Spreading Jam Across the National Toast: Royalties and Local Fiscal Capacities*

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Abstract

How do subnational tax collection efforts respond to windfall revenues from natural resource royalties? Conversely, what are the fiscal implications when these revenues decline? This paper investigates the effects of Colombia's 2012 reform, which substantially restructured the allocation of mining royalties among municipalities. By analyzing this legal shift, we assess changes in municipal tax collection behavior. Municipalities that experienced a reduction in royalties intensified their tax collection efforts; however, these efforts did not fully offset the revenue losses. In contrast, municipalities that benefited from increased royalties reduced their tax collection activities, resulting in no net change in overall municipal income. These findings contribute to the literature on the resource curse by offering a subnational perspective on the fiscal dynamics of resource windfalls.

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All remaining errors are our own.

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1 Introduction

Effective tax collection and proper allocation to public goods and services are fundamental drivers of economic development and well-being. The literature on fiscal federalism presents an unresolved tension regarding the impact of intergovernmental transfers on local fiscal outcomes. On one hand, classic theory posits that transfers are a vital tool for enabling local governments to provide public services efficiently, potentially fostering economic activity that complements and expands the local tax base (Oates, 1999; Weingast, 2014). On the other hand, a body of work on the political economy of resource-rich states warns that large inflows of non-tax revenue, such as royalties, can sever the accountability link between citizens and the state, creating powerful incentives for "fiscal laziness" and the substitution of own-source revenues (Eifert *et al.*, 2003). Whether the potential for efficiency gains outweighs the peril of weakened fiscal effort remains a key empirical question. Our work addresses this tension by exploiting a reform that generated both positive and negative revenue shocks, allowing us to identify the asymmetric response of local governments to both windfalls and shortfalls in natural resource rents.

Natural resource rents can significantly complement tax revenues in resource-abundant regions. However, local governments gaining or losing access to these rents can substantially alter their efforts to collect taxes from local communities. While the natural resource curse—the paradox wherein countries endowed with abundant natural resources often exhibit poorer development outcomes than those with fewer resources—has been extensively examined at the national level, empirical evidence remains limited regarding the impact of resource revenue abundance on the fiscal behavior of subnational governments. Our paper provides empirical evidence on how changes in the flow of nonrenewable natural resource rent revenues impact the fiscal efforts of local governments.

Before 2012, the central government collected royalty revenues and primarily allocated them to regions where non-renewable natural resources (NRNR) were extracted. In 2012,

a policy reform was enacted to broaden the distribution of these revenues, ensuring that non-producing regions also received transfers. The reform introduced allocation criteria that prioritized municipalities with lower levels of socioeconomic development, among other criteria[1]. To promote the reform, the administration employed a now famous metaphor: under the previous system, the *jam* was concentrated in one corner of the national *toast,* whereas the reform aimed to distribute the jam more equitably across the entire country. This metaphor gained considerable traction in public discourse. Over time, however, its connotation evolved, with "jam" increasingly becoming associated with clientelistic practices[2].

The reform established several precise parameters to guide the new distribution of royalties across territories. Some municipalities began receiving more royalties, especially those with low development indices and generally without a relevant mining production. In contrast, others received less, more likely if they were richer and mineral-producing municipalities. We use these parameters to instrument for resources received ex-post by each municipality. We then use this exogenous revenue shock to examine the response of municipal fiscal revenues.

Analyzing the regional redistribution of resources generated by mining royalties offers a fresh perspective on the literature about the "resource curse". This literature indicates that excessive state expansion in resource-rich countries can negatively affect long-term economic performance. Robinson *et al.* (2006) examines the political mechanisms behind this phenomenon claiming that countries lacking institutions that promote accountability and state competence can suffer from a resource curse, as these poor institutions exacerbate the perverse political incentives created by natural resource booms.

Despite the interest in the implications of natural resource wealth, there remains limited

[1]In 2011, the new General System of Royalties (SGR) and the budget for 2012 were established. Along with the procedure for liquidating the previous system National Royalties Fund (FNR). The system's organization, operation, and resource distribution criteria were regulated until May 2012. From now on, we will refer to the 2012 reform when discussing this set of laws.

[2]See Ungar (2021) op-ed for a description of the use of the analogy over time in Colombia, where former Finance Minister Juan Carlos Echeverry coined the term "mermelada" when proposing that royalties be distributed nationwide, rather than just to mineral and hydrocarbon-producing regions.

empirical evidence on how income windfalls—or sudden reductions—in resource revenues affect regional fiscal behavior. In the context of the 2012 royalty reform, how do municipalities that benefit from the new distribution formula adjust their fiscal strategies? Conversely, what are the implications for resource-producing municipalities that experience a relative decline in revenue transfers?

Sachs & Warner (1995) introduce the concept of the resource curse, arguing that countries endowed with abundant natural resources often experience slower economic growth than their resource-poor counterparts. Subsequent literature has expanded this perspective, highlighting the detrimental effects of resource dependence on fiscal autonomy and the quality of public sector governance. For instance, Bornhorst *et al.* (2009) find that resource-rich countries tend to exert lower tax effort and rely more heavily on non-tax revenues, which may weaken the accountability link between governments and citizens. Knack (2009) show that reliance on resource revenues can undermine efforts to develop robust tax systems, leading to fiscal inefficiencies. The latter suggests that the fundamental mechanisms are rent-seeking behavior, corruption, and neglect of other productive sectors.

Moreover, managing the resource windfalls themselves poses significant challenges for governments, including revenue volatility, susceptibility to inefficient public investment cycles, and difficulties in ensuring adequate savings for future generations, issues that are particularly acute in developing countries lacking strong institutional frameworks (Ploeg, 2010; Ploeg & Venables, 2011). Consequently, as Mehlum *et al.* (2006) emphasize, institutional quality plays a critical role in moderating the effects of the resource curse. They argue that strong institutions can mitigate the adverse consequences of resource wealth by fostering more effective governance and accountability. This view is reinforced by Brunnschweiler & Bulte (2008), who revisit the resource curse hypothesis and underscore the centrality of governance quality in shaping development outcomes in resource-rich contexts.

Our research also speaks to the fiscal implications of the global energy transition. As fu-

ture demand for fossil fuels declines, the royalty revenues available to countries like Colombia are expected to shrink. The fiscal responses we document provide evidence of how local governments might face such a shock: royalty windfalls encourage the substitution of own-source revenues, and losses are met with incomplete fiscal adjustments. This behavior indicates a low level of fiscal preparedness, suggesting that the erosion of royalty transfers could weaken subnational capacity for social spending and public investment.

This study contributes to the literature by examining the impact of royalty allocations on the fiscal behavior of Colombian municipalities. Our empirical findings indicate that municipalities receiving higher royalty transfers tend to reduce their tax collection efforts, suggesting a strong substitution effect between intergovernmental transfers and local revenue mobilization. The magnitude of this effect is nearly one-to-one. In contrast, municipalities experiencing a decline in royalty revenues respond by increasing their own-source revenues, although the adjustment is insufficient to fully offset the loss in transfers. These heterogeneous effects—particularly the decline in tax collection efforts observed in municipalities benefiting from royalty windfalls—contribute to the literature by highlighting the nuanced fiscal responses to intergovernmental transfers. Our findings complement those of Bonet-Morón *et al.* (2018), who report limited evidence of generalized fiscal complacency in response to aggregate transfers. While Gallego *et al.* (2020) demonstrate that post-reform royalties were more effective at improving household welfare, we investigate whether these same transfers affected the capacity of municipalities to generate their own-source revenues.

The asymmetric response we document aligns with recent evidence from Brazil: municipalities facing reductions in transfers have strengthened their fiscal capacity and increased tax revenues, while those receiving additional transfers have primarily expanded expenditures without corresponding increases in tax effort (Ferraz *et al.*, 2024). Additionally, our findings are consistent with evidence from Martínez (2023), who shows that increases in royalty revenues driven by international price booms did not translate into improved provision of local public goods, largely due to institutional weaknesses and rent-seeking behavior. This

stands in contrast to recent evidence from Peru, where royalty-funded public spending has been found to stimulate local economic activity and enhance household welfare (Bancalari & Rud, 2024). This divergence underscores the distinction between resource transfers' effects on tax mobilization and their broader economic impacts. Taken together, our findings suggest that the specific design of royalty distribution mechanisms—as well as the direction of the revenue shock—can significantly influence local fiscal incentives and behavior in complex and context-dependent ways.

The remainder of this paper is structured as follows. Section 2 outlines the Colombian institutional context, the 2012 royalty reform, and our data. Section 3 details the empirical approach, including our Instrumental Variable (IV) strategy to address endogeneity and analyze heterogeneity. Section 4 presents the estimation results, focusing on the average and heterogeneous effects of royalties on local tax collection. Finally, Section 5 summarizes the findings, discusses policy implications, and suggests directions for future research.

2 Colombian Context and Data

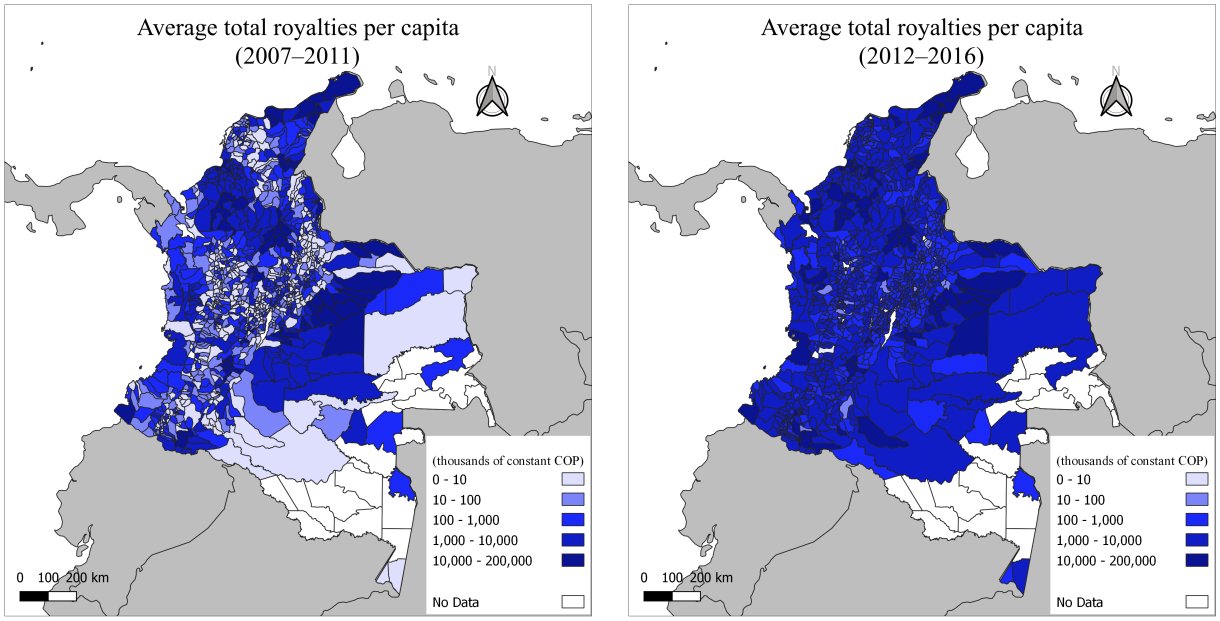
Mineral activities have been important in Colombia for many decades. In the early 2010s, Colombia produced over 1 million oil barrels per day, and coal exports exceeded 70 million metric tons. Mining activities contributed nearly 10% to GDP, accounting for two-thirds of total exports. For the central national government, the total tax revenues from the sector and the dividends from the state-owned oil company accounted for nearly 20% of total revenues.

In Colombia, non-renewable natural resources are publicly owned, and firms engaged in their extraction are required to pay royalties to the central government. These royalties constitute a substantial share of the production value. For example, coal royalties range from 5 to 10%, depending on the volume extracted, while oil royalties vary between 8 and 25%, based on the total extraction volume per field. By 2010–2011, approximately 98%

of total royalty revenues originated from the extraction of oil, gas, and coal. The central government is responsible for collecting these royalties and subsequently redistributing them to departments and municipalities across the country.

Until 2012, royalty revenues were primarily allocated to regions where NRNR were extracted, as well as to municipalities with maritime or river ports used for transporting these resources. This allocation system resulted in a highly concentrated distribution of funds: between 2007 and 2011, just eight out of 32 departments—representing only 17% of Colombia's total population—received 70.5% of total royalties (Perry & Olivera, 2012). Moreover, only 56% of municipalities received any royalty transfers under this regime (Garzón *et al.*, 2011). The left panel of Figure 1 illustrates the geographic distribution of royalty allocations prior to the 2012 reform.

Figure 1: Royalties before and after the reform.



Source: Authors' elaboration.

The right panel of Figure 1 demonstrates a more equitable dispersion of resources across the national territory, in contrast to the pre-reform concentration. The 2012 reform fundamentally shifted the focus away from production location to prioritize municipalities based

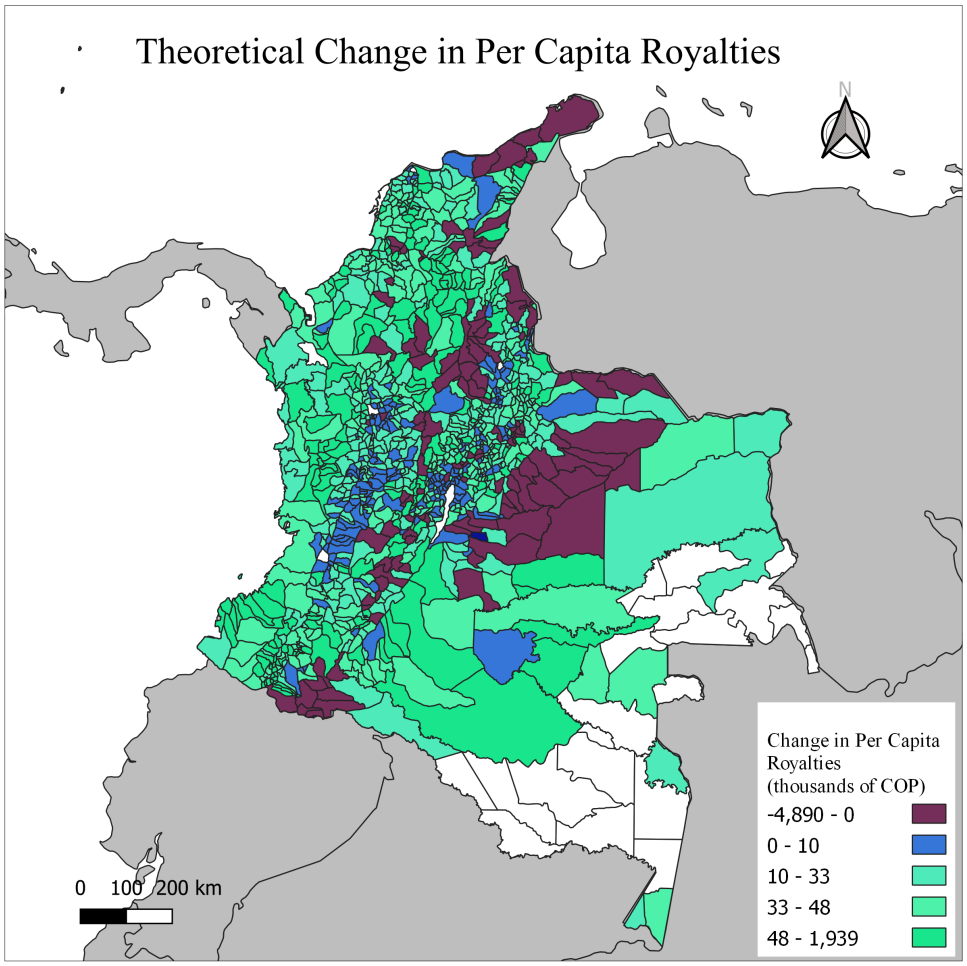
on poverty levels—measured by the Unmet Basic Needs (UBN)[3] index—and population size. This change introduced new allocation funds and reduced the share of royalties going directly to producing regions, from 80% to 28%. However, accessing these funds requires municipalities to propose projects that improve living conditions, which must align with their territorial development plans. These projects are then evaluated and approved by Collegiate Bodies for Administration and Decision (OCADs), based on criteria such as viability, prioritization, and coordination with macroeconomic objectives.

The allocations per territorial entity available for the years following the reform become an important tool for evaluating the 2012 reform. Appendix A.1 provides a detailed explanation of the *de jure* royalty distribution formula used in our analysis. Hereafter, we will call it the *theoretical* distribution or *theoretical* royalties.

Figure 2 presents the expected distributional impact of the 2012 royalty reform by mapping the theoretical change in per capita royalty allocations for each municipality. The figure compares projected allocations under the new reform rules with those under the previous regime. This map highlights the geographic distribution of expected "winners" (in green) and "losers" (purple) resulting from the reform's design. The "losers" in the northern region, are Colombia's major coal-producing municipalities. Additional losses are observed in oil- and gas-producing municipalities in the eastern and southwestern regions. These patterns reflect the shift in allocation criteria away from production-based transfers toward broader redistributive goals.

[3]The UBN (*Necesidades Básicas Insatisfechas*, or Unmet Basic Needs) index is a multidimensional measure used in Colombia to estimate the percentage of the population living under unmet basic needs. Higher values indicate greater levels of deprivation.

Figure 2: Map of Estimated Change in Per Capita Royalties



Notes: Municipalities shaded in purple are expected to experience a reduction ranging from 0 to –4.9 thousand COP per capita and are classified as "losers." Those in blue observed a moderate increase, ranging from 0 to 10 thousand COP per capita. Municipalities in green benefited the most from the reform and are considered "winners." Municipalities shown in white lack sufficient data or are departmental capitals classified under the spatial category, and were excluded from the analysis. Source: Authors' elaboration.

For most municipalities in Colombia, national transfers from the central government constitute the primary source of revenue. Royalties represent an additional, independent source of local income. In addition to these transfers, national legislation permits municipalities to levy a limited set of local taxes. The most significant among these are the property tax and the business tax, followed—albeit to a lesser extent—by taxes on gasoline consumption.

Table 1 reports summary statistics on municipal revenue sources, disaggregated by pre-

reform (2005–2011) and post-reform (2012–2017) periods, as well as by producing and non-producing municipalities. In both groups, *Current Revenues* account for approximately one-quarter of total municipal income. However, the share of *Tax Revenues* is notably higher in producing municipalities ($\approx 15\%$) compared to non-producing ones ($\approx 10\%$). The 2012 royalty reform altered the structure of local revenues: while the importance of *Royalties* increased for non-producing municipalities (from 0.6% to 7%), it declined for producing ones (from 15% to 12%). Additionally, property tax revenues decreased among non-producing municipalities following the reform, whereas producing municipalities experienced an increase in revenues from the business tax.

In this paper, we examine how local tax revenues respond to changes in royalty transfers. Specifically, we focus on three key municipal taxes: the property tax, the business tax (commonly known as ICA in Colombia), and the gasoline tax. For all these taxes, law enforcement efforts, and audits are managed by local authorities. While comprehensive data are available on total revenues collected under each tax category at the municipal level, there are no official records on the specific tax rates applied or changes in those rates over time.

Municipalities exhibit varying degrees of autonomy in managing these revenue sources. In the case of property taxes, local governments are authorized to set annual rates within a relatively broad range—typically between 0.1‰ and 0.16‰ of the property's market price.[4] The base value used to calculate property taxes is determined by the national government. Specifically, the Instituto Geográfico Agustín Codazzi (IGAC) periodically updates the cadastral values that municipalities use for tax assessments.

The business tax (Impuesto de Industria y Comercio, ICA) is levied on the gross revenues—rather than profits—generated by economic activities conducted within municipal boundaries. Municipal councils have the authority to set tax rates within ranges established by national legislation: from 2‰ to 7‰ for industrial activities, and from 2‰ to 20‰ for

[4]Socioeconomic conditions of neighborhoods, land use, and cadastral age are part of the criteria to guide the scale chosen by municipalities as established in Law 44 of 1990.

Table 1: Summary Statistics in Producing and Non-Producing Municipalities

	2005–2011			2012–2017		
Variable	**Mean**	**St. Dev.**	**% Total**	**Mean**	**St. Dev.**	**% Total**
Panel A. Non-Producing Municipalities						
Total revenues	966.96	689.09	100%	1636.61	1080.10	100%
1. Current revenues	263.68	193.59	27%	410.91	284.74	25%
1.1. Tax revenues	96.86	63.47	10%	179.13	114.08	11%
1.1.1. Property tax	35.03	18.87	4%	47.83	24.43	3%
1.1.2. Business tax	16.94	6.11	2%	36.76	12.77	2%
1.1.3. Gasoline surcharge	17.68	10.22	2%	16.06	9.76	1%
1.1.4. Others Tax Revenues	27.47	13.42	3%	78.48	45.78	5%
1.2. Non-tax revenues	28.61	14.93	3%	31.94	14.94	2%
1.3. Transfers (current)	138.21	94.16	14%	199.84	129.91	12%
2. Capital revenues	703.28	598.65	73%	1225.70	1046.05	75%
2.1. Royalties	6.39	0.00	1%	107.96	44.75	7%
2.2. National transfers	591.19	527.95	61%	878.92	815.06	54%
2.3. Co-financing	50.36	0.62	5%	66.26	9.46	4%
2.4. Others Capital Revenues	55.34	10.84	6%	172.56	58.27	11%
Population (thousands)	15.509 47	9.790	–	16.593 75	9.931 50	–
UBN (%)	49.43	46.75	–	46.77	44.75	–
Panel B. Producing Municipalities						
Total revenues	986.54	807.67	100%	1549.23	1170.99	100%
1. Current revenues	253.01	203.72	26%	397.17	307.05	26%
1.1. Tax revenues	136.11	90.47	14%	241.12	154.85	16%
1.1.1. Property tax	41.78	26.73	4%	59.87	35.51	4%
1.1.2. Business tax	38.54	11.66	4%	72.75	24.83	5%
1.1.3. Gasoline surcharge	24.10	18.48	2%	22.45	17.20	1%
1.1.4. Others Tax Revenues	32.00	17.12	3%	86.05	55.49	6%
1.2. Non-tax revenues	30.14	18.23	3%	35.26	19.70	2%
1.3. Transfers (current)	86.76	65.33	9%	120.79	88.16	8%
2. Capital revenues	733.53	687.54	74%	1152.07	959.65	74%
2.1. Royalties	143.89	1.68	15%	192.42	60.21	12%
2.2. National transfers	493.58	452.52	50%	753.43	708.68	49%
2.3. Co-financing	45.70	3.92	5%	73.05	18.11	5%
2.4. Others Capital Revenues	50.37	12.93	5%	133.18	54.54	9%
Population (thousands)	33.816 43	14.628	–	36.445 79	15.563 50	–
UBN (%)	45.96	43.37	–	43.49	40.62	–

Notes: The table reports mean and standard deviation of fiscal and demographic variables for non-producing and producing municipalities during the periods 2005–2011 and 2012–2017. The sample covers 1,095 municipalities. All fiscal variables are expressed in per capita terms and measured in thousands of constant 2018 Colombian pesos (COP), unless otherwise stated. Population is measured in thousands of persons, and the UBN index represents the percentage of the population living under unmet basic needs. 23 municipalities with missing values and 6 departmental capitals classified as Special Category—corresponding to the main cities (Bogotá, Medellín, Cali, Barranquilla, Cartagena, and Bucaramanga)—were excluded. Non-Producing Municipalities indicates municipalities that are not producers of oil, gas, or coal, and that, in theory, received fewer royalties after the reform. A total of 746 non-producing municipalities were identified in the pre-reform period. *"Others Tax Revenues" includes:* stamp duties, public lighting, urban delineation, signs and billboards, among others. *"Non-tax revenues" includes:* fees, fines, and special contributions. *"Transfers (current)" includes:* national transfers from the central government and other intergovernmental transfers from departments or specific programs.

retail and service sectors[5]. In contrast, for the gasoline surcharge tax the rates are defined by national law and cannot be altered by municipalities[6].

Our analysis draws on multiple data sources. Municipal revenue data for the period 2005–2017, expressed in constant 2015 Colombian pesos, are obtained from the Effective Cash Operation dataset compiled by the National Planning Department (*Departamento Nacional de Planeación*, DNP). Socioeconomic and institutional characteristics of municipalities are sourced from the CEDE Municipal Panel maintained by *Universidad de los Andes*. Information on oil and gas production, as well as royalty settlements, is provided by the National Hydrocarbons Agency (*Agencia Nacional de Hidrocarburos*, ANH) and the National Mining Agency (*Agencia Nacional de Minería*, ANM). Data on population, UBN, and municipal classification are drawn from the SICODIS system.

3 Empirical Strategy

This section outlines our empirical approach to estimate the causal effect of royalty revenues on municipal tax collection. We begin by presenting a baseline structural specification, in Equation 1, that relates tax revenues to the amount of royalties received. Let $Taxes_{m,t}$ denote tax revenues in municipality m and year t, and $Royalties_{m,t}$ the royalty revenues in the same period.

$$Taxes_{m,t} = c_0 + b_1 Royalties_{m,t} + u_{m,t} \tag{1}$$

This direct measurement of the impact of royalty revenues on fiscal effort raises several concerns. The causal identification of this effect requires empirical strategies that address the potential issues of endogeneity. The key challenge is that the level of royalty revenues a municipality receives may be correlated with unobserved factors that also influence its

[5]Law 14 of 1983, particularly Article 33 and Article 39 for exceptions related to extractive industries.

[6]Law 488 of 1998, modified by Law 2093 of 2021, establishes the fixed per-gallon surcharge and the distribution between municipalities and departments.

local tax collection. For instance, municipalities with more developed economies or stronger institutions might be more effective in attracting both mining activity (and thus, higher royalties) and raising local taxes. This correlation would bias estimates of the direct effect of royalties on tax collection.

To address these concerns, we adopt an instrumental variable (IV) approach. This strategy leverages the exogenous variation in royalty allocations generated by the reform's distribution rules to estimate the marginal effect of royalties on municipal tax collection. Therefore, we construct a shift-share instrument[7] which consists of the annual *theoretical royalty allocations* that each municipality would have received based solely on the distribution formulas defined by law (details are provided in Appendix A.1, see Equation A.1).

The validity of our IV strategy relies on the exclusion restriction, which is plausible for several reasons. First, the instrument is constructed using the reform's legal formula, which is based on pre-determined municipal characteristics (such as population and poverty levels from years prior to the reform)[8]. Second, the nationwide distribution formula was not designed based on anticipated future trends in local fiscal effort beyond those already captured by our control variables and fixed effects. Because the formula was uniformly applied using historical administrative data, its interaction with each municipality's baseline characteristics generates variation in royalty revenues that is exogenous to contemporaneous local tax revenue shocks. Finally, given that municipal budgets are typically approved one to two years in advance, local governments had limited capacity to adjust the inputs to the allocation formula in anticipation of the reform.

The first-stage regression takes the form:

$$Royalties_{m,t} = \alpha_0 + \alpha_1 \, Theoretical\ Royalties_{m,t} + \phi_m + \phi_t + \epsilon_{m,t} \tag{2}$$

[7]The strategy is similar the one proposed by (Acosta *et al.*, 2025)

[8]Specifically, we calculate the 2010–2011 averages for production, population, UBN, and pension deficit—periods preceding the new allocation rules—to ensure the instrument reflects characteristics untainted by contemporaneous fiscal outcomes.

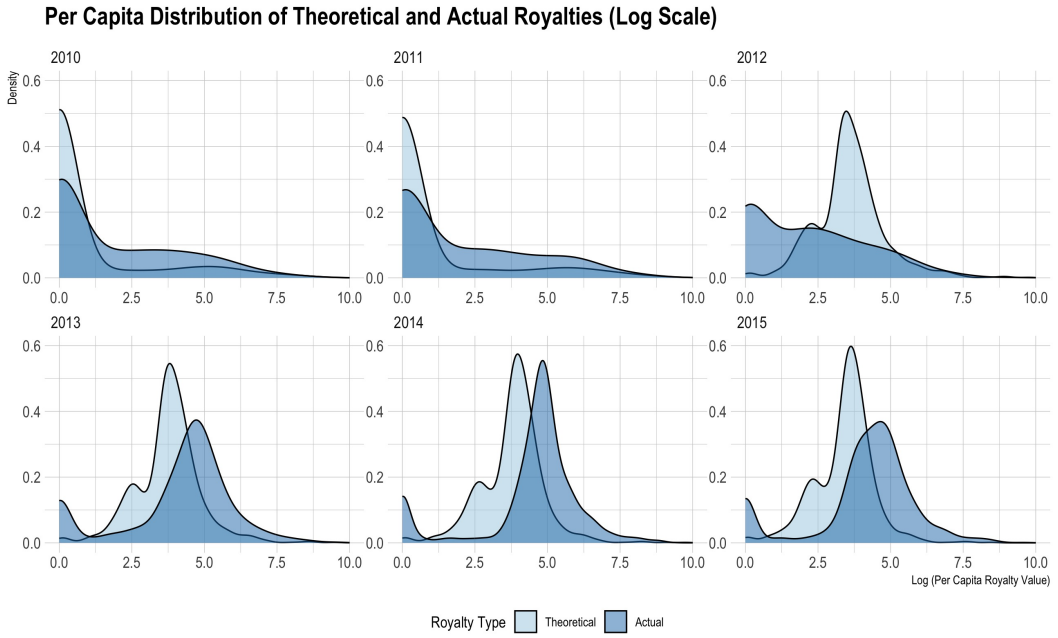
We include fixed effects of municipality ϕ_m and time ϕ_t. Table A.1 presents the first-stage results, showing a strong positive relationship between the theoretical and actual royalty allocations, with an F-statistic above conventional thresholds.

In the second stage, we use the predicted values of royalties to estimate their causal impact on tax collection:

$$Taxes_{m,t} = \beta_0 + \beta_1 \widehat{Royalties}_{m,t} + \phi_m + \phi_t + \eta_{m,t} \tag{3}$$

Figure 3 compares the distribution of actual ($Royalties_{m,t}$) and theoretical per-capita royalties ($Theoretical\ Royalties_{m,t}$) across municipalities. Following the 2012 reform, the distribution of per capita royalties exhibits a broader dispersion, in contrast to the pre-reform period, when most municipalities clustered near zero. This shift reflects the reform's redistributive intent and its impact on the geographic allocation of resource revenues. Although the new distribution rules were introduced in 2012, their implementation began gradually after May.

Figure 3: Per capita distribution of theoretical and actual royalties (log scale).



Notes: This figure presents kernel density distributions comparing average annual per capita theoretical royalty allocations and average annual per capita actual royalty disbursements for Colombian municipalities during the period 2010-2015. *Per capita theoretical royalties* are calculated based on the legally defined allocation rules of the 2012 General System of Royalties (SGR) applied to municipality characteristics (see Appendix A.1 for detailed methodology). *Per capita actual royalties* represent the amounts effectively received by each municipality. Both variables are measured in thousands of constant 2018 Colombian pesos (COP) per person. The sample includes the 1,095 municipalities used in the analysis, following the exclusions detailed in the notes for Table 1. The distributions are plotted on a logarithmic scale to better visualize the variation across municipalities. Data sources for actual royalties include the National Planning Department (DNP), National Hydrocarbons Agency (ANH), and National Mining Agency (ANM). Data for municipal characteristics used in the theoretical calculation are from the CEDE Municipal Panel and SICODIS system.

Heterogeneous effects

To assess the heterogeneous effects of changes in royalty policies across municipalities, we estimate a series of models incorporating interaction terms. For example, some specifications include a dummy variable indicating whether a municipality was a non-producer of natural resources prior to the reform. Models estimated to capture these differential impacts are as follows:

$$Taxes_{m,t} = \beta_0 + \beta_1 \widehat{Royalties}_{m,t} + \beta_2 D_m + \beta_3 (\widehat{Royalties}_{m,t} \times D_m) + \phi_m + \phi_t + \epsilon_{m,t} \quad (4)$$

Where D_m is a dummy variable equal to 1 for municipalities that meet the pre-existing characteristics. Both the royalty variable and its interaction are instrumented using the procedure described above. This specification allows us to test whether the marginal effect of royalty revenue on fiscal effort varies across municipalities with different pre-reform profiles.

Following best practices (e.g., Cui *et al.* (2021), Brambor *et al.* (2006)), we instrument the interaction term in both the first stage and in the second-stage estimates to avoid bias. In the results section, we report the joint marginal effects for subgroups of interest, along with confidence intervals based on clustered standard errors.

4 Results

The 2012 royalty reform can be interpreted as a localized windfall of resources for many municipalities, analogous to a natural resource boom. For others, however, the reform entailed a decline in expected future royalty transfers. This divergence raises questions regarding the reform's implications for local tax revenues. When municipalities invest royalty inflows in public goods and services, such expenditures may stimulate local economic activity. In such cases, taxes closely linked to economic performance—such as business and gasoline taxes—are expected to increase. Moreover, heightened economic activity may exert upward pressure on property values, thereby expanding the property tax base. Increased fiscal resources may also enhance municipal administrative capacity, improving the efficiency of tax collection. Collectively, these mechanisms suggest a potential positive relationship between royalty transfers and local tax revenues.

However, the relationship may also be negative. Municipalities receiving higher transfers may reduce tax rates or enforcement efforts, relying instead on external revenues. Conversely, those facing reduced transfers may respond by intensifying tax collection to compensate for the shortfall. These contrasting responses underscore the importance of examining the

heterogeneous effects of the reform across different types of municipalities.

In this section, we first explore the symmetric setting using Equation 3, and then we allow for different varieties of heterogeneous effects using Equation 4.

4.1 Symmetric effects

Table 2, presents the estimations of the baseline equation to explore the relationship between per capita local tax revenues and the municipalities' royalties. We report the results for total local taxes and property, business, and gasoline taxes, one at a time. For interpretation purposes, we focus on the IV estimates.

Table 2: Effect of Royalties on Local Tax Revenue

	Total Tax		Property Tax		Business Tax		Gasoline Tax	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Royalties per cap.$_{m,t}$	0.073***	-0.825***	-0.001	-0.012	0.042***	-0.502***	-0.000	-0.015*
	(0.003)	(0.178)	(0.001)	(0.019)	(0.002)	(0.108)	(0.000)	(0.007)
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Num. Obs.	14,207	14,207	14,207	14,207	14,207	14,207	14,146	14,146
Municipalities	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095
F-statistic		17.103		17.103		17.103		17.103
Mean Dep. Var.	165.728	165.728	46.649	46.649	43.617	43.617	20.898	20.898

*p<0.1; **p<0.05; ***p<0.01

Notes: This table presents results from OLS and Two-Stage Least Squares (2SLS) regressions estimating the effect of per capita royalties on various municipal tax revenues per capita. The dependent variables are specified in the column headers: Total Tax, Property Tax, Business Tax, and Gasoline Tax. The key independent variable is Royalties per capita ($Royalties_{m,t}$), representing the actual royalty revenues received by municipality m in year t. Columns (1), (3), (5), and (7) report OLS estimates. Columns (2), (4), (6), and (8) report 2SLS estimates where Royalties per capita is instrumented using the Theoretical Royalties per capita ($Theoretical\ Royalties_{m,t}$), constructed based on the 2012 SGR reform allocation rules applied to pre-reform data (details in Appendix A.1). All regressions include Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). No additional control variables are included in these specifications. Standard errors, double-clustered by municipality and year, are reported in parentheses. All variables are measured in thousands of constant 2018 Colombian pesos (COP). The analysis period is 2005-2017. Data sources include DNP, ANH, ANM, and SICODIS. Sample exclusions are detailed in the notes for Table 1. The F-statistic reported for the IV columns is the first-stage F-statistic for instrument relevance, testing the strength of the instrument in predicting the endogenous variable. A value above 10 is a common rule of thumb for strong instruments.

The coefficient on royalty transfers in the total tax revenue regression is negative and statistically significant, indicating that increases in royalty allocations are associated with

reductions in locally collected tax revenues. This suggests that royalty transfers and local tax revenues serve as substitutes rather than complements. The estimated coefficient implies that for every additional peso received in royalties, total local tax revenues decline by approximately 82 cents.

Higher royalty transfers are associated with a decline in local fiscal revenues, despite the potential for these additional resources to stimulate economic activity and improve the provision of public goods. We hypothesize that this outcome reflects a reduction in local governments' incentives to exert fiscal effort—a phenomenon often referred to as fiscal laziness—when alternative, non-tax revenue sources become available. These findings contribute to the broader literature on the natural resource curse by identifying a specific mechanism through which resource windfalls may weaken subnational revenue mobilization.

The subsequent columns analyze the impact of royalty transfers on specific categories of local tax revenues—namely, gasoline, business, and property taxes—which together constitute the primary sources of municipal tax income. The results reveal a negative and statistically significant relationship between royalties and business tax revenues: each additional peso in royalties is associated with a 50-cent reduction in business tax collections. While the coefficients for property and gasoline taxes are also negative, the effect on property taxes is not statistically significant. In the case of gasoline taxes, the estimated coefficient is economically modest and achieves statistical significance only at the 10 percent level.

Our baseline estimation reveals a strong substitution between royalties and local tax revenues. This headline result, however, masks heterogeneities, which we explore in the following subsection.

4.2 Heterogeneous effects

The average negative effect could be driven by losers failing to react, winners reducing their effort, or both. To disentangle these underlying mechanisms, we conduct a heterogeneous effects analysis.

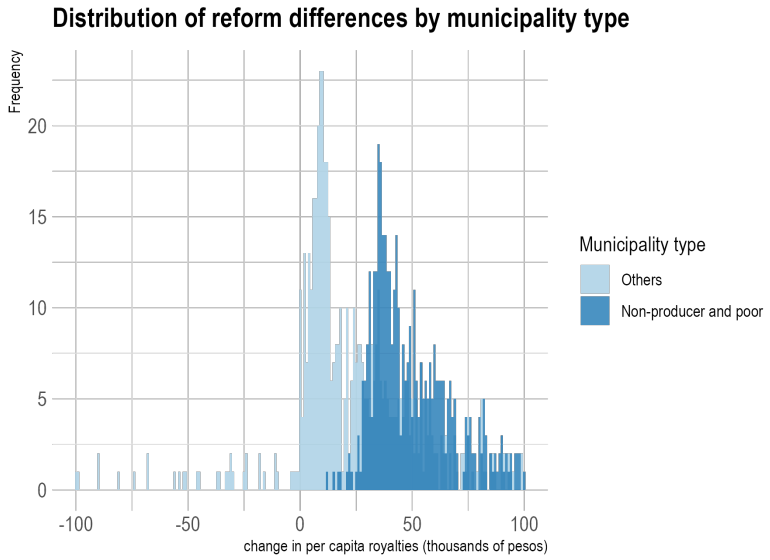
Non-producers with high UBN

Up to this point, our estimates have implicitly assumed that the effects of the reform are symmetric across municipalities. To investigate whether the response of local tax revenues to the reform varies depending on whether a municipality was expected to gain or lose from the redistribution of royalties, we extend the baseline model by including an interaction term. Specifically, we interact royalty transfers with a binary indicator equal to one for municipalities classified as non-producers with high levels of unmet basic needs.

The 2012 reform of the royalty distribution system aimed to allocate resources more equitably across the country by reducing transfers to resource-producing regions and increasing allocations to non-producing and economically disadvantaged municipalities. To identify the municipalities most likely to benefit from this policy shift, we flag those without any oil, gas, or coal production prior to the reform and exhibiting high levels of poverty, that is, if their UBN[9] index exceeded the 35% threshold commonly used in the SGR allocation criteria.

[9]The UBN index represents the percentage of the population living in conditions of Unmet Basic Needs.

Figure 4: Per capita royalty change – non-producing municipalities with high UBN.



Notes: This figure shows the kernel density distribution of the difference between average theoretical per capita royalties in the post-reform period (2012–2017) and the pre-reform period (2005–2011). Each observation represents one municipality (N=1,095). Dark blue: Non-producing municipalities with high Unmet Basic Needs (UBN $>$ 35%, N=463 municipalities), considered the main "winners". Light blue: All other municipalities (N=632 municipalities).

Figure 4 presents the distribution of the average change in theoretical per capita royalty allocations, comparing the period after the reform with the baseline before the reform across municipalities. Most municipalities experienced an increase in royalty transfers (concentration to the right), particularly those that were both economically disadvantaged and lacked fossil production.

The results of estimating Equation 4 with this particular interaction are reported in Table 3. The coefficients on *"Royalties per cap.*$_{m,t}$*"* in the first row of the table should be interpreted as the effect of royalties on tax revenues for producer municipalities with low unmet basic needs. These municipalities are expected to benefit the least from the new distribution rule. For simplicity, we will refer to them as the "losers".

Table 3: Interaction with Municipalities that are Non-Producers and have High UBN

	Total Tax	Property Tax	Business Tax	Gasoline Tax
	(1)	(2)	(3)	(4)
Royalties per cap.$_{m,t}$	-0.781***	0.020	-0.494***	-0.015*
	(0.188)	(0.023)	(0.115)	(0.007)
Royalties per cap.$_{m,t}$ × Non-producer High UBN$_m$	-0.270	-0.194***	-0.051	-0.001
	(0.239)	(0.029)	(0.146)	(0.009)
Joint marginal effect ($\beta_1 + \beta_3$)	-1.051***	-0.175***	-0.545***	-0.017*
	(0.236)	(0.029)	(0.144)	(0.009)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Num. Obs.	14207	14207	14207	14146
F-statistic	17.09	17.09	17.09	17.09

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

Notes: This table presents Two-Stage Least Squares (2SLS) regression results estimating the effect of per capita royalties on various municipal tax revenues per capita, including an interaction term. The dependent variables are specified in the column headers: Total Tax, Property Tax, Business Tax, and Gasoline Tax. The endogenous variables are Royalties per capita ($Royalties_{m,t}$) and its interaction with the Non-producer High UBN dummy ($Royalties_{m,t}$ × Non-producer High UBN$_m$). A "Non-producer High UBN" is defined as a municipality that was not a producer of oil, gas, or coal prior to the reform and had an Unmet Basic Needs index (UBN) greater than 35% in the pre-reform period (463 municipalities). Both endogenous variables are instrumented using Theoretical Royalties per capita ($Theoretical\ Royalties_{m,t}$) and its interaction with the Non-producer High UBN dummy. Theoretical royalties are constructed based on the 2012 SGR reform allocation rules applied to pre-reform data (details in Appendix A.1). All regressions include Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). No additional control variables are included in these specifications. Standard errors, double-clustered by municipality and year, are reported in parentheses. The row "Joint marginal effect ($\beta_1+\beta_3$)" reports the combined effect of Royalties per capita for municipalities where the Non-producer High UBN dummy equals 1. The F-statistic reported is the first-stage F-statistic for the joint relevance of the instruments in predicting the endogenous variables. A value above 10 is a common rule of thumb for strong instruments. All variables are measured in thousands of constant 2018 Colombian pesos (COP). The analysis period is 2005-2017. Data sources include DNP, ANH, ANM, and SICODIS. Sample exclusions are detailed in the notes for Table 1. Significance levels are defined below the table.

The coefficient for total tax revenues reported in Table 3 is negative and statistically significant. This suggests that when municipalities experience a reduction in royalty transfers, they respond by increasing local tax collection efforts in an attempt to offset the resulting fiscal shortfall. The estimated coefficient of 0.78 indicates that for every peso lost in royalties, municipalities recover approximately 78 cents through increased tax revenues. This finding points to an incomplete fiscal adjustment and underscores the limitations of subnational revenue mobilization in the face of external fiscal shocks.

For property taxes, the effect on loser municipalities is statistically insignificant. For business taxes, one peso less in royalties in loser municipalities increases respective revenues by 49 cents. The effect on gasoline taxes is also negative and significant but only at the 10 percent level. The coefficient is small, suggesting one cent of extra tax revenues per peso lost in royalties. This is consistent with the fact that gasoline taxes constitute a small proportion of local tax revenues in Colombia.

Turning to the municipalities that benefited from the more equitable redistribution of royalties—the so-called "winners," primarily non-producing and poorer jurisdictions—the impact of these transfers on tax revenues is captured by the *Joint Marginal Effect* reported in the third row. This effect is calculated as the sum of the coefficients in the first two rows of Table 3.

The resulting estimates are negative and statistically significant across all specifications, indicating that total tax revenues—as well as revenues from each individual tax category—decline when municipalities receive windfall transfers from royalties. These findings suggest that increased reliance on external revenue sources may reduce local fiscal effort, reinforcing the substitution effect between royalties and local taxation.

The estimated effect on total local tax revenues suggests a near one-to-one substitution: each additional peso received in royalties corresponds to an equivalent reduction in total tax collections, indicating a complete crowding-out effect. Disaggregating this impact by tax category, the *Joint Marginal Effects* reveal that an additional peso in royalties is associated with a 54-cent decline in business tax revenues, a 17-cent decline in property tax revenues, and a much smaller reduction in gasoline tax revenues—approximately one-tenth the size of the property tax effect.

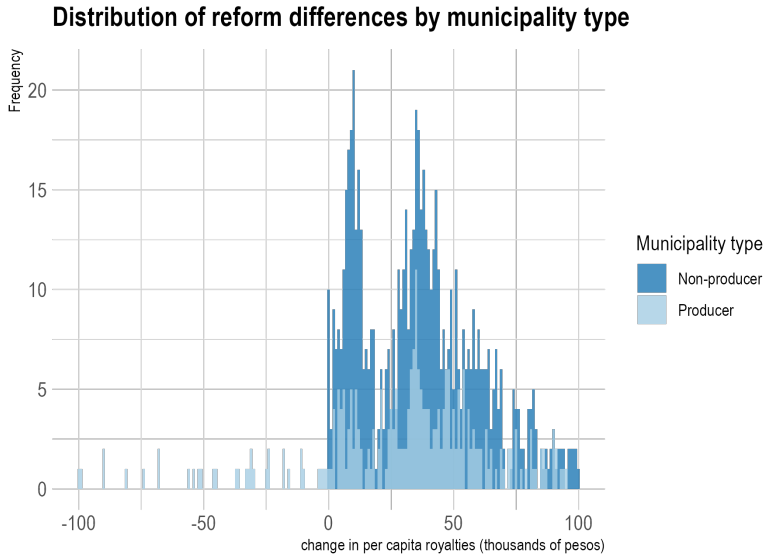
Fossil fuel producers

We next explore additional sources of heterogeneity by examining how the effects of the reform differ based solely on a municipality's status as a fossil fuel producer, independent of its level of socioeconomic development.

Figure 5 displays the theoretical distribution of the average change in per capita royalty allocations—calculated as the difference between post-reform (2012–2017) and pre-reform (2005–2011) averages—separately for producing and non-producing municipalities. As anticipated, the distribution for non-producing municipalities is shifted to the right relative

to that of producers, indicating that non-producers generally are expected to benefit more from the reform. In contrast, many producing municipalities experienced either a decline in royalty transfers or smaller gains compared to their non-producing counterparts.

Figure 5: Per capita royalty change – non-producing and producing municipalities.



Notes: This figure shows the kernel density distribution of the difference between average theoretical per capita royalties in the post-reform period (2012-2017) and the pre-reform period (2005-2011). Each observation represents one municipality (N=1,095). Dark blue: All non-producing municipalities (N=746 municipalities). Light blue: All producing municipalities (oil, gas, or coal) (N=349 municipalities).

Table 4 presents the estimation results. Consistent with earlier findings, the coefficient on Royalties per capita remains negative and statistically significant. This persistent negative relationship suggests that municipalities receiving fewer royalties—particularly those classified as producers under the post-reform allocation—respond by intensifying local tax collection efforts. However, this compensatory response is again only partial. The estimated coefficient of 0.75 implies that for every peso lost in royalties, municipalities recover approximately 75 cents through increased tax revenues, indicating an incomplete fiscal adjustment.

Table 4: Interaction with Non-Producer Municipalities

	Total Tax	Property Tax	Business Tax	Gasoline Tax
	(1)	(2)	(3)	(4)
Royalties per cap.$_{m,t}$	−0.747***	0.039	−0.488***	−0.017*
	(0.196)	(0.028)	(0.120)	(0.008)
Royalties per cap.$_{m,t}$ × Non Producer$_m$	−0.400	−0.264***	−0.074	0.009
	(0.309)	(0.044)	(0.189)	(0.012)
Joint marginal effect ($\beta_1 + \beta_3$)	−1.147***	−0.225***	−0.562***	−0.008
	(0.272)	(0.039)	(0.167)	(0.011)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Num. Obs.	14 207	14 207	14 207	14 146
F-statistic	17.09	17.09	17.09	17.09

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

Notes: This table presents 2SLS regression results estimating the effect of per capita royalties on various municipal tax revenues per capita, including an interaction term. The "Non-producer" dummy is equal to 1 for municipalities that were not producers of oil, gas, or coal prior to the reform (746 municipalities in the pre-reform period). Both endogenous variables are instrumented using Theoretical Royalties per capita (*Theoretical Royalties*$_{m,t}$) and its interaction with the Non-producer dummy. Theoretical royalties are constructed based on the 2012 SGR reform allocation rules applied to pre-reform data (details in Appendix A.1). All regressions include Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). No additional control variables are included in these specifications. Standard errors, double-clustered by municipality and year, are reported in parentheses. The row "Joint marginal effect ($\beta_1 + \beta_3$)" reports the combined effect of Royalties per capita for municipalities where the Non-producer dummy equals 1. The F-statistic reported is the first-stage F-statistic for the joint relevance of the instruments (Theoretical Royalties per capita and its interaction with the Non-producer dummy) in predicting the endogenous variables (Royalties per capita and its interaction with the Non-producer dummy). A value above 10 is a common rule of thumb for strong instruments. All variables are measured in thousands of constant 2018 Colombian pesos (COP). The analysis period is 2005-2017. Data sources include DNP, ANH, ANM, and SICODIS. Sample exclusions are detailed in the notes for Table 1. Significance levels are defined below the table.

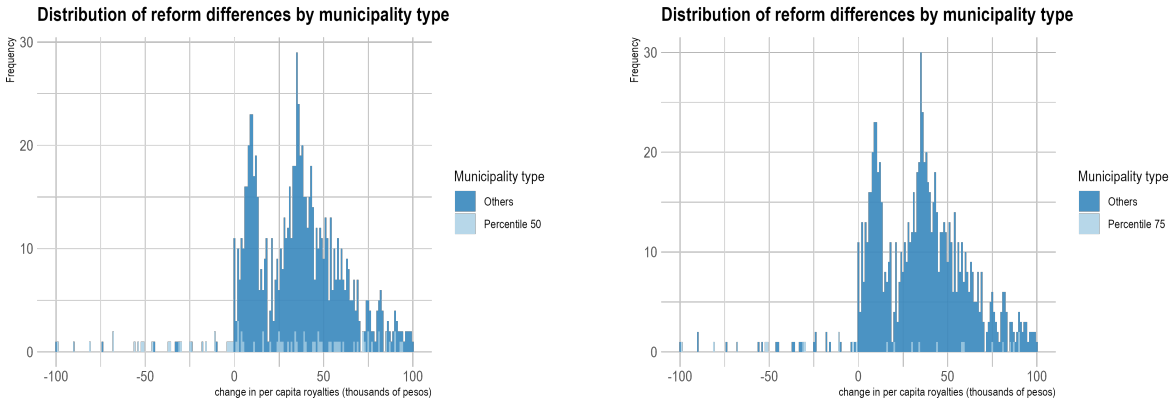
The *Joint Marginal Effect* should be interpreted as the impact of additional royalty transfers received by non-producing municipalities. The coefficients are negative and statistically significant for total, property, and business tax revenues. This pattern indicates that municipalities expecting increased royalty inflows—primarily non-producing jurisdictions—tend to reduce their local tax collection efforts, particularly in business and property taxes. Overall, the fiscal effect appears to be nearly neutral, as the decline in tax revenues largely offsets the increase in royalty transfers, resulting in a limited net change in total municipal resources.

Royalty settlements

The previous analysis identified producing municipalities without accounting for the extent of their contribution to national royalty revenues. We now refine our heterogeneous model by focusing on municipalities that, prior to the 2012 reform, contributed the largest

shares to total royalty collections. These municipalities were particularly vulnerable to substantial revenue losses following the reform, as the new distribution mechanism reallocated royalties more broadly across regions. By isolating this subset, we aim to assess whether the magnitude of pre-reform contributions influenced the fiscal response to the redistribution of royalties.

Figure 6: Difference in theoretical royalties – top producer municipalities.



Panel A: 50th percentile producers.

Panel B: 75th percentile producers.

Notes: These panels show the kernel density distribution of the difference between average theoretical per capita royalties in the post-reform period (2012-2017) and the pre-reform period (2005-2011). Each observation represents one municipality (N=1,095). Panel A: Light blue = Producer municipalities at or above the 50th percentile of pre-reform royalty settlements (N=160 municipalities). Dark blue = All other municipalities (N=935 municipalities). Panel B: Light blue = Producer municipalities at or above the 75th percentile (N=80 municipalities). Dark blue = All other municipalities (N=1015 municipalities).

To capture the differential impact of the reform across municipalities with varying levels of pre-reform royalty contributions, we rank municipalities according to their per capita royalty settlements—that is, the amount each contributed to total national royalty revenues prior to the reform. Figure 6 illustrates the distribution of theoretical changes in per capita royalty allocations. Panel A compares municipalities above and below the 50th percentile, while Panel B focuses on those above and below the 75th percentile in the pre-reform distribution. These percentiles are calculated using data from the 358 municipalities that generated royalties through the extraction of oil, gas, coal, gold, and silver—together accounting for approximately 98% of total royalties collected prior to the reform. It is important to note,

however, that not all high-contributing municipalities experienced a decline in royalty transfers. The post-reform distribution also depended on additional criteria, including poverty indices, population size, and other allocation factors.

Table 5: Interaction Effects on Total Tax Revenue – Non-Producer Percentiles

	Total Tax Revenue per capita	
	(1)	(2)
Royalties per cap.$_{m,t}$	-0.698^{**}	-0.668^{**}
	(0.244)	(0.253)
Royalties per cap.$_{m,t}$ × Non-Producer P50$_m$	-0.593	
	(0.578)	
Royalties per cap.$_{m,t}$ × Non-Producer P75$_m$		-0.599
		(0.469)
Joint marginal effect ($\beta_1 + \beta_3$)	-1.291^{***}	-1.267^{***}
	(0.456)	(0.338)
Municipality FE	Yes	Yes
Year FE	Yes	Yes
Num. Obs.	14 207	14 207
F-statistic	17.09	17.09

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

Notes: This table presents 2SLS regression results estimating the effect of per capita royalties on Total Tax Revenue per capita, including interaction terms based on pre-reform royalty contribution percentiles. The dependent variable is Total Tax Revenue per capita. In Column (1), the interaction is with the *Non-Producer P50* dummy, equal to 1 for municipalities whose average per capita royalty contribution in the pre-reform period (2009-2011) was *below* the 50th percentile of all royalty-generating municipalities (935 municipalities). In Column (2), the interaction is with the *Non-Producer P75* dummy, equal to 1 for municipalities whose pre-reform average per capita royalty contribution was *below* the 75th percentile (1,015 municipalities). Both endogenous variables in each respective column are instrumented using Theoretical Royalties per capita (*Theoretical Royalties*$_{m,t}$) and its interaction with the corresponding percentile dummy. Theoretical royalties are constructed based on the 2012 SGR reform allocation rules applied to pre-reform data (details in Appendix A.1). All regressions include Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). Standard errors, double-clustered by municipality and year, are reported in parentheses. All variables are measured in thousands of constant 2018 Colombian pesos (COP). The analysis period is 2005-2017. Data sources include DNP, ANH, ANM, and SICODIS. Sample exclusions are detailed in the notes for Table 1.

The coefficient on *"Royalties per cap.$_{m,t}$"* in Table 5 captures the effect for municipalities that contributed significantly to per capita royalty revenues prior to the reform and were therefore more likely to experience losses under the new distribution rules. The coefficients are negative and statistically significant in both the 50th and 75th percentile cases. Their magnitude—ranging between 0.67 and 0.70—suggests that while these municipalities increased local tax collection efforts in response to reduced transfers, the adjustment was

only partial. On net, total local revenues declined, indicating that the compensatory fiscal response was insufficient to fully offset the loss in royalty income. The result for each tax category are reported in the Appendix in Tables A.3 and A.4.

In this specification, the *Joint Marginal Effect* should be interpreted as the impact of increased royalty transfers on tax revenues for municipalities outside the group of large pre-reform royalty contributors. The estimated coefficients are again negative and, notably, exceed one in absolute value. This suggests a strong substitution effect, whereby additional royalty income is associated with a more than proportional decline in local tax revenues. Such a pattern is consistent with the hypothesis of reduced fiscal effort—or fiscal laziness—in response to windfall transfers.

Cadastral Updates

A notable result in the estimates presented in this section is that, among the "winning" municipalities in the interacted models, we systematically find that property tax revenues decline with the arrival of more royalties. What could explain this result?

Property tax revenues could fall for three reasons: a reduction in enforcement efforts by local authorities; a reduction in tax rates, which municipalities can adjust within thresholds set by national law (but there is no data, as we explained before on local tax rates over time); or a reduction in cadastral values, which form the basis for estimating property tax liabilities. On this last point, it is the national government, through one of its agencies (IGAC), that periodically updates the cadastral values used by municipalities to calculate property taxes. As explained by Martínez (2023), these updates are staggered over time and should occur every fifth year, meaning not all municipalities receive them simultaneously. The timing of cadastral updates is largely determined by IGAC, based on technical criteria and resource availability. Only 6% of cadastres are updated on time (i.e., in their fifth year). Importantly, Martínez (2023) shows that the timing of updates does not systematically correlate with

observable municipal characteristics, property value trends, or political cycles.

Cadastral updates can significantly influence the assessed property values that municipalities utilize to calculate property tax obligations. Given that in most cases there is a significant lag between market prices and the cadastral values recorded by municipalities, the expected effect of a cadastral update is an increase in the tax base for most properties.

In this subsection, we re-estimate all previously reported models, now adding a dummy variable equal to 1 in the year a municipality underwent a cadastral update.[10] The results of these re-estimations are reported in the tables 6 to 9. Two findings stand out. First, the cadastral update dummy has a positive and statistically significant coefficient for property tax revenues across all specifications. The coefficient is approximately 4, implying an increase in revenues of about 11% percent relative to the pre-reform mean of that variable.

The second finding is that none of the previously estimated effects or magnitudes are altered after including the cadastral update control in the regressions. This reinforces the hypothesis that the mechanisms driving the observed adjustments are related to local tax collection efforts in response to changes in royalty income. Moreover, increasing property tax revenue is likely less flexible than reducing it, as raising property tax rates often requires cadastral updates.

[10]Following Martínez (2023), we construct a dummy variable that takes the value 1 in the first year when an urban update becomes effective in the municipality, and remains 0 thereafter. While Martínez's original dataset spans 2006–2010, we extended the coverage using administrative data from IGAC to match the full period of our panel.

Table 6: Effect of Royalties on Local Tax Revenue

	Total Tax		Property Tax		Business Tax		Gasoline Tax	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Royalties per cap.$_{m,t}$	0.073***	−0.825***	−0.001	−0.012	0.042***	−0.503***	0.000	−0.015*
	(0.003)	(0.178)	(0.001)	(0.019)	(0.002)	(0.108)	(0.000)	(0.007)
Cadastral Update$_{m,t}$	0.318	−10.597	3.276**	3.144**	0.497	−6.125	−0.095	−0.290
	(3.806)	(10.963)	(1.123)	(1.153)	(2.288)	(6.643)	(0.392)	(0.436)
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Num. Obs.	14 207	14 207	14 207	14 207	14 207	14 207	14 146	14 146
Municipalities	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095
F-statistic		17.09		17.09		17.09		17.09
Mean Dep. Var.	165.728	165.728	46.649	46.649	43.617	43.617	20.898	20.898

*p<0.1; **p<0.05; ***p<0.01

Notes: This table presents results from OLS and Two-Stage Least Squares (2SLS) regressions estimating the effect of per capita royalties on various municipal tax revenues per capita. The dependent variables are specified in the column headers: Total Tax, Property Tax, Business Tax, and Gasoline Tax. The key independent variable of interest is Royalties per capita ($Royalties_{m,t}$), representing the actual royalty revenues received by municipality m in year t. Columns (1), (3), (5), and (7) report OLS estimates. Columns (2), (4), (6), and (8) report 2SLS estimates where Royalties per capita is instrumented using the Theoretical Royalties per capita ($Theoretical\ Royalties_{m,t}$), constructed based on the 2012 SGR reform allocation rules applied to pre-reform data (details in Appendix A.1). All regressions include Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t), as well as an exogenous control for Cadastral Update ($Cadastral\ Update_{m,t}$). Cadastral Update is a dummy variable equal to 1 in the year of an urban cadastral update for municipality m and 0 otherwise (following Martínez (2023) and extended to cover the sample period). Standard errors, double-clustered by municipality and year, are reported in parentheses. All variables are measured in thousands of constant 2018 Colombian pesos (COP). The analysis period is 2005-2017. Data sources include DNP, ANH, ANM, SICODIS, and IGAC (for cadastral updates). Sample exclusions are detailed in the notes for Table 1. The F-statistic reported for the IV columns is the first-stage F-statistic for instrument relevance. A value above 10 is a common rule of thumb for strong instruments. Significance levels are defined below the table.

Table 7: Interaction with Municipalities that are Non-Producers and have High UBN

	Total Tax	Property Tax	Business Tax	Gasoline Tax
	(1)	(2)	(3)	(4)
Royalties per cap.$_{m,t}$	−0.781***	0.020	−0.494***	−0.015*
	(0.189)	(0.023)	(0.115)	(0.007)
Cadastral Update$_{m,t}$	−9.003	4.304**	−5.825	−0.282
	(10.995)	(1.355)	(6.708)	(0.442)
Royalties per cap.$_{m,t}$ × Non-Producer High UBN$_m$	−0.268	−0.195***	−0.050	−0.001
	(0.239)	(0.029)	(0.146)	(0.009)
Joint marginal effect ($\beta_1 + \beta_3$)	−1.050***	−0.175***	−0.545***	−0.016*
	(0.236)	(0.029)	(0.144)	(0.009)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Num. Obs.	14 207	14 207	14 207	14 146
F-statistic	17.08	17.08	17.08	17.08

*p<0.1; **p<0.05; ***p<0.01

Notes: This table presents Two-Stage Least Squares (2SLS) regression results estimating the effect of per capita royalties on various municipal tax revenues per capita, including an interaction term and a control for cadastral updates. The dependent variables are specified in the column headers: Total Tax, Property Tax, Business Tax, and Gasoline Tax. The endogenous variables are Royalties per capita ($Royalties_{m,t}$) and its interaction with the Non-producer High UBN dummy ($Royalties_{m,t} \times$ Non-producer High UBN$_m$). A "Non-producer High UBN" dummy is equal to 1 for municipalities that were not producers of oil, gas, or coal prior to the reform and had an Unmet Basic Needs index (UBN) greater than 35% in the pre-reform period (463 municipalities). Both endogenous variables are instrumented using Theoretical Royalties per capita ($Theoretical\ Royalties_{m,t}$) and its interaction with the Non-producer High UBN dummy. Theoretical royalties are constructed based on the 2012 SGR reform allocation rules applied to pre-reform data (details in Appendix A.1). All regressions include Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). Additional exogenous controls include the Non-producer High UBN dummy itself and the Cadastral Update dummy ($Cadastral\ Update_{m,t}$). Cadastral Update is a dummy variable equal to 1 in the year of an urban cadastral update for municipality m and 0 otherwise (following Martínez (2023) and extended to cover the sample period). Standard errors, double-clustered by municipality and year, are reported in parentheses. The row "Joint marginal effect ($\beta_1 + \beta_3$)" reports the combined effect of Royalties per capita for municipalities where the Non-producer High UBN dummy equals 1. The F-statistic reported is the first-stage F-statistic for the joint relevance of the instruments in predicting the endogenous variables. A value above 10 is a common rule of thumb for strong instruments. All variables are measured in thousands of constant 2018 Colombian pesos (COP). The analysis period is 2005-2017. Data sources include DNP, ANH, ANM, SICODIS, and IGAC (for cadastral updates). Sample exclusions are detailed in the notes for Table 1. Significance levels are defined below the table.

Table 8: Interaction with Non-Producer Municipalities

	Total Tax	Property Tax	Business Tax	Gasoline Tax
	(1)	(2)	(3)	(4)
Royalties per cap.$_{m,t}$	−0.748***	0.039	−0.488***	−0.017*
	(0.196)	(0.028)	(0.120)	(0.008)
Cadastral Update$_{m,t}$	−8.727	4.389**	−5.784	−0.334
	(10.896)	(1.547)	(6.684)	(0.446)
Royalties per cap.$_{m,t}$ × Non-Producer$_m$	−0.398	−0.265***	−0.073	0.010
	(0.309)	(0.044)	(0.190)	(0.012)
Joint marginal effect ($\beta_1 + \beta_3$)	−1.146***	−0.225***	−0.561***	−0.008
	(0.272)	(0.039)	(0.167)	(0.011)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Num. Obs.	14 207	14 207	14 207	14 146
F-statistic	17.07	17.07	17.07	17.07

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

Notes: This table presents Two-Stage Least Squares (2SLS) regression results estimating the effect of per capita royalties on various municipal tax revenues per capita, including an interaction term and a control for cadastral updates. The dependent variables are specified in the column headers: Total Tax, Property Tax, Business Tax, and Gasoline Tax. The endogenous variables are Royalties per capita ($Royalties_{m,t}$) and its interaction with the Non-producer dummy ($Royalties_{m,t} \times \text{Non-producer}_m$). The "Non-producer" dummy is equal to 1 for municipalities that were not producers of oil, gas, or coal prior to the reform (746 municipalities). Both endogenous variables are instrumented using Theoretical Royalties per capita ($Theoretical\ Royalties_{m,t}$) and its interaction with the Non-producer dummy. Theoretical royalties are constructed based on the 2012 SGR reform allocation rules applied to pre-reform data (details in Appendix A.1). All regressions include Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). Additional exogenous controls include the Non-producer dummy itself and the Cadastral Update dummy ($Cadastral\ Update_{m,t}$). Cadastral Update is a dummy variable equal to 1 in the year of an urban cadastral update for municipality m and 0 otherwise (following Martínez (2023) and extended to cover the sample period). Standard errors, double-clustered by municipality and year, are reported in parentheses. The row "Joint marginal effect ($\beta_1 + \beta_3$)" reports the combined effect of Royalties per capita for municipalities where the Non-producer dummy equals 1. The F-statistic reported is the first-stage F-statistic for the joint relevance of the instruments (Theoretical Royalties per capita and its interaction with the Non-producer dummy) in predicting the endogenous variables (Royalties per capita and its interaction with the Non-producer dummy). A value above 10 is a common rule of thumb for strong instruments. All variables are measured in thousands of constant 2018 Colombian pesos (COP). The analysis period is 2005-2017. Data sources include DNP, ANH, ANM, SICODIS, and IGAC (for cadastral updates). Sample exclusions are detailed in the notes for Table 1. Significance levels are defined below the table.

Table 9: Interaction Effects – Non-Producer Percentiles with Cadastral Update

	Total Tax Revenue per capita	
	(1)	(2)
Royalties per cap.$_{m,t}$	-0.698^{**}	-0.669^{**}
	(0.244)	(0.253)
Cadastral Update$_{m,t}$	-9.166	-7.281
	(11.628)	(11.914)
Royalties per cap.$_{m,t}$ × Non-Producer P50$_m$	-0.591	
	(0.579)	
Royalties per cap.$_{m,t}$ × Non-Producer P75$_m$		-0.596
		(0.470)
Joint marginal effect ($\beta_1 + \beta_3$)	-1.289^{***}	-1.265^{***}
	(0.456)	(0.339)
Municipality FE	Yes	Yes
Year FE	Yes	Yes
Num. Obs.	14 207	14 207
F-statistic	17.73	17.73

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

Notes: This table presents Two-Stage Least Squares (2SLS) regression results estimating the effect of per capita royalties on Total Tax Revenue per capita, including interaction terms based on pre-reform royalty contribution percentiles and a control for cadastral updates. The dependent variable is Total Tax Revenue per capita. The endogenous variables are Royalties per capita ($Royalties_{m,t}$) and its interactions with the respective percentile dummies ($Royalties_{m,t} \times$ Non-Producer P50$_m$ in Col. 1 and $Royalties_{m,t} \times$ Non-Producer P75$_m$ in Col. 2). In Column (1), the interaction is with the *Non-Producer P50* dummy, equal to 1 for municipalities whose average per capita royalty contribution in the pre-reform period (2009-2011) was *below* the 50th percentile of all royalty-generating municipalities (935 municipalities). In Column (2), the interaction is with the *Non-Producer P75* dummy, equal to 1 for municipalities whose pre-reform average per capita royalty contribution was *below* the 75th percentile (1,015 municipalities). Both endogenous variables in each respective column are instrumented using Theoretical Royalties per capita ($Theoretical\ Royalties_{m,t}$) and its interaction with the corresponding percentile dummy. Theoretical royalties are constructed based on the 2012 SGR reform allocation rules applied to pre-reform data (details in Appendix A.1). All regressions include Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). Additional exogenous controls include the respective percentile dummy itself and the Cadastral Update dummy ($Cadastral\ Update_{m,t}$). Cadastral Update is a dummy variable equal to 1 in the year of an urban cadastral update for municipality m and 0 otherwise (following Martínez (2023) and extended to cover the sample period). Standard errors, double-clustered by municipality and year, are reported in parentheses. The row "Joint marginal effect ($\beta_1 + \beta_3$)" reports the combined effect of Royalties per capita for municipalities where the respective Non-Producer percentile dummy equals 1. The F-statistic reported is the first-stage F-statistic for the joint relevance of the instruments in predicting the endogenous variables. A value above 10 is a common rule of thumb for strong instruments. All variables are measured in thousands of constant 2018 Colombian pesos (COP). The analysis period is 2005-2017. Data sources include DNP, ANH, ANM, SICODIS, and IGAC (for cadastral updates). Sample exclusions are detailed in the notes for Table 1. Significance levels are defined below the table. The result for each tax category are reported in the Appendix in Tables A.7 and A.8.

5 Conclusion

How do resource windfalls—specifically in the form of mining royalties—affect the fiscal behavior of local governments? Conversely, how do local governments respond when they lose access to such transfers? Estimating this causal relationship is empirically challenging due to concerns about endogeneity and omitted variable bias. To address these challenges, we exploit a quasi-experimental setting provided by Colombia's 2012 royalty reform and implement an instrumental variable strategy based on the reform's predetermined allocation rules. This approach enables us to isolate exogenous variation in royalty revenues and rigorously assess their impact on municipal tax collection. In doing so, we contribute novel empirical evidence to the literature on the natural resource curse and its subnational fiscal underpinnings.

We find that changes in royalty revenues have consistent and statistically significant effects on local tax collection. In a simplified specification—where municipalities gaining and losing access to royalty transfers are assumed to respond symmetrically—our estimates indicate that total local tax revenues decline by approximately 0.82 pesos for every additional peso received in per capita royalties. Changes in business tax revenues primarily drive this substitution effect.

This effect is not uniform across municipalities. Non-producing municipalities with high levels of unmet basic needs—those expected to receive substantial royalty windfalls under the reform—exhibit the most pronounced substitution effect, nearly replacing local tax revenues with royalty transfers on a one-to-one basis. In contrast, municipalities that were both resource-producing and relatively affluent—and thus more likely to experience reductions in royalty allocations—responded by intensifying their local tax collection efforts. However, these efforts proved only partially effective, ultimately resulting in a net decline in total municipal revenues. This heterogeneity underscores the importance of considering baseline fiscal dependence and institutional capacity when evaluating the local impacts of transfers.

These findings offer important policy lessons for resource-rich countries considering revenue decentralization or royalty distribution reforms. While reforms like Colombia's 2012 SGR are intended to spread resource wealth more broadly, our results underscore the potential for unintended consequences. The observed fiscal laziness in municipalities benefiting from royalties, suggests that transferring resource rents may not automatically enhance local public service provision. Instead, such transfers may weaken local fiscal accountability and create a dependence trap, hindering the development of robust and self-sustaining local revenue systems. Policies aimed at decentralizing resource revenue should, therefore, be carefully designed to mitigate these disincentive effects, potentially through mechanisms that link royalty transfers to local fiscal efforts or strengthen local institutional capacity for revenue mobilization.

Our findings have implications for the fiscal adjustments necessary for the energy transition. As global demand for fossil fuels declines, royalty-based transfers to subnational governments are expected to contract. The fiscal substitution we document suggests that vulnerable regions may be unprepared for this revenue shock. Policies that strengthen local tax effort are therefore a necessary component of subnational adaptation to a low-carbon economy.

Several avenues for future research emerge from these findings. Further investigation into the specific mechanisms behind weakening fiscal effort is needed. For example, exploring the roles of political incentives, bureaucratic capacity, and citizen engagement in mediating the relationship between royalties and local tax efforts would provide valuable insights. Additionally, analyzing the long-term dynamic effects of royalty shocks on municipal fiscal capacity and economic development can further illuminate the nature of the regional resource curse. Finally, comparative studies across countries and resource revenue regimes could enhance the generalization of our findings and inform best practices for managing resource wealth at the subnational level.

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6 Appendix

Supplementary Tables

Table A.1: First Stage: Effect of Theoretical Royalties on Effective Royalties

	Royalties per capita
Theoretical Royalties$_{m,t}$	0.056***
	(0.010)
Municipality Fixed Effects	Yes
Year Fixed Effects	Yes
Num.Obs.	14,207
R^2	0.591
F-Statistic	17.10

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

Notes: This table presents the first stage results for the Two-Stage Least Squares (2SLS) baseline estimation. The dependent variable is Royalties per capita ($Royalties_{m,t}$), the actual royalty revenues received by municipality m in year t. The excluded instrument is Theoretical Royalties per capita ($Theoretical\ Royalties_{m,t}$), the predicted royalties based on the 2012 SGR allocation rules applied to pre-reform data (details in Appendix A.1). Regression includes Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). Standard errors, double-clustered by municipality and year, in parentheses. The F-statistic reported is the first-stage F-statistic for instrument relevance (>10 rule of thumb). All variables are in thousands of constant 2018 Colombian pesos (COP). Period: 2005-2017.

Table A.2: First Stage Results – Instrumental Variables (Non-Producers with High NBI)

	Royalties per capita
Theoretical Royalties$_{m,t}$	0.054***
	(0.010)
Theoretical Royalties$_{m,t}$ × Non-producer High UBN$_m$	0.114
	(0.095)
Joint marginal effect ($\beta_1 + \beta_3$)	0.168*
	(0.088)
Municipality Fixed Effects	Yes
Year Fixed Effects	Yes
Observations	14,207
R^2	0.591
F-Statistic	17.09***

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

Notes: his table presents the first stage results for the 2SLS estimation. Dependent variable: Royalties per capita ($Royalties_{m,t}$), actual royalty revenues. Instruments: Theoretical Royalties per capita ($Theoretical\ Royalties_{m,t}$) and its interaction with the Non-producer High UBN dummy ($Theoretical\ Royalties_{m,t}$ × Non-producer High UBN$_m$). Non-producer High UBN dummy = 1 for non-producers with UBN > 35% pre-reform (463 municipalities). Theoretical royalties details in App. A.1. Includes Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). Standard errors double-clustered by municipality/year (in parentheses). F-statistic tests joint instrument relevance (>10 rule of thumb). Units: thousands of constant 2018 Colombian pesos (COP). Period: 2005-2017. Data sources: DNP, ANH, ANM, SICODIS, IGAC. Exclusions: Table 1. Significance levels below table.

Table A.3: Interaction with Municipalities in the 50th Percentile of Non-Producers

	Total Tax	Property Tax	Business Tax	Gasoline Tax
Royalties per cap.$_{m,t}$	-0.698^{**}	0.080	-0.479^{***}	-0.019^{*}
	(0.244)	(0.052)	(0.142)	(0.009)
Royalties per cap.$_{m,t}$ × Non-Producer P50$_m$	−0.593	-0.431^{***}	−0.109	0.018
	(0.578)	(0.123)	(0.336)	(0.022)
Joint marginal effect ($\beta_1 + \beta_3$)	-1.291^{***}	-0.350^{***}	-0.588^{**}	−0.001
	(0.456)	(0.097)	(0.265)	(0.017)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Num. Obs.	14 207	14 207	14 207	14 146
F-statistic	17.09	17.09	17.09	17.09

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

Notes: This table presents Two-Stage Least Squares (2SLS) regression results for the effect of per capita royalties on municipal tax revenues (listed in headers), including an interaction based on pre-reform royalty contribution percentiles. Endogenous variables: Royalties per capita ($Royalties_{m,t}$) and Royalties per cap. × Non-Producer P50 dummy ($Royalties_{m,t} \times$ Non-Producer P50$_m$). Non-Producer P50 dummy = 1 for municipalities whose pre-reform royalty contribution was below the 50th percentile of royalty-generating municipalities (935 municipalities). Instruments: Theoretical Royalties per cap. ($Theoretical\ Royalties_{m,t}$) and its interaction with the Non-Producer P50 dummy (details in App. A.1). Exogenous control: Non-Producer P50 dummy. Includes Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). Standard errors double-clustered by municipality/year (in parentheses). Row "Joint marginal effect ($\beta_1 + \beta_3$)" is the effect for municipalities where the dummy = 1. First-stage F-stat tests joint instrument relevance (>10 rule of thumb). Units: thousands of constant 2018 Colombian pesos (COP). Period: 2005-2017. Significance levels below table.

Table A.4: Interaction with Municipalities in the 75th Percentile of Non-Producers

	Total Tax	Property Tax	Business Tax	Gasoline Tax
Royalties per cap.$_{m,t}$	-0.668^{**}	0.031	-0.517^{***}	-0.018^{*}
	(0.253)	(0.031)	(0.146)	(0.009)
Royalties per cap.$_{m,t}$ × Non-Producer P75$_m$	−0.599	-0.166^{**}	0.054	0.010
	(0.469)	(0.058)	(0.272)	(0.017)
Joint marginal effect ($\beta_1 + \beta_3$)	-1.267^{***}	-0.134^{***}	-0.463^{**}	−0.008
	(0.338)	(0.042)	(0.196)	(0.013)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Num. Obs.	14 207	14 207	14 207	14 146
F-statistic	17.73	17.73	17.73	17.73

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

Notes: This table presents Two-Stage Least Squares (2SLS) regression results for the effect of per capita royalties on municipal tax revenues, including an interaction based on pre-reform royalty contribution percentiles. Endogenous variables: Royalties per capita ($Royalties_{m,t}$) and Royalties per cap. × Non-Producer P75 dummy ($Royalties_{m,t} \times$ Non-Producer P75$_m$). Non-Producer P75 dummy = 1 for municipalities whose pre-reform royalty contribution was below the 75th percentile of royalty-generating municipalities (1,015 municipalities). Instruments: Theoretical Royalties per cap. ($Theoretical\ Royalties_{m,t}$) and its interaction with the Non-Producer P75 dummy (details in App. A.1). Exogenous control: Non-Producer P75 dummy. Includes Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). Standard errors double-clustered by municipality/year (in parentheses). Row "Joint marginal effect ($\beta_1 + \beta_3$)" is the effect for municipalities where the dummy = 1. First-stage F-stat tests joint instrument relevance (>10 rule of thumb). Units: thousands of constant 2018 Colombian pesos (COP). Period: 2005-2017. Exclusions: Table 1. Significance levels below table.

Table A.5: First Stage Results – Municipalities in the 50th Percentile of Non-Producers

	Royalties per capita
Theoretical Royalties$_{m,t}$	0.052***
	(0.011)
Theoretical Royalties$_{m,t}$ × Non-Producer P50$_m$	0.086*
	(0.049)
Joint marginal effect ($\beta_1 + \beta_3$)	0.138
	(0.120)
Municipality Fixed Effects	Yes
Year Fixed Effects	Yes
Observations	14,207
R^2	0.591
F-Statistic	17.09

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

Notes: This table presents the first stage results for the 2SLS estimation. Dependent variable: Royalties per capita (*Royalties*$_{m,t}$), actual royalty revenues. Instruments: Theoretical Royalties per capita (*Theoretical Royalties*$_{m,t}$) and its interaction with the Non-Producer P50 dummy (*Theoretical Royalties*$_{m,t}$ × Non-Producer P50$_m$). Non-Producer P50 dummy = 1 for municipalities whose pre-reform royalty contribution was below the 50th percentile of royalty-generating municipalities (935 municipalities). Theoretical royalties details in Appendix A.1. Includes Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). Standard errors double-clustered by municipality/year (in parentheses). F-statistic tests joint instrument relevance (>10 rule of thumb). Units: thousands of constant 2018 Colombian pesos (COP). Period: 2005-2017. Sample exclusions: Table 1. Significance levels below table.

Table A.6: First Stage Results – Municipalities in the 75th Percentile of Non-Producers

	Royalties per capita
Theoretical Royalties$_{m,t}$	0.177***
	(0.010)
Theoretical Royalties$_{m,t}$ × Non-Producer P75$_m$	−0.187***
	(0.038)
Joint marginal effect ($\beta_1 + \beta_3$)	−0.009
	(0.016)
Municipality Fixed Effects	Yes
Year Fixed Effects	Yes
Observations	14,205
R^2	0.600
F-Statistic	17.73

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

Notes: This table presents the first stage results for the 2SLS estimation. Dependent variable: Royalties per capita (*Royalties*$_{m,t}$), actual royalty revenues. Instruments: Theoretical Royalties per capita (*Theoretical Royalties*$_{m,t}$) and its interaction with the Non-Producer P75 dummy (*Theoretical Royalties*$_{m,t}$ × Non-Producer P75$_m$). Non-Producer P75 dummy = 1 for municipalities whose pre-reform royalty contribution was below the 75th percentile of royalty-generating municipalities (1,015 municipalities). Theoretical royalties details in App. A.1. Includes Municipality Fixed Effects (ϕ_m) and Year Fixed Effects (ϕ_t). Standard errors double-clustered by municipality/year (in parentheses). F-statistic tests joint instrument relevance (>10 rule of thumb). Units: thousands of constant 2018 Colombian pesos (COP). Period: 2005-2017. Sample exclusions: Table 1. Significance levels below table.

Table A.7: Interaction with Municipalities in the 50th Percentile of Non-Producers, including Cadastral Update

	Total Tax	Property Tax	Business Tax	Gasoline Tax
Royalties per cap.$_{m,t}$	-0.698^{**}	0.081	-0.479^{***}	-0.019^{*}
	(0.244)	(0.052)	(0.142)	(0.009)
Cadastral Update$_{m,t}$	−9.166	4.189^{+}	−5.863	−0.331
	(11.628)	(2.483)	(6.763)	(0.445)
Royalties per cap.$_{m,t}$ × Non-Producer P50$_m$	−0.591	-0.431^{***}	−0.108	0.018
	(0.579)	(0.124)	(0.337)	(0.022)
Joint marginal effect ($\beta_1 + \beta_3$)	-1.289^{***}	-0.351^{***}	-0.587^{**}	−0.001
	(0.456)	(0.097)	(0.265)	(0.017)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Num. Obs.	14 207	14 207	14 207	14 146
F-statistic	17.73	17.73	17.73	17.73

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

Notes: This table presents 2SLS regression results for the effect of per capita royalties on municipal tax revenues, including an interaction based on pre-reform royalty contribution percentiles and a control for cadastral updates. Endogenous variables: Royalties per capita ($Royalties_{m,t}$) and its interaction with the Non-Producer P50 dummy ($Royalties_{m,t}$ × Non-Producer P50$_m$). Non-Producer P50 dummy = 1 for municipalities whose pre-reform royalty contribution was below the 50th percentile of royalty-generating municipalities (935 municipalities). Instruments: Theoretical Royalties per cap. ($Theoretical\ Royalties_{m,t}$) and its interaction with the Non-Producer P50 dummy (details in App. A.1). Exogenous controls: Non-Producer P50 dummy and Cadastral Update dummy ($Cadastral\ Update_{m,t}$) = 1 in year of urban update (following Martínez (2023) and extended). Standard errors double-clustered by municipality/year (in parentheses). First-stage F-stat tests joint instrument relevance (>10 rule of thumb). Units: thousands of constant 2018 Colombian pesos (COP). Period: 2005-2017.

Table A.8: Interaction with Municipalities in the 75th Percentile of Non-Producers, including Cadastral Update

	Total Tax	Property Tax	Business Tax	Gasoline Tax
Royalties per cap.$_{m,t}$	-0.669^{**}	0.032	-0.517^{***}	-0.018^{*}
	(0.253)	(0.032)	(0.147)	(0.009)
Cadastral Update$_{m,t}$	−7.281	4.076^{**}	−6.441	−0.347
	(11.914)	(1.490)	(6.908)	(0.453)
Royalties per cap.$_{m,t}$ × Non-Producer P75$_m$	−0.596	-0.167^{**}	0.057	0.010
	(0.470)	(0.059)	(0.273)	(0.017)
Joint marginal effect ($\beta_1 + \beta_3$)	-1.265^{***}	-0.136^{***}	-0.461^{**}	−0.008
	(0.339)	(0.042)	(0.196)	(0.013)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Num. Obs.	14 207	14 207	14 207	14 146
F-statistic	17.73	17.73	17.73	17.73

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

Notes: This table presents 2SLS regression results for the effect of per capita royalties on municipal tax revenues, including an interaction based on pre-reform royalty contribution percentiles and a control for cadastral updates. Endogenous variables: Royalties per capita ($Royalties_{m,t}$) and its interaction with the Non-Producer P75 dummy ($Royalties_{m,t}$×Non-Producer P75$_m$). Non-Producer P75 dummy = 1 for municipalities whose pre-reform royalty contribution was below the 75th percentile of royalty-generating municipalities (1,015 municipalities). Instruments: Theoretical Royalties per cap. ($Theoretical\ Royalties_{m,t}$) and its interaction with the Non-Producer P75 dummy (details in Appendix A.1). Exogenous controls: Non-Producer P75 dummy and Cadastral Update dummy ($Cadastral\ Update_{m,t}$) = 1 in year of urban update (following Martínez (2023) and extended). Standard errors double-clustered by municipality/year (in parentheses). First-stage F-stat tests joint instrument relevance (>10 rule of thumb). Units: thousands of constant 2018 Colombian pesos (COP). Period: 2005-2017. Significance levels below table.

A.1 The Instrument: Theoretical Royalties

To develop an instrument that captures the exogenous variation in royalty distributions prompted by the 2012 reform, we calculated the theoretical royalty revenue that municipality m is expected to receive in year t ($Theoretical\ Royalties_{m,t}$). This theoretical value is calculated based solely on the rules and parameters set by the 2012 reform legislation. This calculation was conducted annually from 2005 to 2017, covering both the pre-reform and post-reform periods.

Specifically, the *Theoretical Royalties* are calculated as the sum of the allocations from all the funds that a municipality qualifies for according their characteristics[11], as set by the reform:

$$Theoretical\ Royalties_{m,t} = \sum_{f \in F_m} (Total\ Royalties_t * \%\ Fund_{f,t} * Distribution\ Factor_{m,f,t}) \tag{A.1}$$

Where $Total\ Royalties_t$ represents the total amount of royalties settled in year t; $\%\ Fund_{f,t}$ is the percentage of total royalties allocated to each fund f in year t [12]; $Distribution\ Factor_{m,f,t}$ denotes the percentage of each fund f that corresponds to each municipality m from in year t, which is based on pre-existing characteristics, and whose specific formula varies by fund according to the legal rules; and $f \in F_m$ indicates that the summation is performed over all funds for which the municipality is eligible (i.e., f belongs to the set of eligible funds for the municipality, denoted as F_m).

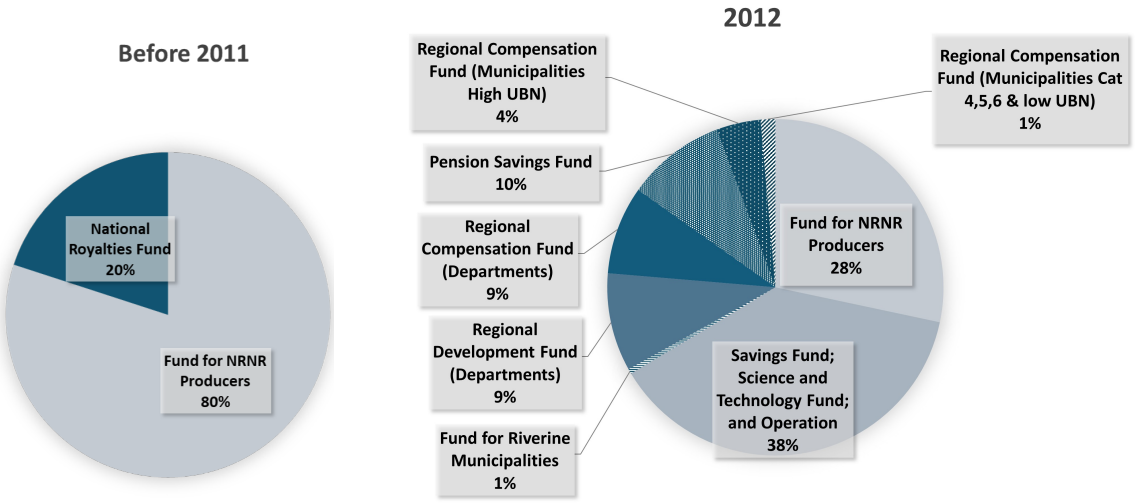
To understand how "$\%\ Fund_{f,t}$" were determined, the figure shows the distribution of royalties across different funds before and after the 2012 reform. Prior to 2012, as shown in

[11] Characteristics of the municipalities prior to the reform, such as whether they were producers or not, percentage of the population with unmet basic needs, and population.

[12] such as Direct Allocations Fund, the Regional Compensation Fund, or the Pension Savings Fund

the left pie chart, the royalty distribution system[13] primarily benefited producing entities. While the 2012 Reform reduced the share to the traditional fund for NRNR producers, and introduced new funds focused on development needs.

Figure A.1: Distribution of royalties by fund: percentage allocated to each fund before and after the Reform.



Notes: The left pie chart illustrates the two funds that existed before the SGR reform and the percentage of total royalties allocated to each. Both departments and municipalities were eligible to receive resources from these funds. The right pie chart shows the new funds created under the SGR starting in 2012, along with their respective shares of total royalty distribution. The light blue segment represents the fund specifically allocated to NRNR-producing entities. The segments with patterned fill indicate funds that municipalities can potentially access under the new system.

Under the previous system, about 80% of royalties were directly allocated to NRNR-producing areas, with 49% going to producing departments, 23% to producing municipalities, and 7% to port municipalities. The remaining 20% went to the National Royalties Fund (*Fondo Nacional de Regalías* – FNR), which financed projects across the country but lacked the broad, formula-based distribution that would later define the SGR.

Following the reform, several new funds were introduced as shown in Figure A.1. The most prominent was the Regional Compensation Fund (FCR), which allocated resources to municipalities based on poverty levels (measured by the UBN index) and administrative category. Other municipal-level benefits included the Pension Savings Fund, and the Fund for

[13]Laws 141 of 1994 and 756 of 2002.

Riverine Municipalities. Meanwhile, funds such as the Regional Development Fund (FDR), the Savings Fund, and the Science and Technology Fund were primarily aimed at departments or served administrative purposes. The shift was gradual from 2012 to 2015, with the law mandating a transition where the share for NRNR producers decreased annually, while the share for Regional Funds increased. Concurrently, the share allocated to municipalities rose from 23% to 37%. This meant that while departments maintained a similar proportion of royalties as before the reform[14], municipalities experienced a significant increase in their share.

The ($Distribution\ Factor_{m,f,t}$) quantifies the percentage of each fund f that corresponds to each municipality m from in year t. For the post-reform period ($t \geq 2012$), these factors were calculated using municipal characteristics observed *before* the reform, typically averaged over 2009-2011. This reliance on predetermined variables, such as population, UBN, production levels, pension liabilities, and geographic features, ensures the instrument's exogeneity.

For instance, in the case of the *Fund for Producing Municipalities*, the distribution factor is calculated based on the average share of each municipality in royalties liquidated between 2009 and 2011. In the *Regional Compensation Fund* (aimed at municipalities with a high rate of Unsatisfied Basic Needs - UBN), the distribution factor was determined according to the percentage of the population of each municipality in relation to the total population of all eligible municipalities in this group.

For the *Regional Compensation Fund* for municipalities in categories 4, 5, and 6 with low UBN, only those municipalities with a high poverty level (UBN greater than 35%) and classified in these categories are eligible. In this case, the distribution factor was determined using the equation A.2 that incorporates both the average municipal population (Pop) and

[14]The percentage of total royalties allocated to departments, encompassing contributions from funds like the Regional Development Fund (Departments), Regional Compensation Fund (Departments), Pension Savings Fund, and Regional Savings and Stabilization Fund, increased from 43.81% in 2012 to 55.10% in 2015.

poverty levels.

$$\textit{Distribution Factor}_{m,f=\text{FCR}(\text{UBN}_{\text{low}}),t} = \frac{\left(\frac{\text{Pop}_m}{\text{Pop}_{\text{total}}}\right)^{0.6} \cdot \left(\frac{\text{UBN}_m}{\text{UBN}_{\text{nal}}}\right)^{0.4}}{\sum_{m=1}^{n} \left(\frac{\text{Pop}_m}{\text{Pop}_{\text{total}}}\right)^{0.6} \cdot \left(\frac{\text{UBN}_m}{\text{UBN}_{\text{nal}}}\right)^{0.4}} \tag{A.2}$$

Similarly, the distribution factor for the *Pension Savings Fund* was also determined based on population and poverty indicators, but with a slight variation in the exponential weights assigned to each variable, as shown in the following equation:

$$\textit{Distribution Factor}_{m,f=\text{Savings},t} = \frac{\left(\frac{\text{Pop}_m}{\text{Pop}_{\text{total}}}\right)^{0.4} \cdot \left(\frac{\text{UBN}_m}{\text{UBN}_{\text{nal}}}\right)^{0.6}}{\sum_{m=1}^{n} \left(\frac{\text{Pop}_m}{\text{Pop}_{\text{total}}}\right)^{0.4} \cdot \left(\frac{\text{UBN}_m}{\text{UBN}_{\text{nal}}}\right)^{0.6}} \tag{A.3}$$

For the fund for riparian municipalities (of major rivers), the distribution factor was the municipality's share of the total river kilometers.

By constructing $\textit{Theoretical Royalties}_{m,t}$ using the share of each fund and the distribution factor based on pre-reform municipal characteristics, we create an instrument that isolates the variation in royalty receipts driven by the reform's design, independent of contemporaneous municipal economic conditions or tax efforts. This construction supports the exogeneity assumption required for the IV strategy.