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THE IMPACT OF NATURAL RESOURCE WINDFALLS ON EDUCATIONAL OUTCOMES IN NONPRODUCING AREAS[♣]

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Abstract

We study the impact of natural resource royalties on educational outcomes in Colombia. We analyze a reform enacted in 2012 that made the distribution of these royalties more equitable. Before the reform, most royalties were assigned to the regions where the natural resources were exploited; with the reform non-producing regions started to receive royalties. We estimate the impact of the reform on regions that most benefited from it, using the international price of oil as an instrument in a difference-in-differences framework. We found positive impacts on enrollment in primary, secondary, and high schools, but no conclusive evidence on academic achievement at any of these levels.

Keywords: royalties, education, public finance, instrumental variables

JEL Codes: C26, H52, H72, O13, O54

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1. Introduction

Analyzing the impact of price-driven mineral windfalls on human capital requires disentangling multiple potential causal channels. A mineral-producing region that enjoys a price surge will see impacts on both household level income (of those involved in the mineral production) and on royalties and taxes local governments receive from the mineral production. Both channels can affect human capital indicators. To determine whether public expenditures have any impact on human capital, an ideal experiment would increase government revenue while keeping household income constant. In this study we approximate this experiment by analyzing the impact of royalties in areas that are not necessarily mineral- or oil-producing areas. We do this by analyzing a reform enacted in Colombia in 2012 that modified how oil- and mineral-royalty revenue was distributed in the country. Since 1991 such royalties were assigned mostly to the municipalities and departments where the resources were exploited. The 2012 reform turned the system into a much more egalitarian one, where all departments and most municipalities receive some royalty income. For most nonproducing small municipalities this led to a substantial increase in their revenues. The purpose of this study is to analyze whether this reform had an impact on educational outcomes in such municipalities.

We use a difference-in-differences approach for this analysis. While the amount of royalties that each municipality receives is endogenous to multiple factors, the maximum amount they can receive is determined exogenously by the rules of the 2012 reform and the international price of minerals, in particular the price of oil. We use these rules and the variation in the price of oil as instruments for the value of resources municipalities receive as total royalties in a difference-in-differences framework with a continuous treatment in order to estimate their impact on educational indicators. This approach identifies the impact of royalties on the municipalities that most benefitted by the reform.

We analyze the impact of the reform on educational outcomes, in particular school enrollment and academic achievement at grades 5, 9, and 11. We found positive impacts on enrollment in primary, secondary, and high schools, but no conclusive evidence on academic achievement at these levels. We hypothesize that the lack of impacts on achievement could be explained by the fact that royalties are increasing enrollment and therefore changing the background composition of students who survive secondary and high school.

This study contributes to the literature on the impact of natural resource exploitation. Early efforts focused on international comparisons at the country level and the so-called resource curse (Sachs & Warner, 1995; Atkinson & Hamilton, 2003; Devlin & Lewin, 2005). Within-countries' analyses have become more prevalent in recent years. For example, Hajkowicz et al. (2011), Inanova (2014), and Fleming et al. (2015)

analyze mining communities in Australia. In the case of Colombia, two recent studies have analyzed the effects of resource windfalls on social and economic outcomes. Dube and Vargas (2013) use coffee and oil exports to understand the potential effects on violence and municipal revenue, where they find opposite results for these two types of natural resource. While drops in coffee prices lowered wages and increased violence for the largest coffee producers, drops in oil prices led to reductions in both revenues and violence. Bonet et al. (2020) analyze the causal effects of the most recent oil boom in Colombia on subnational (departments and municipalities) public investments, where they found positive though heterogeneous effects across sectors and regions, with evidence that the main driver was the 2012 royalties' reform.

Gallego et al. (2020) analyzed the impact of the 2012 reform on oil-producing municipalities, which for the most part saw the amount of royalties they received decrease relative to a scenario without the reform. They found that the new institutional arrangement (which, as we explain in more detail in the following section, created certain controls on how royalties are spent) had a positive impact on producing municipalities' socioeconomic indicators. Bonet et al. (2014) took a wider view by investigating the effect of the 2012 reform on fiscal performance using a dose-response approach. They found that in municipalities where royalties were equal to or lower than 20 percent of total revenue, fiscal performance decreased and dependency on royalties increased, whereas the opposite was the case for municipalities where royalties were more than 20 percent of total revenue. In a more descriptive setting, Bonet and Urrego (2014) show positive results in terms of the distribution and territorial equity of the royalties, in the sense that after the reform all and not just few territories receive resources from the exploitation of no-renewable natural resources. However, they noted that there were delays in accessing the resources due to the difficulties in the design, evaluation and approval of the projects. They also found evidence of fiscal laziness, in particular for those departments that were not receiving royalties before the reform. Finally, using a case study methodology, Bonet (2007), Bonet and Urrego (2014), and Viloria (2005) found evidence of potential resource curse in the fact that most of the investments were aimed at infrastructure projects with low or no impact on welfare.

In this paper we focus on the impact of the 2012 reform on educational indicators. Previous studies in Colombia have analyzed the impact of natural resource exploitation on producing municipalities. Our approach allows us to analyze the impact of royalties on municipalities that are not natural resource producers, but benefited from the 2012 reform. Crucially, the impact we document can be attributed to royalties and not to other factors associated with resource exploitation (e.g., increases in labor demand, environment deterioration, and, in the case of Colombia, security threats). This study thus also contributes to the literature on how government spending affects education outcomes (Jackson et al., 2014).

This study is divided in six sections including this introduction. The following section summarizes the relevant institutional context. The third section discusses the empirical strategy. Section four describes the data. Section five discusses the results and the last section concludes.

2. Institutional context

Colombia produces a significant amount of hydrocarbons and minerals, in particular oil, gas, and coal.[1] The regulation on royalties dates back to the first half of the XX Century (Law 37 of 1931; Decree 1056 of 1953), when the participation of producing territories was differentiated among producing territories according to their level of subnational government. As stated by the Political Constitution in 1991, the royalties coming from natural resources exploitation were mainly destined for the territories in which this activity occurred, and for those through which the extracted resources were transported.[2] This arrangement implied a high concentration of beneficiaries, because only a few departments and municipalities were eligible to receive royalties. Most of the royalties from oil, for example, went to fewer than 100 municipalities (out of a total of 1,100) and half of the departments (Bonet et al., 2020). This royalty-sharing scheme suffered from at least two additional drawbacks. First, no socioeconomic or demographic criteria were considered in the allocation of the funds, and second, royalties were earmarked for particular sectors, such as health, education, nutrition, and drinking water and sanitation.[3] In terms of the distribution to the recipients, the legislation categorized 80 percent as direct royalties (for producers only) and the remaining 20 percent as indirect royalties, which could be accessed by presenting investment projects to the National Royalties Commission (Law 141 of 1994 and Law 756 of 2002). The results under this system were discouraging in terms of development and well-being (Benavides et al., 2000; Gaviria et al., 2002; Viloria, 2005; Sánchez et al., 2005).

These shortcomings led to a deep change in the royalties' sharing system and its general operation. The Legislative Act 05 of 2011, then regulated by the Law 1530 of 2012, gave rise to a new institutional arrangement, the General Royalties System (SGR for its acronym in Spanish). This new scheme introduced

[1] In Latin America, Colombia is the third highest oil producer (over 0,75 mbpd) after Brazil (2,9 mbpd) and Mexico (1,7 mbpd). In the coal market Colombia ranks first in the region and is one of the top producers worldwide. In the gas market, Colombia produces over 1,000 MMcf per day, after Venezuela, Mexico, Argentina and Brazil (Haddad *et al*., 2022).

[2] Colombia is divided into departments and departments in turn are divided into municipalities. We refer to both departments and municipalities as territories.

[3] According to the legislation (Law 141 of 1994 and Law 756 of 2002), territories were able to freely allot royalties once some minimum levels in terms of education, health, basic sanitation, and child mortality indicators were achieved. This law also created the National Royalties Fund, through which resources were allotted for mining promotion, preservation of the environment, and the financing of regional investment projects.

a series of modifications leading to a more equalitarian sharing design. The first major change was that from 2012 onward every department and most municipalities would be receiving resources coming from the exploitation of the natural resources, regardless of their producer status. Another significant modification is that, under the SGR regime, for territories to receive the royalty monies to which they are entitled, they need to develop and present investment projects and have them approved by Administration and Decision Boards (OCADs, for its acronym in Spanish).

While producing departments and municipalities still receive direct royalties, since 2012 the bulk of resources is distributed across producing and nonproducing departments and municipalities according to certain socioeconomic indicators, namely population, poverty, and unemployment. To this end, under the SGR regime a series of funds were created, the most important of which are the Regional Compensation Fund (FCR, from its name in Spanish), which distributes monies to both departments and municipalities, and the Regional Development Fund (FDR, from its name in Spanish), which distributes monies to departments only. Other funds created by the reform are the Savings and Stabilization Fund (FAE, from its name in Spanish) and the Science, Technology and Innovation Fund (FCTeI, from its name in Spanish). In addition, royalties fund the departmental and municipal pension system (FONPET, from its name in Spanish), the monitoring of mineral exploration and general management of the royalties, projects in the municipalities close to the Magdalena River and, since 2017, peace-related projects.[4]

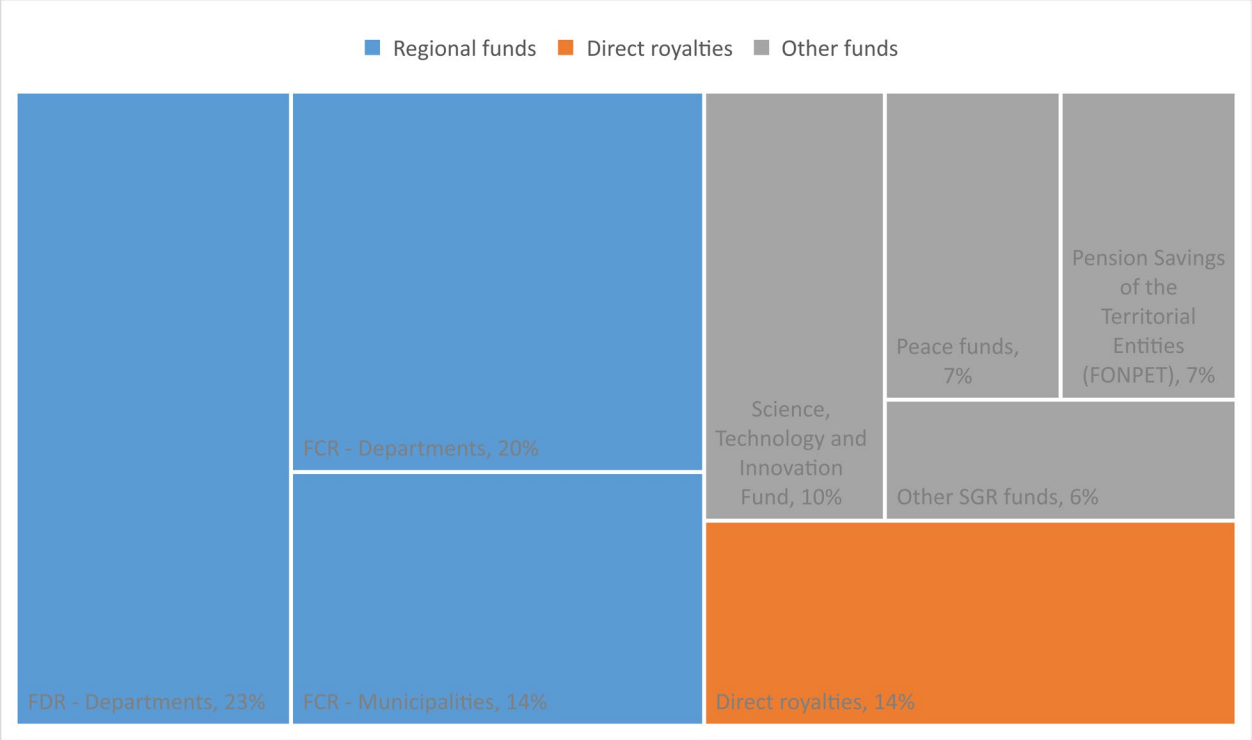
Figure 1 shows the royalties distribution enacted by the 2012 reform. Roughly 57 percent of royalties go to the FCR and FDR (14 percent for municipalities and 43 percent for departments), highlighting the importance of the regional funds in the new institutional arrangement. In the following section we discuss how population, poverty, and unemployment indicators map onto royalty assignments of the regional funds, and how we use this mapping to instrument royalties effectively received by municipalities.

Once it was determined how the resources will be allocated to the different funds, a key issue is how departments and municipalities can access these resources. For this purpose, territories must submit their investment projects to OCADs, which are tasked with reviewing, evaluating, and approving investment projects. The composition of these OCADs varies according to the level of government with which the project is associated (Decree 1075 of 2012). For example, the members of a departmental OCAD are 2 ministers (representatives of the national government), the department governor, and 10 percent of the

[4] Legislative Act 04/2017 determined that part of the royalty resources would be allocated to projects related to the implementation of the peace agreement with the FARC guerrilla group.

mayors in the department. Municipal OCADs include one delegate from the national government, the mayor of the municipality, and the governor of the department in which the municipality is located.

Figure 1. Royalty distribution since 2012 (%)



Source: Own calculations using the rules explained in DNP (2019).
Notes: The figure includes the effect of the 2017 reform that assigned 7 percent of royalties to peace-related projects (see footnote 4). To smooth the fall in royalty revenue for producing departments and municipalities, a transition period was implemented between 2012 and 2015; the percentages in this figure correspond to the long-term distribution. The FAE percentage varies over time (because its objective is to stabilize revenue), but is eventually distributed to the regional funds or as direct royalties, so for the purpose of illustrating the long-term distribution of resources, we assign the FAE to its corresponding final beneficiaries. Other SGR funds include funds for municipalities close to the Magdalena River, monitoring exploitation and cartography, monitoring and evaluation and SGR management.

3. Empirical strategy

We use a difference-in-differences model to estimate the impact of the reform on educational indicators. We first discuss our approach for municipalities' royalties and then incorporate departments in the analysis. The amount of royalties a given municipality effectively receives is endogenous to its capability to put together and have projects approved and possibly other municipality characteristics. However, the amount of royalties a municipality is entitled to is defined by the rules of the 2012 reform, which uses different functions of the municipality's population and the percentage of that population with unmet basic needs

(UBN),[5] and international prices of natural resources. We instrument received royalties using these distribution rules and the international price of oil, specifically West Texas Intermediate grade oil (WTI). Then we estimate

$$y_{mt} = \alpha_m + \beta_t + \hat{R}_{mt}\delta_1 + \mathbf{z_{mt}}\boldsymbol{\rho} + u_{mt}, \quad (1)$$

where y_{mt} is the outcome of interest *i* in municipality *m* in year *t*, $\hat{R}_{mt}$ represents the (first-stage estimated) per capita royalties received by municipality *m* in year *t*, and $\mathbf{z_{mt}}$ are control variables at the school and municipality levels. The coefficient of interest is δ_1, which measures the impact of royalties on the outcomes of interest.

$\hat{R}_{mt}$ is estimated in the first stage as

$$R_{mt} = \alpha_m + \beta_t + B_m^0 P_t \theta_1 + B_m^0 P_t D_t \theta_2 + \mathbf{z_{mt}}\boldsymbol{\rho} + u_{mt}, \quad (2)$$

where B_m^0 is an estimate of the royalty entitlement municipalities earned because of the 2012 reform, P_t is the international price of oil, and D_t is a time dummy for the postreform period. Note that B_m^0, the royalty entitlement, is not measured in monetary revenue, but as a percentage of the overall oil production. We use the rules in the 2012 reform to create municipality-specific royalty entitlements based on municipality population and UBN indicators. To calculate this figure, we divide municipalities into two groups: UBN 35 percent or more (those that have 35 percent or more of their total population classified as poor in terms of the UBN indicator); and UBN less than 35 percent (all the other municipalities).

Taken together, the municipalities with UBN populations of 35 percent or more receive approximately 18 percent of the regional funds created by the 2012 reform. We use this to calculate ω, a royalty entitlement, common to all the municipalities with UBN populations of 35 percent or more. Municipalities with UBN populations of less than 35 percent and categories 3–6 receive a per capita royalty that is increasing in UBN.[6] Together, these municipalities receive approximately 6 percent of the regional funds, so we use a

[5] The unsatisfied basic needs indicator is one of the most frequently used in Latin America to proxy poverty or quality of life. The indicator considers five dimensions: inadequate housing (physical characteristics of the houses), inadequate provision of public services (access to drinking water and sanitation), household crowding (number of people in the household relative to the number of rooms), school absence (1 or more children between the ages of 7 and 11 do not go to school), and high economic dependence within the household (more than 3 household members per 1 member working). A household is classified as poor if it meets at least one of these conditions.

[6] Municipalities are categorized as: special category and categories from 1 to 6, according to their population size and their unrestricted current income, where the lower the category the smallest and less able the municipality is (Law 617/2000).

procedure analogous to the one used before to estimate $f(\cdot)$, which maps UBN onto per capita oil production for nonproducing municipalities with UBN populations of less than 35 percent.[7] Therefore, B_m^0 is defined as follows:

$$B_m^0 = \omega \mathbf{1}[UBN_m^{2005} \geq .35] + f(UBN_m^{2005})\mathbf{1}[UBN_m^{2005} < .35] \quad (3)$$

Note that to calculate royalty entitlement we are using UBN from 2005 rather than contemporaneous values that could be endogenous to the reform. Therefore, identification leverages variation in the oil price and the UBN profile of each municipality in 2005, which maps differently into royalties before and after the reform. We incorporate these estimates in the first stage equations and use the two-stage least squares method (2SLS) to evaluate the impact of royalties on the outcomes of interest. To illustrate how UBN profile determines royalties, Figure 2 shows average per capita royalties for municipalities with high and low entitlement between 2008 and 2019. High entitlement municipalities are those that receive ω or more as the royalty entitlement, and low entitlement municipalities are those that receive less than ω.[8] Although royalties per capita increased for both groups because of the reform, the increase was larger for the high-entitlement group than for the low-entitlement group.

We also estimate royalty entitlements for departments. Departments can receive royalties from both the FCR and the FDR. Half of the FCR monies that go to departments are distributed to departments with 30 percent or more of their population with UBN (departmental poverty) and the other half to departments with municipalities with UBN populations of 35 percent or more (municipal poverty). In both cases funds

[7] Specifically, as a percentage of the total amount that municipalities in categories 3–6 with less than UBN 35 percent receive, each eligible municipality *m* receives:

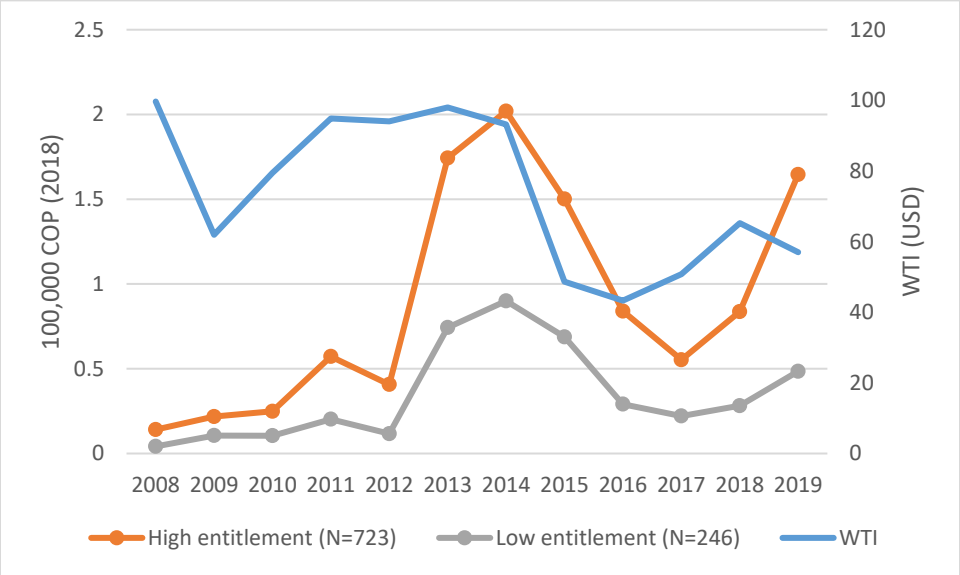
$$r_m^e = \frac{\left(\frac{p_m^e}{P^e}\right)^{0.6}\left(\frac{UBN_m}{UBN}\right)^{0.4}}{\sum_i \left(\frac{p_i^e}{P^e}\right)^{0.6}\left(\frac{UBN_i}{UBN}\right)^{0.4}}$$

where p_m^e is the population of the eligible municipality *m*, P^e is the total population in the eligible municipalities, UBN_m is the percentage of the population with unmet basic needs in the municipality *m* and *UBN* is the fraction of the population with unmet basic needs at the national level.

[8] Municipalities below but close to the UBN 35 percent threshold received more royalties per capita than municipalities at or above that threshold.

are distributed according to departments' population, UBN percentage, and unemployment rate.[9] The funds from the FDR are distributed in their entirety to departments according to their population and UBN.[10]

Figure 2. Received royalties by municipalities' entitlement level, 2008-2019



Source: Own calculations using rules explained in DNP (2019) and data from DNP.
Note: Producing municipalities, defined as those that received more than 2,400 million COP (2018) in royalties a year on average between 2008 and 2010, are not included.

Figure 3 shows average per capita royalties for departments with high and low entitlement between 2008 and 2019. High entitlement departments are those with departmental poverty (all but two departments have municipal poverty, and because all departments receive royalties from the FDR, the ultimate determinant

[9] Specifically, the fraction that each eligible department receives is given by:

$$r_d^e = \frac{\left(\frac{p_d^e}{P^e}\right)^{0.4}\left(\frac{UBN_d}{UBN}\right)^{0.5}\left(\frac{u_d}{u}\right)^{0.1}}{\sum_i \left(\frac{p_i^e}{P^e}\right)^{0.4}\left(\frac{UBN_i}{UBN}\right)^{0.5}\left(\frac{u_i}{u}\right)^{0.1}}$$

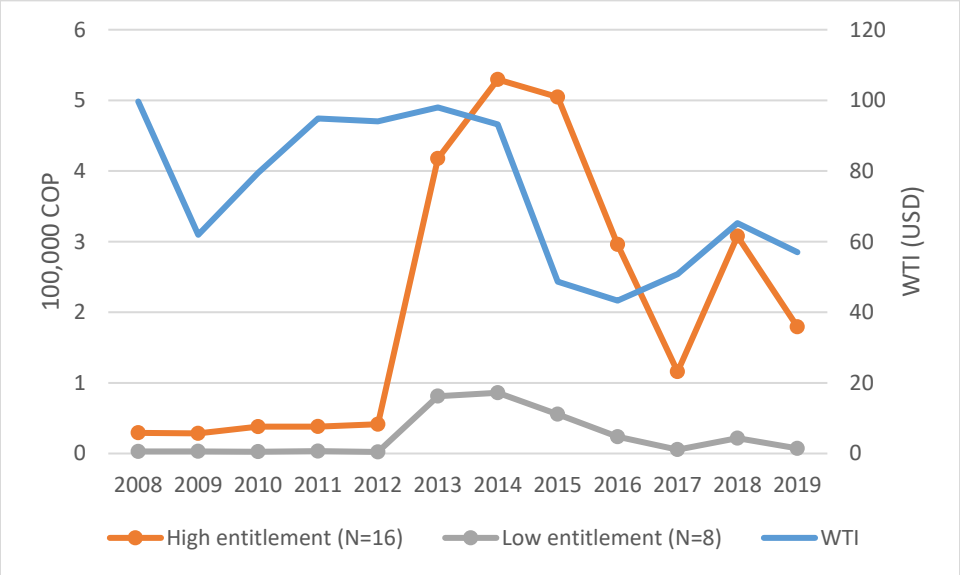
where p_d^e is the population of the eligible department d, P^e is the total population in the eligible departments, UBN_d is the fraction of the population with unmet basic needs in department d, UBN is the fraction of the population with unmet basic needs at the national level, u_d is the unemployment rate of department d and u is the national unemployment rate. Note that there is not a perfect overlap between departments that are eligible due to departmental poverty and departments that are eligible due to municipal poverty.

[10] The fraction that each department receives from the FDR is given by:

$$r_d^e = \frac{\left(\frac{p_d^e}{P^e}\right)^{0.6}\left(\frac{UBN_d}{UBN}\right)^{0.4}}{\sum_i \left(\frac{p_i^e}{P^e}\right)^{0.6}\left(\frac{UBN_i}{UBN}\right)^{0.4}}$$

for receiving more or less royalties is whether departments have UBN populations of 30 percent or more). The contrast between high and low entitlement is even clearer for departments than for municipalities.

Figure 3. Received royalties by entitlement level of department, 2008-2019



Note: Producing departments, defined as those that received more than 100,000 million COP (2018) in royalties a year on average between 2008 and 2010, are not included.

To incorporate into the analysis the royalties received by departments we estimate an alternative first stage, where the endogenous variable R_{mt}^{d} is the sum of the municipality and department per capita royalty as follows:

$$R_{mt}^{d} = \alpha_m + \beta_t + B_m^0 P_t \theta_1 + B_m^0 P_t D_t \theta_2 + B_d^0 P_t \theta_3 + B_d^0 P_t D_t \theta_4 + \mathbf{x_{imt}}\boldsymbol{\varphi} + \mathbf{z_{mt}}\boldsymbol{\rho} + u_{imt} \qquad (4)$$

where B_d^0 is the per capita royalty entitlement for department *d*.

In all specifications the control variables include an indicator for whether the corresponding municipality has autonomy (is "certified") to provide education services (Elacqua et al. 2021); and annual transfers from the national government, specifically transfers from the General Sharing System (SGP from its name in Spanish), which are the main national transfers municipalities receive.

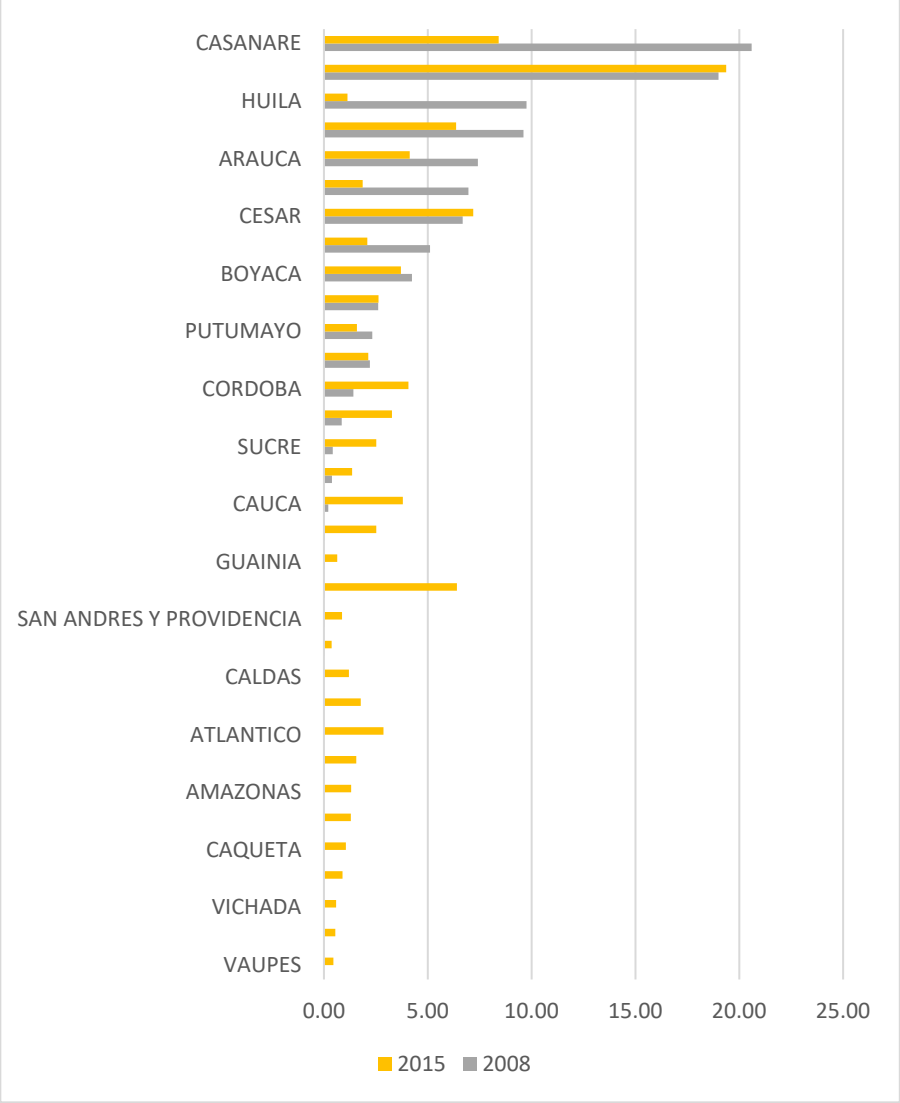
4. Data and descriptive analysis

Royalties

To measure royalty revenue, we use the National Department of Planning's *Operaciones Efectivas de Caja* (OEC), which records the yearly revenue and expenses of municipalities and departments.

The 2012 reform succeeded in distributing royalties more equally than before. At the departmental level, currently all 32 departments and Bogotá (which for the royalty systems counts as a department) receive some royalty revenue, whereas before the reform about half of the country's departments received either zero revenue or a negligible amount. As Figure 4 shows, in 2008 departments such as Casanare, Meta, and Huila received the bulk of royalties; in fact, these three departments together received about half of the royalties destined for departments. In 2015 the top three recipients, namely Casanare, Meta, and Guajira received 34 percent of the departmental royalties, and some departments that did not receive any royalties in 2008, like Chocó, Atlántico, and Cauca, were the recipients of substantial amounts of royalties in 2015.

Figure 4. Departmental royalty distribution in 2008 and 2015 (%)



Source: Authors' calculations using DNP's OEC.

At the municipal level, the change in the distribution is also apparent. Table 1 shows that in 2008, 611 municipalities (56 percent of the total), did not receive any royalty revenue, 346 municipalities (31 percent) received less than the national mean per capita royalty, 108 municipalities (10 percent) received between the mean and the mean plus 2 standard deviations (sd) of the per capita royalty, and 33 municipalities (3 percent) received more than the mean plus 2 sd of the per capita royalty. In 2015 only 108 municipalities (10 percent) did not receive any royalties, 534 municipalities (49 percent) received less than the mean royalty per capita, 424 municipalities (39 percent) received between the mean and the mean plus 2 sd of the per capita royalty, and 34 municipalities (3 percent) received more than the mean plus 2 sd of the per capita royalty.

Table 1. Numbers of municipalities by amount of royalty received in 2008 and 2015

	2008	2015
No royalty	611	108
Less than mean per capita royalty	346	534
Between the mean and the mean plus 2 sd of the per capita royalty	108	424
More than mean plus 2 sd of the per capita royalty	33	34
Total	1098	1100

Source: Authors' calculations using DNP's OEC.

Outcomes

We analyze the impact of royalties on school enrollment and academic achievement. The school enrollment data come from the annual C-600 surveys of the National Administrative Department of Statistics (Departamento Administrativo Nacional de Estadística, DANE), which compile the reports on the number of students, teachers, and other indicators, from all schools in Colombia. We use data aggregated at the municipal level for public schools for years 2008-2019, created by the Center of Economic Development Studies (Centro de Estudios sobre Desarollo Económico, CEDE) of Universidad de Los Andes. Table 2 shows summary statistics and other school indicators for 2009 and 2016. School enrollment fell between 2009 and 2016, reflecting changes in the overall age distribution in the country and an increase in private school enrollment. The academic achievement data come from the Colombian Institute for the Evaluation of Education (Instituto Colombiano para la Evaluación de la Educación, ICFES), which administers the Saber assessments, population-level standardized assessments taken by all students in Colombia in grades 5, 9, and 11 (Saber5, Saber9, and Saber11, respectively). Saber11 is a requirement for high school graduation and thus students take it every year. We use data from 2008 to 2019 in the analysis. Because students do not take Saber5 and Saber9 every year, we use data for 2009 and 2012–2017. We use the results

for math and Spanish aggregated at the school level. Test scores are standardized with the national mean and standard deviation of each year. We only consider students in public schools, but the standardization uses the mean and standard deviation of students in both public and private schools, which is why all mean scores are negative.

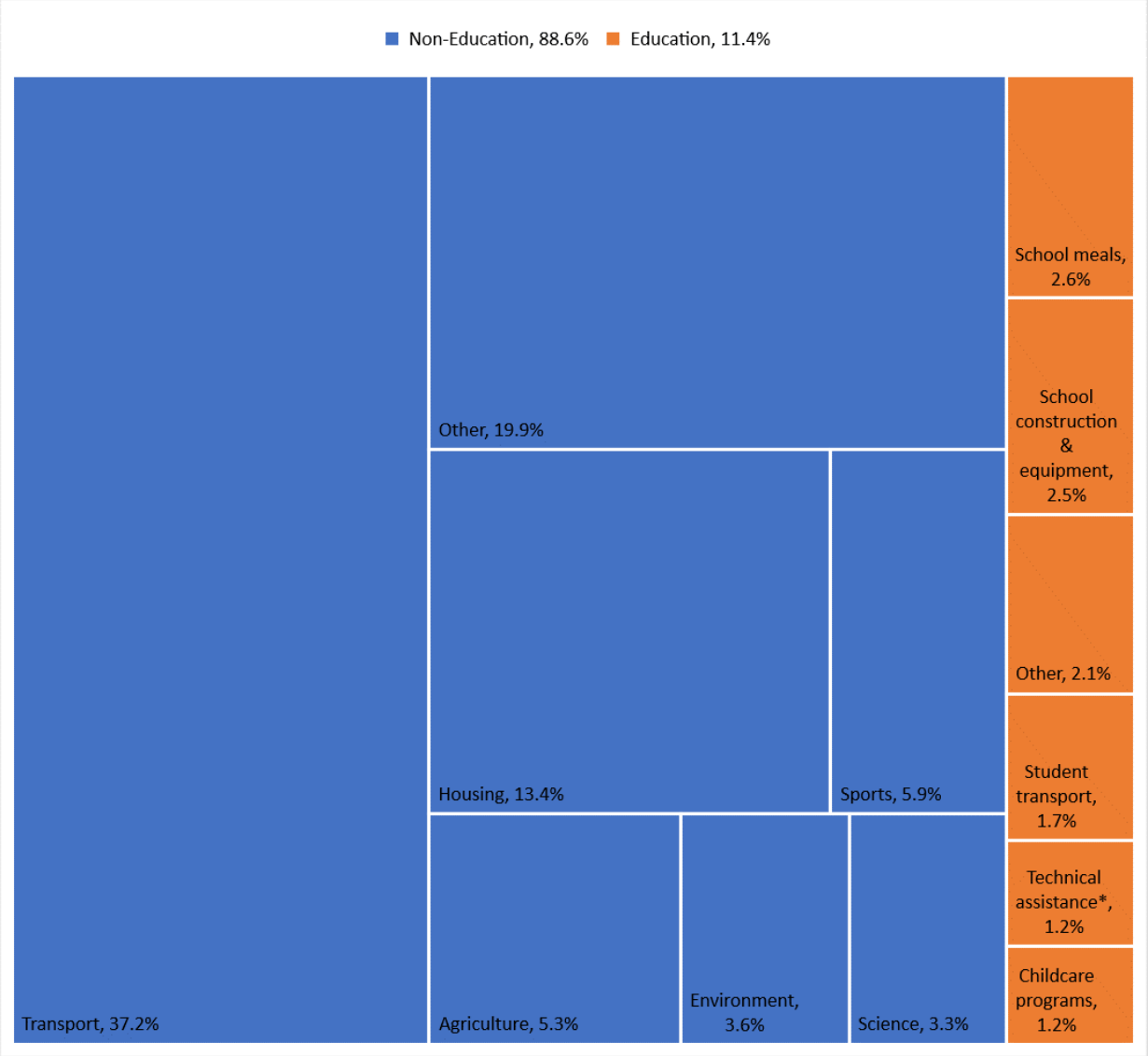
Table 2. Summary statistics, school enrollment and academic achievement

	2009	2016
Enrollment (municipal level means)		
Preschool	580	517
Primary	3,457	2,568
Secondary	2,298	2,112
High school	766	742
Number of schools	9	8
Achievement data (school level means)		
Grade 5		
Spanish	-0.29	-0.27
Math	-0.27	-0.24
Grade 9		
Spanish	-0.28	-0.27
Math	-0.29	-0.28
Grade 11		
Spanish	-0.12	-0.09
Math	-0.14	-0.09

Before looking at how royalties affect education outcomes, we analyze how royalties are spent. Although there are no detailed data on how royalties were spent before the 2012 reform, since 2017 the Contraloría General de la República (CGR) compiles revenues and expenditures of the SGR. Figure 5 shows the royalties distribution in 2018 by sector. Transport infrastructure was the main recipient of royalties with 37 percent, followed by housing (13 percent), and education (11 percent). As a fraction of expenditures on education, school meals and school construction are about a fifth each, while student transport is about a sixth. Note that the education expenditures were not really restricted to capital investments, as student transport and school meal programs are recurrent expenses.

It is important to highlight that royalties can have an impact on educational outcomes even if the investment is not done on education inputs. For example, royalties spent on transport infrastructure could reduce the time children spend going to school, which in turn could increase attendance and enrollment, and investments in housing could ease economic hardships at the household level, making it easier for children to attend school.

Figure 5. Royalties spent by sector, 2018



Source: Authors' calculations using CGR data.

* Includes dissemination and training

5. Results

Table 3 shows the results for enrollment in preschool, primary, secondary, and high schools, as well as for the number of schools, all at the municipal level.[11] We exclude 2012 from the analysis, the year of the

[11] In Colombia, the educational system has three formal education levels. The first one is preschool, with at least one year mandatory, the second one is basic, primary (from 1st to 5th grade) and secondary (from 6th to 9th grade), and the third one is intermediate (from 10th to 11th).

reform. The top panel shows the results for the impact of municipal royalties only. We find positive and statistically significant impacts for all outcomes except preschool enrollment. The bottom panel shows the impact of the sum of municipal and departmental royalties. The coefficients in this case are much smaller, although they are all significant except for preschool enrollment. Given that municipal and departmental entitlement levels are highly correlated, it is not surprising that omitting departmental royalties in most cases overestimates the impact of municipal royalties. The results indicate that school enrollment did increase in the municipalities that were most benefited by the reform.

Table 3. Impact of royalties on enrollment and number of schools, 2008-2019[§]

	Preschool	Primary	Secondary	High school	Schools
Municipal royalties only	-18.17	603.8**	330.0*	197.0**	1.977***
	(50.28)	(268.8)	(172.9)	(98.47)	(0.754)
F test	9.093***	10.10***	9.060***	9.128***	12.87***
N	12088	11934	12082	12050	10853
Municipal + Departmental royalties	2.305	60.56*	50.44**	27.97**	0.337***
	(5.694)	(32.60)	(21.45)	(13.89)	(0.129)
F test	12.88***	13.69***	12.88***	12.85***	19.22***
N	12088	11934	12082	12050	10853

Note: F tests correspond to the joint significance of the instruments in the first stage, namely the price of oil multiplied by the entitlement, and this product multiplied by the posttreatment dummy. All regressions include municipal and year fixed effects, national transfers in 100,000 real COP (2018), and a dummy for whether the municipality is certified. Data for 2012, the year of the reform, is not included.

[§] For the analysis on the number of schools the years for which data are available are 2008-2018.

Standard errors clustered at the municipality level in parentheses.

* p<0.1, ** p<0. 05, *** p<0.01.

The fact that the reform had a positive impact on enrollment implies that our estimates of academic achievement could confound the effect of the program on individual students with the changes in school composition caused by the reform. Previous work shows that there is a negative correlation between Saber9 scores and dropping out between grades 9 and 11 (Ome & Gamboa, 2021). If the students who stay in school thanks to the reform are on average less skilled than students who would stay in school even in the absence of the reform, then even if the reform has no impact on achievement we should expect a negative

estimated impact, just because of the composition of the students in municipalities most benefited by the reform. To try to correct for this selection issue, when analyzing the impact of the reform on student achievement we include as controls school-level socioeconomic indicators.[12]

Table 4 shows the results for academic achievement. The top panel shows the results using municipal royalties only; in this case we find positive and significant effects for both Spanish and math in grades 5 and 9, but in grade 11 we find a negative impact for Spanish and no significant impact for math. When we include municipal and departmental royalties there is a positive impact for 9th-grade Spanish, a negative impact for 11th-grade Spanish, and a very small but statistically significant impact for 11th-grade math. These results suggest that the reform had very little impact on academic achievement. The only three statistically significant effects do not even have the same sign and they are very small in magnitude.

Table 4. Impact of royalties on academic achievement

	5th grade		9th grade		11th grade	
	Spanish	Math	Spanish	Math	Spanish	Math
Municipal royalties only	0.04**	0.05**	0.10***	0.04**	-0.07***	0.01
	(0.020)	(0.023)	(0.017)	(0.016)	(0.013)	(0.010)
F test	26.88***	27.81***	28.70***	29.63***	30.60***	30.60***
N	48028	47990	38061	37700	67495	67495
Municipal + Departmental royalties	-0.01	-0.01	0.04***	0.01	-0.03***	0.01**
	(0.008)	(0.009)	(0.006)	(0.007)	(0.004)	(0.004)
F test	35.37***	36.70***	26.61***	26.45***	27.26***	27.26***
N	48028	47990	38061	37700	67495	67495

Note: F tests correspond to the joint significance of the instruments in the first stage, namely the price of oil multiplied by the entitlement, and this product multiplied by the posttreatment dummy. All regressions include municipal and year fixed effects, a dummy for rural areas, a dummy for school calendar, national transfers in 100,000 real COP

[12] For Saber5 and Saber9 we include a full set of dummies for a four-level socioeconomic categorization ICFES constructs at the school level, using student level data on parental education and occupation, household assets, and access to services (ICFES, 2019). For Saber11, ICFES only started produced this index in 2014; prior to that year they collected households' SISBEN level. Sistema de Identificación de Potenciales Beneficiarios de Programas Sociales (SISBEN) is the identification system government agencies use to target social programs beneficiaries: it classifies households according to their living conditions and income. Each year roughly 70 percent of the students who take the SABER11 are in one of the three levels of SISBEN. To aggregate student level data at the school level, we use the fraction of students in SISBEN in each school. Because ICFES stopped collecting SISBEN data in 2016, from 2017 on we impute whether a student is in SISBEN using the aforementioned ICFES categorization.

(2018), a dummy for whether the corresponding municipality is certified, and school-level socioeconomic indicators (see footnote 12). For Saber5 and Saber9 the years used in the analysis are 2009 and 2013-2017. For Saber11 we use years 2008-2019, except that we drop 2012. Standard errors clustered at the municipality level in parentheses.
* p<0.1, ** p<0. 05, *** p<0.01.

The results indicate that the reform had positive effects on enrollment across all levels. Relative to the mean enrollment at baseline, the estimated impacts on enrollment are between 2 and 3 percent of the corresponding baseline means. In terms of academic achievement, the results are less clear. For Saber5 we do not find any statistically significant impact, we find a positive impact for Saber9 (Spanish), and for Saber 11 we find both a negative impact (Spanish) and a positive impact (math). If the reform is changing the ability distribution of students who take the Saber assessments, and including school-level socioeconomic indicators is not enough to control for this, this could explain why we fail to find strong positive effects. In addition, as shown in Figure 4, the bulk of investments in education are focused on inputs that are likely to increase enrollment (e.g., school construction, school meals, school transport), while initiatives to help improve education quality (e.g., teacher training) seem to have a lower weight. This could also partly explain why royalties are associated with increases in enrollment but not with impacts on achievement.

6. Conclusion

In this study we analyze the impact of royalties on education outcomes, exploiting a reform implemented in Colombia in 2012. We use the distribution rules introduced by this reform and the international price of oil to identify the impact of royalties on school enrollment and academic achievement. In contrast to previous studies that analyzed the impact of royalties on municipalities where resource exploitation takes place, we estimate impacts for municipalities most benefited by the 2012 reform, where exploitation does not take place. We found positive impacts on enrollment for primary, secondary, and high schools, but mixed evidence on academic achievement. This could be because the increase in enrollment is not being accompanied by investments to improve the quality of education; hence, the changing background composition of students who are able to progress in school thanks to the royalties, to grade 11 especially, is reflected in a decline in Spanish test scores.

Finally, in this study we focus on education outcomes, but as it was already discussed, royalties are spent in other sectors as well. Future research should address the impact of the 2012 reform on other sectors of the economy.

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