The impact of oil exploitation on wellbeing in Chad

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Abstract

This paper analyses the impact of oil revenues on wellbeing in Chad. Data is provided from the two last Chad Household Consumption and Informal Sector Surveys (ECOSIT 2 & 3) and from the College for Control and Monitoring of Oil Revenues (CCSRP). After using the multiple components analysis to estimate a synthetic household-based multidimensional wellbeing index (MDW), the Difference-in-Difference approach is employed to assess the impact of oil revenues on the average MDW at departmental level. We find evidence that departments in Chad that received significant oil transfers increased their MDW about 35% more than those disadvantaged by the oil revenues redistribution policy. Also, departments closest to the capital city N'Djamena benefited from spillover effects and score higher MDW. We conclude that in order to promote economic inclusion in Chad, the government should better target oil revenue redistribution policies according to local development needs and toward the poorest departments.

Key words: Poverty, Multidimensional wellbeing, Oil exploitation, Redistribution policy, Chad.

JEL Classification: C23, D63, I30, O18, Q32.

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1. Introduction

Formal investments in the oil sector took place in Chad by 2000 and the oil production started effectively from October 2003. As a leading producer of crude oil, oil exploitation contributed to significantly improve the country's macroeconomic performance. The economic growth rate which averaged at 4% in the 1990s before oil exploitation, reached 7% during the 2000s (INSEED, 2013). Indeed, oil sector accounts for 84.5% of exportations, 71.3% of ordinary budget revenues, and 14.2% of the gross domestic product (EITI, 2014). Despite this favorable pattern of macroeconomic indicators, the country has struggled in achieving the Millennium Development Goals (ECA et al., 2014). For instance, Chad was ranked 184th over 187 countries regarding the human development index in 2013 (UNDP, 2013). Also, the poverty remains high at 47% and fell by only 1 percentage point per year on average between 2003 and 2011 (World Bank, 2013).

Much of the debate around the governance of extractive, particularly in Sub-Saharan Africa, has focused on how to support policy to prevent the so-called 'resource curse'. Thoughts made by scholars and policy makers is increasingly devoted to help governments in managing negative impacts at local levels (Cust & Viale, 2016). These thoughts are predominantly concerned with three main issues (Lipschutz & Henstridge 2013). Firstly, financial issues related to revenue generation and management associated with extractives, especially oil. This is highlighted by the fact that Chad has joined in 2007 the Extractive Industries Transparency Initiative (EITI) which advocates that payments made by companies flow to the government's budget and are effectively overseen. Secondly, environmental negative effects of oil exploitation such as contamination of ground water, accidental chemical spills, reduction in air quality, etc. constitute important issues (Zhang et al., 2013). Chad experienced some accidental spilling of crude oil in the past. One of the most tragic was the spilling of about 200 barrels in October 2010 which led to an environmental catastrophe in *Kome* district with serious costs on income-generating activities, especially agriculture. Lastly, social issues related to citizens' living standards and wellbeing play an important role to strengthen policies against resource curse. Indeed, poor impacts of exploitation of natural resources on citizens' wellbeing accentuate inequalities and spatial disparities in the country that lead to ethnic conflicts and political instability like the most recent 2005-2010 Chadian civil war (Ross 2004; Hoinathy, 2013).

Despite the crucial role of financial and environmental issues, our paper focuses on assessment of social impacts of oil exploitation in Chad. Yet, because of the capital-intensiveness of oil exploitation – contrary to the labour-intensiveness of mining activities – social issues would be effectively tackled through an appropriate management of oil revenues (Sachs & Warner, 2001). This concern was effectively raised in Chad by the World Bank who recommended the adoption of an oil revenues management and redistribution programme in order to better alleviate poverty and improve living conditions and economic inclusion throughout the country (Ndang & Nan-Guer, 2011; Thorbecke, 2013; Fondo et al., 2013). This was formally adopted through the Law 001/PR/99 enacted in 1999 after discovery of first oil wells. The law explicitly states that 70% of direct oil revenues would be allocated to priority sectors (such as education, health, social affairs, infrastructures, agriculture and rural development), 15% for public investments, 5% to the oil producing region, and 10% devoted to future generations.

However, several stakeholders denounced the non-respect of this programme by the Chadian government which led to inappropriate and discretionary management of oil revenues in Chad (World Bank, 2013). Such a situation may accentuate variations in levels of economic wellbeing across regions, though it is a development challenge retained in the Poverty Reduction Strategy Papers and the National Development Plan in Chad (Mabali & Mantobaye, 2015). Our paper therefore aims to provide a causal assessment of the oil revenues redistribution on household wellbeing at local (departmental) level. Our identification strategy considers a hypothetical scenario of a fair redistribution policy so that departments receive amounts of oil revenues according to their demographic weights. This scenario serves as a treatment and the difference-in-difference approach is used to assess its impact on changes in average wellbeing at departmental level before and after oil exploitation in Chad. We find evidence that economic inclusion in Chad would be better promoted in Chad if the government targets effectively oil revenue redistribution policies according to local development needs and toward the poorest departments.

The rest of the paper is organized as follows. Section 2 provides a brief literature review. In section 3, we describe the oil revenue redistribution policy in Chad. Section 4 explains data and methodology used. Section 5 presents the results and section 6 concludes.

2. Literature review

Regarding leadership and economic challenges, exploitation of natural resources is generally viewed as an opportunity for resource-rich countries, especially in developing counties. Yet, an intense literature inspired from the seminal papers of Sachs and Warner (1995, 1999, 2001) pointed out the potential adverse effects on economic development of natural resources. Numerous studies documented the macroeconomic effects of natural resources and argued that rent-seeking and Dutch disease are the main mechanisms which explain why abundance of natural resources is not always a blessing for countries, especially in a context of weak institutions (Gylfason 2001; Acemoglu et al., 2004; Mehlum et al., 2006; Behbudi et al., 2010; Ebeke et al., 2015).

Although studies analysing the macroeconomic effects of natural resources remain abundant, a growing number of research papers have tried to fill the gap of scarcity of studies, which investigate the natural resource curse from a microeconomic or local perspective (Aragon & Rud 2013; Lippert 2014; Loayza & Rigolini, 2016; Bauer et al., 2016). An overview of existing literature on subnational impacts of exploitation of natural resources highlights three main channels: the direct impacts of the projects (mining or hydrocarbon), the indirect impacts from the spending of resource revenues, and finally the spillovers (infrastructures, migration and other supply side responses to resource wealth) from producing to other local areas (Cust & Viale, 2016). Direct socioeconomic impacts include effects such as job creation, purchases and social spending that local communities benefit as a result of the extractive project activities[4]. Some empirical country case studies found that socioeconomic indicators (employment, education and health issues, small businesses and inequality) in oil and mineral producing areas are better than in non-producing areas (Hajkowicz et al., 2011; Arellano-Yanguas, 2011; Aragon & Rud, 2013). Various other studies provide evidence of poor economic performance in resource-rich areas pointing thus the existence of Dutch disease mechanisms and resource curse at the local level (James & Aadland, 2011; Allcott & Keniston, 2014; Beine et al., 2015; Cust & Poelhekke, 2015).

Although the lack of consensus about empirical direct socioeconomic impacts of natural resources may be explained by the use of more sophisticated econometric approaches and several databases, the main theoretical argument relies on the nature of extraction activities. Indeed, labour-intensive extraction such as mining are more prone to exhibit positive direct impacts, while capital-intensive extraction like hydrocarbon in general and oil exploitation in particular tends to produce negative direct impacts. But, this evidence is contrasted while considering the indirect impacts which point out the effects of resource revenue spending by centralized or subnational governments

[4] Also negative impacts such as increased prices of local consumption goods, increased crime rates and prostitution, among others can be considered as the so-called ‘booming town effects’.

according to the identification issues. Some empirical studies (Postali 2009; Caselli & Michaels, 2013) found no significant local impacts of oil windfalls on living standards measured by welfare indicators related to housing, educational and health inputs, road infrastructure, and others. These studies established the existence of resource curse at local level because in some cases municipalities that received oil revenues are worse off in these indicators compared to those that didn't receive them. The authors justify the results by pointing centralized and local governance issues characterized by deviation of funds or corruption within the fiscal decentralized process. Monge and Viale (2011) found similar results of negligible impact of mining and hydrocarbon revenues spent across districts in Peru. They highlighted that these transfers to producing local governments generate symptoms of a within-country Dutch disease.

Various other studies contrast these previous findings of either no effects or negative impacts from resources revenues spent by subnational governments. For instance, Postali and Nishijima (2013) showed that royalties had a positive long-run social impacts on household wellbeing in Brazil, especially in terms of increase of literacy rate, access to electricity and water, and garbage collection. Similar short-run economic performance were found by Cust and Rusli (2014) who noted the role of fiscal spillovers from local government spending associated with revenues windfalls from extraction activity in Indonesia.

Some studies have addressed the issue of the egalitarian nature of the policy of oil revenues redistribution and its role in the cross-county poverty disparities in Chad within the context of oil exploitation (Ndang & Nan-Guer, 2011; World Bank, 2013; Mabali & Mantobaye, 2015; Gadom & Mboutchouang, 2016). However, to our knowledge there is no study that assesses on the local perspective the impact of oil revenues on household wellbeing in Chad. Our paper aims to fill this gap by providing such empirical evidences.

3. Data and Methodology

Data used are derived from the two last Chad Household Consumption and Informal Sector Surveys ECOSITs 2 and 3 carried out by the National Institute of Statistics, Economic and Demographic Studies (INSEED) in 2003 and 2011 respectively. These databases present at least three main characteristics valuable for this study. Firstly, they constitute unique data sources to conduct analyses of non-monetary wellbeing. Secondly, their stratified sampling design allows to cover administrative departments throughout the country. Thirdly, they provide a suitable framework for conducting impact evaluation analysis as ECOSITs 2 and 3 offer pre- and post-intervention information regarding oil exploitation which started in 2003.

These household surveys are completed with administrative data on the amounts of oil revenues allocated across departments since 2005 by the CCSRP organ. However, a specific harmonization at the post-intervention level is required to match both data sources. Indeed, ECOSIT 3 and CCSRP do not cover the same number of geographical units[5]. The first covers 20 regions and 73 departments, while the second covers 12 regions and 62 departments. Nevertheless, one can recover each region and department of the CCSRP from the ECOSIT 3 coverage scheme because the high number of geographical units from ECOSIT 3 is derived from the subdivision of some units from CCSRP. Then, we regrouped departments from ECOSIT 3 in order to find again the departments from CCSRP which serves as our baseline coverage scheme although it provides the lowest number of geographical units.

[5] In Chad, sub-national administrative units are called regions, departments, districts, and sub-districts in decreasing order of size since the Decree N°419/PR/MAT/02 on 17th October 2002. Although the higher number of districts would enable a more refined analysis, the department is the lowest administrative unit retained. There are two main difficulties to use the district as a unit of analysis. Firstly, the selected primary sampling units used for the ECOSIT surveys largely vary from one cross-sectional dataset to another (especially ECOSITs 2 and 3 in our case). Secondly, data on oil revenues redistribution from the CCSRP organ do not go beyond the departmental scope.

Based on the assumption that the Oil Revenues Redistribution Policy (ORRP) may help to improve individuals' living standards across departments as local investments in social sectors like health, education, water provision, infrastructures are mainly financed by oil revenues in Chad, our objective is to assess the local impacts of ORRP on MDW. To do this, we consider an impact evaluation analysis framework based on a hypothetical oil rents redistribution mechanism. Indeed, to better alleviate the resource curse, natural resource governance requires redistribution mechanisms to be set up according to the development needs in different localities[6]. Thus, assuming that development needs are highly correlated to the size of the population in each geographic unit (department), it is possible to consider a ratio for each department that indicates whether the redistribution policy has been favorable or not to its demographic needs. The ratio is given by:

$$r_d = \frac{\frac{Oil\ Revenues\ Budget_{Department}}{Oil\ Revenues\ Budget_{National}}}{\frac{Population_{Department}}{Population_{National}}} = \frac{Oil_d}{Dem_d} \qquad [01]$$

Where Oil_d represents the percentage of oil revenues budget received by the department d, and Dem_d indicates its demographic weight[7]. A ratio $r_d < 1$ shows that the oil share received by the department is lower than what its population represents compared to the national population. Thus, such a redistribution seems disadvantageous for this department given that the percentage of oil revenues received does not match its demographic needs. Conversely, a ratio $r_d > 1$ indicates that the redistribution policy is favorable for the considered department. If $r_d = 1$, the

[6] Several works discuss the social and economic efficiencies of different redistribution mechanisms of natural resources rents around the world. See for instance Sala-i-Martin and Subramanian (2003), Sandbu (2006), Segal (2011), Maguire and Winters (2016) for a detailed literature review.

[7] The percentage of oil revenues is computed through data from CCSRP based on the average amount of direct oil revenues redistributed throughout the country between 2008 and 2011. Information before 2008 is not available, while data after 2011 go beyond the scope of this study. However, demographic weights are given by the second General Population and Housing Census conducted by INSEED in 2009. These demographic weights are easily imputed in year 2011 under the assumption that the population has not largely changed between the two dates.

demographic needs are exactly matched. Then, the per capita oil revenues budget for the department is exactly equal to the one at national level (see equation 2 below). Appendix A shows the values of Dem_d, Oil_d and r_d computed for each department.

$$r_d = 1 \quad \text{if} \quad \frac{Oil\ Revenues\ Budget_{Department}}{Population_{Department}} = \frac{Oil\ Revenues\ Budget_{National}}{Population_{National}} \qquad [02]$$

Regarding our identification strategy, we assume that the treated departments are those which have received a per capita oil revenue at least higher than that at national level as a benchmark reference. Indeed, the ratio r_d allows us to build two groups of departments according to oil transfers received during the post-intervention period (after year 2003). The first group is represented by *treated departments* for which ratio is greater or equal to 1. The second group is constituted by *untreated departments* disadvantaged by the redistribution policy for which ratio is less than 1. To sum up, within a setting of N departments in Chad, $N_1 < N$ departments scoring a ratio $r_d \geq 1$ will be the treatment group, while the remaining $N_0 = N - N_1$ departments will represent the control group. Following Zambrano et al. (2014), we also assume that two potential outcomes exist for each department $d \in [1, N]$. First, $Y_d(0)$ denotes the outcome that would be realized by department d if it had not received oil shares that at least match with its demographic needs. On the other hand, $Y_d(1)$ denotes the outcome that would be realized by department d after receiving oil shares which are not disadvantageous regarding its demographic needs. Assuming that the probability of getting a ratio $r_d \geq 1$ is independent from any observable characteristics of the recipient departments out of their respective demographic weights, difference $Y_d(1) - Y_d(0)$ represents the causal effect at the departmental level[8]. Then, DID approach is our preferred method

[8] These two potential outcomes are mutually exclusive; only one of them can be realized.

to estimate the average effect of the treatment[9]. We implement DID estimation approach within a linear regression framework. Our basic model follows Imbens and Wooldridge (2009):

$$Y_{dt} = \alpha + \gamma.T + \lambda.D_d + \delta.(T.D_d) + \beta.X_{dt} + \varepsilon_{dt} \quad [03]$$

Where Y_{dt} is the outcome (average MDW score) in department d at time t. Appendix B presents the construction of the synthetic index of multidimensional wellbeing (MDW) based on a large set of welfare and access to facilities indicators. T is a dummy variable equal to 0 in the pre-intervention period (2003) and 1 in the post-intervention period (2011); D_d is a dummy variable equal to 1 for the treated department and 0 otherwise; X_{dt} is a set of time invariant and department characteristics for each time period[10]; and ε_{dt} represents the error term assumed independent and identically distributed.

The coefficient δ is the main parameter of interest since it represents the DID estimate of the average treatment effect of the intense oil revenues. Also, coefficient α indicates the full set of department dummies. For the DID estimators to be interpreted correctly, we assume the following assumptions hold $cov(\varepsilon_{dt}, T) = 0$; $cov(\varepsilon_{dt}, D_d) = 0$; and $cov(\varepsilon_{dt}, T.D_d) = 0$. This last covariance shows the most critical assumption known as the parallel trend assumption. It means that unobserved characteristics affecting treatment assignment for each department (intense oil revenues redistribution) do not vary over time with treatment status. It is usual to conduct the Ashenfelter dip test to assess the violation of the parallel trend assumption. However, it requires

[9] Some departments are exposed to the treatment (intense oil revenues $r_d \geq 1$), while others are not. In our two period setting (before and after 2003), DID estimation bypasses biases in second period comparisons that could be the result from permanent differences between treated and untreated departments, as well as biases arising from time trends unrelated to the oil revenues transfers. Indeed, according to the parallel trend assumption, the DID approach assumes that in the absence of oil transfers (pre-intervention period), temporal trends in outcomes across treated and untreated departments would be the same.

[10] Several controls are used in the empirical studies (for example, see Loayza et al., 2013, and Zambrano et al., 2014), for instance, population density and geographical controls (altitude, area, regional or provincial capital dummies). The constraint of data availability led us to retain two variables: the population density for each department in 2003 and 2011, and the distance for each department to the capital city N'Djamena. Their squared values are also considered to capture the curvilinear relationship with MDW score.

more than two periods and we have no idea of its plausibility with two periods as in our case study. Furthermore, the linear structure of the DID model requires the assumption of constant returns (coefficients) of endowments overtime which enables us to have different initial distributions of endowments of the two groups. Therefore, we assume that this assumption holds. In the same line, we can overcome the randomization constraint of the treatment assuming the full independence of the other covariates and a constant return of the treatment. Indeed, in the case where the treatment is affected by the initial endowments, the estimated impact can be attributed to the treated group. However, even with this case, the study enables us to show the nature of the impact of the treatment. Chabé-Ferret (2015) indicated that in the case of permanent fixed effects with transitory shocks, combining DID with conditioning on pre-treatment outcomes is either irrelevant or inconsistent.

Table 1: Definition of variables and descriptive statistics

Variables	N	Mean	S.D.	Min.	Max.
MDW (average scores of multidimensional wellbeing index)	124	0.6799	0.5005	0.2682	3.2439
Time (0 = year 2003 ; 1 = year 2011)	124	0.5	0.5020	0	1
Ratio (computed r_d ratio)	124	0.8390	1.5270	0.2410	8.9378
Treatment (1 = treated ; 0 = untreated)	124	0.2419	0.4299	0	1
Density of population (habitants of department d / km^2)	124	49.309	86.942	0.0206	620.07
Squared density of population	124	9929.4	40487.8	0.0004	384496
Distance from department d to N’Djamena (km^2)	124	441.17	251.033	0	1080.79
Squared distance to N’Djamena	124	257143	286739	0	1168119

Source : Authors.

Table 1 above provides definitions and descriptive statistics of variables. Given the panel data setting, equation [03] was estimated using DID panel models. Fixed effects (FE) and random effects (RE) models were estimated successively. For the choice between the random effect and the fixed effects models, we used the auxiliary test proposed by Mundlak (1978) which is valid even under heteroskedasticity (see also Wooldridge, 2010). Note that the RE model is based on the assumption of unrelated effects or the no correlation between the error term and the observables (X covariates).

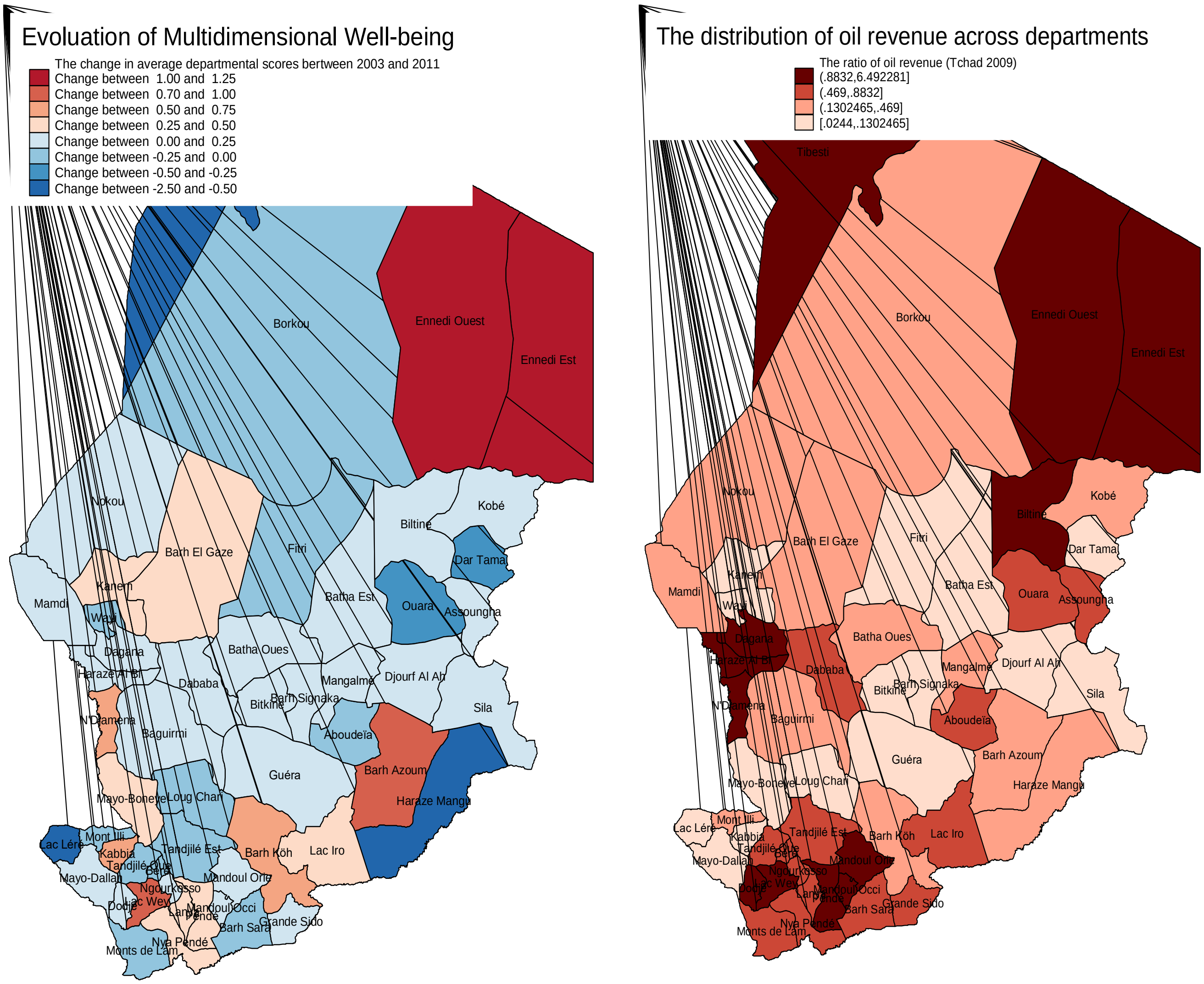
4. Application and results

Some stylized facts on wellbeing and oil revenues redistribution in Chad

We start by showing some descriptive evidence of the change in average departmental wellbeing scores between 2003 and 2011, and its potential link to oil revenues redistribution in Chad. At national level, population wellbeing has increased to 0.596 to 0.616 between the two dates and may be due to oil exploitation. This argument is comforted at the local level when we observe the evolution of multidimensional wellbeing according to the distribution of oil revenues across departments. These spatial descriptive statistics are depicted in figure 1 below. Panel A shows that the highest improvements were specifically registered in *Ennedi East, Ennedi West, Lac Wey, Barh Azoum, N'Djamena* and *Kabbia.* Inversely, the negative or lowest performances were in *Haraze Mangueigne, Lac Léré, Tibesti* and *Dar Tama.* These disparities may be indexed to the unequal redistribution of oil revenues. Indeed, as we can observe in Panel B, *Ennedy East* and *Ennedy West* departments received the highest per capita oil revenues. For the rest of departments, we also observed a positive link between the departmental oil revenue and the improvement in MDW. An exception comes from the *Tibesti* department where the contrast may be explained by its recurrent political instability.

Figure 1: Spatial descriptive statistics

Panel A **Panel B**



Source: Authors compilation

Discontinuous impacts of intense oil revenues on multidimensional wellbeing

Results presented in table 2 below show our DID estimate of the discontinuous impacts of ORRP applied across departments. We estimated that on average, departments receiving intense oil transfers ($r_d \geq 1$) increased their MDW by about 35 percentage points more than those disadvantaged by the ORRP. Although coefficients are not equals, these positive local impacts remain robust and significant at the 5% level of significance for both Fixed Effects (FE) and

Random Effects (RE) models. However, the modified Wald test shows that error terms exhibited groupwise heteroskedasticity (*p-value* = 0.000). In addition, the auxiliary test for the *unrelated effects assumption*[11] leads us to reject the RE assumption (*p-value* = 0.176).

While Caselli and Michaels (2013) found no evidence on the provision of public goods or welfare outcomes of the extra stream of oil revenues to municipalities in Brazil and Argentina, our results establishing positive local effects of ORRP, are in line with several studies focusing on outcomes other than MDW and on different non-renewable resources, especially mining exploitation. For instance, using also a DID approach in the case study of Peru, Arreaza and Reuter (2012) found a positive impact of mining transfers on the levels of expenditures, but no significant differences in terms of public goods provision across recipient and non-recipient districts. Similar results were obtained by Zambrano et al. (2014) who found a trend suggesting incremental positive marginal effects of the level of exposure to mining transfer on the reduction of poverty and inequality.

We added some covariates to the treatment variable in order to control for some heterogeneity effects. These variables are especially population density per kilometer squared and its squared value, as well as the distance of the department to Ndjamena and its squared value. Obviously, there are a large number of other covariates that can explain MDW levels. However, we prefer to avoid the redundancy, since these covariates were already used as basic indicators of MDW. Results showed that there were some positive externalities for departments closest to the capital city N'Djamena since they score higher MDW[12]. The concentration of oil revenue

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[11] This assumption considers that the departmental specific effects are uncorrelated with the explanatory variables overtime of the same department.

[12] It is also usual in studies analyzing local impacts of natural resource exploitation to account for neighboring spillover effects. However, these effects could be easily overcame from our study. Indeed, unlike various forms of mining activities (Loayza et al., 2013), oil exploitation is not likely to be subject of such effects. Since, mining activities are intensive in labor, workers living in neighboring departments would get job opportunities in mining producing departments. But, oil exploitation requires more skilled

investment in the capital city and its neighbouring departments may explain such a result. Nevertheless, the relation between the distance to N'Djamena and the levels of MDW is nonlinear as the squared distance is positive and significant.

Table 2: DID estimates of intense oil revenues impacts on MD wellbeing – binary treatment

Variables	***Treatment*** $r_d \geq 0.9$		***Treatment*** $r_d \geq 1$		***Treatment*** $r_d \geq 1.1$	
	F.E.	**R.E.**	**F.E.**	**R.E.**	**F.E.**	**R.E.**
Basic DID dummy variables						
Time	- .032286 (.099154)	- .088831 (.099840)	- .036982 (.100738)	- .092947 (.098978)	- .031785 (.097432)	- .089126 (.095309)
Treatment		- .112995 (.117875)		- .099949 (.122242)		- .088026 (.120165)
Time × Treatment	**.35646**** **(.143260)**	**.258156*** **(.140945)**	**.34922**** **(.136368)**	**.28986**** **(.137958)**	**.3895***** **(.141217)**	**.32514**** **(.144035)**
Department characteristics						
Density of population	- .001504 (.001575)	.001452 (.001345)	- .001114 (.001487)	.001454 (.001294)	- .001150 (.001471)	.001386 (.001301)
Squared density of population	.000002 (.000002)	- .0000002 (.000002)	.000002 (.000002)	- .0000001 (.000002)	.000002 (.000002)	- .0000001 (.000002)
Distance to N'Djamena		- .001799 (.001305)		- .001760 (.001281)		- .001703 (.001269)
Squared distance to N'Djamena		.000001* (.000001)		.000001* (.000001)		.000001* (.000001)
Constant	.695117*** (.051117)	.957571*** (.310014)	.685042*** (.047862)	.944760*** (.304104)	.686308*** (.047492)	.928670*** (.302297)
Observations (N)	124	124	124	124	124	124
Within R-squared (R^2)	.075	.042	.074	.048	.080	.055
Between R-squared (R^2)	.001	.259	.021	.261	.029	.262
Overall R-squared (R^2)	.019	.180	.039	.184	.047	.188
Heteroskedasticity (p-value)	.000		.000		.000	
Auxiliary test (p-value)	.115		.176		.184	

Source: ECOSIT 2 and 3. Notes: Discrete change of dummy variable from 0 to 1. $^{*}p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in brackets.

Sensitivity analyses and robustness checks

Several analyses were conducted to appreciate sensitivity and check for robustness of our results. First, we consider the ratio threshold $r_d \geq 1$ excluding departments whose ratios are just below or above 1 from the treatment group. However, the MDW of excluded departments may be affected

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jobs and is mainly intensive in capital and in technology. There are more less job opportunities in oil sector and even workers living in an oil producing department would miss job in that sector. For that reason, we have not taken into account for the departmental neighboring spillover effects.

by oil revenue too. For that reason, we see the extent to which the results were sensitive to two other ratio thresholds $r_d \geq 0.9$ and $r_d \geq 1.1$. Results reported in table 2 show that the arbitrariness of the threshold was not a serious challenge. Indeed, results obtained for all ratio thresholds were very similar. Intense oil revenues received by treated departments led them to significantly increase their average MDW compared to untreated departments. This positive local effect is robust and significant at the 1% level for the ratio threshold $r_d \geq 1.1$.

Secondly, in addition to a binary treatment approach, it is also important to capture the intensity effects of oil revenues by considering a continuous treatment, which is in our case the computed ratio. For this purpose, we propose using the DID continuous treatment model[13]:

$$Y_{dt} = \alpha + \gamma . T + \delta . (T . r_d) + \beta . X_{dt} + \varepsilon_{dt} \quad [04]$$

Results of FE and RE models are summarized in table 3. Although the local impacts were less robust than that of the binary treatment, in general, results from the continuous treatment were consistent and confirmed the existence of positive impacts of departmental oil revenues transfers on MDW.

[13] This model is mainly inspired by Acemoglu et al., (2004), and Goldin and Olivetti (2013) who assessed the role of World War II on women's labor supply in the USA.

Table 3: DID estimates of local impacts of intense oil revenues on MD wellbeing – continuous treatment

Variables	*Without Departmental covariates*		*With Departmental covariates*	
	F.E.	**R.E.**	**F.E.**	**R.E.**
Basic DID dummy variables				
Time	.138026* (.080996)	.159879 (.099764)	.137901 (.112777)	.054890 (.095015)
Time × Ratio	**.081546*** **(.045735)**	**.098846**** **(.049520)**	**.078836** **(.047643)**	**.062755*** **(.035961)**
Department characteristics				
Density of population			- .000595 (.001574)	.001658 (.001325)
Squared density of population			.000001 (.000002)	- .0000007 (.000002)
Distance to N'Djamena				- .001683 (.001266)
Squared distance to N'Djamena				.000001* (.000001)
Constant	.662438*** (.036843)	.662438*** (.072588)	.673577*** (.047881)	.902900*** (.303806)
Observations (N)	124	124	124	124
Within R-squared (R^2)	.044	.044	.049	.029
Between R-squared (R^2)	.055	.055	.060	.269
Overall R-squared (R^2)	.049	.049	.053	.184
Heteroskedasticity (p-value)	.000		.000	
Auxiliary test (p-value)	.563		.431	

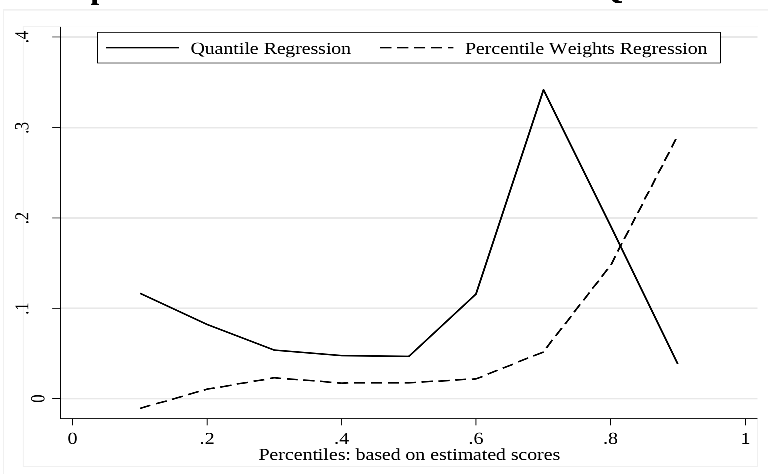
Source: ECOSIT 2 and 3. Notes: Discrete change of dummy variable from 0 to 1. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Robust standard errors in brackets.

Finally[14], another important question is whether the impacts of the treatment can differ according to initial level of MDW. The usual models to show such heterogeneity in the impact of treatment is the Quantile regression (*QR*) model, which is used to assess the effects of treatment at a given percentile of MDW scores. In addition to the *QR* model, Araar (2016) suggests the Percentile Weights Regression (*PWR*) as a complementary model used to assess such heterogeneity. In Figure 2, we show the impact of treatment with both models according to the MDW percentiles. Results established that for the two econometric models, the impact of treatment increased in general with the levels of wellbeing. In other words, in the departments with a high

[14] In addition, we have also performed some tests of outliers and the results showed an acceptable level of robustness. Indeed, based on Cook's distance, we found that no outlier problem was identified from extreme ratio values of 16.3, 62, 7.6 and 8.9 for *Tibesti-Est*, *Biltine*, *Dagana* and *Ennedi* departments, respectively. Only *N'Djamena* showed an excessive influence on the estimates. However, we have checked the change in results should the two *N'Djamena* observations be removed, but the results remain practically the same.

average MDW, intense oil revenues received would have higher impacts on MDW. This can be explained by the cumulative effects of oil transfers which were not considered in our models because of lack of data. It can be noted that the results of the two models are quite different at higher percentiles. As it was reported by Araar (2016), results of the *QR* model can be highly sensitive to the impact of treatment at percentiles that are far from the percentile of interest, explaining thus the difference in results between the two models.

Figure 2: Local impacts of intense oil revenues with the QR and the PWR models



Source: ECOSIT 2 and 3.

5. Conclusion

The three sources through which extraction of natural resources, such as crude oil, has social impacts at subnational level are: via the extraction activity, via the revenues generated by the extraction which are allocated and spent at the subnational level, and via local spillovers. This paper investigated narrowly the second source and aimed to evaluate, with a local perspective, the impact of oil revenues redistribution policy on wellbeing at the departmental level in Chad. To do this, we considered an impact evaluation analysis framework based on a hypothetical scenario which assumed that oil rents redistribution mechanism across departments match effectively local development needs proxied by their demographic weights.

As expected, spatial descriptive statistics shed light on a potential link between oil revenues redistribution and changes in average departmental wellbeing scores between 2003 (before) and 2011 (after oil exploitation). The results are comforted by the difference-in-difference estimations which provide evidence that departments in Chad that received significant oil transfers increased their MDW about 35% more than those disadvantaged by the oil revenues redistribution policy. Furthermore, departments closest to the capital city N'Djamena benefited from spillover effects and score higher MDW. These results are robust to several sensitivity and robustness checks. The we conclude that an inclusive governance of natural resources in Chad, especially oil, requires that the government better targets oil revenue redistribution policies according to local development needs and toward the poorest departments.

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Appendices

Appendix A: Construction of the ratio used to treat departments

Table A: Demographic weights, oil revenues shares and ratio by region and department

Regions/ Departments	*Demographic weights*	*Oil shares*	*Ratio*	*Regions/ Departments*	*Demographic weights*	*Oil shares*	*Ratio*
Batha	**0.0442**	**0.0079**	**0.1792**	**Chari Baguirmi**	**0.0524**	**0.0105**	**0.2011**
Batha-Ouest	0.0179	0.0048	0.2655	*Baguirmi*	0.0190	0.0053	0.2772
Batha-Est	0.0163	0.0020	0.1213	*Chari*	0.0166	0.0032	0.1907
Fitri	0.0100	0.0012	0.1193	*Loug-Chari*	0.0168	0.0021	0.1253
Borkou	**0.0085**	**0.0031**	**0.3620**	**Lac**	**0.0393**	**0.0094**	**0.2395**
Borkou	0.0062	0.0021	0.3471	*Mamdi*	0.0202	0.0066	0.3252
Borkou Yala	0.0023	0.0009	0.4025	*Wayi*	0.0191	0.0028	0.1489
Guera	**0.0488**	**0.0135**	**0.2764**	**Logone Occidental**	**0.0624**	**0.1312**	**2.1029**
Guera	0.0156	0.0067	0.4314	*Lac Wey*	0.0300	0.0655	2.1829
Abtouyour	0.0152	0.0027	0.1777	*Dodjé*	0.0096	0.0197	2.0410
Barh Signaka	0.0094	0.0013	0.1437	*Gueni*	0.0083	0.0198	2.3777
Mangalmé	0.0086	0.0027	0.3136	*Ngourkosso*	0.0144	0.0262	1.8185
Hadjer Lamis	**0.0513**	**0.2150**	**4.1865**	**Kanem**	**0.0302**	**0.0041**	**0.1360**
Dagana	0.0171	0.1290	7.5599	*Kanem*	0.0139	0.0025	0.1767
Dababa	0.0207	0.0322	1.5583	*Nord-Kanem*	0.0082	0.0008	0.0992
Haraze Al Biar	0.0136	0.0537	3.9534	*Wadi-Bissam*	0.0081	0.0008	0.1037
Logone Oriental	**0.0706**	**0.1467**	**2.0787**	**Mayo Kebbi Est**	**0.0702**	**0.0117**	**0.1665**
La Pendé	0.0145	0.0508	3.4958	*Mayo-Boneye*	0.0214	0.0037	0.1744
Kouh Est	0.0092	0.0215	2.3388	*Kabbia*	0.0207	0.0009	0.0448
Kouh Ouest	0.0045	0.0084	1.8702	*Mayo-Lemié*	0.0074	0.0009	0.1214
La Nya	0.0128	0.0246	1.9253	*Mont Illi*	0.0206	0.0061	0.2966
La Nya Pendé	0.0098	0.0158	1.6178	**Moyen Chari**	**0.0533**	**0.0382**	**0.7177**
Monts de Lam	0.0198	0.0257	1.2933	*Barh Koh*	0.0278	0.0239	0.8592
Mandoul	**0.0569**	**0.1406**	**2.4709**	*Grande Sido*	0.0097	0.0090	0.9252
Mandoul Oriental	0.0232	0.0833	3.5912	*Lac Iro*	0.0158	0.0054	0.3411
Barh Sara	0.0197	0.0278	1.4107	**Salamat**	**0.0274**	**0.0157**	**0.5729**
Mandoul Occidental	0.0140	0.0295	2.1049	*Barh Azoum*	0.0165	0.0077	0.4678
Ouaddaï	**0.0653**	**0.0140**	**0.2149**	*Aboudéia*	0.0059	0.0067	1.1403
Ouara	0.0298	0.0113	0.3808	*Haraze Mangueigne*	0.0050	0.0013	0.2563
Abdi	0.0097	0.0012	0.1266	**Tandjilé**	**0.0600**	**0.0527**	**0.8796**
Assoungha	0.0259	0.0015	0.0569	*Tandjilé Est*	0.0231	0.0211	0.9146
Mayo Kebbi Ouest	**0.0511**	**0.0041**	**0.0799**	*Tandjilé Ouest*	0.0369	0.0316	0.8578
Mayo-Dallah	0.0303	0.0025	0.0809	**Barh-El-Gazal**	**0.0233**	**0.0061**	**0.2630**
Lac Léré	0.0208	0.0016	0.0785	*Barh-El-Gazal Sud*	0.0177	0.0043	0.2424
Wadi Fira	**0.0460**	**0.1029**	**2.2345**	*Barh-El-Gazal Nord*	0.0056	0.0018	0.3280
Biltine	0.0153	0.0949	6.1961	**Ennedi**	**0.0152**	**0.0505**	**3.3213**
Darh Tama	0.0162	0.0032	0.1940	*Ennedi*	0.0055	0.0490	8.9214
Kobé	0.0145	0.0049	0.3361	*Wadi Hawar*	0.0097	0.0015	0.1577
Sila	**0.0277**	**0.0020**	**0.0737**	**Tibesti**	**0.0023**	**0.0219**	**9.5085**
Kimiti	0.0277	0.0012	0.0442	*Tibesti Est*	0.0013	0.0213	16.3716
Djourouf Al Almar	0.0074	0.0008	0.1107	*Tibesti Ouest*	0.0010	0.0006	0.6098

Source: From CCSRP (2012) and INSEED (2012). Note: In the absence of data on oil revenues redistribution within the capital city N'Djamena, this region is considered as a department and its ratio greater than 1.

Appendix B: Construction of the synthetic index of multidimensional wellbeing

There are many dimensions of wellbeing which can be influenced by oil revenue through its investments and transfers. In this study, we focus on four dimensions of wellbeing according to information available in both ECOSITs 2 and 3 databases[15]: housing infrastructures and environmental facilities, education, health, and possession of durable goods. For each dimension, we used a set of primary non-monetary indicators as shown in Table B. Given the categorical structure of these indicators, the Multiple Components Analysis (MCA) technique becomes the appropriate method used to estimate Multidimensional Wellbeing (MDW) index based on a total of 15,954 households after appending ECOSITs 2 and 3:

$$W_i = \frac{\sum_{k=1}^{K} \sum_{J_k=1}^{J_k} w_{jk} . I_{i,J_k}}{K} \quad [04]$$

Where K is the number of categorical variables, J_k the number of categories for indicator k, I_{i,j_k} the binary indicator taking 1 if the individual i has the category j_k and w_{j_k} is the normalized first axis score of the category j_k.

The first MCA is carried out initially with a total of 23 variables spread over the four dimensions of indicators. This step allows the choice of the primary indicators that will be used to construct the MDW scores. Two criteria serve to select or eliminate the variables, and to conclude the MCA analysis: the first one consists of appreciating the discriminatory power of each variable over the first axis, while the second relies on the First Axis Ordering Consistency (FAOC) property. The following variables are then removed after the first MCA: consultation, reason of

[15] These dimensions reflect the sectors where oil revenues are mostly spent according to the National Poverty Reduction Papers (NPRP1 from 2003 to 2006, and NPRP2 from 2008 to 2011).

dissatisfaction, sanitary facility, type of house, and possession of bicycle (see table B). Therefore, 03 dimensions and 18 variables were retained to run the second MCA. The results show that the explanatory power – percentage of total inertia – of the first axis increased from 68.53% to 79.28% for the first and second MCA, respectively. The discrimination power of the first axis is more than 50% and can be named the multidimensional wellbeing access axis. The First Axis Ordinary Consistency (FOAC) property is checked for all the remaining variables within the second MCA.

Table B: Descriptive statistics and results of the multiple components analysis (MCA)

Dimensions of indicators / modalities	%		First MCA		Second MCA	
	2003	2011	Coord.	Contrib.	Coord.	Contrib.
Dimension 1: Housing infrastructures and environmental facilities						
Occupational status						
1. Owner in urban area	11.80	38.09	4467	73	4073	77
2. Owner in rural area	61.76	30.07	- 766	20	- 697	21
3. Not owner in urban area	16.28	29.27	3915	44	3547	47
4. Not owner in rural area	10.17	2.57	- 551	1	- 500	1
Residence area						
1. Urban	28.07	67.36	4222	116	3840	123
2. Rural	71.93	32.64	- 746	21	- 679	22
Type of house						
1. Isolated house	46.93	53.14	- 730	14		
2. Agglomeration	23.17	10.69	1664	14		
3. Private house	27.80	35.90	1033	12		
4. Other	2.09	0.27	- 937	0		
Number of bedrooms						
1. One room	36.42	42.38	- 483	3	- 335	2
2. Two to three rooms	40.75	40.05	- 185	1	- 187	1
3. Four to five rooms	13.29	11.55	495	2	376	1
4. More than five rooms	9.54	6.03	1266	7	1069	7
Source of cooking energy						
1. Electricity	0.52	0.13	3074	1	2922	1
2. Gas	2.27	3.86	4629	16	4335	18
3. Charcoal	24.06	19.63	1635	16	1469	17
4. Wood	64.30	74.90	- 385	5	- 348	5
5. Other	8.85	1.48	- 54	0	- 87	0
Nature of roof						
1. Solid	0.31	40.51	4193	81	3801	85
2. Thatched	99.54	58.55	- 494	9	- 450	10
3. Other	0.15	0.94	- 963	0	- 697	0
Nature of ground						
1. Cement	4.60	15.35	5442	71	4990	76
2. Clay	89.10	83.16	- 294	3	- 275	4
3. Other	6.30	1.49	- 921	1	- 698	1
Nature of walls						
1. Cement	11.57	25.24	3484	64	3134	66
2. Straw/banco	87.10	71.11	- 471	8	- 425	8
3. Other	1.33	3.65	- 638	1	- 538	1

Lighting type						
1. Modern	9.44	9.32	4442	45	4117	50
2. No modern	71.29	87.71	- 122	1	- 123	1
3. Other	19.28	2.97	- 1188	7	- 1031	7
Garbage vacation						
1. Hygienic	31.81	18.46	1939	26	1752	27
2. No hygienic	68.19	81.54	- 393	5	- 336	5
Sanitary facility						
1. Hygenic bathroom	36.11	46.41	602	6		
2. No hygienic bathroom	63.89	53.59	- 418	4		
Nature of toilet						
1. Hygienic	16.53	16.64	3249	44	2931	46
2. No hygienic	83.47	83.36	- 343	5	- 309	5
Dimension 2: Education						
Writing knowlegde						
1. Yes	44.11	36.06	1318	17	1172	17
2. No	55.89	63.94	- 382	5	- 340	5
Problem at school						
1. Yes	81.38	76.37	- 292	3	- 263	3
2. No	18.62	23.63	1264	13	1137	13
Dimension 3: Health						
Consultation						
1. Authorized person	12.68	19.56	189	0		
2. Non authorized person	1.31	2.46	- 643	0		
3. Missing	86.01	77.98	- 13	0		
Dissatisfaction at the nearest hospital						
1. No	7.45	12.88	206	0		
2. Yes	6.48	9.14	- 108	0		
3. Missing	86.07	77.98	- 13	0		
Dimension 4: Durable goods						
Own a phone						
1. Yes	8.12	3.03	2575	11	2324	11
2. No	91.88	96.97	- 98	0	- 88	0
Own radio						
1. Yes	27.50	52.04	1093	18	948	17
2. No	72.50	47.96	- 580	10	- 503	9
Own a fridge						
1. Yes	1.08	2.19	10881	42	10180	47
2. No	98.92	97.81	- 90	0	- 84	0
Own a fan						
1. Yes	1.05	6.87	9280	72	8667	80
2. No	98.95	93.13	- 18	1	- 169	2
Own an air conditioning						
1. Yes	0.22	1.13	11841	22	11151	25
2. No	99.78	98.87	- 44	0	- 41	0
Own a car						
1. Yes	1.05	2.30	8433	32	7922	36
2. No	98.95	97.70	- 87	0	- 82	0
Own a bicycle						
1. Yes	10.32	17.97	602	3		
2. No	89.68	82.03	- 159	1		

Source: ECOSIT 2 and 3. Note: for the occupational status of housing the milieu should be considered (urban/rural factor). In urban areas, owning the house is an indicator of wealth, but this is the reverse in rural areas. For this purpose, we crossed this categorical variable with the variable of residence area to generate a new categorical variable with four modalities.