-probability lotteries involving possible losses (Figure 2.1a) depending on a coin toss. They were then asked to choose one lottery to play. All 122 made their choice at once. At that point they did not know they would have further choices to make.

Figure 2.1: Games and payoffs



(a) Game 1: Possible losses **(b)** Game 2: Gains only

Notes: In each game, both risk and expected return increase clockwise from the top. However, lotteries E and F have the same expected return. Payoffs in thousands of Colombian Pesos (COP) (Exchange rate (USD): COP 1,971).

After collecting their choices, they were handed a second set of six lotteries (Figure 2.1b). None of these involved losses and they were told that the outcome would depend on another coin toss and that their payments would be computed using the sum of results of both lotteries. After collecting their new choices,

societies where students pay much of their expenses using debit or credit cards, the question "how much money did you have in your pocket when you entered the class room" might be blurred. We are confident, however, that this should not be of concern as Colombian students rarely use electronic payments for their daily expenses in food, transportation or entertainment, among others because most establishments have a minimum amount for allowing such transactions, and the access to banking in general is more limited than in industrialized countries; also, not all establishments take electronic payments around and on campus.

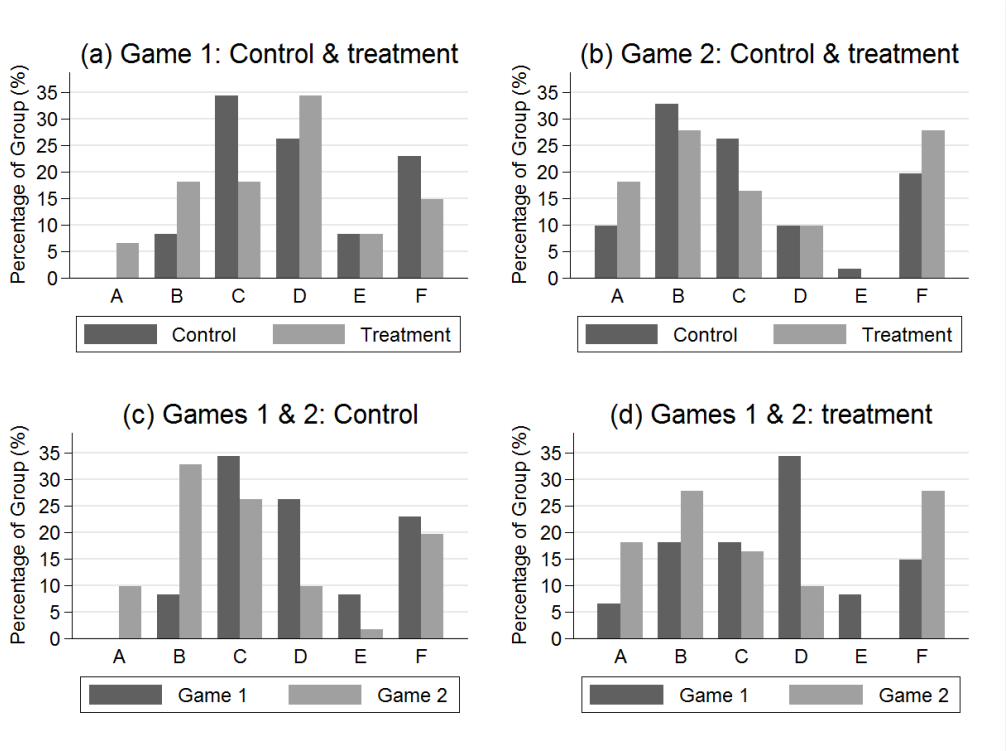
[4]We thank two reviewers for this suggestion.

they were asked to fill out a brief socioeconomic survey. Only then did both coin tosses take place. The first coin toss determined the outcome in the first game (possible losses) and the second coin toss determined the outcome for the gains only lottery.

2.3. Results

Figure 2.2 shows the distribution of choices in two different ways. In Panels (a) and (b) we show the distributions of choices for Game 1 and Game 2 respectively. In panels (c) and (d) we compare the same data but splitting in control and treatment respectively. From a first look at the distributions one can infer that prospect theory is alive and well and that in general people made riskier choices in Game 1 where losses were possible. However, there seems to be no major difference between the treatment and control groups and therefore a more rigorous statistical analysis is needed.

Figure 2.2: Decisions in Game 1 and Game 2



Notes: Lotteries increase in riskiness as you move from A to F. Treatment equals one for participants who received cash in advance.

These results can be compared to data from a more comprehensive study (Cárdenas and Carpenter, 2013) that included more than 3 000 subjects

representative of several Latin American cities using this same design of the potential losses and gains with these six lotteries. In the case of the lottery with potential losses, the variation found in that large sample is higher with more people choosing the more conservative lotteries than here and a smaller fraction (17.2 %) of subjects in that sample choosing the riskiest lottery E than in our students sample (23.8 %). In the case of the second game with gains only, again our students showed a slightly higher level of risk tolerance with more students choosing lottery E than in the adults sample and fewer students choosing the safe ones.

Table 2.2 shows the means of choices in each game for the treatment (cash in advance) and control (cash experiment day) groups. Game 1 and Game 2 indicate the choice in each game. In both games, lotteries A through F of Figure 2.1 are coded 1 through 6: Game 1 = 1 means the subject chose lottery A in Game 1, and a larger value indicates the choice of a riskier lottery. As expected through prospect theory, the average player moved from riskier lotteries in Game 1 to safer ones in Game 2 creating two different distributions of choices when comparing within subjects (Wilcoxon signed-rank test, p-value=0.0001). However, this result seems driven mostly by the control group and rather minor for the treatment group both for men and women. This could mean that, if there was a house money effect operating, it could be leading to attenuation in loss aversion. Within games we only find a significant difference between treatment and control groups when comparing the choices of men in Game 1 (see Table 2.2). That difference vanishes for Game 2, suggesting that the effect is exacerbated when involving the possibility of losses.

These differences however open up more questions than answers. To assess in more detail the effect of being treated on risk aversion, we estimate for each game a series of structural models of choice under uncertainty, using the survey data as explanatory variables and following closely Harrison and Rutström (2008, pp. 69-74).

Table 2.2: Experimental results by treatment and gender

Lottery (1-6)	All			Male			Female		
	Treatment	Control	p-value	Treatment	Control	p-value	Treatment	Control	p-value
Game 1 (losses)	3.64	4.03	0.206	3.62	4.31	0.095*	3.66	3.55	0.659
Game 2 (gains)	3.30	3.20	0.956	3.27	3.31	0.929	3.31	3.00	0.886
p-value	0.130	0.000***	-	0.360	0.004***	-	0.242	0.059*	-

Notes: Lotteries are coded 1-6 for each game, with a higher number indicating a riskier choice. p-values from a Rank-sum (Mann-Whitney) test for differences in distributions. *** p<0.01, ** p<0.05, * p<0.1

In these exercises, each subject i is assumed to have a CRRA utility function

$$u_i(I) = \frac{I^{1-\gamma_i}}{1-\gamma_i} \tag{2.1}$$

where I denotes total wealth and γ_i is the relative risk aversion parameter of that individual - a higher γ_i is associated with a lower level of risk tolerance, $\gamma_i < 0$ corresponds to risk loving, $\gamma_i > 0$ to risk aversion and $\gamma_i = 0$ to risk neutrality.[5]

For both games 1 and 2, Let $\text{EU}_i(j)$ denote the expected utility for subject i of choosing lottery j in that game, where $j \in \{A, B, C, D, E, F\}$ according to Figure 2.1. Let L_j and R_j denote the payoff if the left or right outcomes of lottery j are realized. The expected utility of choosing this lottery, with the CRRA utility function and a probability 1/2 for each outcome, is given by:

Using this formula for the expected utility, for each individual we compute a probability of observing the choice the individual actually made. In order to do so and following Harrison and Rutström (2008), we assume a multinomial logit probability specification. Let $h \in \{A, B, C, D, E, F\}$ denote the lottery the individual actually chose. The probability of individual i choosing lottery h is given by:

$$P_i(h) = \frac{e^{\text{EU}_i(h)}}{\sum_j e^{\text{EU}_i(j)}} \tag{2.2}$$

where again $j \in \{A, B, C, D, E, F\}$.[6]

We further assume that the risk aversion coefficient γ_i is a linear function of observed characteristics X_i, i.e. $\gamma_i = \alpha + X_i \cdot \beta$, where α is a constant and β is a vector of size $k \times 1$, k being the number of variables included in the model. Our objective is to estimate the values of α and β. The maximum likelihood (MLE) routine that we implement finds the values of α and β that maximize the following log likelihood function (i.e. that maximize the probability of observing our sample of choices assuming a multinomial logit probability specification):

[5]Total wealth I is defined as initial wealth (w) plus the payoff of the realized outcome of the game. For Game 1 we set w=40 000 so that there is no negative total wealth I in any of the outcomes (note that the utility function is well defined for non negative values of I). This assumption is grounded on the fact that all individuals were given an initial endowment of 40 000, the only difference being one of timing. For Game 2, we set w=0.

[6]This statistical assumption implies a possibility of decision error, since an individual may not choose with certainty a lottery that has a higher expected utility than all the others. For example, among lotteries with expected payoffs [1, 1, 1, 1, 1, 10], a risk neutral person will choose the one with expected payoff equal to 10 only with probability 2/3, even though the expected utility of this lottery is higher than that of all others. We thank an anonymous referee for pointing this out and suggesting the above example.

$$\ln L = \sum_i \ln(P_i(h_i)) \tag{2.3}$$

Note that once the estimated values $\hat{\alpha}$ and $\hat{\beta}$ are obtained, we can use the characteristics of the individual i, namely X_i, to obtain a linear prediction of γ_i, $\hat{\gamma}_i = \hat{\alpha} + X_i \cdot \hat{\beta}$. The value of $\hat{\gamma}_i$ will depend on the model being estimated (i.e. on the individual characteristics that we include in the linear function of γ_i).

We estimate four different specifications of the structural model for each one of the games. Tables 2.3 and 2.4 report the results for Game 1 and Game 2 respectively.[7] Each column corresponds to one specification. We report the estimated coefficients and their respective standard errors. For example, column (1) of Table 2.3 corresponds to a linear specification of γ_i given by $\gamma_i = \alpha + \beta_1 \times \text{Treatment} + \beta_2 \times \text{Session}$, where Session is a dummy that takes a value of 0 if the experimental session is the one conducted in 2009, and a value of 1 if it is the one conducted in 2012.

Consider Game 1 which involves the possibility of losses (Table 2.3). We confirm our previous finding that males are more tolerant to taking risks than females, and find that people of higher socio-economic status measured by the variable Stratum also choose riskier lotteries.

We do not find that the treatment in itself has an effect on the risk coefficient of the subjects (across columns the coefficient of Treatment is not statistically significant). However, as illustrated by column (4) the interaction between the available pocket money at the start of the experiment and the treatment does tell a story: the less money an individual in the treatment group had in her pocket, the more conservative her decision was. No such effect is found for the controls.[8]

Our interpretation of this result rests on the following assumption: it is necessary that subjects in the treatment group actually spent part of the endowment for them to consider that they are actually playing with their own money. In other words, receiving money in advance is not a sufficient condition for the house money effect to operate. It could be the case that the treatment

[7] All the monetary variables enter the estimations in thousands of COP.

[8] To see this, denote by π_1 the estimated coefficient of Pocket Money (adj) and by π_2 that of Pocket Money(adj)*Treatment. For the cash-in-advance treatment, an increase of one thousand COP in Pocket Money (adj) implies a change in γ of $\pi_1 + \pi_2$. For the control group, it implies a change in γ of π_1 (recall that the Treatment dummy takes a value of 1 for the cash-in-advance treatment). Nevertheless, since π_1 is not statistically different from 0, the effect of Pocket money (adj) for the control group is $\pi_1 = 0$, and that of the cash-in-advance treatment is $\pi_1 + \pi_2 = \pi_2 = -0{,}0019$.

subjects who kept their money over this time felt an obligation to bring the money to the decision stage session, but as a reviewer noted, we would need to ask directly the participants about their reasons for spending or keeping their money over the period of time. This assumption implies that in the extreme case of a participant in the treatment group who did not spend any of his endowment before the decision-making session, we should not observe any difference in his behaviour relative to the control group.

Table 2.3: Maximum likelihood estimation of γ (Game 1)

	(1)	(2)	(3)	(4)
VARIABLES	Dependent variable: lottery choice in Game 1			
Treatment	0.070	-0.028	-0.023	0.138
	[0.045]	[0.078]	[0.080]	[0.120]
D(Session 2)	0.019	0.042	0.034	0.038
	[0.044]	[0.048]	[0.048]	[0.05]
D(Male)		-0.13*	-0.16**	-0.15**
		[0.070]	[0.072]	[0.070]
D(Male)*Treatment		0.164	0.149	0.131
		[0.107]	[0.108]	[0.109]
Expenses			-0.0003	-0.006
			[0.009]	[0.011]
Stratum			-0.051*	-0.05*
			[0.026]	[0.030]
Pocket Money (adj.)				0.0012
				[0.0009]
Pocket Money (adj.)*Treatment				-0.0019*
				[0.0011]
Constant	0.29***	0.37***	0.63***	0.54***
	[0.034]	[0.063]	[0.15]	[0.16]
Observations	122	122	122	122

Notes: Standard errors in brackets. Treatment equals one for participants who received cash in advance. *** p<0.01, ** p<0.05, * p<0.1

If we additionally assume that the money that the controls brought into the room is a good proxy for the average pocket money in the population, then the difference in means of Table 2.1 of the variable Money in Pocket (67 000 COP - 41 000 COP = 26 000 COP) gives us an idea of how much the treatment subjects actually spent on average of their cash in advance (approximately 40 000 COP – 26 000 COP = 14 000 COP, which is 35 % of the cash in advance). This already suggests that any house money effect found should not be large. Under the assumptions just mentioned, the coefficient of

the interaction between Treatment and Pocket money (adj) can be seen as the effect of cash in advance that is actually spent. The higher the amount of the endowment spent by the subjects in the treatment (i.e. the more they are "playing with their own money"), the lower the adjusted pocket money will be. Since the coefficient is negative, this implies a higher estimated value of γ, or in other words, a higher level of risk aversion as participants in the treatment group played with more of their own money.

Phrased differently, we can think of the cash in advance actually spent as having some distribution across individuals in the treatment group, where some of them spent all the endowment, some of them did not spend at all and on average they spent 14 000 COP. For those that spent all the money we would expect more risk averse behavior during the decision stage of the experiment when compared to the controls. For those that did not spend any amount we would expect no difference with the controls. To put numbers to this interpretation, the linear prediction of γ_i using the model of column (4) in Table 2.3 implies an average estimated γ_i of 0.34 with a standard deviation of 0.09.[9] If the participants in the cash-in-advance treatment had spent all the endowment they would have values of γ_i larger on average than those of the controls by an amount of (-0.0019)*(-40) = 0.076 which is almost one standard deviation.[10] From our rough approximation of the average money that was actually spent by participants in the cash-in-advance treatment, i.e. 14 000 COP, we can infer that their γ_i is on average greater by an amount of only (-0.0019)*(-14) = 0.026 which is approximately 0.3 standard deviations. We can summarize our finding by saying that the evidence suggests a small house money effect driven by the fact that members of the treatment group spent less than half of the cash in advance provided. Further, the fact that the effect does not happen among the control group rules out the explanation of more risk aversion caused by diminishing marginal utility of money.[11]

Let us now turn to the analysis of the second game, our control for risk under uncertainty but with no potential losses involved. Although we already reported that most individuals did switch from riskier to more conservative

[9]Harrison and Rutström (2008, pp. 69-71) assume the same utility function and apply a similar version of the MLE procedure we employ to the data of Hey and Orme (1994). In one of the versions of this exercise they find a pooled value of γ of 0.66 with a standard error of 0.04.

[10]As mentioned in Table 2.1, Pocket money (adj) is defined as money at time of play (i.e. the money brought in plus 40 000 COP for the control group). If subjects in the treatment group spent all their cash in advance, money brought in would have been equal for the two groups and the adjustment would leave the treatments at -40 000 COP.

[11]We thank Reviewer 2 for highlighting this.

choices, the results in Table 2.4 show similar patterns to those reported for Game 1. Males, although not significant now, show less risk aversion, those who with higher socio-economic levels (expenses) also show more tolerance to risk and once again the available pocket money makes a difference but only for the treatment group and in the same direction as before.

Table 2.4: Maximum likelihood estimation of γ (Game 2)

	(1)	(2)	(3)	(4)
VARIABLES	Dependent variable: lottery choice in Game 2			
Treatment	-0.038	-0.129	-0.223*	0.194
	[0.075]	[0.125]	[0.121]	[0.223]
D(Session 2)	0.090	0.104	0.118	0.106
	[0.077]	[0.079]	[0.076]	[0.086]
D(Male)		-0.097	-0.104	-0.098
		[0.125]	[0.125]	[0.128]
D(Male)*Treatment		0.159	0.213	0.168
		[0.164]	[0.161]	[0.177]
Expenses			-0.057***	-0.069***
			[0.0164]	[0.0180]
Stratum			-0.027	-0.037
			[0.0446]	[0.041]
Pocket Money (adj.)				0.003*
				[0.002]
Pocket Money (adj.)*Treatment				-0.005**
				[0.002]
Constant	0.41***	0.47***	0.94***	0.82***
	[0.063]	[0.111]	[0.251]	[0.254]
Observations	122	122	122	122

Notes: Standard errors in brackets. Treatment equals one for participants who received cash in advance. *** p<0.01, ** p<0.05, * p<0.1

A few notes are worth mentioning here. Recall that Game 2 took place after the students had made their choice for Game 1 but before the toss of the coin for Game 1 was made. Also, they were not told in Game 1 that a second game was going to be played later on. One could argue that the choice made for the second game involved some kind of risk hedging between games since they did not know the outcome of the coin toss. To control for this possibility we ran a separate regression not reported here where the choice in Game 1 was used as a control for the choice in Game 2 and no effect was found.

2.4. Conclusions

The use of monetary incentives is central to the experimental methods in economics. The code of ethics among experimentalists continues to suggest that we refrain from using the disposable income of our experimental subjects, that is, from having participants walk out of the lab with negative earnings and instead it requires that we provide them with an endowment they can use to allow for decisions involving losses. This has caused concern among skeptics of experiments because of the so called house-money effect and the implications it would have for external validity of laboratory or field lab experiments.

To get at this debate, some labs have introduced the notion that the endowment is earned during a task performed at the experiment, partially correcting for the problem of subjects thinking of the endowment as a windfall gain. We have, however, taken a different approach, by giving the endowment well in advance (21 days) to half of our sample and the endowment to the other half at the day of the experiment. Further, they had to make decisions about risk involving losses and gains. We asked everyone at the day of the experiment what cash they had available in their pockets and confirmed that the treatment group had in fact spent part of the endowment they had received and kept another part, suggesting the money was incorporated as part of their disposable income. On average there is no major statistical difference in the distributions of the observed coefficient of risk behavior across the two groups. However, when controlling for the available cash they had in their pockets at the time of the experiment, we find that those in the treatment group who had more money with them on the day of the experiment tended to be more risk tolerant while those who had less were more risk averse during the experiment. If we interpret the spending of the endowed money as a signal of considering it as one's own, our findings suggest a small house money effect.

By providing the endowment in advance we have both complied with the ethical code of experimental economics but also introduced more realism and external validity as the subjects seem to have incorporated some of the mental accounting processes of their daily life into the experiment. In other words, the more I spent part of my endowment the more it felt like "it's my money". The data suggest that those who spent more of their endowment arrived facing the experiment much like a risky decision involving losses but constrained by their pocket money whereas those with more cash –provided by the experimenter, felt like taking riskier decisions, in other words "it's not my money".

Experiments that involve studying strategic behavior with possible losses

should take into account that when subjects receive an endowment they might not treat it as part of their real income. Our results would suggest that experimenters could control for available cash in the pockets of the subjects at the time of the experiment, even if the experiment provides an endowment to cover for losses as this would help explain variation in behavior. These factors should be tested, using a similar design of giving an endowment to subjects well in advance, but for other domains of interactions such as fairness and bargaining games (ultimatum, dictator, Coase bargaining), cooperation games (trust an public goods) or labor relations (effort, gift exchange) where a subject must decide over the allocation of her own resources and test for robustness and potential house-money effects.

Our research opens other new questions for further experimental tests on decisions under uncertainty.[12] We are well aware that this design is based on the same probability of 0.50 over all possible lotteries and this might impose a strong assumption about the application of expected utility theory, although it minimizes the potential problems of humans handling probabilities (Kahneman et al., 1982). Nevertheless, further tests with variable probabilities would enrich this finding, using other risk experiments available. On the one hand we could estimate this effect in other samples with different demographics including age, education level, financial literacy or income. On the other hand one could explore how the magnitude of the house-money bias changes with the time delay between the transfer of the endowment and the experimental decision. These could all deepen our understanding of how incentives work in the laboratory and of how income shocks may interact with behavior under uncertainty.

[12] A natural test of our findings could be conducted with occasional tourist casino players. Imagine a random group of tourists that receive a voucher-like gift in cash well in advance before their visit to the casino and another group that receives the voucher in the day of the visit. If our hypothesis holds, the latter group would make riskier decisions in the casino.

Chapter 3

Did Colombian guerrillas take refuge in Chávez's Venezuela? Evidence from the Geography of Conflict

Hugo Chávez always denied providing support to Colombia's leftist insurgent groups, FARC and ELN, during his time in office as President of Venezuela. I show in this chapter that FARC reveal their increased ability to hide in Venezuela following Chávez's election by disproportionately increasing their activities in Colombian border municipalities, as short-range weapons and large distances geographically constrain the group's ability to benefit from a safe haven across the border. ELN activity at the border also increases early in the Chávez administration but this group is crowded out by FARC in later years. The availability of a cross-border sanctuary is shown to have a large impact on the intensity of civil conflict in Colombia and on the homicide rate in the border region. I dismiss alternative explanations, such as political and economic shocks, the expansion of paramilitary groups and "Plan Colombia."

3.1. Introduction

Diplomatic relations between the neighbouring countries of Colombia and Venezuela were very tense during the years of the administration of Hugo Chávez in the latter (1999-2013). Most contentious were Chávez alleged links to the left-wing guerrilla groups operating in Colombia (particularly to FARC, the largest such group), with which he had a strong ideological affinity.[1] Although the Venezuelan president's public attitude towards FARC ranged from neutral to outspokenly supportive, with occasional criticism and calls for the insurgent group to give up armed struggle, the Chávez administration always denied any active collaboration with the insurgents.

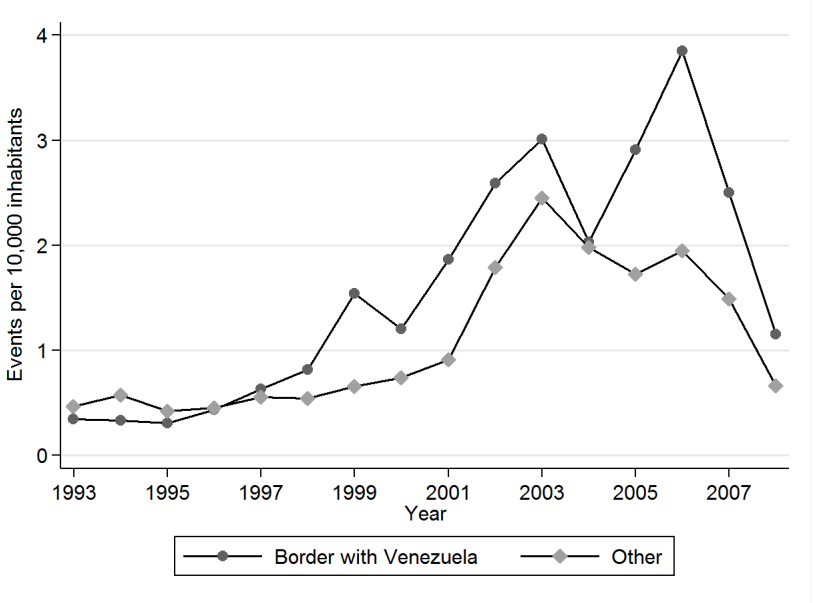
A mounting body of evidence, ranging from intercepted FARC communications to satellite images of FARC camps inside Venezuela, suggests otherwise. This chapter provides quantitative evidence of FARC's increased ability to operate inside Venezuela during the Chávez administration. I use data on the geography of the conflict inside Colombia to test whether the intensity of FARC activity increased disproportionately near the border with Venezuela when Chávez came to power. The underlying assumption is that due to both the short range of FARC's military technology and the magnitude of distances in Colombia, FARC's ability to increase their activities as a result of the availability of refuge in Venezuela should be greater in places closer to the border.

Figure 3.1 illustrates the main result of this investigation: municipalities at the border with Venezuela had similar levels of FARC activity to municipalities elsewhere in the country up to 1998. Chávez comes to power in February 1999 and from then on we observe a relative increase in the intensity of FARC activity at the border. The regression results, including municipality and region-year fixed effects, suggest that during the Chávez administration FARC activity in border municipalities was 0.3 standard deviations higher than in the rest of the country. This is a large increase and corresponds to 1.16 extra FARC events per 10,000 inhabitants, relative to a sample mean of 1.11. It is also a quite costly increase, as it is mainly driven by FARC attacks and terrorist attacks and it leads to a large increase in the homicide rate in border municipalities.

I also find an increase in ELN activity at the border with Venezuela in

[1]The other main guerilla group, though much smaller than FARC, is ELN. FARC is the acronym for "Fuerzas Armadas Revolucionarias de Colombia" (Revolutionary Armed Forces of Colombia). ELN is the acronym for "Ejército de Liberación Nacional" (National Liberation Army).

Figure 3.1: FARC activity near the border with Venezuela



Note: The graph shows yearly unweighted averages of the variable "FARC Events" for municipalities located at the border with Venezuela and for all other municipalities. FARC events is the sum of 19 activity indicators, divided by 1993 population.

the early years of the Chávez administration, but this effect disappears after 2004. Additional results indicate that the collapse in ELN activity is driven by FARC expansion into areas traditionally dominated by ELN. This occurs particularly in the department of Arauca at the border with Venezuela, where conflict between the two organisations took place between 2005 and 2010 (Avila, 2012).

The results on FARC are robust to (i) the inclusion of a broad set of control variables for the time-varying effect of municipality characteristics; (ii) different ways of measuring proximity to the border; (iii) the use of different datasets on the Colombian conflict; (iv) additional controls for both the paramilitary expansion and the increase in US military aid (Plan Colombia) that roughly coincided with the start of Chávez's term. I also provide evidence against alternative explanations based on changes in economic or political conditions specific to the border region.

A similar exercise reveals a disproportionate increase in FARC activity in municipalities at the border with Ecuador starting in 2003, when FARC leader Raúl Reyes is believed to have relocated in the area amid increased military pressure from the Uribe administration in Colombia, but well before Chávez's ally Rafael Correa assumed as President of Ecuador in 2007. This

finding is consistent with the existing evidence on FARC's ability to exploit weak Ecuadorian presence at the border, as well as on its inability to obtain guarantees regarding the safety of its operatives in Ecuador from Correa or any of his predecessors (ICG, 2004; IISS, 2011a).

This study contributes to the literature on civil conflict. It is hard to overstate the importance of this topic, as more than half of the countries in the world have experienced internal conflict since the end of World War II, with conflict lasting for 10 years or more in one out of every five (Blattman and Miguel, 2010). Colombia is a case in point, as the fight between the guerrilla groups and the democratic government dates back to 1964. The Colombian conflict is estimated to have caused over 200,000 deaths over its fifty year history and to have reduced GDP growth by between one half and two percentage points per year.[2] This chapter contributes more specifically to the recent literature that has exploited rich sub-national data from Colombia to better understand internal conflict. [3] It is also related to the literature on Venezuela's recent history and the Chávez administration.[4]

This investigation is also related to recent research studying the effects of foreign influence on political outcomes and conflict.[5] It has been estimated that 60 % of post-Cold War insurgent movements relied critically on support from foreign governments (Byman et al., 2001), while 55 % of rebel groups since 1945 are believed to have operated outside of their country of origin (Salehyan, 2007, 2008). However, little is known on the impact of foreign assistance on conflict intensity. I contribute to this literature by using a "forensic" approach that uncovers the geographic trail left behind by FARC's cross-border operations (Zitzewitz, 2012).

The remainder of the chapter is structured as follows. Section 3.2 provides some background information on the Colombian conflict and Venezuela's involvement. In sections 3.3 and 3.4 I discuss the data and the empirical strategy employed. Section 3.5 presents the results and the robustness checks. It also provides evidence against alternative explanations. Finally, section 3.6 concludes.

[2]Deaths figure from GMH (2013). On the economic costs of the conflict see Cárdenas (2007); Echeverry et al. (2001); Alvarez and Rettberg (2008); Riascos and Vargas (2011).

[3]See Angrist and Kugler (2008); Cortés et al. (2012); Acemoglu et al. (2013b); Dube and Vargas (2013); Camacho and Rodriguez (2013); Fergusson et al. (2013, 2014); Dube and Naidu (2015).

[4]See Ortega and Rodriguez (2008); Rodríguez (2008); Hsieh et al. (2011). Also see the papers in Clem and Maingot (2011) and in Hausmann and Rodríguez (2013).

[5]See, for example, Dube et al. (2011); Berger et al. (2013); Albornoz and Hauk (2014); Nunn and Qian (2014).

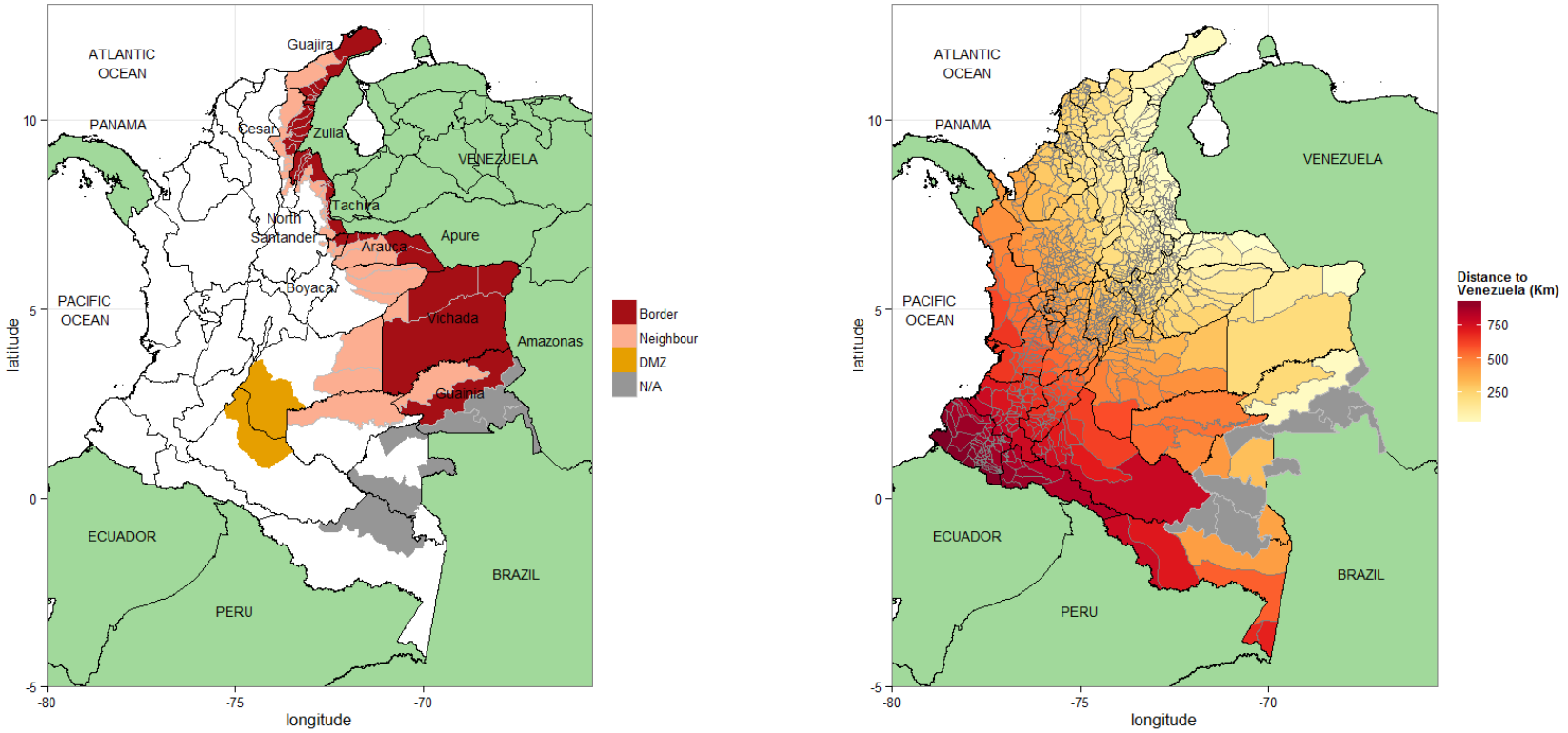
3.2. Background

As shown in Figure 3.2a, Colombia borders with Venezuela to the east. The border is Colombia's longest, at 2,219 kilometers long, and on the Colombian side includes 41 municipalities in 7 different departments.[6] Venezuela separated from what at the time was "Gran Colombia" in 1830, but despite a history of diplomatic disputes regarding border delimitation, there have never been any military confrontations between the two countries (Ramírez, 2003; Boraz, 2007). Throughout the sample period, Venezuela was Colombia's second most important trade partner after the U.S., representing on average 10 % of Colombian exports and 7 % of Colombian imports.

I will next provide some brief background information on the internal armed conflict in Colombia. I will make particular emphasis on three events that took place around the same time that Hugo Chávez became president of Venezuela in 1999. First, the establishment of a 42,000 square kilometer demilitarized zone, in which peace talks between FARC and the Pastrana administration in Colombia were held. Second, the improvement in the Colombian security forces' military capability as a result of a 1.2 billion USD military aid package from the U.S. government known as "Plan Colombia." Third, the rise of right-wing paramilitary groups under the umbrella organization AUC after 1997. Afterwards, I will provide background information on insurgent presence in Venezuela and on the role of the Venezuelan government in the Colombian conflict.

[6] Colombia is divided into 32 departments, each of which is fully divided into municipalities. There are 1123 municipalities, which roughly correspond to US counties, while departments are similar to US states.

Figure 3.2: Measuring proximity to Venezuela



(a) Border municipalities and their neighbours

(b) Distance to Venezuela (Km)

Note: Panel (a) shows municipalities located at the border with Venezuela and their neighbours inside Colombia. The demilitarized zone (1998-2002) is also highlighted. Panel (b) shows the great-circle distance from the urban area of each municipality (Cabecera municipal) to the border with Venezuela. Areas in grey correspond to municipalities with missing data.

3.2.1. A Recent History of Colombia's Internal Armed Conflict

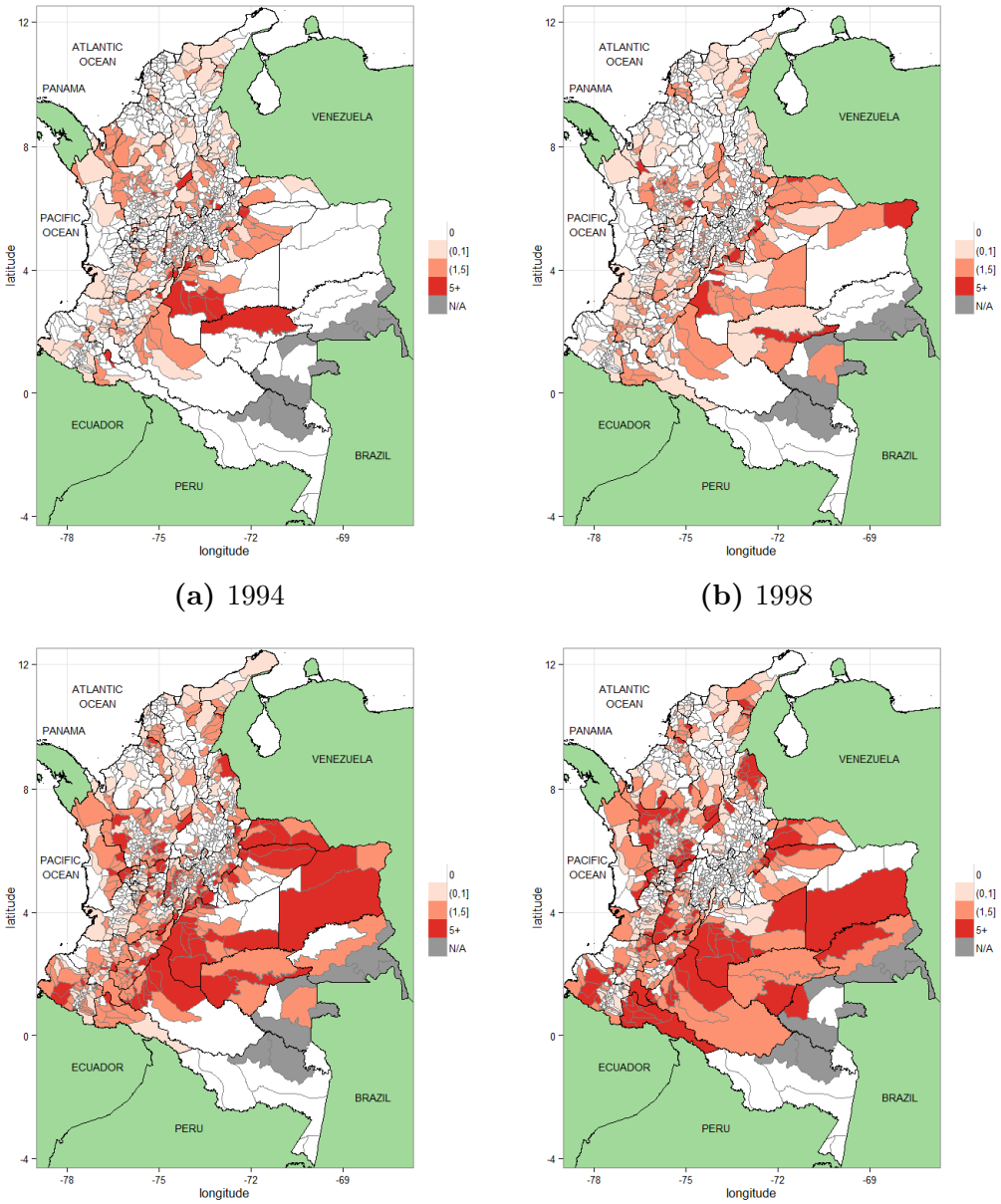
Left-wing insurgent groups FARC and ELN have been trying to overthrow Colombia's democratic government since 1964. FARC is the largest guerrilla group and was estimated to have up to 20,000 operatives at its peak around 2002 (Boraz, 2007; El Tiempo, 2012; Dube and Vargas, 2013). As shown in Figure 3.3, the heartland of FARC activity are the jungles and mountains of southern Colombia, stretching from the border with Ecuador in the south-west to the border with Venezuela in the east. ELN is believed to have had up to 5,000 operatives and its activity, as can be seen in Figure 3.4, is largely concentrated in three areas: Arauca department, the 'Catatumbo' region in North Santander department and the "Magdalena Medio" region in the departments of Antioquia and Bolívar (Boraz, 2007). The first two of these regions are at the border with Venezuela.

Even though neither insurgent group has ever had the military capacity nor the popular support necessary to overthrow the government, they have been able to survive for over four decades (Pizarro, 2007). The Colombian State's limited presence in rural areas has allowed the insurgents to find a stable source of income in the extortion of local businessmen, at the same time as they carry out guerrilla warfare amid favourable geographic conditions (Rangel, 2000; Palacios, 2012).

In the 1990s FARC were increasingly able to raise revenue through drug trafficking as coca cultivation in Colombia soared (Boraz, 2007; Angrist and Kugler, 2008; Otis, 2014). The additional resources allowed FARC to further implement its 'Strategic Plan', which dated from the early 1980s and called for the expansion of the guerrilla throughout rural Colombia (IISS, 2011a). Figures 3.5 and 3.3 show how FARC activity escalated during this period. ELN, on the other hand, has always formally refused to take part in the drug business, although compliance with this directive seems limited (El Espectador, 2014). This has left ELN at a financial disadvantage and helps to explain the group's stagnation and decadence throughout the sample period, as documented in Figures 3.5 and 3.4.

FARC's military success led president Andres Pastrana (1998 - 2002) to seek peace negotiations with the group, agreeing to establish a demilitarised zone comprising 5 municipalities in the departments of Meta and Caquetá (DMZ). These are shown in Figure 3.2a. The peace talks were held between 1999 and 2002, simultaneously with a dramatic escalation of the conflict, as can be seen

Figure 3.3: The location of FARC events

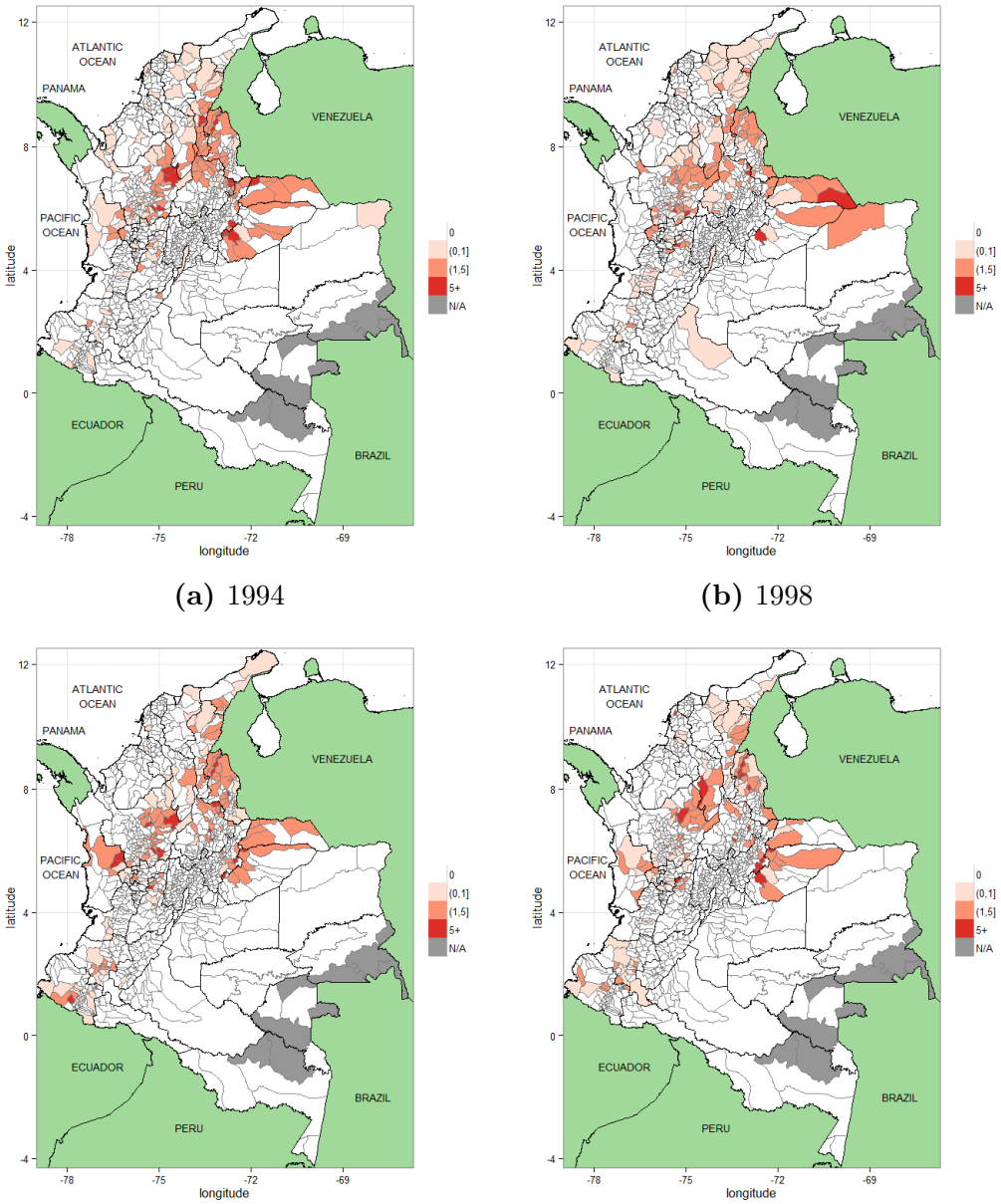


(a) 1994 **(b)** 1998

(c) 2002 **(d)** 2006

Note: The maps show the number of FARC events per 10,000 inhabitants. Events is the sum of 19 activity indicators. Areas in grey correspond to municipalities with missing data.

Figure 3.4: The location of ELN events

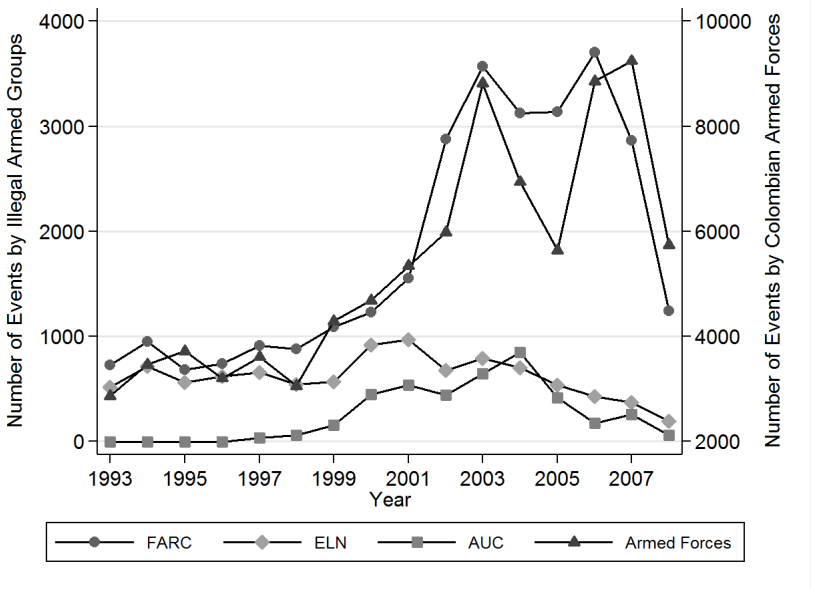


(a) 1994 **(b)** 1998

(c) 2002 **(d)** 2006

Note: The maps show the number of ELN events per 10,000 inhabitants. Events is the sum of 19 activity indicators. Areas in grey correspond to municipalities with missing data.

Figure 3.5: Activity by each party in Colombia's conflict



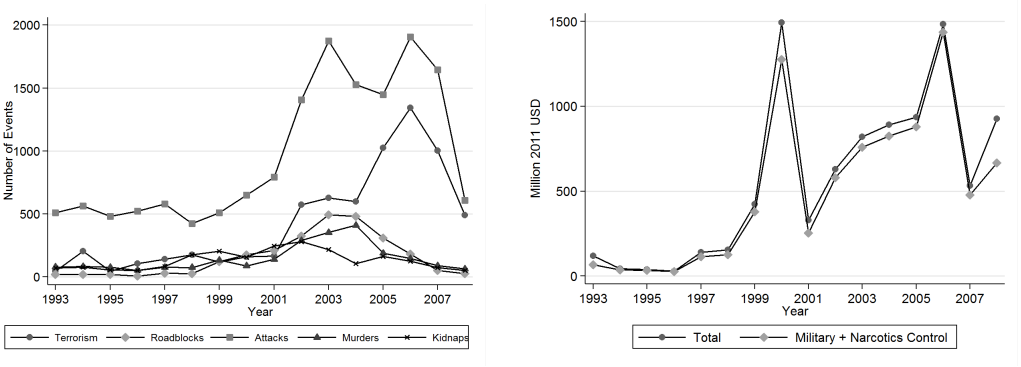
Note: The graph shows the aggregate number of events per year for each party. For FARC, ELN and AUC, "Events" is the sum of 19 activity indicators (axis on the left), while for the Colombian Armed Forces it is the sum of 9 indicators of activity (axis on the right).

in Figure 3.5. The DMZ allowed FARC to keep expanding during this period in the southern departments of Meta, Caquetá and Guaviare (Boraz, 2007), but also in the border regions of Vichada, Arauca, North Santander and Cesar, as Figure 3.3 illustrates. FARC increasingly moved into ELN territories, further contributing to the latter's decline (Boraz, 2007).[7]

The peace talks collapsed without any agreement and this contributed to Alvaro Uribe's victory in the presidential race of 2002. Uribe was elected (and re-elected in 2006) with a clear mandate to fight the guerrillas. Uribe was able to carry out a series of successful military campaigns against the rebels partly as a result of the large increase in U.S. military aid documented in Figure 3.6b, particularly a 1.2 billion USD aid package from the year 2000 known as "Plan Colombia" (El Tiempo, 2004b; Boraz, 2007; Cortés et al., 2012; Dube and Naidu, 2015). Figure 3.5 illustrates the large increase in Armed Forces activity during the Uribe administration. Starting in 2008 FARC received a series of major blows, such as the death of four members of the group's top decision-making unit, the Secretariat (three of them during attacks by government forces), as well as the rescue of FARC's most high-profile hostages by Colombian security forces (BBC News, 2008b, 2011; Fergusson et al., 2014).

[7]This would eventually lead to war between the two organizations in Arauca in 2005 (El Tiempo, 2005b,d; IISS, 2011a; Avila, 2012).

Figure 3.6: FARC activity and U.S. aid to Colombia



(a) Sub-categories of FARC activity **(b)** U.S. aid to Colombian government

Note: Panel (a) shows the number of events per year for different categories of FARC activity. "Terrorism" includes explosive, incendiary and other terrorist acts. "Roadblocks" includes assaults to private property, roadblocks, terrestrial piracy and illegal checkpoints. "Attacks" includes armed contact, ambush, siege, incursion, attacks against installations and massacres. "Murder" includes failed and successful political assassination plus murder of civilians. "Kidnap" includes politicians, military and civilians. Panel (b) shows the total value of U.S. government assistance to the government of Colombia, as well as the value of the component destined for military and anti-narcotics purposes (in millions of 2011 USD). Source: USAid.

It was also during the Uribe administration that the paramilitary organization AUC partially demobilized.[8] The first paramilitary groups were created in the early 1980s by land owners and drug lords who decided to organize private armies as a response to extortion from the guerrillas (Acemoglu et al., 2013b). These groups survived thanks to their involvement with the drugs trade and to contributions from businesses who paid for security in their areas of operation. In 1997 many of these groups united as the AUC, with the explicit purpose of defeating the guerrillas. Between 1999 and 2004 the paramilitaries expanded dramatically, as documented in Figure 3.5, and it is estimated that they had around 15,000 combatants at their peak in 2003 (Dube and Vargas, 2013). The AUC demobilization had mixed success since not all paramilitary groups agreed to demobilize while others kept operating under new names.

3.2.2. Venezuela's Role in Colombia's Armed Conflict

The presence of Colombian insurgent groups at the border with Venezuela dates back at least to the 1980s, when ocassional skirmishes between ELN and Venezuelan security forces contributed to the increasing militarization of

[8] AUC stands for "Autodefensas Unidas de Colombia" (United Self-defense Groups from Colombia).

the border on the Venezuelan side (IISS, 2011a; Avila, 2012). A particularly violent ELN raid on Venezuelan troops in 1995 led then Venezuelan president Rafael Caldera (1994-1998) to create two new military units to patrol the border. Additional measures included curtailing local population's civil rights and providing military tribunals with legal authority in the area (El Tiempo, 1995a, 1996a, 1997). Caldera allowed Colombian troops into Venezuela when in hot pursuit of insurgents and demanded that the Colombian government allow Venezuelan troops to do likewise (El Tiempo, 1995b, 1996b, 1998; Avila, 2012).

FARC's presence at the border was less visible than ELN's at the time due to the groups asymmetric approaches to foreign policy. While ELN considered foreign security forces as legitimate military targets, FARC claimed not to carry out military operations in foreign territory, under what they referred to as their "Border Policy" (Semana, 1995; Ramírez, 2003; IISS, 2011a). Still, it is estimated that by the time of the Venezuelan presidential elections in 1998 six FARC 'Fronts' from the Eastern, Magdalena Medio and Caribbean 'Blocs' were operating at the border (Boraz, 2007; IISS, 2011a).[9]

This election was won by Hugo Chávez, a former army lieutenant, with 56 % of the votes. Chávez led a failed coup attempt in 1992 and was imprisoned until 1995, apparently receiving a contribution of 130,000 USD from FARC during that time.[10] Chávez's presidential campaign had strong support from the left and from the military and was able to capitalize on popular discontent with the traditional political parties following years of sluggish economic performance, as shown in Figure 3.7a (Corrales, 2013).

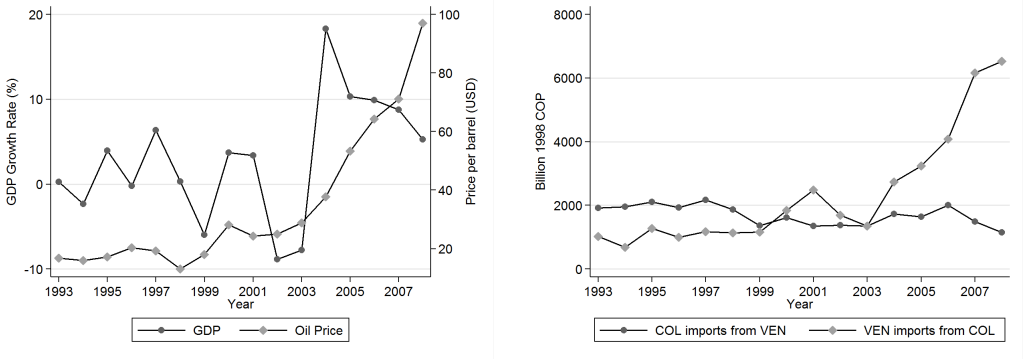
The initial attitude of the Chávez administration towards the Colombian guerrillas can be described as one of tolerance or mild sympathy (IISS, 2011a; Avila, 2012). Shortly after coming into power in February of 1999 Chávez declared Venezuela a neutral country in Colombia's armed conflict, abandoning his country's traditional support to the Colombian government in its fight against insurgent groups (Ramírez, 2003). He also discontinued the border security policies implemented by Caldera in the previous years.

News reports on Chávez's willingness to supply weapons to FARC started emerging in this period, some of which were soon confirmed by former members of the Chávez administration (El Tiempo, 1999, 2000b,c; Robinson, 2003). A

[9]Each Front can have anywhere between 100 and 500 operatives. Based on their location, Fronts are organized into Blocs, which are FARC's largest military unit. There are seven such regional Blocs, each under the command of a member of FARC's Secretariat.

[10]See items I.22, I.773, I.782, I.2995 and I.2997 of Raul Reyes' personal correspondence in (IISS, 2011b).

Figure 3.7: Economic conditions in Venezuela and Trade with Colombia



(a) Venezuela's economy and oil **(b)** Bilateral trade

Note: Panel (a) shows Venezuela's GDP growth rate (left axis) as a percentage and the price of oil in current USD. Source: World Bank (GDP), IMF-IFS (oil). Panel (b) shows the value of imports from Venezuela to Colombia and from Colombia to Venezuela in billions (short) of 1998 COP. Source: COW Trade.

document would later appear, dated August 1999, in which a senior member of the Venezuelan government agreed to provide FARC with supplies and refuge in exchange for moderated activities on the Venezuelan side of the border (El Universal, 2002; Semana, 2002; Ramírez, 2003; IISS, 2011a).

These first years of the Chávez administration were characterised by swift reforms of the country's main institutions amid signs of economic recovery, as shown in Figure 3.7a (El Tiempo, 2000a). New elections were held following the approval of a new constitution in 2000 and Chávez was re-elected for a six-year presidential term (2001-2006) with 60 % of the vote. But political polarization quickly rose as Chávez's political agenda radicalized. In April 2002 a failed coup attempt took place and in December of that same year employees from Venezuela's national oil company (PDVSA) went on a prolonged strike, paralysing the country's most important industry for over sixty days.[11] As figure 3.7a shows, economic conditions deteriorated significantly in that year.

Chávez seems to have distanced from FARC in the aftermath of the events of 2002 (IISS, 2011a; Avila, 2012). Political polarization remained high and the opposition movement, highly critical of Chavez' alleged links to FARC, raised enough signatures for a referendum to recall Chávez to be held in August 2004 (El Tiempo, 2003; Hsieh et al., 2011). Political conditions abroad also contributed to Chávez's moderated attitude, with Uribe taking office as Colombian President in mid-2002 and the U.S. becoming less tolerant

[11] 95 % of Venezuela's exports (and 12 % of GDP) comes from oil revenues, according to the CIA World Factbook.

to insurgent groups amid its "war on terror" (IISS, 2011a). Cooperation between the authorities of Colombia and Venezuela apparently resumed as the Venezuelan security forces proved willing to strike against FARC (El Tiempo, 2004a,d; Boraz, 2007).

Tension between the two countries rose significantly in December 2004 after Colombian security forces illegally captured FARC spokesman Rodrigo Granda in Caracas and transported him back into Colombia (BBC News, 2004). The Venezuelan government suspended diplomatic relations in response, but the crisis was short-lived (BBC News, 2005b; Avila, 2012). FARC's inability to use this incident to rekindle its relation with the Chávez administration was apparently related to the murder of seven Venezuelans by the organization in September 2004 (El Tiempo, 2004c; IISS, 2011a).

Chávez won the recall referendum with 60 % of the votes and was re-elected for a second six-year term (2007-2012) in 2006. The ensuing stabilisation of domestic political conditions allowed Venezuela's diplomacy to become more aggressive. In December 2004, Venezuela and Cuba launched "ALBA" as a counterpart to the US-led free-trade initiative known as "ALCA" and in 2005 Chávez started to characterise the political agenda of his government as "Socialism of the 21st century" (El Tiempo, 2005a). The price of oil was on the rise (see Figure 3.7a) and the resulting increase in government revenue allowed Chávez to pursue a strategy of "petro-diplomacy" (El Tiempo, 2005c; Corrales, 2009; Ortiz, 2011). Over the next four years, candidates friendly to Chávez's agenda would go on to win presidential elections in seven Latin American countries.[12]

Chávez regained prominence in the Colombian conflict in 2006 as the Uribe administration and FARC tried to agree terms for a 'humanitarian' exchange of prisoners (El Tiempo, 2006). While Chávez's potential role as mediator to the exchange was being discussed, representatives of the Venezuelan government apparently re-established communication with members of FARC's Secretariat and in a series of meetings offered refuge, supplies, weapons and money to the group (IISS, 2011a).

Uribe designated Chávez as a mediator for the humanitarian exchange in 2007, which allowed Chávez to publicly meet with senior FARC representatives (BBC News, 2007b). At a parallel private meeting, Chávez offered to provide

[12]These countries are Honduras (2005), Bolivia (2006), Ecuador (2006), Nicaragua (2006), Argentina (2007), Guatemala (2007), Paraguay (2008). Only in Mexico and Peru candidates backed by Chávez failed to win the Presidency in 2006.

FARC with 300 million USD (IISS, 2011a).[13] Uribe ended Chávez's involvement in the exchange two months after his appointment, in what led to another suspension of diplomatic relations between the two countries (The Washington Post, 2007). FARC responded by releasing several hostages through Chávez's unofficial mediation (BBC News, 2007a, 2008d).

The events of 2007 led to a dramatic deterioration in the relations between the governments of Colombia and Venezuela. During his annual address to the Venezuelan National Assembly in January 2008 Chávez claimed that "recognition must be given to FARC and ELN, they are insurgent forces that have a political project, that have a bolivarian project that is respected here" (El Tiempo, 2008, own translation), in what was perhaps his most explicit statement in support of the Colombian guerrillas.

The attack on a FARC camp in Ecuador in March 2008, in which Secretariat member Raúl Reyes was killed and his laptop was seized, led to another suspension of diplomatic relations and the deployment of Venezuelan troops at the border (BBC News, 2008c,e). The documents found in Reyes' laptop, which Interpol certified as legitimate, provide extensive evidence of the ties between FARC and the Chávez government (The Economist, 2008; IISS, 2011a).

The documents in Raul Reyes' laptop also indicate that FARC contributed 100,000 USD to the 2006 presidential campaign of Rafael Correa, the Ecuadorian President at the time of Reyes' death and a political ally of Chávez. However, FARC presence at the border with Ecuador precedes Correa's election, with Reyes settling in the area around 2003, and the available evidence suggests that FARC were not able to receive any guarantees regarding the safety of their operatives inside Ecuador from Correa, nor from any of his predecessors (IISS, 2011a). In 2009, weapons captured by Colombian troops at a FARC camp were found to have been sold by a Swedish manufacturer to the Venezuelan Armed Forces (Semana, 2009; The New York Times, 2009a). Chávez denied the allegations, suspended again diplomatic relations with Colombia and imposed restrictions on bilateral trade (BBC News, 2009b). However, intercepted FARC communications provided additional evidence on Venezuela acting as intermediary in arms deals involving the insurgents (The New York Times, 2009b). A military agreement between Colombia and the U.S. in late 2009 further contributed to bilateral tension (BBC News, 2009a).

In 2010 the Colombian government divulged satellite images of alleged FARC

[13] See also items I.2838, I.2850, I.2866, I.2890, I.2907 and I.2929 of Raul Reyes' personal correspondence in (IISS, 2011b).

camps inside Venezuela at an OAS summit (BBC News, 2010a). Colombian intelligence reports estimated at the time that FARC could have over 1,500 of their members distributed among 28 camps inside Venezuela (El Espectador, 2010b,a). Chávez denied the allegations and suspended diplomatic relations (El Tiempo, 2010b). However, he also criticised FARC and put into question the validity of guerrilla warfare, something he had already sporadically done since 2008 (El Espectador, 2008; BBC News, 2008a; El Tiempo, 2010a).

Relations between the two countries improved after Uribe left office in 2010 (BBC News, 2010b). Uribe's succesor, Juan Manuel Santos, started a new round of peace talks with FARC in 2012, with Venezuela acting as mediator (BBC News, 2015). Chávez was re-elected as president in 2012 with 55 % of the votes, but died from cancer in March 2013.

3.3. Data

I use conflict data from two sources. The main one is CEDE at Universidad de los Andes in Bogotá. CEDE collects information from official government sources and provides 19 different activity indicators for each illegal armed group (FARC, ELN, AUC) at the municipality-year level.[14] The CEDE dataset also has 9 indicators on the activities of the Colombian Armed Forces at the municipality-year level.[15] Data is available for 1,099 municipalities (98 %) from 1993 until 2008.[16] Municipalities lacking CEDE conflict data are shown in grey in Figures 3.2a-3.4. Following Acemoglu et al. (2013b) and Camacho and Rodriguez (2013), I add the 19 activity indicators and normalize by 1993 population (or initial population for new municipalities created during the sample period) to create an "Events" variable for each illegal armed group at

[14]These indicators are: terrorist act (explosive, incendiary, other), assault to private property, road block, terrestrial piracy, illegal checkpoint, armed contact, ambush, siege, incursion, attack against installation, massacre, political assassination (failed, succesful), murder of civilian, kidnap (politician, military, civilians). CEDE's sources are mainly the National Department of Planning (Departamento Nacional de Planeación - DNP) and the Observatory on Human Rights (Observatorio de Derechos Humanos), which is managed by the Office of the Vicepresident of Colombia. These agencies gather information from the National Police (Policía Nacional) and from newspaper reports.

[15]These indicators are: arrest, explosive defusal, demobilization, destruction of cocaine laboratory, other anti-narcotic operation, raid, seizure of weapons, hostage release, hostage rescue.

[16]Although four of the illegal-armed-group indicators have no non-zero values from 2004 on, while another four are also always zero from 2007 on. It is not obvious whether this corresponds to there actually being no events of those types in those years or if it is simply an incorrect coding of missing values. In any case, results are robust to the exclusion of years from 2004 on.

the municipality-year level.[17] I do likewise with the 9 activity indicators for the Colombian Armed Forces. CEDE also provides the murder rate (per 100,000) inhabitants, at the municipality-year level.

To check the robustness of the results to the source of conflict data employed, I use the publicly available replication data from Dube and Vargas (2013), which I will refer to as the DV dataset. This dataset, which is also used by Fergusson et al. (2014), is an enriched version of the dataset from think-tank CERAC. CERAC collects information from national and local newspapers and complements it with reports from non-government organizations working in remote areas.[18] The DV dataset includes the yearly number of attacks, massacres and political kidnappings by "Guerrillas" for 966 municipalities from 1988 to 2004. I create a "Guerrilla Events" variable by adding the three indicators and dividing again by 1993 population. For ease of comparison, all conflict variables are standardized.

The correlation between the CEDE and DV datasets is not as high as would be expected. For example, the correlation between "FARC Events" from CEDE and "Guerrilla Events" from DV is only 0.33. Of course, "FARC Events" is constructed adding 19 activity indicators while "Guerrilla Events" is the sum of only 3, but even for a more comparable indicator, the number of political kidnappings, the correlation is still only 0.55. This makes it all the more important to check the robustness of results to the use of different sources of information about the conflict, something that is not frequently done in the expanding literature on Colombia.[19]

For most of the analysis that follows, I divide municipalities into three groups: municipalities located right at the border with Venezuela, municipalities that are neighbours of border municipalities (but not at the border themselves) and municipalities that are none of the above. These are shown in Figure 3.2a. I also classify municipalities with respect to the border with Ecuador using the same criteria. To check the robustness of the results to the way in which proximity to Venezuela is measured I also calculate the geodesic or great-circle distance from the urban area of each municipality (Cabecera Municipal) to the border with Venezuela.[20] Figure 3.2b shows the results. The mean distance to

[17] Results are robust to using contemporary population instead, as well as to the exclusion of both new and broken up municipalities.

[18] See Restrepo et al. (2004) for a detailed account of the construction of the CERAC dataset.

[19] Albertus and Kaplan (2012), Acemoglu et al. (2013b) and Fergusson et al. (2013) are some exceptions.

[20] Miguel and Roland (2011) calculate distances in a similar way in their analysis of the

Venezuela of border municipalities is 27 km, while that of neighbours is 92 km.

Data on fixed physical characteristics (area, altitude, distance to the nearest market) as well as on State presence (notary office, agricultural bank office, tax collection office, health center or hospital) comes from CEDE. The source for the Unmet Basic Needs index, total population and the share of rural population is the National Department of Statistics (DANE), based on the 1993 census. DANE also provides information on the creation of new municipalities.[21] Yearly information on local public finance (natural resource royalties, transfers from central government, local tax revenue) is provided by DNP. Data on electoral results comes from the National Civil Registry.

Table 3.1 shows summary statistics for the main variables that I employ in this chapter.

effect of US bombing on economic conditions in post-war Vietnam. An alternative would be to use driving distances to the border, as in Dell (2014) and Dube et al. (2013). But the geodesic distance I use is arguably better suited for the present study because insurgents in Colombia do not make heavy use of the road network.

[21] 69 new municipalities are created between 1993 and 2008. They are created from 92 existing ones in 20 different departments

Table 3.1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Panel A: Panel-level Variables					
FARC Events[1]	1.11	3.88	0	149.37	17338
FARC Terrorist Acts[1]	0.24	1.36	0	55.03	17338
FARC Roadblocks[1]	0.08	0.48	0	15.72	17338
FARC Attacks[1]	0.62	2.31	0	76.98	17338
FARC Murders[1]	0.09	0.6	0	33.36	17338
FARC Kidnaps[1]	0.08	0.39	0	7.86	17338
FARC Losses[1]	0.49	2.76	0	130.33	17328
ELN Events[1]	0.33	1.55	0	89.15	17338
AUC Events[1]	0.14	0.75	0	27.45	17319
Guerrilla Events[1] (DV)	0.37	1.12	0	39.15	11736
Murder Rate (per 100,000 inh.)	55.93	83.72	0	2724.71	17338
Armed Forces Events[1]	2.21	7.67	0	340.61	17328
Winner's vote share in last presidential election	0.46	0.22	0	0.96	17183
Left's vote share in last presidential election	0.06	0.1	0	0.99	17183
Mayor from Liberal party (dummy)	0.36	0.48	0	1	17338
Mayor from Conservative party (dummy)	0.25	0.43	0	1	17338
Property tax revenue (Millions of 1998 COP)[1]	100.17	146.72	0	3072.55	17338
Business tax revenue (Millions of 1998 COP)[1]	67.96	228.7	0	5057.36	17338
Transfers (Millions of 1998 COP)[1]	1095.74	1088.64	0	25678.36	17338
Royalties (Millions of 1998 COP)[1]	175.19	1333.3	0	55574	17338
Panel B: Municipality-level Variables					
Border with Venezuela (dummy)	0.03	0.18	0	1	1099
Neighbour of border municipality (dummy)	0.04	0.19	0	1	1099
Distance to border with Venezuela (Km)	360.07	232.36	0.24	938.79	1099
Area (Km^2)	947.35	3090.58	15	65674	1099
Altitude (Metres above sea level)	1148.07	906.15	2	3087	1099
Distance to nearest market (Km)	123.46	97.61	0	926.47	1099
Unmet Basic Needs index in 1993	54.17	19.78	9.15	100	1099
Share of rural population in 1993	0.64	0.23	0	1	1099
Royalties in 1998 (million COP)[1]	91.62	584.04	0	10340.44	1099
Transfers in 1998 (million COP)[1]	1276.14	705.96	0	7806.84	1099
New municipality (dummy)	0.07	0.26	0	1	1099
Divided to create new municipality (dummy)	0.08	0.28	0	1	1099
Notary office in 1996 (dummy)	0.42	0.49	0	1	1099
Agricultural bank office in 1996 (dummy)	0.91	0.29	0	1	1099
Tax collection office in 1996 (dummy)	0.44	0.5	0	1	1099
Health center or hospital in 1996 (dummy)	0.74	0.44	0	1	1099
FARC demilitarized zone (dummy)	0.02	0.14	0	1	1099
Coca crops in 2000 (dummy)	0.17	0.38	0	1	1099

Notes: [1] per 10,000 inhabitants.

3.4. Empirical Strategy

To test for a disproportionate increase in guerrilla activity near the border with Venezuela after Chávez comes to power I implement a difference-in-differences strategy. The identifying assumption is that guerrilla activity near Venezuela would have been the same as in the rest of the country, conditional on controls, had Chávez not come to power in 1999. Using data from the years prior to 1999 I explicitly test this parallel trends assumption.

Two important premises underlie the ability of this design to inform us about the causal impact of increased insurgent presence in Chávez's Venezuela on the intensity of guerrilla activity in Colombia. The first one is that the election of Hugo Chávez as president of Venezuela in December 1998 was an exogenous shock to the Colombian conflict.[22] The second premise is that the possibility to hide across the border only allows the guerrillas to increase the intensity of their activities in areas near the border. This constraint is driven by the large magnitude of distances in Colombia and by the military technology available to the rebels, which consists mostly of small arms (Cragin and Hoffman, 2003; BBC News, 2005a).[23] Other types of support, like the provision of weapons or money, are more easily transported and are less geographically constrained.

El Tiempo (2002) provides an example of the type of insurgent activity that the empirical strategy is meant to capture. This article reports how FARC operatives entered the Colombian municipality of Tibú in North Santander from Venezuela and burnt eleven vehicles on the main road in March 2002. As troops from the Colombian Army approached, the insurgents crossed back into Venezuela, only to re-enter Tibú three days later to engage in combat with the army. Twelve insurgents and five soldiers died as a result. The remaining FARC combatants retreated back into Venezuela but attacked the Army with gas cylinders filled with explosives from across the border. The following day

[22] As discussed in section 3.2.2, Chávez's electoral victory was the result of a local political and economic crisis unrelated to the Colombian conflict. Only in April 1998 did Chávez lead the polls for the first time and over the following months there was a large degree of uncertainty regarding both the ability of the candidates from the traditional parties to catch up with Chávez and the possibility that the elections could be disrupted by violence (McCoy, 1999).

[23] The guerrilla's arsenal includes mostly AK-47 rifles, M-60 machine guns, 60 mm. mortars, hand grenades and home-made explosives (e.g. explosive-filled gas cylinders). None of these weapons have an effective range of more than 5 or 6 km. Even the AT-4 Swedish rocket launchers seized at a FARC camp in 2009 have a maximum range of 2 km. On average, the urban center of border municipalities is 27 km away from the border, while for their neighbours this distance is 92 km. These are large distances given that guerrilla units mainly move on foot.

the guerrillas attacked again, with nine insurgents and seventeen soldiers dying during the fighting.

The main specification used in the empirical analysis is the following:

$$y_{i,j,t} = \beta_1(\text{Chávez}_t \times \text{D(Border Ven.)}_i) + \beta_2(\text{Chávez}_t \times \text{D(Neighbour Ven.)}_i) + \alpha_i + \delta_{j,t} + \gamma X_{i,j,t} + \epsilon_{i,j,t} \tag{3.1}$$

where 'y' is an outcome of interest (mainly FARC events) and the unit of observation is municipality i in region j in year t. Chávez_t is a dummy equal to one for years ≥ 1999. The coefficients of interest, β_1 and β_2, estimate the change in the difference in the dependent variable between border municipalities (or their neighbours in the case of β_2) and non-border non-neighbour municipalities after Chávez comes to power, conditional on the controls discussed next.

α_i is a municipality fixed effect that accounts for all persistent heterogeneity across municipalities.[24] $\delta_{j,t}$ is a region-year fixed effect that controls for events affecting equally all municipalities within a region in the same year. For this purpose, I divide the country into six regions, roughly corresponding to the country's natural geographic regions.[25] For example, these region-year fixed effects should absorb the effect that less geographically-constrained forms of foreign support, like weapons or money, have on the intensity of guerrilla activity.

Fixed characteristics with a time-varying effect on conflict could potentially bias the estimates of β_1 and β_2 if these characteristics are correlated with proximity to the border. For instance, estimates would be biased if border municipalities are further away from markets and if guerrilla activity increases in these more remote locations after 1999, as could be the case after the implementation of Plan Colombia in 2000.

Therefore, I include a full set of year interactions with a wide range of such characteristics: area, altitude, distance to the nearest market, UBN index (1993), share of rural population (1993), natural resource royalties (1998), transfers from central government(1998), presence of notary office dummy (1996), presence of agricultural bank dummy (1996), presence of tax collection office dummy (1996), presence of health center or hospital dummy (1996). I also interact the year fixed effects with a dummy for the five municipalities comprising

[24] Buhaug and Rod (2006) find that proximity to the border was positively correlated to separatist conflict but unrelated to political conflict in Africa between 1970 and 2001. Buhaug and Gates (2002) report that internal conflicts taking place near an international border tend to have a larger geographical scope.

[25] Results are qualitatively similar if I use department-year fixed effects instead, but these absorb most of the variation in the distance to the border.

the demilitarized zone and their neighbours, a dummy for new municipalities created during the sample period, as well as one for the municipalities they belonged to. These controls correspond to $X_{i,j,t}$ in equation (3.1).

The error term, $\epsilon_{i,j,t}$, is two-way clustered in all regressions by municipality and department-year, following Cameron et al. (2011).

I check that the results are robust to the use of an alternative metric of proximity to the border by estimating a modified version of equation (3.1), where I interact the Chávez dummy with dummies based on distance to the border. I confirm the existence of a non-linear increase in FARC activity at the border by including the interactions between year dummies and the distance to the border as additional controls.

I test for heterogeneous effects over time (and the parallel trends assumption) by estimating the following modified version of equation (3.1), where I interact the 'Border' and 'Neighbour' dummies with dummies for pairs of years (Δ_t) instead of with the 'Chávez' dummy:

$$\begin{aligned} \mathrm{y}_{i,j,t} = & \sum_{t=94/95}^{07/08} \beta_t(\Delta_t \times \mathrm{D(Border\ Ven.)}_i) + \eta_t(\Delta_t \times \mathrm{D(Neighbour\ Ven.)}_i) \\ & + \alpha_i + \delta_{j,t} + \gamma X_{i,j,t} + \epsilon_{i,j,t} \end{aligned} \tag{3.2}$$

I similarly test for heterogeneous effects along the border by interacting the Chávez dummy with department-specific 'Border' and 'Neighbour' dummies.

I check that the results are robust to the inclusion of a quadratic trend specific to municipalities at the border with Venezuela and their neighbours. I verify that the results are not driven by guerrilla activity increasing in their traditional strongholds by adding the interaction between the year dummies and the intensity of guerrilla activity in 1998. Although adding a similar interaction with a dummy for coca crops in 2000 could lead to a problem of "bad controls", I do so to ensure that this is not driving the results (Angrist and Pischke, 2009). I also check that the results are robust to the use of municipalities at the other borders (Brazil, Peru, Ecuador, Panama, coasts) as controls.

As a placebo check, I estimate a modified version of equation (3.1), where I interact the 'Chávez' variable with dummies for municipalities at the 'Border' with Ecuador, and their 'Neighbours'. I also use these Ecuador 'Border' and 'Neighbour' dummies interacted with a 'Correa' time variable (year$\geq$2007) to look for evidence of increased guerrilla presence in Ecuador after Rafael Correa comes to power in that country.

I deal with the possibility that the paramilitary expansion may be confounding the results in three different ways. First, I look for increased paramilitary activity near the border after 1999 by estimating equation (3.1) with AUC events as the dependent variable. Second, I return to FARC events as the dependent variable in (3.1), but add AUC events (contemporary) as an additional control. Third, I include the interaction between year fixed effects and a dummy for municipalities that had non-zero AUC events at any point in the sample period as additional controls.

I also check that the results are not driven by changes in Armed Forces activity due to a change of policy during the Uribe administration or to extra resources from Plan Colombia. Like with AUC, I estimate equation (3.1) using Armed Forces events as dependent variable or as control (with FARC events on the LHS). I additionally estimate an enlarged version of (3.1) where I include the interaction between the 'Border' and 'Neighbour' dummies with the aggregate yearly number of FARC losses (captured+demobilized). This way I can check whether the results are driven by FARC retreating to the border in years when they are hit particularly hard by government forces. I also estimate a similar modification where I include the interaction between the 'Border' and 'Neighbour' dummies with the yearly amount of U.S. foreign aid received by Colombia.

I further modify equation (3.1) to control for the possibility that economic conditions are changing differentially near the border during the years of the Chávez administration. This could be particularly worrying if we believe that economic conditions in Venezuela have a spill-over effect on the border economy in Colombia. To assuage these concerns, I first add as control the interaction between the 'Border' and 'Neighbour' dummies with Venezuela's GDP growth rate, plotted in Figure 3.7a. I do likewise with the price of oil. I also include as an additional control the most geographically disaggregate GDP measure available for Colombia, which is at the department level. Finally, I include the contemporary values of local public finance indicators (property and business tax revenue, transfers, natural resource royalties) as controls.

I look for changes in local political conditions near the border over time by estimating a modified version of equation (3.2), where only election years are included and the dependent variable is some electoral outcome of interest.[26] These outcomes are the vote share for the Liberal party and for the main left-

[26]Presidential elections took place in 1986, 1990, 1994, 1998, 2002 and 2006. Mayoral elections took place in 1988, 1990, 1992, 1994 1997, 2000, 2003 and 2007.

wing party in presidential elections, as well as the vote share for the traditional parties (Liberal and Conservative) and for the winning candidate in the mayoral elections.[27] This way I can look at changes in both political preferences and the competitiveness of elections specific to municipalities near Venezuela. I also check that the results from (3.1) are robust to the inclusion of political controls.

3.5. Results

3.5.1. Main Results

The first column in Table 3.2 shows estimates of equation (3.1) using FARC events as the dependent variable. The point estimates indicate that after Chávez comes to power in 1999 the intensity of FARC activities in border municipalities increases by 0.32 standard deviations (SD). Not only is this estimate statistically significant at the 1 % level, but it also represents quite a large effect: 1.16 extra FARC events per 10,000 inhabitants, relative to a sample mean of 1.11. Column 8 provides additional evidence of the human cost of the increase in insurgent activity, as the murder rate is found to increase by almost 20 extra homicides (per 100,000 inhabitants) in border municipalities when Chávez comes to power, a very large increase (35 %) relative to the sample mean of 56.

Panel (a) in Figure 3.8 shows estimates of equation (3.2), exploring the variation in FARC activity at the border region over time. The plot shows that the difference in FARC activity between the border region and the rest of the country before 1999 was statistically indistinguishable from zero, which provides support to the parallel trends assumption underlying the empirical strategy. The graph also indicates that FARC activity increased as soon as Chávez came to power in 1999 (0.25 SD) and that it remained roughly constant until 2004. FARC activity in border municipalities further increased in the period 2005-2006 (0.60 SD), which is consistent with the anecdotal evidence on renewed collaboration from the Chávez administration around this time. The drop of the point estimate for border municipalities to 0.19 in the final period (2007-2008) is surprising given the low level of bi-national cooperation at the time but may be related to Chavez' increased prominence in the Colombian conflict after 2007 and to the Colombian raid on Raul Reyes' camp in Ecuador in March 2008.

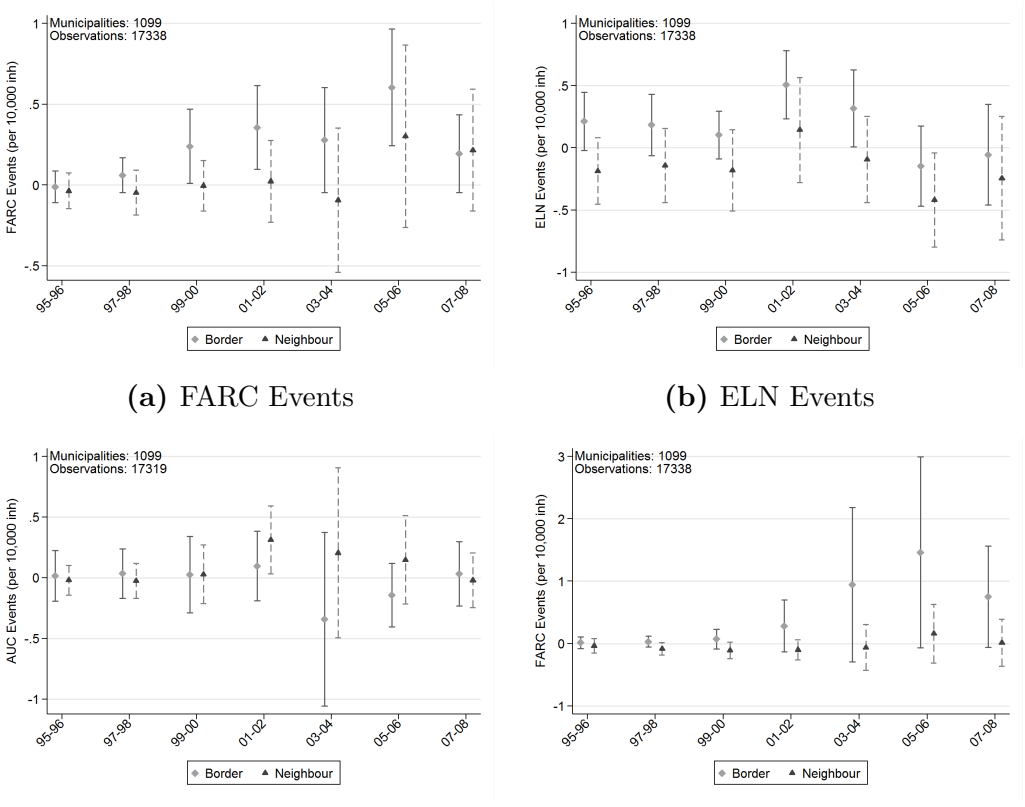
[27] I focus on the Liberal party in the presidential elections as it is the only party that always presented a candidate of its own during the sample period. As main left-wing party I use UP in 1986, M19 in 1990-1998, PDI in 2002 and PDA in 2006.

Table 3.2: Guerrilla activity at the border with Venezuela

VARIABLES	(1) FARC Events	(2) FARC Events	(3) FARC Events	(4) ELN Events	(5) ELN Events	(6) ELN Events	(7) ELN Events	(8) Murder Rate
Chavez x D(Border Ven.)	0.318***			0.0115			-0.0276	19.58*
	[0.0950]			[0.105]			[0.110]	[11.23]
Chavez x D(Neighbour Ven.)	0.117			-0.0479			-0.0623	13.32*
	[0.132]			[0.115]			[0.115]	[7.779]
Chavez x D(Dist. Ven.≤30 Km)		0.262***			0.0486			
		[0.0922]			[0.0972]			
Chavez x D(Dist. Ven.≤10 Km)			0.398**			-0.162		
			[0.190]			[0.172]		
Chavez x D(10 Km<Distance Ven.≤20 Km)			0.201*			0.199		
			[0.118]			[0.123]		
Chavez x D(20 Km<Distance Ven.≤30 Km)			0.186*			0.100		
			[0.0951]			[0.122]		
Chavez x D(30 Km<Distance Ven.≤100 Km)		0.0254	0.0252		-0.164*	-0.163*		
		[0.0661]	[0.0663]		[0.0992]	[0.0993]		
FARC Events (per 10,000 inh.)							0.123**	
							[0.0603]	
Observations	17,338	17,338	17,338	17,338	17,338	17,338	17,338	17,338
Number of municipalities	1,099	1,099	1,099	1,099	1,099	1,099	1,099	1,099

Notes: Standard errors clustered by municipality and department-year in brackets. *** p<0.01, ** p<0.05, * p<0.1. All regressions include municipality and region-year fixed effects. They also include a full set of year interactions with fixed municipality characteristics. The dependent variable is the standardized sum of 19 indicators of activity by the illegal armed group in the header divided by 1993 population, except for column 8, where it is the murder rate (per 100,000 inh.).

Figure 3.8: Yearly variation in border activity by illegal armed groups



(a) FARC Events **(b)** ELN Events

(c) AUC Events **(d)** FARC Events (Ecuador)

Note: The graph shows point estimates and 95 % confidence intervals for the interaction between dummy variables for each pair of years (e.g. 1995 and 1996) and the dummies for municipalities at the "Border" with Venezuela (Ecuador in panel (d)) and their "Neighbours". The omitted pair is 1993/1994. The regression includes municipality and region-year fixed effects. It also includes a full set of year interactions with fixed municipality characteristics. The standard errors have been clustered two-way by municipality and department-year. The dependent variable is the standardized sum of 19 indicators of activity by the group in the caption divided by 1993 population.

The point estimate for neighbour municipalities is positive in column 1 of Table 3.2, but smaller than for border municipalities and not statistically significant at conventional levels. This is consistent with the hypothesis that the strategic advantage resulting from the cross-border provision of refuge is decreasing in the distance to the border. The results in columns 2 and 3 show that the increase in FARC activity is negatively related to distance to the border up to 30 km, with no statistically significant difference between municipalities 30-100 km from the border and those further away. The fact that FARC activity only increases in the area immediately next to the border provides evidence in favour of FARC's increased ability to operate inside Venezuela as the driving mechanism and against less geographically-constrained forms of support like

money or weapons.

Panel (a) in Figure 3.9 shows results from a modified version of equation (3.1) that includes separate Border and Neighbour dummies for each Colombian border Department.[28] The graph shows that the increase in FARC activity during the Chávez years is observed in all border Departments, with the exception of Vichada and Guainia in the southernmost section (Figure 3.2a). This heterogeneity may be driven by FARC already being quite strong in this area before Chávez (Boraz, 2007), or by conflict data being less accurate in this scarcely populated jungle area. The coefficients for Guajira, Cesar and North Santander are all around 0.25, with the estimate for the latter being noisier (p=0.106). Border municipalities in Arauca, as well as their neighbours, experience a much larger increase in FARC events of 0.71 SD when Chávez is in power.

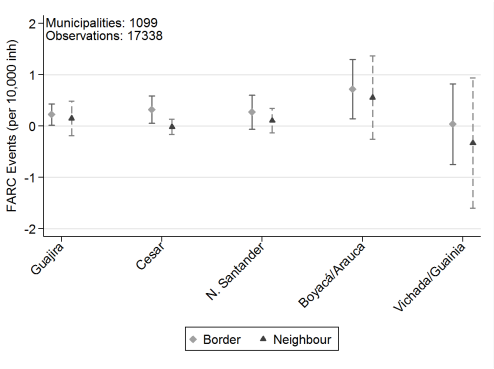
We can relate these findings to the anecdotal evidence on FARC activity in Venezuela. The maps in Figure 3.3 show that FARC activity in Cesar and Guajira expands from the point where these two Departments meet with Venezuela. It is in a nearby area, twenty kilometres inside Venezuela, where the Colombian government claimed that four FARC camps were located at the OAS summit in 2010 (El Espectador, 2010a; IISS, 2011a). In fact, coordinates of FARC camps in this area had already been divulged seven years before (Robinson, 2003). The other locations mentioned in the accusation made by the Colombian Government in 2010 were spread through the Venezuelan state of Apure, which borders with Arauca and Vichada (See Figure 3.2a).

Columns 4-7 of Table 3.2 replicate the previous analysis but using ELN events as the dependent variable. According to column 4, there is a very small and insignificant increase in ELN activity in border municipalities during the Chávez years and a decrease in neighbouring ones, which is also insignificant. Columns 5 and 6 show that ELN events decreased in the area 30-100 km away from the border, consistently with the results on neighbour municipalities. These findings are consistent with the group retreating towards the border and into Venezuela during this period, without having the resources with which to launch attacks from across the border.

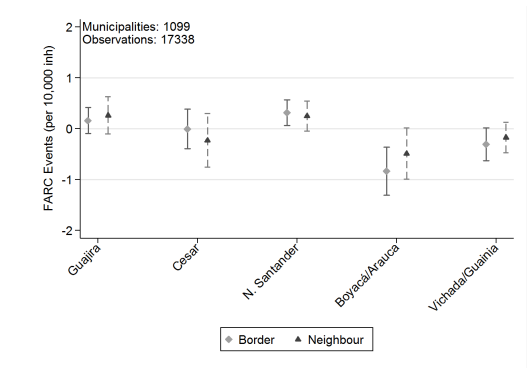
Figure 3.8 provides a more nuanced picture. The estimates of equation (3.2) in panel (b) show how ELN activity actually increased in border municipalities in the period 2001-2004 and collapsed afterwards. This can be explained by

[28]I join Boyacá with Arauca and Vichada with Guainía due to the small number of municipalities in these departments.

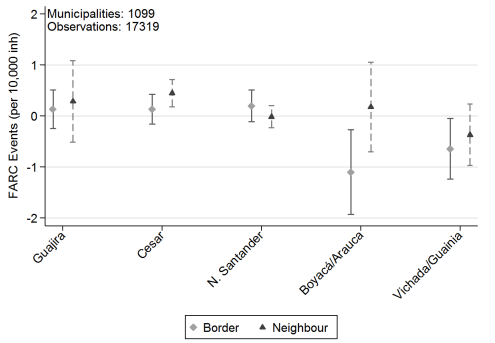
Figure 3.9: FARC activity at different segments of Venezuelan border



(a) FARC Events



(b) ELN Events



(c) AUC Events

Note: The graphs shows point estimates and 95 % confidence intervals for the interaction between dummy variables for "Border" and "Neighbour" municipalities in each border department with the Chávez (post-1999) dummy. The regression includes municipality and region-year fixed effects. It also includes a full set of year interactions with fixed municipality characteristics. The dependent variable is the standardized sum of 19 indicators of activity by the illegal armed group in the caption, divided by 1993 population. The standard errors have been clustered two-way by municipality and department-year.

the large increase in FARC activity in ELN's stronghold in Arauca and the conflict that erupted between the two organisations after 2005 (Avila, 2012). Panel (b) of Figure 3.9 confirms that ELN activity decreased drastically in the Arauca border region after 1999, but this graph also shows that ELN events rose 0.3 SD in the group's other traditional stronghold, the North Santander border region, during the Chávez administration. Column 7 of Table 3.2 further stresses the influence of FARC expansion on ELN activity , as it shows that controlling for FARC activity changes the sign of the coefficient for border municipalities, although it remains very small and statistically insignificant.

3.5.2. Guerrilla Activity at the Border with Ecuador

Table 3.3 examines the evolution of insurgent activity at the border with Ecuador during the Chávez administration in Venezuela. Column 1 shows estimates of equation (3.1) using border and neighbour municipalities in Ecuador instead of Venezuela. The results indicate that there is a large increase of 0.69 SD, significant at the 10 % level (p=0.075). However, panel (d) of Figure 3.8 shows that FARC events increase in municipalities at the border with Ecuador only after 2003 and then decrease somewhat in the period 2007-2008. That is why the estimates in column 2 of Table 3.3 fail to support the hypothesis that FARC activity increased at the border with Ecuador after Rafel Correa came to power in 2007.

These findings are consistent with the anecdotal evidence on FARC not being provided with protection by President Rafael Correa nor by any of his recent predecessors, but nevertheless being able to exploit the weak presence of the Ecuadorian State in the border region and its low levels of cooperation with the Colombian government (ICG, 2004; IISS, 2011a). For example, Secretariat member Raul Reyes is believed to have moved to Ecuador in 2003, when the Uribe administration intensified military operations in the former DMZ (El Tiempo, 2004b; Boraz, 2007), which could explain the documented rise in FARC activity after this year. The fact that Reyes was able to remain in the area until his death in 2008, although constantly forced to change location and shut down communications, further illustrates the ambiguity of FARC's situation in Ecuador (IISS, 2011a).

Although FARC activity only increased in Ecuador after 2003, I assuage concerns about a generalized increase in FARC activity across Colombian border regions in the Chávez years by estimating equation (3.1) with a restricted sample that only includes municipalities that are located at any of Colombia's

Table 3.3: Guerrilla activity at the border with Ecuador

VARIABLES	(1) FARC Events	(2) FARC Events	(3) FARC Events	(4) ELN Events	(5) ELN Events	(6) ELN Events
Chavez x D(Border Ecu.)	0.687*			-0.00291		
	[0.386]			[0.0805]		
Chavez x D(Neighbour Ecu.)	0.0216			0.106		
	[0.107]			[0.0731]		
Correa x D(Border Ecu.)		0.348			-0.149	
		[0.222]			[0.0971]	
Correa x D(Neighbour Ecu.)		0.0471			-0.0882	
		[0.144]			[0.0658]	
Chavez x D(Border Ven.)			0.280**			-0.119
			[0.111]			[0.108]
Chavez x D(Neighbour Ven.)			0.111			-0.152
			[0.116]			[0.151]
Observations	17,338	17,338	3,343	17,338	17,338	3,343
Number of municipalities	1,099	1,099	213	1,099	1,099	213

Notes: Standard errors clustered by municipality and department-year in brackets. *** p<0.01, ** p<0.05, * p<0.1. All regressions include municipality and region-year fixed effects. They also include a full set of year interactions with fixed municipality characteristics. The dependent variable is the standardized sum of 19 indicators of activity by the illegal armed group in the header divided by 1993 population.

borders and their neighbours. The results in column 3 of Table 3.3 indicate that FARC events rose in municipalities at the border with Venezuela, relative to municipalities near to any of the other borders, with the point estimates being very similar to the ones from the full sample in Table 3.2.

Columns 4 and 5 of Table 3.3 show that there is no evidence of changes in ELN activity near the border with Ecuador at any point after 1999. The estimates in column 6 suggest that ELN events at the border with Venezuela decreased relative to other borders after 1999, but the coefficients are not statistically significant. These results are consistent with the evidence on ELN activity near Venezuela being relatively high during the Caldera administration and collapsing in the final years of the sample.

3.5.3. Robustness Checks

The results presented in the previous section provide evidence of a large, sustained and costly increase in FARC activity at the border with Venezuela after Chávez came to power in 1999. In this section I test the robustness of this main finding, taking equation (3.1) with FARC events as the dependent variable as the baseline specification.

I begin by disaggregating FARC events into five sub-categories of activity

to see whether one particular type of activity is driving the results. This decomposition also provides more information on the relative importance of the increase in FARC activity, as not all events have the same human or material costs. The estimates in Table 3.4 show a statistically significant increase for all types of FARC activity in municipalities at the border with Venezuela during the Chávez administration, with the exception of murder.

Table 3.4: Categories of FARC activity at the border with Venezuela

VARIABLES	(1) FARC Terrorism	(2) FARC Roadblocks	(3) FARC Attacks	(4) FARC Murder	(5) FARC Kidnap
Chávez x D(Border Ven.)	0.244**	0.302***	0.286***	0.0769	0.129*
	[0.106]	[0.0938]	[0.0866]	[0.0531]	[0.0693]
Chávez x D(Neighbour Ven.)	-0.00264	0.214	0.135	-0.000139	0.113
	[0.103]	[0.143]	[0.134]	[0.0879]	[0.0724]
Observations	17,338	17,338	17,338	17,338	17,338
Number of municipalities	1,099	1,099	1,099	1,099	1,099

Notes: Standard errors clustered by municipality and department-year in brackets. *** p<0.01, ** p<0.05, * p<0.1. All regressions include municipality and region-year fixed effects. They also include a full set of year interactions with fixed municipality characteristics. "Terrorism" includes explosive, incendiary and other terrorist acts. "Roadblocks" includes assaults to private property, roadblocks, terrestrial piracy and illegal checkpoints. "Attacks" includes armed contact, ambush, siege, incursion, attacks against installations and massacres. "Murder" includes failed and succesful political assasination plus murder of civilians. "Kidnap" includes politicians, military and civilians.

Figure 3.6a plots the evolution of each of these categories of FARC activity over time. A comparison with Figure 3.5 indicates that "Attacks", which rises dramatically between 1999 and 2003, is the main source of variation in FARC events over time, followed by "Terrorism." The results in Table 3.4 thus suggest that FARC's increased ability to hide in Venezuela after 1999 was a significant contributor to the intensification of the war in Colombia that took place at the time.

I test next whether the main result is robust to the use of a different dataset on the Colombian conflict. Column 1 in Table 3.5 shows estimates of equation (3.1) with Guerrilla events, constructed using the replication data from Dube and Vargas (2013), as the dependent variable. Although data from this source is available for a smaller number of municipalities and for a shorter time period (1993-2004), the estimates are remarkably similar to those obtained using the CEDE conflict dataset.

We can get a sense of the magnitude of the increase in guerrilla activity at the border by comparing these results to the findings of Dube and Vargas (2013). If I estimate equation (3.1) using the number of guerrilla attacks as

Table 3.5: Robustness tests

VARIABLES	(1) Guerrilla Events	(2) FARC Events	(3) FARC Events	(4) FARC Events	(5) FARC Events
Chavez x D(Border Ven.)	0.391***	0.266***	0.345***	0.298***	0.205*
	[0.140]	[0.0897]	[0.0944]	[0.0941]	[0.121]
Chavez x D(Neighbour Ven.)	0.0529	0.0498	0.139	0.123	0.00459
	[0.0944]	[0.128]	[0.128]	[0.130]	[0.0820]
Observations	11,508	17,338	17,338	17,338	17,338
Number of municipalities	959	1,099	1,099	1,099	1,099
Coca crops in 2000 x Year FE	No	Yes	No	No	No
Distance to Venezuela x Year FE	No	No	Yes	No	No
FARC events in 1998 x Year FE	No	No	No	Yes	No
Border/Neighbour quadratic trend	No	No	No	No	Yes

Notes: Standard errors clustered by municipality and department-year in brackets. *** p<0.01, ** p<0.05, * p<0.1. All regressions include municipality and region-year fixed effects. They also include a full set of year interactions with fixed municipality characteristics. The dependent variable in column 1 is the standardized sum of unilateral attacks, massacres and political kidnappings by guerrilla groups, from Dube and Vargas (2013), divided by 1993 population. In the other columns it is the standardized sum of 19 indicators of FARC activity divided by 1993 population. Columns 2, 3 and 4 include as additional controls yearly interactions with a dummy for presence of coca crops in 2000, the distance to Venezuela (km) and the value of the dependent variable in 1998, respectively. Column 5 includes a quadratic time trend specific to municipalities at the border with Venezuela and their neighbours.

the dependent variable (without normalizing for population or standardizing), the point estimate for "Chávez x Border (Ven.)" is 0.96 (p=0.012). This is a very large increase in guerrilla activity relative to the one of 0.09 that Dube and Vargas (2013) find for the average coffee-growing municipality in Colombia following a 50 % drop in coffee prices between 1997 and 2003.

I next address the concern that the growth in coca cultivation that took place in the 1990s, which was particularly high in border regions, may be confounding the results (Angrist and Kugler, 2008). In column 2 I include as additional controls in equation (3.1) the interactions between year dummies and a dummy for municipalities with coca crops in 2000, which is the earliest date for which municipality-level data is available. I leave these set of controls out of the main specification as they could lead to a "bad control" problem, since the location of coca crops in 2000 is potentially affected by FARC's increased ability to move in Venezuela from 1999 on (Angrist and Pischke, 2009). However, the fact that the estimates are very robust to the inclusion of this set of controls indicates that increased coca cultivation is not the mechanism leading to more insurgent activity at the border with Venezuela.

In column 3 I include a similar set of interactions between year dummies and the distance to Venezuela (See Figure 3.2b). This way I can test whether the estimates are picking up variation in FARC activity far from the border,

though correlated with the distance to it. The results suggest this is not the case.

The estimates in column 4 are obtained when I include the interactions between year dummies and the value of the dependent variable in 1998 as additional controls. The results are unaffected by this modification, which implies that the increase in FARC activity after 1999 is not due to border municipalities having different levels of FARC activity before Chávez (e.g. regression to the mean).

Lastly, column 5 indicates that the results are robust to the inclusion of a quadratic time trend specific to border and neighbour municipalities. This is a particularly stringent test, as the trend is likely to capture a large share of the variation in FARC activity near the border over time, but still the point estimate for border municipalities remains relatively high at 0.2 SD, although it is much noisier than before (p=0.091).

3.5.4. Alternative Explanations

In this section I provide evidence against four possible alternative explanations for the increase in FARC activity at the border with Venezuela during the Chávez administration. The first one is the expansion of the paramilitary organization AUC after 1997. The second one is the strengthening of the Colombian Armed Forces during the Pastrana and Uribe administrations, thanks partly to increased U.S. military assistance. Third, I explore the possibility that the results may be driven by variation in economic conditions in the border region during the Chávez years. Finally, I use data on electoral results to see if Chávez's election somehow spilled over to local politics in the border region.

As discussed in section 3.2.1, several atomized paramilitary groups combined to form AUC around 1997. This move was driven to a large extent by FARC's military success at the time, making the defeat of the leftist guerrillas AUC's main objective. I explore next whether AUC's intense counterinsurgent campaign (Figure 3.5), which roughly coincided with the start of the Chávez administration, can explain the previous results.

Column 1 of Table 3.6 shows estimates of equation (3.1) using AUC events as the dependent variable. The results indicate that AUC activity decreased in border municipalities after 1999 but increased in neighbour municipalities, which is consistent with FARC having a military advantage at the border, although the estimates are statistically insignificant. Panel (c) in Figure 3.8

shows that this result is not driven by AUC's demobilization after 2003, since at no point in the sample period is there a statistically significant change in AUC activity near the border with Venezuela, with the exception of neighbour municipalities in 2001-2002.

Panel (c) in Figure 3.9 reveals that the increase in paramilitary activity in neighbour municipalities took place in Cesar, which is consistent with the anecdotal evidence on the control that AUC's North Bloc, led by 'Jorge 40', had on this department (Boraz, 2007; Avila, 2012). The graph also reveals that AUC activity decreased in the southern half of the border, providing further evidence on the hegemony of FARC's Eastern Bloc in the border areas of Arauca and Vichada after Chávez came to power.

However, the main result on FARC events could still be driven by the intensification of paramilitary activity in the interior of the country after 1999. Column 2 in Table 3.6 shows that the results are robust to controlling for AUC activity, suggesting this is not the case. Column 3 provides further evidence against this alternative explanation, as it shows that the results are robust to the inclusion of yearly interactions with a dummy for municipalities that have non-zero AUC events at any point in the sample period.

Another alternative explanation for the increase in FARC activity at the border with Venezuela after 1999 has to do with the changes in counterinsurgent activities by the Colombian security forces that occurred around the same time. This concern is particularly relevant since the U.S. started disbursing the "Plan Colombia" military aid package in 2000 (Figure 3.6b) and the breakdown of peace talks in 2002 led to an increase in military actions against FARC during the Uribe administration (Figure 3.5).

Table 3.6: Activity by paramilitary groups and the Armed Forces

VARIABLES	(1) AUC Events	(2) FARC Events	(3) FARC Events	(4) Armed Forces Events	(5) FARC Events	(6) FARC Events	(7) FARC Events
Chávez x D(Border Ven.)	-0.0825	0.328***	0.304***	0.109	0.267***	0.303***	0.207*
	[0.141]	[0.0983]	[0.0956]	[0.0879]	[0.0817]	[0.100]	[0.119]
Chávez x D(Neighbour Ven.)	0.150	0.105	0.106	-0.0616	0.156	0.192*	0.0261
	[0.126]	[0.132]	[0.133]	[0.0986]	[0.0952]	[0.104]	[0.107]
AUC Events		0.0944					
		[0.0799]					
Armed Forces Events					0.520***		
					[0.0648]		
Observations	17,319	17,319	17,338	17,328	17,328	17,338	17,338
Number of municipalities	1,099	1,099	1,099	1,099	1,099	1,099	1,099
Paramilitary presence x Year FE	No	No	Yes	No	No	No	No
Border/Neighbour x FARC losses	No	No	No	No	No	Yes	No
Border/Neighbour x US aid	No	No	No	No	No	No	Yes

Notes: Standard errors clustered by municipality and department-year in brackets. *** p<0.01, ** p<0.05, * p<0.1. All regressions include municipality and region-year fixed effects. They also include a full set of year interactions with fixed municipality characteristics. The dependent variable in column 4 is the standardized sum of 9 indicators of activity for the Colombian Armed Forces divided by 1993 population. In the other columns, the dependent variable is the standardized sum of 19 indicators of activity for the corresponding group (FARC or AUC) divided by 1993 population. Column 4 includes as additional controls yearly interactions with a dummy for positive values of "AUC Events" at any point in the sample period. Columns 6 and 7 include the interactions between the dummies for "Border" and "Neighbour" municipalities with the aggregate yearly number of FARC losses (demobilizations + captures) and the amount of aid from the US government (in Millions of 2011 USD), respectively.

The results in column 4 of Table 3.6, obtained from estimating equation (3.1) with Armed Forces events as the dependent variable, show no statistically significant change in Armed Forces events near the border during the Chávez years. Column 5 then shows that the increase in FARC activity at the border after 1999 is robust to controlling for Armed Forces Events, despite the strong correlation between the intensity of activities by the Armed Forces and FARC. Column 6 shows that the results are robust to the inclusion as additional controls of interactions between the yearly nationwide FARC losses (captures + demobilizations) and both the Border and Neighbour dummies. This means that the results are not driven by FARC retreating to the borders in years when they are suffering higher losses. Column 7 shows that the results are robust to the inclusion of a similar set of interactions with the yearly amount of U.S. aid instead. The magnitude of the increase in FARC events at border municipalities drops but remains quite high at 0.2 SD, while the standard error gets bigger, which is understandable given the very high correlation between U.S. aid and the Chávez dummy (0.83).

Economic conditions have been found to be important determinants of insurgent activity both internationally (Collier and Hoeffler, 2004; Miguel et al., 2004) and in Colombia (Dube and Vargas, 2013), so I turn next to the possibility that economic fluctuations specific to the border region may explain the results. In columns 1 and 2 of Table 3.7 I look for evidence of economic spillovers from Venezuela into the border region. Column 1 shows that the results are very robust to the inclusion of the interactions between Venezuela's GDP growth rate and both the Border and Neighbour dummies as additional controls in equation (3.1). Column 2 shows results after I include the interaction between the price of oil and both the Border and Neighbour dummies. This regression is motivated by the high dependency of the Venezuelan economy on oil, whose price rose dramatically in the period 2002-2008 (Figure 3.7a), and also by the fact that Colombia's main oil-producing region is in the eastern departments of Meta, Casanare and Arauca, which are located near to (or at) the border. Again, the results are quite robust, suggesting that it is not variation in the price of oil what is driving the results.

One could still argue that the main mechanism for economic spillovers is bilateral trade, which may not be properly accounted for by the variation in Venezuelan GDP. However, while it is true that the Chávez administration imposed restrictions on trade at times of diplomatic tension, this only started in 2009, after the end of the sample period (BBC News, 2009a). As can be

Table 3.7: Changes in local economic and political conditions

VARIABLES	(1) FARC Events	(2) FARC Events	(3) FARC Events	(4) FARC Events	(5) FARC Events
Chávez x D(Border Ven.)	0.319***	0.325***	0.302***	0.313***	0.326***
	[0.0923]	[0.107]	[0.0904]	[0.0942]	[0.0924]
Chávez x D(Neighbour Ven.)	0.0828	-0.00346	0.0633	0.113	0.160
	[0.117]	[0.104]	[0.117]	[0.132]	[0.126]
Observations	17,338	17,338	14,041	17,338	17,183
Number of municipalities	1,099	1,099	1,099	1,099	1099
Final year	2008	2008	2005	2008	2008
Border/Neighbour x Venezuela GDP	Yes	No	No	No	No
Border/Neighbour x Oil price	No	Yes	No	No	No
Department DGP	No	No	Yes	No	No
Local public finance	No	No	No	Yes	No
Political characteristics	No	No	No	No	Yes

Notes: Standard errors clustered by municipality and department-year in brackets. *** p<0.01, ** p<0.05, * p<0.1. All regressions include municipality and region-year fixed effects. They also include a full set of year interactions with fixed municipality characteristics. The dependent variable is the standardized sum of 19 indicators of FARC activity divided by 1993 population. Columns 1 and 2 include as additional controls the interactions of the dummies for "Border" and "Neighbour" municipalities with Venezuela's GDP growth rate and the price of oil, respectively. Column 3 includes log real GDP of the department where the municipality is located. Column 4 includes as additional controls property tax revenue, business tax revenue, transfers from the central government and natural resource royalties, all in 1998 pesos per capita. Column 5 includes as additional controls the vote share for the winning candidate and for the most important left-wing candidate in the last presidential election. Also included are separate dummies for Liberal and Conservative mayors.

seen in Figure 3.7b, the data on bilateral trade shows a steady increase in Venezuelan imports from Colombia between 2003 and 2008, which should lead to less conflict at the border according to the opportunity cost mechanism.

Columns 3 and 4 of Table 3.7 use the available data on local economic conditions to further assuage concerns related to this alternative explanation. In column 3 I include the log of real departmental yearly GDP as an additional control in equation (3.1). This is the most disaggregate level at which GDP is available in Colombia and the data is available up to 2005. Again, the results are quite robust, suggesting that it is not variation in economic conditions, common to all municipalities in the same department, what is driving the results. I try to circumvent the lack of municipal GDP data by using the yearly balance sheets from the municipal governments that are published yearly by DNP (Sánchez and Núñez, 2000). I am thus able to include as additional controls in column 4 the yearly amounts of property tax revenue, business tax revenue, transfers from the central government and natural resource royalties, all in 1998 pesos per capita. Again the results are unaffected by this further modification.

The previous results indicate that economic conditions across the border, which were a significant factor in Venezuela's turn to the left after 1999,

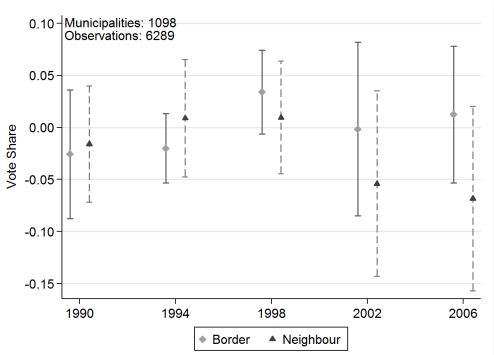
are not driving insurgent activity at the border. However, it could be the case that the change in political preferences in Venezuela spilled over to the border region, making this area fertile ground for insurgent activity. This is a particularly relevant concern given Chávez's observed willingness to influence foreign elections in favour of candidates akin to his views, as mentioned in section 3.2.2.

Figure 3.10 plots results from a modified version of equation (3.2) that only includes election years. Panels (a) and (b) look at presidential elections, which take place every four years and where the omitted year is 1986, while panels (c) and (d) look at mayoral elections, which were more frequent during the sample period (term length changed in 1994 and 2003) and where the omitted year is 1988.

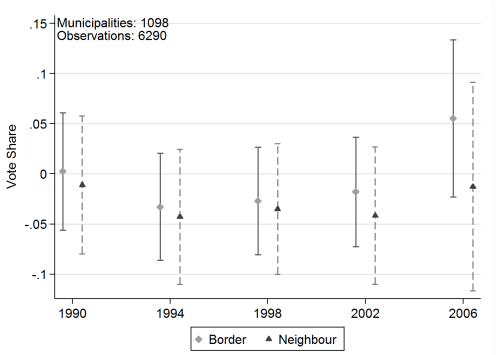
The results in panel (a) indicate that there is no statistically significant change in the vote share for the Liberal party (only party to present its own candidate in all presidential elections) in border or neighbour municipalities for any presidential election between 1990 and 2006, relative to 1986. Panel (b) shows a similar result for the main left-wing party taking part in the presidential race. This finding is particularly illustrative as the main left-wing party in the 1986 presidential election, "Unión Patriótica" (UP), was created with support from top FARC cadres in 1985 amid peace negotiations with the government of Belisario Betancur.

Panel (c) shows that there is no significant change in the vote share for the two traditional parties (Liberal and Conservative) in the elections for municipal mayor between 1990 and 2007, relative to 1988. This provides further evidence against systematic shifts in political preferences in the border region. Finally, panel (d) explores the possibility that the competiveness of elections was what changed by using as dependent variable the winner's vote share in the mayoral election. The graph shows that the difference in winning mayor's vote share between border/neighbour municipalities and interior ones seems to be fairly stable over time. Column 5 in Table 3.7 shows that the results on FARC events are robust to the inclusion of additional controls for time-varying political characteristics such as the vote share for the main left-wing party in the last presidential election and dummies for the party in control of the local government.

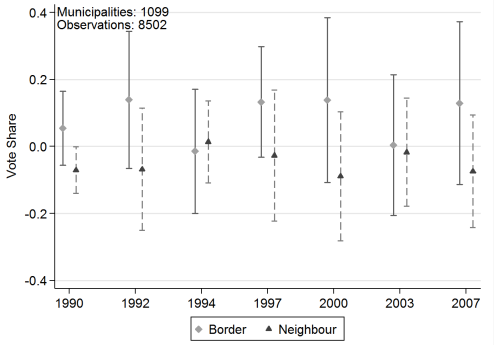
Figure 3.10: Electoral results in municipalities near Venezuela



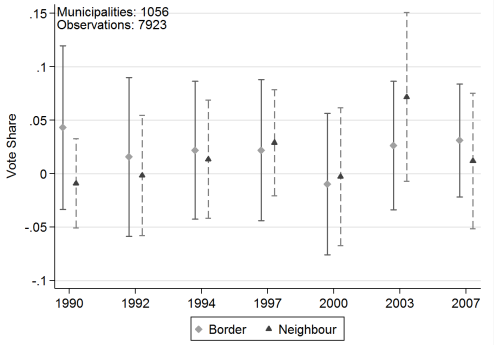
(a) Liberal party (President)



(b) Main left-wing party (President)



(c) Traditional parties (Mayor)



(d) Winning party (Mayor)

Note: The graphs shows point estimates and 95 % confidence intervals for the interaction between dummy variables for each presidential (mayoral) election year and the "Border" and "Neighbour" dummies. The omitted year is 1986 for presidential elections, 1988 for mayoral ones. The regression includes municipality and region-year fixed effects. It also includes a full set of year interactions with fixed municipality characteristics. The standard errors have been clustered two-way by municipality and department-year. The dependent variable in panel (a) is the share of votes (0-1) for the candidate of the Liberal party in that year's presidential election. In panel (b) it is the share of votes (0-1) for the candidate of the main left-wing party in that year's presidential election: UP (1986), M19 (1990-1998), PDI (2002), PDA (2006). In panel (c) it is the share of votes (0-1) for the two traditional parties (Liberal and Conservative) in that year's mayoral election. In panel (d) it is the share of votes (0-1) for the winning party in that year's mayoral election.

3.6. Discussion and Concluding Remarks

This chapter documented a sharp increase in FARC activity at the border with Venezuela after Chávez became president in 1999. This effect is robust to the inclusion of a broad set of control variables as well as to the use of different data sets on the Colombian conflict. Additional robustness tests suggest that this differential increase in guerrilla activity was specific to the border with Venezuela, only occurred after Chávez came to power and was not the result of some time-varying heterogeneity of border municipalities. The additional insurgent activity at the border had a high cost, as a large part of it was attacks and terrorist acts, which led to an increase in homicide rates in the affected municipalities.

This finding is consistent with a growing body of evidence in support of the hypothesis that the Chávez administration actively collaborated with Colombian insurgent groups. However, it is clear that the ability of the central governments of either country to control activity in the border is limited by agency problems, the size of the border and its geographic characteristics (Boraz, 2007; Avila, 2012). Hence, FARC (and to some extent ELN) could have exploited the worsening of border security that took place during the Chávez administration without having received any active collaboration from Venezuelan authorities. Incidents such as the murder of seven Venezuelans by FARC in 2004 certainly suggest that not all of the group's activities inside Venezuela were coordinated with the Chávez government. But even leaving aside the qualitative evidence on FARC-Chávez ties, the fact that the increase in activity is so specific to this insurgent group (relative to ELN, AUC and the Colombian Armed Forces) is hard to reconcile with worse border security being the underlying mechanism.

Accepting that collaboration from the Venezuelan government is what drives the results, an additional question that arises is what specific type of collaboration led to the increase in FARC activity at the border. The available evidence suggests that FARC received assistance from the Chávez government in various different ways, ranging from the provision of intelligence to the supply of weapons and possibly even money. But, as discussed above, of all the plausible ways in which Chávez could have helped FARC, the provision of refuge and safe passage through Venezuela is the one that is most consistent with the fact that guerrilla activity only increases in the area less than 30 km from the border, as it is the one that provides the most geographically constrained benefits. The rough coincidence between the results on the segments of the

border where FARC activity increases and the available information on the location of FARC camps in Venezuela further supports this explanation.

Independently of the way in which the Chávez government helped FARC, the final question left to be answered is why did Chávez help the rebels? Although answering this question is beyond the scope of this study, there are several possible motives. There was a clear ideological affinity between the two parties, one that FARC repeatedly referred to in their communications with Venezuelan officials and to which Chávez corresponded occasionally. Hence, aiding the rebels would fit with Chávez's documented use of "petro-diplomacy" to see groups sharing his ideology gain political power throughout Latin America (Corrales, 2009; Ortiz, 2011; Clem and Maingot, 2011). Additionally, Chávez's fear of a U.S. conspiracy apparently led him to consider FARC as a useful ally should an invasion occur (Avila, 2012).

These motivations allow us to understand the different treatment received by FARC in Chávez's Venezuela relative to Correa's Ecuador, as the latter lacked both the agressive diplomatic aims and the fear of U.S. intervention that characterized Chávez (IISS, 2011a). These motivations also fit with the conclusion from previous research on affinity but mainly geo-political considerations as being the main drivers of support to insurgent movements by foreign governments (Byman et al., 2001).

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Appendix A

Appendix to Chapter 1: "Sources of Revenue and Government Performance: Evidence from Colombia"

A.1. Theoretical Appendix

A.1.1. Set-up of the Model and Equilibrium

This is a two-period model in which a citizen/voter obtains utility from private consumption of her disposable income and also from consumption of a public good. At the end of the first period an election between the incumbent and a random opponent takes place. The incumbent as well as his opponent are drawn from a pool of potential politicians, each endowed with some level of ability $\theta_i > 0$. The ability of all politicians is unknown to everyone but there is a common prior that is normally distributed with mean m and precision h.

The citizen receives a constant income $y_t = y$ each period. She pays a tax on the fraction of her income $\eta \in (0, 1)$ at an exogenous rate $\tau \in (0, 1)$. The citizen's private consumption is equal to her disposable income: $c_t = (1 - \tau\eta)y_t$. Her utility function is $U_t = U(c_t, g_t)$, where g_t is the amount of the public good that is supplied that period. $U(\cdot)$ is increasing in both of its arguments.

Government revenue (R_t) is equal to tax revenue (amounting to $\tau\eta y_t$) plus revenue from an external source (T_t) such as royalties from the extraction of natural resources or transfers from another level of government. I assume that operational expenditures eat up the constant share of revenue $1 - \mu$, so the amount of revenue available for public good provision is μR_t, $\mu \in (0, 1)$.

The amount of public good provided by the mayor with ability level θ at time $t \in \{1, 2\}$ is given by the function

$$g_t = \theta + \mu R_t + e_t \tag{A.1}$$

where $R_t = \tau\eta y_t + T_t$ and $e_t \geq 0$ is the amount of effort put in by the mayor, which is unobservable to the citizen.[1] The cost of effort borne by the mayor is given by the increasing and strictly convex function $\gamma C(e), \gamma > 0$. The mayor also gets a benefit $E > 0$ from being in power each period, which includes financial rewards and "ego rents". Total per-period utility for the mayor is then $E - \gamma C(e)$.

At the end of the first period the citizen observes the amount of public good provided. She also receives a noisy signal ($\tilde{R}_t$) on the total amount of revenue (R_t). I assume that the signal is equal to the actual revenue minus a mean-zero normally distributed noise term: $\tilde{R}_t = R_t + \epsilon_t^R$ where $\epsilon_t^R \sim N[0, 1/h_R^\epsilon]$ Based on this information and a conjecture on effort she updates her beliefs on the

[1] See Dewatripont et al. (1999) for a discussion of more general versions of this type of model.

incumbent's ability. She then votes for the candidate of her liking.

Before making additional assumptions about the link between the sources of revenue and the noisy signal that the citizen receives, I summarize the timing of the game (I will drop the time subscripts for everything that is not changing over time):

1. The incumbent (with ability θ_I unknown to all) receives revenue $R = T + \tau\eta y$ and chooses the amount of effort e_1.

2. A quantity of public goods g_1 is provided according to equation A.1.

3. The citizen observes g_1 and receives the noisy signal $\tilde{R}$. She uses this information to update her beliefs on the incumbent's ability: $\hat{\theta}_I$.

4. The citizen votes either for the incumbent or for a random opponent with the same prior ability (m).

5. The winner of the election chooses e_2 and this determines g_2.

We can find the PBE in pure strategies using backwards induction. The winning candidate (with ability θ_2) solves the following problem in the second period:

$$\max_{e_2 \geq 0} \quad E - \gamma C(e_2)$$

Since $\gamma C(\cdot)$ is an increasing function, the second-period mayor will set $e_2^\star = 0$ and will get utility E that period. Therefore, the amount of public good provided will be $g_2^\star(\theta_2) = \theta_2 + \mu R$, which is an increasing function of the ability of the second-period mayor. If the voter chooses a candidate with believed ability $\hat{\theta}$, her second period utility is $U(c_2, g_2^\star(\hat{\theta})) = U(1 - \tau\eta y, \hat{\theta} + \mu R)$. Since $U(\cdot)$ is increasing in g_2, the incumbent will be re-elected only if the voter believes him to have higher ability than the opponent. That is, if $\hat{\theta}_I \geq m$.

The citizen updates her beliefs on the incumbent's ability based on the amount of first-period public goods (g_1), her conjecture on the level of effort put in by the incumbent ($\hat{e}_1$), and the noisy signal on revenue ($\tilde{R}$). The problem that the citizen faces is that the discrepancy between the observed amount of public goods and the amount she expected, which I will label $Z_1 \equiv g_1 - \mu\tilde{R} - \hat{e}_1$, is equal to the incumbent's ability (θ_I) minus the noise term's impact on expected public goods ($\mu\epsilon_t^R$). Given that θ_I and $\mu\epsilon_t^R$ are two independent normally distributed random variables, the solution to the signal extraction problem is:

$$\hat{\theta}_I = E[\theta_I | Z_1] = \frac{mh + Z_1 h_R}{h + h_R} \tag{A.2}$$

This expression says that the posterior belief on the incumbent's ability is a weighted average of the prior m and the discrepancy Z_1, where the respective weights are given by the precision of the prior (h) and of the noise term ($h_R = h_R^{\epsilon}/\mu^2$). As the signal gets noisier ($h_R \to 0$), it becomes less informative and the posterior gets closer to the prior. Similarly, as the signal gets more precise ($h_R \to \infty$) it perfectly reveals the incumbent's ability and full updating occurs (all the discrepancy is attributed to ability). Equation A.2 implies that the re-election condition simplifies to $Z_1 \geq m$.

From the incumbent's perspective, his probability of re-election is:

$$\begin{aligned} p_I(e_1) &= \text{prob}(g_1 - \mu\tilde{R} - \hat{e}_1 \geq m) \\ &= \text{prob}(\theta + \mu R + e_1 - \mu R - \mu\epsilon_t^R - \hat{e}_1 \geq m) \\ &= \text{prob}(\theta - \mu\epsilon_t^R \geq m + \hat{e}_1 - e_1) \\ &= \text{prob}(Z_1 \geq m + \hat{e}_1 - e_1) \\ &= 1 - \Phi_Z(m + \hat{e}_1 - e_1) \end{aligned}$$

where Φ is the cumulative distribution function of the normally distributed Z_1, which has mean m and precision $h_Z \equiv \frac{h \cdot h_R}{h + h_R}$. The expression above tells us that the incumbent can increase his probability of re-election by increasing the amount of effort (e_1) relative to the voter's conjecture ($\hat{e}_1$). Therefore, the problem solved by the incumbent in period 1 is:

$$\max_{e_1 \geq 0} \quad E - \gamma C(e_1) + (1 - \Phi_Z(m + \hat{e}_1 - e_1))\, \beta E$$

Assuming an interior solution, the first-order condition of this problem is:

$$\gamma C'(e_1^\star) = \phi_z(m + \hat{e}_1 - e_1^\star)\beta E$$

where ϕ_z is the probability density function of Z_1. Given that in equilibrium $\hat{e}_1 = e_1^\star$, the first-order condition characterizing optimal first-period effort simplifies to:[2]

$$\gamma C'(e_1^\star) = \frac{\beta E}{\sqrt{2\pi/h_Z}} \tag{A.3}$$

As equation A.3 shows, $e_1^\star$ does not depend on revenue. Hence, a \$1 increase from either source has a mechanical and homogeneous effect of size μ on public

[2]The equilibrium re-election probability is thus $1 - \Phi_z(m) = 1/2$ since m is the mean of the normally distributed Z_1.

good provision.[3] Equation A.3 also shows that $e_1^\star$ is an increasing function of h_Z (since $C(e)$ is strictly convex), which is itself an increasing function of the precision of the revenue signal h_R. Hence, as the signal becomes more precise, the voter becomes more attentive to public good provision and the incumbent provides more effort in equilibrium.

A.1.2. Taxes as a Source of Information

Having solved the model, I now examine two extensions that link the source of revenue to the precision of the revenue signal and yield predictions of a heterogeneous effect of revenue from different sources on incumbent effort and public good provision. I start by assuming that the share of exogenous revenue amplifies the noise in the voter's signal:

Assumption 1. $\tilde{R}_t = R_t - \epsilon_t^R$ *where* $\epsilon_t^R = \epsilon_t \times \left(\frac{T}{T+\tau\eta y}\right)^{\frac{1}{2}}$ *and* $\epsilon_t \sim N[0, 1/h_\epsilon]$

Hence, the precision of the revenue signal is $h_R = \left(\frac{T+\tau\eta y}{T}\right)\frac{h_\epsilon}{\mu^2}$. This assumption captures the idea that citizens are better informed about changes in tax revenue than about changes in external revenue. Now, as tax revenue increases, the signal becomes more precise and the citizen becomes more attentive to the amount of public goods provided in her assessment of the incumbent's quality. This in turn makes it optimal for the incumbent to increase effort in order to influence the election in his favour. By the same logic, an increase in exogenous revenue makes the revenue signal noisier and the citizen less responsive, so the incumbent reduces effort.

As before, the functional form of the production function for public goods implies that revenue from any source has a mechanical effect on public good provision. However, the total or net effect of a revenue increase depends also on the indirect effect through incumbent effort. Under assumption 1, an increase in tax revenue has a larger effect on public good provision than an equivalent increase in external revenue due to the opposite indirect effect through incumbent effort. The following proposition formalizes this result.

[3] In a modified version of the model, in which the incumbent's choice is over private rents rather than effort, revenue does have a positive effect (the electoral cost of a fixed amount of rents decreases as revenue increases), but this effect is still homogeneous across sources. See Persson and Tabellini (2000), Alesina and Tabellini (2007), Brollo et al. (2013) or Matsen et al. (2015) for examples. If the incumbent is unconstrained on the amount he can appropriate, extra revenue has the additional effect of increasing the value of staying in power. This mechanism is at play in the model of the resource curse in Robinson et al. (2006). Still, this does not give rise to any heterogeneity across sources.

Proposition 1. *Under assumption 1, the equilibrium first-period effort of the incumbent is increasing in tax revenue and decreasing in external revenue. Hence, public good provision in the first period increases by more than the mechanical revenue effect when there is an increase in tax revenue and by less than the mechanical revenue effect when there is an increase in external revenue.*

Demostración. Using the implicit function theorem and noting that $C(\cdot)$ is a strictly convex function, when we differentiate (A.3) with respect to $\tau\eta y$ we obtain:

$$\gamma \frac{\partial^2 C}{\partial e_1^{\star 2}} \frac{\partial e_1^\star}{\partial \tau\eta y} = \frac{\partial \phi_Z}{\partial h_Z} \frac{\partial h_Z}{\partial \tau\eta y} \beta E \tag{A.4}$$

From $\phi_Z = \sqrt{h_Z/2\pi}$ we can see that $\partial\phi_Z/\partial h_Z > 0$. Using the definitions of h_Z and h_R we find that

$$\frac{\partial h_Z}{\partial \tau\eta y} = \frac{(\mu h)^2 h_\epsilon T}{\left(h_\epsilon(T + \tau\eta y) + \mu^2 h T\right)^2} > 0$$

Since all other terms on both sides of equation A.4 are positive, $\frac{\partial e_1^\star}{\partial \tau\eta y} > 0$. Hence, the overall effect of a tax revenue increase on first-period public good provision, based on equation 1.1, is given by

$$\frac{\partial g_1^\star}{\partial \tau\eta y} = \mu + \frac{\partial e_1^\star}{\partial \tau\eta y} > \mu$$

where μ is the mechanical revenue effect.

Using again implicit differentiation on equation (A.3) but with respect to T we get

$$\gamma \frac{\partial^2 C}{\partial e_1^{\star 2}} \frac{\partial e_1^\star}{\partial T} = \frac{\partial \phi_Z}{\partial h_Z} \frac{\partial h_Z}{\partial T} \beta E \tag{A.5}$$

The argument works the same as in the case of taxes, except that now

$$\frac{\partial h_Z}{\partial T} = \frac{-(\mu h)^2 h_\epsilon \tau\eta y}{\left(h_\epsilon(T + \tau\eta y) + \mu^2 h T\right)^2} < 0$$

Since all the other terms on both sides of equation A.5 are positive, $\frac{\partial e_1^\star}{\partial T} < 0$. Therefore, the overall effect of an increase in exogenous revenue on first-period public good provision is given by

$$\frac{\partial g_1^\star}{\partial T} = \mu + \frac{\partial e_1^\star}{\partial T} < \mu < \frac{\partial g_1^\star}{\partial \tau\eta y}$$

where again μ is the mechanical revenue effect.

□

A.1.3. Taxes as an Incentive for Information Acquisition

I now substitute Assumption 1 with the following three assumptions:

Assumption 2. $\tilde{R}_t = R_t + \epsilon_t^R$, *where* $\epsilon_t^R \sim N[0, 1/h_R^\epsilon]$

Assumption 3. $U_t = U(c_t + \alpha g_t)$ *where* $U(\cdot)$ *is a strictly concave function and* $\alpha \in (0, 1/\mu)$

Assumption 4. *At the start of the game, the voter can choose how much effort* $(f_1 \geq 0)$ *to spend on the improvement of the revenue signal. Effort increases the precision of the revenue signal according to the linear function* $h_R^\epsilon = \lambda f_1$, $\lambda > 0$, *but has a cost given by the strictly convex function* $K(f_1)$

Under assumptions 2-4 the model is essentially unchanged: the incumbent's first-period effort is still determined by (A.3) and is increasing on the precision of the revenue signal.

If we substitute the public good production function and the voter's budget constraint into her first-period utility function we can see that the problem the voter solves is

$$\begin{aligned}\max_{f_1 \geq 0} U_1 &= U(c_1 + \alpha g_1) - K(f_1) \\ &= U[(1-\tau\eta)y + \alpha\left(\theta_I + \mu(\tau\eta y + T) + e_1^\star(h_Z)\right)] - K(f_1) \\ &= U[y + (\alpha\mu - 1)\tau\eta y + \alpha\mu T + \alpha\theta_I + \alpha e_1^\star(h_Z)] - K(f_1)\end{aligned}$$

Assuming an interior solution, the optimal amount of voter effort is implicitly defined by the following first-order condition:

$$U'[y + (\alpha\mu - 1)\tau\eta y + \alpha\mu T + \alpha\theta_I + \alpha e_1^\star(h_Z)]\alpha\frac{\partial e_1^\star}{\partial h_Z}\frac{\partial h_Z}{\partial h_R^\epsilon}\lambda = K'(f_1^\star) \qquad \text{(A.6)}$$

Just like before, the voter is more responsive to public good provision in her assessment of the incumbent's quality the better she is informed about revenue. In turn, the incumbent puts in more effort as the voter becomes more responsive. Under the new assumptions, what sets this mechanism in motion is information acquisition by the voter, which depends on the marginal utility of public goods. When tax revenue increases, private consumption mechanically decreases. Although public good provision also increases due to the mechanical revenue effect, assumption 3 ensures that the marginal utility of the public good increases as well, which raises the benefit the voter gets from additional

incumbent effort.[4] External revenue, on the other hand, has a negative effect on the marginal utility of the public good due to the positive mechanical revenue effect and the fact that it does not affect the voter's disposable income. Hence, extra taxation provides an incentive for more information acquisition while the opposite holds true for external revenue. The following proposition formalizes this result:

Proposition 2. *Under Assumptions 2-4, the equilibrium first-period effort of the voter and the incumbent are increasing in tax revenue and decreasing in external revenue. Hence, public good provision in the first period increases by more than the mechanical revenue effect when there is an increase in tax revenue and by less than the mechanical revenue effect when there is an increase in external revenue.*

Demostración. Using the implicit function theorem we can differentiate both sides of (A.6) with respect to $\tau\eta y$ to obtain:

$$\alpha\lambda\frac{\partial e_1^\star}{\partial h_Z}\frac{\partial h_Z}{\partial h_R^\epsilon}U''(\cdot)\left((\alpha\mu-1)+\alpha\frac{\partial e_1^\star}{\partial h_Z}\frac{\partial h_Z}{\partial h_R^\epsilon}\lambda\frac{\partial f_1^\star}{\partial\tau\eta y}\right)=K''(f_1^\star)\frac{\partial f_1^\star}{\partial\tau\eta y}$$

$$\Rightarrow \alpha\lambda\tfrac{\partial e_1^\star}{\partial h_Z}\tfrac{\partial h_Z}{\partial h_R^\epsilon}U''(\cdot)(\alpha\mu-1)=\tfrac{\partial f_1^\star}{\partial\tau\eta y}\left(K''(f_1^\star)-\alpha^2\lambda^2\left(\tfrac{\partial e_1^\star}{\partial h_Z}\tfrac{\partial h_Z}{\partial h_R^\epsilon}\right)^2U''(\cdot)\right) \tag{A.7}$$

Since $U(\cdot)$ is a strictly concave function while $K(f_1)$ is strictly convex, the LHS in equation A.7 is positive and the term in brackets on the right is also positive. Hence, $\partial f_1^\star/\partial\tau\eta y>0$. This implies, from equation 1.1, that the overall effect of an increase in tax revenue on public good provision is given by

$$\frac{\partial g_1^\star}{\partial\tau\eta y}=\mu+\frac{\partial e_1^\star}{\partial h_Z}\frac{\partial h_Z}{\partial h_R^\epsilon}\lambda\frac{\partial f_1^\star}{\partial\tau\eta y}>\mu$$

Using implicit differentiation on equation A.6 but with respect to exogenous revenue (T) yields:

$$\alpha\lambda\frac{\partial e_1^\star}{\partial h_Z}\frac{\partial h_Z}{\partial h_R^\epsilon}U''(\cdot)\alpha\mu=\frac{\partial f_1^\star}{\partial T}\left(K''(f_1^\star)-\alpha^2\lambda^2\left(\frac{\partial e_1^\star}{\partial h_Z}\frac{\partial h_Z}{\partial h_R^\epsilon}\right)^2U''(\cdot)\right) \tag{A.8}$$

[4] Assumption 3 implies that taxation for the purpose of public good provision is inefficient in a setting where overhead costs are relatively large. This is consistent with the findings of Pritchett and Aiyar (2014), who report that the median cost of one pupil in public elementary school in India is twice as high as in a private school, but educational achievement is much lower.

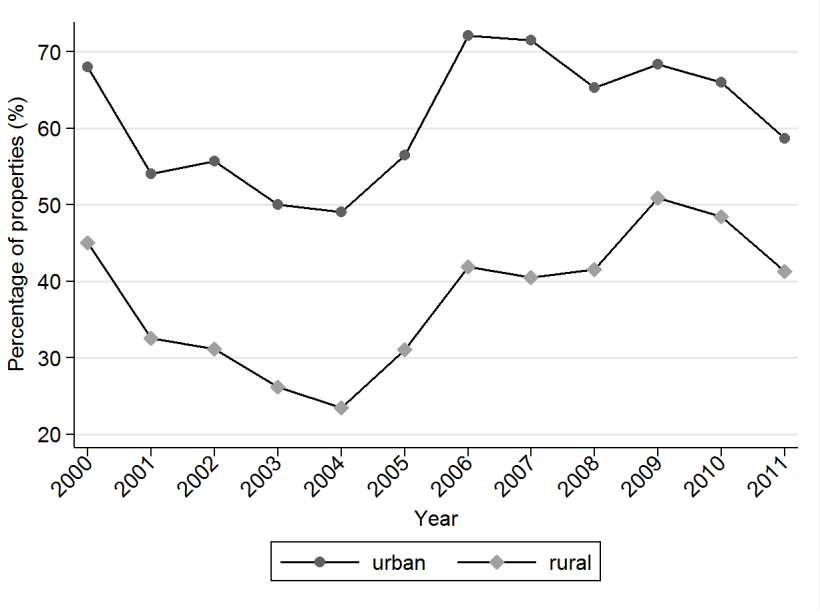
Now the LHS in equation A.8 is negative, while the term in brackets on the right remains positive. Hence, $\partial f_1^\star / \partial T < 0$. Using again equation A.1, we can see that the net effect of an increase in exogenous revenue on first-period public good provision is

$$\frac{\partial g_1^\star}{\partial T} = \mu + \frac{\partial e_1^\star}{\partial h_Z} \frac{\partial h_Z}{\partial h_R^\epsilon} \lambda \frac{\partial f_1^\star}{\partial T} < \mu < \frac{\partial g_1^\star}{\partial \tau \eta y}$$

□

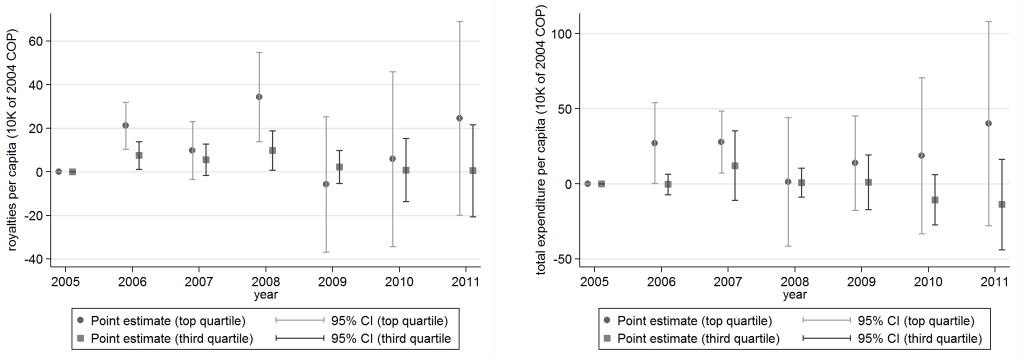
A.2. Empirical Appendix

Figure A1: Percentage of properties with up-to-date cadastres



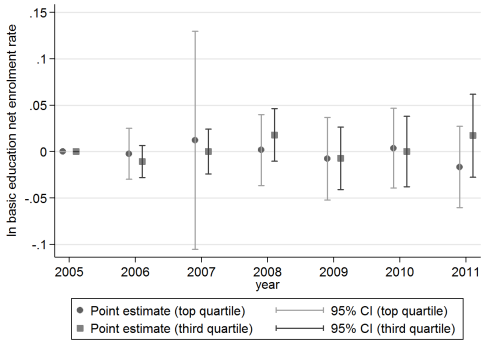
Note: The figure shows the percentage of properties in the sample located in urban/rural areas of municipalities that had a cadastral update in the last five years (up to date). The sample does not include Bogota, Cali, Medellín and the department of Antioquia, which have their own cadastral agencies.

Figure A2: Medium-run impact of oil price shocks for the top two quartiles of oil abundance

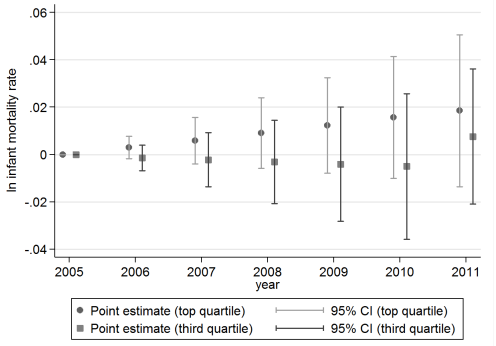


(a) Royalties

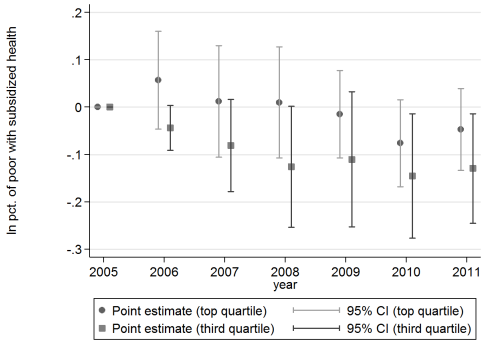
(b) Expenditure



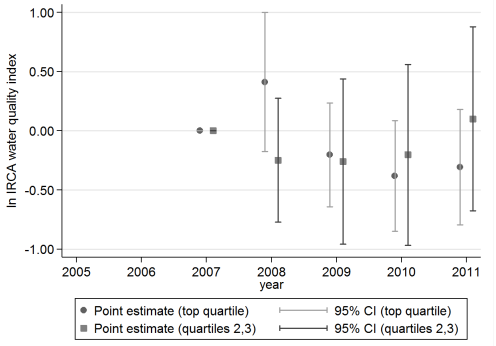
(c) Educational enrolment



(d) Infant mortality



(e) Health insurance



(f) Water quality

Note: Graphs show point estimates and 95 % confidence intervals from two separate regressions of the variable in the caption on a set of year interactions (2006-2011) with a dummy for municipalities with positive oil royalties between 2000 and 2004. Sample period: 2005-2011. Sample includes municipalities with no oil royalties or municipalities in the relevant quartile of the 2000-2004 oil royalties distribution. All regressions include municipality and department-year fixed effects. Standard errors clustered by province.

Table A1: Social indicators in Colombia and Latin America

COUNTRY	(1) GDP per capita (USD)	(2) Primary enrolment rate (%)	(3) Secondary enrolment rate (%)	(4) Infant mortality rate (‰)	(5) Female life expectancy (years)	(6) Improved water source (%)	(7) Improved sanitation facilities (%)
Argentina	4,696	99	-	16	78	98	94
Bolivia	978	92	72	46	67	94	53
Brazil	3,598	-	-	22	75	98	84
Chile	6,324	-	-	8	81	99	97
Colombia	**2,740**	**92**	**63**	**19**	**76**	**97**	**84**
Ecuador	2,709	97	51	25	77	89	82
Mexico	7,115	95	63	17	78	95	84
Panama	4,349	97	61	20	79	98	80
Paraguay	1,409	94	57	25	73	94	87
Peru	2,445	97	68	23	75	90	77
Uruguay	4,117	97	-	13	79	99	95
Venezuela	4,273	92	61	16	76	94	94

Notes: GDP per capita in current USD. Percentages of improved water source and improved sanitation facilities refer to urban population. Data from 2004 (2003 or 2005 if 2004 unavailable). Source: World Development Indicators (World Bank).

Table A2: Cadastral updates and statutory tax rates

VARIABLES	(1) Property tax rate	(2) Property tax rate	(3) ln Property tax rate	(4) ln Property tax rate
D(post-cadastral-update)$_{i,t}$	0.0964	0.176	0.0103	0.0185
	[0.151]	[0.160]	[0.0201]	[0.0203]
Time fixed effects	year	dpt-year	year	dpt-year
Observations	799	799	799	799
Number of municipalities	211	211	211	211

Notes: Dependent variable in the header. All regressions include municipality fixed effects. Columns 1 and 3 include year fixed effects while columns 2 and 4 include department-specific year fixed effects. Sample period: 1999-2002. Average tax rate is 8.4 ‰. Standard errors clustered two-way by municipality and by department-year. *** p<0.01, ** p<0.05, * p<0.1

Table A3: Sources of revenue and public good provision (cumulative royalties)

	natural log [columns 1-4]				D(target achievement) [columns 5-8]			
VARIABLES	(1) Educational enrolment	(2) Infant mortality	(3) Health insurance	(4) Water quality	(5) Educational enrolment	(6) Infant mortality	(7) Health insurance	(8) Water quality
				PANEL A: REDUCED FORM				
D(post-cadastral-update)$_{i,t}$	0.00886***	0.00302	0.0127	0.121**	0.0133	-0.000528	0.0318*	0.0769***
	[0.00333]	[0.00210]	[0.00856]	[0.0559]	[0.0133]	[0.0109]	[0.0174]	[0.0219]
$\sum_{k=2006}^{t}$ royalties$^{\text{oil}}_{i,00-04} \times$ price$^{\text{oil}}_{k}$	-5.25e-06	-1.49e-05	-0.000112**	-0.000833	-6.13e-05	-8.39e-06	-1.39e-05	-0.000466
	[1.84e-05]	[1.33e-05]	[4.89e-05]	[0.000580]	[0.000180]	[2.57e-05]	[0.000183]	[0.000305]
				PANEL B: IV				
property tax revenue$_{i,t}$	0.0142**	0.00483	0.0203	0.145*	0.0213	-0.000851	0.00508*	0.0918***
	[0.00619]	[0.00359]	[0.0138]	[0.0772]	[0.0209]	[0.0174]	[0.0288]	[0.0283]
natural resource royalties (cum.)$_{i,t}$	-2.06e-05	-2.33e-05	-0.000159***	-0.00130**	-9.72e-05	-9.57e-06	-6.77e-05	-0.000751**
	[2.39e-05]	[1.65e-05]	[6.12e-05]	[0.000659]	[0.000224]	[3.65e-05]	[0.000226]	[0.000310]
1st stage F-statistic	11.807	11.807	11.807	7.381	11.807	11.807	11.807	7.381
p-value H0:tax=royalties	0.022	0.176	0.139	0.059	0.306	0.962	0.077	0.0001
Dependent variable mean in 2005 (level)	86.1	24.2	74.3	30.5	0.15	0.16	0.15	0.18
Observations	6,704	6,704	6,704	4,467	6,704	6,704	6,704	4,467
Number of municipalities	969	969	969	937	969	969	969	937

Notes: Dependent variable in the header: in columns 1-4 the dependent variable is in natural log, while in columns 5-8 it is a dummy for target achievement. Money variables in tens of thousands of 2004 COP per capita. In panel B, D(post-cadastral-update) and $\sum_{k=2006}^{t}$ royalties$^{\text{oil}}_{i,00-04} \times$ price$^{\text{oil}}_{k}$ are used as instruments for property tax revenue and cumulative natural resource royalties, respectively. All regressions include municipality-term and department-year fixed effects (sample period: 2005-2011, except column 4: 2007-2011). Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

Table A4: Sources of revenue and public good provision with municipality -term fixed effects

	natural log [columns 1-4]				D(target achievement) [columns 5-8]			
VARIABLES	(1) Educational enrolment	(2) Infant mortality	(3) Health insurance	(4) Water quality	(5) Educational enrolment	(6) Infant mortality	(7) Health insurance	(8) Water quality
			PANEL A: REDUCED FORM					
D(post-cadastral-update)$_{i,t}$	0.00506*	0.00186*	0.00749	0.0403	0.00820	0.000218	0.00366	0.0686**
	[0.00285]	[0.00105]	[0.00823]	[0.0779]	[0.0139]	[0.0106]	[0.0179]	[0.0295]
royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$	0.000109	1.60e-05	-0.000394	0.0113*	0.00131	7.53e-05	-0.00182	0.00287
	[7.80e-05]	[4.06e-05]	[0.000750]	[0.00625]	[0.000844]	[0.000114]	[0.00156]	[0.00351]
			PANEL B: IV					
property tax revenue$_{i,t}$	0.00771*	0.00282	0.0112	0.0491	0.0130	0.000363	0.00476	0.0731**
	[0.00448]	[0.00188]	[0.0119]	[0.0870]	[0.0207]	[0.0161]	[0.0274]	[0.0344]
natural resource royalties$_{i,t}$	0.000176*	3.66e-05	-0.000389	0.0108	0.00161	9.01e-05	-0.00209	0.00314
	[0.000103]	[4.66e-05]	[0.000846]	[0.00842]	[0.00110]	[0.000193]	[0.00207]	[0.00385]
1st stage F-statistic	9.424	9.424	9.424	4.968	9.424	9.424	9.424	4.968
p-value H0:tax=royalties	0.090	0.135	0.334	0.656	0.577	0.986	0.801	0.041
Observations	6,698	6,698	6,698	3,609	6,698	6,698	6,698	3,609
Number of municipality-terms	1,931	1,931	1,931	936	1,931	1,931	1,931	936

Notes: Dependent variable in the header: in columns 1-4 the dependent variable is in natural log, while in columns 5-8 it is a dummy for target achievement. Money variables in tens of thousands of 2004 COP per capita. Standardized coefficients for royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$. In panel B, D(post-cadastral-update) and royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$ are used as instruments for property tax revenue and natural resource royalties, respectively. All regressions include municipality-term and department-year fixed effects (sample period: 2005-2011, except column 4: 2007-2011). Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

Table A5: The effects of oil price shocks on municipalities in the top quartiles of the oil abundance distribution

VARIABLES	(1) Royalties	(2) ln population	(3) Business tax	(4) Murder rate	(5) FARC events	(6) Educational enrolment	(7) Infant mortality	(8) Health insurance	(9) Water quality
PANEL A: third quartile - contemporary royalties									
$\text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{t}$	2.082*	-0.000401	0.243	-2.685	0.150	0.00447***	0.000951	-0.00402	0.0504
	[1.165]	[0.00110]	[0.202]	[1.881]	[0.201]	[0.00171]	[0.00147]	[0.00868]	[0.0705]
Observations	5,990	5,990	5,990	5,990	5,131	5,990	5,990	5,990	3,970
Number of municipalities	969	865	865	865	862	865	865	865	833
PANEL B: top quartile - contemporary royalties									
$\text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{t}$	0.868***	-2.77e-07	0.0227	-0.114	0.0416***	0.000161	-1.63e-05	-0.000836	0.0112
	[0.184]	[2.69e-05]	[0.0281]	[0.0953]	[0.0155]	[0.000115]	[2.90e-05]	[0.000704]	[0.00731]
Observations	5,975	5,975	5,975	5,975	5,116	5,975	5,975	5,975	3,957
Number of municipalities	862	862	862	862	859	862	862	862	830
PANEL C: third quartile - cumulative royalties									
$\sum_{k=2006}^{t} \text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{k}$	1.448***	0.000421*	0.0164	-0.0536	-0.0161	0.000274	6.46e-05	-0.00257*	0.00208
	[0.517]	[0.000231]	[0.0306]	[0.242]	[0.0324]	[0.000448]	[0.000277]	[0.00144]	[0.00945]
Observations	5,990	5,990	5,990	5,990	5,131	5,990	5,990	5,990	3,970
Number of municipalities	865	865	865	865	862	865	865	865	833
PANEL D: top quartile - cumulative royalties									
$\sum_{k=2006}^{t} \text{royalties}^{\text{oil}}_{i,00-04} \times \text{price}^{\text{oil}}_{k}$	0.802***	5.56e-05***	0.0104***	-0.0108	0.00201	1.00e-05	-6.82e-05	-0.000121***	-0.000977
	[0.0556]	[1.36e-05]	[0.00214]	[0.0167]	[0.00148]	[1.8e-05]	[1.76e-05]	[4.42e-05]	[0.000676]
Observations	5,975	5,975	5,975	5,975	5,116	5,975	5,975	5,975	3,957
Number of municipalities	862	862	862	862	859	862	862	862	830

Notes: Dependent variable in the header (natural log in columns 6-9). Sample in panels A and C (B and D) only includes municipalities with zero oil royalties between 2000 and 2004 and municipalities in the third (top) quartile of the distribution of positive average 2000-2004 royalties. All regressions include municipality and department-year fixed effects. Standard errors clustered two-way by municipality and department-year. Sample period: 2005-2011, except columns 5 (2005-2010) and 9 (2007-2011). *** p<0.01, ** p<0.05, * p<0.1

Table A6: Heterogeneous effects of oil-price shocks by FARC activity

VARIABLES	(1) Royalties	(2) Educational enrolment	(3) Infant mortality	(4) Health insurance	(5) Water quality
		PANEL A: NATURAL LOG			
D(post-cadastral-update)$_{i,t}$	-0.266	0.00884***	0.00300	0.0116	0.124**
	[0.896]	[0.00335]	[0.00206]	[0.00847]	[0.0561]
royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$	0.831***	0.000164	8.12e-06	-0.000458	0.0117*
	[0.173]	[9.10e-05]	[7.72e-06]	[0.000738]	[0.00657]
royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$ × FARC events$_{i,05-10}$	0.0568	-0.000133**	3.14e-05	0.000111	-0.00149***
	[0.0939]	[6.74e-05]	[2.49e-05]	[0.000117]	[9.12e-05]
		PANEL B: D(TARGET ACHIEVEMENT)			
D(post-cadastral-update)$_{i,t}$		0.0134	-0.00123	0.0324*	0.0762***
		[0.0134]	[0.0109]	[0.0173]	[0.0219]
royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$		0.00143**	6.19e-05	-0.00177	0.00290
		[0.000715]	[6.22e-05]	[0.00143]	[0.00365]
royalties$^{oil}_{i,00-04}$ × price$^{oil}_{t}$ × FARC events$_{i,05-10}$		-0.000197	2.62e-05	-1.28e-05	-0.000398
		[0.000329]	[4.25e-05]	[0.000611]	[0.000291]
Observations	6,684	6,684	6,684	6,684	4,453
Number of municipalities	966	966	966	966	934

Notes: Dependent variable in the header. In panel A, the dependent variable is in natural log, while in panel B it is a dummy for target achievement. Money variables in tens of thousands of 2004 COP per capita. All regressions include municipality-term and department-year fixed effects (sample period: 2005-2011, except column 4: 2007-2011). Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

Table A7: Sources of revenue and public good provision (coal royalties)

	natural log [columns 1-4]				D(target achievement) [columns 5-8]			
VARIABLES	(1) Educational enrolment	(2) Infant mortality	(3) Health insurance	(4) Water quality	(5) Educational enrolment	(6) Infant mortality	(7) Health insurance	(8) Water quality
			PANEL A: REDUCED FORM					
$D(\text{post-cadastral-update})_{i,t}$	0.00884***	0.00297	0.0121	0.118**	0.0131	-0.000671	0.0316*	0.0747***
	[0.00334]	[0.00210]	[0.00852]	[0.0562]	[0.0134]	[0.0109]	[0.0173]	[0.0221]
$\text{royalties}^{\text{coal}}_{i,2004} \times \text{price}^{\text{coal}}_{t}$	0.000983	0.00352	0.00139	0.0437	0.00781	-0.0109	-0.0135	0.00376
	[0.00383]	[0.00246]	[0.00317]	[0.0391]	[0.0153]	[0.00725]	[0.0290]	[0.00709]
			PANEL B: IV					
$\text{property tax revenue}_{i,t}$	0.0141**	0.00491	0.0193	0.140*	0.0212	-0.00166	0.0494*	0.0874***
	[0.00612]	[0.00355]	[0.0137]	[0.0757]	[0.0206]	[0.0173]	[0.0285]	[0.0276]
$\text{natural resource royalties}_{i,t}$	5.72e-05	0.000313	8.26e-05	0.00360	0.000669	-0.000996	-0.00136	-0.000186
	[0.000341]	[0.000215]	[0.000287]	[0.00350]	[0.00142]	[0.000748]	[0.00282]	[0.000855]
1st stage F-statistic	11.240	11.240	11.240	2.901	11.240	11.240	11.240	2.901
p-value H0:tax=royalties	0.022	0.195	0.160	0.074	0.325	0.969	0.075	0.002
Observations	6,704	6,704	6,704	4,467	6,704	6,704	6,704	4,467
Number of municipalities	969	969	969	937	969	969	969	937

Notes: Dependent variable in the header: in columns 1-4 the dependent variable is in natural log, while in columns 5-8 it is a dummy for target achievement. Money variables in tens of thousands of 2004 COP per capita. In panel B, D(post-cadastral-update) and $\text{royalties}^{\text{coal}}_{i,2004} \times \text{price}^{\text{coal}}_{t}$ are used as instruments for property tax revenue and natural resource royalties, respectively. All regressions include municipality-term and department-year fixed effects (sample period: 2005-2011, except column 4: 2007-2011). Standard errors clustered two-way by municipality and department-year. *** p<0.01, ** p<0.05, * p<0.1

Table A8: Sample disciplinary processes involving mayors of municipalities with oil royalties

(1) Municipality	(2) Period	(3) Mayor's name	(4) Findings	(5) Ban from office (years)
Arauquita, Arauca	2001-2003	Jorge Aperador	Signed two contracts with the same firm for the same multi-purpose sports court	18
Puerto Boyaca, Boyaca	2004-2007	Luis Alvarez	The firm hired to build a public library sub-contracted for 1/3 of the original value	15
Coloso, Sucre	2004-2007	Manuel Ruiz	Bypassed selection process for sewerage construction by declaring an unwarranted "state of urgency"	11
Villavicencio, Meta	2004-2007	Carlos Gómez	Unauthorized expenditures at local hotel were later deducted from tax liabilities	11
Tolu, Sucre	2004-2007	Liceloth Luquez	Falsely divorced from current mayor to be able to succeed him in office	10
Gigante, Huila	2008-2011	Julian Diaz	Built a road through his parents' and uncles' properties	10
Melgar, Tolima	2008-2011	Eduardo Tautiva	Allowed a mayoral candidate to inaugurate two schools	15
Cantagallo, Bolivar	2008-2011	Ramiro Escobar	Used royalties to buy furniture for city hall	15
Arauca, Arauca	2008-2011	William Reyes	Purchase of bonds through irregular firm led to 50 % loss on royalties (5 million USD)	20
Yopal, Casanare	2012-2015	Willman Celemin	Bought 157 spa sessions for members of staff	11

Notes: The table shows 10 cases in which the mayor of a municipality with positive oil royalties in the 2000-2004 period was removed from office between 2001 and 2015. There are 64 such processes in the sample. Source: News bulletins in PGN website.

Table A9: Keywords from disciplinary processes of mayors of municipalities with oil royalties

Panel A: Misconduct		Panel B: Sector	
	Percentage of cases (%)		Percentage of cases (%)
Asset Management	6.9	Royalties	12.0
Investment/Procurement	36.4	Education	8.3
General Administration	24.0	Health	3.2
Hirings/Appointments	9.2	Utilities	15.2
Payments/Obligations	17.5	Elections	6.4

Notes: The tables show the percentage of the disciplinary processes initiated by PGN involving mayors of oil-royalty recipients (positive oil royalties in period 2000-2004) that include each keyword. Panel A shows keywords for the type of offence, while panel B shows keywords for the sector. Source: News bulletins in PGN website.