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The Effectiveness of Natural Resources Funds: Evidence from Colombia[♣]

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Abstract

This study analyzes the impact of natural resource funds (NRF) on municipal fiscal results in Colombia, using an instrumental variable approach. It specifically analyzed the case of the Oil Savings and Stabilization Fund (FAEP). The results suggest that a 1 percent increase in royalty revenue caused a 0.2 percent increase in gross capital formation (GCF) expenses and that this effect was cancelled out by FAEP participation. We also find that neither resource revenue windfalls nor participation in the FAEP had any impact on operating expenses nor on tax revenues, and that resource revenues have had impact on capital expenses other than GCF, but FAEP participation did not. Although we find that FAEP was indeed effective in reining in GFC expenses, the results suggest that other factors, such as subnational fiscal rules, could have had a strong effect on operating and other investment spending. Countries should thus consider a range of instruments to promote fiscal discipline and smooth out spending, including regulation and NRFs, in the face of natural resource revenue windfalls.

Key words*:* natural resource funds, local public finances, instrumental variables
JEL Classification: Q32, H72, C36

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La Efectividad de los Fondos de Recursos Naturales: Evidencia para Colombia[♣]

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Resumen

Este estudio analiza el impacto de los fondos de recursos naturales (FRN) en los resultados fiscales municipales en Colombia utilizando un enfoque de variables instrumentales. En particular, se examinó el caso del Fondo de Ahorro y Estabilización Petrolera (FAEP) de Colombia. Los resultados sugieren que un aumento del 1 por ciento en los ingresos por regalías provocó un incremento del 0,2 por ciento en los gastos de formación bruta de capital (FBK), y que este efecto fue contrarrestado por la participación en el FAEP. También se encontró que ni los aumentos inesperados en los ingresos por recursos ni la participación en el FAEP tuvieron impacto en los gastos de funcionamiento ni en los ingresos tributarios. Aunque los ingresos por recursos sí afectaron los gastos de capital distintos a la FBK, la participación en el FAEP no lo hizo. Si bien se concluye que el FAEP fue efectivo para contener los gastos en FBK, los resultados sugieren que otros factores —como las reglas fiscales subnacionales— podrían haber tenido un efecto significativo en el gasto operativo y en otras inversiones. Por lo tanto, los países deberían considerar una variedad de instrumentos para fomentar la disciplina fiscal y estabilizar el gasto ante aumentos inesperados en los ingresos provenientes de recursos naturales, incluyendo la regulación y los FRN.

Palabras clave: fondos de recursos naturales, finanzas públicas locales, variables instrumentales
Clasificación JEL: Q32, H72, C36

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1. Introduction

Natural resource funds (NRFs), or natural resource sovereign wealth funds, are special-purpose investment funds that have become increasingly important fiscal and public asset management tools in resource dependent countries worldwide. They are generally used for fiscal and macroeconomic stabilization, as well as for savings and investment, with implications on public wealth, growth and development (Schwartz and Beuermann (2021)). Despite their prevalence among natural resource rich countries, identifying the treatment effect of NRFs on fiscal indicators has proven challenging due to self-selection and lack of appropriate comparison groups. In this study we overcome these challenges and analyze the effect of royalties and the smoothing out effect of the Colombian Savings and Price Stabilization Fund (we hereby use its Spanish acronym, FAEP) on municipal governments' public finances between 2000 and 2010.

Many studies have analyzed the factors that lead to the implementation of NRFs and their impact on fiscal or macroeconomic indicators. Most of these studies focus on national level NRFs, studying the effects of these funds in single countries (Crain and Devlin (2003); Davis et al. (2001), amongst others), or multiple countries that have each adopted NRFs with different characteristics (Sugawara (2014); Bagattini (2011)). In general, these studies use a predetermined definition of countries that are resource-dependent, resource-rich and/or resource exporting. Within those country groups, comparisons are generally made between countries with and without NRFs (Sugawara (2014); Crain and Devlin (2003)). Yet because NRFs work differently in every country, identifying the impact of these funds and interpreting lessons learned relevant to other countries is challenging. Also, as countries decide whether to have an NRF, self-selection can affect any attempt to identify a treatment effect. Therefore, the literature to date has very limited studies using a valid comparison group.

In Colombia, the FAEP was created to smooth out the effect of oil revenue volatility on national and subnational expenditures. Although it was applied to both departments and municipalities (as well as at the national level), this study focuses on municipalities only. Interestingly, not only oil producing municipalities were eligible for the FAEP, non-oil producing ones were also included. Specifically, those classified as ports through which oil

was exported. Moreover, not all oil producing municipalities were included in the FAEP, and municipalities that received revenue income from resources other than oil were also excluded from the FAEP. This created a natural experiment where some municipalities that received royalty revenue were included in FAEP, while other municipalities that also received royalty revenues were not.

In this study we use a municipality and year fixed effects approach to study the extent to which royalty revenue variation impacted fiscal results, and if so, whether the FAEP smoothed out such effects. Our approach overcomes the challenges experienced by previous studies in various ways. First, this study evaluates the impact of the FAEP on municipalities that had to follow the same NRF rules set by law. This allows for an identification of a definable treatment rather than analyzing different NRFs with varying saving rules. Second, by including municipalities with and without the FAEP that are relatively comparable, identification is based on the variation between treated and non-treated municipalities, not the variation within participant municipalities before and after their participation. Third, municipalities did not self-select into the FAEP, as this was a national law, which reduces the risk of selection bias. Selection bias might still be an issue considering that the FAEP was created after the Cusiana and Cupiagua (CC) discovery, and likely because of it. It is true that during the second half of 90s the amounts received by the subnational governments located in CC and the Caño Limón (CL) fields makes it hard to find a valid comparison group. However, by the 2000s the oil price boom made it profitable to exploit additional fields, so a number of non-FAEP subnational governments started receiving royalty revenues from oil producing on par to what FAEP governments were receiving, reducing the selection bias risk stemming from the CC and CL fields. In other words, there were not good reasons for several governments to not have FAEP throughout the 2000's just because they were not located in CC or CL or produced a resource different from oil.

We find that natural resource windfalls increased gross capital formation (GCF) expenditures, but this effect was offset if municipalities participated in the FAEP. We do not find an impact of natural resource windfalls or FAEP participation on operating expenditures or tax revenue. Finally, although capital expenditures other than GCF were positively affected by royalties' revenues, we found no effect of FAEP participation on this type of

capital expenditure. In sum, the FAEP was effective in weakening the relationship between royalty revenue and only one type of expenditure: GCF.

The paper is divided into 6 sections. Section 2 presents the literature review; Section 3 discusses the institutional setup of royalties and the FAEP in Colombia; Section 4 presents the data and methodology; Section 5 discusses the results, and Section 6 concludes.

2. Literature Review

Existing literature that analyzes the impact of NRFs focuses on indicators such as economic growth (Ouba, 2016), fiscal performance (Bagattini, 2011; Davis et al., 2001; Crain and Devlin, 2003; Sugawara, 2014; Koh, 2016; Villafuerte et al., 2008; Ayadi and Adegbite, 2018; Kudrin, 2006; and Bortolotti and Fotak, 2020), institutional quality (Tsani, 2013 and 2015), income per capita (Udo et al., 2024) and other macroeconomic outcomes (Shabsigh and Ilahi, 2007). A much smaller sample of studies have analyzed the effects of NRFs at the subnational level. In Nigeria, the subnational sovereign wealth fund showed a positive correlation with economic development (Udo et al., 2024). Specifically, some papers describe how the political and institutional structure determines the success of subnational NRFs (Rose, 2011), whereas other point out that NRFs' success depends on management and organizational choices of the fund. Most of these studies are descriptive and do not establish causation (Baena, Sevi, and Warrack (2012)).

Studies looking at the fiscal impact of NRFs find a range of results using quantitative and qualitative approaches, both in case studies and panel analyses. Using econometric approaches with panel data, Sugawara (2014) and Bagattini (2011) find that the presence of a NRF improves fiscal outcomes. Case studies by Crain and Devlin (2003) show the same effects in the cases of Chile and Norway but find that the effects are negative for a panel of oil-exporting countries. Moreover, Davis et al. (2001) and Villafuerte et al. (2008) find, through both econometric evidence and case studies, that NRFs do not have an identifiable impact on government spending. They do find that the nature of a more prudent government - which is more likely to set a fund - is the key element for its success.

In general, researchers use a predetermined definition of countries that are resource-dependent, resource-rich and/or resource exporting. They also differentiate between the treatment and control groups, based on the existence of a NRF, to construct such a

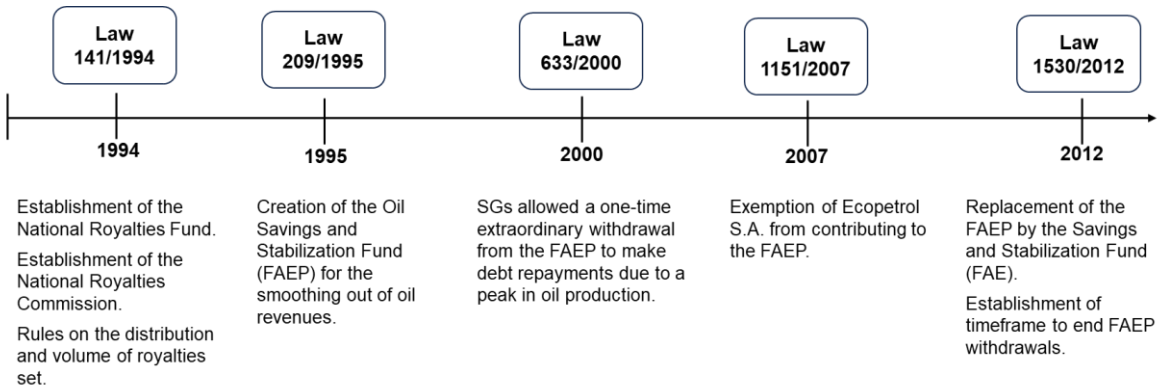
comparison group (Sugawara, 2014; Crain & Devlin, 2003). Contrastingly, others measure the impact of NRFs by examining fiscal indicators prior to and following the implementation of a stabilization fund in selected countries (Bortolotti & Fotak, 2020). Yet, analyzing the impacts of NRFs across countries can be challenging, particularly given that they are highly influenced by country-specific economic and political factors, making it hard to clearly define treatment and control groups when analyzing them.

In Colombia, although there is very limited evidence on the effectiveness of NRFs, there is a body of evidence on the effects of oil revenues on public spending. Bonet et al. (2020) exploited a royalties' reform in 2012 and found that higher international oil prices had mostly positive effects on public investment in oil producing departments and municipalities in Colombia. Higher investment seemed to be prioritized in sectors with high social returns (including education, health and water and sanitation). Bonet et al. (2014) find differing effects depending on the volume of oil revenues received by a municipality. Those receiving 20% of their revenues from oil showed a deterioration in fiscal indicators as dependency increased. Whilst those with 20% of their revenues or higher coming from oil showed improved fiscal outcomes, but a worsening level of investment.

3. Royalties and the Oil Savings and Stabilization Fund (FAEP)

Colombia's experience with stabilization funds dates to the 1940s, when the Coffee Price Stabilization Fund was created. Its main purpose was to mitigate the local economic externalities stemming from the volatility of the international price of coffee, one of the country's main export products at the time (Ocampo, 2015). Decades later, when Colombia experienced a significant increase of oil production due to new discoveries of oil, particularly those related to CC and CL fields, the country faced another boom of commodities. In response to this, Law 209 of 1995 created the FAEP. The objective was to establish a mechanism that would help stabilize oil revenue inflows by saving a portion of the income generated by the exploitation of oil. The fund was designed to also stabilize the revenues of the largest state-owned oil company (Ecopetrol) and certain territorial entities (Bottía, 2009). Several pieces of legislation were key for the creation and operation of the FAEP, outlined in Figure 1 and discussed below.

Figure 1. FAEP-relevant legislation timeline

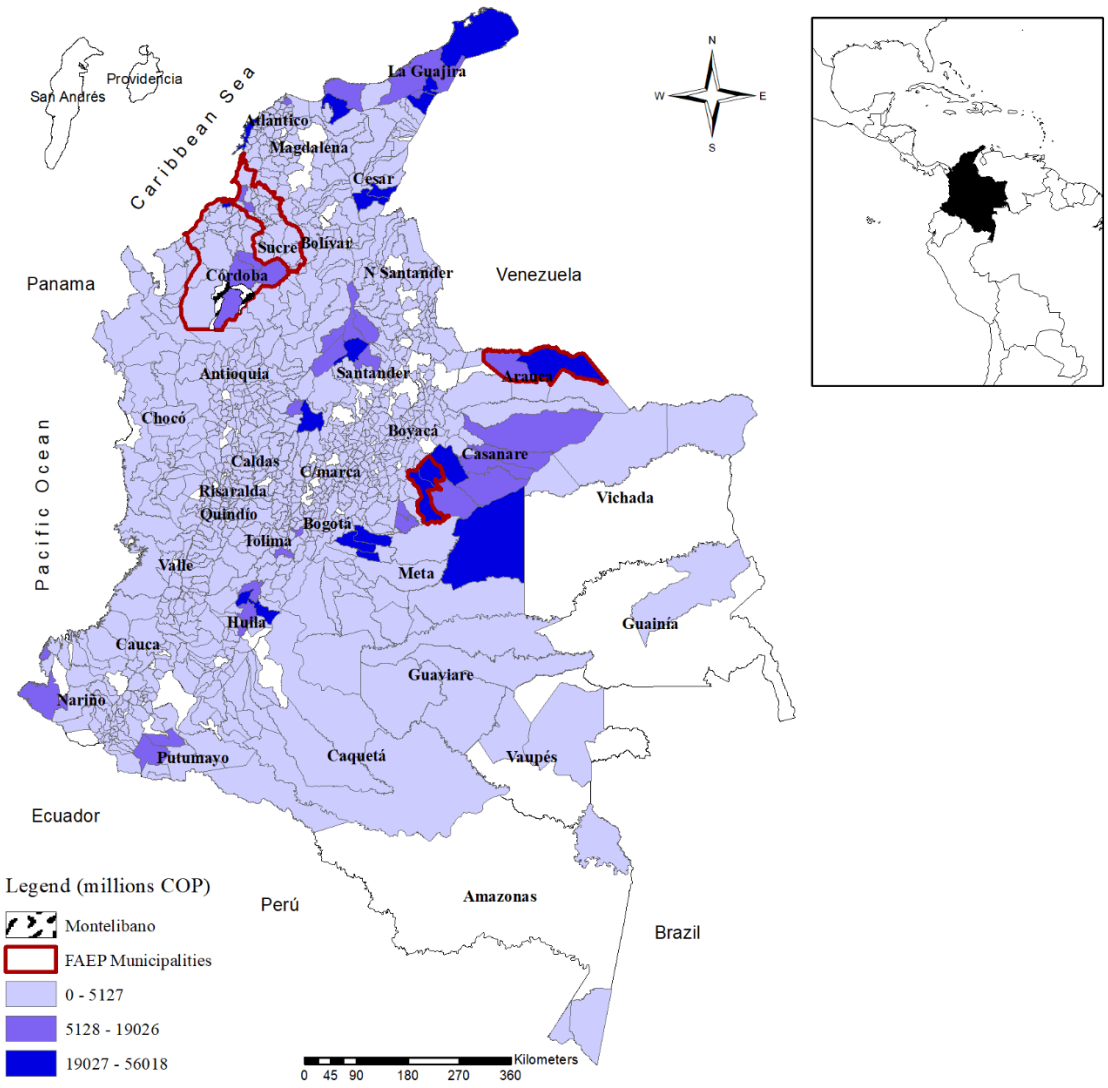


Source: Authors' elaboration based on the corresponding legislation.

As seen in Figure 1, in 1994 the Government issued Law 141 to regulate revenues from natural resources, including oil, gas, coal, silver, platinum, emeralds, and salt amongst others. Royalties from hydrocarbons (oil and natural gas) have historically been much higher than royalties received from other natural products. For example, in 2004, hydrocarbon royalties were COP$ 1,694.5 billion, while royalties from coal, the second in royalty participation value, were COP$ 167.2 billion (about 10% of the royalties from hydrocarbons).[1] Revenues for each natural resource had specific distribution rules and were transferred to municipalities based on specific criteria. Law 141 also established the distribution of direct royalties to producing and port municipalities through which minerals were transported. It also established indirect royalties, that were transferred to the rest of municipalities through the National Royalties Fund.[2] One peculiarity of this law is that it granted port status to most of the municipalities located in Caribbean departments of Sucre and Cordoba, being located in the area of influence of the port of Tolú-Coveñas (a municipality of the department of Sucre). In fact, most of the municipalities included in the FAEP were from these two departments. Many of these municipalities are not coastal (see the north-western municipalities of Córdoba and Sucre in Figure 2). Law 619 of 2000 modified the amount of royalties for the municipalities of Sucre and Cordoba set by Law 141 (see Box 1).

[1] Law 141 established that hydrocarbon royalties were distributed as follow: 47.5% for producing departments, 12.5% for producing municipalities, 8% for port municipalities and 32% for the National Royalties Fund.
[2] Law 141 also created the National Royalties Commission, with the aim of controlling and monitoring the correct use of resources from royalties and compensations related to the exploitation of non-renewable natural resources owned by the State. It also administered the resources of the National Royalties Fund.

Figure 2. Map of municipalities by the amount of royalties received



Note: Sucre and Córdoba have a thick line around the department border because all municipalities within these two departments were included in the FAEP. The only exception is Montelibano, which was excluded because it was a mining municipality.
Source: Author's calculations using data from DNP.

Royalties had to be used to finance investment projects. Specifically, direct royalties had to be invested in projects included in municipalities' development plans, and in specific sectors, namely education, health, water and sanitation and electricity. Whereas indirect royalties had to be used in investment projects related to mining, the environment, and priority sectors established in local development plans.

Box 1. Distribution of the Coveñas Port royalties*

Law 141 of 1994	Law 619 of 2000
Sucre municipalities (65%): ✓ Tolú-Coveñas: 35%. ✓ San Onofre: 2.5%. ✓ Special fund for Sucre's administrative authorities to distribute among the rest of its municipalities: 27.5%.	**Sucre municipalities (50%):** ✓ Tolú-Coveñas: 17.5%. ✓ Sucre's maritime port municipalities in Golfo de Morrosquillo: 3.0%. ✓ Remaining non-mining municipalities: 29.5%.**
Córdoba municipalities (35%): ✓ San Antero, San Bernardo, Moñitos, Puerto Escondido and Los Córdobas: 8.5% (1.75% each). ✓ Special fund from which the departments' administrative authorities would equally distribute the resources among the rest of the municipalities: 26.5%.	**Córdoba municipalities (50%)**: ✓ San Antero: 11.5%. ✓ Córdoba's maritime port municipalities in Golfo de Morrosquillo: 9.0%. ✓ Remaining non-mining municipalities: 27.5%. ✓ Transferred to "Corporación Autónoma de los Valles del Sinú and San Jorge", with the purpose of reforestation: 2.0%.

*All percentages are expressed as % of the royalty revenues received by the Coveñas port.
** The distribution of the 29.5% is determined by the following criteria: (1) 8.85% is equally distributed among all municipalities; (2) 11.8% is proportionally distributed according to the population; and (3) 8.85% is proportionally distributed according to poverty, in particular the number of inhabitants with Unmet Basic Needs (NBI by its acronym in Spanish).
Source: Author's elaboration.

To smooth out the royalties from oil, the FAEP was created in 1995 (Law 209 of 1995). It required Ecopetrol, the National Royalties Fund and municipalities that received direct oil-related royalties to save a portion of these revenues when they exceeded a certain threshold. This smoothed out the inflow of funds over time. The law determined different initial thresholds for producing departments, producing municipalities and port municipalities. At the time the law was issued, only a handful of municipalities in the departments of Arauca and Casanare were included, as well as all the municipalities classified as ports in the departments of Sucre and Córdoba by Law 141 of 1994.

The amount saved in the FAEP was calculated using the average surplus revenues from previous months, where surplus revenue was defined as the difference between accrued revenue and an amount determined by the law. If, in any given month, surplus revenue exceeded that average, the difference between the surplus revenue and the average surplus

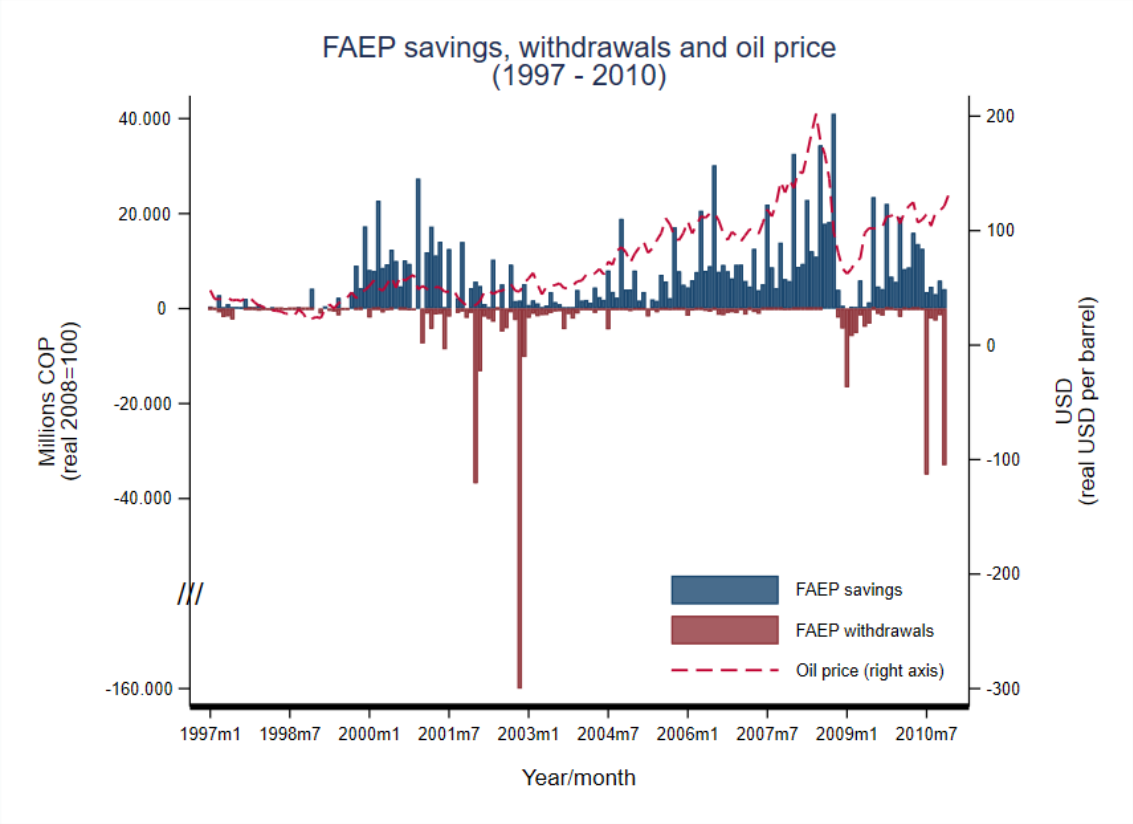
revenue would be allocated to the FAEP. Conversely, if surplus revenues fell below the average surplus revenue, municipalities were allowed to withdraw a portion of the resources. Finally, the maximum withdrawal permitted was 2.5% of the fund's balance (DNP, 1994). The Central Bank was responsible for managing the resources of the FAEP (Banco de la República, 2014; Law 209 of 1995), and it defined the fund's valuation method, considering the nature and type of securities in which the resources were invested. The Central Bank managed the FAEP until 2003. Starting in 2004, the National Hydrocarbon Agency, an office created to administer the hydrocarbon resources, took on the management of the fund.

Due to the rise in international oil prices, in 2000 there was a significant increase in oil revenues and an accumulation of resources in the FAEP. Municipalities were then permitted to make an extraordinary withdrawal of resources for repayments of public debt (Law 633 of 2000).[3] As Figure 3 shows, these extraordinary withdrawals were substantial relative to the stream of savings that had been accumulated until then. Law 781 of 2002 later established that municipalities were allowed to allocate the remaining balances of resources, after debt repayment, for investment projects identified by the respective municipality in their regional development plan.[4] In cases where these resources were insufficient, the municipality would guarantee full financing.

[3] Law 633/2000 established that payments were to be made for contracted debt as of the 29th of December 2000. Decree 1939/2001 also established more details on eligible expenses and how additional resources were to be divided.

[4] To do so, the entity had to meet some requirements to the National Royalties Commission: a) a certification of available resources issued by the Ministry of Finance (General Directorate of Public Credit); b) a certificate from the planning division of the entity, outlining the projects in accordance with its Development Plan to be financed by FAEP; c) a certificate issued by the National Planning Department (DNP), showing that the projects to be financed by the fund were registered in the Investment Projects Bank (BPIN).

Figure 3. FAEP monthly savings and withdrawals of municipalities between 1997 and 2010



Source: Authors' calculations based on data from The Central Bank of Colombia for 1997-2003 and the National Mining Agency for 2004-2010.

Finally, Ecopetrol was exempted from the FAEP in 2007, following its partial privatization (Law 1151 of 2007) and the FAEP was finally set to stop withdrawals in 2012 over an 8-year period (Law 1530 of 2012).[5]

4. Data

We use municipal-level fiscal and FAEP data from 2000 to 2010. We focus on this period so we can analyze the impact of the oil price surges during this period. In addition, between 1997 and 1999 Sucre municipalities were in this vague FAEP status where they did not have a FAEP account because their royalty revenue was managed by a department-level fund, but the fund itself did save/withdraw in FAEP so indirectly these municipalities were participating in FAEP. Focusing on 2000-2010 allows to analyze a FAEP- treatment of time

[5] All local governments with resources in the fund could withdraw up to 100% of the savings annually until depletion.

where all FAEP participating municipalities were formally included so the treatment is the same for all.

Fiscal data contains variables on revenues and spending for municipalities from the National Planning Department (DNP for its name in Spanish).[6] The data corresponds to the yearly budget executions carried out by each municipality within the corresponding fiscal year. All data is in real Colombian pesos of 2008.

Data on the FAEP is obtained from two sources. First, from the Central Bank, which holds records of the contributions and withdrawals for each municipality from July 1996 to December 2003. Second, from the National Hydrocarbons Agency that holds these records from December 2003 onwards. The databases report the withholdings and refunds made to FAEP by each participant (i.e., Ecopetrol, National Royalties Fund, departments and municipalities). The information is reported in US dollars, which is then converted to Colombian pesos of 2008.

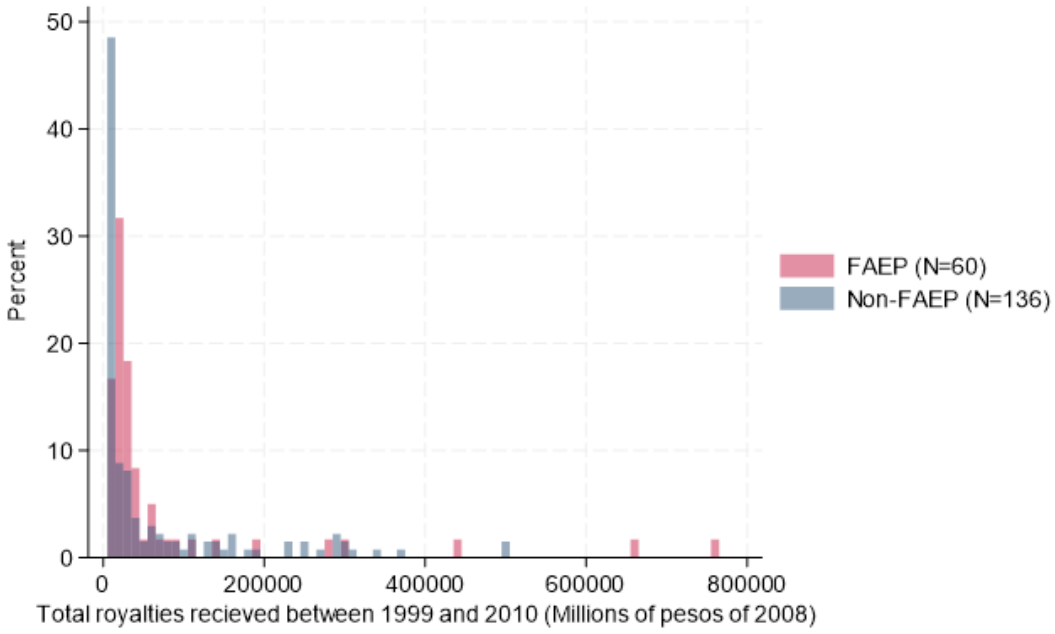
Royalties have historically been widespread across Colombia without discernible differences in receipts between municipalities participating and those not participating in the FAEP. Between 1999 and 2010, 87% of municipalities received royalties in Colombia at least once, either from oil or from other natural resources (e.g., coal and gold). Of these municipalities, only 6% participated in the FAEP. Figure 4 shows the distribution of royalties received between 1999 and 2010 for both FAEP and non-FAEP municipalities that received more than COP 5,000 million during this period.[7] As seen in the figure, the distributions of royalties received by FAEP and non-FAEP municipalities overlap almost completely (except for two extreme FAEP observations), suggesting these two groups are comparable.[8]

[6] This dataset contains, among others, information of the tax revenues such as the property tax and the corporate income tax, and from capital revenue such as national transfers and the royalties coming from the extractive activities. From the spending side, the data records information on the operating expenditures and investment, both gross capital formation and social investment.

[7] COP 5,000 million was the amount selected because it is slightly below the amount of total royalties received by the FAEP municipality that had the lowest allocation.

[8] Notably, the long tail for the FAEP distribution is due to the municipalities of Aguazul (Casanare) and Arauca (Arauca), that received COP 757,054 million and COP 660,130 million between 1999 and 2010 in royalties, respectively, while the non-FAEP municipalities that received the closest amount were Cartagena (Bolívar) and Neiva (Huila), each receiving a little over COP 500,000 million.

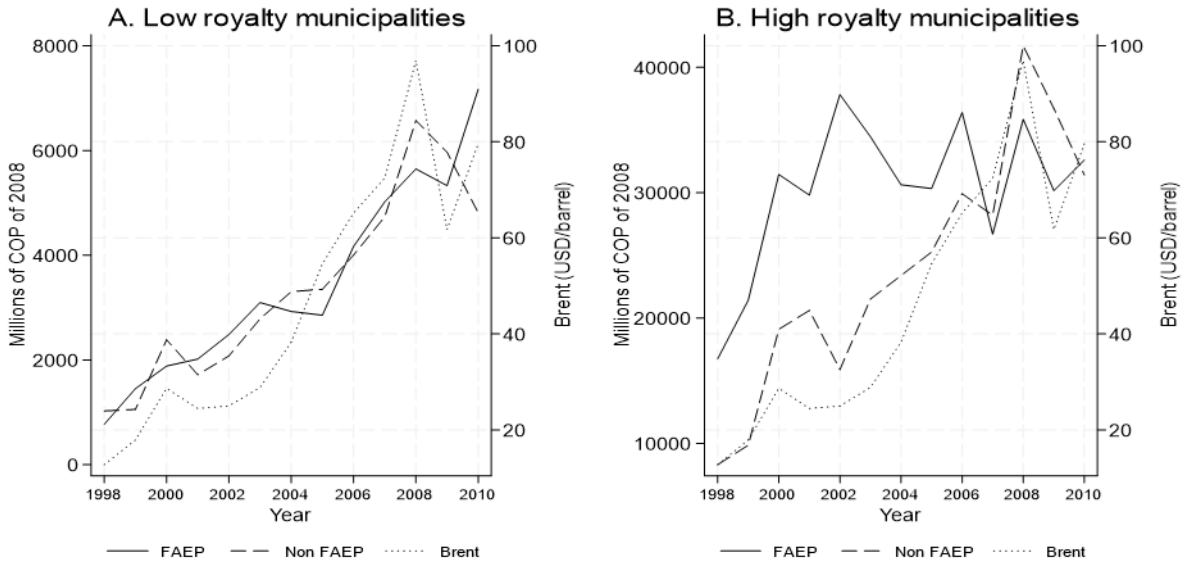
Figure 4. Total royalties received by municipalities between 1999 and 2010



Note: Royalties for FAEP municipalities are gross, meaning that they are before FAEP. We estimate gross royalties as royalties received plus FAEP savings minus FAEP withdrawals. Only municipalities that received at least COP 5,000 million between 1999 and 2010 are included, which is a little below what the FAEP municipality that received the least received.

To analyze the extent to which FAEP reduced royalty volatility for participating municipalities, Figure 5 shows royalties received between 1999 and 2010 by FAEP status. Panel A shows results for low-royalty municipalities. These are defined as municipalities receiving between COP 500 million and COP 10,000 million in 2000. We also show the annual international price of oil during that period (Brent). The figure shows that non-FAEP municipalities follow closely the Brent trajectory, while FAEP royalties' trajectories are smoother. Panel B shows the same figure for high-royalty municipalities, defined as those that received more than COP 10,000 million in 2000. While royalties received by non-FAEP municipalities follow closely the international price of oil, in the case of high-royalty ones, this is less clear; suggesting the FAEP reduces the correlation between oil price changes and royalties.

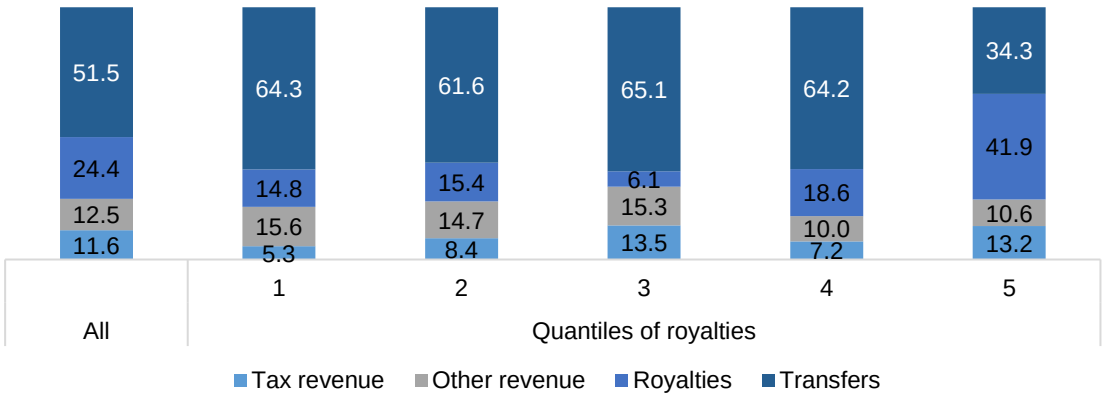
Figure 5. Royalties received by FAEP and non-FAEP municipalities between 1999 and 2010



Source: Authors' calculations using data from DNP.

For FAEP municipalities, royalties were one of their most important revenue sources. Figure 6 shows the distribution of the sum of revenues of FAEP municipalities between 1999 and 2010, by source and quantiles of royalties. The first bar pools all municipalities that participated in the FAEP. The main source of revenue was transfers from the national government. Most of these come from the Sistema General Participaciones (SGP), which are transfers from the national government, mostly earmarked to pay for education, healthcare, as well as water and sanitation related expenses. The second source are royalties, which amounted to 24.4% of total revenue. Royalties were more than twice the tax revenue. The other five columns in the figure show the same results dividing municipalities into five quantiles of royalties received. Across the whole distribution, royalties are consistently larger than tax revenue, with the one exception of quantile 3; this quantile includes the city of Montería, the capital of the department of Córdoba, which has substantial tax revenue.

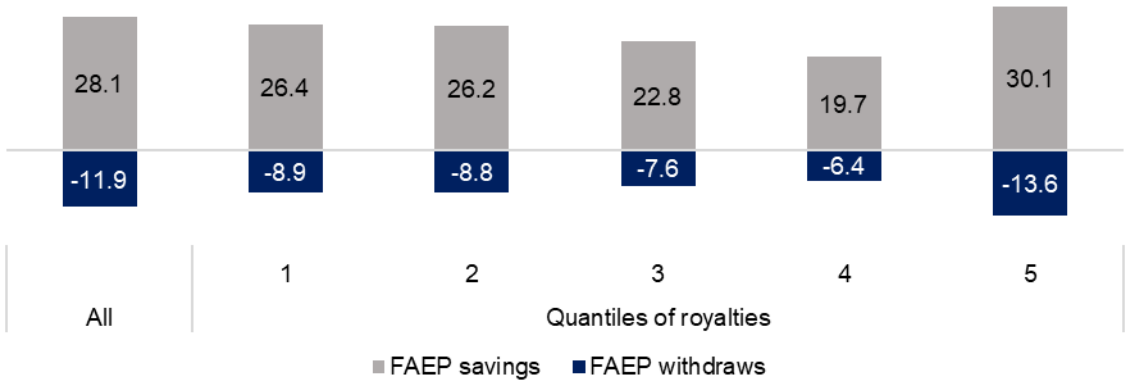
Figure 6. Revenue sources distribution of FAEP Municipalities between 1999 and 2010, by source and quantiles of royalties (%)



Note: N=60.
Source: Authors' calculations.

FAEP savings were sizeable in participating municipalities. Between 1999 and 2010, municipalities saved in the FAEP a total of COP 1 trillion and withdrew COP 0.4 trillion, resulting in net savings of COP 0.6 trillion. As Figure 7 shows, savings amounted to 28.1% of royalties, while withdrawals were 11.9% of royalties. Across the royalty quintiles, FAEP savings were also sizeable, between 19.7% and 30.1% of received royalties, depending on the royalty quintile.

Figure 7. FAEP savings and withdrawals as percentage of royalties between 1999 and 2010 (%)



Note: FAEP savings and withdrawals correspond to the yearly net result of savings and withdrawals.
Source: Authors' calculations.

We analyze the impact of royalty revenue and FAEP participation on operating expenses, tax revenue, gross capital formation (GCF) and other capital expenses. We expect natural resource windfalls to increase both operating and capital expenses, and that the FAEP offsets this impact partially or totally.[9] Regarding tax revenue, it is possible that an increase in royalty revenue can undermine tax revenue by prompting governments to reduce tax rates to transfer part of the windfall to taxpayers, or by decreasing the fiscal effort of tax authorities. This phenomenon has been analyzed for a wide range of countries with different backgrounds, such as Chile (Oyarzo and Dusan, 2021), Argentina (Besfamille et al., 2023), Russia (Alexeev and Zakharov, 2022), Brazil (Caselli and Michaels, 2013), and Peru (Murillo and Sardón, 2024), amongst others. In general, these papers show evidence of a negative relationship between natural resources windfalls and tax revenues.

Figure 8 shows mean values for these outcomes by FAEP municipalities, non FAEP municipalities that received at least 500 COP 500 million in 2000, and the rest of municipalities, for the 1997–2010 period. Although our identification strategy does not rely on a parallel trends assumption, the trends between the three groups before 2000 are relatively similar for all four outcomes. For both FAEP and non-FAEP municipalities, GCF presents pre-electoral spikes in investments, corresponding with the periods prior to the 2000, 2003, 2007 and 2011 municipal elections (Bonet et al., 2020; Granger et al. 2018; Eslava 2005). Capital expenditures other than GFC comprise several types of expenses, including programs for vulnerable population, justice, sports and recreation, and others such as recurrent expenses like teacher salaries and health insurance premiums for low-income people, which are largely funded by the central government through the Sistema General de Participaciones (SGP).[10] The SGP grew consistently over the study period, which largely explains the positive trends observed for FAEP and non-FAEP municipalities. Operating expenses show a decline until 2002 and stabilize thereafter, coinciding with the implementation of subnational fiscal rules, as discussed in Pérez-Valbuena et al. (2024). At the same time, FAEP

[9] Although the legislation required royalty revenues to be spent on capital expenditures only, we cannot rule out the possibility that, as municipalities received more royalty revenue, they reallocated part of their own revenues (e.g., tax collections) from capital to operating expenses, thereby indirectly channeling the royalty windfall toward operational spending. Therefore, both operating and capital expenditures could increase due to a royalty windfall.

[10] Given this particularity, we would expect GFC to be particularly responsive to the effect of the FAEP, as other capital investments also include expenditure items classified as operating expenses in other countries.

municipalities exhibit weaker tax revenue growth during the period. Higher tax collection for non-FAEP municipalities could indicate greater efforts in revenue mobilization, which could be explained by bigger municipalities driving tax revenue up more rapidly than in small municipalities, such as most FAEP municipalities.

Figure 8. Fiscal outcomes over time (average values per year and municipality group)

Source: Authors' elaboration.

5. Methodology

To analyze the impact of FAEP on municipalities' fiscal indicators, we estimate the following regression:

$$g_{mt} = \alpha R_{mt} + \beta F_m R_{mt} + \gamma_m + \phi_t + \mu_{mt} \quad (1)$$

Where g_{mt} is the outcome of interest for municipality m in year t, for example operational expenses; R_{mt} is the amount of royalties received by the municipality; F_m is an indicator

variable for FAEP participation; γ_m and ϕ_t are municipality and year fixed effects, respectively; μ_{mt} is an error term and α and β are parameters to be estimated. The parameter if interest is β, which captures the effect of how the FAEP mediates the impact of royalties on the outcome of interest. Specifically, if participating in the FAEP reduces the impact of royalties on the outcome of interest, β should be negative, so the final impact of royalties would be higher for municipalities that don't participate in the FAEP than for those participating in it.

Because we want to estimate the impact of FAEP, the royalties used in equation (1) need to be purged from the impact of the fund on royalty flows. In other words, for FAEP municipalities we need to use the amount of royalties they would receive in the absence of FAEP. For this, for each year and municipality, we estimate accrued royalties as royalties received plus FAEP savings minus FAEP withdrawals.

Using (observed or accrued) royalties as an independent variable can bias the estimated effect of royalties (and FAEP's) if these are correlated with other variables that affect the outcomes of interest (such as institutional quality or governance, amongst others). In the Colombian context, few studies have circumvented the endogeneity problem of using royalties as an independent variable by instrumenting them using the price of oil (Dube and Vargas, 2013; Ome and Pérez, 2022; and Martínez, 2023).[11] We follow this approach and estimate equation (1) replacing a R_{mt} with the following estimation:

$$R_{mt} = \rho^1 Q_{mt_0} P_t + \vartheta^1 F_m Q_{mt_0} P_t + \theta_m^1 + \varrho_t^1 + \sigma_{mt}^1$$

And $F_m R_{mt}$ with:

$$F_m R_{mt} = \rho^2 Q_{mt_0} P_t + \vartheta^2 F_m Q_{mt_0} P_t + \theta_m^2 + \varrho_t^2 + \sigma_{mt}^2$$

Where Q_{mt_0} is oil produced before the period of study (t_0) (we use oil production in 1996), and P_t is the international price of oil. One limitation of this approach is that, as discussed

[11] The international price of oil is used as an instrument, deemed exogenous and unaffected by the Colombian production of oil. Colombia produces less than 1% of global production and therefore does not affect international prices. International prices are interacted with oil produced or transported in 1996, none of which are related to royalties, production or price at municipal level during the period of analysis. This approach is also used by Ome and Pérez (2022).

before, the majority of FAEP municipalities were in the departments of Sucre and Córdoba. They received royalties because they are classified as port municipalities, not because they produce oil. Because the first stage of the instrumental variable (IV) approach uses the product between the international price of oil and oil production before the period of analysis, port municipalities do not contribute to the regression, so the identification of the impact of the FAEP is based only on the relatively few FAEP oil producing municipalities. To overcome this shortfall and include port municipalities in the analysis, in the first stage we use data on transported oil in 1996 from the Transport Superintendency of Colombia,[12] multiplied by the price of oil.[13] We also include in the first stage royalties for other natural resources that produce royalty revenue, specifically coal and gold.[14]

Mathematically, the first stage is estimated as:

$$R_{mt} = \sum_{\substack{k=oil,\\ transport,\\ coal,gold}} \rho^{1,r} Q^{r}_{mt_0^r} P^{r}_{t} + \sum_{\substack{k=oil,\\ transport}} \vartheta^{1,k} F_m Q^{k}_{mt_0^k} P^{k}_{t} + \theta^{1}_{m} + \varrho^{1}_{t} + \sigma^{1}_{mt} \quad (2)$$

And

$$F_m R_{mt} = \sum_{\substack{k=oil,\\ transport,\\ coal,gold}} \rho^{2,r} Q^{r}_{mt_0^r} P^{r}_{t} + \sum_{\substack{k=oil,\\ transport}} \vartheta^{2,k} F_m Q^{k}_{mt_0^k} P^{k}_{t} + \theta^{2}_{m} + \varrho^{2}_{t} + \sigma^{2}_{mt} \quad (3)$$

Where $Q^{r}_{mt_0^r}$ is the quantity of a natural resource that is produced or transported that causes a royalty revenue in municipality m in t_0 and P^{r}_{t} is the corresponding price. This allows us to estimate the impact of royalties and FAEP on the outcomes of interest for municipalities that were impacted by the change in prices of oil, including the port municipalities.

[12] For more information: https://www.supertransporte.gov.co/documentos/2019/Diciembre/Puertos_20/2019-12-06_TRAFICO_PORTUARIO_1994-2007_ok.pdf

[13] This data includes oil for international trade only. In addition, the volumes that determine royalties paid to municipalities in Sucre and Córdoba are not discriminated by municipality. Instead, they are collapsed in the port of Morrosquillo Gulf. Law 141 of 1994 mandates how the royalties that this port receives should be distributed across the municipalities of the two departments. This regulation was marginally modified by Law 619 of 2000. We use Law 141 of 1994 to assign the volumes distributed through Morrosquillo Gulf (see Box 1). To distribute the 27.5% royalties assigned to non-coastal Sucre municipalities, we divide them equally given the lack of clarity in the law on how to distribute this part of the resources. This was later clarified by Law 619 of 2000.

[14] Based on the identification of coal and gold producer municipalities in 2022 taken from Mining-Energy Planning Units.

6. Results

Table 1 shows first stage regressions as described in equations (2) and (3). We use the $log(x+1)$ transformation given that several municipalities receive 0 royalties. For the instruments we also use the $log(x+1)$ transformation on the products of quantities and prices.[15] For royalties (Column 1), the results indicate a strong correlation with the production value of oil and coal, while the correlations with the value of transported oil and gold producing are also positive but the coefficients are not statistically significant at standard levels of confidence. Regarding the interaction between royalties and the FAEP (Column 2), the coefficients on the two FAEP interactions (oil production and oil transported) are positive and statically significant, as expected. Notably, the coefficients on gold and coal production are negative and, albeit small in absolute value, statically significant. This is likely to reflect the fact that most FAEP municipalities do not produce other minerals. In the case of the port municipalities in Cordoba and Sucre, this was by design, as the only municipality excluded from receiving oil transport royalties (and consequently, FAEP participation), was Montelibano, a mining municipality.

Table 1. First stage regressions for GCF

Instruments	Royalties	Royalties X FAEP
Oil production value	1.135***	-0.003
	(0.202)	*(0.003)*
Oil production value X FAEP	-0.506	0.420*
	(0.401)	*(0.193)*
Oil transport value	1.419	-0.023
	(0.764)	*(0.013)*
Oil transport value X FAEP	-0.777	0.778***
	(0.758)	*(0.069)*
Coal production value	0.281*	-0.027**
	(0.135)	*(0.010)*
Gold production value	0.332	-0.007**
	(0.176)	*(0.002)*

Note: All specifications include municipality fixed effects, population, and regional time trends as control variables. Standard errors clustered at the municipality level are shown in parentheses.
* p < 0.05, ** p < 0.01, *** p < 0.001

[15] By some accounts, the log(x+1) transformation could affect large scale results (such as those measured in millions and billions). Therefore, we conduct all estimations using a hyperbolic sine transformation and confirm that the results are robust.

Table 2 shows the regression results for the impact of royalties on selected fiscal indicators, namely operating expenses, tax revenue, GCF, and other capital expenses. Panel A shows OLS results. The first row corresponds to the coefficient on royalties and the second row to the coefficient on royalties interacted with a binary indicator for FAEP participation. FAEP participation is defined as 1 if municipalities ever participated in the FAEP, regardless of whether they contributed or withdrew money in a given year. In Panel B we show the results instrumenting royalties as indicated in equations (2) and (3). For each regression in panels A and B, we test whether the coefficients on royalties and on the interaction between royalties and FAEP offset each other and report the p-value of the test on their sum. For the IV results we also report the Sanderson and Windmeijer (2016) F statistics to test for weak instruments. As a placebo test for the IV results, we also ran a simulation in which we randomly assigned FAEP status to 50 high-royalty, non-FAEP municipalities. We repeated this procedure 1,000 times, re-estimating the model each time and recording the coefficient on the royalties x FAEP interaction. The table reports the share of simulated coefficients whose absolute value exceeds that of our actual estimate, providing a benchmark for assessing whether the observed effect is likely to be spurious. All results exclude the year 2003, when the best part of the FAEP extraordinary withdrawals were made by municipalities (as shown in Figure 3).[16]

Both the OLS and the IV results indicate that neither royalties nor royalties interacted with FAEP participation had any impact on operating expenses. This shows that municipalities did not overspend when they experienced a royalty windfall, at least not through operating expenses. These results are also consistent with the fact that, by law, royalties and FAEP withdrawals had to be used to finance investment projects (as mentioned in previous sections). The results also indicate no relationship between royalties nor FAEP participation with tax revenue. OLS results show that GCF expenses were correlated with royalties, but not with the interaction between royalties and FAEP. In the case of the IV results for GCF indicate that a 1 percent increase in royalty revenue caused an increase of 0.2 percent on GCF expenses and this effect was cancelled out by FAEP participation. Although in absolute value

[16] The reason behind this exclusion is to avoid the results to be contaminated by the significant amount withdrawn from the fund allowed by Law 633 of 2000. In fact, what happened that particular year could make us think that the fund operated contrary to what is was conceived for, which could work as an implicit confounding factor in the estimations.

the coefficient on the FAEP and royalties' interaction is larger than the coefficient on the royalties, the sum of the two coefficients is not statistically different from 0, as the test in table shows. Finally, results indicate that both royalties and the interaction of royalties and FAEP participation have a positive and statistically significant effect on other capital expenses in the case of OLS. In the case of the IV results, only the coefficient on royalties is statically significant. For all outcomes the Sanderson and Windmeijer (2016) F-statistic on the royalties' coefficient are only marginally below 10—the critical value commonly used in the literature to assess instrument strength.[17]

Table 2. Fixed effects regressions on fiscal results

	Operating expenses	Tax revenues	GCF	Other investment
A. OLS				
Royalties	0.001	0.003	0.039***	0.009***
	(0.002)	*(0.003)*	*(0.003)*	*(0.002)*
Royalties x FAEP	0.027	0.037	0.052	0.103**
	(0.033)	*(0.048)*	*(0.061)*	*(0.032)*
p-value for joint test[1]	0.386	0.400	0.137	0.000601
B. IV				
Royalties [a]	0.009	0.048	0.202***	0.137***
	(0.025)	*(0.045)*	*(0.046)*	*(0.039)*
Royalties x FAEP [b]	0.000	-0.176	-0.317**	0.072
	(0.075)	*(0.116)*	*(0.106)*	*(0.083)*
p-value for joint test[1]	0.900	0.251	0.264	0.00615
SW F statistic [a]	9.66	9.62	9.65	9.62
SW F statistic [b]	44.74	44.51	38.63	38.53
Observations	10,622	10,654	10,643	10,646
Municipalities	1,101	1,101	1,101	1,101

Note: All specifications include municipality fixed effects, population, and regional time trends as control variables. Standard errors clustered at the municipality level are shown in parentheses. Sanderson- Windmeijer (SW) first-stage F-statistic reported for each endogenous variable; [a] for Royalties and [b] for Royalties#FAEP.
[1] H0: Royalties + Royalties x FAEP =0
*** p<0.001, ** p<0.01, * p<0.05

Table 3 includes the results of lagged royalties, given that royalty spending might not have affected fiscal outcomes contemporaneously, especially expenses. This can happen as it might take time for municipal governments to plan and execute the budget increases. Despite

[17] Although some of these coefficients are 9.6-9.7, given their proximity to 10, we do not think this compromises the results. The results of the placebo test indicate that for the outcomes included in the regressions in Table 2, between 10% and 25% of the placebo results are statistically significant at 5%. These results confirm that the estimated impacts are not spurious.

small differences in the magnitude of the coefficients, the results are relatively consistent with those presented in Table 2.

Table 3. Fixed effects regressions on fiscal results – Lagged royalties

	Operating expenses	Tax revenues	GCF	Other investment
A. OLS				
Royalties (t-1)	0.000	0.005	0.025***	0.008***
	(0.002)	*(0.003)*	*(0.004)*	*(0.002)*
Royalties (t-1) x FAEP	0.018	0.017	0.007	0.080*
	(0.024)	*(0.030)*	*(0.040)*	*(0.038)*
p-value for joint test	0.432	0.442	0.408	0.0212
B. IV				
Royalties [a]	0.020	0.090	0.183***	0.129***
	(0.026)	*(0.047)*	*(0.040)*	*(0.038)*
Royalties x FAEP [b]	-0.022	-0.136	-0.334**	0.134
	(0.073)	*(0.092)*	*(0.102)*	*(0.070)*
p-value for joint test[1]	0.980	0.630	0.150	0.000
SW F statistic [a]	11.21	11.53	11.29	11.30
SW F statistic [b]	35.83	42.27	39.32	39.33
Observations	10,337	10,333	10,369	10,372
Municipalities	1,099	1,099	1,099	1,099

Note: All specifications include municipality fixed effects, population, and regional time trends as control variables. Standard errors clustered at the municipality level are shown in parentheses. Sanderson- Windmeijer (SW) first-stage F-statistic reported for each endogenous variable; [a] for Royalties and [b] for Royalties#FAEP.
[1] H0: Royalties + Royalties x FAEP =0
*** p<0.001, ** p<0.01, * p<0.05

7. Conclusions

In this study we analyze the effects of implementing the FAEP on revenue and expenses for municipal governments in Colombia between 2000 and 2010. We find that, despite deviations from the original saving model due to the extraordinary withdrawals registered in the early 2000's, the FAEP was successful in increasing municipalities' savings and reducing their exposure to oil price volatility. Countries and subnational governments considering creating NRFs with this objective should consider these results as evidence of the success of this type of instrument.

However, we find no evidence that higher royalties or FAEP participation had an impact on operating expenses. This is not surprising considering that royalties could not be spent on this type of expense. Undoubtedly, after receiving a natural resource windfall, municipalities could increase their operational budgets by shifting royalty funds from capital projects to

operational spending and then using the new royalty income to replace the capital funds. However, the fact that Law 617 of 2000 restricted the use of operating expenses, relative to the freely allocated revenues collected by municipalities, could have been an important factor in the seeming fiscal discipline that the results suggest. Existing regulation could therefore have been the key instrument ensuring fiscal discipline for operating spending. Countries seeking to use a NRF to weaken or sever the link between natural resource revenues and operational spending should focus on directly controlling the latter. Relying solely on an NRF for this purpose may prove ineffective, even if the country's regulation stipulates that natural resource revenues can only be used for capital expenditures.

We also fail to find a relationship between royalties and tax revenue. These findings are consistent with national and international literature. For example, Iyoha and Iyobhebhe (2023) analyze, for a group of oil-abundant developing countries, the relationship between oil rents and tax capacity where they found, using different estimations' alternatives, that there are no clear effects of oil rents and tax collections efforts. For the case of Colombia, Collazos and Schakel (2024) and Bonet, Pérez and Haddad (2023) find that oil rents in Colombia do not systematically alter tax revenues.

We do however find a positive relationship between royalties and GCF expenses, similar to Bonet et al. (2020). Notably, this correlation between royalties and GCF is offset by FAEP participation. These results suggest that the FAEP was indeed successful in installing fiscal discipline on capital expenses in the face of higher natural resource revenues. We also find a positive impact of royalties on capital expenses other than GCF, consistent with Bonet et al. (2020), but in this case FAEP does not cancel out this positive effect. If other capital expenses are prioritized over GCF, then it is natural that FAEP would be more effective in smoothing expenses on the latter than the former, when municipalities receive natural resource windfalls.

In sum, our results show that the FAEP was successful in smoothing out the impact of royalties on GFC. It did not, however, affect operating expenses, tax revenues nor capital expenses other than GFC. In this sense, the instrument seemed to be partially successful in implementing fiscal discipline in the face of a natural resource revenue windfall. Countries that are using NRFs should consider whether these are the appropriate instruments for their

objectives. If they want to prevent an excess increase in operational expenses, regulation that can directly control these expenses might be more effective.

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