Is the natural resource curse present in Rio de Janeiro municipalities? A spatial approach

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Overview

This paper aim was to analyze the direct and spillover effects of oil royalties in Rio de Janeiro municipalities *per capita* GDP. The LM and LR tests and the analysis of AIC information criterion and the value of likelihood function helped the decision of using a Durbin model with errors spatial lagged, called SDEM. The spatial lag matrix was the Haversine's inverse distance. The oil dependence, symbolized by the ratio of royalties and GDP, was negative and significant, while the abundance, *per capita* royalties, was positive and significant. The interaction term between oil dependence and IFGF was positive, yet it was not significant. Thus, the results allow to conclude that the empirical phenomenon known as natural resource curse is present in the Rio de Janeiro municipalities, but the symptoms do not overcome the municipalities border, because the spillover effect was positive and significant.

1. Introduction

Although Australia, Canada, United States, Finland and Sweden have used all their natural resources during the economic development process, Sachs and Warner (1995; 1999; 2001)[1], through a cross country regression using the participation of natural resources exports in the GDP as proxy for the natural resources dependence, have showed a negative relation between natural resources endowments and economic growth.

Since then, the lower economic growth of countries which have high natural resources endowments has been called the natural resource curse (SACHS; WARNER, 2001).

The recent economic growth history of countries poor in natural resources, such as Japan and the Asian Tigers, and some empirical papers which analyzed the resources impacts at national level (BRÜCKNER, 2010; PAPYRAKIS; GERLAGH, 2004; GYLFASON, 2001; STEVENS; DIESTSCHE, 2008; MEHLUM; MOENE; TORVIK, 2006; AUTY 2001; AUTY, 2007) supports the SW's result. Beyond the resources impact at national level, James and Aadland (2011) and Elliott, Hartarska and Bainey (2007) found that USA municipalities rich in natural resources grew less than the municipalities poor in resources, especially in the states that are more dependent on natural resources.

Meanwhile, the recent history of Botsuana, the United Arab Emirates and Norway contradicts the SW results (PLOEG, 2011). Empiricaly, the papers of Alexeev and Conrad (2011), Brunnschweiler (2008), Brunnschweiler and Bulte (2008) did not find evidence of natural resource curse at national level, while Ji, Magnus and Wang (2013) did not find evidence of that either in the Chinese provinces.

Hence, there is no agreement in the natural resources curse existence, and according to Stijns (2005), the natural resource presence in a country is not a reason to be named as a curse. Thus, the curse is an empirical phenomenon. So, there is no theory supporting this observed fact and therefore all authors after SW had put effort on identifying the causes of the lower economic growth associated with natural wealth.

Auty (2001) assigns the lower economic growth of countries rich in natural resources to a high-handed government, which creates competition bottlenecks by falling in provide land, good education, efficient markets, opened economy and production diversification. Yet Robinson, Torvik and Vernier (2006) suggested a simplified model with two hypothetical politicians, A and B. By this model, the curse would happen if the elected politician decided to govern close to the private interests of the economic group which helped him to win the election.

The specialized literature lists some transmission mechanisms for the negative effect of natural endowments in economic growth, such as institutional quality, rent-seeking, corruption, economic illusion and Dutch disease (PESSOA, 2010; PLOEG, 2011; SALA-I-MARTIN; SUBRAMANIAN, 2012).[2] [3]

In the applied economic literature, there are authors who underpin that the natural resource income creates a fake sensation of economic stability, which influence negatively the government budget constraint and the public spending efficiency (ATCKINSON; HAMILTON, 2003; AUTY, 2007; STEVENS; DIETSCHE, 2008; HARFORD; KLEIN, 2005).

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[1] Henceforth Sachs and Warner will be called just as SW.

[2] According to Grossman and Helpman (1994), rent-seeking can be summarized by some economic groups putting pressure on the government to get better business opportunities than their competitors.

[3] The classical Dutch-Disease symptom is the deindustrialization caused by the exchange rate appreciation due to the natural resource production and exporting specialization (PLOEG, 2011).

Gylfason (2001), Papyrakis and Gerlagh (2004) and Stijns (2006) attribute that fake stability sensation to inefficient educational expenditures, what compromise the human capital accumulation and the economic growth consequently.

The low efficiency of public expenditure can be attributed to the public policies towards the private interests of some economic group instead of towards general welfare, fostering rent-seeking and corruption (ROBINSON; TORVIK; VERNIER, 2006; STEVENS; DIETSCHE, 2008; BRÜCKNER, 2010).

Therefore, the institutions' actions could change the negative impacts of these resources into positive ones, especially when it is taken against bad fiscal policies (ROBINSON; TORVIK; VERNIER, 2006; MEHLUM; MOENE; TORVIK, 2006). The institutions well performance not only guarantee the efficient allocation of the resources, but also influences the physical and human capital investments, which is great important to the economic growth (ACEMOGLU, 2009; ACEMOGLU; ROBINSON, 2008; MANKIW, 2010).

The results of Sala-i-Martin and Subramanian (2012), Barnett and Ossowski (2002), Brunnschweiler and Bulte (2008), Brunnschweiler (2008), Alexeev and Conrad (2011), Ji, Magnus e Wang (2013) and Mehlum, Moene and Torvik (2006) confirms the institution importance in dealing with the natural resource curse, because after considering the institutions action the resource wealth had positive impact into economic growth.

All these cited papers focused on the impacts of natural resource production, but the externalities of the incomes from natural resources paid to the government should be monitored as the production is (HARFORD; KLEIN, 2005).

For this reason and because Rio de Janeiro municipalities had received almost R$ 20.00 billion among 2008 and 2012 (approximately 65% of the total paid to the Brazilian municipalities), this paper aims to analyze the oil royalties impacts over the economic growth of Rio de Janeiro municipalities through a spatial econometric approach.

The Morans' I, Geary's C, LM, LR tests plus the AIC criterion and log-likelihood value analysis supported the SDEM model decision. Even though the econometric tests have showed the needy of the spatial models, oil endowments are not randomly distributed because of the oil distribution was stablished a million years ago. Sachs and Warner (2001) then suggested that spatial effects should be considered to avoid some spatial biases in the analysis. Thus, this study aims to contribute with specialized literature by analyzing spatial effects of natural resources dependence in the GDP of Rio de Janeiro municipalities.

The results confirm that natural resource curse is present in the Rio de Janeiro municipalities. The curse is not a regional phenomenon though as the spillover effect of oil dependence was positive and showed statistical significance.

This article is divided into four more sessions, followed by this brief introduction. The second section summarizes the oil royalties' role in the Brazilian municipalities and shows some applied papers about the impacts of royalties in there. The third section briefly describe the methodology utilized. The fourth section contains the results and its discussion. Finally, the fifth section has the article conclusions.

2. Oil Royalties in Brazil

In Brazil, law #9.478/97, by changing the regulation of Brazilian oil sector, was responsible for the national oil industry boost. That law increased the tax of royalties and created more three sources of revenues: Especial Participations (PE, as Portuguese acronym), Signing Bonus and Payment for area retention (PIRES; SCHECHTMAN, 2013; BRASIL, 1997; 2010). In 2010, the regulatory mark was changed toward a more government leading model by the pass of the law #12.351, known as *"Sistema de Partilha"*. Besides the laws different economic core, the fresh one has not changed the oil tax of the previous law.

According to *ANP* data (Portuguese acronym means Oil National Agency), the oil income is shared among States (29%), Municipalities (34%), Brazilian Marine (15%), Science and Technology Ministry (12%), Especial Found (7%) and Social Found (3%).[4] This 34% paid to the municipalities meant almost R$ 4 billion yearly and, on average, 65% of this value went to the Rio de Janeiro municipalities, as can be seen in the Graph A.1 of Appendix.

The expressive revenues paid to the Brazilian municipalities as royalties, motivated plenty of researchers to study this revenues effects, highlighting Postali (2009), Postali (2015), Caselli and Michaels (2013), Caçador and Monte (2013), Nogueira and Menezes (2011) and Tavares and Almeida (2014).

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[4] The percentages are alluded to the Royalties and Especial Participations sharing among 2008 and 2012, but the percentages do not vary significantly throughout years.

The general symptom of natural resource curse, the low economic growth, was identified in the benefited states and municipalities (NOGUEIRA; MENEZES, 2011; POSTALI, 2009). Postali (2015), through a stochastic frontier model, found the royalties impact negatively the tax effort of the benefited city halls, so, the municipalities seem to exchange the taxes for royalties.

Caselli and Michaels (2013) and Tavares and Almeida (2014) identified the royalties had positive impacts in the health and education expenditures, but there were no evidences of service quality and welfare improvements in these areas. Monteiro's (2015) result corroborate Caselli and Michael (2013) results, because she found a positive effect of the royalties in the education budget, but no quality improvement. Caçador and Monte (2013) did not found any evidence of life quality improvement due to royalties, measured by IFDM index, in the *Espírito Santo* municipalities.

3. Methodology

3.1 Econometric Model

The methodology of this study consists of a spatial panel data model. The panel data model demands three assumptions to consistent and efficient parameters: strict exogeneity of the exogenous variables, homoscedasticity and nonautocorrelation (GREENE, 2012).

The spatial components are summarized by the effects that space has in the relation among people, cities or countries, and the negligence of these factors can produce biased estimators (ELHORST, 2014).

The spatial econometric model was supported by the LM and LR tests and by the analysis of the AIC criteria information and the likelihood function value. These tests pointed out the Durbin model with the exogenous variables and errors components spatial lagged as the best, known as SDEM. After the model was decided, the spatial components were modeled by the Haversine inverse distance spatial matrix. This matrix decision was supported by the highest Morans' I coefficient for the residuals.

In power of the properly econometric model, we estimated the direct, indirect and the total effects of the model SDEM, but also of the models SAR, SEM, SAC, SDM and SLX for check the robustness of the SDEM parameters.[5] The Table 1 shows how the effects are estimated by each model.

Table 1 **-** Direct and Indirect eefects of SAR, SEM, SAC, SDM, SDEM and SLX models.

	Efeito Direto	**Efeito Indireto (Transbordamento)**
OLS/SEM	β_k	0
SAR & SAC	Elementos da diagonal principal da matriz $(I-\rho W)^{-1}\beta_k$	Elementos fora da diagonal principal da matriz $(I-\rho W)^{-1}\beta_k$
SLX & SDEM	β_k	θ_k
SDM	Elementos da diagonal principal da matriz $(I-\rho W)^{-1}[\beta_k + W\theta_k]$	Elementos fora da diagonal principal da matriz $(I-\rho W)^{-1}[\beta_k + W\theta_k]$

Source: Adapted by Vega and Elhorst (2013).

3.2 Data

The data used in this study is from 92 municipalities of Rio de Janeiro state, covering the years among 2008 and 2012 and totalizing a strict balanced panel with 460 observations. Even though some cities do not have datum to one or another year, we decided not to cut off these cities and, thus, not to create fake spatial islands.

The independent variable is the logarithm of *per capita* GDP. The exogenous variables are inserted in the model to control urbanization aspects (Agricultural GDP/ GDP), municipal investments (FPM *per capita*, Capital expenditures *per capita*, Energy consumption *per capita* and Investments expenditures *per capita*), human capital (IFDM – Educational and Educational expenditure *per capita*), Health aspects (IFDM – Health), Labor market (IFDM – Job & Income), institutional action (IFGF), the oil income dependence (Royalties/GDP) and the oil income abundance (Royalties *per capita*). The Appendix Tables A.1 and A.2 shows the statistical summary and description of all variables used in the econometric models, respectively.

[5] The total effect was not showed in the Table 1 because it is the exactly sum of direct and indirect effect.

4. Results

4.1 EDA – Explanatory Data Analysis

In order to analyze the spatial autocorrelation in the dependent variable we estimated the tests Moran's I and Geary's C. Table 2 shows the results.

Table 2 - Morans' I and Geary's C tests for natural logarithm of *per capita* GDP among 2008 and 2012.

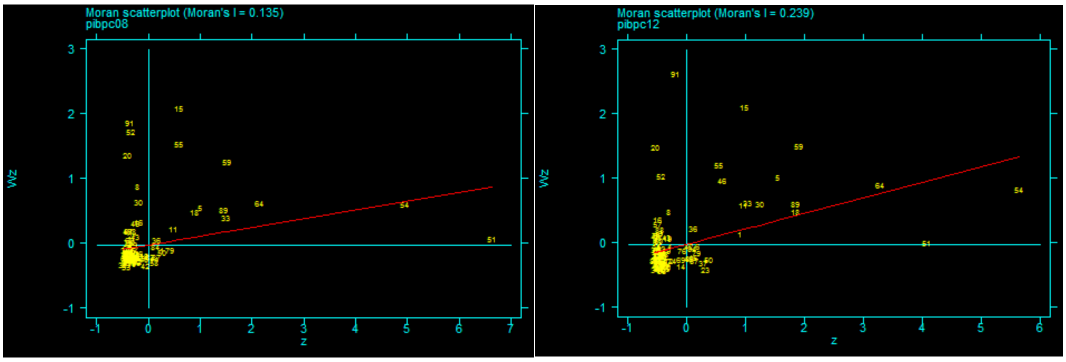
	Moran's I		Geary's C	
Spatial Matrix	W_inv. Haversine		W_inv. Haversine	
Variables	I	E(I)	C	E(C)
ln(PIB *per capita* 2008)	0.115***	-0.011	0.837***	1
	(0.029)		(0.038)	
ln(PIB *per capita* 2009)	0.108***	-0.011	0.853***	1
	(0.029)		(0.037)	
ln(PIB *per capita* 2010)	0.131***	-0.011	0.823***	1
	(0.029)		(0.037)	
ln(PIB *per capita* 2011)	0.138***	-0.011	0.8***	1
	(0.029)		(0.036)	
ln(PIB *per capita* 2012)	0.155***	-0.011	0.781***	1
	(0.029)		(0.035)	

Source: Made by the authors with research data.
*, **, *** represents statistical significances at 1%, 5% and 10%, respectively.

The Moran's I and Geary's C have as the null hypothesis the spatial nonautocorrelation. Therefore, the results confirm the presence of positive spatial autocorrelation in the *per capita* GDP natural logarithm, it means that municipalities with similar *per capita* GDP are close. However, by the global autocorrelation tests, we cannot identify if the neighbor municipalities have high or low *per capita* GDP.

The Moran's scatter plot can help in this global test limitations, because it shows four kinds of clustering pattern: High-High; High-Low; Low-High; Low-Low. The Figure 1 illustrates the Moran's box plot.

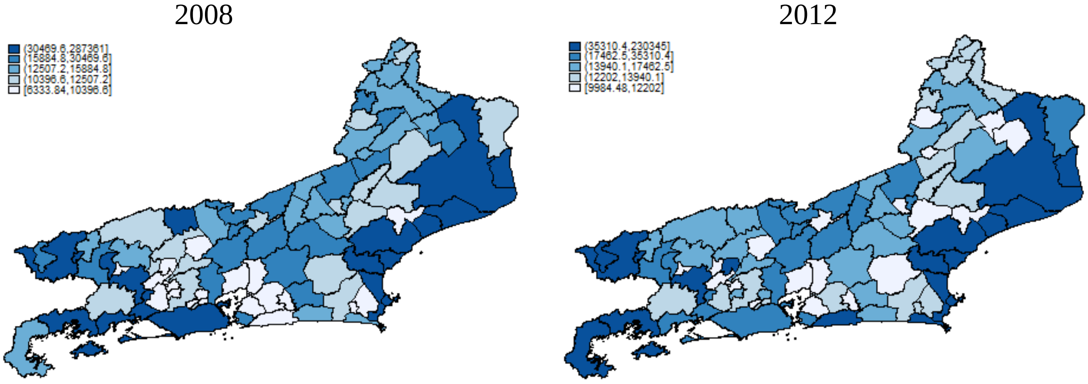
Figure 1 - Moran's I Box Plot for per capita GDP 2008 and 2012.



Source: Made by authors with research data.

The Moran's I scatter plot analysis indicates that the Rio de Janeiro municipalities are clustered in a Low-Low process, which means the Low *per capita* GDP municipalities are gathered in the state map. The Figure 2 confirms the association of low *per capita* GDP by a map which draws the *per capita* GDP in 2008 and 2012.

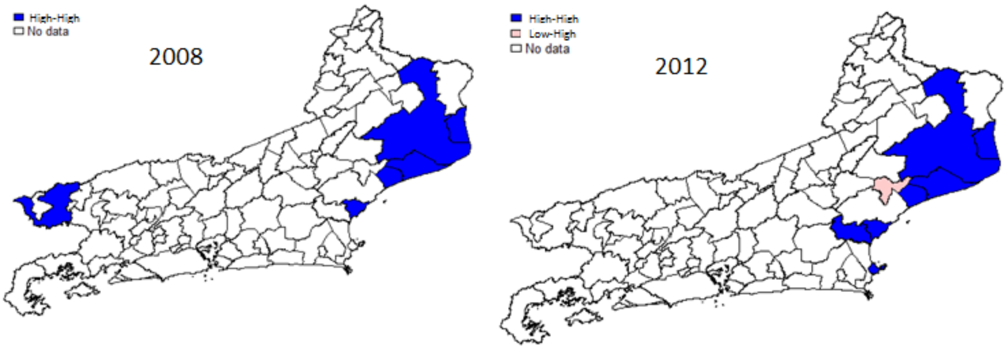
Figure 2 – Per capita GDP in 2008 and 2012.



Source: Made by the authors with the research data.

The Figure 2 confirms the global autocorrelation results in the sense of most of the lighter municipalities are close from each other, but there are two evident darker areas in the maps. The global test can hide some local clusters and that hidden clusters can have a different cluster pattern than the global has (ALMEIDA, 2012). Willing to test the presence of local clusters, the Figure 3 shows the Moran's Local Indicator of Spatial Association (LISA).

Figure 3 – Local Moran for per capita GDP in 2008 and 2012.



Source: Made by the authors with the research data.

Despite the global test have pointed the low-low agglomeration process, the Morans's Local test found seven municipalities in a High-High local cluster in 2008 and eight High-High in 2012. In 2012, LISA found one city as Low-High solo cluster, which means this municipality has low per capita GDP but it neighbors have not.

4.2 Econometric Model

The dependent variable is the natural logarithm of *per capita* GDP and the estimated parameters are the semi elasticities, because of the log-linear functional form.[6] The municipalities specific aspects were treated by the Fixed Effect. The tests Morans' I, Geary's C, LM and LR had supported the model decision and all the tests results are illustrated in the Appendix Tables A.3, A.4, A.5 and A.6. Then, the proposed model is given by:

$$\ln(PIBPC)_{it} = \mu_i + \beta_2 AGROPIB_{it} + \beta_3 INVPIB_{it} + \beta_4 DESPKPC_{it} + \beta_5 CENERGIAPC_{it} + \beta_6 FPMPC_{it} + \beta_7 IFDMS_{it} + \beta_8 IFDMEDUC_{it} + \beta_9 IFDMER_{it} + \beta_{10} IFGF_{it} + \beta_{11} EDUCMAT_{it} + \beta_{12} ROYPIB_{it} + \beta_{13} ROYPC_{it} + \beta_{14} ROYPIBINSTIT_{it} + \theta_2 AGROPIB_{it} + \theta_3 INVPIB_{it} + \theta_4 DESPKPC_{it} + \theta_5 CENERGIAPC_{it} + \theta_6 FPMPC_{it} + \theta_7 IFDMS_{it} + \theta_8 IFDMEDUC_{it} + \theta_9 IFDMER_{it} + \theta_{10} IFGF_{it} + \theta_{11} EDUCMAT_{it} + \theta_{12} ROYPIB_{it} + \theta_{13} ROYPC_{it} + \theta_{14} ROYPIBINSTIT_{it} + v_{it} \quad (1)$$

with,

$$v_{it} = \lambda W v_{it} + u_{it}. \ (25.1)$$

The Table 3 shows the estimated parameters of SDEM model.

[6] The precise semi elasticities is $e^{\beta_i} - 1$.

Table 2 **-** Parameters estimated by SDEM model.

Dependent Variable: ln(GDP *per capita*)			
	DE	SE	TE
agropib	-1.437***	5.172***	3.735
	(0.2453)	(1.4589)	(1.7042)
invpib	-2.046***	-18.36***	-20.406
	(0.6218)	(5.7466)	(6.3684)
despkpc	-0.0000187	0.00002	1.3E-06
	(0.0001)	(0.0005)	(0.0006)
cenergiapc	0.0623	0.552	0.6143
	(0.1067)	(1.0850)	(1.1917)
fpmpc	-0.000279	-0.0021	-0.00238
	(0.0002)	(0.0013)	(0.0015)
ifdms	-0.232	-2.239	-2.471
	(0.3652)	(2.0632)	(2.4284)
ifdmeduc	-0.185	5.691***	5.506
	(0.6096)	(1.6750)	(2.2846)
ifdmer	0.549***	0.584	1.133
	(0.1695)	(1.2776)	(1.4471)
ifgf	0.139	2.286*	2.425
	(0.1614)	(1.3251)	(1.4865)
educmat	0.00000940**	-3E-05	-2E-05
	0.0000	0.0000	0.0000
roypib	-5.553***	36.40**	30.847
	(2.0404)	(18.2034)	(20.2438)
roypc	0.000140***	0.000394	0.000534
	0.0000	(0.0003)	(0.0003)
roypibinstit	0.587	-38.44	-37.853
	(3.4943)	(28.0636)	(31.5579)

Source: Made by the authors with the research data.
Std. deviations are between parenthesis below the coefficients.
*, **, *** represents statistical significances at 1%, 5% and 10%, respectively.
DE – Direct Effect; SE – Spillover Effect; TE – Total Effect.

The robustness check is made by comparing the estimated parameters of Table 3 to the results of Appendix Tables A.7, A.8 and A.9. These tables provide the direct, spillover and total effects of models SAR, SEM, SAC, SDM and SLX, through which were possible to check the parameters are similar, what indicates the robustness of the estimators.

Almost all the variables had the expected signs. The urbanization level, measured by the participation of the agricultural GDP in the total GDP, was negative and significant, which indicates that municipalities which are more rural grow less, as Henderson (2003) suggested.

In reference to the municipality investment, only the *per capita* energy consumption had the expected sign, while all the others were negative and only the ration between investment expenditure and GDP was significant, though. The negative signs can be explained by the variables weakly approximation to the municipalities investments, but all them are suggested in economic papers (FIRME; SIMÃO FILHO, 2014). Another plausible explanation is the municipalities investments are not being able to generate economic growth in the Rio de Janeiro municipalities due to the diminishing of the public investment efficiency, what is a consequence of the natural resource curse scenario (AUTY, 2007).

The labor market had a positive impact in the municipalities *per capita* GDP, as the positive and significant IFDM – Labor & Wage coefficient showed. The educational investment was captured by the educational expenditure per student, and that was positive and significant. These two results confirmed the initial expectation.

This paper aim was to analyze the oil royalties impacts in the municipalities *per capita* GDP. Firstly, we divided the oil effects in dependence and in abundance, to see if the oil presence by itself was a curse reason. The oil abundance was positive and significant, increasing the *per capita* GDP in 0.14% by R$ 1.00 received of that income. This result confirms what Stijns (2005) said, the oil income can sustain plenty of important infrastructure projects and social expenditures, as educational and health programs. Therefore, the natural wealth existence by itself is not a curse.

Nevertheless, the basic SW (1995; 1999; 2001) results affirms that countries most dependent upon natural resources grew less than the less dependents. The negative and significant coefficient of oil dependence confirms that result too, but our oil dependence was measured by the oil royalties over GDP. The oil dependence increment at 1 percentual point diminishes the per capita GDP in 5.55%.

This result agrees with the Postali (2009), James and Aadland (2011), Nogueira and Menezes (2011) and Elliott, Hartarska and Bailey (2007), because our results confirm the presence of the natural resource curse in the Rio de Janeiro municipalities.

Although the reasons of the curse were not approached in this paper, the results pointed out by Postali (2015), Monteiro (2015), Caselli and Michaels (2013), Caçador and Monte (2013), Nogueira and Menezes (2011) and Tavares and Almeida (2014) regarding Brazilian local regions confluence with the results pointed out by national level of Brückner (2010), Stevens and Diestsche (2008), Gylfason (2001) and Papyrakis and Gerlagh (2004).

So, the natural wealth dependence seems to be a problem for the governments, as already exposed. In order to test the assumption of Robinson, Torvik and Vernier (2006) that institutions action could solve the resources' curse, we utilized the Brunnschweiler (2008) and Brunnschweiler and Bulte (2008) interaction term, by multiplying the oil dependence and the FIRJAN Fiscal Management Index (IFGF as Brazilian acronym).

The coefficient of interaction term was positive, but not significant. This mean that the best the institutions' actions are, the lower the resource curse symptoms become, despite the lack of statistical significance. The absence of statistical significance might have been caused by the fact that institutions' effects take time to be totally absorbed by the population.

Regarding the spillover effect, the abundancy coefficient was not significant, indicating the presence of oil royalties in the reference city does not affect the neighbors. On the other hand, the oil income dependence was positive and significant, increasing the neighbor per capita GDP in 36.4%. This result corroborates the Ji, Magnus and Wang (2013) result for Chinese provinces.

5. Conclusion

This paper aimed to analyze the oil royalties impacts in the Rio de Janeiro municipalities, by a spatial approach. For that, the SDEM econometric was choose because of the tests Morans' I, Geary's C, LM and LR had supported the model decision.

This paper concluded that the natural resource curse is present in Rio de Janeiro municipalities and caused by the oil income dependence, considering the negative direct effect. However, our results showed the oil royalties abundance is not a reason to be called as curse, because of the positive and significant coefficient of *per capita* royalties.

The royalties dependence spillover effect was positive and significant, indicating the natural resource curse is not a regional issue. This positive result was explained because the reasons to having a curse (rent seeking, corruption, low public investment efficiency, low institutional quality, etc.) do not transpose the municipality border.

The institutional action upon the resource curse was tested by the multiplication of oil dependence and IFGF. This coefficient was positive, as expected, but no significant. The sign agrees with the theory, that institutions can solve the curse, but the proxy or the period were not enough to find this relation between institutions and Rio de Janeiro municipalities economic growth.

Thus, this paper contributes with the natural resource curse literature by bringing a spatial analysis of oil impacts in Rio de Janeiro municipalities. Moreover, besides better supervisory institutions, we suggest to the Brazilian and Rio de Janeiro government to save more the oil income to the next generation by diminishing the oil transfers to municipalities and states and increasing the Social Found from 3% to more than 50%, becoming Brazilian oil policy closer than the Norway policy.

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Appendix

Table A.1 - Statistical Summary of utilized variables.

Variables	Mean	Std. Dev.	Min	Max	Unit	Sign. Expect	Fonte
GDP per capita	27.095,3	37.776,6	945,8	33.7473,4	R$		IBGE
GDP Agro/GDP	0,0	0,1	0,0	0,6	%	-	IBGE
Investment/GDP	0,0	0,1	0,0	0,6	%	+	FINBRA
K exp./GDP	352,8	390,8	0,0	4.661,6	R$	+	FINBRA
Energy cons. per capita	0,3	0,1	0,0	0,9	MWh	+	CEPERJ
FPM per capita	357,8	175,7	0,0	982,4	R$	+	FINBRA
IFDM – Health	0,7	0,1	0,4	0,9	Índice	+	FIRJAN
IFDM – Education	0,7	0,1	0,5	0,9	Índice	+	FIRJAN
IFDM – Job & Income	0,6	0,1	0,3	0,9	Índice	+	FIRJAN
IFGF	0,6	0,1	0,0	0,9	Índice	+	FIRJAN
Educational exp./student	3.497,5	3.438,8	0,0	35.018,5	R$	+	FINBRA
Royalties/GDP	0,0	0,1	0,0	0,6	%	?	ANP
Royalties *per capita*	590,7	1.154,4	0,0	9.382,7	R$	?	ANP

Source: Made by authors with research data.

Table A.2 – Variables description.

Variables	Definition
Per Capita GDP	Per capita GDP of Rio de Janeiro municipalities
Agricultural GDP/GDP	The ration between agricultural GDP and total GDP
Investment Expenditures/GDP	The ration between investment expenditures in the year and the same year GDP. The investment expenditures account the physical capital acquisitions for the people use.
Capital Expenditures	The capital expenditures account the investment expenditures plus the financial inversions and transfers
Per Capita Energy Consumption	The ratio between energy consumption and population
Per Capita FPM	It is the received transfers from Federal Government to equalize the revenues imbalances
IFDM - Health	It is a Health Index made by FIRJAN. The index accounts the basic health attendance and child death reasons.
IFDM - Education	It is an Educational Index made by FIRJAN. The index accounts the child number in school, elementary school students dropping out, weakly hours' class and IDEB score (Brazilian educational test).
IFDM - Labor & Wage	It is a Labor and Wage Index made by FIRJAN. It accounts the formal labor generation, local work force absorption, formal income generation, average wage and Gini's wage index.
IFGF	It is a Fiscal Quality Index made by FIRJAN. It accounts the tax collection capability, investment capacity, people expenditures, liquidity and debt cost.
Educational Expenditure per student	Total municipality educational expenditure over number of students till high school.
Royalties over GDP	Total royalties received in relation to GDP
Per Capita Royalties	Total royalties received over total population

Source: Made by the authors.

Table A.3 – Moran's I for SDEM model residuals.

Matrizes	I de Moran
Queen	0.00760491
Euclidiana Inversa	0.03
Euclidiana Inversa até 2 vizinhos	0.02208972
Haversine Inversa	0.03
Haversine Inversa até 90 milhas	0.02683003

Source: Made by the authors with research data.

Table A.4 – LM test for OLS model and SLX model.

teste	estat	pvalor
SEM	7.8546	0.005069
SAR	2.5519	0.1102
SEM rob	5.3817	0.02035
SAR rob	0.078948	0.7787
SAC	7.9336	0.01893
SDEM	4.3925	0.0361
SDM	3.738	0.05319
SDEM rob	1.7364	0.1876
SDM rob	1.0819	0.2983

Source: Made by the authors with research data.

Table A.5 – LR tests for all estimated models.

LR test	pvalor
SARxSAC	0.6387
SARxSDM	0.0049
SARxSDEM	0.011
SEMxSDM	0.00008
SEMxSDEM	0.002
SEMxSAC	0.0211

Source: Made by the authors with research data.

Table A.6 – AIC criterion information and value of the function Log likelihood.

Models	AIC	Log-Likelihood
SAR	-67.744	48.872
SEM	-62.32267	46.32
SAC	(65.964)	48.98223
SDM	-71.64621	63.82311
SDEM	-69.20786	62.604
SLX	-71.17558	62.58779

Source: Made by the authors with research data.

Table A.7 – SAR, SEM, SAC, SDM and SLX Direct Effects.

Variables	SAR	SEM	SAC	SDM	SLX
agropib	-1.514***	-1.536***	-1.474***	-1.449***	-1.436***
	(0.1841)	(0.2254)	(0.1842)	(0.2067)	(0.2843)
invpib	-1.346**	-1.408**	-1.398**	-1.973***	-2.055***
	(0.6708)	(0.6114)	(0.6751)	(0.6781)	(0.7261)
despkpc	0.00000577	0.00000412	0.00000742	-0.0000163	-0.0000187
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
cenergiapc	0.031	0.0433	0.0296	0.0609	0.0626
	(0.1038)	(0.1075)	(0.1037)	(0.1037)	(0.1244)
fpmpc	-0.000341	-0.000398	-0.000376*	-0.00022	-0.000273
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)
ifdms	0.0653	0.0196	0.0628	-0.166	-0.243
	(0.3583)	(0.3579)	(0.3532)	(0.3739)	(0.4225)
ifdmeduc	0.151	0.511	0.142	-0.21	-0.193
	(0.4146)	(0.4087)	(0.3882)	(0.6364)	(0.7056)
ifdmer	0.541***	0.546***	0.542***	0.536***	0.545***
	(0.1635)	(0.1712)	(0.1617)	(0.1664)	(0.1969)
ifgf	0.0117	0.0602	0.0152	0.103	0.141
	(0.1436)	(0.1594)	(0.1434)	(0.1448)	(0.1874)
educmat	0.00000918**	0.00000827**	0.00000905**	0.00000943**	0.00000953**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
roypib	-6.166***	-6.032***	-6.176***	-5.747***	-5.533**
	(2.0060)	(2.0624)	(1.9971)	(2.0196)	(2.3757)
roypc	0.000179***	0.000184***	0.000182***	0.000135***	0.000142***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)
roypibinstit	0.296	0.254	0.344	0.803	0.575
	(3.4966)	(3.5578)	(3.4827)	(3.4807)	(4.0664)

Source: Made by the authors with the research data.
Std. deviations are between parenthesis below the coefficients.
*, **, *** represents statistical significances at 1%, 5% and 10%, respectively.
DE – Direct Effect; SE – Spillover Effect; TE – Total Effect.

Table A.8 **-** SAR, SAC, SDM and SLX spillover effects

Variables	SAR	SAC	SDM	SLX
agropib	-0.593	-0.721	4.096***	5.196***
	(0.3793)	(0.4386)	(1.5267)	(1.7595)
invpib	-0.535	-0.701	-14.70**	-18.95***
	(0.4646)	(0.5865)	(6.2927)	(6.7606)
despkpc	2.36E-06	4.11E-06	-5.9E-05	-2.5E-05
	0.0000	0.0000	(0.0005)	(0.0006)
cenergiapc	0.00932	0.0106	0.336	0.414
	(0.0492)	(0.0623)	(0.8978)	(1.2779)
fpmpc	-0.00013	-0.00018	-0.00205	-0.00221
	(0.0001)	(0.0002)	(0.0013)	(0.0016)
ifdms	0.0367	0.0439	-1.666	-2.059
	(0.2059)	(0.2551)	(1.8847)	(2.5063)
ifdmeduc	0.00738	0.00779	5.039***	5.938***
	(0.1801)	(0.2165)	(1.7358)	(2.0010)
ifdmer	0.211	0.267	0.337	0.453
	(0.1455)	(0.1782)	(1.0565)	(1.5344)
ifgf	-0.00073	-0.00123	2.056	2.316
	(0.0615)	(0.0763)	(1.3917)	(1.5819)
educmat	3.74E-06	4.61E-06	-2.7E-05	-3.1E-05
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
roypib	-2.375	-2.999	30.35*	35.29
	(1.6304)	(1.9949)	(16.8979)	(22.0582)
roypc	0.000071	9.07E-05	0.000357	0.000378
	(0.0000)	(0.0001)	(0.0002)	(0.0003)
roypibinstit	0.0345	0.0907	-33.21	-35.87
	(1.5225)	(1.8517)	(25.2762)	(34.1212)

Source: Made by the authors with the research data.

Std. deviations are between parenthesis below the coefficients.

*, **, *** represents statistical significances at 1%, 5% and 10%, respectively.

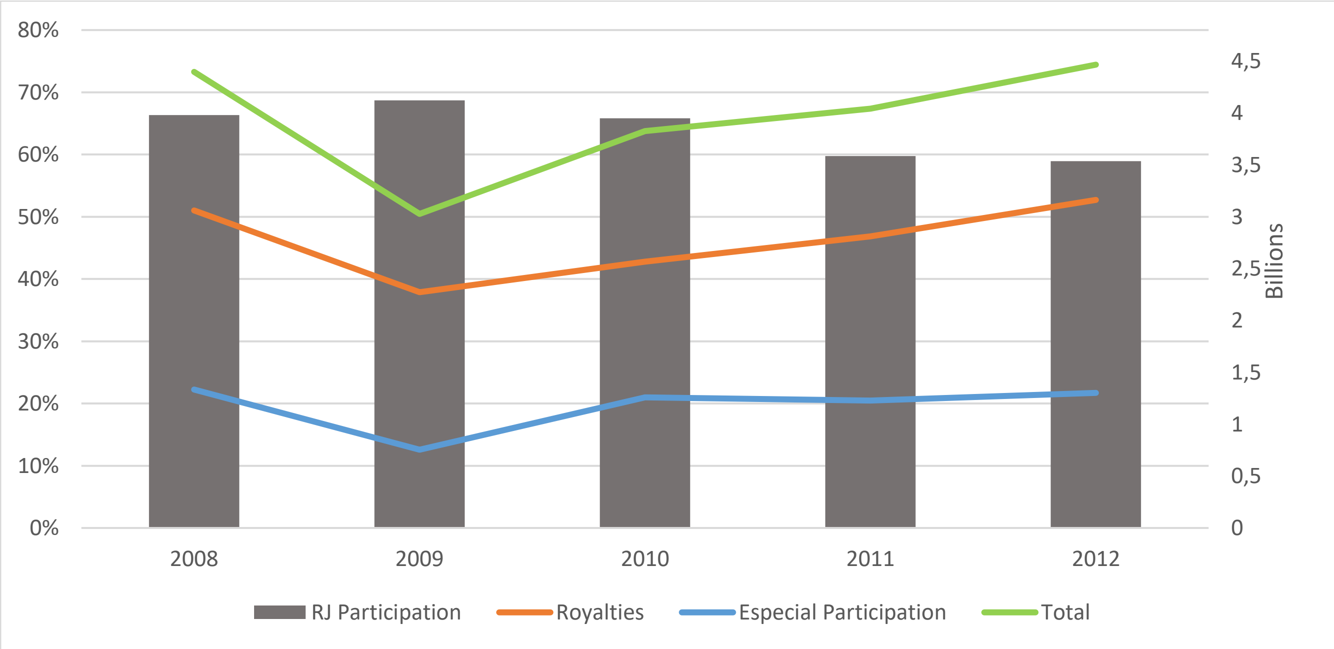
DE – Direct Effect; SE – Spillover Effect; TE – Total Effect.

Table A.9 - SAR, SAC, SDM and SLX total effects.

Variables	SAR	SAC	SDM	SLX
agropib	-2.107***	-2.195***	2.647*	3.76
	(0.4433)	(0.4895)	(1.5506)	(2.044)
invpib	-1.880*	-2.099*	-16.68***	-21.005
	(1.0009)	(1.1143)	(6.4651)	(7.487)
despkpc	8.12E-06	1.15E-05	-7.5E-05	-4.4E-05
	(0.0001)	(0.0001)	(0.0005)	(0.001)
cenergiapc	0.0403	0.0401	0.397	0.4766
	(0.1485)	(0.1609)	(0.9014)	(1.402)
fpmpc	-0.00047	-0.00056	-0.00227*	-0.00248
	(0.0003)	(0.0004)	(0.0013)	(0.002)
ifdms	0.102	0.107	-1.832	-2.302
	(0.5442)	(0.5853)	(1.7830)	(2.929)
ifdmeduc	0.159	0.15	4.830***	5.745
	(0.5715)	(0.5802)	(1.6850)	(2.707)
ifdmer	0.753***	0.809***	0.874	0.998
	(0.2538)	(0.2820)	(1.0722)	(1.731)
ifgf	0.011	0.014	2.159	2.457
	(0.1974)	(0.2111)	(1.4173)	(1.769)
educmat	0.0000129**	0.0000137*	-1.8E-05	-2.2E-05
	0.0000	0.0000	0.0000	0.000
roypib	-8.541***	-9.175***	24.6	29.757
	(3.0146)	(3.3228)	(17.3957)	(24.434)
roypc	0.000250***	0.000273***	0.000492**	0.00052
	(0.0001)	(0.0001)	(0.0002)	(0.000)
roypibinstit	0.331	0.434	-32.41	-35.295
	(4.8596)	(5.1649)	(25.7829)	(38.188)

Source: Made by the authors with the research data.
Std. deviations are between parenthesis below the coefficients.
*, **, *** represents statistical significances at 1%, 5% and 10%, respectively.
DE – Direct Effect; SE – Spillover Effect; TE – Total Effect.

Graph A.1 – Oil Royalties and Especial Participation paid to the municipalities governments and the Rio de Janeiro municipalities share of total.



Source: Made by the authors with research data.