Oil Windfalls and Educational Development

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Resumo

This paper's objective is to estimate the causal effects of oil and gas royalties resources on municipal educational development at elementary School measured by IDEB. To do so, we explore within-country variation of both royalties revenues and educational results across municipalities in Brazil for 15 years. The results indicate that royalties, on the mean, contribute to municipal educational development, but the effects are non-monotonic and heterogeneous. The impacts are more present at municipal schools and some specifications find negative effects for the state schools.

Resumo

O objetivo deste artigo é estimar os efeitos causais dos royalties do petróleo e gás sobre o desenvolvimento educacional municipal no ensino fundamental medido pelo IDEB. Para tanto, exploramos variações dentro do país de recursos dos royalties e resultados educacionais no Brasil por 15 anos. Os resultados indicam que os royalties, na média, contribuem para o desenvolvimento educacional municipal, mas os efeitos são não-monotônicos e heterogêneos. Os impactos se concentram nas escolas da rede municipal e algumas especificações encontram efeitos negativos sobre as escolas da rede estadual.

Keywords: Exhaustible Resources, Public Education, Public Sector, Regional Government Budget

Palavras-Chave: Recursos Exauríveis, Educação Pública, Setor Público, Orçamento Governo Regional

JEL: O13, Q320, H52, I280

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0.1 Introduction

Do oil windfalls contribute to municipal development? The theoretical and empirical literature that explores the linkage between natural resource exploitation and development argue that it can be whether a blessing or a curse (VAN DER PLOEG, (2011)). The outcome depends on a variety of factors, such as the nature of the resource exploitation industry, the institutional context, and the socio-economic characteristics of the city.

In the context of Brazil's Oil production, where most of the production is offshore, it is mostly a question about how the city hall uses the Oil and Gas rents, that due to the Brazilian regulation of the sector is a quite orthogonal windfall. Following a strand of research that goes back to Hartwick (1977), economists argue that the rents should be invested in productive capital to obtain the socially optimal inter-temporal trajectory. There is also a large literature that situates human capital development as a central driver of socioeconomic development, going back to the introduction of human capital at augmented Solow models, passing through the later endogenous growth models.

Productive capital can be whether physical or human capital and so being, educational development should be a good metric for whether the natural resource exploitation is contributing to the social development of a municipality.

With this in mind, this paper intends to identify the impact of oil windfalls on municipal educational development. The empirical strategy exploits within-country variation of royalties resources and educational outcomes measured by IDEB, a Brazilian educational development indicator. It presents econometric evidence that more royalties resource positively affects educational outcomes, even though the effects may be non-monotonic and heterogeneous. As expected, the effects are concentrated at municipal schools.

This paper is organized as follows: Section 2 is a brief literature review of some important theoretical and empirical results; Section 3 describes the institutional context as well as the data used for the econometric analysis; Section 4 presents the identification strategy; Section 5 presents and discuss the results.

0.2 Literature Review

The first more widely known theoretical analysis about the use of natural resources into a microeconomic framework goes way back to Hotelling (1931). In his seminal paper "Economics of Exhaustible Resources", he set the foundation of what would be known as the Hotelling Rule, which describes the optimal rate of extraction of the non-renewable resource and introduce the concept of user cost. The user cost brings the intuition that extracting resources today means less extraction in the future, and this should be incorporated in the optimal decision of the producer.

The notion of Oil Royalties is directly connected to the user cost concept and could be interpreted as the owner of the resource (the federal-estate) forcing the producer to consider the user cost. Hartwick (1977), using a neoclassical growth model that considers the existence of non-renewable resources, states that the social optimal inter-temporal trajectory would be obtained if the resource rents were invested in productive capital, either physical or human.

This literature never considered possible negative effects of resource abundance, but in the 1990s, looking at cross-country evidence, economists started to observe a negative correlation between resource abundance and economic growth. Sachs and Warner (2001) coined the term "Natural Resource Curse" which would be a big field of scientific inquiry, both theoretical and empirical.

Van der Ploeg (2011) is a big survey of this literature and describes the main theoretical paths to explain the so-called resource curse. They can be systematized into three categories. The first can be called the macroeconomic prices mechanism [1], where resource abundance leads to more exportation and currency appreciation, changing internal relative prices in a way that avoids productive development at sectors not related to the resource extraction sector. The second is related to possible armed conflict between different sources of *de facto political power*[2] in dispute of the property and exploitation rights of the natural resource. The third one is more related to political economy, and analyses how the budgetary increase caused by the windfall can lead to the worsening of the municipal governance.

Both cross-country analysis and theoretical models place a high emphasis on the possibility of negative impacts of natural resource abundance for development. But, when more recent research with more credible identification using quasi-experimental designs and exploring within-country variation is considered, the negative relation is not clear anymore (VAN DER PLOEG & POELHEKKE, (2017)).

For Brazil, the empirical literature connecting the Oil Industry and its effects on municipal development finds mixed results. Cavalcanti et al. (2019) , to understand the impact of on-shore Oil production, compares municipalities where Petrobras drilled for Oil but had no success with municipalities where it had success along the second half of the twentieth century. Their results point that oil discoveries increased local production and had positive spillovers in the labor market. These results make sense for the case of onshore production, but when the production is offshore, one would expect limited impacts on the labor market, except for a few municipalities like Macaé-RJ, where Petrobras settled itself and employed lots of people. Even though, much of the new job positions may be filled with migration of skilled labor from other cities.

In the case of offshore production, the impact on municipal social outcomes may

[1] Commonly referred to as the Dutch Disease
[2] In the sense of Acemoglu Johnson and Robinson (2004).

come from the increase in the budget caused by oil windfalls. There are a couple of empirical papers exploring the relationship between these windfalls and municipal development, focusing on the first decade of the 2000s. In this sense, Postali and Nishijima (2011) regressed the Firjan Development indicator on oil and gas royalties and didn't find any positive statistically significant impact on neither education nor health nor labor market. However, looking at more specific social indicators taken from the Brazilian Census, Postali and Nishijima (2013) find positive impacts on access to electric wiring, piped water, waste collection, and decrease of illiteracy rate.

Caselli and Michaels (2013), using oil production as an instrument for royalties to avoid possible endogeneity problems, find that even though there is a positive effect of royalties on public expenditure in health, education, housing, transportation, and social transfers there is no evidence of any improvement at the indicators they selected to represent real outcomes, with a possible exception in garbage collection and education. Monteiro (2015), using the same instrument but a slightly different identification strategy, also finds a positive impact on education expenditure, but no impact on test scores and some other educational indicators, except for professors' salaries. Taken together, these two papers indicate that the royalties increase the city hall effort to develop the municipality, but for some reason, it is not impacting the social indicators.

Both authors argue that the mechanism driving the results may be inefficiency or corruption, but do not provide sound evidence regarding those mechanism. Brollo et all. (2013) provides empirical evidence that an unexpected increase in the municipal budget increase observed corruption and reduce average education of candidates for mayor election. She is not specifically studying oil royalties, but one could argue that her evidence supports the mechanism of resource misallocation.

For Peru, Agüero et. al (2021) inferred positive but decreasing effects of the redistribution of mining rents to municipalities on padronized test scores for language and mathematics. He strongly argues that the impact of natural-resource windfalls should be modeled non-monotonically, which also makes sense according to the theoretical literature already cited.

0.3 Institutional Context and Data

0.3.1 Oil and its rents

Brazil oil production began in the 1940s but it was only in the 1980s that Petrobras, the national Oil company, would find huge offshore oil fields in Campos Basin. In 1997, the Oil Law was enacted, opening the sector for other producers, and defining the basis of the current legislation of Governmental Participation. It also opened the sector to private and foreign producers and gave the municipalities greater importance in the sharing of the sector revenues.

Governmental Participation are financial compensations owed by the producer to the national treasury, it is justified by the loss caused by the extraction of a non-renewable natural resource. This compensation is then distributed to the federal government, to the states, and municipalities. In Brazil, there are four types of Governmental Participation: signature bonus; royalties; special participation; payment for occupation of land. In this paper we will focus on royalties and special participation, which are the most important ones.

Since the 1997 Oil Law, oil companies operating in Brazil must pay up to 10% [3] of brute output value in royalties to the national treasury. The brute output value equals to the volume of oil and gas production multiplied by its reference price, which is determined each month based on international markets and a quality differential. The distribution of this payment have different rules for onshore and offshore production, as well as for the first 5% parcel, determined by Law 7,990/89 and Decree 01/91, and the second 5% parcel, determined by Law 9,478/97 and Decree 2,705/98.

For the first parcel of onshore production, 20% of the royalties goes to producer municipalities and 10% goes to municipalities with facilities to support transportation to and from oil sites. For the second parcel of onshore production, 15% goes to producer municipalities and 7.5% goes to municipalities with facilities to support transportation to and from oil sites.

For the first parcel of offshore production, 10% goes to municipalities with oil and gas transportation infrastructure and 30% to municipalities facing production wells. For the second parcel of offshore production, 22.5% goes to municipalities facing production fields, and 7.5% goes to municipalities with oil and gas transportation infrastructure.

The facing quotas are determined by parallel and orthogonal lines extracted from nautical letters. For the first parcel, they are related to oil wells, while for the second parcel it relates to oil fields.

The onshore royalties distribution is simple, if the well is located inside the municipality, it receives the royalties. The offshore royalties distribution is way more complicated and will be discussed in more detail.

The first parcel focuses on the production wells and benefits a larger number of municipalities when compared to the second parcel. For example, the 10% amount related to transportation infrastructure is distributed equally to all beneficiaries. The following 30% is distributed according to the separation of facing municipalities in three zones:

- Main Production Zone (60%) : Well-facing municipalities that have three or more oil and gas related infrastructure. The distribution within this group also follows a population size rule.

[3] 15% if the production is done under the "sharing regime".

- Secondary Production Zone (10%) : Municipalities cut by oil or gas ducts directly connected with the transportation of production.

- Limit zone (30%) : Municipalities that neighbor the municipalities from the Main Production Zone.

The second parcel focuses on the production fields, and benefit a smaller number of municipalities. The 7.5% quota related to municipalities with facilities to support transportation to and from oil sites considers the amount of oil transported by each facility. The 22.5% quota is distributed to municipalities according to the mean percent of confrontation with a producer field at the continental platform. This mean is calculated by the ratio of the field area between the projection lines of its territorial limits and the sum of the field areas between the same projection lines regarding all the facing municipalities.

For highly productive fields, the producer also pays the special participation, that follows progressive quotas. For onshore production, 10% of this financial compensation goes to producing municipalities and, in the case of offshore production, 10% goes to the facing municipalities, according to the mean percent of confrontation. This legislation contributes to the concentration of the oil rents in some municipalities.

The legislation of the governmental participation is more complex than described here, and since the 1997 Oil Law a few more laws and decrees were approved changing some details, but for the purpose of this paper the brief summary presented here is enough. What matters the most is that the oil rents each municipality receives are correlated with the oil production, reference prices, population, and productive structure. This assignment rule may cause some endogeneity problems for our identification strategy, and the ideal procedure would be to instrument royalties with the arguably exogenous to municipalities offshore production. But, because of time and resource constraints, this paper will have to use the actual royalty [4], including some controls in the regression aiming to avoid these endogeneity problems. Data for royalties is available at ANP website, and population and municipal GDP is available at IBGE website.

One particular thing about the royalties is that municipalities have almost no restriction regarding their use. The only real restriction is specific to the first parcel and prohibits its use for permanently contacting public workers and paying debts.

By 2019, approximately 75% of the sample have received some amount of royalty resource, but the treatment intensity presents plenty of heterogeneity within the sample. The biggest amount of oil and gas production situate at Campos Basin, where the production peaked in the first decade of the 2000s, and the Santos Basin, where most of the pre-salt production occurs. The fields situated in these two basins face mostly municipalities in Rio de Janeiro, Espírito Santo, and São Paulo. Tables 1 and 2 present

[4] for now on, when we talk about royalties we are actually talking about royalties plus special participation.

the amount received by the top 15 municipalities at 2018 prices, at the absolute value, and per capita. The tables makes it clear that the these three states from the south-east region of Brazil are by far the largest beneficiaries of the royalties distribution and Rio de Janeiro is particularly privileged.

Table 1 – 15 top beneficiaries (milion reais, 2018 prices)

	State	Municipality	Royalties + SP
1	RJ	Campos dos Goytacazes	23556.66
2	RJ	Macaé	11750.57
3	RJ	Rio das Ostras	7312.19
4	RJ	Maricá	5200.76
5	RJ	Cabo Frio	5008.75
6	RJ	Niterói	4940.36
7	RJ	São João da Barra	3383.29
8	ES	Presidente Kennedy	3125.66
9	SP	Ilhabela	3111.89
10	RJ	Quissamã	2588.05
11	RJ	Rio de Janeiro	2322.03
12	ES	Itapemirim	1967.94
13	RJ	Casimiro de Abreu	1950.98
14	SP	São Sebastião	1833.71
15	RJ	Angra dos Reis	1600.45

Source: ANP

Table 2 – 15 top beneficiaries (per capita, 2018 prices)

	UF	Município	Royalties + PE (pcap)
1	ES	Presidente Kennedy	284438.60
2	RJ	Quissamã	142144.41
3	RJ	Rio das Ostras	106401.37
4	RJ	São João da Barra	104191.27
5	SP	Ilhabela	96711.65
6	RJ	Carapebus	77723.32
7	RJ	Macaé	62459.46
8	RJ	Casimiro de Abreu	61044.51
9	RJ	Armação de Búzios	60671.60
10	ES	Itapemirim	58954.81
11	RN	Guamaré	54749.76
12	RJ	Campos dos Goytacazes	52432.70
13	SP	Ilha Comprida	44911.69
14	BA	Madre de Deus	42535.48
15	SE	Carmópolis	39784.04

Source: ANP

0.3.2 IDEB

IDEB is a Brazilian educational development indicator that combines padronized test scores with approval rates of each school, calculated by INEP and available at its website. It is calculated for the whole country, state level, municipal level and for each school. Its divulgation occurs every two years since 2005. The IDEB formula is:

$$IDEB_{it} = N_{it}P_{it}$$

$$0 \leq N_i \leq 10 \qquad 0 \leq P_i \leq 1 \qquad 0 \leq IDEB_i \leq 10$$

Where t indexes the year of the exam, i indexes the unity of analysis; N_{it} is the proficiency mean in Portuguese and Mathematics; P_{it} is an indicator based on the approval rate. For the municipal level, IDEB summary results for students of the elementary school fifth grade and ninth grade, and third year of high school of the following schools:

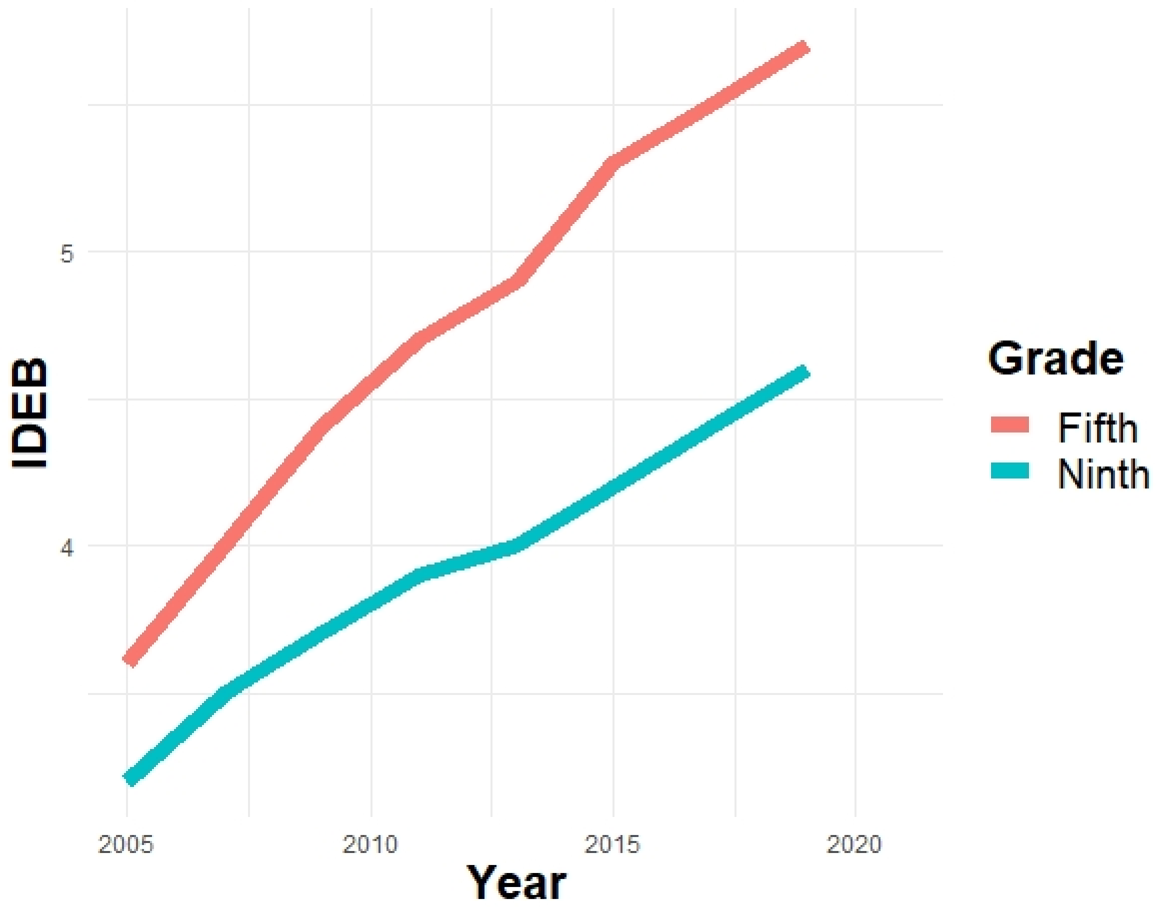
- Public schools (urban public schools);
- Federal schools (urban federal public schools);
- State schools (urban state public schools);
- Municipal schools (urban municipal public schools).

The analysis focus on the public schools, that aggregate the other three, and also report results specifically for state and municipal schools. This is done for two reasons. First, some municipalities don't have any federal school, what makes for missing problems. Also, the educational system of Brazil makes the municipalities more focused on elementary schools. Second, we don't focus only on municipal schools because it is possible that the oil windfall benefits educational development for other channels besides the direct administration and spending levels, such as an increase in municipal income per capita, provision of other public goods that have a positive association with schooling results, such as roads, health, electricity, and potable water.

Figure 1 plots the IDEB national trend from 2005 to 2019 for the fifth and ninth grades of the public schools. It clearly shows a growing trend on the indicator, and the analysis will focus on identifying if the municipalities benefited from royalties managed to develop more than the non-beneficiaries.

Besides data from ANP and INEP, data from IBGE will also be used on the econometric analysis. The final database is a panel where each line is one observation of one municipality at one year. To avoid the comparison of apples with oranges, we restrict the sample only to coastal states. The sample size range from approximately 2500 municipalities to 3500. It varies depending on the specification due to missing data.

Figure 1 – National mean IDEB Public schools



0.4 Empirical Strategy

To identify the impact of oil windfalls on municipal educational development we explore variation within Brazil across years. Our identification strategy consists of two methodologies. The first one is a two-way fixed effects model, which will compute year-by-year variation on IDEB and deliver a mean of these variations. The second one is a long difference approach which is better suited to understand the long-term trends of educational development in the presence of oil windfalls.

0.4.1 Two Way Fixed Effects

The first methodologies consists of the estimation of a two-way fixed effects model (TWFE). It is comparing for every two years (due to IDEB divulgation) the difference in the educational outcome between the treatment and control group. A quadratic version of the treatment variable (royalties) will be included to test the hypothesis of non-monotonic effects, in line with recent literature for Peru (AGÜERO et al., 2021).

The model specification is:

$$Y_{it} = \beta_0 + \beta_1 Royalties_{it} + \beta_2 Royalties_{it}^2 + \beta_3 X_{it} + \gamma_i + \delta_{st} + \epsilon_{it} \tag{1}$$

Where i indicate municipality, t indicates time, and s indicate state. Y_{it} is the IDEB for the fifth and ninth grade of public, municipal, and state schools; $\beta_1 Royalties_{it}$ is royalties plus special participation per capita at 2018 values, as a mean of the amount received in t and $t-1$. X_{it} is the vector of controls, which include the log of population and added value of the industrial sector. Those two controls are included to avoid the endogeneity problem caused by royalties allocation being correlated with population and oil-related economic activity in the municipalities, once it is plausible to assume these two variables are also correlated with IDEB.

γ_i is municipal fixed effects, which control for time-invariant municipal specific characteristics that could bias the estimate, and δ_{st} is the state-specific time fixed effects, which will control for state-specific confounders that can vary over time. The stochastic error term is clustered at municipal level.

Traditionally, it would be stated that under the identifying assumption of no time-variant unobserved variables specific to the municipalities affecting both royalties and the outcome variable $\hat{\beta}_1 + 2\hat{\beta}_2 Royalties$ would deliver the parameter of interest, the average treatment effect on treated (ATT). But nowadays it is clear that under the TWFE framework with time-varying treatment we are also assuming other additional hypotheses. Goodman-Bacon (2018) demonstrates that in such context the TWFE only delivers the ATT when the treatment effects are homogeneous between treatment units and non-dynamic. Chaisemartin and D'Haultfœuille (2020) provide similar results and extend them to the case of a continuous treatment variable.

Those last two hypotheses seem kind of heroic in the assignment context of this paper, nevertheless, the TWFE results will still be reported as a benchmark, once it is such a common estimator at economics research. The quasi-orthogonality of the treatment assignment helps to sustain the basic hypothesis of no unobserved time-varying confounders. It is important to have in mind that this is a reduced-form exercise aiming to estimate the impact of royalties on IDEB through a wide variety of channels, which explain the conservative position on the inclusion of controls. For example, it is possible to control for each period municipal GDP per capita, once it is correlated both with royalties and IDEB, but this would close one possible causal channel of interest. If the royalty cause GDP growth from t to $t+1$, and this growth have negative impact on infant labor market participation through an increase at family budget, which in turn make possible for the kid to dedicate more time to studying, the inclusion of this control would make the estimation blind to this mechanism.

0.4.2 Long Differences

The second estimation is a long differences approach in line with the one proposed by Burke and Emerick (2016). The model is derived from the following equations:

$$Y_{i2005} = \alpha + \alpha_1 \overline{Royalties_{i2005}} + \alpha_2 \overline{Royalties_{i2005}}^2 + \alpha_3 X_{i2005} + \gamma_i + \overline{\epsilon_{i2005}} \tag{2}$$

Where Y_{i2005} is IDEB at the year 2005, $\overline{Royalties_{i2005}}$ is the mean of the amount of royalties per-capita received from 2000 to 2005 for municipality i. A similar equation for 2019 is:

$$Y_{i2019} = \alpha + \alpha_1 \overline{Royalties_{i2019}} + \alpha_2 \overline{Royalties_{i2019}}^2 + \alpha_3 X_{i2019} + \gamma_i + \overline{\epsilon_{i2019}} \tag{3}$$

Where $\overline{Royalties_{i2019}}$ is the mean of the amount of royalties per-capita received from 2014 to 2019. Taking the difference of (3) with (2) and including state fixed effects we get:

$$\triangle Y_i = \alpha_1 \triangle Royalties_i + \alpha_2 \triangle Royalties_i^2 + \alpha_3 \triangle X_i + \psi_s + \triangle \epsilon_i \tag{4}$$

This specification rules out time-invariant municipal-specific confounders and is not subject to the TWFE problems described at Goodman-Bacon (2018). Since state fixed effects are included, the estimator will compute within-state comparisons. The error term is clustered at municipal level. Differently from the TWFE approach, it estimates the long-term impact of royalties on IDEB.

The identifying assumption is that the royalties variation is not correlated with any unobserved time-varying factors that also affect IDEB. Once again, the quasi-orthogonality of royalty assignment helps to sustain this evidence. Offshore oil production is a large-scale long-term operation and it is not plausible to assume that the city hall has any power to affect this production decision. Monteiro and Ferraz (2017) provide evidence that for the case of offshore production there is no correlation with labor market outcomes, which also helps to sustain the identifying assumption. Furthermore, the argumentation regarding the reduced-form nature of this econometric exercise developed for the TWFE subsection also applies to the long differences approach.

0.5 Results

Tables 3, 4, and 5 present the results for the TWFE models estimation, for the public, municipal, and state schools. Tables 6, 7, and 8 present the results for the long differences model estimation. All the tables have the same column ordering. Column 1 presents the monotonic treatment specification results for the ninth grade, column 2 presents the addition of the quadratic treatment for the same grade, column 3 and 4 presents the monotonic and the addition of the quadratic treatment for the fifth grade.

0.5.1 Results from TWFE

The estimation of the TWFE models didn't find any significant impact of the royalties on IDEB indicators when all the public schools are considered. When only the municipal public schools are considered at the IDEB calculation, a positive impact for the Ninth-grade students is significant at 10% , in the case were the treatment effect is assumed to be monotonic. For this sample, one standard deviation[5] (914.45R\$ per capita) of the two years mean of royalties revenues is associated with a 0.13 increase at the IDEB score. For the state schools ninth grade students, the model inferred a negative impact significant at 5% for both the monotonic and quadratic specifications. For the monotonic specification, one standard deviation is associated with a decrease of 0.123 on the IDEB indicator. For the non-monotonic specification, the estimated impact is larger, but since we didn't reject the null hypothesis for the quadratic treatment, we only consider the monotonic specification.

Table 3 – Results for Public schools (TWFE)

	Dependent variable:			
	Ninth Grade		Fifth Grade	
	(1)	(2)	(3)	(4)
Royalties	−0.000016666	−0.000162613	0.000022840	−0.000025443
	(0.000050167)	(0.000104662)	(0.000049066)	(0.000107451)
Royalties^2		0.000000080**		0.000000027
		(0.000000039)		(0.000000050)
Population	0.005343357	0.005400703	−0.023191930	−0.023090310
	(0.045862340)	(0.045861840)	(0.049920600)	(0.049931460)
Industry AV	−0.000000042	−0.000000129	0.000000650	0.000000622
	(0.000000701)	(0.000000708)	(0.000000586)	(0.000000601)
Observations	23,232	23,232	23,808	23,808
R^2	0.882586600	0.882605100	0.923738400	0.923739500
Adjusted R^2	0.865055600	0.865070200	0.912363700	0.912360700

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

0.5.2 Results from Long Differences

When all the public schools are considered and non-monotonic effects are assumed, the long differences models inferred positive and statistically significant at 5% treatment effects of royalties on the performance of fifth grades students. The quadratic treatment variable estimates a marginally decreasing effect, significant at 1%. The estimates tell

[5] The standard deviation was estimated taking into account all the observations of the treatment group

Table 4 – Results for Municipal schools (TWFE)

	Dependent variable:			
	Ninth Grade		Fifth Grade	
	(1)	(2)	(3)	(4)
Royalties	0.00014*	0.0002	0.00005	−0.0000009
	(0.000083)	(0.00014)	(0.000049)	(0.00011)
Royalties^2		−0.00000003		0.00000003
		(0.00000004)		(0.00000005)
Population	0.279***	0.279***	0.152***	0.152***
	(0.057745380)	(0.057749280)	(0.059223180)	(0.059236470)
Industry AV	−0.0000006	−0.0000005	0.0000007	0.0000007
	(0.0000004)	(0.0000004)	(0.0000007)	(0.0000007)
Observations	19,672	19,672	22,272	22,272
R^2	0.978940900	0.978941600	0.940021300	0.940022500
Adjusted R^2	0.975771900	0.975771200	0.931049100	0.931046900

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

Table 5 – Results for State schools (TWFE)

	Dependent variable:			
	Ninth Grade		Fifth Grade	
	(1)	(2)	(3)	(4)
Royalties	−0.000135**	−0.00030667**	−0.000036	−0.0001245
	(0.000062322)	(0.000138397)	(0.000063966)	(0.00018328)
Royalties^2		0.00000009		0.00000004
		(0.00000006)		(0.00000006)
Population	−0.1376343**	−0.1385866**	0.001559873	0.0015978
	(0.05591440)	(0.0559228)	(0.05365125)	(0.05365426)
Industry AV	−0.00000000	−0.00000010	−0.00000085	−0.0000009
	(0.00000061)	(0.00000062)	(0.00000074)	(0.00000076)
Observations	16,800	16,800	16,776	16,776
R^2	0.973991900	0.973996700	0.987006000	0.987006800
Adjusted R^2	0.970043800	0.970047300	0.985033300	0.985033200

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

that one standard deviation at the 6 years means of royalties revenue from 2005 to 2019 is associated with 0.12 positive variation at IDEB score on the same time period.

For the municipal schools, the results go in the same direction as the ninth-grade students at the public schools for the fifth and ninth-grade students. For the ninth grade, one standard deviation of the treatment intensity is associated with a 0.23 increase at the IDEB score and a 0.18 increase for fifth-grade students. When only the state schools are considered, the only significant effect is found at the non-monotonic specification for the fifth grade. It says that one standard deviation on royalty revenue causes a 0.12 reduction at the IDEB score.

Table 6 – Results for Public schools (Long-diff)

	Dependent variable:			
	Ninth Grade		Fifth Grade	
	(1)	(2)	(3)	(4)
Royalties	−0.000006	0.000068875	−0.000055945	0.000167409**
	(0.00006)	(0.000088290)	(0.000064048)	(0.000085326)
Royalties^2		−0.000000014		−0.000000042***
		(0.000000011)		(0.000000012)
Population	−0.000001	−0.000001339	0.000000494	0.000001513
	(0.000001)	(0.000001614)	(0.000001440)	(0.000001370)
Industry AV	−0.0000	−0.000000029	−0.000002026**	−0.000001961**
	(0.0000)	(0.000000817)	(0.000000918)	(0.000000915)
Observations	3,229	3,229	3,227	3,227
R^2	0.371382500	0.371552100	0.267126400	0.268474500
Adjusted R^2	0.367857600	0.367831100	0.263014300	0.264140500

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

Table 7 – Results for Municipal schools (Long-diff)

	Dependent variable:			
	Ninth Grade		Fifth Grade	
	(1)	(2)	(3)	(4)
Royalties	0.00007	0.000280416**	−0.00001	0.000240522***
	(0.00009)	(0.000133284)	(0.00007)	(0.000092085)
Royalties^2		−0.000000035***		−0.000000048***
		(0.000000012)		(0.000000012)
Population	−0.00000**	−0.000001313	0.00000	0.000002326
	(0.00000)	(0.000000973)	(0.00000)	(0.000001530)
Industry AV	0.00000***	0.000006076***	−0.00000	−0.000000031
	(0.00000)	(0.000001392)	(0.00000)	(0.000001013)
Observations	2,683	2,683	2,966	2,966
R^2	0.579260400	0.579901800	0.267206400	0.268697900
Adjusted R^2	0.576417600	0.576904500	0.262730500	0.263981400

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

0.5.3 Discussion

Taken together, the evidence presented in this paper indicates an overall positive but decreasing effect of royalties revenue on municipal educational development, with important heterogeneity. When all the public schools are considered, only the fifth grade has positive statistically significant effects, the estimated coefficient for the ninth grade is positive, but the standard error is too big. But, when we decompose the public school system between state and municipal schools, we see that the municipal schools are driving the results upward, and the state schools are pushing it the opposite way. The positive effects being concentrated at city hall managed schools make sense, but the negative effects on the state managed schools is puzzling.

There are multiple possible mechanisms driving these results, but maybe the city hall is

Table 8 – Results for State schools (Long-diff)

	Dependent variable:			
	Ninth Grade		Fifth Grade	
	(1)	(2)	(3)	(4)
Royalties	−0.000127**	−0.0001	−0.000099583	−0.000216629
	(0.000060)	(0.0001)	(0.000074636)	(0.000164147)
Royalties^2		0.000		0.000000019
		(0.000)		(0.000000022)
Population	−0.000002	−0.000	0.000001710	0.000001209
	(0.000002)	(0.000)	(0.000002905)	(0.000003175)
Industry AV	0.000003**	0.000**	0.000008452***	0.000008439***
	(0.000001)	(0.000)	(0.000002207)	(0.000002209)
Observations	2,371	2,371	2,258	2,258
R^2	0.303142000	0.303184900	0.457839100	0.458005700
Adjusted R^2	0.297808900	0.297553400	0.453480500	0.453404300

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

investing in the municipal network schools and attracting better social condition students to it, making the pool of state school students to be composed of socially disadvantaged kids. It is quite well established that social inequalities matter when one is talking about educational results, once kids that come from a higher income home have both more time and more incentives to study. There is robust evidence that royalties cause an increase in public spending(CASELLI, MICHAELS, 2013; MONTEIRO, 2015), which makes public spending a strong possible mechanism. Another possible mechanism is that the expansion of the municipal school system in both qualitative and quantitative terms crowds-out state government efforts to offer good quality schools.

0.6 Conclusion

This paper presented evidence that municipalities that receive royalties are having better educational results, measured by a mean of test scores and approval rates, than the ones not receiving royalties. Although, the effects are heterogeneous and non-monotonic.

Assuming that educational development is both a cause and a consequence of social development, one can state that the royalties are helping to develop some Brazilian municipalities. This doesn't mean that the rules shouldn't be changed, it doesn't appear to make sense so much money being concentrated in only a few municipalities. The econometric exercise provides evidence that the marginal effect decrease according to the amount of royalties received, and this result enforce the argument for better distribution of these resources if the aim of the national estate is to maximize social welfare across the whole territory.

We still have a lot to advance at the analysis of the relation of royalties with educational development. In the future, we pretend to apply more robust identification methods, instrumenting royalties for offshore oil and gas production and limiting the sample for municipalities with no onshore production. We also pretend to go beyond the IDEB, constructing more specific indicators to better understand the pattern of educational development and the channels of causation.

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