Fiscal Behavior and Natural Resource Curse: New Evidence from Brazilian Municipalities

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Abstract

We use data from Brazilian municipalities to investigate if local public budget management is one of the channels whereby the resource curse affects local economies. We find that oil royalties change the distribution of public spending between different functions: local governments spend less on education and culture and more in housing and urbanization when oil royalties increase than when non-oil current revenues do. There is also asymmetric behavior at the municipal level regarding the response of payroll-related public expenditures and capital expenditures to changes in oil royalties: during oil busts the difficulty in reducing payroll expenditure forces municipalities to cut public investment. Furthermore, we also find that local governments tend to save more than they would in the absence of constraints regarding the use of oil revenues. In this sense, there is no curse. However, this is the average behavior. We estimate quantile treatment effects and find that low-saver municipalities may be trapped by the oil curse. Therefore, to some extent, we reinforce the evidence, now at the local level, that the resource curse is a manifestation of the inability of governments to manage resource revenues properly.

Keywords Public budget management · Natural resource curse · Oil windfall · Brazilian municipalities · Quantile treatment effects

JEL Classification H72 · H75 · H76 · O13 · Q32 · Q33

Statements and Declarations

Conflict of Interest The authors did not receive support from any organization for the submitted work. The authors have no relevant financial or non-financial interests to disclose.

Acknowledgments

Acknowledgments to Winicius Farquieri and Gabriel Dischon for their excellent research support, and to Eduardo Lima Campos for reviewing the manuscript. The findings and views expressed in this paper, as well as any errors and omissions, are entirely the authors' responsibility.

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1 Introduction

There is anecdotal evidence that some resource-rich economies tend to have worse economic performance than resource-poor ones: the so-called natural resource curse. The possibility of occurrence of this phenomenon is widely documented.[3] Much of this literature investigates the natural resource curse at the country level and shows that natural resources, by themselves, are not bad for economic growth. To avoid the curse, countries must build institutions to make the best use of a resource boom, that is, to guarantee that the resources will not be wasted (through corruption, for example) or consumed (rather than reinvested).

However, the country-level evidence hides some features of resource curse occurrence. For example, it does not allow for an investigation of local impacts of resource booms, which usually occur most strongly in certain regions, and not homogenously throughout the whole country. Local-level data also improves the identification strategy, since it explores variations within a country. For this reason, there is a recent but expanding literature investigating the resource curse at the subnational level.[4]

In Brazil, federal government shares part of oil rents with the municipalities and this makes it possible to investigate the resource curse at the local level. Thus, the Brazilian experience with oil royalties is widely used for this purpose. The available evidence indicates that oil royalties increase both current and capital public expenditure in the Brazilian municipalities (Monteiro and Ferraz 2012; Ardanáz 2014).[5] The economic rule of thumb is to invest part of natural resources rents, but not all, in capital. Therefore, in isolation these empirical findings cannot shed much light on the question of whether Brazilian municipalities are correctly managing oil royalties. The existing literature using Brazilian data indirectly infers the presence of bad management by showing that the extra public expenditure does not generate a sizeable expansion of economic growth, local living standards, and public goods provision (Postali 2009; Postali and Nishijima 2011; Monteiro and Ferraz 2012; Caselli and Michaels 2013; Ardanáz (2014)].[6]

We take a different route. Unlike in the existing literature, we also include non-oil revenues as covariates when explaining the behavior of different public expenditures in

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[3] See Frankel (2012), van der Ploeg (2012), Ross (2015), and Badeeb *et al.* (2017) for literature reviews

[4] See Aragón *et al.* (2015) and Manzano and Gutiérrez (2019) for surveys on this topic.

[5] The same can be said regarding public expenditure on health, education, transportation, and so on (Caselli and Michaels 2013).

[6] Natural resource booms in other developing countries have also led to modest local impacts by means of public spending increases (Aragón and Rud 2013).

Brazilian municipalities. By doing so, we can contrast how local public budgets react to oil royalties and to non-oil revenues. In this regard, our findings reveal that the impact of oil royalties on current public spending (investment) is positive (positive), but smaller (larger) than the impact of non-oil current revenues. That is, the constraints imposed by oil regulation are binding and seem to push municipalities in the right direction. In fact, oil regulation makes local governments spend royalties just as they do with capital revenues.

Moreover, raising oil royalties changes the distribution of public spending between different functions. Local governments spend less on education and culture and more on housing and urbanization when oil royalties increase than when non-oil current revenues do.

The empirical literature also indicates that resource-rich countries tend to save relatively less. This inability to properly manage the large revenues associated with natural resources abundance, especially by the public sector, seems to explain at least part of their poor growth performance (Atkinson and Hamilton 2003).[7] We find that, on average, oil regulation seems to prevent this kind of behavior by Brazilian local governments. However, the impact of royalties is different depending on the level of public savings. To investigate this issue, we estimate quantile models and discover that the oil curse may affect low-saver Brazilian municipalities.

Additionally, the existing literature with Brazilian data only includes the oil boom period, from the end of the 1990s until the beginning of the 2000s, when municipal royalties increased significantly. However, what happens when royalties go down? Is there an opposite impact of the same magnitude? To answer these questions, we explore a longer period to also include the recent decline in oil-derived public revenues. By doing so, we can investigate if Brazilian local governments behave differently during oil booms and busts, particularly with respect to possible asymmetric adjustments in public expenditure.

This issue connects with the literature that investigates, usually at the national level, how the public budget behaves during good and bad times.[8] If certain expenditure components behave differently in booms and busts, such asymmetries could undermine fiscal sustainability or change the composition of public expenditure in a non-desirable way, by compressing spending on the provision of public services, for example. In this sense, if such asymmetric behavior occurs in response to oil booms and busts, it may be considered a channel whereby

[7] Furthermore, Dietz *et al.* (2007) find evidence that corruption is one of the drivers that explain the negative influence of natural resource abundance on savings at the country level, which matches the available Brazilian evidence at the municipal level.

[8] See Ardanáz and Izquierdo (2017) for a recent contribution.

the natural resource curse can emerge at the local level. This concern is particularly relevant in Brazil, where subnational governments face difficulties, including legal ones, in reducing certain components of expenditure, notably payroll ones. For example, some Brazilian states, such as Rio de Janeiro, Rio Grande do Sul, and Minas Gerais, faced this problem in the late 2010s.

We find an asymmetric behavior at the municipal level regarding the response of payroll-related public expenditures to changes in oil royalties. However, unlike in the anecdotal evidence from some Brazilian oil states, such as Rio de Janeiro, the asymmetry occurs only in expenditure relating to active personnel, and not in spending on retired public employees and on people hired on a temporary basis. There is also asymmetric behavior in the response of capital expenditure: positive changes in oil royalties generate a smaller increase in public investment than the decrease caused by negative changes. In a nutshell, during oil busts the difficulty in reducing payroll expenditure forces municipalities to cut public investment.

We organize the paper as follows. Section 2 briefly describes the Brazilian oil sector, as well its oil royalty policy. Section 3 presents the empirical strategy and describes the database. Section 4 shows the results and section 5 presents some final remarks.

2 Background

Until 1997, oil exploration, production, and refining were a legal monopoly of Petrobras, the Brazilian national oil company. In that year, the Brazilian National Oil Agency (ANP) was established and made responsible, among other duties, for holding biding rounds to auction the rights to explore and produce oil in certain areas – onshore and offshore – in Brazil. Since then, in almost 20 bidding rounds, although Petrobras has remained the dominant player, many foreign and national companies have entered the Brazilian oil market. For this reason, oil production has increased sharply in Brazil since 1997, and so has the government take, that is, the monetary compensation paid by oil companies to the Brazilian public sector (see Fig. 1). However, in 2015 and 2016 there was a sharp decrease in government take.

Regarding the data we use, there are, in practical terms, two categories of compensation: regular oil royalties, of between 5 percent and 10 percent (but typically 10 percent) of the value of oil and gas output, and special participations, representing extraordinary compensation only owed by oil companies operating in fields with a large volume of production.[9] Federal, state, and municipal governments share both. From now on, when we refer only to royalties, we mean the total amount of regular royalties and special participations. If we want to refer only to regular royalties, we will do so explicitly.

The data presented in Fig. 1 contemplates oil revenues accruing to all levels of government (federal, state, and municipalities). For reasons that will become clear later, the paper focuses on coastal municipalities. Therefore, regarding offshore oil production, it is worth detailing the rules for the distribution of royalties and special participations at the local level. Here, it is essential to understand the concept of facing municipality: one whose parallel and orthogonal lines of projection on the continental shelf, drawn from its boundaries with the coast, delimit an area in which at least one oil field is located (see Appendix A for more details).

Regarding offshore production, typically 21.25 percent of regular royalties are destined to the producing municipalities and to the ones within the economic area of influence, and 8.75 percent go to those affected by oil loading and unloading operations. The remaining 70 percent goes to federal and state governments.[10] As mentioned before, regular royalties typically correspond to 10 percent of the oil production value of a field. Municipalities account for 30 percent of these regular royalties and, accordingly, capture 3 percent (30% × 10%) of the production value.

Special participation varies from 0 percent to 40 percent of oil and gas net revenue from a field. Net revenue is gross revenue minus deductible expenses, which include regular royalties, investments, operational costs, and depreciation. Local governments take 10 percent of the special participation, but only in facing municipalities.[11] In other words, facing municipalities capture between 0 percent (0% × 10%) and 4 percent (40% × 10%) of net revenue from oil and gas sales.

On average, during the oil boom peak, royalties reached more than 10 percent of current public revenues in coastal municipalities (see Fig. 2, gray line, right axis). In the last year for

[9] There is also an upfront fee paid by oil companies to the federal government to guarantee the right to explore oil and gas in a field. However, since the federal government does not share this compensation with municipalities (and states), we are not considering it here.

[10] Distribution rules are different regarding onshore production: 17.50 percent of regular royalties are destined to the producing municipalities and to the ones within the economic area of influence, 5 percent go to those with oil and gas facilities, and 3.75 percent go to those affected by oil loading and unloading operations. The remaining 73.75 percent goes to federal and state governments.

[11] There is no special participation in onshore fields. See more details in CNM (2010).

which data is available (2016), during the most severe oil bust, they asked for 8.6 percent. Royalties per capita had a similar evolution (see Fig. 2, black line, left axis).

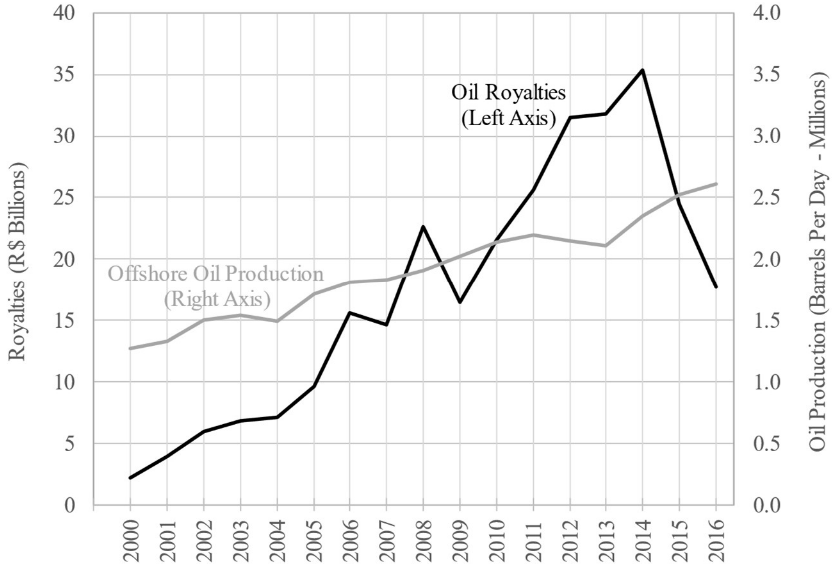

Fig. 1 Brazil – Offshore Oil Production and Royalties. *Notes:* Monetary values at constant 2017 prices (deflated using the IPCA – the Brazilian official inflation index). All data from ANP.

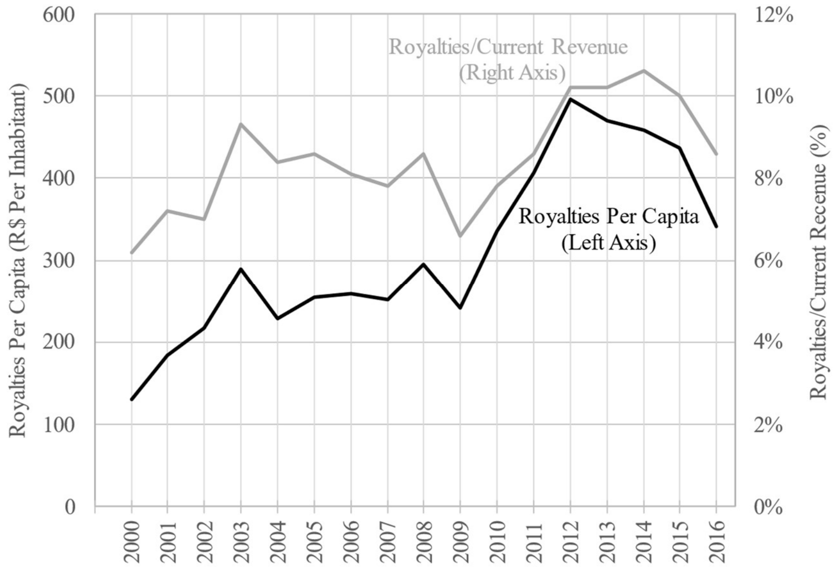

Fig. 2 Royalties as Percentage of Current Revenues and Royalties Per Capita: Coastal Municipalities (Non-Weighted Average). *Notes:* Monetary values at constant 2017 prices (deflated using the IPCA – the Brazilian official inflation index). Calculated with data from ANP, FINBRA, and Brazilian National Bureau of Statistics (IBGE).

However, for some coastal municipalities – mostly important offshore oil producers – royalties are a relevant share of current public revenues. For example, in 2016 total compensation (regular royalties + special participation) reached 82 percent of current revenues in Maricá, 61 percent in Itapemirim, and 58 percent in São João da Barra (see Table 1).

Finally, Brazilian federal law forbids using royalties to cover expenses in permanent personnel payroll (except in public basic education, since 2013) or debt payments (except to the federal government, since 2001). Since 2001, municipalities have also been able to use oil rents to capitalize public pension funds.[12]

At the end of 2010, there was a change in the O&G sector regulatory framework. There was no re-writing of old contracts, but the new Pre-Salt areas became governed by a different kind of arrangement, known in the industry as the production-sharing contract – see Hernandez-Perez (2011) for more details. Moreover, regular royalties increased by up to 15 percent of the value of oil output in these areas. The auction of the first area under this new regulation took place in 2013, but oil production only started in 2018. For this reason, this article does not cover these new contracts, since the period under review ends in 2016.

Table 1 Royalties – Top Ten Coastal Municipalities (2016)

	Total Compensation (1)		Regular Royalties (2)		Special Participation (3)	
	R$ Per Capita	Current Revenue (%)	R$ Per Capita	Current Revenue (%)	R$ Per Capita	Current Revenue (%)
Maricá (RJ)	2,091.96	82%	1,244.88	49%	847.08	33%
Itapemirim (ES)	3,652.57	62%	2,355.49	40%	1,297.08	22%
São João da Barra (RJ)	2,897.11	57%	2,081.63	41%	815.48	16%
Tibau (RN)	2,248.16	54%	2,248.16	54%	0.00	0%
Grossos (RN)	908.94	51%	908.94	51%	0.00	0%
Marataízes (ES)	1,415.31	47%	1,123.87	37%	291.44	10%
Ilhabela (SP)	3,679.73	39%	1,082.58	11%	2,597.15	28%
Paraty (RJ)	1,372.41	37%	1,372.41	37%	0.00	0%
Esplanada (BA)	802.54	36%	802.54	36%	0.00	0%
Carapebus (RJ)	1,384.00	35%	1,381.06	35%	2.94	0%

Notes: Municipalities ordered by the share of royalties in public current revenue. RJ – Rio de Janeiro, ES – Espírito Santo, RN – Rio Grande do Norte, BA – Bahia, SP – São Paulo. Monetary values at constant 2017 prices (deflated using the IPCA – the Brazilian official inflation index). All data from ANP.

3 Empirical Strategy and Data

3.1 Linear Models

From the public budget, we have the following identity:

$$R_{it} + R_{it}^{C} + R_{it}^{K} = E_{it}^{C} + E_{it}^{K} + FS_{it}, \tag{1}$$

[12] See Laws 7990/1989, 10195/2001, and 12858/2013. See also Seabra *et al.* (2015).

where subscripts $i = 1, \dots, N$ and $t = 1, \dots, T$ indicate municipality and year, respectively. Moreover, E_{it}^C denotes current public expenditure, E_{it}^K is the capital public expenditure, FS_{it} indicates the fiscal surplus, R_{it} is the volume of royalties, R_{it}^C denotes non-oil current public revenue, and R_{it}^K indicates capital public revenue, all in per capita terms.

We find solid evidence that non-oil public revenue (R_{it}^C and R_{it}^K) does not depend on royalties, at least for coastal municipalities (see Appendix E). Therefore, if we suppose additionally that public expenses and the fiscal surplus depend on royalties, from (1) we get:

$$\frac{\partial FS_{it}}{\partial R_{it}} = 1 - \frac{\partial E_{it}^C}{\partial R_{it}} - \frac{\partial E_{it}^K}{\partial R_{it}}. \tag{2}$$

Additionally, supposing linearity and considering the restriction implied by (2), it is possible to define the following three-equation model:

$$\begin{bmatrix} E_{it}^C \\ E_{it}^K \\ FS_{it} \end{bmatrix} = \begin{bmatrix} \beta^C & \mu^C & \vartheta^C \\ \beta^K & \mu^K & \vartheta^K \\ \beta^{FS} & \mu^{FS} & \vartheta^{FS} \end{bmatrix} \begin{bmatrix} R_{it} \\ R_{it}^C \\ R_{it}^K \end{bmatrix} + \begin{bmatrix} \boldsymbol{\varphi}^C \\ \boldsymbol{\varphi}^K \\ \boldsymbol{\varphi}^{FS} \end{bmatrix} \mathbf{W}_{it} + \begin{bmatrix} \alpha_i^C \\ \alpha_i^K \\ \alpha_i^{FS} \end{bmatrix} + \begin{bmatrix} \alpha_{st}^C \\ \alpha_{st}^K \\ \alpha_{st}^{FS} \end{bmatrix} + \begin{bmatrix} e_{it}^C \\ e_{it}^K \\ e_{it}^{FS} \end{bmatrix}, \tag{3}$$

where subscript $s = 1, \dots, S$ indicates state, $\mathbf{W}_{it}$ is a vector of controls, α_i and α_{st} indicate, respectively, municipality and state-year fixed effects, and e_{it} are error terms. Moreover, superscripts *C*, *K*, and *FS* denote parameters associated with current expenses, capital expenses, and the fiscal surplus equation, respectively.

Since this last equation is redundant, it is impossible to estimate the parameters of (3) as a three-equation simultaneous system. We can drop the last equation, estimate model (3) with a multiple equations approach, and then infer the parameters from the last equation by using restriction (2).[13] Specifically, $\beta^{FS} = 1 - \beta^C - \beta^K$, $\mu^{FS} = 1 - \mu^C - \mu^K$, and so on.

Besides dropping the last equation, we can also estimate a first-differenced version of (3) to eliminate the fixed effects and deal with potential serial autocorrelation in the errors:

$$\begin{bmatrix} \Delta E_{it}^C \\ \Delta E_{it}^K \end{bmatrix} = \begin{bmatrix} \beta^C & \mu^C & \vartheta^C \\ \beta^K & \mu^K & \vartheta^K \end{bmatrix} \begin{bmatrix} \Delta R_{it} \\ \Delta R_{it}^C \\ \Delta R_{it}^K \end{bmatrix} + \begin{bmatrix} \boldsymbol{\varphi}^C \\ \boldsymbol{\varphi}^K \end{bmatrix} \Delta \mathbf{W}_{it} + \begin{bmatrix} \Delta \alpha_{st}^C \\ \Delta \alpha_{st}^K \end{bmatrix} + \begin{bmatrix} \Delta e_{it}^C \\ \Delta e_{it}^K \end{bmatrix}, \tag{4}$$

[13] Given cross-equation restrictions, the results depend on which equation we delete (Hayashi 2000). However, the estimates are quite robust (results available upon request) and do not change substantially if we choose to drop another equation.

where Δ denotes the first-difference operator.

If there is no relation between the equations, in the sense that the covariance matrix of errors in (4) is block-diagonal, we can efficiently estimate one equation at a time. We pursue this strategy and find similar results to the multiple equations approach. However, we prefer the system approach because we can guarantee that the restriction implied by (2) will be satisfied and can calculate the impact of covariates on the fiscal surplus (with their respective standard errors).

Regardless of legal constraints on the use of oil royalties to cover current expenditures, we can expect some increase in this kind of public spending. After all, even countries that are considered successful in managing oil royalties use part of these revenues on current expenditures.[14] Thus, finding a positive impact of royalties on current expenditures ($\beta^C > 0$) is not evidence of bad public budget management. Neither does a positive impact on investment ($\beta^K > 0$) indicate good governance.

The correct approach is to compare the impact of royalties and other revenue categories, especially those not subject to legal constraints regarding their use. For example, we can use the difference between β^C and μ^C as a measure of how local governments are constrained by the oil regulation, which limits them in using royalties for current expenses (see section 2). The larger this difference the more binding the constraint and the weaker the (potential) oil curse. A similar approach can be taken with β^C and ϑ^C.

The specification of equations (3) and (4) is different from the ones adopted by existing literature with municipal Brazilian data. Particularly, Monteiro and Ferraz (2012) omitted non-oil current and capital public revenues from their model ($\mu^C = \mu^K = \vartheta^C = \vartheta^K = 0$), and Caselli and Michaels (2013) use total public revenues as the treatment variable ($\beta^C = \mu^C = \vartheta^C$ and $\beta^K = \mu^K = \vartheta^K$). That is, our model encompasses theirs and, unlike the existing literature, allows us to test the difference between β^C and μ^C (or β^C and ϑ^C) and then, better identify if the oil curse really occurs, at least through this channel.

3.2 Quantile Models

We can also rearrange equation (1) so that:

$$GS_{it} \equiv R_{it}^C - E_{it}^C = FS_{it} + E_{it}^K - R_{it}^K - R_{it}, \tag{5}$$

[14] See the Norway experience, for example (Holden 2013).

where GS_{it} denotes the genuine public savings, that is, net public savings adjusted for public oil rents (royalties).[15]

From (5), and supposing linearity, we can define the following model:

$$GS_{it} = \beta R_{it} + \mu R_{it}^{C} + \vartheta R_{it}^{K} + \boldsymbol{\varphi}\mathbf{W}_{it} + \alpha_{st} + \alpha_i + e_{it} \equiv \mathbf{BX}_{it} + \alpha_i + e_{it}, \tag{6}$$

From (6), we can retrieve the effects of covariates on those savings and relate them with parameters from model (3) or (4):

$$\frac{\partial GS_{it}}{\partial R_{it}} = \beta = -\frac{\partial E_{it}^{C}}{\partial R_{it}} = -\beta^{C}, \tag{7}$$

$$\frac{\partial GS_{it}}{\partial R_{it}^{C}} = \mu = 1 - \frac{\partial E_{it}^{C}}{\partial R_{it}^{C}} = 1 - \mu^{C}, \tag{8}$$

$$\frac{\partial GS_{it}}{\partial R_{it}^{K}} = \vartheta = -\frac{\partial E_{it}^{C}}{\partial R_{it}^{K}} = -\vartheta^{C}. \tag{9}$$

Since it implies conditional mean regression estimation techniques, model (6) masks the possibility of heterogeneity impacts of royalties on the public budget. Empirical evidence suggests that the resources curse occurs only in countries for which genuine savings are negative (Atkinson and Hamilton 2003). Therefore, we may be interested in estimating the impact of royalties on genuine public savings (*GS*), depending on whether those savings are low or high. This suggests a quantile regression approach, which allows us to estimate the impact of royalties on *GS* at different points of the *GS* distribution. Particularly, we expect the adjustment in current public expenditures to be relatively larger in municipalities at the bottom of that distribution, that is, with small or even negative per capita genuine public savings.

To implement this approach, let $U_{it}^{*} \sim U(0,1)$ be a latent rank variable – distributed uniformly in the $(0,1)$ interval – that represents the public-sector propensity to save (genuinely). Following Powell (2022), we suppose that U_{it}^{*} depends on two kinds of unobservable variables: a municipal-specific (α_i) and a general (U_{it}) propensity to save: $U_{it}^{*} = f(\alpha_i, U_{it})$. Assuming linearity regarding covariates $(\mathbf{X}_{it})$, we have:

$$GS_{it} = \mathbf{B}(U_{it}^{*})\mathbf{X}_{it}, \quad U_{it}^{*} \sim U(0,1). \tag{10}$$

[15] The concept of national savings adjusted for the depletion of natural resources was called genuine savings by Pearce and Atkinson (1993). We adapt this concept to the public sector.

By construction, the structural quantile function $q_{GS}(\tau|\mathbf{X}_{it}) \equiv \mathbf{B}(\tau)\mathbf{X}_{it}$ is the τ^{th} quantile of GS_{it} conditional on $\mathbf{X}_{it}$. The vector of quantile treatment effects (QTE) collects the impact in this τ^{th} quantile given a change from covariates, that is, $\frac{\partial q_{GS}(\tau,\mathbf{X}_{it})}{\partial \mathbf{X}_{it}} = \mathbf{B}(\tau)$. We assume q_{GS} is strictly increasing in τ.

From (10), besides $\mathbf{X}_{it}$, genuine public savings also depend on non-observable municipal fixed effects, but we do not include them directly in equation (10). In the mean regression approach, we could simply include additive fixed effects to deal with this kind of unobserved heterogeneity.

By analogy, we would include a further term in (10), so that $GS_{it} = \widetilde{\mathbf{B}}(U_{it})\mathbf{X}_{it} + \alpha_i$, with $U_{it} \sim U(0,1)$. Furthermore, the structural quantile function would become $q_{GS}(\tau|\mathbf{X}_{it}, \alpha_i) \equiv \widetilde{\mathbf{B}}(\tilde{\tau})\mathbf{X}_{it} + \alpha_i$ (Chernozhukov and Hansen 2008).[16]

However, this approach poses some difficulties in interpreting the results. For example, observations at the bottom of the $(GS_{it} - \alpha_i)$ distribution may be at the top when compared to the GS_{it} distribution. When adding α_i to the structural quantile function, the QTE vector is supposed to vary only by the unobserved general propensity to save. Thus, since we are interested in the impacts on GS_{it}, and not on $(GS_{it} - \alpha_i)$, we need an alternative approach.

Another option, also valid under the mean regression approach, is to estimate a first-difference version of (10). Again, this is not a good strategy because it implies estimating the impact of covariates at different points of the $(GS_{it} - GS_{it-1})$ distribution, which is generally different from the GS_{it} distribution. Moreover, as emphasized by Powell (2022), even with the inclusion of additive fixed effects in (10), differencing the data does not deal properly with unobserved municipal-level heterogeneity.

Fortunately, it is possible to deal with this issue by not including α_i directly in q_{GS}, but in U_{it}^*. By doing so, we consider the interplay between unobserved municipal heterogeneity and the distribution of the latent rank variable, and, at the same time, we can estimate unconditional (in α_i) quantile treatment effects.

We follow Powell (2022) and assume that our instruments $(\mathbf{Z}_{it})$ are such that $E\left[1(U_{it}^* \leq \tau) - 1\left(U_{it'}^* \leq \tau\right)|\mathbf{Z}_i\right] = 0$ for all *t* and t', where $1(\cdot)$ is an indicator function, which returns 1 if the condition is true and zero if it is not, and $\mathbf{Z}_i = [\mathbf{Z}_{i1} \ \dots \ \mathbf{Z}_{iT}]$. In other words, we

[16] Like Powell (2016), we use $\widetilde{\mathbf{B}}(\tilde{\tau})$ to highlight the difference from $\mathbf{B}(\tau)$ in equation (10).

suppose there is no systematic relation between Z_i and changes in U_{it}^* over time. Therefore, we can estimate (10) by 2SGMM, since the model is overidentified.

Moreover, it is straightforward to estimate the mean treatment effects (MTE) by integration over quantile treatment effects: $\mathbf{MTE} = \int_0^1 \mathbf{B}(\tau)d\tau$ (Powell 2022).

3.3 A Two-Regime Model for Oil Booms and Busts

If we want to investigate whether the behavior of Brazilian local governments is different during oil booms and oil busts, we need a nonlinear model. Specifically, we need these behaviors to depend on the state of oil and gas production and prices (and, so, on oil royalties).

Therefore, we plan to estimate the following asymmetric version of (4):

$$\begin{bmatrix} \Delta E_{it}^C \\ \Delta E_{it}^K \end{bmatrix} = \begin{bmatrix} \beta_+^C & \mu_+^C & \vartheta_+^C & \beta_-^C & \mu_-^C & \vartheta_-^C \\ \beta_+^K & \mu_+^K & \vartheta_+^K & \beta_-^K & \mu_-^K & \vartheta_-^K \end{bmatrix} \begin{bmatrix} \Delta R_{it}^+ \\ \Delta R_{it}^{C+} \\ \Delta R_{it}^{K+} \\ \Delta R_{it}^- \\ \Delta R_{it}^{C-} \\ \Delta R_{it}^{K-} \end{bmatrix} + \begin{bmatrix} \boldsymbol{\varphi}^C \\ \boldsymbol{\varphi}^K \end{bmatrix} \Delta \mathbf{W}_{it} + \begin{bmatrix} \Delta \alpha_{st}^C \\ \Delta \alpha_{st}^K \end{bmatrix} + \begin{bmatrix} \Delta e_{it}^C \\ \Delta e_{it}^K \end{bmatrix}, \quad (11)$$

where $\Delta R_{it}^+ = \max\{0, \Delta R_{it}\}$and $\Delta R_{it}^- = \min\{0, \Delta R_{it}\}$. Definitions of ΔR_{it}^{C+}, ΔR_{it}^{C-}, ΔR_{it}^{K+}, and ΔR_{it}^{K-} are analogous.

Equation (11) captures possible asymmetries between oil booms ($\Delta R_{it} > 0$) and busts ($\Delta R_{it} < 0$) by the potential difference in parameters associated with ΔR_{it}^+ and ΔR_{it}^-. Testing the presence of two regimes is equivalent to testing the null hypothesis of equality between those parameters.

3.4 Relevant Sample, Identification Strategy, and Validation Tests

To improve identification, we restrict the relevant sample to coastal municipalities, such as in Monteiro and Ferraz (2012) and Caselli and Michaels (2013). During much of Brazilian history, the interior of the country has been very sparsely populated. For this reason, coastal municipalities – more populated and more developed – are still quite different from landlocked ones even today (see Appendix C). Restricting the sample to coastal municipalities only gives us a better control group than the sample that includes all municipalities.

Moreover, oil royalties are not exogenous in model (3). Royalty revenues depend on oil and gas production and prices, but also on population and on the location of oil facilities within the territory of municipalities. As pointed out by Caselli and Michaels (2013), the location of these facilities may vary over time, and it is difficult for econometricians to observe. Therefore, local outcomes correlate with royalties, but they may also affect the location of oil facilities or population size. To deal with this potential problem, we apply an instrumental variable approach by defining our excluded instruments as $\mathbf{Q}_{it} = [O_{it} \;\; G_{it}]'$, where O_{it} and G_{it} denote, respectively, oil and gas production (both per capita).

By instrumenting municipal royalty revenues using O_{it} and G_{it}, we want to isolate the effect of local revenue generated only by oil and gas production (and not by other sources). For this approach to be valid, we need the instruments to affect the instrumented variable (R_{it}). We can confirm this by running the following regression (the first stage in a 2SLS approach):

$$R_{it} = \theta O_{it} + \gamma G_{it} + \eta R_{it}^{K} + \lambda R_{it}^{C} + \boldsymbol{\delta}\mathbf{W}_{it} + \xi_i + \xi_{st} + u_{it}, \tag{12}$$

where ξ_i indicates municipal fixed effects, ξ_{st} indicates state-year fixed effects, and u_{it} is an error term. We define the remaining variables as before. The estimated values of θ and γ are highly jointly significant (see Table 10 – Appendix D). In summary, we apparently have strong instruments.[17]

Furthermore, it is important for our identification strategy that oil and gas production is randomly assigned to the municipalities and not related to local factors. In this regard, we are convinced that hydrocarbon discoveries as well as prospecting decisions are independent from local market shocks. As argued by Caselli and Michaels (2013), oil companies that prospect offshore oil – particularly Petrobras, the Brazilian national oil company – are big multinationals and procure most of their input, equipment, labor force, and financing globally (or at least outside local economies). It is unlikely that local factor prices will affect these decisions.

It is also unlikely that local governments can influence Petrobras to drill or develop oil areas that may somehow benefit them, primarily because they do not typically have the political power to do this, given that they are tiny compared to Petrobras and other oil companies (Monteiro and Ferraz 2012; Caselli and Michaels 2013). For statistical evidence on this issue, see Cavalcanti *et al.* (2019).[18]

[17] The procedures to deal with endogeneity in models (4) and (11) are similar to the one in model (3). We transform $\mathbf{Q}_{it}$ into $\Delta\mathbf{Q}_{it}$, $\Delta\mathbf{Q}_{it}^{+}$, and $\Delta\mathbf{Q}_{it}^{-}$ to use as instruments for ΔR_{it}, ΔR_{it}^{+}, and ΔR_{it}^{-}, respectively. The results indicate we also have strong instruments for these models (Table 10 – Appendix D).

[18] It is true that there is anecdotal evidence of federal political interference in some of Petrobras' investment decisions, but always related to refining and other downstream activities, where there is more freedom to choose the location of the facilities, and never related to oil and gas production.

To validate the instrumental variable approach, we also need O_{it} and G_{it} to only have an impact on local outcomes through R_{it}. The existing evidence supports this conjecture: oil drilling has few linkage effects in Brazilian municipalities (Postali 2009). Moreover, only onshore oil drilling has a positive impact on GDP per capita (Cavalcanti *et al.* 2019), which reinforces our decision to restrict the sample to coastal municipalities only.

To check this assumption, we follow a similar approach to Monteiro and Ferraz (2012) by regressing both the number of private employees (per capita) and average private wage on the excluded instruments. The results show non-significant joint effects of oil and gas production on both variables (see Table 11 – Appendix D), confirming our conjecture.[19]

Furthermore, given that most of the variables are defined in per capita terms, we also check, as suggested by Caselli and Michaels (2013), if royalties drive changes in population (through migration, for example). We regress population on oil royalties (and some controls) and find no statistically significant relationship between both variables (see Table 14 – Appendix D).

Regarding identification in model (10), given that both the covariates and instruments are continuous, it is necessary for deviations from $q_{GS}(\tau|X_{it})$ to be correlated with the instruments to guarantee the uniqueness of $B(\tau)$ (Powell 2020). The results in Table 10 (see Appendix D) confirm that the excluded instruments are strong and guarantee identification.

3.5 Data

The database covers the period between 1999 and 2016 annually. Our data on municipal public finances, including different expenses and revenue components, come from FINBRA, a database of the Brazilian National Treasury. The source of information on oil royalty payments and oil production is ANP.

Data on wages and employment – public and private – at the local level come from the Social Security Registry (RAIS), a database provided by the Brazilian Labor Ministry. Other information on municipalities – population, sectoral municipal GDP, geographical issues – comes from the Brazilian National Bureau of Statistics (IBGE).

Finally, all monetary values are in Brazilian currency and represent real values at 2017 prices (deflated using the IPCA – the Brazilian official inflation index). Table 9 in Appendix C shows some summary statistics for Brazilian municipalities.

[19] The same occurs for models (4) and (11) – see Table 11 and Table 12 in Appendix D.

4 Results

4.1 How Do Oil Royalties Impact the Public Budget at the Local Level?

The results in Table 2 show the impact of royalties on public expenditure. The parameters in italics are not directly estimated but calculated from restrictions implied by the public budget constraint. We estimate the models in first differences, but the results are quite the same when using data in levels (see Appendix F).

Oil royalties negatively affect genuine public savings: each extra R$ 1.000 in oil rents reduces *GS* by R$ 0.581 – see column (4), first row. The effect of current non-oil revenues on *GS* is quite small: if royalties increase by R$ 1.000, current spending rises by R$ 0.970 – see column (2), second row. The impacts of capital revenues on current and capital expenses are not statistically significant.

Table 2 Public Expenses and Per Capita Oil Royalties – Coastal Municipalities

	Total Expenses (1)	Current Expenses (2)	Capital Expenses (3)	*Genuine Public Savings* (4)	*Fiscal Surplus* (5)
ΔRoyalties	*0.732**** *(0.116)*	0.581*** (0.127)	0.151*** (0.036)	*-0.581**** *(0.127)*	*0.268**** *(0.116)*
ΔCurrent Non-Oil Revenues	*1.027**** *(0.011)*	0.959*** (0.019)	0.068*** (0.022)	*0.041*** *(0.019)*	*-0.027*** *(0.011)*
ΔCapital Revenues	*0.336* *(0.298)*	0.094 (0.126)	0.242 (0.178)	*-0.094* *(0.126)*	*0.664*** *(0.297)*
Fixed Effects	*NO*	NO	NO	*NO*	*NO*
Differenced Data	*YES*	YES	YES	*YES*	*YES*
Municipalities	*178*	178	178	*178*	*178*
Observations	*2,646*	2,646	2,646	*2,646*	*2,646*

Notes: The table shows the estimated parameters related to per capita royalties, current non-oil revenues, and capital revenues. Below them, in parentheses, are their robust (to heteroscedasticity and municipality clustering) standard errors. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. The parameters are estimated by System Two-Stage GMM (S2SGMM), that is, as a two-equation system with the possibility of correlation between errors from both equations. The columns in italics are not directly estimated but calculated from the model's restrictions. The model also includes (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production.

In Table 3 we show more detailed results. We estimate a four-equation version of model (4), using a thinner classification of public expenditures. We split current expenses into payroll and other current expenditures, and capital expenses into investment and other capital spending. Again, the parameters in italics are not directly estimated, but calculated from restrictions implied by the model. The results do not change substantially when compared to Table 2, which indicates that they are robust to the way we sort public expenditures.

Table 3 Municipal Public Expenses (by Budgetary Component) and Per Capita Oil Royalties – Coastal Municipalities

	Total Expenses	*Current Expenses*	Payroll	Other Current Expenses	*Capital Expenses*	Investment	Other Capital Expenses	*Genuine Public Savings*	*Fiscal Surplus*
	(1)	*(2)*	(3)	(4)	*(5)*	(6)	(7)	*(8)*	*(9)*
ΔRoyalties	*0.723*** (0.104)*	*0.564*** (0.116)*	0.161* (0.097)	0.402*** (0.089)	*0.159*** (0.035)*	0.168*** (0.040)	-0.009 (0.009)	*-0.564*** (0.116)*	*0.277*** (0.104)*
ΔCurrent Non-Oil Revenues	*1.025*** (0.012)*	*0.963** (0.021)*	0.558*** (0.016)	0.405*** (0.033)	*0.062*** (0.016)*	0.035* (0.019)	0.027*** (0.003)	*0.037* (0.021)*	*-0.025** (0.012)*
ΔCapital Revenues	*0.399** (0.192)*	*0.116 (0.076)*	-0.254** (0.112)	0.370** (0.179)	*0.282** (0.126)*	0.307** (0.138)	-0.025 (0.016)	*-0.116 (0.076)*	*0.601*** (0.192)*
F-Test ΔRoyalties = ΔCurrent Non-Oil Revenues	*8.60****	*12.32****	16.03***	0.00	*1.69*	10.22***	12.55***	*27.87****	*8.60****
F-Test ΔRoyalties = ΔCapital Revenues	*1.96*	*9.42****	8.56***	0.02	*0.11*	0.96	1.02	*9.42****	*1.96*
Fixed Effects	*NO*	*NO*	NO	NO	*NO*	NO	NO	*NO*	*NO*
Differenced Data	*YES*	*YES*	YES	YES	*YES*	YES	YES	*YES*	*YES*
Municipalities	*178*	*178*	178	178	*178*	178	178	*178*	*178*
Observations	*2,646*	*2,646*	2,646	2,646	*2,646*	2,646	2,646	*2,646*	*2,646*

Notes: The table shows the estimated parameters related to per capita royalties, current non-oil revenues, and capital revenues. Below them, in parentheses, are their robust (to heteroscedasticity and municipality clustering) standard errors. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. The parameters are estimated by System Two-Stage GMM (S2SGMM), that is, as a four-equation system with the possibility of correlation between errors from all equations. The columns in italics are not directly estimated but calculated from the model's restrictions. The model also includes (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production.

Each R$ 1.000 in royalties increases current expenditures by R$ 0.564 – column (2), first row – and decreases *GS* by the same amount. Of this R$ 0.564 increase, R$ 0.161 refers to payroll expenditures – see column (3), second row. In turn, each additional R$ 1.000 in non-oil current revenue increases public spending on personnel by R$ 0.558. This impact is statistically different from and substantially larger than the one caused by oil royalties – see column (3), fourth row. On the other hand, there is no such difference regarding other current revenues: each additional R$ 1.000 in royalties or non-oil current revenues generates about R$ 0.400 in extra spending – see column (4), first and second rows.

These results make sense, given that Brazilian oil regulation limits spending royalties on payroll. They also complement the findings that institutions – including royalty regulation – somehow induce Brazilian local governments to make good use of oil rents, by limiting their capacity to enlarge the public sector by increasing public jobs (Monteiro and Ferraz 2012).

Royalties also generate more public investment than non-oil current revenues: R$ 0.168 versus R$ 0.035 – see column (6), first and second rows. Moreover, these differences are statistically different from zero. Again, apparently the royalty regulation is binding, since it seems to induce more increments in investment than would occur without legal constraints.

Briefly, legal constraints seem to induce desirable behavior regarding oil revenues, in which municipalities spend less on personnel and more on investments, when compared to non-oil current revenues. In this sense, institutions apparently hamper one of the channels whereby the oil curse arises. Indeed, the spending patterns of oil royalties and capital revenues are similar: there is no statistical difference between them, particularly regarding other current and capital expenditures (including public investment).

The results in Table 4 complement the conditional mean regression estimates in Table 3. We pursue a quantile regression strategy to identify the impact of royalties on genuine public savings at different points of the *GS* unconditional distribution. Particularly, we use the Quantile Regression for Panel Data (QRPD) approach (Powell 2022), described in more detail in section 3.2 and Appendix B. The negative impact of royalties on genuine public savings persists and it is quite robust and strongly significant. The mean treatment effect (MTE) is similar in magnitude to the treatment effect estimated by the mean regression approach (-0.586 in Table 4 versus -0.564 in Table 3), which reinforces the robustness of our findings. However, this negative effect decreases as genuine savings increase. A R$ 1.000 increase in royalties means a R$ 0.695 decrease in genuine public savings in municipalities located at the 25th percentile of the *GS* distribution, a R$ 0.634 decrease at the 50th percentile, and a R$ 0.542 decrease at the

75th percentile. The lower the genuine public savings, the more an increment in royalties translates into current public spending. In other words, the oil curse – at least when understood as using oil rents to fund current expenditures – is more severe in municipalities that were low-savers previously to the receipt of the royalties.

Table 4 Genuine Public Savings and Oil Royalties – Coastal Municipalities (Quantile Regression)

	25th	50th	75th	*MTE*
Royalties	-0.695*** (0.080)	-0.634*** (0.131)	-0.542*** (0.065)	*-0.586*
Current Non-Oil Revenues	0.041 (0.051)	0.098*** (0.008)	0.156*** (0.017)	*0.101*
Capital Revenues	-0.116 (0.077)	-0.150** (0.062)	-0.103 (0.131)	*-0.165*
Municipalities	178	178	178	*178*
Observations	2,914	2,914	2,914	*2,914*

Notes: The table shows the estimated parameters related to per capita royalties, current non-oil revenues, and capital revenues. Below them, in parentheses, are their robust standard errors. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. Estimations are made using the Quantile Regression for Panel Data (QRPD) approach (Powell 2022). The models also include (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production. Columns refer to the effects on the 25th, 50th, and 75th percentiles and mean treatment effect (MTE), respectively.

Like in the models in Table 2 and Table 3, an expansion in non-oil current revenues increases current expenditure almost on a one-to-one basis. Moreover, this effect is stronger in high-saver municipalities. In other words, those municipalities that save relatively more regarding non-oil current revenues are also the ones that do the same with respect to oil royalties. However, even at the top of the genuine public saving distribution, most of the increment in non-oil revenues translates into more current spending. For example, in municipalities in the 75th percentile, a R$ 1.000 increment in non-oil current revenues increases current spending by R$ 0.834 (R$1.000 – R$ 0.156). This can reach R$ 0.959 (R$1.000 – R$ 0.041) for municipalities in the 25th percentile.

Finally, we estimated a negative impact of capital revenues on genuine public savings, but it is statistically non-significant and almost the same throughout the *GS* distribution. This result matches existing empirical evidence that low genuine savings explain the resource curse mostly via a mechanism associated with the bad way resource-rich governments manage current expenses (and not public investment) (Atkinson and Hamilton 2003).

4.2 Do Municipal Governments Respond Asymmetrically to Oil Booms and Busts?

The two-regime model in Table 5 indicates that the impact of royalties on public expenditures is the same during both oil booms and busts for current and total spending. We accept the null hypothesis of symmetry for all expenditures, except for investment and total capital expenses. An increase (decrease) of R$ 1.000 in oil rents raises (reduces) public investment by R$ 0.152 (R$ 0.319) – column (6), first and second rows. The numbers are similar for total capital expenses. That is, the adjustment in capital expenses, particularly in public investment, is more severe during oil busts. These results are consistent with the existing evidence for public budget behavior in developing countries during good and bad times (Ardanáz and Izquierdo 2017).

Another important issue regarding public budget management in Brazil is the difficulty in adjusting payroll expenses during crises. We capture this pattern: R$ 1.000 more (less) in royalties increases (decreases) payroll spending by R$ 0.149 (R$ 0.044), but the difference between both estimated parameters is not statistically significant – column (3). Anyway, the impacts are small, especially when compared to the effect of non-oil royalties on personnel expenditure. The impact of royalties on other current expenditures is also symmetrical. As a result, the response of current expenses to a R$ 1.000 change in oil rents is highly symmetric: R$ 0.445 during oil booms and R$ 0.432 during oil busts.

4.3 A Closer Look at Public Expenses

Table 6 presents the estimated impacts of public revenues on different functions of public expenditures. Again, we estimate all the equations simultaneously and calculate the effect on total public expenses as the sum of all effects. In this regard, the results for total expenditure (and so for the fiscal surplus) are very similar to the ones found in Table 3. This shows that the results are robust to the way we group expenses. The impact of royalties is positive and statistically significant in all functions except Administration & Planning. Each extra R$ 1.000 in oil rents generates R$ 0.213 of new expenses in Health & Sanitation – column (4). This is more than in Education & Culture (R$0.141) – column (3) – and Transport (R$ 0.039) – column (6) – but less than in Housing & Urbanization (R$ 0.309) – column (5).[20]

Furthermore, the impact of royalties is statistically different from the impact of non-oil current revenues for Education & Culture and Housing & Urbanization spending. Specifically, raising oil rents makes public expenses relatively skew away from the first function toward the latter. However, this conclusion warrants a caveat: local governments transform part of royalties into fiscal surplus (25.1 percent, see the last column), and the model is silent on how municipalities allocate such savings in later years.

[20] Nishijima *et al.* (2020) and Chan and Karim (2023) also find that receiving more oil royalties increases municipal education expenditures in Brazil. Despite this increase, there is also evidence that the impact in human capital is negligible.

Table 5 Public Expenses and Per Capita Oil Royalties – Coastal Municipalities (Two-Regime Model)

	Total Expenses	*Current Expenses*	Payroll	Other Current Expenses	*Capital Expenses*	Investment	Other Capital Expenses	*Genuine Public Savings*	*Fiscal Surplus*
	(1)	*(2)*	(3)	(4)	*(5)*	(6)	(7)	*(8)*	*(9)*
Δ(Royalties)$^{+}$	*0.619****	*0.445****	0.149**	0.296***	*0.174****	0.152***	0.022	*-0.445****	*0.381****
	(0.077)	*(0.084)*	(0.073)	(0.041)	*(0.027)*	(0.036)	(0.019)	*(0.084)*	*(0.007)*
Δ(Royalties)$^{-}$	*0.741****	*0.432****	0.044	0.387***	*0.309****	0.319***	-0.010	*-0.432****	*0.259**
	(0.154)	*(0.152)*	(0.054)	(0.139)	*(0.054)*	(0.054)	(0.011)	*(0.152)*	*(0.154)*
Test | H_0: No Asymmetry	*0.49*	*0.01*	1.15	0.41	*5.14***	*8.23****	*1.62*	*0.01*	*0.49*
Δ(Current Non-Oil Revenues)$^{+}$	*0.858****	*0.744****	0.216***	0.529***	*0.114****	0.082***	0.032***	*0.256****	*0.142****
	(0.044)	*(0.040)*	(0.017)	(0.034)	*(0.012)*	(0.020)	(0.008)	*(0.040)*	*(0.044)*
Δ(Current Non-Oil Revenues)$^{-}$	*1.070****	*1.014****	0.610***	0.404***	*0.056****	0.038	0.018**	*-0.014*	*-0.070****
	(0.010)	*(0.013)*	(0.014)	(0.025)	*(0.017)*	(0.023)	(0.007)	*(0.013)*	*(0.010)*
Test | H_0: No Asymmetry	*31,12****	*33.04****	286.3***	5.87**	*10.99****	2.78*	1.89	*33.04****	*31,12****
Δ(Capital Revenues)$^{+}$	*0.450**	*0.250*	-0.054	0.303	*0.201****	0.220***	-0.020	*-0.250*	*0.550***
	(0.245)	*(0.184)*	(0.040)	(0.202)	*(0.070)*	(0.085)	(0.020)	*(0.184)*	*(0.245)*
Δ(Capital Revenues)$^{-}$	*0.261*	*-0.003*	-0.230*	0.227	*0.264*	0.282	-0.017	*0.003*	*0.739****
	(0.227)	*(0.075)*	(0.136)	(0.191)	*(0.181)*	(0.196)	(0.019)	*(0.075)*	*(0.227)*
Test | H_0: No Asymmetry	*3.81**	*2.38*	2.09	0.68	*0.29*	0.26	0.02	*2.38*	*3.81**
Fixed Effects	*NO*	*NO*	NO	NO	*NO*	NO	NO	*NO*	*NO*
Differenced Data	*YES*	*YES*	YES	YES	*YES*	YES	YES	*YES*	*YES*
Municipalities	*178*	*178*	178	178	*178*	178	178	*178*	*178*
Observations	*2,652*	*2,652*	2,652	2,652	*2,652*	2,652	2,652	*2,652*	*2,652*

Notes: The table shows the estimated parameters related to per capita royalties, current non-oil revenues, and capital revenues. Below them, in parentheses, are their robust (to heteroscedasticity and municipality clustering) standard errors. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. All the models are estimated by System Two-Stage GMM (S2SGMM), that is, as a two-equation system with the possibility of correlation between errors from both equations. The models also include (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production.

Table 6 Municipal Public Expenses (by Function) and Per Capita Oil Royalties – Coastal Municipalities

	Total Expenses	Administration & Planning	Education & Culture	Health & Sanitation	Housing & Urbanization	Transportation	Other Functions	*Fiscal Surplus*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	*(8)*
ΔRoyalties	*0.749**** *(0.113)*	-0.308** (0.148)	0.141*** (0.034)	0.213*** (0.051)	0.309*** (0.061)	0.039*** (0.014)	0.355** (0.172)	*0.251*** *(0.113)*
ΔCurrent Non-Oil Revenues	*1.018**** *(0.013)*	0.089*** (0.027)	0.289*** (0.005)	0.210*** (0.012)	0.069*** (0.020)	0.025*** (0.002)	0.337*** (0.038)	*-0.019* *(0.013)*
ΔCapital Revenues	*0.362* *(0.338)*	0.035 (0.033)	0.075 (0.068)	0.040 (0.032)	0.163 (0.141)	0.029 (0.024)	0.020 (0.073)	*0.638**** *(0.338)*
F-Test ΔRoyalties = ΔCurrent Non-Oil Revenues	*5.37***	6.89***	21.67***	0.00	16.13***	0.97	0.01	*5.37***
F-Test ΔRoyalties = ΔCapital Revenues	*1.38*	4.25**	1.51	9.14***	1.04	0.12	3.76*	*1.38*
Fixed Effects	*NO*	NO	NO	NO	NO	NO	NO	*NO*
Differenced Data	*YES*	YES	YES	YES	YES	YES	YES	*YES*
Municipalities	*178*	178	178	178	178	178	178	*178*
Observations	*2,295*	2,295	2,295	2,295	2,295	2,295	2,295	*2,295*

Notes: The table shows the estimated parameters related to per capita royalties, current non-oil revenues, and capital revenues. Below them, in parentheses, are their robust (to heteroscedasticity and municipality clustering) standard errors. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. All the models are estimated by System Two-Stage GMM (S2SGMM), that is, as a six-equation system with the possibility of correlation between errors from all equations. The models also include (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production.

4.4 An Even Closer Look at Payroll Expenses

Table 7 presents the results of our baseline linear model estimated only to payroll expenses. Compared with Table 3, the impact of royalties on payroll spending remains small, but now it becomes statistically non-significant. Furthermore, there is also no statistically significant impact on any of the four categories of payroll expenses. Regulation seems to prevent the excessive use of oil royalties in this kind of expenditure.[21]

Table 7 Public Payroll Expenses and Per Capita Oil Royalties – Coastal Municipalities

	Payroll	Retired Personnel	Active Personnel	Outsourced Personnel	Not Classified
	(1)	(2)	(3)	(4)	(5)
ΔRoyalties	*0.043*	0.010	0.051	-0.004	-0.015
	(0.189)	(0.069)	(0.104)	(0.013)	(0.121)
ΔCurrent Non-Oil Revenues	*0.564****	0.125***	0.381***	0.012***	0.046*
	(0.025)	(0.010)	(0.011)	(0.001)	(0.025)
ΔCapital Revenues	*-0.280***	0.093*	-0.269**	0.019	-0.122*
	(0.135)	(0.055)	(0.135)	(0.012)	(0.068)
Fixed Effects	*NO*	NO	NO	NO	NO
Differenced Data	*YES*	YES	YES	YES	YES
Municipalities	*178*	178	178	178	178
Observations	*2,589*	2,589	2,589	2,589	2,589

Notes: The table shows the estimated parameters related to per capita royalties, current non-oil revenues, and capital revenues. Below them, in parentheses, are their robust (to heteroscedasticity and municipality clustering) standard errors. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. All the models are estimated by System Two-Stage GMM (S2SGMM), that is, as a four-equation system with the possibility of correlation between errors from all equations. The models also include (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production.

Another important issue regarding public budget management in Brazil is the difficulty in adjusting payroll expenses during crises, and this is not different in local Brazilian governments. To investigate this issue, we estimate a two-regime version of the model presented in Table 8 and it confirms this asymmetry. When royalties increase by R$ 1.000, spending on active personnel increases by R$ 0.208 – column (3). However, a decrease in oil revenues of the same magnitude does not affect these expenses. As we can see in Table 5, this asymmetry is compensated for by an opposite asymmetry in capital expenditures. In other words, during oil busts the difficulty in reducing payroll expenditure forces municipalities to cut public investment.

[21] Carnicelli and Postali (2014) and Leão *et al.* (2024) found similar evidence.

However, unlike in the anecdotal evidence from some Brazilian oil states, such as Rio de Janeiro, the asymmetry occurs only in expenditure relative to active personnel, and not in spending on retired public employees. One possible explanation is that, unlike the states, most municipalities in Brazil do not spend a relevant part of their public revenues on retired people. Since this expenditure increases in the future, and certainly will, the cost in terms of cutting investment during oil busts tends to be greater in Brazilian municipalities.

Table 8 Public Payroll Expenses and Oil Royalties – Coastal Municipalities (Two-Regime Model)

	Payroll	Retired Personnel	Active Personnel	Outsourced Personnel	Not Classified
	(1)	(2)	(3)	(4)	(5)
$\Delta(\text{Royalties})^+$	*0.251*** *(0.110)*	0.025 (0.037)	0.208*** (0.076)	-0.001 (0.010)	0.019 (0.053)
$\Delta(\text{Royalties})^-$	*-0.049* *(0.074)*	0.043 (0.052)	0.006 (0.068)	-0.003 (0.009)	-0.096 (0.065)
Test | H_0: No Asymmetry	*3.70**	0.07	2.97*	0.02	2.02
$\Delta(\text{Current Non-Oil Revenues})^+$	*0.206**** *(0.023)*	0.117*** (0.013)	0.154*** (0.011)	-0.002 (0.005)	-0.063*** (0.022)
$\Delta(\text{Current Non-Oil Revenues})^-$	*0.629**** *(0.013)*	0.108*** (0.013)	0.417*** (0.004)	0.015*** (0.001)	0.088*** (0.016)
Test | H_0: No Asymmetry	*165,5****	0.18	492.0**	14.01***	24.65***
$\Delta(\text{Capital Revenues})^+$	*0.037* *(0.067)*	0.076 (0.061)	-0.027 (0.032)	0.016 (0.020)	-0.102 (0.123)
$\Delta(\text{Capital Revenues})^-$	*-0.199*** *(0.010)*	0.021 (0.035)	-0.251* (0.149)	0.005 (0.004)	0.026 (0.030)
Test | H_0: No Asymmetry	*2.74**	1.74	2.07	0.40	0.77
Fixed Effects	*NO*	NO	NO	NO	NO
Differenced Data	*YES*	YES	YES	YES	YES
Municipalities	*178*	178	178	178	178
Observations	*2,583*	2,583	2,583	2,583	2,583

Notes: The table shows the estimated parameters related to per capita royalties, current non-oil revenues, and capital revenues. Below them, in parentheses, are their robust (to heteroscedasticity and municipality clustering) standard errors. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. All the models are estimated by System Two-Stage GMM (S2SGMM), that is, as a four-equation system with the possibility of correlation between errors from all equations. The models also include (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production.

4.5 Robustness Check: Skipping Non-Oil Revenues as Covariates

Part of the existing literature using Brazilian data – Monteiro and Ferraz (2012), for example – estimates models without controlling for non-oil revenues. For the sake of robustness, we estimate models like this and observe no important changes in the estimated parameters (see Table 18 and Table 19, second row, in Appendix G). That is, the inclusion of non-oil revenues does not drive our findings. The fact that most of our results are consistent with those of the previous literature reinforces this statement.[22] However, our specification encompasses the previous models (see section 3.1) and enables us to compare royalties and non-oil revenues in terms of their impact on public expenditures.

5 Discussion and Final Remarks

Is there such a thing as an oil curse? This paper uses a database of Brazilian municipalities to answer this question. Specifically, we investigate the public budget channels whereby this curse may occur.

We find that, on average, oil royalties regulation – which limits the use of oil revenues to fund current expenditures – seems to induce municipalities to save more than they would otherwise. These results complement the findings of Monteiro and Ferraz (2012), which show that these rules somehow constrain local government to make good use of oil rents, that is, by investing rather than consuming them.

We also find that public spending on active personnel responds asymmetrically to changes in oil royalties. It increases when oil royalties expand but does not adjust when royalties decrease. Moreover, the adjustment in capital expenses, particularly in public investment, is more severe during oil busts. In other words, during oil busts the difficulty in reducing payroll expenditure forces municipalities to cut public investment. These results are consistent with the existing evidence for public budget behavior in developing countries during good and bad times (Ardanáz and Izquierdo 2017).

Regarding payroll, the asymmetry occurs only in expenditure relative to active personnel, and not in spending on retired public employees, as occurs in some Brazilian oil states. Nowadays, public spending on retired people is not large in most municipalities, but will certainly increase in the future, and so will the cost in terms of cutting investment during oil busts.

Nevertheless, these are average behaviors. We find that the undesirable behavior of consuming most oil rents is stronger among municipalities at the bottom of the *GS* distribution. That is, the oil curse usually traps low-saver local governments. In addition, the curse has mostly to do with the bad management of current public expenses (and not investments). This evidence confirms – now at the local level – the patterns found when using country level data (Atkinson and Hamilton 2003).

[22] See, for example, Table 10 in Monteiro and Ferraz (2012).

These findings, combined with the evidence that royalties do not substantially increase public goods provision in Brazilian oil municipalities, point to the occurrence of the oil curse to some extent. But they also confirm that the curse is avoidable. Maybe the most successful example is Norway (Holden 2013). And even among Brazilian municipalities and states we can identify different patterns. Rio de Janeiro and Espírito Santo are neighbors and both oil-abundant states. While Rio de Janeiro went into severe fiscal crisis during the recent oil bust, Espírito Santo did not. The difference is just in how governments manage this abundance.[23]

An issue we do not consider here is the political determinants of the asymmetric adjustment in local public budgets. There is a growing literature relating the resource curse to political economy issues, particularly applied to Brazilian municipalities.[24] The existing evidence indicates that corruption (Caselli and Michaels 2013) and adverse selection of politicians (Brollo *et al.* 2013), as well a lack of fiscal transparency (Ardanáz 2014), are possible determinants.[25] In political terms, an oil-based fiscal windfall enable an increase in public spending and raises the chances of bad politicians remaining in office, despite their unproductive and illegal activities. It would also be interesting to address other channels whereby the resource curse affects local economies, for example, the Dutch disease (Allcott and Keniston 2018). However, we only intend to explore these issues in future research.

A Allocating Oil and Gas Production to Municipalities

Fig. 3 and Fig. 4 illustrate the application of orthogonal and parallel lines criteria, used by ANP to define which oil and gas fields face each municipality. To allocate production in a field to a specific municipality, ANP takes the average between the percentages of the field faced by the municipality under the two criteria. For example, if the orthogonal and parallel lines indicate that a municipality faces, respectively, 20 percent and 60 percent of a field, then ANP allocates 40 percent (½ × 20% + ½ × 60%) of oil and gas production to this municipality.

23 The existing evidence shows that Rio de Janeiro consumed its oil rents by more than desirable (Pessôa and Barbosa-Filho 2012).

24 See Robinson *et al.* (2017) for a theoretical model regarding this theme.

25 Notice that Brollo *et al.* (2013) focus not only on oil-based, but on all kinds of fiscal windfalls.

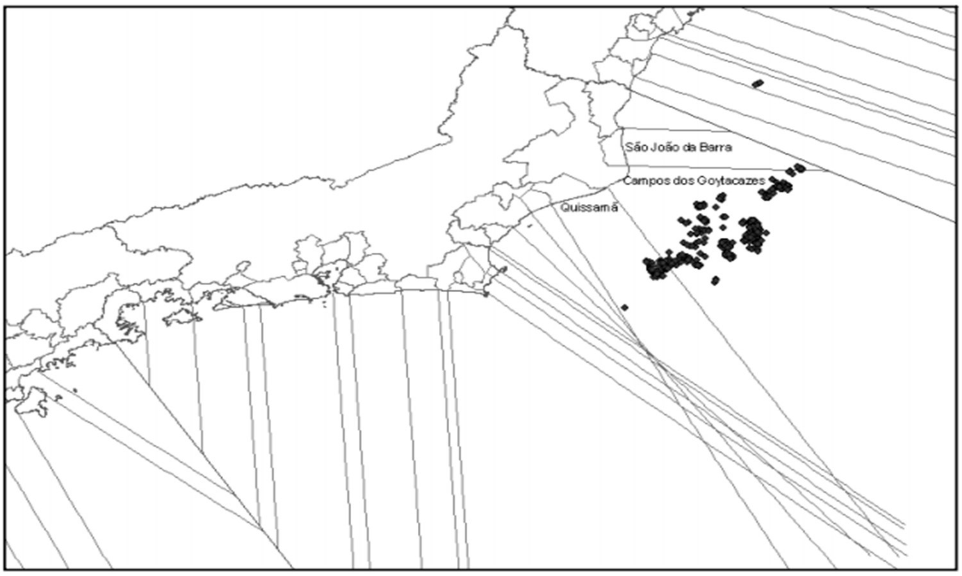

Fig. 3 Orthogonal Lines at Coastal Municipalities – Rio de Janeiro. *Notes:* IBGE (2009).

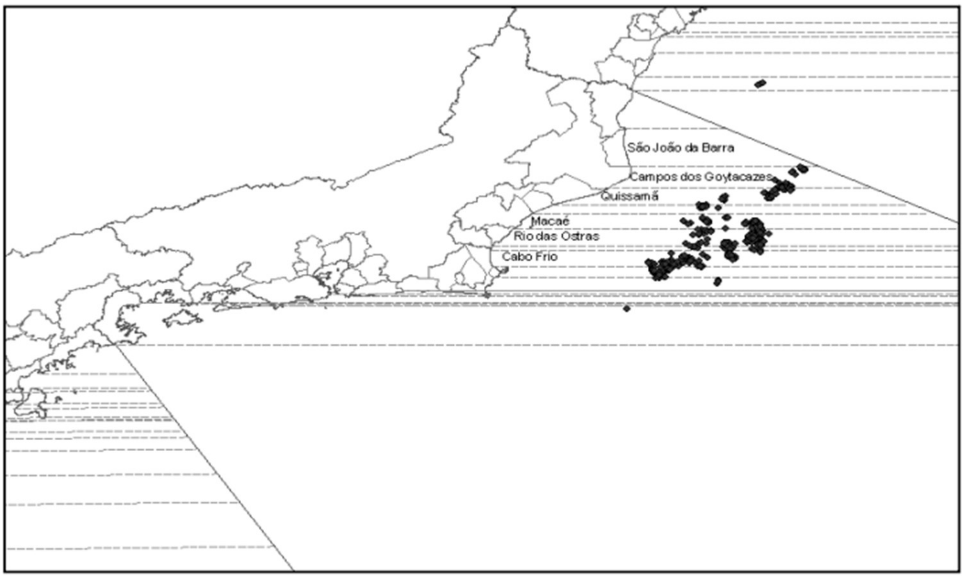

Fig. 4 Parallel Lines at Coastal Municipalities – Rio de Janeiro. *Notes:* IBGE (2009).

B Quantile Regression for Panel Data (QRPD) – Some Details

Assuming that $U_{it}^{*} \sim U(0,1)$, $E\left[1(U_{it}^{*} \leq \tau) - 1\left(U_{it'}^{*} \leq \tau\right)|\mathbf{Z}_i\right]$ for all t and t', and monotonicity of the structural quantile function, we have (Powell 2022):

$$E[1(GS_{it} \leq \mathbf{B}(\tau)\mathbf{X}_{it}) - \tau] = 0, \tag{13}$$

$$E\left\{\frac{1}{T}\sum_{t=1}^{T}(\mathbf{Z}_{it} - \bar{\mathbf{Z}}_i)\,[1(GS_{it} \leq \mathbf{B}(\tau)\mathbf{X}_{it})]\right\} = 0, \tag{14}$$

where $\bar{\mathbf{Z}}_i = \frac{1}{T}\sum_{t=1}^{T} \mathbf{Z}_{it}$. We can use the sample moment conditions equivalent to (13) and (14) to estimate $\mathbf{B}(\tau)$ by 2SGMM.

For computational purposes, one can also constrain the sample version of (13) to hold with equality. When the model includes time fixed effects as covariates, (13) and (14) imply $P(GS_{it} \leq B(\tau)X_{it}) = \tau$ for all *t* (Powell 2022). So, we can restrain the parameter set to:

$$\mathcal{B} \equiv \left\{ \mathbf{b} \mid \tau - \frac{1}{N} < \frac{1}{N}\sum_{i=1}^{N} 1(GS_{it} \leq \mathbf{bX}_{it}) \leq \tau \text{ for all } t \right\}. \quad (15)$$

As argued by Powell (2016), (15) is a way to force $GS_{it} \leq \mathbf{bX}_{it}$ to hold for 100τ percent of observations in each period. Therefore, a GMM estimator for $\mathbf{B}(\tau)$ can be:

$$\widehat{\mathbf{B}(\tau)} = \underset{\mathbf{b}\in\mathcal{B}}{\operatorname{argmin}}\ \hat{\mathbf{g}}(\mathbf{b})'\hat{\boldsymbol{\Omega}}\hat{\mathbf{g}}(\mathbf{b}), \quad (16)$$

where $\hat{\mathbf{g}}(\mathbf{b}) = \begin{bmatrix} \frac{1}{NT}\{\sum_{t=1}^{T}(\mathbf{Z}_{1t} - \bar{\mathbf{Z}}_1)\,[1(GS_{1t} \leq \mathbf{bX}_{1t})]\} \\ \vdots \\ \frac{1}{NT}\{\sum_{t=1}^{T}(\mathbf{Z}_{Nt} - \bar{\mathbf{Z}}_N)\,[1(GS_{Nt} \leq \mathbf{bX}_{Nt})]\} \end{bmatrix}$ and $\hat{\boldsymbol{\Omega}}$ is a weight matrix.[26]

C Some Descriptive Statistics

Table 9 Summary Statistics for Brazilian Municipalities (Non-Weighted Average)

	1999			2016		
	Landlocked	Coastal Non-Producers	Coastal Producers	Landlocked	Coastal Non-Producers	Coastal Producers
Population	27,765	161,549	103,231	32,034	134,172	243,511
GDP (R$ 2017 Per Capita)	14,958	21,719	28,639	24,365	31,287	49,205
Average Private Wage (R$ 2017 per month)	387.36	449.39	459.76	1,351.76	1,447.58	1,700,38
Public Current Revenue (Per Capita)	2,007.84	2,616.24	2,336.21	3,688.49	4,438.93	4,246.89
Royalty Revenues (Per Capita)	5.74	73.47	633.15	10.43	138.48	1,007.96
Royalty Revenues (% of Current Revenue)	0.3%	3.2%	18.0%	0.3%	3.2%	23.0%
Observations	5,220	125	43	5,182	115	60

Notes: Monetary values at constant 2017 prices (deflated using the IPCA – the Brazilian official inflation index). All data from ANP.

[26] We use the Stata command *qregpd* (Baker 2016) to estimate $\mathbf{B}(\tau)$.

D Instruments Diagnostics and Validation Tests

Table 10 First-Stage Results

	Royalties		Δ(Royalties)	
	All Municipalities	Coastal Municipalities	All Municipalities	Coastal Municipalities
Oil Production	19.896*** (4.800)	19.753*** (4.617)	-	-
Gas Production	1.989 (2.806)	-0.489 (3.786)	-	-
Δ(Oil Production)	-	-	7.523 (5.381)	6.887 (5.415)
Δ(Gas Production)	-	-	0.000** (0.000)	0.000*** (0.000)
F Joint Significance Test	10.49***	9.419***	6.892***	13.36***
Fixed Effects	YES	YES	NO	NO
R^2	0.390	0.541	0.008	0.212
Municipalities	5,568	178	5,568	178
Observations	95,512	2,920	88,079	2,656

Notes: Parameters estimated by OLS. The model also includes the (log of) population (or its first difference) and state-year dummies as covariates. We omitted constant and other estimated parameters for convenience. In parentheses are the robust (to heteroscedasticity and municipality clustering) standard errors and in brackets are the *p*-values. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively.

Table 11 Instruments Validation Tests – Level Model

	Private Employees		Average Private Wage	
	All Municipalities	Coastal Municipalities	All Municipalities	Coastal Municipalities
Oil Production	-0.000 (0.000)	-0.000 (0.000)	-0.042 (0.590)	0.028 (0.571)
Gas Production	0.001* (0.001)	0.001 (0.001)	0.339 (0.527)	0.566 (0.645)
F Joint Significance Test	1.425	1.446	0.224	0.453
Fixed Effects	YES	YES	YES	YES
R^2	0.062	0.444	0.463	0.657
Municipalities	5,568	178	5,568	178
Observations	80,556	2,453	80,556	2,453

Notes: Parameters estimated by fixed-effects OLS. The models also include the (log of) population and state-year dummies as covariates. We omitted constant and other estimated parameters for convenience. In parentheses are the robust (to heteroscedasticity and municipality clustering) standard errors and in brackets are the *p*-values. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively.

Table 12 Instruments Validation Tests – First-Differenced Model

	Δ(Private Employees)		Δ(Average Private Wage)	
	All Municipalities	Coastal Municipalities	All Municipalities	Coastal Municipalities
Δ(Oil Production)	-0.000 (0.000)	-0.000 (0.000)	-0.094 (0.109)	-0.154 (0.133)
Δ(Gas Production)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
F Joint Significance Test	1.169	1.051	0.374	0.786
Fixed Effects	NO	NO	NO	NO
R^2	0.215	0.682	0.027	0.166
Municipalities	73,470	2,204	73,470	2,204
Observations	5,568	178	5,568	178

Notes: Parameters estimated by OLS. The models also include the first-differenced (log of) population and state-year dummies as covariates. We omitted constant and other estimated parameters for convenience. In parentheses are the robust (to heteroscedasticity and municipality clustering) standard errors and in brackets are the *p*-values. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively.

Table 13 Instruments Validation Tests – Two-Regime Model

	Δ(Private Employees)		Δ(Average Private Wage)	
	All Municipalities	Coastal Municipalities	All Municipalities	Coastal Municipalities
Δ(Oil Production)$^+$	0.000 (0.000)	-0.000 (0.000)	-0.026 (0.122)	-0.108 (0.163)
Δ(Oil Production)$^-$	-0.000* (0.000)	-0.001 (0.000)	-0.315 (0.390)	-0.292 (0.446)
Δ(Gas Production)$^+$	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Δ(Gas Production)$^-$	-0.000** (0.000)	-0.000* (0.000)	-0.000 (0.000)	-0.000 (0.000)
F Joint Significance Test	2.296*	1.447	0.512	1.297
Fixed Effects	NO	NO	NO	NO
R^2	0.215	0.683	0.027	0.167
Municipalities	73,470	2,204	73,470	2,204
Observations	5,568	178	5,568	178

Notes: Parameters estimated by OLS. The models also include the first-differenced (log of) population and state-year dummies as covariates. We omitted constant and other estimated parameters for convenience. In parentheses are the robust (to heteroscedasticity and municipality clustering) standard errors and in brackets are the *p*-values. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively.

Table 14 Population does Not Depend on Royalties

	1000 × ln (Population)		Population	
	Level	First-Difference	Level	First-Difference
Royalties	-0.027 (0.017)	-	-4.020 (2.703)	-
Δ(Royalties)	-	0.032 (0.039)	-	1.334 (2.399)
Fixed Effects	YES	NO	YES	NO
R^2	0.408	0.100	0.198	0.085
Municipalities	178	178	178	178
Observations	2,923	2,662	2,923	2,662

Notes: Parameters estimated by OLS. The models also include state-year dummies as covariates. We omitted constant and other estimated parameters for convenience. In parentheses are the robust (to heteroscedasticity and municipality clustering) standard errors.

E Public Revenues and Royalties

Table 15 below shows the impact of royalties on public revenues. We estimate all models by System Two-Stage GMM (S2SGMM), that is, as a two-equation system with the possibility of correlation between errors from both equations. The results in the columns regarding total revenues (in italics) were not estimated but calculated as the sum of parameters from current and capital revenue models. We estimate models (2) and (3) in levels (with municipal fixed effects), models (5) and (6) in first differences, and models (8) and (9) in first differences and with potential two-regimes. We find small and statistically non-significant impacts. Apparently, Brazilian local governments do not change their tax efforts in response to variations in oil royalties.

Note that Postali (2015) finds a small negative but statistically significant impact using a stochastic production frontier approach and Brazilian data. In that case, the production function includes much more controls (inputs) than we used here. That is, the results are not directly comparable. Anyway, the effect is actually very small: increasing R$ 1 million in oil royalties generates a R$ 0.002 reduction in tax revenues. For this reason, we are quite confident in assuming that public current and capital revenues do not depend on royalties.

Table 15 Municipal Public Revenues and Per Capita Oil Royalties – Coastal Municipalities

	Total Revenue (Except Royalties)	Current Revenue (Except Royalties)	Capital Revenue	*Total Revenue (Except Royalties)*	Current Revenue (Except Royalties)	Capital Revenue	*Total Revenue (Except Royalties)*	Current Revenue (Except Royalties)	Capital Revenue
	(1)	(2)	(3)	*(4)*	(5)	(6)	*(7)*	(8)	(9)
Royalties	*0.000* *(0.073)*	0.021 (0.071)	-0.020 (0.027)	-	-	-	-	-	-
Δ(Royalties)	-	-	-	*0.114* *(0.142)*	0.081 (0.120)	0.033 (0.052)	-	-	-
$\Delta(\text{Royalties})^{+}$	-	-	-	-	-	-	*-0.095* *(0.085)*	-0.088 (0.071)	-0.007 (0.035)
$\Delta(\text{Royalties})^{-}$	-	-	-	-	-	-	*0.130* *(0.251)*	0.031 (0.211)	0.099 (0.091)
Fixed Effects	*YES*	YES	YES	*NO*	NO	NO	*NO*	NO	NO
Differenced Data	*NO*	NO	NO	*YES*	YES	YES	*YES*	YES	YES
Asymmetry	*NO*	NO	NO	*NO*	NO	NO	*YES*	YES	YES
Municipalities	*178*	178	178	*178*	178	178	*178*	178	178
Observations	*2,919*	2,919	2,919	*2,655*	2,655	2,655	*2,655*	2,655	2,655

Notes: The table shows the estimated parameters related to per capita royalties (or their transformations), and below them, in parentheses, their robust (to heteroscedasticity and municipality clustering) standard errors. Models (2), (3), (5), (6), (8), and (9) are directly estimated by System Two-Stage GMM (S2SGMM), that is, as a two-equation system with the possibility of correlation between errors from both equations. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. For the other models (in italics) the parameters (and their respective standard errors) were calculated indirectly. The models also include (the log of) population, or their first-difference form models (5), (6), (8), and (9), and state-year dummies as covariates. All these parameters are omitted for convenience. The excluded instruments for royalties are oil and gas production (or their transformations).

F Estimating Models with Variable in Levels

Table 16 Municipal Public Expenses (by Budgetary Component) and Per Capita Oil Royalties – Coastal Municipalities

	Total Expenses	*Current Expenses*	Payroll	Other Current Expenses	*Capital Expenses*	Investment	Other Capital Expenses	*Genuine Public Savings*	*Fiscal Surplus*
	(1)	*(2)*	(3)	(4)	*(5)*	(6)	(7)	*(8)*	*(9)*
Royalties	*1.101**** *(0.061)*	*0.669**** *(0.150)*	0.178* (0.102)	0.491*** (0.069)	*0.432**** *(0.111)*	0.430*** (0.119)	0.002 (0.012)	*-0.669** *(0.150)*	*-0.101** *(0.061)*
Current Non-Oil Revenues	*1.010**** *(0.043)*	*0.957**** *(0.050)*	0.505*** (0.015)	0.452*** (0.044)	*0.053* *(0.040)*	0.030 (0.043)	0.023*** (0.005)	*0.043* *(0.050)*	*-0.010* *(0.042)*
Capital Revenues	*0.424**** *(0.161)*	*0.133* *(0.091)*	-0.517 (0.431)	0.650 (0.399)	*0.291** *(0.154)*	0.289* (0.160)	0.002 (0.014)	*-0.133* *(0.091)*	*0.576**** *(0.161)*
Fixed Effects	*YES*	*YES*	YES	YES	*YES*	YES	YES	*YES*	*YES*
Differenced Data	*NO*	*NO*	NO	NO	*NO*	NO	NO	*NO*	*NO*
Municipalities	*178*	*178*	178	178	*178*	178	178	*178*	*178*
Observations	*2,919*	*2,919*	*2,919*	*2,919*	*2,919*	*2,919*	*2,919*	*2,919*	*2,919*

Notes: The table shows the estimated parameters related to per capita royalties, current non-oil revenues, and capital revenues. Below them, in parentheses, are their robust (to heteroscedasticity and municipality clustering) standard errors. The symbols *, **, and *** indicate p-values lower than 10%, 5%, and 1%, respectively. All the models are estimated by System Two-Stage GMM (S2SGMM), that is, as a four-equation system with the possibility of correlation between errors from all equations. The models also include (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production.

Table 17 Municipal Public Expenses (by Function) and Per Capita Oil Royalties – Coastal Municipalities

	Total Expenses	Administration & Planning	Education & Culture	Health & Sanitation	Housing & Urbanization	Transportation	Other Functions	*Fiscal Surplus*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	*(8)*
Royalties	*1.118**** *(0.053)*	0.216*** (0.059)	0.125*** (0.033)	0.174*** (0.058)	0.312*** (0.060)	0.017 (0.018)	0.275*** (0.062)	*-0.118*** *(0.053)*
Current Non-Oil Revenues	*1.008**** *(0.020)*	0.072*** (0.021)	0.297*** (0.014)	0.224*** (0.024)	0.061*** (0.020)	0.029*** (0.003)	0.326*** (0.019)	*-0.008* *(0.020)*
Capital Revenues	*0.558*** *(0.245)*	-0.094* (0.057)	-0.017 (0.038)	-0.019 (0.103)	0.131 (0.101)	0.029 (0.018)	0.528** (0.230)	*0.442** *(0.245)*
Fixed Effects	*YES*	YES	YES	YES	YES	YES	YES	*YES*
Differenced Data	*NO*	NO	NO	NO	NO	NO	NO	*NO*
Municipalities	*178*	178	178	178	178	178	178	*178*
Observations	*2,647*	2,647	2,647	2,647	2,647	2,647	2,647	*2,647*

Notes: The table shows the estimated parameters related to per capita royalties, current non-oil revenues, and capital revenues. Below them, in parentheses, are their robust (to heteroscedasticity and municipality clustering) standard errors. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. All the models are estimated by System Two-Stage GMM (S2SGMM), that is, as a six-equation system with the possibility of correlation between errors from all equations. The models also include (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production.

G Some More Results – Without Non-Oil Revenues Controls

Table 18 Municipal Public Expenses (by Budgetary Category) and Per Capita Oil Royalties – Coastal Municipalities

	Total Expenses	*Current Expenses*	Payroll	Other Current Expenses	*Capital Expenses*	Investment	Other Capital Expenses	*Genuine Public Savings*	*Fiscal Surplus*
	(1)	*(2)*	(3)	(4)	*(5)*	(6)	(7)	*(8)*	*(9)*
Royalties	*1.533*** *(0.393)*	*1.021**** *(0.281)*	0.374*** (0.132)	0.647*** (0.157)	*0.512**** *(0.135)*	0.506*** (0.136)	0.007 (0.006)	*-1.021**** *(0.281)*	*-0.533* *(0.393)*
Δ(Royalties)	*0.730**** *(0.207)*	*0.530**** *(0.194)*	0.113 (0.108)	0.417*** (0.114)	*0.199**** *(0.038)*	0.216*** (0.043)	-0.017 (0.015)	*-0.530**** *(0.194)*	*0.270* *(0.207)*

Notes: The table shows the estimated parameters related to per capita royalties. Below them, in parentheses, are their robust (to heteroscedasticity and municipality clustering) standard errors. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. All the models are estimated by System Two-Stage GMM (S2SGMM), that is, as a four-equation system with the possibility of correlation between errors from all equations. The models also include (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production.

Table 19 Municipal Public Expenses (by Function) and Per Capita Oil Royalties – Coastal Municipalities

	Total Expenses	Administration & Planning	Education & Culture	Health & Sanitation	Housing & Urbanization	Transportation	Other Functions	*Fiscal Surplus*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	*(8)*
Royalties	*1.174**** *(0.241)*	0.249*** (0.072)	0.174*** (0.060)	0.207*** (0.056)	0.294*** (0.080)	0.025 (0.018)	0.226** (0.100)	*-0.174* *(0.241)*
Δ(Royalties)	*0.684**** *(0.162)*	-0.186 (0.132)	0.097** (0.039)	0.192*** (0.048)	0.325*** (0.065)	0.039** (0.018)	0.218** (0.109)	*0.316*** *(0.162)*

Notes: The table shows the estimated parameters related to per capita royalties. Below them, in parentheses, are their robust (to heteroscedasticity and municipality clustering) standard errors. The symbols *, **, and *** indicate *p*-values lower than 10%, 5%, and 1%, respectively. All the models are estimated by System Two-Stage GMM (S2SGMM), that is, as a six-equation system with the possibility of correlation between errors from all equations. The models also include (the log of) population and state-year dummies as covariates. We omitted those parameters for convenience. The excluded instruments for royalties are oil and gas production.

Data Availability Data on municipal public finances, including different expenses and revenue components, come from FINBRA, a database of the Brazilian National Treasury available online at https://www.gov.br/tesouronacional/pt-br/estados-e-municipios/dados-consolidados/finbra-financas-municipais. The source of information on oil royalty payments and oil production is ANP. However, data on oil and gas production in Brazilian municipalities are not directly available. There is monthly information on the production of each oil field and the share of each municipality in the fields. It is necessary to combine this information to calculate the production in each municipality. Data on wages and employment – public and private – at the local level come from the Social Security Registry (RAIS), a database provided by the Brazilian Labor Ministry, available online at https://www.gov.br/trabalho-e-emprego/pt-br/assuntos/estatisticas-trabalho/rais/rais-2024. Other information on municipalities – population, sectoral municipal GDP, geographical issues – comes from the Brazilian National Bureau of Statistics (IBGE), available online at https://cidades.ibge.gov.br/. Finally, all monetary values are in Brazilian currency and represent real values at 2017 prices (deflated using the IPCA – the Brazilian official inflation index).

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