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The impact of oil exploitation on wellbeing in Chad

Abstract

This study assesses the impact of oil revenues on wellbeing in Chad. Data used come from the two last Chad Household Consumption and Informal Sector Surveys ECOSIT 2 & 3 conducted in 2003 and 2011 by the National Institute of Statistics and Demographic Studies. A synthetic index of multidimensional wellbeing (MDW) is first estimated using a multiple components analysis based on a large set of welfare indicators. The Difference-in-Difference approach is then employed to assess the impact of oil revenues on the average MDW at departmental level. Results show that departments receiving intense oil transfers increased their MDW about 35% more than those disadvantaged by the oil revenues redistribution policy. Also, the farther a department is from the capital city N'Djamena, the lower its average MDW. Economic inclusion may be better promoted in Chad if oil revenues fit local development needs and are effectively directed to the poorest departments.

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

JEL Codes: I32, D63, O13, O15

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I. Introduction

Chad has been experiencing oil exploitation since 2003. The investments in the oil sector made between 2000 and 2002, and the oil production which started in October 2003, have greatly accelerated economic growth since 2000. The GDP growth rate which was 3% in the 1990s, reached 7% on average from 2001 to 2013 (INSEED, 2013). Furthermore, oil provides a bulk of funding to the Chadian government. Since 2004, oil has accounted for 88% of exports on average (PND, 2013). In addition, the commercialization of refined oil from Djarmaya[1] since 2010, and the derivative products (e.g. gas) have helped to strengthen the financial capacity of the Chadian authorities. On average, oil activity accounts for over 30% of GDP (WDI, 2015) and provides at least 75% of ordinary budget revenues (BEAC, 2013).

In early 2000, the development of the oil sector generated a brief employment possibility[2] to the natives of the producing region, and also to the population of the neighbouring regions. The number of oil well drillings was estimated at 800 in 2012 (Hoinathy, 2012). The compensations were paid to farmers for the loss of their farmland and their trees[3]. Therefore, the oil project has been seen as a driver of the development in Chad. Oil exploitation provides important financial resources. Total oil revenues in Chad are constituted by the direct revenues (dividends and royalties)[4], and indirect revenues (income tax, fees and taxes paid by employees, work permits, customs duties and other fees).

According to the report of the oil company ESSO (2012), total oil revenues received by the government of Chad between 2003 and 2012 is estimated at $10.195 billion (USD) of which 65% comes from taxes on profits made by oil companies. Since 2010, these resources from the sale of crude oil have been reinforced by the commercialization of refined oil done by National Hydrocarbon Society (SHT) and the China National Petroleum Corporation International Chad (CNPCIC). Given the high level of poverty incidence in Chad in the 1990s, Chadian authorities and its partners in the oil project have taken ex-ante dispositions to ensure a better track of the management of oil revenues in order to effectively reduce the poverty. The Law 001/PR/1999 constituted the legal framework that was supposed to ensure this proper management (Mabali & Mantobaye, 2015). This Law on oil revenue management, adopted in 1999 has

[1] Djarmaya is the locality where the oil industry is installed.

[2] As the development of oil fields (navying, drilling and pipeline construction) provides the job possibility for unskilled workers, the natives of the producing region and the population from the neighboring regions have benefited from brief job possibilities between 2000 and 2004.

[3] *Hointhy (2013)* noticed that individual compensations have been used for five types of expenditures: (i) productive investment (hitch oxen, ploughs, ploughs, …) and means of transportation (motorcycle and bicycle), (ii) commercial activities (mills, shops, liquor) and real estate investment (acquisition of land/building), (iii) acquittal of marital benefits for new or old wives, (iv) consumption and leisure expenditures (food, school for children, alcohol,...).

[4] According to CCSRP (2012), Chadian Government earns 12.5% of dividends and royalties from the first oil fields in Doba (first producing regions since 2003), and 14.25% of direct revenue from the production in the new producing regions (e.g Logone Occidental and Chari Baguirmi).

predetermined the distribution of expected oil revenues across the priority sectors[5] without ignoring future generations.

Initially, this law projected that 70% of direct oil revenues were allocated to priority sectors, 15% to specific investment of the state, 5% to the producing region and 10% to future generations. However, in 2006 the new management program was set up and the fund for future generations was abolished. The share of specific investment of state increased to 30%, the list of priority sectors was expanded to the department of defence and national security, and their share decreased to approximately 65%. The government set up the National Poverty Reduction Papers (NPRP1 from 2003 to 2006, and NPRP2 from 2008 to 2011) and established the National Development Plan (PND) in 2013 to support the oil revenues management law, in order to better reduce poverty. In this vein, the oil revenues allocated to the priority sectors have been invested in the building of different types of infrastructure (schools, hospitals, water wells, energy, roads, markets, etc.) in the different administrative departments. These revenues are also used for rural development (agriculture, life stock) and environmental improvement.

Oil revenues constitute one of the main sources of economic growth in Chad and are used to finance major investments. The allocation of oil revenue, under the control of the College for Control and Monitoring of Oil Revenues (CCSRP), is being directed towards the so-called priority ministries, namely infrastructure, education, health, social affairs, and agriculture, with the aim of promoting economic inclusion through the reduction of poverty and inequality across localities. However, the country is still struggling to achieve such an objective and does not have good indicators of development. For instance, the country was ranked 184th out of 187 countries in 2013 according to its Human Development Index (UNDP, 2013). The World Bank (2013) reported that 46.7% of Chadians lived in extreme poverty in 2011, the poverty rate was around 19.7%, and the gap between the rich and the poor widened. These challenges raise the issue of *resource curse*, which questions the situation in which abundant natural resources hinder the improvement of socio-economic outcomes. According to several politicians and scholars, the resource curse could be tackled if an appropriate management or governance of revenues derived from the exploitation of natural resources is set up (Sachs & Warner, 1995; Sala-i-Martin & Subramanian, 2003). Thus, resource-rich countries should implement policies aiming to efficiently redistribute income from resource rentals and to promote economic inclusion.

The oil project has provided more positive impacts in terms of financial resources, but the negative effects cannot be ignored. In the literature, it has been shown that oil exploitation has generated several environmental negative effects: contamination of ground water, accidental chemical spills, and reduction in air quality etc. (Lipscomb et al., 2012; Atkin, 2014). In the case of Chad, the accidental spilling of

[5] Priority sectors under the law N° 001/PR/1999 were: education, health and human services, rural development, infrastructure, and environmental and water resources.

crude oil in October 2010 contaminated the rivers in some parts of the producing region[6]. In 2014, the conflicts of the spill of chemical waste confronting the Chadian government and the Chinese oil company CNPCIC (China National Petroleum Corporation International Chad) rightly confirm the deterioration of the environment in Chad. The destruction of the environment has made the poorest riverside communities vulnerable and has had harmful impacts on agricultural activity. There are many negative effects as a result of the oil exploitation project in Chad and these effects are likely to affect the wellbeing in the producing and neighbouring regions. However, this issue is not the concern of our study. We focus specifically on the effect of the distribution of oil revenues on wellbeing rather than analysing the harmful impacts of environmental deterioration.

Despite the high petroleum potential of Africa in general, and specifically of Chad, relatively few empirical studies have been conducted on the wellbeing effect of oil resources. To better design redistributive policies, the government needs information about the underlying factors explaining how resources are distributed. More recently, the World Bank (2013) attempted to analyze the dynamic of poverty and inequality since the emergence of oil production in Chad, although this study did not raise the oil revenues redistribution policy across the country. In addition, wellbeing cannot only be summarized into the monetary dimension, but it can also be extended into the non-monetary dimensions, such as the access to public goods (Araar, 2009). Therefore, by raising the problematic of oil revenue distribution, our study attempts to address the gap in the existing empirical literature on Africa. The study is expected to result in relevant recommendations for decision makers to better invest oil revenues in order to improve the wellbeing of the population. Chad conducted the second and third survey on consumption and the informal sector (ECOSIT 2 & 3) in 2003 and 2011, with 2003 being the year in which Chadian oil exploitation began. To this end, this study assesses the impact of oil revenues on the average *Multidimensional Wellbeing* (MDW) at departmental level eight years later by employing the Difference-in-Difference (DID) approach.

The rest of the paper is organized as follows. Section 2 presents a brief literature review related to empirical studies on the impact of exploitation of natural resources on wellbeing. Section 3 describes the oil revenue redistribution policy in Chad. Section 4 explains the methodology, and section 5 presents the results. Finally, section 6 concludes and provides policy recommendations to improve wellbeing in Chad.

II. Literature review

When analysing the role of natural resources in economic development, the starting point is resource curse theory (also known as the paradox of plenty), which implies that the countries largely endowed in natural resources grow less than resource poor countries (Sachs & Warner, 1995). The resource curve can also be

[6] 200 barrels were accidentally spilled in Komé, the main site of oil production in 2010 (ESSO, 2011).

seen as a failure for natural-resource-rich countries to fully benefit from their natural resource wealth and effectively respond to public welfare needs (Bauer et al., 2016). As noted by Gylfason (2001), four main transmission channels for the resource curse has been widely documented in literature, namely, the Dutch disease, the rent seeking, overconfidence, and neglect of education. First, Dutch disease can be explained by the fact that the resource boom reduces the competitiveness of other economic sectors (non-resource sectors) as well as the total factor productivity growth rates through the appreciation of the real exchange rate. Second, different forms of damaging rent-seeking behaviour seem to be present in natural-resource-rich economies. Third, governments may lose sight of the need for good economic management (institutional quality, bureaucratic efficiency and free trade) in the context of natural resource abundance (Sachs & Warner, 1999). Fourth, a neglect of the development of human resources by inadequate expenditure and attention to education in abundant natural resources nations have been observed (Ebeke et al., 2015)

With regards to the last point, several authors examine the nexus between natural resource abundance and human development. Knowing that education is an important driver for economic development and improves people's lives by improving health, increasing the efficiency of the labor force, and enhancing equality (Aghion et al., 1999), numerous studies put more emphasis on education. For instance, Gylfason et al. (1999) and Gylfason (2001) found an inverse relationship between natural resource abundance and education (inputs, outcomes, and participation). Similar negative correlations between natural resource abundance and human capital accumulation was found by Kronenberg (2004), Behbudi et al. (2010), Blanco and Grier (2012), and Wadho (2014). Cockx and Francken (2014) and El Anshasy and Katsaiti (2015) establish that there is a resource curse effect on public health provision. Furthermore, education can have a direct link with the reduction of poverty and inequality (Abdullah et al., 2015; Gregorio & Lee, 2002).

A resource curse effect was also observed on living standards and other development outcome in resource-rich-countries as pointed out by Cust and Viale (2016). For example, two important studies in Brazil from Caselli and Michaels (2013) and Monteiro and Ferraz (2010) investigated the impacts of oil windfalls on political variables and living standards. Both studies confirm that a significant increase in spending on housing, urban infrastructure, education, health, transportation, and household transfers was reported by municipalities receiving oil windfalls. However, there were no significant impacts on welfare as measured by the aforementioned dimensions. Surprisingly, with regards to these dimensions, the situation was actually better in some municipalities that did not receive oil revenues than in those who received them; the authors point to corruption as the main explanation for this. Some others, such as Bauer et al. (2016), document that natural-resource-rich countries have a tendency to underspend on health, education, and other social services while they overspend on government salaries, large monuments, and inefficient fuel subsidies, such as was the case in Mexico, Nigeria, and Venezuela in the 1980s.

Some authors focus on the ambiguous relationship between natural resource booms and inequality. While some authors, such as Lopez-Feldman et al. (2006), Goderis and Malone (2008), Mehlum et al. (2012), Howie and Atakhanova (2014) show that natural resources can reduce inequality, others emphasize the depleting nature of these resources (Buccellato & Mickiewicz, 2009; Carmignani, 2013; Fum & Hodler, 2009; Gylfason & Zoega, 2003; Mallaye et al., 2014; Sarraf & Jiwanji, 2001; Munasib & Rickman, 2015). So, according to Goderis and Malone (2008) the boom in mineral resources reduced income inequality in the short run, but in the long run, these inequalities returned to their original level. Similar results were established by Mallaye et al. (2014) for which there was a non-linear relationship (U-shaped) between oil rent and inequality. In turn, Howie and Atakhanova (2014) established that the resource boom reduced inequality. Moreover, unlike rural areas, the quality of institutions is the most important factor in reducing inequality in urban areas.

In contrast, Gylfason and Zoega (2003) showed that the dependence on natural resources led to two effects: a decrease in growth and an increase in inequality. Fum and Hodler (2009) argued that the ethnical composition of the societies was a key factor in reducing or increasing inequalities related to natural resources. In ethnically polarized countries, one group can have enough power to take over the entire resource rents. Therefore, this group becomes richer than other groups. In contrast, in ethnically homogenous countries, none of the ethnic groups can capture the resource rents. Finally, Carmignani (2013) provides evidence that inequality is a transmission channel of the effect of natural resources on human development since the resource boom increased inequality, and higher inequality contributed to lower human development.

Analyses of the impact of the mining/oil production or mining/oil revenue transfers on social and economic behavior have been performed in several recent studies. Postali (2009) evaluated whether royalties distributed under the new law contributed to the development of benefited municipalities in Brazil. Using difference-in-difference (DID) estimations, she showed that royalty receivers grew less than municipalities that did not receive such resources. Furthermore, resource-dependent countries exhibit more anemic economic growth, even after controlling for state-specific effects, socio-demographic differences, initial income, and spatial correlation (James & Aadland, 2011). In terms of poverty alleviation, Mabali and Mantobaye (2015) observed the spillover effects of oil revenues in Chad and found evidence that non-monetary poverty, as a social indicator, did not decrease in the oil producing region compared to other regions. However, the impact of royalties or rents could be positive in some cases. The nature of the impact depends on the institutions' quality and the redistribution policy. Postali and Nishijima (2013) showed that royalties had a positive impact on household access to electric wiring, piped water and waste collection, as well as on the decrease of the illiteracy rate. In the same line of research, Zambrano et al. (2014), assessed the systematic differences in district-level welfare outcomes between mining and non-mining districts. They found evidence that the condition of being in a mining-abundant district had a significant impact on the pace of reduction of poverty rates and inequality levels.

All in all, it appears that the initial conditions, governance, institutional quality and democracy, among others are important for a nation to transform the abundance of natural resources into an advantage, by increasing wellbeing, and reducing poverty and inequality. The most famous example was the case of Norway, where natural resources have improved the living standard of population and reduced income inequality. The main factors that led to this success are: the redistribution of public spending on social security and social services, the accumulation of human capital through investment in education and health, and the creation of a stabilization fund (Mehlum et al., 2012). Because of its strategic place and importance of disposable income, oil is the natural resource with the highest probability of occurrence of the resource curse (Alexeev & Conrad, 2005; Ross, 2004). Therefore, the question for oil rich countries is: *how is it possible to be so rich, yet so poor?*

III. Data and Methodology

Data used in this research are drawn from two main sources. Firstly, we used the two recent Chad household consumption and informal sector surveys ECOSIT 2 and ECOSIT 3 conducted in 2003 and 2011, respectively, by the National Institute of Statistics, Demographic and Economic Studies (INSEED). After controlling for missing data, 6,695 households were considered through the survey in 2003 and 9,259 in 2011. Besides the fact that these household surveys provide unique data sources to conduct analyses of non-monetary wellbeing in Chad, their stratified sampling design also helps to cover all of the departments within the country. In addition, they are appropriate for conducting our DID analysis since ECOSIT 2 and ECOSIT 3 offer pre- and post-intervention information. Secondly, the CCSRP organ provides data on the amounts of oil revenue allocated between departments since 2005.

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[7]. ECOSIT 3 covers 20 regions and 73 departments, while CCSRP covers 12 regions and 62 departments. Nevertheless, we were still able to recover each region and each department of the CCSRP from the ECOSIT 3 coverage

[7] 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 from CCSRP for oil revenues redistribution do not go beyond the departmental scope. To our knowledge, no institutional or statistical evidence could help to devise a rule of the distribution of oil revenues across districts. For these reasons, we recognize the limitations of using the department as unit of analysis, but even with this aggregation, we expect that we can have some evidence on the impact of oil revenue.

scheme because the high number of geographical units from ECOSIT 3 is derived from the division of some units from CCSRP. Therefore, our baseline coverage scheme is the one from the CCSRP because it provides the lowest number of geographical units. Then, we regrouped departments from the ECOSIT 3 coverage scheme in order to find again the departments from the baseline.

Based on the assumption that the Oil Revenues Redistribution Policy (ORRP) could help to improve individuals' living standards across departments, since 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 in Chad. To do this, we considered an impact evaluation analysis framework based on a hypothetical oil rents redistribution mechanism[8]. Indeed, it is acknowledged that to better alleviate the resource curse and achieve development goals, natural resource governance requires redistribution mechanisms to be set up according to the development needs in different localities[9]. 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:

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

where Oil_d represents the percentage of oil revenues budget received by the department d, and Dem_d indicates its demographic weight[10]. 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 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 in detail and computed for each department.

[8] The law 001/PRC/99 from 1999 describes the management and allocation of oil revenues by the central government throughout regions and departments of the country.

[9] 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.

[10] 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.

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 for each department $d \in [1, N]$, there are two potential outcomes. 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[11]. Then, DID approach is our preferred method to estimate the average effect of the treatment[12].

We implement DID estimation approach within a linear regression framework. Our basic model follows the one discussed by Imbens and Wooldridge (2009) and is given by:

$$Y_{dt} = \alpha + \gamma . T + \lambda . D_d + \delta . (T . D_d) + \beta . X_{dt} + \varepsilon_{dt} \tag{02}$$

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. In equation (02), 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[13]; and ε_{dt} represents the error term assumed independent and identically distributed.

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

[12] 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.

[13] 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

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 test for the violation of the parallel trend assumption. However, it requires 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 / *km²)*	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 (km²)*	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 (02) 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

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.

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 (UE) or the no correlation between the error term and the observables (X covariates).

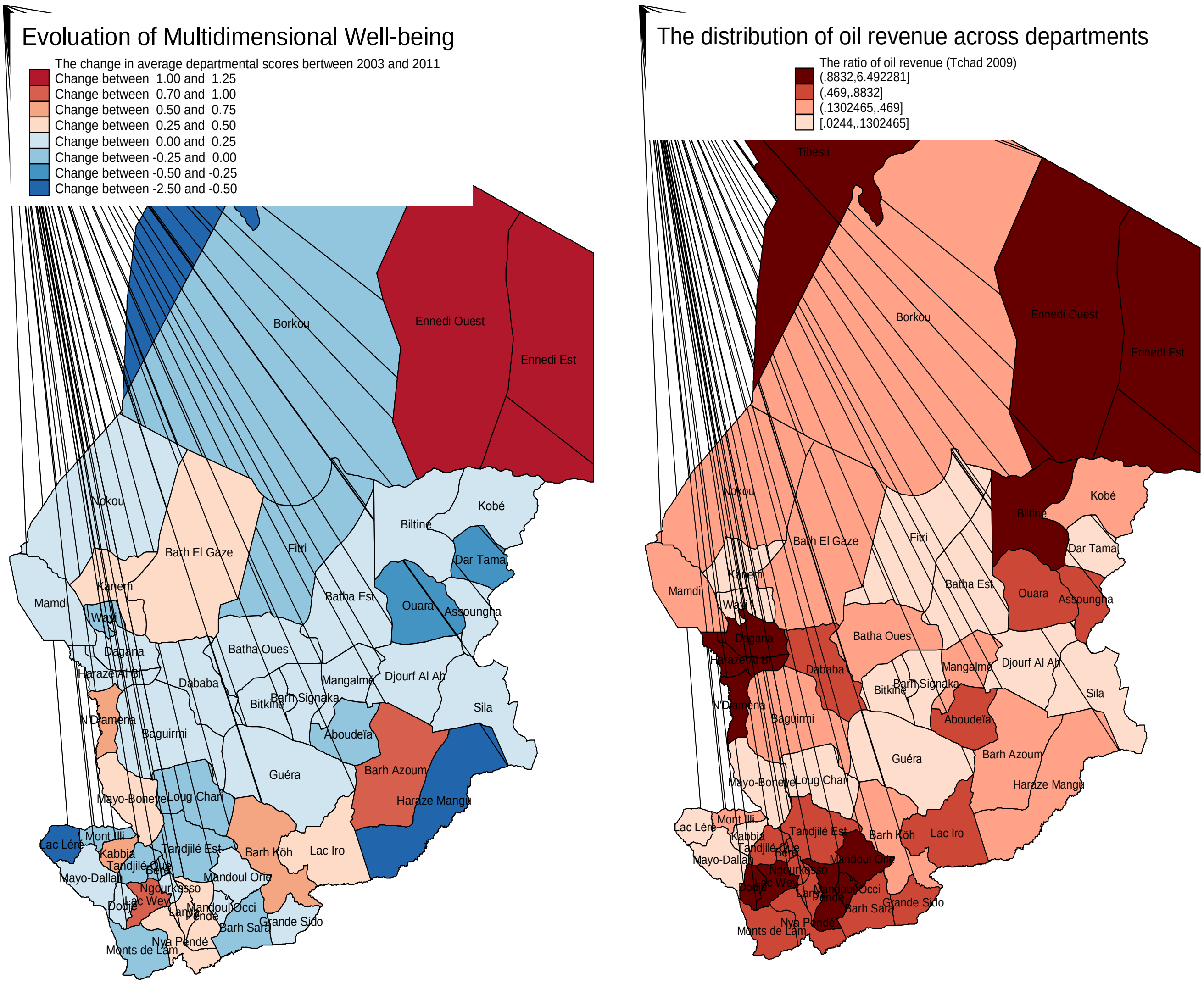
IV. Application and results

Some stylized facts on wellbeing and oil revenues redistribution in Chad

We start the analysis by showing descriptive evidence on household wellbeing and its potential link to the oil revenues redistribution in Chad. On the one hand, the construction of MDW scores based on Multiple Components Analysis allows us to distinguish the poverty status of households according to their multidimensional wellbeing. Intuitively, this factorial analysis technique seeks to determine the inter-correlation between the different indicators to summarize the information and to quantify the MDW. The results showed that the possession of durable goods such as air conditioning units, fridges, cars and fans characterized the wealthy. In addition, living in urban areas improved wellbeing, even if the inidividual did not own a house. This can be explained by the fact that in urban areas, the living conditions are more comfortable than in rural areas. In urban areas, houses are built using cement for the grounds and walls. Individuals have access to modern sources of lighting, hygienic toilets and garbage collection. Furthermore, houses are spacious (more than 5 bedrooms) and individuals use electricity or gas to cook. However, the poor do not have the same standards of living. They lack many kinds of durable goods, thus, they do not and cannot have any access to information and communication. They live in rural areas where wood is the most used cooking fuel. Moreover, their housing conditions are not safe or secure since they are made of materials which have very little resistance to natural disasters (for example, straw/banco and clay). Furthermore, in poor environments, garbage is dumped outside, rather than being collected, and there are no hygienic toilets. This suggests that the poor live in unhealthy environments. In general, this disparity results in an increase of multidimensional inequality between 2003 and 2011, from 0.596 to 0.616 (Table C).

Figure 1: Spatial descriptive statistics

Panel A **Panel B**



Source: Authors compilation

In the above Figure 1, panel A depicts the changes in average departmental MDW scores between 2003 and 2011. The highest improvements were specifically registered in *Ennedi Ouest*, *Ennedi Est*, *Lac Wey*, *Barh Azoum*, *N'Djamena and Kabbia*. Inversely, the negative or lowest performances were in *Haraze Mangueigne*, *Lac Léré*, *Tibesti and Dar Tama*. Among the explanations of this unequal development, the level of benefits from the oil revenue should be considered. Indeed, as we can observe in Panel B, the *Ennedy* departments received the highest per capita oil revenue, and this, through the allocation of oil revenue across departments. The advantageous result of the relatively high departmental budget of oil revenue was the remarkable increase in MDW within this region. For the rest of the departments, we also observed a positive link between the departmental oil revenue and the improvement in MDW. The exception was in the department of *Tibesti*, where its bad performance may be explained by political instability[14].

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*[15] 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 used some covariates in addition to the treatment with the aim of controlling 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 a department to be as close as possible to the capital city N'Djamena[16].

[14] Since Independence in 1960, Tibesti is the areas where the armed conflicts are frequent. The social investment doesn't attain the population needs.

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

[16] 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 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.

Indeed, the further a Department was from N'Djamena, the lower its average MDW was. These results may be explained by the concentration of oil revenue investment in the capital city and its neighbouring departments[17]. 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 all those departments whose ratios are just below or above 1 from the treatment group. However, the MDW of excluded departments may be affected 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

[17] Chadian Government has as option to invest oil revenue in order to improve the image of capital city by constructing the infrastructures in some sectors as education (schools), health (hospitals), housing, etc.

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[18]:

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

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.

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

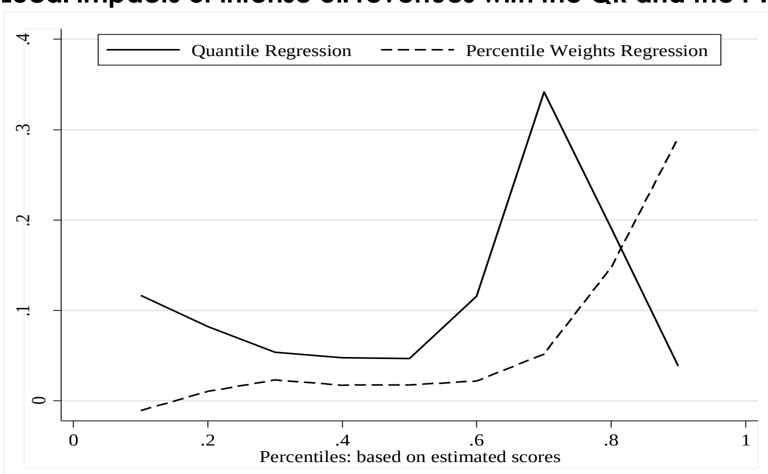
Variables	***Without Departmental covariates***		***With Departmental covariates***	
	F.E.	**R.E.**	**F.E.**	**R.E.**
Basic DID dummy variables				
Time	.138026* (.080996)	.159879 (.099764)	.137901 (.112777)	.054890 (.095015)
Time × Ratio	**.081546* (.045735)**	**.098846** (.049520)**	**.078836 (.047643)**	**.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.

[18] 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.

Finally[19], 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 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. This can explain 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.

[19] 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.

V. Conclusions and policy implications

This study investigated the impact of oil revenues redistribution policy on wellbeing at the local level in Chad. The study employs the framework based on the construction of a multidimensional wellbeing score between 2003 and 2011, based on the Multiple Components Analysis (MCA) technique. It also used the continuous Difference-in-Difference model to assess the impact of increase in the governmental budget wellbeing. Data used came from the Chad household consumption and informal sector surveys (ECOSIT 2 and ECOSIT 3 conducted in 2003 and 2011 respectively), the first and second General Population and Housing Census (GPHC) carried out in 1993 and 2009 respectively, as well as data on oil revenues redistribution policy reported by the Control and Monitoring College of oil revenues (CCSRP). The MCA analysis showed that the first axis factory explains about 79% of the total inertia. Three dimensions of wellbeing indicators contributed to this explanation: housing infrastructures and environmental facilities, education and durable goods. The possession of durable goods such as air conditioning units, refrigerators, cars and fans characterized the rich class in Chad between 2003 and 2011. In terms of an inequality dynamic, we observed that multidimensional inequality slightly increased between 2003 and 2011, from 0.591 to 0.609.

In the issue of oil revenue redistribution impact, the Difference-in-Difference panel results show that on average, departments receiving intense oil transfers ($r_d \geq 1$) increased their MDW by about percentage points more than those disadvantaged by the oil revenues redistribution policy. In addition, there were some positive externalities for a department to be as close as possible to the capital city N'Djamena. Indeed, the further a Department was from N'Djamena, the lower its average MDW was. This is due to the fact that oil revenues were largely invested in the capital city and the closest departments to the capital. Since, multidimensional inequality increased and the individuals' MDW in departments which received greater oil share were better off than others, the government should draw up a specific policy to better direct the oil revenue investment into the poorest departments by focusing on public services such as education, environmental facilities and by promoting employment. Overall, the improvement in the distribution of oil revenue by targeting the poorer, or those in high need of infrastructure can largely improve the human capital of the latter group, and then, improve their MDW. Finally, the paper provides a distributional map of the observed level of MDW. Combined with other criteria like population density or other secondary information on regional needs, the policy makers can propose better schemes of the geographical/departmental distribution of oil revenue, and this to be more equitable, as well as, to have a better return in human capital and the MDW.

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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 ECOSIT 2 and 3 databases[20]: (i) housing infrastructures and environmental facilities; (ii) education; (iii) health; (iv) possession of durable goods. For each dimension, we used a set of primary non-monetary indicators as shown in Table B. Considering the fact that all used indicators are categorical, the Multiple Correspondence Analysis (MCA) technique becomes the appropriate method to estimate the household scores of wellbeing. The two databases ECOSIT 2 and 3 are then appended given a total of 15,954 households (6,695 and 9,259 respectively). Therefore, the household i non-monetary wellbeing can be quantified following the formula:

$$W_i = \frac{\sum_{k=1}^{K} \sum_{j_k=1}^{J_k} w_{j_k} I_{i,j_k}}{K} \qquad (05)$$

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 indicates the well-known First Axis Ordering Consistency (FAOC) poverty. Over the first MCA, we removed the following variables since either they presented a low discriminatory power, or they did not respect the FAOC property: consultation, reason of dissatisfaction, sanitary facility, type of house, and possession of bicycle. Finally, one dimension (Health) and a total of five variables were removed after the first MCA. Therefore, three 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.

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20 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).

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.

Table C: Calculation of the MDI

	MDI index	Dimensions Relative Contributions to the MDI (%)		
		Housing	Education	Durable Goods
2003	0.596226	28.59	31.78	39.62
2011	0.615578	30.76	33.14	36.10
Population	0.609208	30.11	32.38	37.51

Source : Authors calculation