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Oil windfalls and local fiscal effort: a propensity score analysis

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Abstract:

With the pre-salt discoveries, the discussions about the impact of oil windfalls – royalties and special participation – on Brazilian localities have intensified. This article aims to contribute to the understanding of the issue, using a methodology that allows the building of a counterfactual for municipalities treated with oil resources. The aim is to investigate whether these transfers reduce the own tax effort of cities covered by such revenues. For this, we apply the doubly robust method to a panel of municipalities observed from 2000 to 2009. The method consists of two stages. Firstly, it estimates the likelihood of receiving oil revenues conditioned to observable variables; in the second stage, a fixed-effects model is estimated with data belonging to a common support constructed through the estimated propensity scores in the first stage. The results show that there is a negative effect of oil royalties on the fiscal effort of the cities benefited. However, this result does not occur when one computes the average effect on all cities..

Keywords: Propensity score, doubly robust, oil royalties, fiscal effort, panel.

JEL Codes: H77, C21.

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1. Introduction

Brazil is in the midst of an intense discussion on the sharing of oil rents across the subnational governments. In 2007, huge oil deposits were discovered in the pre-salt oceanic layer offshore from Brazil. In 2012, the Congress approved a new law (12.734/2012) that shifts a substantial portion of the oil revenues from the current beneficiaries to non-producing localities, but the law has been temporarily suspended by the judiciary, after protests from some damaged states. If the new law becomes effective, the number of beneficiary municipalities will be extended considerably.

Moreover, the Brazilian municipalities present growing dependence on oil rents. Graph 1 shows the average annual oil revenues of all the beneficiaries, in per capita terms. In 2002, this value was around R$47.00,[1] jumping to a level above R$60.00 in subsequent years, with a peak of R$110.00 in 2008, due to high oil prices in the international market. Graph 2 shows the average share of these resources in the municipal budget revenues of the beneficiaries. Only in 2009, when the international oil prices plummeted, did the fraction of royalties and special participation in the budgets of the beneficiaries fall to an average below 3%.

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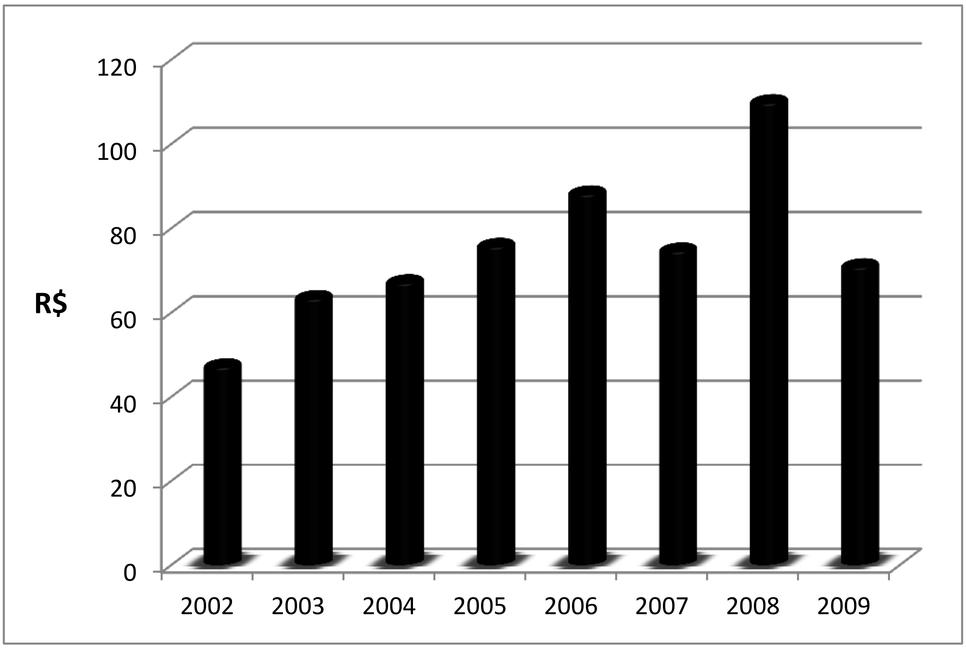
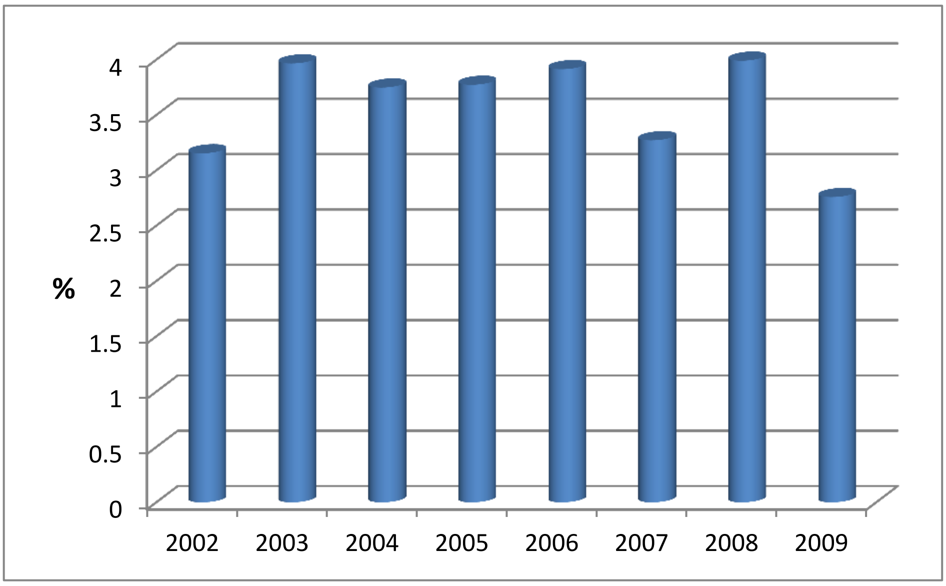
[1] "Real" is the Brazilian currency. The exchange rate reais/US dollars is around 2.30 (March 2014).

Graph 1: Oil windfalls, per capita



Source: Elaborated by the authors, based on data from ANP and Finbra.

Graph 2: Oil windfalls to budget revenues ratio



Source: Elaborated by the authors, based on data from ANP and Finbra.

The sharing of oil rents across subnational governments involves fiscal federalism issues. From a federative perspective, the fundamental rationale behind a fiscal federalism system is the equalization of fiscal capacities across regions (Dahlby & Wilson, 1994; Oates, 1999), which is relatively common in continental nations. According to Winer (1983), fiscal federalism, understood as the separation between the ability to tax and the decision to spend by federal entities, raises the relative size of subnational governments as a consequence of grants from the central government, a phenomenon attributed to the reduced perceived cost of public funds (Logan, 1986). There is some evidence that federal grants also raise the rates of local distorting taxes (Smart, 1998; Smart, 2007) and increase the moral hazard problems (Sanguinetti & Tommasi, 2004), leading to overspending and failure to collect local taxes.

Ahmad and Mottu (2002) make an assessment of the sharing of oil revenues of some representative countries, classifying them into four groups: i) fully centralized oil revenues (common in unitary countries such as Libya, Iran, Indonesia, Saudi Arabia, Qatar, Norway and the United Kingdom), ii) fully decentralized oil revenues, in the charge of subnational governments (e.g., the United Arab Emirates); iii) revenue sharing among levels of governments (e.g., Mexico, Nigeria, Russia and Venezuela); and iv) a shared revenue base, the main examples of which are Canada and the United States. The Brazilian case can also fit into the latter category. According to the authors, centralized systems are preferable to the others, because oscillations in international oil prices make such revenues volatile, which may produce instabilities in the budget of localities that are highly dependent on them. Central governments would have a greater ability to protect themselves against this risk. Furthermore, the high dependence of subnational governments on oil rents can reduce the incentives to diversify the local tax base. Mixed systems, on the other hand, may be an opportunity to reduce the regional inequalities by transferring oil revenues from oil-rich/producing regions to poor/non-producing ones (Ahmad & Mottu, 2002).

Regarding the Brazilian case, several studies (e.g., Shah, 1994; Cossio, 1998; Ribeiro & Shikida, 2000) find evidence of an inverse relationship between subnational fiscal effort and grants from the federal government. Similar evidence is reported for other countries: Buettner (2006) finds similar evidence for German localities, while Dahlberg et al (2008), in a study on Sweden, conclude that such grants worsen spending, but not tax revenues.

On the government spending side, several studies report evidence of the flypaper effect (e.g., Hines & Thaler, 1995; Cossio & Carvalho, 2001; Gamkhar & Shah, 2007; Inman, 2008; Dahlby, 2011; Mattos et al, 2011), i.e., the elasticity of the current expenditures with respect to federal grants is greater than the elasticity of such expenditures with respect to the local income per capita.

Some papers assess how municipalities benefiting from oil revenues have been employing them and whether they affect local development. The studies focus on cases of a very large concentration of oil grants (Leal & Serra, 2002; Navarro, 2003; Serra, 2003; Serra, 2007) and conclude with mixed evidence regarding their impact on local social development.

Among the more comprehensive studies, Bregman (2007) analyzes the relationship between royalties and capital expenditure, observing that municipalities that are more dependent on oil revenues invest those resources in proportion to the amount received. Postali (2009) concludes that the municipalities benefiting most from oil royalties after 2000 have seen their products grow less than municipalities that do not enjoy such rents. Through a dynamic panel, Postali and Rocha (2009) observe that the oil revenues reduce the fiscal effort and increase the share of the local budget destined for investment, but there is no evidence that the municipalities allocate more resources to health, education and energy as a consequence of such rents.

Based on the Municipal Development Index, calculated by Rio de Janeiro's Industrial Federation (FIRJAN) between 1999 and 2007, Postali and Nishijima (2011) find no evidence of differential evolution in health and education in municipalities that enjoyed oil rents, relative to the national average. Furthermore, Caselli and Michaels (2013) conclude that oil windfalls have generated some increased spending on social items, like health and education, but the corresponding indicators have not evolved significantly.

With respect to the aforementioned studies, two important considerations must be made. First, the cities benefiting from oil rents are strongly heterogeneous, which hampers comparability for the purposes of identifying how the oil revenues affect the local realities. Secondly, although the criteria for granting oil royalties are set by law, their sharing is not random, so that the enjoyment of these rents is not a genuine experiment.

This paper aims to contribute to the discussion on the effects of oil windfalls on the fiscal effort of the benefiting municipalities, using the doubly robust estimator, which allows those limitations to be overcome. This method allows the pairing of the municipalities according to the likelihood of receiving a treatment (i.e., enjoying oil resources), creating a common support of comparable municipalities, in order to identify the effects of oil rents – royalties and special participation tax – on the incentive to collect tax revenue.

Besides this introduction, this paper is divided into three sections. Section 2 describes the methodology employed to identify the aforementioned effect, section 3 presents the data and section 4 discusses the results. The last section concludes.

2. Methodology

Municipalities benefiting from oil revenues in Brazil are scattered all over the country, with a consequently high degree of heterogeneity among them. The primary goal of propensity score analysis is to create a counterfactual that allows the comparison of the treatment effects (in this case, oil rents) on the treated.

The procedure to estimate the doubly robust method is performed in two steps. Firstly, through a logit model, one estimates the probability of receiving the treatment conditional on the observed characteristics of the municipalities. Based on the estimated propensity scores, a common support is created, in which treated municipalities can be compared with non-treated ones. In the second step, in order to assess whether oil rents reduce the fiscal effort, a panel of fixed effects is estimated with independent variables balanced by the propensity scores calculated in the previous step.

The method is based on Rosenbaum and Rubin (1983) and consists of working with potential results. In the present case, the idea is to compare the tax effort of single municipalities with and without oil rents, in order to identify the effect of these revenues on the fiscal behavior. However, it is not possible to observe the two situations simultaneously. In order to create a criterion of comparison, the method proposes the use of the conditional likelihood of receiving a treatment. Thus, municipalities with the same propensity score would be comparable to each other.

The methodology can be expressed briefly as follows: let $y(T)$ be the observed result of treatment T, where $T = 1$ means the presence of the treatment, while $T = 0$ indicates that the agent is not subjected to it. Under the conditional independence assumption (unconfoundedness[2]), there should be no unobservable characteristic other than the likelihood of treatment correlated with the treatment itself and its results, so that:[3]

$$T \perp (Y(1), Y(0)) | p(X)$$

where $p(X) = \text{prob}(T = 1 | X = x)$ is the likelihood of taking part in the treatment, conditional on the vector of observable characteristics X.

To the extent that only municipalities with the same propensity score are comparable to each other, it is necessary to build a common support for the observations. Thus, the method aims to measure the effect of treatment ($T = 1$) compared with non-treatment ($T = 0$), conditional on the likelihood of receiving oil revenues, by checking the statistical significance of:

$$\boldsymbol{E}[\boldsymbol{Y}(\mathbf{1}) - \boldsymbol{Y}(\mathbf{0}) | \boldsymbol{p}(\boldsymbol{X})] \quad \textbf{(1)}$$

The propensity score estimation creates a metric that allows the reduction of the vector of covariates to a single variable. Thus, it is possible to create a common support for municipalities, which improves the comparability among them. As shown by Dehejia and Wahba (1999), the creation of a common support through the propensity score generates efficient estimates. The advantage over estimates of the tax effort via fixed effects (Piancastelli, 2001) or via a dynamic panel (Postali & Rocha, 2009) is that it ensures that each municipality is comparable to a similar one belonging to the control group (non-beneficiary), eliminating potential biases from omitted variables. Imbens and Wooldridge (2009:p.38) show that the use of propensity scores to weight the variables in the second stage (fixed effect or otherwise) avoids this source of bias. According to the authors, combining the regression with weighting allows the removal of biases from omitted variables in the determinants of the tax effort. It introduces additional robustness, both by eliminating the correlation among the omitted covariates and by reducing the correlation between the omitted variables and the included ones. This is a doubly

[2] See Imbens and Wooldridge (2009).
[3] The notation ⊥ means "independent of."

robust estimator (Bang & Robins, 2005), which produces consistent estimations when the regression model or the propensity score is correctly specified.

According to Bang and Robins (2005), depending on the type of weights used in the second stage, one can identify the average treatment effect on the treated (ATT) or the average treatment effect (ATE). Thus, by employing the doubly robust estimator, it is possible to identify more accurately the effect of oil grants on the municipalities that already receive them, using the ATT, and to assess their possible impact on all the Brazilian municipalities, via ATE.

3. Data

The database consists of a national panel containing 5594 municipalities observed from 2000 to 2009. The data were gathered from three sources: the municipal fiscal variables were extracted from FINBRA[4] – Brazilian Finance – a database from the Brazilian National Treasury; municipal products were obtained from IBGE – the Brazilian Institute of Geography and Statistics; and data on oil rents (royalties and special participation) were obtained from the National Petroleum Agency – ANP. Among the universe of approximately 5500 Brazilian municipalities, about 1000 are eligible to receive such oil revenues, either because they border productive areas offshore or because their territories are affected by the producing activities of oil and gas, according to Law 9478/97. The amount of royalties is the sum of three portions: the revenue up to 5% of the gross value of oil production, concerning the compensation for the affected municipalities (Law 7.990/89, clause 7), the portion exceeding 5% (Law 9.478/97, clause 49) and the revenue from the special participation tax (Law 9478/97, clause 50).

We use the collection of urban real estate tax (IPTU) per capita as a measure of fiscal effort.[5] The reason for choosing this tax mode is its low sensitivity to the economic cycle. Moreover, the IPTU's base value is the registration of the property (and not the market value), and its revenues depend on the rates set by the municipal government. Instruments of supervision and administration are also set locally.

An increase in the revenues of the real estate tax can be attributed to two factors. First is an increase in the population, which expands the grounds and the buildings. In order to eliminate this effect, we divide the tax collection by the municipal population. The second factor is an increase in the tax effort: if the tax base is kept constant (number of properties), the only way to raise the revenue per capita is to strengthen the rigor and the control and reduce the exemptions.

The aim of this paper is to identify the impact of oil rents on the tax effort of the municipalities benefiting from such revenues in the last decade. The independent variables entering the fixed-effects model (second step) are as follows:

[4] Finanças Brasileiras/STN.

[5] The Brazilian Constitution establishes three types of municipal taxes: the IPTU, tax on services of any nature (ISSQN) and tax on transfers of real estate (ITBI). Municipalities are also allowed to collect fees on several services.

a) *Municipal economic product per capita*: in order to control for the municipality's fiscal capacity, since it affects the local tax revenue positively.

b) *Population*: this controls for the size of the locality. The hypothesis is that larger municipalities collect more real estate tax per capita.

c) *Governmental grants per capita*: the hypothesis is that financial grants from the upper levels of governments (federal and state) contribute to reducing the fiscal effort of localities.

d) *Other budget revenues per capita*: controlling for the availability of financial resources to local governments.

e) *Share of the agricultural product in the municipal economic product*: this variable is a proxy for the inverse of the degree of urbanization of the municipality, aiming to control for the tax base, since the IPTU is only levied on urban real estate.

Furthermore, year dummies are included.

Table 1 reports the descriptive statistics of the variables used in this study. As can be seen, there is huge asymmetry in the sharing of oil rents across the Brazilian municipalities, since the average value is much lower than the median, with a high standard deviation.

Table 1: Descriptive statistics

Municipal variable	***# Obs.***	***Mean***	***Median***	***Std Deviation***
IPTU (millions of reais)	51193	1.80	0.029	36.47
Economic product (millions of reais)	54309	385.45	50.22	4412.8
Population (thousands)	53290	33.33	10.97	197.40
Oil revenues (thousands of reais)	54661	405.90	0.00	10596.69
Agricultural product/econ. prod. (%)	54309	23.90	21.56	15.98
Budgetary revenues per capita (reais)	51119	217.31	167.37	213.08
Grants per capita (reais)	51119	765.12	612.19	1006.58

Source: Calculated by the authors. The exchange rate of reais/US dollars is around 2.32 (March 2014).

4. Results

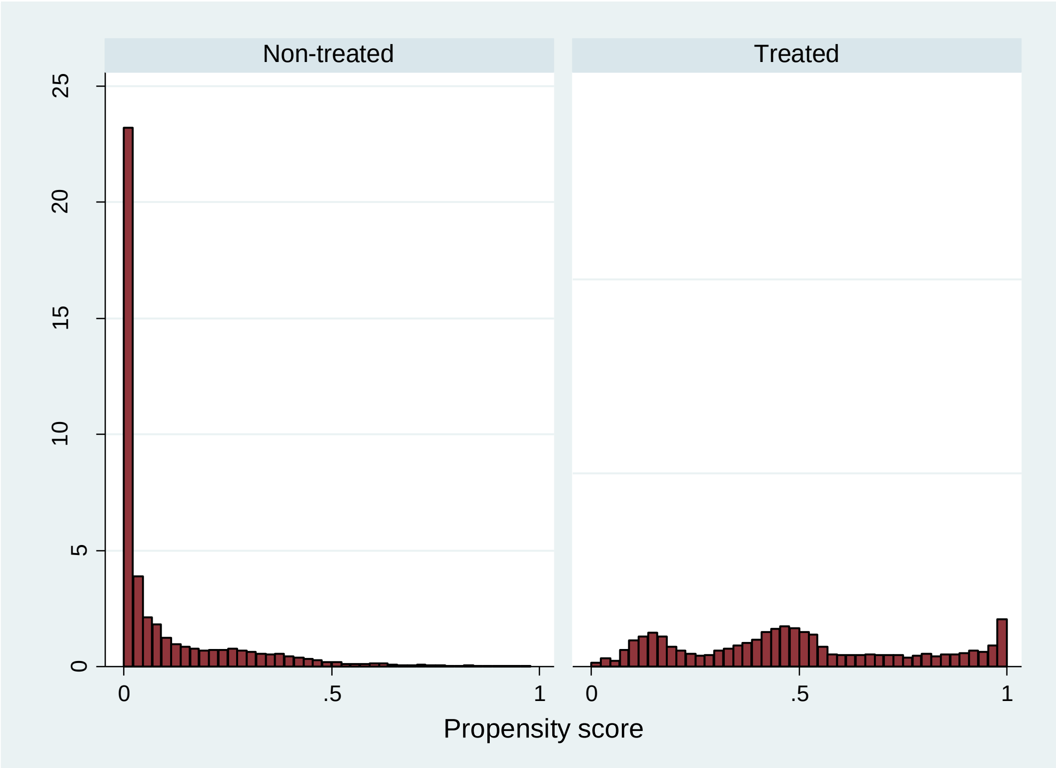
Estimating the propensity scores is the first stage of the doubly robust method. Accordingly, we need to estimate the likelihood of receiving the treatment (oil windfalls) conditional on the observed characteristics. As suggested by Dehejia and Wahba (2002), this can be achieved through a logit model:

$$\boldsymbol{Prob(T = 1|X) = F(\beta_0 + \beta_1 x_1 + \cdots + \beta_L x_L)} \qquad (2)$$

where $F(.)$ is the logistic function, $x_1, \ldots, x_L$ a vector of covariates representing municipal characteristics and $\beta_1, \cdots, \beta_L$ the coefficients to be estimated. Considering that the aim of the first stage is to enable the comparison of municipalities with different profiles, the likelihoods of receiving treatment are estimated based on the observable municipal characteristics, namely: the economic product, population, tax and budgetary revenues, fiscal result of previous year, federal and state grants, share of agricultural produce in the local product and variables to control for geographic location. The obtained pseudo-R^2 is 0.4165, which indicates a good fit according to the parameters in the literature. The results of the first stage (logit) are provided in the Appendix.

Graph 3 exhibits a histogram with propensity scores calculated through (2). As can be seen, the distribution is concentrated around zero, which reflects the large asymmetry in the distribution of oil resources in Brazil. This may generate a bias in the conventional fixed-effects estimates.

Graph 3: Histogram of propensity scores, for treated and non-treated groups



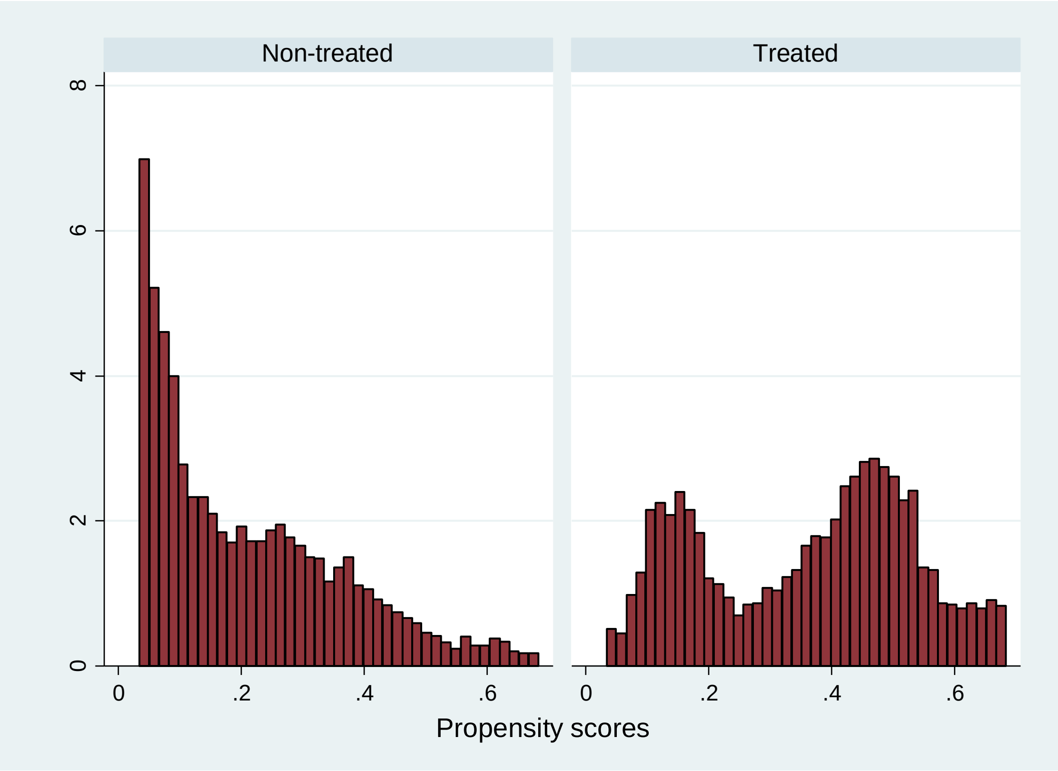
With the purpose of eliminating such potential bias and improving the comparison between the groups, a common support is created, following the procedure of Galiani et al (2005), as follows:

a) For the lower bound, observations with scores lower than the propensity score of the municipality in the first percentile of the treatment group are excluded.
b) For the upper bound, observations with scores higher than the propensity score of the municipality in the ninety-ninth percentile of the control group (non-beneficiaries) are excluded.

The reason for building this support is to ensure the presence of a mass of comparable municipalities, since localities with very high or very low propensity scores lack a reasonable number of municipalities to serve as an appropriate counterfactual.

Graph 4 shows the distribution of the propensity scores calculated for the municipalities belonging to this common support.

Graph 4: Histogram of propensity scores, for treated and non-treated groups, within the common support



Once the common support has been created, it is necessary to check whether the variables are balanced, i.e., whether the propensity scores and the common support are effective in making the treatment and control groups comparable to each other. Table 2 presents the test of mean difference of independent variables between the two groups (treated and untreated). The first column (without correction) shows this difference without the common support; the second column (CS) displays the same difference, but only for the municipalities belonging to the common support. Finally, the third column (CS & PS) exhibits the mean difference for municipalities within the common support, given the propensity score. In the latter, the difference of means between the treatment group and the control group is statistically significant at the 5% level only for the dummy of the northeast region. For the other variables, there is no statistical difference, which means that the balancing procedure through propensity scores can be considered successful.

Table 2: Balancing the variables and the test of mean difference

Variable	*Without correction*	*CS*	*CS & PS*
Economic product per capita	-592.1***	-253.5*	-59.78
Population	56,611***	6,454***	1.367
Other budget revenues per capita	41.94***	10.92***	1.035
Grants per capita	-161.3***	-35.14***	-5.358
Relative agricultural product	-0.0976***	-0.0179***	0.00510*
Dummy south	-0.177***	-0.0597***	-0.00532
Dummy south-east	-0.0457***	-0.0460***	-0.00799
Dummy north-east	0.284***	0.178***	0.0246**
Dummy north	-0.0563***	-0.0619***	0.00475

Source: Calculated by the authors. (***) Significant at 1%; (**) significant at 5%; (*) significant at 10%.

After balancing, the explanatory variables of fiscal effort should be weighted by the propensity scores estimated in the first stage. Following Imbens and Wooldridge (2009), to obtain the Average Treatment Effect (ATE), the weighting is given by:

$$X_{ATE} = \begin{cases} \dfrac{X_i}{p(T=1|X)} \; if \; T = 1 \\ \dfrac{X_i}{1 - p(T=1|X)} \; if \; T = 0 \end{cases}$$

where $p(T = 1|X)$ is the estimated likelihood of receiving oil revenues. Likewise, the weights for obtaining the Average Treatment Effect on Treated (ATT) are given by:

$$X_{ATT} = \begin{cases} \dfrac{X_i}{P} \; if \; T = 1 \\ \dfrac{p(T=1|X)}{1 - p(T=1|X)} \dfrac{1-P}{P} \dfrac{X_i}{1-P} \; if \; T = 0 \end{cases}$$

where $P = \sum_{Ti=1} P(T = 1|X)$.

The impact of oil royalties on the fiscal effort can be identified with a fixed-effects model, in which the independent variables are corrected as described above. The ATT allows the identification of the effect on the tax collection of benefiting municipalities, whereas the ATE identifies the average effect on the Brazilian municipalities as a whole, as if all localities were submitted to the treatment.

Table 3 presents the results for each correction above. For purposes of comparison, we also present two conventional fixed-effect models, one with observations belonging to the common support (FE & CS) and the other with the full sample, without balancing (FE). The latter is not able to capture the decrease in the tax effort due to a rise in oil windfalls, because the lack of balanced variables fails to create a proper counterfactual, in which the treatment and control groups have similar characteristics other than oil revenues. The fixed-effects panel using only observations within the common support proves a negative impact of oil rents on tax collection of about a penny. The difference between the estimated coefficients of (2) and (3) is the bias that is removed due to the weighting of the variables.

When the fixed-effects model is weighted to identify the ATT, one can note that an increase in oil revenues results in reduced tax effort in the municipalities covered, because the coefficient that measures this impact is negative and significant at the 5% level. On average, for every 1.00 real[6] in royalties, the municipality benefiting from it tends to reduce its tax revenue per capita by 0.017 reais. In addition, the estimated coefficients of the control variables have signs in accordance with those expected, especially those of the other grants, which also contribute to reducing the tax effort.

However, when the average treatment effect for the full sample (ATE) is calculated, the coefficient of oil windfalls is not significant, revealing that such revenues do not reduce the fiscal effort in the country as a whole.

[6] "Real" is the Brazilian currency. The exchange rate in March 2014 was around 2.30 reais/US$.

Table 3: Estimation results – Doubly robust estimator

Dependent variable: Urban real estate tax (IPTU) per capita				
	(1)	*(2)*	*(3)*	*(4)*
	ATE	*ATT*	*FE & CS*	*FE*
Oil windfalls per capita	0.0274	-0.0170**	-0.0106**	-0.00125
	(0.0343)	(0.00732)	(0.00423)	(0.00198)
Economic product per capita	0.00198	0.000861**	0.000484***	0.000262**
	(0.00125)	(0.000378)	(0.000140)	(0.000115)
Population	3.18e-05	0.000274***	0.000292***	0.000174***
	(3.45e-05)	(0.000103)	(5.77e-05)	(3.45e-05)
Budgetary revenues	0.0528	0.0152***	0.0144***	0.0291*
	(0.0369)	(0.00456)	(0.00231)	(0.0150)
Grants	-0.000782	-0.000691	0.000175	-2.23e-05
	(0.00251)	(0.00146)	(0.00132)	(0.00141)
Relative agricultural product	-21.48	1.988	8.302***	8.508***
	(13.46)	(3.792)	(1.619)	(2.181)
Year dummies	Yes	Yes	Yes	Yes
Constant	-5.507	-0.00162	-5.316**	-3.471
	(16.15)	(0.00223)	(2.224)	(5.743)
# Observations	12,975	3,341	12,975	51,118
R^2	0.214	0.132	0.138	0.182
# Municipalities	2,505	711	2,505	5,554

Source: Estimated by the authors. Robust standard deviation in parenthesis. (***) Significant at 1%; (**) significant at 5%; (*) significant at 10%.

5. Concluding remarks

As the commercial exploration of deposits from pre-salt is becoming a reality and the law governing royalty sharing is being modified in Brazil, studies that measure the impact of oil windfalls on the fiscal behavior of the localities benefiting from such revenues have been gaining momentum. This paper aims to shed light on the issue by using a methodology that allows a better comparison between a treatment group and a control group of municipalities, allowing a better identification of this effect.

We have used the doubly robust method to estimate both the impact of oil grants across the Brazilian cities (ATE) and this effect only in municipalities benefiting from such grants (ATT). Regarding the latter, a negative effect was verified of about two cents, on average, for every real of oil revenue transferred to the beneficiaries. When the estimations were performed under conventional fixed effects, this inefficiency was not captured, probably due to the bias from improper control groups.

Therefore, it is possible to identify inefficiencies in the fiscal behavior of localities benefiting from oil windfalls, since such grants should not alter the optimal allocation between public and private goods and, consequently, the optimal taxation coming from this decision. However, we did not find evidence of decreasing tax effort when computing the average effect all over the country. Possibly, this reflects the very low fiscal capacity of most Brazilian municipalities: they already collect too little tax (or do not collect it at all), and it is impossible to reduce it even more.

This study can be extended in several directions, particularly to measure the effects of oil rents on other municipal variables, such as social indicators and the level of local development. The pre-salt has generated very optimistic prospects for these revenues in the coming years and such studies are very important to design more efficient sharing rules. This debate is on the Brazilian political agenda.

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Appendix: Probability of treatment – first stage – logit model

Independent variable	
Economic product per capita	5.58e-06
	(3.69e-06)
Population	7.59e-07
	(5.85e-07)
Other budgetary revenues per capita	0.00203***
	(0.000142)
Relative agricultural product	-0.887***
	(0.193)
Services product	-7.78e-08
	(5.60e-08)
Industrial product	3.14e-07***
	(8.02e-08)
Public sector product	2.80e-07
	(5.05e-07)
Dummy south	135.5***
	(6.963)
Dummy south-east	85.26***
	(5.751)
Dummy north-east	71.41***
	(5.671)
Dummy north	59.03***
	(5.691)
Year dummies	Yes
Latitude	1.938***
	(0.134)
Longitude	-1.844***
	(0.150)
Interation south_latitude	-1.665***
	(0.140)
Interation south_longitude	3.191***
	(0.167)
Interation south-east_latitude	-3.777***
	(0.149)
Interation south-east_longitude	3.277***
	(0.156)
Interation north-east_latitude	-2.279***
	(0.134)
Interation north-east_longitude	2.155***
	(0.150)
Interation north_latitude	-1.698***

	(0.136)
Interation north_longitude	1.793***
	(0.150)
Constant	-63.67***
	(5.655)
# Observations	28,172
Pseudo-R^2	0,4165

Source: Estimated by the authors. Robust standard deviation in parenthesis. (***) Significant at 1%; (**) significant at 5%; (*) significant at 10%.