# Resource curse, petroleum rents and Municipal growth in Brazil

Fernando Antonio Slaibe Postali[1]

*Working paper*
September 2008

***Abstract:***

*In 1997, Brazil approved law* n$^{er}$ *9478, establishing new rules for sharing petroleum royalties with Brazilian Municipalities. The goal of this paper is to evaluate whether* royalties *distributed under the new law have contributed to the growth of the Brazilian local GDP. For that, it is used the differences-in-differences estimator (*Diff-in-Diff*), which compares the evolution of GDP into the Municipality affected by the new law with the unaffected ones, assuming that the new legislation constitutes a natural experiment. The data refer to the municipal GDP growth rate before and after the event. Results confirm the so called "natural resources curse", showing that the municipality contemplated with royalties grew less than Municipalities that did not receive such resources. In general, an increase of 1 real in royalties per capita reduces the municipal GDP growth rate in 0.00028 percentile points.*

Keywords: *royalties, differences-in-differences, petroleum.*

JEL's Classification: Q32, H27.

[1] Departmento de Economia, USP. E-mail: postali@usp.br.

## 1. Introduction

According to the Brazilian Constitution, the Federal Union is the single owner of onshore and offshore natural resources (Vilhena Filho, 1997), but production can be leased to private corporations. This legal arrangement, usual in many countries, aims at avoiding common pool inefficiencies. As the sole owner, the government has the right to grab resource rents and the main instrument to collect them is by creating a special tax regime over nonrenewable resources upstream, including oil and natural gas.

Since the middle of 90s, Brazil has been performing institutional changes in the regulation of oil and gas industry[2]. In 1995, a Constitutional Amendment eliminated a 40 years old state monopoly over oil and gas upstream; two years later, the so-called Petroleum Law[3] was approved, which not only introduced meaningful changes in the regulation of this market, but also created new criteria for transferring resource rents to Municipalities[4] in Brazil. According to the new law, all concessionaires working on both onshore and offshore upstream activities must pay royalties to the government. In general, these royalties consist in a 10% ad valorem tax over the gross value of production, but this rate can be reduced under very specific circumstances. The Federal Treasure collects royalties and transfers them to states and Municipalities in order to offset possible deleterious effects generated by oil and gas activities. The Petroleum Law forbids Municipalities to use these revenues for ordinary expenditures, like wages and debt management.

The goal of this paper is to investigate whether royalties transferred under the new law have contributed to the growth of Municipal GDP in Brazil. We use the differences-in-differences estimator (diff-in-diff), which compares the growth of Municipalities that received royalties – called treatment group – with the performance of Municipalities unaffected by the new law – the control group. In other words, this study aims at evaluating whether royalties have contributed to improve the growth of Municipalities eligible for receiving these benefits vis-à-vis the non-eligible ones. There are two important assumptions: firstly, the eligible Municipalities, as productive unities, usufruct their mineral rents by collecting those royalties; secondly, we assume that the

[2] Such changes can be understood under an international context described by Otto (1997).
[3] Law # 9478/1997.
[4] Loosely speaking, Municipality (or Municipio or Municipal district) can be understood as a city in Brazil.

new law is an exogenous experiment affecting a restricted set of municipalities. This investigation is relevant since the Brazilian Petroleum Law defines criteria and prohibitions for using these revenues.

Results bring evidences of some kind of "resource curse" in a local level, that is, our estimates show that, on average, eligible Municipalities performed worse in terms of GDP growth than non-affected ones.

This article is divided in seven sections, besides this introduction. Section 2 shortly describes the regulatory changes introduced by the Petroleum Law in Brazil, focusing on the new rules for sharing royalties with Municipalities. Section 3 presents a brief report on evidences of resource curse in the literature. Section 4 describes the diff-in-diff estimator, showing how it isolates the effect of treatment (royalty revenues) on the growth of Municipalities. Section 5 describes the data and section 6 presents the results. The last section brings some concluding remarks.

## 2. The Brazilian Petroleum Law

The Petroleum Law was approved by the Brazilian Parliament in 1997, two years after a Constitutional Amendment had broken the state monopoly over oil and gas upstream. Before the Amendment, the state-owned Petrobras was the single corporation allowed to operate such activities in Brazil. The law changed meaningfully the Brazilian oil industry regulation: firstly, the state monopoly regime was replaced by a concession system (Otto, 1997) in which private firms are allowed to undertake upstream activities (exploration and production) on behalf of government. Secondly, the law introduced a special fiscal regime on upstream activities, aiming at collecting resource rents, which belong to the public as the legal resource's owner. But the novelty that matters to our study is the creation of a stronger mechanism of compensation[5] for localities impacted by oil and gas upstream activities.

The Brazilian Petroleum Law defines four basic modalities of fiscal charges levying on oil and gas exploration: i) Signature fee; ii) Royalties rate; iii) Special participations and iv) Occupation fee. Royalties and occupation fee are obligatory in every lease contract. Special participations are levied only on highly productive fields.

[5] According to Hartwick (1977), the resource's owner has the right to grab rents in order to avoid welfare losses. Basically, the owner must be offset due to the depletion effect, since the resource is a capital stock.

Signature fee is the winner bid in the lease auction managed by ANP -- National Petroleum Agency. There are also other criteria for assigning concessions, like minimum investment programs and local purchase commitments. The tax must be paid at once in the beginning of the lease contract.

Royalty is a monthly ad valorem tax, charging 10% of gross revenue, priced according to an averaged basket of international oil prices. The rule for natural gas is more complex, due to the absence of a developed international market, but the royalty rate is the same (10%). ANP can reduce the royalty rate to 5% if geological risks and poor productive conditions justify such measure. The royalty revenues are shared among Brazilian states, Municipalities, National Treasure and public R & D funds.

Special participations are extra fiscal charges over highly productive projects. The tax is calculated for each lease according to progressive rates over the net revenue, that is, the gross revenue minus royalties, exploratory investments, operating costs, depreciation and other legal taxes. The government wishes to grab higher portions of rent from highly profitable projects. There are six rates: exemption, 10%, 20%, 30%, 35% and 40% of net revenue according to a rule that considers the volume of extraction, the wells deep and the field's age. Resources collected are shared among states, producer localities and Federal Government.

Finally, the Occupation Fee is some sort of rent paid to the government by $km^2$ of retained area. The concessionaire must pay this tax in the beginning of each year.

Royalties are transferred to Brazilian localities since at least 1986, but only after the Petroleum Law was approved, in 1997, such resources increased substantially, for many reasons (Serra, 2003): firstly, the royalty rate was raised from 5% to 10% over the gross revenue. Secondly, new rules for sharing revenues were created, which have enlarged significantly the volume of royalties in the hands of Municipalities[6] as well as the set of benefited districts.

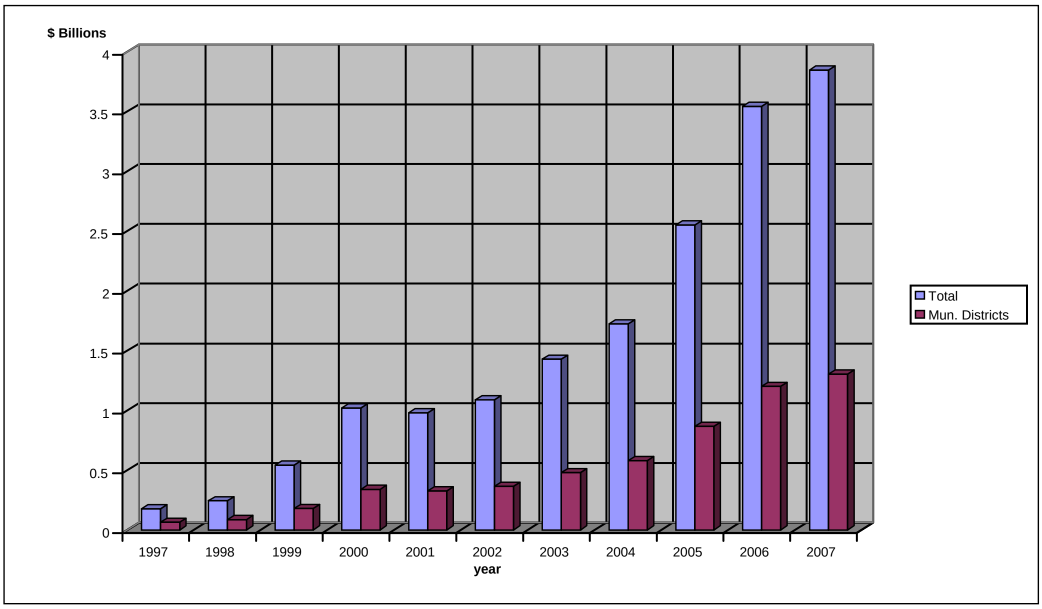
The new law also changed rules for investing royalties: according to the previous rule (from 1986), these resources could be invested only in energy, environment, sewage and roads. The law from 1997 does not establish any specific type of investment, widening considerably the set of possibilities. However, city halls are not allowed to use royalties

[6] Special participations are also shared, but less than two dozens of Municipalities are eligible for receiving them.

for ordinary expenditures, like wage and debt interest payments. Finally, as Serra (2003) points out, in order to calculate royalty revenues, the new law introduced the *reference price*, an average of international oil prices. Such measure represents an important change, since royalty revenues have become very sensitive to the oscillation of oil prices. Before the new law, indemnities[7] were calculated based on controlled prices in refineries. Since Petrobras used to fix the price in a discretionary basis[8], those resources were completely insensitive to changes in international prices. Moreover, the volume of royalties available for Municipalities also increased by two reasons: the progressive raise in oil prices in the last eight years and the change in the exchange policy in 1999, when the Brazilian currency started to float and devaluate (remembering that royalties are priced in dollars).

These legal changes generated a substantial increase in royalty revenues to the eligible Municipalities, which have acquired more freedom to allocate them. In fact, royalties in the hands of Municipalities have been increasing since 1999, as graph 1 shows.

**Graph 1: Royalty revenues, in billions of dollars[9].**




Source: ANP

There are very few studies analyzing the relationship between royalty revenues and local development in Brazil. Leal and Serra (2002) investigate the destination of royalties in Municipalities in the northern of Rio de Janeiro state. They show that eligible Municipalities invested above the average within Rio de Janeiro state, but the

7 Royalties were called indemnities before 1997.
8 The government used to freeze oil prices in refineries in order to control the inflation.
9 Converted by the annual average exchange rate “Reais”/$.

investment/royalties ratio was systematically below 1. Through a fiscal study, Costa Nova (2005) concludes that selected eligible Municipalities in Bahia state did not succeed in increasing their social indicators faster than non-eligible ones, despite the surplus in their budgets due to royalties.

Although such studies have the unquestionable merit of analyzing each city's budgetary data and its relationship with royalty revenues, one notices the lack of investigation in a national basis, involving all Municipalities that receive such revenues in Brazil. Moreover, based on those studies, it is impossible to evaluate the true impact of royalties on Municipal performance in terms of GDP growth, since unobservable local characteristics are also important factors.

The relationship between economic performance and resource rent is widely studied in the literature, with intriguing empirical evidences. The next section approaches this subject.

## 3. The resource curse, evidences and explanations in the literature

An interesting phenomenon in the literature about economic growth is the so-called *natural resource curse*, that is, widely documented empirical evidences that the GDP growth rates of resource-rich countries are lower than the non-endowed ones. Examples of such evidences can be found in Sachs and Warner (1995, 1999, 2001), Sala-I-Martin (1997), Mehlum et Al. (2006), among others.

Given such robust evidences, the literature always tried to analyze the curse in different ways from a theoretical perspective. A common explanation links the resource curse to the 'Dutch disease', that is, a chronic competitiveness loss faced by resource-dependent economies. The term "Dutch disease" firstly appeared to describe the impact of discoveries of natural gas on Dutch economy by the middle of 1960s, when the export boom that followed the increased gas production has contributed to overvalue the exchange rate[10]. As a result, exports competitiveness was seriously impaired and the economic growth was negatively impacted. Since then, the 'Dutch disease' is the general description of similar phenomena regarding the adverse effect of overvalued currencies on the economic dynamism.

[10] For a survey about Dutch disease, see Stevens (2003).

Besides the Dutch disease hypothesis and its variations, several other explanations have emerged in the literature in order to explain the resource curse. Some examples are investment crowding out in (dynamic) manufacturer sectors, the peculiar production path of nonrenewable resources, differentiated growth path of resource-endowed countries and institutional quality.

After observing empirically that resource-rich countries exhibit smaller growth rates than the world average[11], Sachs and Warner (1999) link the phenomenon to the role of big push in a resource based economy. They suggest a dynamic Dutch disease model, in order to explain the curse. Their model assumes a two sector economy: tradeables and non-tradeables. If the production function exhibits increasing returns to scale in the former, a resource boom tends to reduce the economic growth, since it generates a positive demand shock in the latter, requiring a shift in the labor factor in order to sustain the higher consumption (by definition, non-traded goods only can be produced locally). Consequently, the traded-sector loses scale, the economic growth is impaired and the economy can deep in a de-industrialization process. The empirical analysis comprehends eleven Latin American countries.  Life expectancy, institutional quality and public savings are used for controlling purposes in the econometric estimates. They find strong evidences suggesting a negative relationship between resource's intensity (measured by the exports/GDP ratio) and GDP growth.

Under the same line of investigation, Sachs and Warner (2001) collect evidences suggesting that countries highly dependent on natural resources exhibit modest GDP growth rates when compared to the non-endowed ones, even when estimates are controlled for commodities' prices. They also control for geographic elements of each country, like the percent of land area within 100 kilometers from the sea, distance to the closest major port, the fraction of land area in the Earth tropics and a malaria index. The explanation for the resource curse is also based on Dutch disease.

Among explanations based on growth theories, Rodriguez and Sachs (1999) link the low growth rate of petroleum exporting countries to the trend to "live beyond their means". These countries would be inclined to an excessive consumption/capital ratio (overshooting) provoked by high resource rents, mainly when these rents are invested in domestic assets. They assume an extended Ramsey model with natural resources, in

[11] Sachs & Warner (1995).

which positive export shocks generate an overshooting in capital and, consequently, a GDP per capita above the average. Therefore, in these economies, transition to steady state would display negative growth rates on average. They calibrate a dynamic general equilibrium model with Venezuelan data, whose results explain Venezuela's growth path right after oil shocks during the 70s.

Neumayer (2004) also supports the unsustainable over-consumption to explain the curse. However, he argues that Gross Domestic Product is not a good indicative of rent in resource-endowed countries, since a significant share of their capital is composed by natural resources, which present a high depreciation rate due to the depletion effect. When gross product is used, the depreciation is accounted as rent, signaling erroneously to policy makers a non-optimal level of sustainable consumption. Therefore, he proposes a 'genuine measure of rent', that is, the Net Domestic Product estimated according to a proxy of Hotelling's user cost (Hotelling, 1931). Results confirm the resource curse when the net product is used as dependent variable (instead of the gross product), but the estimated coefficients are lower.

Another class of explanations tries to establish the relationship between natural resource curse and institutional quality. Atkinson and Hamilton (2003) investigate the role of institutions in a panel of 91 countries observed during sixteen years, for several types of natural resources, like petroleum, natural gas, coal, iron, gold, forest resources, among others. They found that countries mostly affected by resource curse also exhibited problematic fiscal profiles and low levels of domestic savings, so the resource rents were wasted in financing ordinary governmental expenses. Conversely, countries which have invested in physical and human capital were able to avoid the phenomenon. The authors conclude that institutional quality is important to allocate rent resources properly, avoiding rent seeking and dissipation of values[12].

Kronenberg (2004) confirms the negative relationship between natural resource abundance and economic growth. He uses the basic education as a proxy for human capital. According to this study, the major causes of resource curse in developing countries are corruption and the low level of educational investments.

[12] In this sense, this conclusion confirms Hartwick's rule (Hartwick, 1977), which states that nonrenewable resource rent must be invested (and not consumed) in order to avoid intergenerational welfare loss.

Mehlum et Al. (2006) also link the resource curse to institutional weaknesses. They build a model in which institutions are classified in two categories: “producer friendly institutions” and “grabber friendly institutions” (e.g.: fragile laws, dysfunctional bureaucracy and corruption). The abundance of natural resources would push per capita income down in countries with a high degree of grabber friendly institutions. Conversely, producer friendly institutions tend to increase income. They use the same database as Sachs and Warner (1995) by adding an institutional quality index[13], concluding that institutional disabilities explain an expressive part of resource curse, since institutions in these countries are not able to avoid rent expropriation by political groups.

Boyce and Emery (2007) provide an alternative explanation, trying to reconcile the well documented evidence of high per capita income with low growth rates in resource-rich countries. Based on the dynamics of optimal extraction of depletable resources (Hotelling, 1931), they develop a model of competitive economy with two sectors: resource and manufacturer. By assuming that resource’s owners maximize the rent at each instant in time, they show that labor allocated to the resource sector is decreasing due to the progressive depletion and the resource rent falls as time goes on. So, under certain circumstances (enough decreasing resource prices and relatively slow technological change in resource sector), the growth rate of manufacture-oriented countries is higher than resource-oriented ones. Therefore, they refuse to use the word ‘curse’ to call this phenomenon, because it would be a direct consequence of the extractive dynamics and depletion of natural resources. Evidences on the phenomenon within USA states are provided.

Summing up, there are several theoretical explanations for the “resource curse” and this small survey does not cover them all. But there are robust evidences that countries dependent on resource exports tend to exhibit modest growth rates when compared to the others.  The following section describes the methodology.

## 4. Methodology

[13] This index is calculated by *Political Risk Services* and is composed by the average of five indexes regarding law enforcement, quality of bureaucracy, corruption and sovereign risk.

The methodology consists in comparing the effects of royalty revenues on eligible Municipalities relative to the non-eligible ones, before and after the approval of Petroleum Law. We assume the new law is an exogenous event, since it changed significant rules for transferring royalties in order to benefit local districts, increasing substantially their revenues.

We wish to investigate whether eligible Municipalities under the new law exhibited different growth patterns than non-eligible ones. We use the difference-in-difference estimator (Meyer, 1995) [14] , in order to compare the performance of a group affected by some event – treatment group – with the performance of non-affected ones – control group. In our case, we aim at comparing Municipal GDP growth between eligible (treatment group) and non-eligible (control group) districts before and after the new law. The basic assumption is that the new law is an exogenous event.

Let $y_{it}$ be the GDP growth rate of district $i$ in period $t$, such that $t = 0$ means before the event (up to 2000) and $t = 1$ means after the event (after 2000), when localities started to be impacted by royalties under the new law. Diff-in-diff searches to isolate the effect of treatment on dependent variable and, since we have a genuine panel composed by Municipalities, an excessive set of covariates in order to control for unobservable characteristics is unnecessary. The district $i$ will belong to the treatment group ($j = T$) or to the control group ($j = C$) whether it is eligible for receiving royalties under the new law or not. If we compare the growth averages only within eligible districts before and after the law ($E[y_{i1} \mid j = T] - E[y_{i0} \mid j = T]$), the estimates will be biased, since local product is also affected by other factors unrelated to policy change (Wooldridge, 2002, p. 130); on the other hand, if one compares both groups after the new regime ($E[y_{i1} \mid j = T] - E[y_{i1} \mid j = C]$), the bias emerges from unobservable systematic differences between them and such differences would be wrongly attributed to the new policy.

Our approach is based on a non-binary treatment (e.g.: Kiel and McClain, 1995), that is, we are interest not only in the *treatment effect* per se but also in the *treatment size* – the volume of royalties transferred to each Municipality. Each observation is put on a continuum of possible treatments. To show in a simple way how diff-in-diff allows

[14] Some overviews are presented by Angrist and Krueger (2000) and Blundell and MaCurdy (2000). Slaughter (2001) studies the effect of trade liberalization over income convergence; Meyer, Viscusi and Durbin (1995) use the estimator to evaluate the impact of higher benefits on the duration of job licenses.

isolating the treatment effect without a wide set of control variables, one assumes that the GDP growth rate ($y_{it}$) has been estimated by the following regression:

$$y_{it} = f_i + g_t + \delta_1 \mathbf{Z}_{it} + \delta_2 x_{it} + \varepsilon_{it} \quad (1)$$

$\delta_2$ is the parameter of interest that measures the effect of royalties per capita $x_{it}$ on the growth of district $i$ during period $t$. $\mathbf{Z}_{it}$ is the vector containing all control variables; $f_i$ is the Municipal fixed effect and $g_t$ is the macroeconomic effects in period $t$. $\varepsilon_{it}$ is a white noise.

One could evaluate the impact of treatment on the dependent variable by comparing $y$ before ($t = 0$) and after ($t = 1$) the effect of the new law, such that, by (1):

$$E[y_{i1} \,|\, j = T] = f_i + g_t + \delta_1 Z_{i1} + \delta_2 x_{i1,T}$$

$$E[y_{i0} \,|\, j = T] = f_i + g_t + \delta_1 Z_{i0}$$

Since $x_{i0,T} = 0$. Likewise, for the control group:

$$E[y_{i1} \,|\, j = C] = f_i + g_t + \delta_1 Z_{i1}$$

$$E[y_{i0} \,|\, j = C] = f_i + g_t + \delta_1 Z_{i0}$$

Since the control group is the set of non-affected Municipalities, $x_{it,C} = 0,\ t = 0, 1$. In order to investigate the impact of Petroleum Law, we could find the change in the dependent variable after the experiment within groups, that is:

$$\Delta y_{t,T} = \mathrm{E}[y_{i1} \,|\, j = T] - \mathrm{E}[y_{i0} \,|\, j = T] = \delta_1 (Z_{i1} - Z_{i0}) + \delta_2 x_{it} \quad (2)$$

$$\Delta y_{t,C} = \mathrm{E}[y_{i1} \,|\, j = C] - \mathrm{E}[y_{i0} \,|\, j = C] = \delta_1 (Z_{i1} - Z_{i0}) \quad (3)$$

However, such estimates can be biased since growth is also affected by other factors unrelated to the policy change (Wooldridge, 2002, p. 130), as we can see by $\delta_1(Z_{i1} - Z_{i0})$. In order to investigate the genuine effect of treatment, diff-in-diff allows eliminating such unobserved variables through the difference:

$$\Delta y_{t,T} - \Delta y_{t,C} = \delta_2 x_{it}$$

That is:

$$\delta_2 = \frac{d(\Delta y_{t,T} - \Delta y_{t,C})}{dx_{it}} \quad (4)$$

Therefore, it is possible to find consistently the effect of royalties without adding controls ($Z_i$), since we have a panel of the same districts observed through time.

The estimator can be implemented by the following regression model:

$$y_{it} = \alpha + \alpha_1 d_t + \alpha_2 d^j + \beta_2 d_t^j x_{i,} + \varepsilon_{it} \quad (5)$$

in which $y_{it}$ is the Municipal GDP growth rate in $t$. $d_t$ is a time dummy variable, that equals 1 if the district is observed after the treatment ($t = 1$) and zero otherwise; $d^j$ is a dummy for eligible Municipalities (equals one if $J = T$ and zero if $J = C$). $d_t^j$ is a dummy variable that equals 1 if $t = 1$ *and* $J = T$, and zero otherwise, indicating the effect of royalties on eligible districts. Identification requires $E(\varepsilon_{it}|\ d_t^j = 1) = 0$, meaning that the approval of the new law is an exogenous experiment. The treatment effect on eligible districts is measured $\beta_2$. The dummy variable $d_t^j$ indicates whether the Municipal district is eligible for royalties or not, according to the new law.

Taking the first difference in (5), we have the functional model to be tested:

$$\Delta y_{it} = y_{i1} - y_{i0} = \alpha_1 + d_t^j \beta_2 x_{i,} + \varepsilon_{it}$$

Equivalently, remembering that $\mathbf{d_t^j} = 1$ if and only if $x_i > 0$:

$$\Delta y_{it} = \alpha_1 + \beta_2 x_{i,} + \varepsilon_{it} \quad (6)$$

The constant $\alpha_1$ tests possible changes in the Municipal GDP growth pattern as a whole between $t = 0$ and $t = 1$. The parameter of interest is $\beta_2$, which searches to measure whether the volume of royalties has some significant impact on local product growth.

## 5. Data

Brazilian Municipalities are commonly split in Brazil in order to create new ones. Since the number of districts varies across the years, we used a device called *Minimum Comparable Area* (MCA), calculated by IPEA, Applied Economics Research Institute. MCAs are groups of cities that allow for time-consistent comparisons of Municipal data, considering Municipalities created over time. Therefore, instead of the current 5560 Municipalities in Brazil, the dataset has 4266 MCAs, according to 1990's criteria[15]. From now on, 'Municipalities' and 'MCA' are treated as synonymous for our purposes.

Municipal GDP from 1999 to 2005 were estimated by IBGE, while in 1996, they were estimated by IPEA, Applied Economics Research Institute[16]. Municipal populations were estimated by IBGE[17]. The data regarding royalty transfers to Municipalities were supplied by ANP, the National Petroleum Agency in Brazil. Among the current 5560 Municipalities in Brazil, about 800 receive royalties in very different amounts, either for sheltering productive units or for being producer localities, according to the Petroleum Law[18].

All estimates were performed in Brazilian currency, in constant values of 2000. Table 1 summarizes data, in dollar. One can notice the enormous variability in royalty's revenues across Municipalities.

**Table 1: Descriptive statistics**

| Variable | # Obs. | Average | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Municipal Product growth[19] (1996-2000) | 4266 | 0.4437 | 0.4307 | -2.566 | 4.138 |
| Municipal Product growth (2001-2005) | 4266 | 0.1063 | 0.3241 | -1.766 | 2.292 |
| Difference (2001-2005) - (2000-1996) | 4266 | -0.3373 | 0.5982 | -4.567 | 2.575 |
| Royalties 1999 (per capita) | 734 | 11.09102 | 53.9956 | 0.000711 | 1027.42 |
| Royalties 2000 (per capita) | 681 | 19.5637 | 87.0992 | 0.000656 | 1586.18 |
| Royalties 2001 (per capita) | 726 | 18.94602 | 86.8969 | 0.000711 | 1667.654 |
| Royalties 2002 (per capita) | 726 | 25.08461 | 113.1131 | 0.000656 | 1936.839 |
| Royalties 2003 (per capita) | 725 | 31.3708 | 129.2604 | 0.000984 | 2077.912 |
| Royalties 2004 (per capita) | 726 | 30.10263 | 122.0067 | 0.000875 | 1878.126 |
| Royalties 2005 (per capita) | 743 | 32.28913 | 130.8401 | 0.000601 | 1938.211 |

Source: Elaborated by the author, based on IBGE, IPEA and ANP data. 2006 values, in dollars. Municipalities measured in MCA.

It is interesting to notice the great variability in royalty's revenues across eligible Municipalities in Brazil. The largest portion is transferred to districts in Rio de Janeiro, since the major oil basins – Campos Basin and Santos Basin – are located in this state.

[15] Source: IPEA.

[16] The diff-and-diff allows controlling for such global changes in methodology, since their effects vanishes as we take the difference between control group and treatment group. In 1996, local products were estimated by IPEA while from 1999 on, IBGE is in charge. Moreover, another global change in methodology was introduced in 2002 (see www.ibge.gov.br for details), but the estimator is not affected as well for the same reason.

[17] For 1996 and 2000: population census; for the other years: IBGE estimates.

[18] The distribution criteria are described by Serra (2003) and Leal and Serra (2002). For producer districts, the main criterion is the projection of the Municipal area over the sea.

[19] The growth rate was calculated as the difference of log of Municipal products.

Table 2 shows the top ten Municipalities in volume of royalties in 2005. Table 3 presents the top ten in per capita terms.

**Table 2: The top 10 most benefited Municipalities in 2005**

| State | Municipal district | Royalties ($) | % |
|---|---|---|---|
| RJ | Campos dos Goytacazes | 149,223,055.21 | 15.38% |
| RJ | Macaé | 133,563,314.95 | 13.76% |
| RJ | Rio das Ostras | 73,077,007.77 | 7.53% |
| RJ | Cabo Frio | 64,830,588.88 | 6.68% |
| RJ | Quissamã | 24,412,348.64 | 2.52% |
| AM | Coari | 21,426,338.90 | 2.21% |
| SP | São Sebastião | 21,088,997.84 | 2.17% |
| RJ | Rio de Janeiro | 20,703,478.14 | 2.13% |
| RJ | São João da Barra | 19,639,048.87 | 2.02% |
| RJ | Niterói | 18,150,609.57 | 1.87% |
| Sum | | 546,114,788.76 | 56.28% |
| Others | | 424,246,573.35 | 43.72% |
| Total transferred to Municipalities | | 970,361,362.11 | 100.00% |

Source: ANP – elaborated by the author.

**Table 3: The top 10 most benefited Municipalities in 2005, per capita**

| State | Municipal district | Royalties per capita ($) |
|---|---|---|
| RJ | Quissamã | 1556.61 |
| RN | Guamaré | 1087.17 |
| RJ | Rio das Ostras | 986.70 |
| RJ | Macaé | 801.79 |
| BA | Madre de Deus | 731.27 |
| SE | Pirambu | 727.50 |
| SE | Divina Pastora | 476.69 |
| ES | Presidente Kennedy | 412.62 |
| RN | Macau | 402.80 |
| RJ | Cabo Frio | 354.85 |
| RJ | Campos dos Goytacazes | 340.16 |

Source: ANP and IBGE – elaborated by the author.

The Petroleum Law was approved in 1997 but their effects were felt gradually only after 1999, when the volume of royalties increased substantially. So, year 2000 was defined as the beginning of the experiment. In order to implement the diff-in-diff, the dependent variable $\Delta y_{it}$ was calculated as the difference between Municipal GDP growth rate four years before (from 1996 to 2000, equivalent to $t = 0$) and the growth rate four years after the experiment (from 2001 to 2005, equivalent to $t = 1$). In other words, we wish to investigate whether royalties have caused a differentiated growth pattern in eligible districts relative to others. Variable $x_i$ is the cumulative royalties per capita transferred to district *i* from 1999 to 2005.

## 6. Results

Table 4 exhibits simple average tests in the dependent variable, that is, the difference in the growth rate of eligible and non-eligible Municipalities, before and after the treatment. As we can notice, t-test rejects the null hypothesis that both groups have the same average, showing that royalty receivers have grown less after 2000 than districts that did not receive such resources.

**Table 4: Mean comparison test, assuming unequal variances**

| *Group* | *Observations* | *Average* | *Standard deviation* | *t - statistic* |
|---|---|---|---|---|
| Treatment | 742 | -0.44815 | 0.762948 | 4.543** |
| Control | 3524 | -0.31401 | 0.554749 | |

(**) 1%-significant; Satterthwaite's degree of freedom.

Table 5 shows estimated coefficients of (6). We have also included state dummies with the purpose of incorporating local characteristics, controlling for fixed effects of each federative unit (model b). Among 4266 MCA's, 743 are eligible for receiving royalties, according to the legal criteria introduced by the new law.

**Table 5: Estimates for the whole country. (a) Without regional dummies (federative unit); (b) With regional dummies.**

| Estimated coefficients (6) | (a) | (b) |
|---|---|---|
| Constant ($\alpha_1$) | -0.3228**<br>(0.0087) | 0.1794<br>(0.2025) |
| Royalties per capita (00-05) ($\beta_2$) | -0.00037**<br>(0.000049) | -0.00028**<br>(0.000039) |
| Federative unit dummies | No | Yes |
| $R^2$ | 0.062 | 0.2311 |
| Significance *F (k, M-k)* | F(1, 4264) = 55.36** | F(26, 4238) = 48.19** |
| # Total Observations (MCA's) | 4266 | 4266 |
| # Obs. Control group | 3524 | 3524 |
| # Obs. Treatment group | 742 | 742 |

*White's robust standard deviations in parenthesis.*
*(**) Significant at 1%; (*) Significant at 5%.*

Firstly, consider model (a). The constant $\alpha_1$ is significantly negative, which express a global trend of decreasing in Municipal growth rates after 2000. The coefficient that measures the marginal effect of royalties ($\beta_2$) is negative and significant as well, that is, the higher the royalty revenue per capita, the lower the Municipal growth rate.

Considering now the model with fixed effect of federative unit (model b), the constant is no longer significant and the treatment effect is significantly negative: one-Real[20] increase in royalties per capita reduces in 0.00028 percentile points, on average, the Municipal product growth rate.

The volume of royalties varies enormously across municipalities (see table 1 to 3) and the distribution is highly skewed[21]. With the purpose of investigating whether the effect of royalties on municipal growth is different among districts that receive high level of revenues, we performed a spline regression (Greene, 2003, p. 127), breaking the sample in quartiles. Results are shown in table 6. As we can see, the marginal effect of royalties is positive for municipalities with low level of royalties (first quartile), but the coefficient sign turns to negative as one moves toward higher quartiles. That is, the impact of higher volume of royalties per capita on GDP growth is negative when municipality is highly endowed with such transfers. This can be interpreted as a further evidence of resource curse.

**Table 6: Estimates for the whole country. (a) Without regional dummies (federative unit); (b) With regional dummies.**

| Estimated coefficients (6) | (a) | (b) |
|---|---|---|
| Constant ($\alpha_1$) | -0.3121** (0.0092) | 0.1794 (0.2026) |
| Royalties per capita (00-05) ($\beta_2$) | | |
| First quartile | -0.0067 (0.0958) | 0.3030** (0.1019) |
| Second quartile | 0.0262* (0.0128) | -0.0239 (0.0148) |
| Third quartile | -0.0185** (0.0028) | -0.0071* (0.0032) |
| Fourth quartile | -0.0002** (0.00003) | -0.0002** (0.00003) |
| Federative unit dummies | No | Yes |
| $R^2$ | 0.08 | 0.23 |
| Significance *F (k, M-k)* | 36.21** | 44.72** |
| # Total Observations (MCA's) | 4266 | 4266 |
| # Obs. Control group | 3524 | 3524 |
| # Obs. Treatment group | 742 | 742 |

*White's robust standard deviations in parenthesis.*
*(**) Significant at 1%; (*) Significant at 5%.*

[20] Brazilian currency (R).
[21] The average royalty per capita is R 34, while the median is R 0.49.

Royalties are shared very unequally across Municipalities, with a huge concentration in few federative units, mainly Rio de Janeiro. An interesting exercise is to investigate whether such effects also exist within each state. Table 6 shows the estimated coefficients of (6) for the six largest Brazilian producer states – and consequently, the most benefited with royalties:  Rio de Janeiro, Rio Grande do Norte, Espírito Santo, Bahia, Sergipe and Amazonas. As we can see, the pattern is the same than in the whole country and there is a negative relationship between royalties per capita and Municipal growth.

**Table 7: Results for the major producer states:  RJ, RN, SE, BA, AM and ES.**

| Estimated coefficients (6) | |
|---|---|
| Constant ($\alpha_1$) | -0.4078**<br>(0.0228) |
| Royalties per capita (00-05) ($\beta_2$) | -0.00037**<br>(0.00005) |
| $R^2$ | 0.1890 |
| Significance *F (k, M-k)* | F(1, 834) = 34.51** |
| # Total Observations (MCA's) | 837 |
| # Obs. Control group | 346 |
| # Obs. Treatment group | 491 |

*White's  robust standard deviations in parenthesis.*
*($^{**}$) Significant at 1%; ($^{*}$) Significant at 5%.*

Summing up, results suggest the existence of a phenomenon analogous to the resource curse: Municipalities most benefited with royalties either for producing or for sheltering productive facilities tend to exhibit lower GDP growth rates and higher revenues tend to reduce the growth relative to the control group. This result is analogous within the major producer states.

Although these results deserve a deeper investigation in order to evaluate whether each district in fact allocate such resources according to the new law, the explanation related to the Dutch disease is not satisfactory, since, in this case, it cannot be linked to foreign trade. On the other hand, blaming local institutions for inefficiencies in the use of such revenues can be a tempting, but premature explanation.

## 7. Concluding remarks

The international literature about growth and economic development presents robust evidences that countries rich in natural resources tend to exhibit GDP growth rates smaller than non rich ones. Several explanations were provided: Dutch disease, investment crowding out, capital and consumption overshooting, nonrenewable resources dynamics, institutional weaknesses, corruption, rent seeking, etc. In this context, although Brazil is not considered a big oil producer, deposits are located unevenly across the territory. Producer Municipalities or the affected ones receive part of royalty revenues in order to usufruct mineral rents, aiming at offsetting them for possible damages due to oil and gas production activities.

In 1997, Brazil approved a new law (#9478/97) establishing the new regulatory paradigm in its oil and gas market. The new criteria for calculating and sharing royalties are one of the most important novelties, resulting in a substantial increase in the availability of such revenues for Municipalities. There are about 800 districts eligible for receiving royalties in Brazil, among the universe of 5500. The volume of royalties depends directly on the impact of oil and gas production over the district as well as on geographic areas.

We aimed at exploring the Petroleum law as an experiment in order to evaluate whether royalties shared across Municipalities have impacted positively on their product growth rates. Diff-in-diff estimator was used to do so, assuming that the policy change is an exogenous event, affecting differently producer and non-producer districts.

Results confirm a phenomenon analogous to the resource curse, since Municipalities that received royalties grew less than the non-eligible ones after 2000, when the new law started to be effective. Moreover, the marginal effect of royalty on Municipal growth is negative.

Although we did not intend to offer an explanation for such results, it is possible to rule out Dutch disease-based explanations, in the extent that the phenomenon seems unrelated to foreign trade.

This study offers fewer answers than questions and some shortages still need to be overcome, suggesting further possible developments. A detailed investigation is needed in order to enlighten the phenomenon, but a natural question emerging from this study is whether royalties are being invested in a suitable basis. Moreover, an instrumental variable in order to control for endogeneity may be desirable. Nonetheless, given the lack of studies in a national basis in Brazil, this one intends to begin the debate of evaluating the consequences of Petroleum Law eleven years after its approval.

**References**


Angrist, J., Krueger, A., 2000. Empirical Strategies in Labor Economics. In Ashenfelter, O. e Card, D.. *Handbook of Labor Economics*, Amsterdam: Elsevier, 1277–1366.

Athey, S., Imbens, G.W., 2006. Identification and Inference in Nonlinear Difference-in-differences models. *Econometrica 74* (2), 431-497.

Atkinson, G., Hamilton, K., 2003. Savings, Growth and the Resource Curse Hypothesis. *World Development 31* (11), 1793-1807.

Blundell, R., MaCurdy, T., 2000. Labor Supply. In Ashenfelter, O. e Card, D.. *Handbook of Labor Economics*, Amsterdam: Elsevier, 1559–1695.

Boyce, J.R., Emery, J.C.H., 2007. What can exhaustible resource theory tell us about per capita income growth and levels in resource abundant economy. *Working Paper*. University of Calgary, Canadá.

Costa Nova, L., 2005. *Análise do impacto social de receitas provenientes de royalties do petróleo em municípios do estado da Bahia*. Dissertação de Mestrado, Universidade de Brasília, 2005.

Greene, W.H., 2003. *Econometric Analysis*. 5th edition. Prentice Hall.

Hartwick, J.M., 1977. Intergenerational Equity and the Investing of Rents from Exhaustible Resources. *American Economic Review* 67, nº 5, dez/1977, 972-974.

Hotelling, H., 1931. The Economics of Exhaustible Resources. *Journal of Political Economy*, Abr/1931, pp.137-175.

Kiel, K.A., McClain, K.T., 1995. House Prices during Siting Decision Stages: The Case of an Incinerator from Rumor through Operation. *Journal of Environmental Economics and Management 28*, 241-255.

Kronenberg, T., 2004. The curse of natural resources in the transition economies. *Economics of Transition* 12 (3), 399-426.

Leal, J.A.A., Serra, R.V., 2002. Notas sobre os Fundamentos Econômicos da Distribuição Espacial dos Royalties Petrolíferos no Brasil. *Anais do XXX Encontro Nacional de Economia (ANPEC)*. Nova Friburgo, RJ, 2002.

Mehlum, H., Moene, K., Torvik, R., 2006. Institutions and the Resource Curse. *Economic Journal* 116, 1-20.

Meyer, B.D., 1995. Natural and Quasi-experiments in Economics. *Journal of Business and Economic Statistics 13*, 151-161.

Meyer, B.D., Viscusi, W.K., Durbin, D.L., 1995. ‘Workers’ compensation and Injury Duration: Evidence from a Natural Experiment. *American Economic Review 85* (3), 323-340.

Neumayer, E., 2004. Does the ‘resource curse’ hold for growth in genuine income as well? *World Development* 32 (10), 1627-1640.

Otto, J., 1997. A national mineral policy as a regulatory tool. *Resources Policy 2*3, 1-7.

Quintella, S. F. 2000. *Os royalties de petróleo e a economia do estado do Rio de Janeiro. TCE-RJ*. Rio de Janeiro.

Rodriguez, F., Sachs, J., 1999. Why do Resource-Abundant Economies grow more slowly? *Journal of Economic Growth 4* (Sept. 99): 277-301.

Sachs, J., Warner, A., 1995. Natural Resource Abundance and Economic Growth. *NBER working paper 5398*. Cambridge, MA.

Sachs, J., Warner, A., 1999. The big push, natural resource booms and growth. *Journal of Development Economics vol. 59,* pp. 43-76.

Sachs, J., Warner, A., 2001. The curse of natural resources. *European Economic Review 45,* 827-838.

Sala-I-Martin, X.,1997. I Just Ran Two Million Regressions. *American Economic Review 87* (2), 178-183.

Serra, R.V. 2003. Desdobramento Espacial da Exploração e Produção de Petróleo no Brasil: em busca de um nexo para a distribuição dos royalties entre os Municípios. Belo Horizonte: X ENANPUR, 2003.

Slaughter, M.J., 2001. Trade liberalization and per capita income convergence: a difference-in-differences analysis. *Journal of International Economics 55,* 203–228.

Stevens, P. 2003. Resource Impact: Curse or Blessing? A literature survey. *Journal of Energy Literature IX* (1).

Wooldridge, J.M., 2002. *Econometric Analysis of Cross Section and Panel Data*. MIT Press, Cambridge.

Vilhena Filho, C.A., 1997. Brazil’s Mineral Policy. *Resources Policy 23*, 45-50.