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RESEARCH ARTICLE

Natural resources and development: new insights from strong curse to strong blessing

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Abstract

We revisit the nonconsensual econometric works – although the natural resource curse may have flourished – on the relationship between natural resources and economic performance. We first question the two terms of the relationship. We consider the role of institutions (separately and in interaction with the variable of interest) and of a number of usual or new control variables (income inequality and current account). The model, based on development accounting, is tested using four econometric techniques on the full sample (130 countries, 1990–2019) and by sub-samples according to *per capita* income, illustrating the non-linearity of the relationship. Three stylized facts emerge: first, the overall results converge towards a strong blessing of resource rents on GDP *per capita*. This can be explained mainly by the role of these rents in countries with very high GDP *per capita*. Second, institutional variables significantly mitigate the negative effect or reinforce the positive effect of these resources on development. Finally, among the categories of resources considered, it is the oil rent that favors this strong natural resource blessing. The effects of the observed categories may offset each other. Detailed analyses of estimation's results in sub-samples and articulated with the results of the full sample are also proposed.

Keywords: Comparative studies of countries; development accounting; econometrics; natural resources and economic development; share of resources rents in GDP; weak and strong resource curse (or blessing)

JEL Codes: C20; O13; O57; Q32

Introduction

This article is an econometric contribution to the theme linking natural resources and macroeconomic performance. As recommended in literature, the role played by institutions in this relationship is included – both as independent variables and in interaction with our natural resources variable – in the proposed and tested model. Control variables are also considered in the examination of this relationship. This examination is conducted within four econometrics techniques based on a theoretically sound economic model (using development accounting framework).

Rightly or wrongly, the relationship of natural resource-economic performance is most often presented in terms of unfavorable and cumulative chains leading to the "resource curse," an expression popularized since Auty (1993). We summarize the content of this relationship in 2 presentations and then highlight the reservations that they raise.

The expression « Dutch disease », which appeared in the 1970s following the discovery in 1959 of a large natural gas deposit in the Netherlands (Groningen) and its subsequent management by the Dutch government, is the most established. The abundance of natural resources is likely to lead to an overvaluation of the real exchange rate[1]. This overvaluation also undermines the external markets for the products of other sectors of an economy, reducing their profitability and shifting a country's production to that of the natural resource. As long as the activity provided by the natural resource is in an ascending phase, it is theoretically possible to think that the economy will continue to do well. However, in the medium and long term, the rise of the real exchange rate, the atrophy of other sectors, the growing dependence on income (based on fluctuating prices of the resource because they are determined by world prices) derived from the resource, as well as external dependence for other goods and services, will eventually no longer be compensated by the dynamism of the resource, which will be depleted or technically substituted by another resource. At this point, the national productive system no longer has fundamentals that are favorable to its growth and development. Each of these effects occurs to a greater extent the greater the weight of the rents from natural resources in GDP and/or the greater their weight in relation to that of the world economy.

Another presentation, which is probably complementary, is put forward. The OECD (2011) and Sala-i-Martin and Subramanian (2013) refer to rent-seeking and its consequences in terms of corruption. Venables (2016) reports that in the overwhelming majority of countries, natural assets are the property of the public authorities. Thus, in order to move towards a judicious use of resources, the competence and virtuous intentionality of political leaders must first be taken for granted. When this is not the case, governance mechanisms, and therefore institutional mechanisms, negatively affect the resource-growth-development relationship. According to OECD (2011), concessions for natural resource extraction are usually granted by governments to large companies, whether public or private. This reduces or eliminates competition for concessions, and companies often find themselves in a cartel or illegitimate (in the sense of noncompetitive) monopoly position and seek to defend their position, which includes the likelihood of corruption of the managers and companies in question. We believe that this progressively weakens institutions. When they are already weak at the outset, rent-seeking and corruption, but also incompetence, contribute to their collapse[2]. The latter, which is not necessarily corrupt, can appear, for example, in the optimal management of resource

[1] *Via* the increase in demand for the resource but also *via* the increase in domestic demand for all goods and services following the increase in income generated by the sale of the resource.

[2] In Political Science area, Wiens (2013) points out that the influence of natural resources on development is conditioned by the quality of institutions that prevail at the time these resources are discovered and then exploited. Using a model of electoral competition, the author points out that in countries where institutional mechanisms to limit ruler discretion are absent prior to the onset of resource dependence, resource revenues undermine any efforts to establish "good" institutions in their wake and help stabilize "bad" institutions. When this is the case, the emergence of stable democratic institutions and the achievement of economic development is difficult to envisage. Only in the symmetrical case is the effect of resources positive. However, it is also possible to think that the author's observation could apply more or less depending on the type of resources involved.

exploitation (Hotelling's rule of 1931) and resource revenues (Hartwick's rule of 1977), to ensure that resources in the general sense (i.e., including other forms of resources than just natural resources) are not depleted. It can also be linked to the legal and fiscal regime that organizes the sharing of the rent between companies and public authorities. It can also be linked to this presentation that resource abundance can also lead to underinvestment in human capital (Gylfason, 2001; Dialga and Ouoba, 2022), but this may differ from sector to sector. Revenues from natural resources are more tangible in the short term than those from investments in education, which manifest themselves only in the longer term, a horizon further away than that of political power.

From these two presentations, several questions can be formulated. It is important to know whether the described sequences, separately or cumulatively negative on the relationship between resources, growth, and development, are indeed immutable. Have all countries that manage resources followed them? Do Australia, Botswana, Canada, Chile, China, or Malaysia follow the same trajectories as the Democratic Republic of Congo, Azerbaijan, or Nigeria? Mien and Goujon (2022) point out that Dutch disease has a differentiated empirical existence as some resource-rich countries have experienced an appreciation of the exchange rate and/or an adverse effect on exporting sectors.

Kim and Lin (2017) suggest that while in general natural resources have a negative effect on development, this effect is heterogeneous depending on the role of institutions in a broad sense (extent of government intervention, currency stability, property rights, corruption . . .). For Daw (2017), the ability of a country to extract value added from the productive use of resources is simply different. Does the country's level of development at the time of the discovery of deposits matter? At a given level of development, does the degree of inequality in the GINI sense influence the macroeconomic impact of the resource discovery? Is the crowding-out effect on capital, especially human capital, robustly verified? The share of resource rents in GDP *per capita* (notion of dependence) and that of resource rents *per capita* (notion of abundance) influence the impact results (rather positive for abundance and negative for dependence) of resources on GDP as shown by or Lashitew and Werker (2020).

What about the share of the resource (or the rent from that resource) in the world total of the same resource (or resource rent)? Shouldn't they be explicitly considered (and in general, specify the measure of the resource chosen) when considering the macroeconomic influence of resources? Doesn't the nature (Boschini et al., 2007) of the major resource families in question (coal, forest, gas, mineral, oil, etc.) play a role? And within the same large family, for example, mineral, does the influence of copper, cobalt, or manganese resource follow the same sequence as that of lithium, niobium, europium, or scandium? Are there not compensatory phenomena between large families of resources on the one hand and, between categories of resources on the other? Are all natural resources considered? Certainly not, the lists of resources are improving but remain incomplete to date.

Boschini et al. (2007), point out that natural resources do not, in themselves, influence growth but begin to play a role depending on the quality of institutions. Like these authors and many others, we believe that the interactions between the institutional framework (rule of law, degree of corruption of actors, degree of legal, fiscal, economic, and technical competence) and the aggregate resource are important in assessing the impact of resources on GDP. Do the components of this aggregate resource have the same direction, magnitude, and significance on GDP? What if we were to decline this question according to the level of development of the countries examined? Are the macroeconomic (neo-classical) chains described in our first presentation not also open to question? For example, is the expansion of the primary sector not likely to have positive spillover effects, via intermediate consumption, on the other sectors? Like a public expenditure multiplier, spillover effects are reinforced not only by investment but also by intermediate consumption (Jones, 2011). Moreover, when this intermediate consumption includes technical change, its use by other sectors provides more economic growth (Ngai and Samaniego, 2009 or Daw, 2024).

Is the role of economic policy doomed to ineffectiveness? Can foreign exchange policy, particularly in the face of foreign exchange inflows from resource exports, mitigate or even sterilize, if necessary, exchange rate instability and/or appreciation?

All the questions raised in this general background related to the natural resources-economic performance topic illustrate the diversity of economic trajectories that a country can take following the discovery of natural resources. Not all of them will be evaluated here, but the article is nonetheless intended as a contribution to a multi-factorial search for reasons and some of their interactions in explaining the resource-development nexus.

Indeed, our article focuses more specifically on the econometrics of the link between natural resources and economic performance. The concerns raised in this second part of the introduction are reflected in the literature we are now reviewing. This review of the econometric literature illustrates the variety of frameworks and results that exist today. A summary of the sources of these divergences is then proposed in section "Synthesis of the discrepancies."

Econometric studies examining the relationship 'natural resources-economic performance' differ in many respects (see list provided in section "Synthesis of the discrepancies"), and even meta-analyses cannot list them exhaustively. We have simply sought to present a certain number of them, commenting on the econometric results whenever possible, and we have done so in the most pedagogical way possible, i.e., by trying to provide the same set of information whenever possible.

Given the heterogeneous nature of literature, we thought it more pedagogical to propose a chronological review of some of the contributions between the 1990s and today.

With regard precisely to the meaning and extent of the relationship between natural resources and development, there is a large empirical and econometric literature on the "resource curse" or "natural resource curse[3]" as Auty (1993) calls it. However, although results are not directly comparable, they nevertheless provide a quick overview.

Auty (1993, 2001) shows that resource-rich countries are generally developing more slowly than others, even if this is not a general rule and that economic policy has a role to play. Sachs and Warner's (1995, 2001) cross-sectional[4] econometric work on 95 countries between 1970 and 1990 confirms this curse for countries with a high ratio of natural resource exports to GDP (close to resource dependence). Authors attribute low GDP *per capita* growth exclusively to resources dependence (control variables such as income *per capita* in 1970 or quality of institutions – variable *RULAW* used in our article – do not prevent the significantly negative relationship of −0.03 between dependence and GDP *per capita* growth (see their Table 2). Manzano and Rigobon (2001) re-estimate

[3]Whereas the expression "Dutch disease" or "Dutch Syndrome," dates back to 1997 in the columns of *The Economist* magazine.

[4]Moreover, in the event of a correlation between the selected explanatory variables and one or more omitted explanatory variables, this would bias the estimated coefficients, a problem that the panel specifications solve. The econometrics papers, in addition to those mentioned in our literature review (for e.g.: Mehlum et al., 2006a and 2006b, Papyrakis and Gerlagh, 2007, Sala-i-Martin and Subramanian, 2013, Lashitew and Werker, 2020 . . .) use mainly cross-sectional data. Some works on a given country use time series (for e.g.: Ogunleye, 2008, Rawashdeh and Maxwell, 2013. Other studies (for e.g.: Tella and Ades, 1999, Limi, 2007, Williams, 2011 . . .) use alternately cross-sectional and panel data.

Sachs-Warner's model but in panel specification with 216 observations ($N = 54$; $T = 4$). They find a positive relationship between GDP growth and the ratio of resource exports to GDP (significant coefficient of 0.07, see their Table 5).

Brunnschweiler and Bulte (2008) using cross-section data, estimate the relationship between natural resources and economic performance for samples of 60 and 80 countries, examined between 1970 and 2000. Economic performance is the change in the average GDP in PPP. The variable of interest, representing natural resources, is questioned and the authors enrich the definitions of this variable, by proposing some variants whose impact on economic performance is not the same. As with Sachs and Warner (1995), the resource abundance is the GDP shares of total natural resource exports. The authors consider that the latter is endogenous given that its denominator is GDP and that therefore this "resource abundance" may be affected by GDP growth rate. Their preferred natural resource abundance measures, the "resources rents" is total natural capital and mineral resource assets in US$ *per capita* based on World Bank Data. As the authors use a less endogenous variable of interest (because all are more or less so), they manage to highlight a positive and statistically significant effect of natural resources on economic growth (but also on institutions).

Alexeev and Conrad (2009) use a resource (oil) that is not expressed as a percentage of GDP[5]. In a few cross-sectional regressions (between 1970 and 2000) of GDP *per capita* on oil endowments accompanied by a few geographical or religious control variables, the authors find significantly positive coefficients between 0.028 and 0.04 depending on the year of the regression. Arezki and van der Ploeg (2011) show in cross-sectional data that using instrumental variables for$RULAW$ and the degree of openness of economies, the relationship between economic growth and abundance is no longer negative (but it would have remained significantly so if the problem of the endogeneity of institutions and international trade had not been addressed in this way).

van der Ploeg and Poelhekke (2010) use cross-sectional data to re-examine the findings of Brunnschweiler and Bulte (2008) – who questioned the validity of the "resource curse" thesis – over the same period and in the same countries. The authors attempt, among other things, to reduce the endogeneity of the "rented resources" used by Brunnschweiler and Bulte (2008) by replacing them with proven reserves of substances, notably from the United States Geological Survey (USGS). These proven reserves, which depend on prices and the country's extractive technology are therefore not completely exogenous (but are more so than the World Bank's natural capital data). It is important to mention, however, that the substances listed are exclusively mineral resources (35 substances) whereas it seems to us that those of the World Bank were much less important and that moreover,

[5]Using a ratio of resources to GDP as the literature does would exacerbate the endogeneity problem. This criticism can be found in Brunnschweiler and Bulte (2008). These authors also find a positive relationship. The initial GDP is removed from their estimate because it would be endogenous, impacted as it is by the revenues from the exploitation of the deposits. They show that the quality of institutions is endogenous to natural resource richness and discriminate between natural resource dependence (flows) and natural resource abundance (stocks). They conclude that while resource dependence does not affect growth, resource abundance is growth-enhancing. More recently, Clootens and Kirat (2017) examined the robustness of the latter two results. The authors introduce heterogeneity between the countries considered by Brunnschweiler and Bulte (2008). By grouping these countries, for example between OECD and non-OECD countries, they qualify these results: On page 4, we read: "The results are in line with those of Brunnschweiler and Bulte (2008) except for the impact of resource dependence on economic growth, which is now strongly and significantly negative in non-OECD countries." The resource curse, as measured by resource dependence, thus appears to be non-linear with respect to the level of development. This is not the case if it was measured by resource abundance.

they included oil, gas, coal, and forestry resources. By estimating with their proven reserves (evaluated in 2002, therefore after the period 1970–2000 while an average evaluation over 2 or 3 moments would perhaps have presented other results because the production at least, which was counted in addition reserves, may have varied in the interval), the authors corroborate the absence of a resource curse without fully confirming the blessing on growth found by Brunnschweiler and Bulte (2008).

Cavalcanti et al. (2011), using panel data from 53 countries between 1980 and 2006, investigate whether or not natural resource abundance contributes to economic performance. The authors evaluate econometrically a theoretical model based on a Cobb-Douglas function with capital and labor as factors of production, but also natural resources. The latter are approximated by the oil resource alone (this resource being approximated in turn by the value of oil production *per capita* or the value of oil reserves *per capita*). The endogenous variable is the level of GDP *per capita* (as in our article) but also the growth *per capita*. Their results in the long term (on the balanced path) or in the short term, but also according to different partitions of the sample (OPEC countries, OECD countries), suggest significantly positive coefficients between oil resources and growth or development.

Boyce and Herbert Emery (2011), on panel data for the US countries between 1970 and 2001 show a negative relationship between annual GDP growth and the size of natural resources (size being the ratio of employment in resources to total employment in each State). This choice of abundance measure does not allow for a perfect comparison of the magnitude of the coefficients estimated for the resources considered by these authors (mines, forests, and fishery products) with the resource categories considered in our article. The relationship between the average GDP over the period and these same resources is found to be positive. The authors conclude that the negative effect on the growth rate is explained by the gradual decline in resource yields in production. However, for them, there is no curse since average levels of GDP *per capita* increase with the size of the resources. If we use the vocabulary of our article, there would be a weak natural resource curse but not a strong one.

Frankel (2012) proposes reflections (among others, the downward trend in prices and their volatility or the Dutch disease *or the* quality of institutions at the very moment of resource discovery) and solutions to elucidate and remedy the negative link between resource abundance and development.

Konte (2013), using a sample of panel data (91 countries, 1970–2005) from Penn World Tables 6.3 version (Heston et al., 2009), raises the question of the impact of natural resources according to the growth regime to which a given country belongs.

The variable of interest, 'natural resources', is measured by the share of exports of primary fuels and non-fuel substances, as in Sachs and Warner (1995). The author uses a semi-parametric method (finite-mixture-of-regression models) to classify countries into homogeneous growth regimes. This classification is based on the conditional distribution of their growth rates given all the explanatory variables (including economic and political institutions, levels of education, and democracy . . .) and is estimated by maximum likelihood. This is a promising alternative to the *per capita*-based classification used in our article and in the literature in general. The results indicate that data are best generated by a model of two regimes. In the first regime (which concerns 42% of the countries, with an average annual growth rate for the dependent variable – GDP *per capita* – of 2.32% and an estimated coefficient for the 'natural resources' variable of 0.036 and significant), natural resources have a positive impact on growth. In the second (1.5% growth rate and estimated coefficient of natural resources of –0.015 and non-significant), the impact is neutral or negative, depending on the measure of natural resources considered. The author also presents a cross-sectional significant estimation result comparable to that of Sachs and Warner (−0.044), whereas their panel estimation (fixed-effects) results in a positive but insignificant correlation of 0.02 of natural resources on growth (see their Table 3). Another aspect of the article is that the variable of interest is then disaggregated into three sub-categories of resources according to the *per capita* income net of production costs generated by each.

James (2015) takes a complementary approach, looking at the relationship between natural resources and economic growth at a sectoral level. Each country's economic growth is the result of its sectoral growth, including that of natural resources. In our view, this approach resembles the teachings of growth accounting exercise. A sector with high or low growth will see its contribution to macroeconomic growth attenuated or reinforced according to its weight in GDP. Based on World Bank data for 111 countries, OLS estimates, without control variables, of the influence of natural resources on *per capita* growth at both macroeconomic and sectoral levels are carried out for different sub-periods between 1970 and 2010. In each sub-period, the significantly (or non-significantly) positive or negative coefficients of the relationship tested between natural resources and economic performance will therefore depend on the weight and growth of each sector within the economy. The prices of the natural resources considered in the estimation play a predominant role in the growth or decline of each sector. Finally, the mechanism whereby dependence on resources would imply negative effects on other sectors of the economy is not confirmed, whatever the estimation period.

Kim and Lin (2017), based on a panel of developing countries, find that countries with the greatest abundance of natural resources experience on average lower development trajectories than those with more limited resources. This average coefficient confirms the curse of natural resources, but the authors also mention governance factors (rule of law, degree of corruption, etc.) that could explain the strong heterogeneities in this relationship that have been observed from one country to another.

van der Ploeg and Poelhekke (2017) focus on recent quantitative evidence on the resource curse and provide a critical review of new methods, datasets, and empirical analysis. They examine the problems with macroeconometric works that address the resource curse theme: endogeneity of the mineral wealth measure, multicollinearity, omitted variables… The authors also discuss new empirical approaches (e.g., natural experiments), which could allow for more robust estimates.

Shahbaz et al. (2019) examine econometrically on panel data, the impact of natural resource abundance (which they find to be growth-enhancing) but also of natural resource dependence (which they find to be growth-impeding) on economic growth for 35 resource-abundant countries over the period 1980–2015.

Tiba and Frikha (2019) examine econometrically on panel data, the long-run relationship (FM-OLS method) between natural resources and economic growth for 26 African countries between 1990 and 2016. The authors find that a 1% increase in natural resources significantly reduces growth by about 18%. The content and database (WDI) of the 5 natural resources categories are identical to this paper.

Majumder et al. (2020), in a dynamic panel (with several control variables) for 95 countries between 1980 and 2017 find a negative relationship (–0.04) between GDP *per capita* and the share of net oil revenues (revenues minus production cost) in GDP. International trade would reduce this curse by 25% (it has a significant positive effect of 0.01). But it is a curse due to a single natural resource.

Nzié and Pepeah (2022) examine econometrically, using panel data, the effects of resources on growth in 37 Sub-Saharan African countries between 1996 and 2019.

Their sample is split into resource-rich and resource-poor countries. The role of institutions is considered, including the interaction with natural resources. The results of the regressions are also distinguished according to the short or long term. One result concerns the interaction term between resources and institutions (separate non-significant terms) in resource-rich countries. The authors find that it is positive in the short run and insignificant in the long run. This could indicate that resource rent-seeking eventually weakens institutions.

Sharma and Paramati (2022) econometrically (panel two-stage least square method with country fixed effect) explore the nexus between economic growth and natural capital as defined by the World Bank (fossil fuel energy, minerals, and agricultural indicators (land, forests, and protected areas) for 137 countries, over the period 1995–2018. Results show that a 1% increase in natural capital raises *per capita* income by 0.22% to 0.29%, *ceteris paribus*. Authors reject the resource curse hypothesis and support the resource blessing hypothesis. These results are fairly consistent (see Tables 5 and 6) for both developing and developed economies.

A **second section** summarizes the literature review presented in the introduction and describes the article's contributions. A **third** presents the proposed model and the estimated econometric relationship. The **fourth section** presents the model variables and descriptive statistics. The **fifth section** presents and discusses the results of the four econometric estimates of the relationship at the full sample level, successively when the variable of interest is aggregated and disaggregated. The same work is undertaken in **section six** but at the level of each of the four subsamples according to their level of GDP *per capita*. A **final section** concludes.

Summary of discrepancies in literature and main contributions

Synthesis of the discrepancies

In the second part of the introduction, a number of econometric studies carried out since the 1990s on the link between natural resources and economic performance were presented. Here, we provide a summary of the divergences encountered in this literature.

As we have just seen with the literature review, the econometric works are therefore voluminous but also quite different and imperfectly comparable in both the direction and magnitude of the relationship between resources and economic growth-development. The use of different panels by country and period (the countries considered are sometimes exclusively resource-rich and sometimes mixed with others, country studies, natural experiments); the structure of the data mobilized (cross-section, times series or, as in this article, panel data); different econometric methods (parametric, semi-parametric, instrumental variable, panels with oneway individual or time fixed-effects model or twoways fixed-effects model, dynamic panels, long-term relationship tested by FM-OLS or by DOLS, Panel Smooth Transition Regression to further investigate non-linearities, etc . . . ; number and nature of the regressors retained in the econometric relationship tested referring to the difference between the models used, which are often *ad-hoc*; short or long-term relationships; control variables; interaction terms etc.; different natural resources considered (single resource to several resources); different components associated with each resource (for e.g., for the precise category "mineral resources," the list of materials is obviously not the same, etc.); different valuations for the same resource; dependent variable in terms of GDP *per capita* (our article's case, developed in section "Article's key contributions") or GDP *per capita* growth (case of all literature) or even an explanatory variable of interest linked to resource abundance, resource dependence or other concepts and whose definition varies according to the author etc . . . are some of the common characteristics that alter comparisons of the estimates (signs, magnitude, significance).

Article's key contributions

In this subsection, we extend what was very briefly stated at the very beginning of the introduction, i.e., the purpose of the article, by specifying here its main contributions.

The article is intended as a contribution to an econometric investigation of multifactorial reasons and some of their interactions in an attempt to study the relationship between natural resources and development.

A first key contribution is to consider that the endogenous variable to evaluate the effects of natural resources on development is no longer the evolution of GDP (or GDP *per capita*) but GDP *per capita* itself. As already stated, very few studies use the GDP level as an endogenous variable. The article by Cavalcanti et al. (2011), for e.g., does so for 53 countries between 1980 and 2006, but the resources considered are restricted to oil alone. The same is true of for 95 countries between 1980 and 2017. We take into account here all natural resources for which statistics are available according to the World Bank (WDI, 2022).

Below, we set out our reasoning through a few semantic clarifications concerning growth and development, on the one hand, and the strong and weak curse (or blessing) on the other. Finally, we propose a new typology (Table 1) of the relation between natural resources and economic performance.

Indeed, a distinctive contribution to the existing literature is that we question the very terms of the issue, particularly what is meant by "natural resources." By using resource rents as explanatory variable in relation to GDP *per capita*, we examine the impact of natural resource dependence on economic performance. But it is what is covered by the term "economic performance" that is just as questionable, and perhaps even more so. Clearly, the 43 studies mentioned above did not use the level of GDP *per capita* as a dependent variable but rather GDP growth *per capita*.

They retain that economic performance is synonymous with economic growth, which is hardly disputable but nevertheless raises, in our opinion, at least one question. By opting for a growth rate of GDP (or growth rate of GDP *per capita*) as an endogenous variable, the current literature basically asks what impact natural resources have on the acceleration or deceleration of this endogenous variable. Our question is simpler: What is the impact of natural resources on GDP (or GDP *per capita*)? Our endogen is therefore the level and not the rate of change of this GDP. Here is the intuition.

Let us imagine that the regression coefficient of the variable representing natural resources, which is significantly negative, implies, for example, that a 1% variation in natural resources is accompanied by a 0.5% drop in GDP growth, bringing it down to 0.3% for instance. In literature, this would be interpreted as a "resource curse" even though there is no reason to consider that GDP has fallen (which would corroborate our « strong resource curse » thesis) since growth nevertheless remains at 0.3%. In other words, lower growth is simply not always synonymous with lower GDP.

When, for e.g., the growth rate falls, this does not mean that GDP is falling (we have the same analogy with disinflation which is a reduction in the rate of inflation and deflation which is a reduction in prices). By reasoning with GDP, it is as if we were analogically reasoning directly with deflation, hence the adjective "strong." The fact that GDP is falling is a bigger curse than if it is just its growth rate that is falling.

Table 1. Suggested terminology for studying the Natural resource-Economic performance nexus

Endogenous variable	Decreases	Increases
GDP *per capita* (level)	Strong curse	Strong blessing
GDP *per capita* (growth)	Weak curse	Weak blessing

Note: In blue, the terminology used in this article.
Source: Author's terminology

We, therefore, propose to call the first relationship a "weak resource curse" and the second a "strong resource curse." As illustrated in Table 1, this article examines the latter econometrically, which seems to us to be more innovative and perhaps even more intuitive, since it asks about the impact of natural resources on GDP *per capita* rather than the acceleration or deceleration of this GDP *per capita*.

Our approach to the dependent variable is, however, complementary to existing practice but provides additional details as Brunnschweiler and Bulte (2008) did for e.g., regarding the independent variable of interest representing natural resources (See introduction). This choice of the endogenous variable (GDP *per capita*) makes it possible to clearly observe the degrees of impact of natural resources on economic performance without therefore entering into conflict with the growth rate usually adopted. When natural resources are associated with a drop in GDP, the impact seems more considerable to us than if it was just the growth rate that fell. It is simply this, i.e., the question of the impact degree, which guided our choice.

Table 1 below summarizes our first contribution to the econometric analysis of the relationship:

A second key contribution is that the article seeks to show estimation results from several econometric techniques (4) rather than the usual single one. If, in terms of economic modeling, no theoretical trend emerges, the results of this relationship also remain enigmatic in the current econometric literature. Although popularized by the "resource curse" (Auty, 1993 and Sachs and Warner, 1995), the econometric results are in fact very mixed. However, the studies do not focus on the same perimeters (see section "Synthesis of the discrepancies"), which partly explains the divergence of results. Of the econometric works on the effect of natural resources on economic growth published between 1995 and 2013 (43 studies containing 605 regression estimates of this effect), the meta-analysis proposed by Havranek et al. (2016) reports that about 40% of these estimates are negative and statistically significant, 40% insignificant, and about 20% are positive and statistically significant.

Using a global sample of 130 countries from 1990 to 2019 (World Bank and PWT 10.0 data), our article, therefore, examines the question of strong blessing/curse through the relationship between resource rents and the level of GDP *per capita*. This examination is conducted within an econometric work based on a theoretically sound economic model (using development accounting framework, see start of section "The theoretical economic model and the estimated relationship"). This framework brings together several disparate aspects of the literature and recommended meta-analysis findings: four econometric regression techniques (Ordinary Least Square, OLS, Least Square Dummy Variables, Fully Modified-OLS, FM-OLS, Dynamic-OLS, D-OLS), full sample and sub-samples according to the level of GDP *per capita* of the countries (4 sub-samples) to consider non-linearities of the relationship, aggregate natural resources, natural resources by resource category (5 categories), consideration of institutional variables and resource-institution interactions, and several control variables, including 2 new ones (Income inequality, GINI, and Current account balance *per capita,* CURBOPC).

The theoretical economic model and the estimated relationship

The literature on the link between natural resources and growth (here development) does not refer to a standard explicit theoretical model. Instead, it uses *ad-hoc* models in which the variable of interest is regressed on more or less freely chosen variables, often without identifying the underlying mechanism giving rise to the relationships.

We present here the theoretical economic basis of our model and the estimated econometric equation.

$$\textbf{\textit{Per capita development level in PPP}} = f\begin{pmatrix} \textbf{\textit{factors from the development accounting framework}} - \textbf{\textit{excluding TFP}}, \\ \textbf{\textit{institutional factors}} - \textbf{\textit{recommended by the meta}} - \textbf{\textit{analysis}}, \\ \textbf{\textit{control variables}} - \textbf{\textit{used in the literature}}, \\ \textbf{\textit{specific effects}} - \textbf{\textit{countres and time}} \end{pmatrix}$$

The econometric regression equation at level-level[6], evaluated with OLS, fixed effects estimator, FM-OLS, and DOLS is therefore written as follows:

$$\boldsymbol{GDPPC}_{i,t} = \alpha + \beta_1 KPC_{i,t} + \beta_2 EMPC_{i,t} + \beta_3 HC_{i,t} + \beta_4 TOTALNRRPC_{i,t} + \beta_5 \boldsymbol{INST}_{i,t} + \beta_6 \boldsymbol{X}_{i,t} + \gamma_i + \delta_t + u_{i,t}$$

GDPPC is the *per capita* GDP in PPP; α, overall intercept of the regression; *KPC*, *per capita* Capital; *EMPC*, ratio of the Number of persons engaged to Population; *HC*, Human capital index, based on years of schooling and returns to education; The variable of interest *TOTALNRRPC*, *per capita* Total natural resource rents (% of GDP) are the sum of *per capita*: oil rents (*OILRPC*), natural gas rents (*NGRPC*), coal rents (*COALRPC*), mineral rents (*MINRPC*), and forest rents (*FORRPC*); *INST*, Institutional variables which are Rule of law (*RULAW*) and Control of corruption (*CONTCOR*); *X*, a vector of macroeconomic control variables which are, *TOTR*, terms of trade; *CURBOPC*, current account balance *per capita*; *GINI*, Gini coefficient;γ_i, country-specific effects; δ_t, period-specific effects and $u_{i,t}$, error term.

As discussed earlier, the endogenous variable is the level of GDP *per capita* at PPP, not the growth of GDP *per capita* at PPP. The choice of the first three explanatory variables (KPC, EMPC, HC) is based on the growth and development accounting exercise. Total factor productivity (TFP), whose magnitude is calculated from the development accounting equation as a residual between the endogenous and these three factors in accounting exercises, is not considered in our equation, which is econometric and not accounting. TFP is likely to encompass a very diverse set of influences on GDP and with

[6]As many of our explanatory variables, including the variable of interest, are expressed in % and the endogenous is level, the interpretation of these coefficients is exactly identical to a level-log specification (the estimated coefficients then represent the change in units of the endogenous variable relative to a variation of 1 percentage point in the explanatory variable). For the other variables, the level-level interpretation will correspond to the effect of the variation of one unit of the variable on the endogenous variable. Systematically, whatever the explanatory variable, the interpretation of the estimated coefficients is illustrated numerically (the detailed calculations are shown).

this in mind, all other variables, including the variable of interest TOTALNRRPC, can potentially play a similar role alongside these first 3 variables.

The growth accounting framework is associated with Abramovitz (1956), Solow (1956,1957), then Jorgenson (1966), and Hulten (1978, 1992), but also with the many related works in literature. The latter is now more abundant than the literature on development accounting.

Without claiming exhaustivity, we cite several growth accounting works that are more or less standard but do not proceed from general equilibrium growth accounting[7]: Jorgenson (1995), Young (1995), Griliches (1996), Oliner and Sichel (2002), Oulton (2002), Barro and Sala-i-Martin (2004), Cette (2014), Cette et al. (2004, 2005a, 2005b, 2021, 2022), Hulten (2001), Jorgenson (2001), Jorgenson et al. (2004, 2006, 2008), Van Ark et al. (2008), Marrano et al. (2009), Sato and Tamaki (2009), Madsen (2010a, 2010b), Zuleta (2012), Cabannes et al. (2013), Fernald and Jones (2014), Niebel et al. (2016), Bergeaud et al. (2017, 2018a, 2018b), Crafts and Woltjer (2019), Daw (2019).

The development accounting framework can be associated with the pioneering work of Denison (1967) on the detailed explanatory factors of wealth differences between the United States and eight European countries in levels (1960s) and rates from 1950 to 1964, or Christensen et al. (1981) on the differences in levels, output, factors of production and productivity between the United States and eight of its most important trading partners.

Development accounting literature is less voluminous (some papers perform both growth and development accounting): Klenow and Rodriguez-Clare (1997), Hall and Jones (1999), Caselli (2005), Baier et al. (2006), Hsieh and Klenow (2010), Turner et al. (2013), Sturgill (2014), Tamura et al. (2019) or Daw (2022).

In growth or development accounting, calculations of contributions to growth or development can be made in the short, medium, or long term. They can be retrospective or prospective, macroeconomic, or disaggregated, i.e., multi-sectoral. The essential technique for evaluating the contribution of a factor to the growth of a variable of interest (GDP *per capita* growth for growth accounting; GDP *per capita* for development accounting) is as follows: The contribution of a production factor to GDP growth is measured by the product of the volume growth rate of that factor and its value share in GDP. The growth residual (Solow residual) or TFP then stands out as the difference between the evolution of GDP and the sum of the factor contributions calculated as before.

With regard to the institutional variables (INST) that the literature is increasingly mobilizing as guaranteeing a more legal sharing of rents from natural resources, there are two proxies: Rule of law (RULAW) and Control of corruption (CONTCOR), based on the WGI (Kaufmann and Kraay, 2021).

RULAW is the quality of institutions and is defined by WGI as capturing "the way agents trust and respect the rules of society, in particular, the quality of contract enforcement, property rights, police and courts, and the likelihood of crime and violence." The list of criteria used to build *RULAW* is in WGI (see *Description of Methodology*). Respect for property rights, independence of the judiciary, separation of powers,

[7]There are also today (Greenwood et al., 1997; Cummins and Violante, 2002; Whelan, 2003; Bakhshi and Larsen, 2005; Fisher, 2006; Martínez et al., 2008; Ngai and Samaniego, 2009; López and Torres, 2012; Byrne et al., 2013; Byrne and Corrado, 2017 ...) a second growth accounting family that simultaneously allows for growth analysis. This one is conducted starting from a uni-sectoral but also multi-sectoral modeling even more functional of the economy (*à la* Uzawa 1963). This makes it possible to measure the contributions of the production factors in steady state while considering the channels that influence them. One can thus measure not only the factors'contributions to growth – as in standard growth accounting – but also the impact of a shock affecting the factors of production on their contributions to growth.

confidence in the justice system, law enforcement, crime statistics (including tax statistics), etc. are examples of criteria.

CONTCOR captures "perceptions of the extent to which public power is exercised for private purposes, including both petty and grand forms of corruption, as well as the 'capture' of the state by elites and private interests" (WGI). It thus reflects the corruption of political, administrative, judicial, and private institutions and thus the degree to which society practices corruption in its functioning. The list of criteria used to construct*CONTCOR* is in WGI (see *Description of Methodology*). Capture of public power by political authorities and the private sector, corruption of administrative, political, and judicial institutions, corruption of the education system, etc. are some criteria.

Interaction terms between TOTALNRRPC and the 2 institutional variables are introduced in all regressions and for all samples. The same is true for each of the 5 natural resources included in TOTALNRRPC and these 2 institutional variables. The interest of interaation terms is to examine whether the effect on the development level of natural resources and each of their components is amplified or attenuated by the quality of these institutional variables.

For the 3 control variables, we have chosen a variable that is common in the literature, namely the terms of trade TOTR (ratio of the price of exports to that of imports). For the United States, this ratio is set equal to 1, and ratios for the other countries are therefore assessed with reference to that of the USA.

Price competitiveness is thus taken into account. However, it is also possible to consider the influence of foreign trade on the level of GDP *per capita* in a more general way by using the current account balance *per capita* (CURBOPC), which is found in the balance of payments (BP). The BP is a document that brings together and arranges in accounting form all the economic, monetary, and financial transactions that took place during a given period between the residents of a country and those of the rest of the world. However, in the literature, this document is not used as a control variable for macroeconomic conditions affecting GDP *per capita*, although it is a crucial document in open macroeconomics. The IS-LM-BP model easily illustrates how and by how much macroeconomic equilibria are modified with respect to those prevailing in a closed economy framework.

The third variable concerns inequality (GINI) and is also new compared to what is used in the literature. This index ranges from 0 (0%) when all individuals have the same income to 1 (100%) when one individual has all the income. Income and wealth inequality are characteristic of all the economies studied. The question is basically whether the inequality elasticity of GDP *per capita* plays a significant role or not. For e.g., an OECD study (Causa et al., 2015) indicates that, depending on the part of the income distribution concerned, any 1% increase in inequality is correlated with a reduction of between 0.6 and 1.1% of GDP. However, the causal relationship between inequality and growth or development remains more difficult to establish, in particular, because of the endogeneity of inequality (bi-causality with GDP). Moreover, the relationship may well prove to be non-linear. A recent work by Grigoli and Robles (2019) on 77 countries at various stages of development and over some 20 years takes into account this issue of endogeneity. The authors report that the tested relationship between income inequality and economic development is positive below a GINI coefficient of 27%, while beyond that it is negative and of more pronounced magnitude on development.

Finally, regarding data and estimation methods, we note that in the literature, Havranek et al. (2016), find that the samples are mostly cross-sectional (about 80%) and the rest panel-based. Estimates based on these samples are mostly OLS (about 2/3) indicating that they remain vulnerable to endogeneity and omitted variables problems.

In addition, Ehigiamusoe and Lean (2018) note that using multiple econometric simulation methods on the same sample can provide more informative and robust estimates. The results of all our regressions will be presented here in cross-section (OLS), in panel (fixed-effect model LSDV), and in the long term, i.e., in a cointegrated way (Fully Modified OLS estimator FM-OLS, Phillips and Hansen, 1990, Pedroni, 1996). Long-term results of the Dynamic OLS estimator (DOLS, Saikkonen, 1991) are presented for all regressions, but more systematically for those relating to sub-samples. The analysis of the results will be done with the objective of providing robust ranges of estimates. For this, it will highlight the common and differentiated results from each of the four techniques used.

Presentation of model variables and descriptive statistics

In this section, Table 2 describes the variables used and their source, and Table 3 provides descriptive statistics. Figure 1 illustrates the relationship between the share of rents in GDP *per capita* and the level of GDP *per capita* for total resources and each of their 5 components and Figure 2, the relationship between institutional variables and the level of GDP *per capita*. The section ends with the Correlation matrix of our explanatory variables (Figure 3).

The average distribution of GDP *per capita* in PPP (2017$) is as follows: HI: > $10,648; UMI: > $4,253 and < $10,648; LMI: > $1,604 and < $4253 and LI: < $1,604. The dispersion of these GDP *per capita* around their mean in the full sample (1.14, see Var.coeff line) is almost twice as large as in the 4 sub-samples. In lower *per capita* income countries (LMI and LI) the dispersion around the mean is greater than in higher income ones (HI and UMI).

For the institutional variables (RULAW and CONTCOR), their average values are, as expected, significantly lower in low-income countries. Moreover, the values of the two variables are very close or even similar, as shown by their overlap in Figure 2. Since these mean values are relevant to econometric comments on their interaction with the natural resource variables, it is important to keep them in mind.

The distribution of the natural resource rents' share in GDP *per capita* are spread out to the right (Median (about 0.2% in the EG) < Mean (about 1.2% in the EG)). This is true for the aggregate resources (TOTALNRRPC) as well as for each of their 5 components, whether for the full sample or for each of the 4 sub-samples (HI-UMI-LMI and LI). It is the rents from petroleum products (OILRPC) that essentially contribute (57.4% or 0.66%/1.15%) to the total rents. They are followed by forestry products (FORRPC) with 26%. The relationship between the share of natural resources in GDP and GDP is not linear but sinusoidal (see Figure 1, Blue Line). The average share of natural resource rents is highest in LI countries (1.3%). For these countries, the distribution of this share is largely dominated by rents from forest products, which account for more than 75% of the total ((1/1.3)%), whereas for the other three sub-samples, rents from petroleum products are predominant. For the rents from gas products (NGRPC), these are the prerogative of the highest incomes which, with 0.15%, yield 15 times more (0.15%/0.01%) than for the countries in the other three sub-samples. Finally, because of the undoubtedly restrictive list of mining resources considered by the World Bank, the figures associated with mining rents (MINRPC) are legitimately underestimated. Nevertheless, they account for nearly 9% (0.1%/1.15%) of total rents, with LMI countries being the main beneficiaries at 57.6% (221/384, see Sum Line).

Table 2. Description of the variables

Variables/ Periods	Description	Source
Dependent variable		
GDPPC	GDP *per capita* is the ratio (in US$): Output-side real GDP at current PPPs (in millions 2017 US$) to POP, the population (in millions)	Feenstra et al. (2015) PWT 10.0
Explanatory variables		
KPC 1990–2019	*Per capita* Capital stock at current PPPs (in 2017US$)	Feenstra et al. (2015) PWT 10.0
EMPC 1990–2019	Ratio of the Number of persons engaged (in millions) to Population (in millions)	Feenstra et al. (2015) PWT 10.0
HC 1990–2019	Human capital index, based on years of schooling and returns to education	Feenstra et al. (2015) PWT 10.0
TOTR 1990–2019	Terms of trade is ratio: (Price level of exports, price level of USA GDPo in 2017=1) to (Price level of imports, price level of USA GDPo in 2017=1)	Feenstra et al. (2015) PWT 10.0
COALRPC 1990–2019	*Per capita* Coal rents (as % of GDPPC) are the difference between the value of both hard and soft coal production at world prices and their total costs of production.	WDI (2022)
FORRPC 1990–2019	*Per capita* Forest rents (as % of GDPPC) are roundwood harvest times the product of regional prices and a regional rental rate.	WDI (2022)
MINRPC 1990–2019	*Per capita* Mineral rents (as % of GDPPC) are the difference between the value of production for a stock of minerals at world prices and their total costs of production. Minerals included in the calculation are tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate.	WDI (2022)
NGRPC 1990–2019	*Per capita* Natural gas rents (as % of GDPPC) are the difference between the value of natural gas production at regional prices and total costs of production.	WDI (2022)
OILRPC 1990–2019	*Per capita* Oil rents (as % of GDPPC) are the difference between the value of crude oil production at regional prices and total costs of production.	WDI (2022)
TOTALNRRPC 1990–2019 (variable of interest)	*Per capita* Total natural resource rents (% of GDPPC) are the sum *per capita* of oil rents, natural gas rents, coal rents, mineral rents, and forest rents.	WDI (2022)
CURBOPC 1990–2019 (Discontinuous)	*Per capita* Current account balance of payments is the sum of net exports of goods and services, net primary income, and net secondary income. Data are in current U.S.$.	WDI (2022)
GINI 1990–2019	Gini coefficient between 0 and 100.	Our World in Data (2022)

(*Continued*)

Table 2. (*Continued*)

Variables/ Periods	Description	Source
RULAW 1996–2019	Rule of law reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Estimate of governance ranges from approximately −2.5 (weak) to 2.5 (strong) governance performance.	Kaufmann and Kraay (2021) WGI
CONTCOR 1996–2019	Control of coruption reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the State by elites and private interests. Estimate of governance ranges from approximately −2.5 (weak) to 2.5 (strong) governance performance.	Kaufmann and Kraay (2021) WGI

Source: Author's compilation.

Results of the econometric estimates in the full sample

Full sample with aggregated TOTALNRRPC

We present estimation results at the aggregate level without decomposing the TOTALNRRPC variable of interest into its 5 components. The estimates are successively in OLS (Table 4) and panel (LSDV, Table 5) but also in the long run where the long-run cointegrating vector is estimated by FM-OLS (Table 6). In addition, the results where the long-term cointegration vector is estimated by DOLS will be presented and commented on.

Although subject to the largest number of sources of endogeneities in the regressors (dual causality, omitted variables), this first set of OLS estimates remains by far the most common in the literature on the natural resources-growth-development nexus (about 2/3 according to Havranek et al. 2016). It does not exploit the panel nature of the data (thus, no consideration of country and time-fixed effects). The first column tests a standard development accounting model without TFP but with natural resources. On the one hand, it includes the usual growth and development accounting variables: physical capital *per capita* (KPC), the ratio of employed population to total population (EMPC), and the human capital index (Feenstra et al., 2015) based on the number of years of schooling and the returns associated with these different degrees of schooling. Thus, on the other hand, we find the share in GDP *per capita* of the sum of total resource rents (TOTALNRRPC). In columns (2) and (3), the institutional variables relating to the rule of law and control of corruption (RULAW and CONTCOR) are added. They managed to slightly raise the quality of the association of the explanatory variables, which was already very high (R^2 close to 0.9). Columns (4) and (5) consider a country's relations with the rest of the world via the terms of trade (TOTR, equal to 1 for the USA taken as a reference) and, more generally than the impact of prices alone (TOTR), the *per capita* current account balance (CURBOPC). To our knowledge, this last variable is not used in the literature, even though the BP is a central document for examining foreign relations. Note that considering only CURBOPC (thus, excluding TOTR) in the regression does not change the meaning, magnitude, and significance of CURBOPC.

Table 3. Descriptive statistics: Global sample (**EG**, 130 countries), High income (**HI**, 45 countries), Upper middle-income (**UMI**, 31 countries), Lower middle-income (**LMI**, 35 countries) and Low income (**LI**, 19 countries)

	GDPPC ($US PPP 2017)	KPC ($US PPP 2017)	EMPC (% of Population)	HC (Index)	CURBOPC ($US, current)
	EG – HI – UMI – LMI – LI	EG – HI – UMI – LMI – LI	EG – HI – UMI – LMI – LI	EG – HI – UMI – LMI – LI	EG – HI – UMI – LMI – LI
Observations	3900|1350|930|990|570	3900|1350|930|990|570	3900|1350|930|990|570	3900|1350|930|990|570	3900|1350|930|990|570
Min.	244|682|251|468|244	543|13824|5354|1221|543	0.18|0.27|0.2|0.19|0.18	1.03|1.94|1.5|1.14|1.03	−169297|−31759|−169297|−56083|−52640
Max.	151006|151006|28919|15524|7211	636302|636302|133157|67502|64525	0.75|0.75|0.57|0.58|0.52	4.35|4.45|3.61|3.58|3.17	181729|181729|22879|38194|101473
Sum	62186830|46658990|9902880|4210462|914240	266917700|20934400|36658950|14616360|3087992	1569|621|356|367|204	9433|4122|2312|1964|888	879995|1035926|−229288|−10456|82294
Median	8916|31363|9653|3380|1278	30637|142971|34042|10041|3247	0.4|0.46|0.38|0.37|0.36	2.46|3.11|2.51|1.88|1.46	−33|−51|−51|−29|−26
Mean	15945|34562|10648|4253|1604	68440|155211|39418|14764|5418	0.4|0.46|0.38|0.37|0.36	2.42|3.05|2.49|1.98|1.56	226|767|−247|−11|144
Std. Dev	18098|19121|5234|2757|1068	86246|94510|25490|13089|6805	0.09|0.07|0.08|0.08|0.07	0.71|0.44|0.44|0.49|0.47	5334|6040|6051|2426|6106
Var.coeff	1.14|0.55|0.49|0.65|0.67	1.26|0.61|0.65|0.9|1.26	0.22|0.15|0.22|0.21|0.2	0.3|0.14|0.18|0.25|0.3	24|7.87|−24.5|−230|42.29

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	TOTR (Ratio, 1 for USA)	**GINI (Index, 0–100)**	**RULAW (Index, 0–100)**	**CONTCOR (Index, 0–100)**	TOTALNRRPC (% of GDPPC)
Observations	3900|1350|930|990|570	3900|1350|930|990|570	3900|1350|930|990|570	3900|1350|930|990|570	3900|1350|930|990|570
Min.	0.4|0.62|0.4|0.63|0.71	20.2|20.2|22.9|23|24.8	3.54|14.11|3.54|13|7.4	15.5|16.4|15.5|15.97|15.54	0|0|0|0|0.03
Max.	1.46|1.46|1.3|1.29|1.37	65.8|65.8|65.8|63.3|65.8	92.59|92.59|90.7|91.4|90.52	99.4|99.4|98.14|98.76|97.4	36.65|26.54|36.7|18.5|11.1
Sum	3996|1386|948|1004|595	151640|47650|39034|39749|22953	194819|88880|41320|40911|21364	192344|87739|41520|38685|21880	4473|1436|1142|952|739
Median	1.04|1.04|1.03|1.03|1.06	36.9|33.6|41.6|39.5|38.6	45.17|68.3|42.02|39.3|36.17	43.1|64.16|42.4|37.1|35.43	0.17|0.05|0.15|0.24|0.64
Mean	1.02|1.03|1.02|1.01|1.04	38.9|35.3|42|40.2|40.3	49.95|65.8|44.43|41.3|37.48	49.32|64.99|44.7|39.1|38.4	1.15|1.06|1.23|0.96|1.3
Std. Dev	0.1|0.1|0.11|0.11|0.1	9.15|7.82|9.34|8.99|8.95	20|18.42|14.98|14.86|15.27	20.46|20.55|14.66|13.9|15.2	3.23|3.39|4.22|2.42|1.63
Var.coeff	0.1|0.1|0.11|0.1|0.1	0.24|0.22|0.22|0.22|0.2	0.4|0.28|0.34|0.36|0.41	0.41|0.32|0.33|0.36|0.4	2.81|3.19|3.44|2.52|1.26

	COALRPC (% of GDPPC)	FORRPC (% of GDPPC)	MINRPC (% of GDPPC)	NGRPC (% of GDPPC)	OILRPC (% of GDPPC)
Observations	3900|1350|930|990|570	3900|1350|930|990|570	3900|1350|930|990|570	3900|1350|930|990|570	3900|1350|930|990|570
Min.	0|0|0|0|0	0|0|0|0|0	0|0|0|0|0	0|0|0|0|0	0|0|0|0|0
Max.	9.37|0.16|0.39|9.37|0.16	11.11|1.56|4.13|2.8|11.1	9.05|1.03|7.13|9.05|2.85	7|7|0.23|0.4|0.18	33.36|26.41|33.4|17.35|2.8
Sum	90|5|13|62|1	1182|83|181|215|607	384|20|97|221|43	231|205|9|13|4	2586|1123|843|441|83
Median	0|0|0|0|0	0.02|0.01|0.01|0.08|0.46	0|0|0|0|0	0|0|0|0|0	0|0|0.01|0|0
Mean	0.02|0|0.01|0.06|0	0.3|0.06|0.19|0.22|1.07	0.1|0.02|0.1|0.22|0.08	0.06|0.15|0.01|0.01|0.01	0.66|0.83|0.91|0.45|0.15
Std. Dev	0.25|0.01|0.04|0.49|0.01	0.83|0.18|0.56|0.35|1.62	0.49|0.07|0.39|0.85|0.26	0.4|0.67|0.02|0.05|0.02	2.81|3.13|3.8|1.87|0.46
Var.coeff	10.89|3.61|2.97|7.77|5.04	2.74|2.87|2.89|1.62|1.5	4.94|4.82|3.77|3.8|3.43	6.77|4.42|2.38|3.49|3.53	4.24|3.76|4.2|4.21|3.14

Source: Author's calculations.

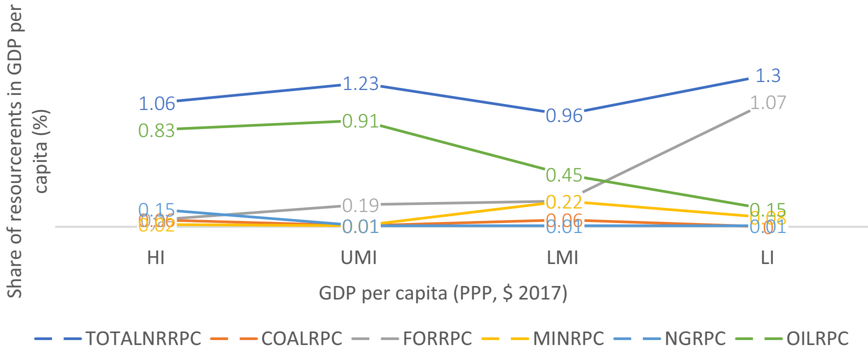

Figure 1. Relationship between the share of rents in GDP *per capita* and the level of GDP *per capita* for total resources and each of their 5 components.
Source: Author.

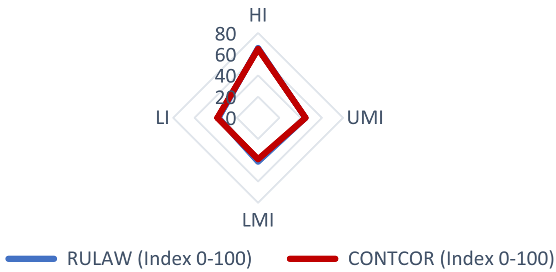

Figure 2. Relationship between institutional variables and the level of GDP *per capita*.
Source: Author.

Column (6) which adds to (5), in an innovative way compared to existing works on the subject, the consideration of income inequality (GINI) is the most complete model (9 variables) without the presence of resource-institution interaction variables as in (7) and (8). Havranek et al. (2016) report that the average number of variables used in the literature studying the natural resources-growth link is between 6 and 7, with a maximum of 16 variables.

In model (6), a 1% increase in total rents in GDP *per capita* is significantly associated with an increase in GDP *per capita* of $5.05 (1%*504.98). Model (7) introduces an interaction between resources and the rule of law (TOTALNRRPC*RULAW).

In presence of an interaction term in a regression, the coefficients for the variables involved in the interaction have a specific meaning when considered outside of that interaction. For e.g., the estimated coefficient for TOTALNRRPC (which here is significantly negative −245.07) is understood for RULAW equal to zero. Put another way, TOTALNRRPC negatively impacts GDP *per capita* when the rule of law index is valued at zero. The negative coefficient on natural resources here illustrates the positive role played by institutional quality in the positive impact of resources on GDP *per capita*. Table 3 shows that, on average, RULAW is valued at 49.95, which explains why the coefficient on TOTALNRRPC was positive when the interaction term was not in play. Interaction term

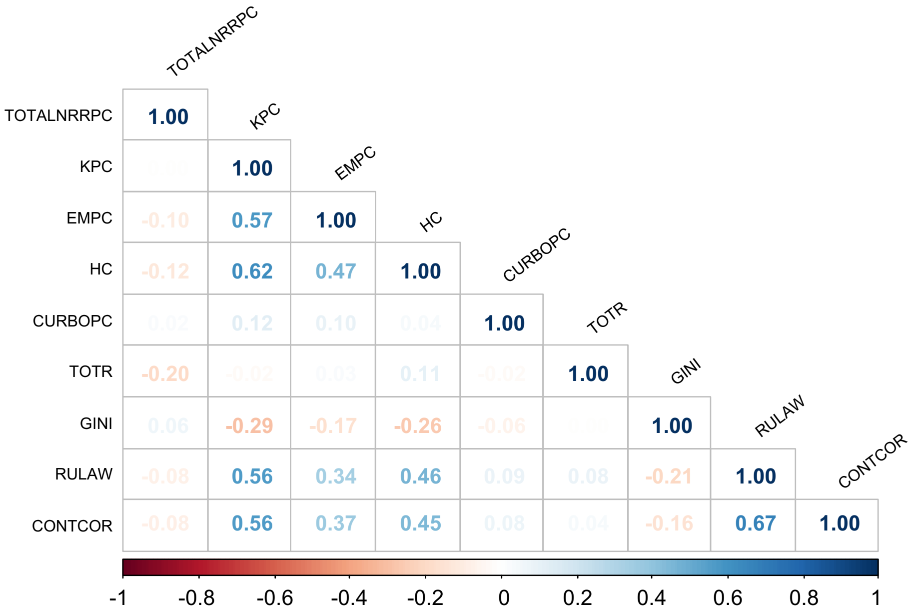

Figure 3. Correlation matrix between model explanatory variables.
Note: The matrix shows the correlations between the 9 explanatory variables of the model presented at the start of section "The theoretical economic model and the estimated relationship." The variable of interest, TOTALNRRPC, representing natural resources, precisely measures *Per capita* Total natural resource rents (% of GDPPC). Its correlations with the other explanatory variables are very weak and statistically insignificant. For example, the strongest correlation, in absolute terms, is with the TOTR variable. The significance test for the presence of a true correlation is rejected at 100% in this example. The same applies to all the other 7 correlations in Column 1.
Source: Author.

suggests that natural resources negatively influence GDP *per capita*, but that this negative influence is mitigated by RULAW.

A 1% increase in *per capita* natural resources rents reduces *per capita* GDP by $2.45 (1%*(−245.07)) but this decrease is mitigated for $0.16 (1%*15.67) if at the same time RULAW also increases by 1%. In total, the effect remains negative but is only $2.29. This first empirical finding shows that within the same econometric technique (OLS here), the influences of natural resources can be very different depending on whether interactions with institutional variables are considered (reduction in GDP *per capita* of $2.29) or not (increase in GDP *per capita* of $5.05).

The same reasoning applied to the CONTCOR variable leads to the same diagnosis, with the difference that this variable mitigates to a greater extent (coefficient of the interaction term of 23.57 > 15.67) the negative effects of the negative influence of total natural resource rents.

Fixed effects are considered here in the econometric estimation. Fixed effects are the deviations of the constant of a given country from the general constant of the regression.

Specification choice tests (Honda (1985), Hausman (1978)) confirm the relevance of the fixed effects model. Honda's test will verify whether the correlation between random fixed effects and idiosyncratic effects is significantly different from 0 (H1) or not (H0).

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Table 4. OLS – Global panel (130 countries, 1990–2019)

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
KPC	0.18****	0.17****	0.17****	0.17****	0.17****	0.17****	0.17****	0.17****
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
EMPC	12,002.64****	12,241.82****	11,665.26****	11,780.84****	11,391.37****	11,287.57****	10,523.56****	10,383.40****
	(1,413.38)	(1,393.68)	(1,382.89)	(1,342.37)	(1,335.95)	(1,334.37)	(1,321.89)	(1,309.25)
HC	2,018.57****	1,702.58****	1,625.00****	1,922.25****	1,985.02****	2,037.83****	2,127.54****	2,177.93****
	(177.38)	(175.85)	(174.61)	(171.75)	(171.29)	(172.09)	(170.66)	(169.35)
TOTALNRRPC	557.50****	579.54****	592.14****	513.67****	509.99****	504.98****	−245.07***	−527.05****
	(30.22)	(29.87)	(29.64)	(29.46)	(29.32)	(29.34)	(81.88)	(82.87)
RULAW		64.90****	35.55****	43.06****	41.97****	43.11****	25.21****	46.48****
		(5.18)	(5.32)	(5.46)	(5.53)	(5.53)	(5.91)	(5.64)
CONTCOR			56.83****	55.31****	55.16****	54.09****	58.04****	33.64****
			(5.25)	(5.36)	(5.43)	(5.43)	(5.54)	(5.75)
TOTR				−14,041.07****	−13,974.58****	−14,023.61****	−13,720.72****	−13,315.64****
				(922.33)	(917.55)	(916.83)	(909.35)	(898.36)
CURBOPC					0.11****	0.11****	0.10****	0.10****
					(0.02)	(0.02)	(0.02)	(0.02)
GINI						32.70***	31.78***	31.30***
						(10.33)	(10.25)	(10.16)

(*Continued*)

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Table 4. (*Continued*)

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TOTALNRRPC*RULAW							15.67****	
							(1.59)	
TOTALNRRPC*CONTCOR								23.57****
								(1.75)
Constant	−6,638.29****	−8,761.50****	−9,483.89****	4,116.96****	4,147.28****	2,787.23**	3,311.11***	2,963.20***
	(590.26)	(617.17)	(619.53)	(1,055.74)	(1,051.65)	(1,136.27)	(1,128.86)	(1,114.38)
Observations	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900
R^2	0.887	0.89	0.892	0.898	0.899	0.899	0.902	0.901
Adj. R^2	0.887	0.89	0.892	0.898	0.899	0.899	0.902	0.901

Note: Signif. codes: **** = 0.001 *** = 0.01 ** = 0.05 and * = 0.1; (): Standard deviations robust to heteroskedasticity, autocorrelation, and inter-individual correlation.
Source: Author's estimations.

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Table 5. Fixed effects model – Global panel (130 countries, 1990–2019)

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
KPC	0.13****	0.12****	0.12****	0.12****	0.12****	0.12****	0.12****	0.12****
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
EMPC	40,508.46****	40,505.19****	40,097.09****	39,643.00****	40,440.24****	40,632.36****	40,632.41****	40,725.50****
	(2,469.39)	(2,446.85)	(2,440.59)	(2,435.17)	(2,431.23)	(2,431.41)	(2,431.05)	(2,432.28)
HC	2,726.51****	3,200.89****	3,394.44****	4,071.81****	4,058.39****	4,017.55****	4,032.44****	4,016.17****
	(429.52)	(428.56)	(427.99)	(444.14)	(444.99)	(445.14)	(445.10)	(444.44)
TOTALNRRPC	342.05****	341.48****	345.97****	325.00****	302.78****	301.90****	214.43***	237.15***
	(50.18)	(49.62)	(49.45)	(49.46)	(49.16)	(49.10)	(80.45)	(84.13)
RULAW		40.81****	31.71****	31.30****	30.41****	30.10****	27.97****	30.20****
		(4.22)	(4.51)	(4.49)	(4.49)	(4.50)	(4.74)	(4.50)
CONTCOR			24.27****	22.20****	22.09****	22.21****	22.49****	20.74****
			(4.40)	(4.38)	(4.39)	(4.39)	(4.40)	(4.61)
TOTR				−5,966.32****	−6,022.96****	−6,104.55****	−6,162.52****	−6,132.20****
				(1,065.53)	(1,060.44)	(1,061.05)	(1,060.99)	(1,060.05)
CURBOPC					0.07****	0.07****	0.07****	0.07****
					(0.01)	(0.01)	(0.01)	(0.01)
GINI						−15.40**	−15.47**	−15.39**
						(7.83)	(7.83)	(7.83)

(Continued)

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Table 5. (*Continued*)

	Dependent variable: ***GDPPC***							
TOTALNRRPC*RULAW							1.76	
							(1.34)	
TOTALNRRPC*CONTCOR								1.51
Observations	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900
R^2	0.644	0.652	0.654	0.657	0.661	0.661	0.661	0.661
Adj. R^2	0.631	0.639	0.642	0.645	0.648	0.648	0.649	0.649
Pesaran test	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16
Honda test	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16
Hausman test	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16

Note: Signif. codes: **** = 0.001 *** = 0.01 ** = 0.05 and * = 0.1; (): Standard deviations robust to heteroskedasticity, autocorrelation and inter-individual correlation. Pesaran CD test for cross-sectional dependence, p-value; Alternative hypothesis: cross-sectional dependence Honda test (fixed vs ols), p-value; Alternative hypothesis: cross-sectional dependence Hausman test (fixed vs random), p-value; Alternative hypothesis: Fixed effects model is consistent.
Source: Author's estimations.

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Table 6. FM-OLS – Global panel (130 countries 1990–2019)

	Dependent variable: **GDPPC**							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
KPC	0.19****	0.19****	0.19****	0.16****	0.16****	0.17****	0.17****	0.17****
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
EMPC	712.39	−1,518.6	−3,025.7	12,527***	11,867***	10,588**	8,899.4**	8,304.5**
	(3,600.6)	(3,744.3)	(3,781.2)	(4,367.8)	(4,298)	(4,313.7)	(4,083.8)	(3,965.9)
HC	897.47	601.97	510.84	2,058.6****	2,169****	2,196.9****	2,266.1****	2,285.8****
	(612.47)	(641.02)	(637.58)	(616.67)	(607.14)	(599.47)	(568)	(551.58)
TOTALNRRPC	463.53****	460.86****	464.75****	532.29****	529.08****	508.76****	−390.6	−724.62**
	(117.73)	(116.11)	(114.71)	(102.3)	(100.56)	(100.51)	(279.76)	(283.38)
RULAW		35.13*	10.27	47.79**	47.753**	49.45**	29.09	54.88***
		(22.09)	(26.08)	(23.64)	(23.24)	(22.94)	(22.57)	(21.08)
CONTCOR			43.67**	66.61***	68.05***	65.63***	72.41****	43.98**
			(25.79)	(23.01)	(22.61)	(22.38)	(21.22)	(21.22)
TOTR				−11,344****	−11,394****	−12,961****	−12,108****	−11,772****
				(1,849.4)	(1,818.3)	(2,085.9)	(1,984.4)	(1,926.5)
CURBOPC					0.12*	0.12**	0.11*	0.11*
					(0.06)	(0.06)	(0.06)	(0.06)
GINI						50.25	56.82*	54.52*
						(34.33)	(32.47)	(31.52)

(*Continued*)

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Table 6. (*Continued*)

	Dependent variable: ***GDPPC***							
TOTALNRRPC*RULAW							18.78****	
							(5.52)	
TOTALNRRPC*CONTCOR								28.02****
								(6.13)
Observations	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900

Note: Signif. codes: **** = 0.001 *** = 0.01 ** = 0.05 and * = 0.1; (): Long-term standard deviations.
Source: Author's estimations.

The p-value suggests rejecting the null hypothesis (H0) and therefore concluding that significant non-random fixed effects are present.

The estimator with random fixed *effects* is more efficient than the one with nonrandom fixed *effects*. It is therefore worth considering whether the random specification is preferable to the fixed effects one. This is the object of Hausman test verifying the H0 hypothesis of an insignificant difference between random and fixed estimator (alternative hypothesis: Fixed effects model is consistent). If this difference is not significant, the two estimators would be consistent and thus the more efficient one (the random) should be used. If this difference is significant, which is the case here (p-value 0) then applying a random estimator would be inconsistent (the random estimator is inconsistent if the true model is a nonrandom fixed effect). Therefore, the fixed effects estimator is chosen. It is also called within estimator or an LSDV[8] estimator.

According to Havranek et al. (2016), true panel estimates (not panel data estimated with OLS) account for about 20% of the estimates. Compared to OLS where only control variables were available, endogeneity problems due to unobserved heterogeneity (omitted variables correlated with the regressors and influencing the endogenous) are corrected by considering country-fixed effects (γ_i) in the case of the fixed effects estimator. If the unobserved variable changes over time and not only between countries, it is also considered with the time fixed effect (δ_t). The question of simultaneity (reciprocal regressor-endogenous causality), another source of endogeneity, may remain.

The usual factors of the production function (KPC, EMPC, and HC) change strongly. The coefficients remain significant and in the expected direction (positive), but their magnitude is almost quadrupled (EMPC) and almost doubled (HC). It is also worth noting that terms of trade (TOTR), which had strong negative effects on GDP *per capita* in OLS (the highest absolute value), continue to do so, but lose more than half their magnitude and even their 1st rank to EMPC. The institutional variables maintain a significantly positive role, but this role has declined compared to OLS. Now, a 1% increase (i.e., a 1-point increase in the index) in RULAW is associated with a $0.3 increase in GDP *per capita* (1%*30.1, see Model 6). For CONTCOR, the effect is $0.22.

For the variable of interest, a 1% increase in TOTALNRRPC significantly increases GDP *per capita* by $3.02 (1%*301.9). This influence is less than with OLS ($5.05). Taking into account resources-institutions interactions does not change the positive influence of resources on GDP *per capita* seen in Column 6. The effect of TOTALNRRPC remains significantly positive whether the interaction is RULAW ($2.14) or CONTCOR ($2.37).

However, the result here seems less favorable to the influence of institutions on resources and ultimately on development. The interaction terms appear to be positive but of smaller magnitude than in OLS and are not significant. The observation of the TOTALNRRPC coefficient suggests that rents from natural resources have a significant positive influence on GDP *per capita*, without the role of institutions having any significant effect on these resources. This role remains positive, however.

We propose here the use of the FM-OLS estimation method suggested by Phillips and Hansen (1990) and then by Pedroni (1996, extending it to the case of heterogeneous panels where the cointegration relationship is specific to each individual in the panel) for cointegrated variables. This method makes semi-parametric (i.e., parametric and non-parametric) modifications to the cointegrating relationship. These are supposed to lead to a long-run covariance matrix corrected for the endogeneity of the regressors present in the

[8]Least square dummy variables. It is equal to: $\hat{\beta} = \frac{\sum_{i=1}^{N}\sum_{t=1}^{T}(Y_{it}-\bar{Y}_i)(x_{it}-\bar{x}_i)}{\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-\bar{x}_i)^2}$ with Y the endogenous variable and $x$the exogenous ones.

cointegrating relationship (second-order bias), for the autocorrelation and the heteroscedasticity of errors (non-centrality bias at 0 of the distribution).

Unlike time series data, regression results from non-stationary panel data are convergent in probability to their true value. Similarly, whether the variables involved in the regression are cointegrated or not, this estimator remains convergent in probability. Consequently, if we only want to estimate the coefficients for non-stationary variables, it is not necessary that they be cointegrated. On the other hand, in order to make inference, the cointegration relation must be validated to avoid the distributions of the usual test statistics (such as Student's t test) becoming divergent as with time series[9].

The results of the FM-OLS estimations show (see Model (6)) that TOTALNRRPC has an influence on GDP *per capita* very close to or even identical to that obtained in OLS ($5.09 versus $5.05 for OLS). The latter is, moreover, an estimate for 1990 to 2019, i.e., for the long term, hence the results are probably quite close. These influences are therefore greater than the one obtained with the LSDV ($3.02).

In all three estimations, the inclusion of the institutional variables (RULAW and CONTCOR) reduces the influence of TOTALNRRPC because on average the two institutional variables are significantly different from 0 (and in the presence of interactions, the interpretation of the separate TOTALNRRPC variable assumes that these institutional variables are zero). In the long run, the effect of the institutional variables appears to be greater than that of OLS and LSDV. Assuming them to be zero (Models (7) and (8)) reverses the direction of the impact of TOTALNRRPC. It goes from significantly positive to significantly negative[10] and this is greater in absolute value than in the other two estimates. This finding is logically reflected in the coefficients associated with the interaction terms, which are always significantly positive and of greater magnitude than in the other two estimates. Thus, for e.g., on the basis of model (8), we can say that in the long run, total resource rents negatively influence GDP *per capita*, but that this negative influence is mitigated by the corruption control variable. A 1% increase in resource rents *per capita* significantly reduces GDP *per capita* by $7.25 (1%*-724.62) but this decrease is mitigated by $0.28 (1%*28.02) if at the same time, CONTCOR also increases by 1%. In total, the negative effect is only $6.97. A similar reasoning with model (7) leads to the same conclusion with a slightly smaller mitigating effect of RULAW (0.19 versus 0.28).

We have also simulated these results using the DOLS estimator of Saikkonen (1991) and extended from time series to panel data by Kao and Chiang (2000) and then Mark and Sul (2003). The DOLS method, whose estimators are asymptotically distributed according to a normal distribution, nevertheless restricts the degrees of freedom because of the introduction of lags and leads, which are supposed to enforce the exogeneity assumption of the explanatory variables. Mark and Sul (2003) applied it to a study on money demand (income elasticity of money demand) for 19 countries from 1957 to 1996, i.e., a time dimension close to ours. It should be noted that in the empirical literature, given their different specifications, FM-OLS and DOLS methods do not often generate identical results.

We reproduce here the results of the regressions obtained with the DOLS method for comparison purposes.

In model (6), the influence of TOTALNRRPC remains significantly positive on GDP *per capita* but is slightly smaller at $4.47 (1%*446.7) compared to the FM-OLS estimate

[9]For a literature review on panel data estimation and cointegration, see Hurlin and Mignon (2007, 249-250).

[10]Note that the p.value of the TOTALNRRPC coefficient (-390.6) is 0.16, which is not far from being significant.

($5.09). In the models with « total natural resources-institution » interactions, for e.g., (7), the influence of resources, when the rule of law (RULAW) is neutralized (value equal to 0), remains significantly negative but of a much larger magnitude, going from −$3.9 to −$28 (1%*-2,805.06). At the same time, the mitigating effect of this negative influence is greater than in the FM-OLS case. Indeed, we go from a significantly positive influence of $0.19 to $0.7 (1%*69.34). The regressions carried out for model (8) show results that are particularly close to (7). In (8), TOTALNRRPC has a significantly negative influence (−$28.14 or 1%*2814 versus −$7.25 with FM-OLS) on GDP *per capita*. The « total natural resource rents-corruption » interaction term, which was significantly positive ($0.28), becomes $0.74 (1%*74.22) with DOLS.

Based on the results of the regressions (6), (7) and (8) performed with the DOLS method, the influence of natural resources on GDP *per capita* emerges as significantly positive but of a slightly smaller magnitude than with FM-OLS and significantly negative (for (7) and (8)) but of a larger amount in absolute value than those obtained with FM-OLS. The DOLS method suggests a stronger intermediate role for institutions in influencing the GDP *per capita*.

In all three specifications as well as the DOLS estimate, the observation of models (6) shows a positive relationship between natural resource rents and GDP *per capita*. This relationship is almost identical between OLS, FM-OLS, and DOLS around $5. It is weaker in the panel estimation (LSDV), around $3.

In all four specifications, the following pattern is verified in models (7) and (8): the institutional variables significantly attenuate the negative effect of natural resources on development (FM-OLS, DOLS) or reinforce the positive effect of these resources on development (OLS, LSDV). It should be noted that the negative effect of natural resources and their positive effect, albeit of lesser magnitude than in model (6), are explained by the neutralization, in (7) and (8), of the positive role played by institutions on GDP *per capita* via natural resources.

Full sample with disaggregated TOTALNRRPC

Here, the estimation results still concern the full sample but the variable of interest TOTALNRRPC is now replaced by its 5 components COALRPC, FORRPC, MINRPC, NGRPC, and OILRPC. The estimates are in OLS (Table 7) and panel (LSDV, Table 8) but also in the long run where the long-run cointegration vector is estimated by FM-OLS (Table 9). In addition, the results when the cointegration vector is estimated by DOLS will also be commented.

The decomposition of rents from total resources into rents by type of resource reveals two groups according to the OLS estimation of the full sample. The goodness of fit that was very high in the aggregate case, around 90%, is maintained here, or even very slightly improved. We thus have the group with the components positively influencing GDP *per capita*, which are, in order of importance: the *per capita* rents from natural gas (NGRPC with an influence of $16.7, i.e., 1668.12*1%), those from crude oil before refining (OILRPC with $6.15), while those from mineral resources (MINRPC) – but for which it has been mentioned that the list of components retained by the World Bank does not exhaust all the existing mineral resources – present a weaker ($0.44) and non-significant, but positive influence. The second group consists of *per capita* rents from coal (COALRPC) and *per capita* forestry rents (FORRPC) from roundwood, before industrial processing, which have a significantly negative influence on GDP *per capita*, respectively of −$9.04 and −$4.42.

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Table 7. OLS – Global panel (130 countries, 1990–2019) and by resource category

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
KPC	0.18****	0.17****	0.17****	0.16****	0.16****	0.16****	0.16****	0.16****
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
EMPC	11,142.83****	11,369.13****	10,751.29****	11,082.08****	10,669.21****	10,580.87****	9,433.98****	9,373.00****
	(1,385.49)	(1,363.19)	(1,350.79)	(1,323.39)	(1,316.61)	(1,315.28)	(1,300.67)	(1,288.35)
HC	1,785.65****	1,440.52****	1,348.11****	1,684.12****	1,739.67****	1,787.05****	1,966.53****	2,010.87****
	(176.74)	(174.97)	(173.59)	(173.05)	(172.42)	(173.14)	(171.88)	(170.77)
COALRPC	−742.51	−676.00	−595.21	−927.96*	−912.56*	−904.14*	3,959.34	655.78
	(526.33)	(518.11)	(515.32)	(498.71)	(489.09)	(488.91)	(4,385.12)	(3,620.76)
FORRPC	−620.84****	−660.30****	−683.23****	−398.27****	−436.50****	−440.82****	724.82****	1,093.10****
	(107.63)	(106.15)	(105.04)	(106.37)	(106.72)	(106.71)	(212.35)	(261.79)
MINRPC	−217.93	−202.29	−195.24	46.61	33.56	43.83	347.06	571.42
	(259.59)	(255.19)	(252.67)	(248.01)	(244.45)	(244.64)	(760.02)	(734.84)
NGRPC	1,677.01****	1,689.36****	1,716.78****	1,722.94****	1,678.50****	1,668.12****	590.40	−1,324.73
	(276.96)	(272.45)	(270.07)	(261.93)	(258.69)	(258.40)	(1,362.97)	(1,192.42)
OILRPC	690.31****	720.75****	736.62****	617.67****	620.45****	615.36****	−297.33***	−470.94****
	(35.49)	(35.05)	(34.73)	(35.52)	(35.34)	(35.36)	(102.13)	(100.40)
RULAW		67.52****	37.14****	43.07****	41.95****	43.00****	42.26****	43.68****
		(5.10)	(5.30)	(5.41)	(5.48)	(5.48)	(6.12)	(5.60)

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Table 7. (*Continued*)

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CONTCOR			58.99****	57.02****	56.94****	55.97****	55.95****	53.66****
			(5.21)	(5.31)	(5.39)	(5.38)	(5.54)	(5.97)
TOTR				−11,981.43****	−11,839.01****	−11,893.37****	−12,118.95****	−11,238.16****
				(940.39)	(935.36)	(934.83)	(925.37)	(914.51)
CURBOPC					0.11****	0.11****	0.11****	0.10****
					(0.02)	(0.02)	(0.02)	(0.02)
GINI						29.89***	32.18***	33.15****
						(10.19)	(10.09)	(10.01)
COALRPC*RULAW							−109.54	
							(99.24)	
FORRPC*RULAW							−26.58****	
							(4.46)	
MINRPC*RULAW							−7.47	
							(17.00)	
NGRPC*RULAW							17.96	
							(26.22)	
OILRPC*RULAW							18.71****	
							(1.97)	

(*Continued*)

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Table 7. (*Continued*)

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
COALRPC*CONTCOR								−41.22
								(97.76)
FORRPC*CONTCOR								−38.07****
								(6.46)
MINRPC*CONTCOR								−14.28
								(18.19)
NGRPC*CONTCOR								57.26**
								(23.95)
OILRPC*CONTCOR								24.48****
								(2.08)
Constant	−5,288.28****	−7,430.91****	−8,139.64****	3,090.62***	3,080.86***	1,844.72	2,134.03*	1,208.84
	(589.07)	(612.42)	(613.28)	(1,049.08)	(1,044.58)	(1,126.67)	(1,118.52)	(1,108.20)
Observations	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900
R^2	0.892	0.895	0.898	0.902	0.903	0.903	0.906	0.908
Adj. R^2	0.892	0.895	0.897	0.901	0.903	0.903	0.906	0.907

Note: Signif. codes: **** = 0.001 *** = 0.01 ** = 0.05 and * = 0.1; () : Standard deviations robust to heteroskedasticity, autocorrelation and inter-individual correlation.
Source: Author's estimations.

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Table 8. Fixed effects model – Global panel (130 countries, 1990–2019) and by resource category

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
KPC	0.13****	0.12****	0.12****	0.12****	0.12****	0.12****	0.12****	0.12****
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
EMPC	40,012.59****	39,934.43****	39,474.35****	39,064.85****	39,837.42****	40,029.28****	40,028.94****	39,960.16****
	(2,464.79)	(2,441.96)	(2,435.82)	(2,430.80)	(2,428.49)	(2,428.74)	(2,429.22)	(2,422.50)
HC	2,675.44****	3,117.34****	3,301.45****	3,940.48****	3,917.69****	3,882.00****	3,888.95****	3,911.55****
	(433.99)	(432.45)	(431.68)	(446.92)	(447.83)	(447.94)	(448.24)	(446.70)
COALRPC	−265.63	−214.29	−169.66	−250.55	−258.86	−259.11	−2,599.76	−3,976.63
	(346.91)	(343.27)	(343.82)	(344.86)	(338.43)	(338.28)	(3,196.34)	(3,195.88)
FORRPC	393.14**	320.58*	301.22	238.74	174.69	188.19	635.63***	645.68**
	(195.56)	(193.12)	(192.20)	(191.73)	(191.84)	(191.84)	(231.84)	(283.04)
MINRPC	58.51	107.28	130.89	164.89	170.62	167.15	259.25	219.01
	(204.53)	(201.28)	(200.36)	(200.48)	(198.26)	(198.02)	(563.08)	(586.32)
NGRPC	2,572.16****	2,622.14****	2,663.58****	2,588.78****	2,475.95****	2,473.98****	437.80	−924.91
	(357.13)	(354.78)	(354.69)	(354.90)	(351.66)	(351.71)	(1,029.84)	(878.55)
OILRPC	344.34****	341.68****	344.03****	325.12****	305.99****	304.29****	136.38	300.93***
	(56.56)	(55.91)	(55.74)	(55.72)	(55.38)	(55.33)	(97.58)	(100.33)
RULAW		40.88****	31.74****	31.40****	30.59****	30.28****	30.72****	29.81****
		(4.19)	(4.48)	(4.46)	(4.47)	(4.48)	(4.86)	(4.46)

(*Continued*)

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Table 8. (*Continued*)

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CONTCOR			24.57****	22.58****	22.49****	22.60****	21.81****	22.17****
			(4.37)	(4.36)	(4.36)	(4.37)	(4.38)	(4.75)
TOTR				−5,773.88****	−5,853.26****	−5,929.63****	−6,002.21****	−5,941.12****
				(1,062.24)	(1,057.75)	(1,058.32)	(1,056.45)	(1,053.94)
CURBOPC					0.07****	0.07****	0.07****	0.07****
					(0.01)	(0.01)	(0.01)	(0.01)
GINI						−15.21*	−14.96*	−14.01*
						(7.78)	(7.78)	(7.76)
COALRPC*RULAW							54.35	
							(73.70)	
FORRPC*RULAW							−9.98***	
							(3.19)	
MINRPC*RULAW							−1.93	
							(12.95)	
NGRPC*RULAW							43.95**	
							(20.86)	
OILRPC*RULAW							2.97*	
							(1.66)	

(*Continued*)

Table 8. (*Continued*)

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
COALRPC*CONTCOR								105.67
								(89.69)
FORRPC*CONTCOR								−11.40**
								(5.65)
MINRPC*CONTCOR								−1.33
								(14.24)
NGRPC*CONTCOR								74.96****
								(17.40)
OILRPC*CONTCOR								0.34
								(1.80)
Observations	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900
R^2	0.648	0.656	0.659	0.662	0.665	0.665	0.667	0.668
Adj. R^2	0.636	0.644	0.646	0.649	0.652	0.652	0.654	0.655
Pesaran test	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16
Honda test	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16
Hausman test	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16	< 2.2e−16

Note: Signif. codes: **** = 0.001 *** = 0.01 ** = 0.05 and * = 0.1; () : Standard deviations robust to heteroskedasticity, autocorrelation, and inter-individual correlation. Pesaran CD test for cross-sectional dependence, p-value; Alternative hypothesis: cross-sectional dependence Honda test (fixed vs ols), p-value; Alternative hypothesis: cross-sectional dependence Hausman test (fixed vs random), p-value; Alternative hypothesis: Fixed effects model is consistent.
Source: Author's estimations.

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Table 9. FM – OLS Global panel (130 countries, 1990–2019) and by resource category

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
KPC	0.18****	0.18****	0.18****	0.16****	0.16****	0.16****	0.16****	0.16****
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
EMPC	2,984.6	113.1	−1,634.3	11,257***	10,216**	9,262.1**	6,741.3*	6,512.5*
	(3,383.7)	(3,451.6)	(3,455.4)	(4,154.5)	(4,080.9)	(4,108.7)	(3,853.7)	(3,783.5)
HC	797.83	432.9	305.66	1,713.6***	1,801***	1,827.2***	1,998****	2,010.8****
	(569.4)	(590.08)	(583.5)	(598.04)	(587.32)	(582.72)	(548.07)	(537.07)
COALRPC	−786.5	−739.56	−617.13	−1,224.7	−1,196.4	−1,178	5,747.2	1,319
	(1,623)	(1,582.1)	(1,553.3)	(1,441.3)	(1,413.8)	(1,401.3)	(13,160)	(11,381)
FORRPC	−1,114.2**	−1,243.1***	−1,295.3***	−710.94*	−778.54*	−761.51*	684.46	1.097
	(443.12)	(434.01)	(426.47)	(411.67)	(404.29)	(400.69)	(787.9)	(965.06)
MINRPC	−204.85	−311.06	−367.31	131.53	103.85	137.51	1,114.4	1,143.6
	(837.92)	(816.6)	(801.41)	(747.17)	(732.94)	(726.59)	(2,270.8)	(2,291.3)
NGRPC	1,632.7*	1,617.7*	1,636.6*	1,610.3**	1,512.5*	1,492.4*	213.8	−2,063.6
	(910.84)	(887.46)	(871)	(805.55)	(790.51)	(783.52)	(4,200.5)	(3,867.3)
OILRPC	670.17****	682.4****	692.77****	683.32****	692.66****	670.25****	−423.43	−615.43*
	(132.3)	(128.97)	(126.64)	(117.2)	(114.97)	(115.48)	(321.57)	(322.2)
RULAW		45.87**	17.77	47.74**	47.34**	48.68**	49.93**	49.67**
		(20.24)	(23.64)	(22.3)	(21.88)	(21.7)	(21.88)	(19.93)

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Table 9. (*Continued*)

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CONTCOR			51.64**	69.52***	70.68****	68.54***	70.26****	69.15****
			(23.39)	(21.72)	(21.3)	(21.19)	(19.9)	(20.96)
TOTR				−9,787.4****	−9,594.8****	−10,819****	−10,811.2****	−10,350****
				(1,828.9)	(1,795.3)	(2,059.4)	(1,931.4)	(1,888.1)
CURBOPC					0.13**	0.13**	0.13**	0.12**
					(0.06)	(0.06)	(0.05)	(0.05)
GINI						38.41	51.33*	46.58*
						(32.56)	(30.45)	(29.82)
COALRPC*RULAW							−150.99	
							(299.17)	
FORRPC*RULAW							−33.88**	
							(17.07)	
MINRPC*RULAW							−25.6	
							(53.09)	
NGRPC*RULAW							17.73	
							(81.47)	
OILRPC*RULAW							22.45****	
							(6.26)	

(*Continued*)

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Table 9. (*Continued*)

	Dependent variable: ***GDPPC***							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
COALRPC*CONTCOR								−62.7
								(306.5)
FORRPC*CONTCOR								−46.24*
								(23.9)
MINRPC*CONTCOR								−28.56
								(57.26)
NGRPC*CONTCOR								64.51
								(77.9)
OILRPC*CONTCOR								28.77****
								(6.8)
Observations	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900

Note: Signif. codes: **** = 0.001 *** = 0.01 ** = 0.05 and * = 0.1; () : Long-term standard deviations.
Source: Author's estimations.

For the specifications with interaction terms, that is columns (7) and (8), only FORRPC and OILRPC are significantly positive and negative respectively. The positive relationship between FORRPC and GDP *per capita* when RULAW is 0 (7) or when CONTCOR is 0 (8) suggests that for forest rents, institutional quality is penalizing. This result is not what one would expect. The average institutional quality calculated earlier (see Table 3) is 45.2 for RULAW and 43.1 for CONTCOR. The latter two figures likely hide disparities across economic sectors. The positive relationship found suggests the idea that institutional quality in the forestry sector is actually less than 0 and that, therefore, when it is set equal to 0 to interpret the isolated term (FORRPC) in each of the two FORRPC interactions, the role of forestry rents in economic development is mechanically improved. However, even under this assumption, improving the institutions quality should in principle improve the influence of forest rents on GDP *per capita*. However, observation of the interaction terms of FORRPC with the institutional variables shows that they are both significantly negative. This means that the improvement in the global institutional quality indicator can be achieved while accounting for a parallel deterioration in institutional quality. In other words, an improvement in a global indicator does not mean that this improvement concerns all economic activities. The above assumption that global institutional quality is < 0 in the case of forest resources is thus challenged by the results of interaction terms. The dichotomy between this global indicator of institutional quality and the institutional quality (or a resource-specific governance index) specific to this sector seems considerable. It does not allow RULAW and CONTCOR to be considered as representative of the intrinsic institutional quality in forest sector.

The results obtained for the other 4 resource categories are more intuitive and highlight the positive role of institutional variables in the positive (but not always significant) influence that natural resources have on GDP *per capita*. For e.g., crude oil rents negatively influence GDP *per capita* by about \$3 (−297.33*1%) when RULAW is neutralized (0). However, this negative effect is mitigated by about \$0.2 each time the institutional quality captured by RULAW improves by 1%.

When individual and time-fixed effects are considered (LSDV), the results for the group of variables positively influencing GDP *per capita* (NGRPC, OILRPC, and MINRPC) continue to play the same role. However, the magnitude of this role is modified. For e.g., natural gas rents rise from \$16.7 to about \$25, while crude oil rents fall from \$6.15 to \$3.04. The mining rent, still not significant, is more positive, rising from \$0.44 to \$1.67.

For this group, the comparison between model (6) and (7) and (8) shows that the institutional variables RULAW and CONTCOR are relevant in the reinforcing role of the effects on GDP *per capita*. As an illustration, a 1% increase in the control of corruption indicator reinforces the influence of gas rent by \$0.75 (74.96*0.01). This positive role of the institutions is reinforced compared to the OLS case.

For the group of resources that negatively influenced GDP *per capita* in OLS, namely COALRPC and FORRPC, these are no longer significant. However, FORRPC is now positive while COALRPC keeps a negative influence.

With FM-OLS estimation, the long-term results can still be interpreted from the two resource groups discussed with OLS and LSDV. The proximity with the results obtained with OLS and to a lesser extent with LSDV should also be noticed. In particular, in the group of resources with a positive influence on GDP *per capita*, gas rents have a significant effect of \$14.92 on GDP *per capita* (\$16.68 with OLS and \$24.74 with LSDV), whereas oil rents contribute \$6.7 here (\$6.15 with OLS and \$3.04 with LSDV). The mining rents remain insignificant but positive and of an intermediate amount with \$1.38 versus \$0.44 with OLS or \$1.67 with LSDV. However, our simulations with the DOLS method reveal a difference, since the gas rent still appears positive in the specification (6) but in a smaller and insignificant amount ($6.36). On the other hand, the oil rent remains positive and significant ($6.88) while the mining rent is still insignificant and intermediate ($0.9) between OLS and FM-OLS.

When we look at the negative influence group, coal rent continues to have a negative influence (−$11.78), close to OLS (−$9.04 and significant) but no longer significant. The impact of forest rent is here significantly negative

(−$7.62) and of a higher amount than with OLS (−$4.41). As a reminder, in the LSDV estimation, these two resources did not significantly impact *per capita* GDP. The results of the DOLS estimation can be reconciled with FM-OLS as the influence of coal rent is negative at −$12.43 without being significant while forest rent has a significantly negative influence of $9.65 (which compares to $7.62 above).

In the case of the models with "natural resource rents-institutions" interactions, the results show that, for the group of resources with a significantly positive influence (NGRPC and OILRPC), the RULAW and CONTCOR variables reinforce the positive effects of the resources on GDP *per capita* and attenuate the negative effects. This positive effect is not significant for the particular case of gas rent. When we use the results of the DOLS estimation, this positive effect is, on the contrary, quite significant.

On the other hand, an examination of the results of models (7) and (8) suggests, as we indicated earlier, that the use of RULAW and CONTCOR is not the most appropriate for studying « natural resource rents-institutions » interactions in the specific case of coal and forest rents, or even mining rents. In other words, the variables included in the interaction are independent of these categories of resources, and it is appropriate to stick with model (6). An appropriate indicator reflecting institutional quality more specific to these activities might also be more relevant. This observation in FM-OLS is also confirmed by our DOLS estimates where we note significantly negative coefficients for the interaction terms (e.g., FORRPC*RULAW = −$1.65 or FORRPC*CONTCOR = −$1.35).

Results of the econometric estimations in the sub-samples

We now want to examine how the results for the full sample look for our 4 subsamples broken down by GDP *per capita* levels for both the aggregate variable of interest and for each of the 5 natural resources included in TOTALNRRPC. Since readers are now familiar with the form of the tables that can be compiled from the four methods (OLS, LSDV, FM-OLS, and DOLS), we will not reproduce these tables. Also, we will present the results in the form of impact in $ on GDP *per capita* in $ (instead of estimated coefficients, which is more direct) and the significance of these impacts. We will do this only for model (6), the most complete one, and the models with « resources-institutions » interaction terms, i.e., models (7) and (8). This reduces the size of the presentation considerably. Nevertheless, detailed tables like those presented for the full sample are still available upon request.

Results of the models without and with « total resources-institutions » interactions

For the full sample, as a reminder, and for each of the 4 sub-samples according to GDP *per capita* in PPP (> $10,648 (HI), > $4,253 and < $10,648 (UMI), > $1,604 and < $4,253 (LMI), and < $1,604 (LI)), 4 types of estimates (OLS, LSDV, FM-OLS, and DOLS) are performed. They focus on the influence of total resources rents *per capita* (TOTALNRRPC), the interaction between total resource rents and rule of law (TOTALNRRPC*RULAW), and the interaction between total resources rents and the degree of control over corruption (TOTALNRRPC*CONTCOR) on GDP *per capita* in PPP.

The results of these estimates are directly converted into PPP$. For the full sample, the results (for recall) read on the left axis and on the right axis for the 4 sub-samples. On the figure, only the significant results at 1‰, 1%, 5%, and 10% are plotted. The table accompanying the figure therefore includes significant and non-significant results. As an illustrative e.g., the OLS estimate of the influence of TOTALNRRPC on GDP *per capita* reveals that only the figure for UMI countries (0.05, see Figure 4, table, Column 1) is non-significant. Thus for this technique and this variable, Figure 4 shows 4 significant values out of 5 possible.

Results of the model without interaction

This analysis also allows us to investigate how the results of the full sample can be understood from the sub-samples. Thus, the positive influence of natural resource rents on GDP *per capita* that was established regardless of the econometric method (all 4 methods) is explained by the positive influence of these rents in countries with very high *per capita* incomes (>$10,648). This positive influence supplants the weakly negative and sometimes insignificant ones (depending on the estimation method) in countries with lower middle *per capita* incomes (> $1,604 and < $4,253) and in those with low *per capita* incomes (< $1,604). Upper-middle income countries (> $4,253 and < $10,648) show significantly positive but small influences with LSDV ($0.8 on GDP *per capita* for a 1% increase in total natural resource rents) and significantly negative but virtually zero in the long run with FM-OLS (−$0.13).

Results of the two models with "total natural resource rents-institutions" interaction

With regard to the "total resources rents-institutions" interaction terms, we find a result already obtained with the full sample via LSDV. Indeed, the estimates with this method show that the institutions, apprehended here by RULAW and CONTCOR, do not have a significant influence on the impact of rents on GDP *per capita*. In other words, the variables included in the interaction appear to be independent. On the other hand, with OLS and FM-OLS, the results that were significantly positive for the full sample are insignificant for the sub-samples. Only the estimation with DOLS suggests a significant role for institutions in the "total resource rents-institutions" interactions. For e.g., according to this estimation method, in high-income countries, a 1% increase in the rule of law index (RULAW) amplifies the influence of natural resources on GDP *per capita* by $0.94. The latter figure is $0.74 for CONTCOR. In lower middle-income countries, RULAW amplifies the positive effect of rents on GDP *per capita* (or mitigates the negative effect) by $0.29. Also according to DOLS, in both upper-middle-income and low-income countries, the interaction terms are significantly negative suggesting that RULAW attenuates the positive effects of resources on GDP *per capita* or amplifies the negative effects. In contrast, CONTCOR does not play a significant role in upper- and lower-middle-income countries or in low-income countries.

Results of the models without and with "resource category-institutions" interactions

Just as the influence of total resource rents on GDP *per capita* in the full sample can be understood from the same influence in each of the 4 sub-samples, this discussion can also offer a look at how each of the 5 resource categories contributes to the influence of total resources in each of the 4 sub-samples.

Results of the model without interaction

Figure 4 on the impact of total resources rents on GDP *per capita* shows that for high-income countries, a 1 percent increase in total rents is accompanied by a significant increase in GDP *per capita* of between \$8.66 and \$11.7. However, it was previously established that whatever the econometric method (the 4 methods), the overall positive impact of resources on GDP *per capita* is explained by the positive influence of these natural resources in the high-income countries *per capita*. Observation of the impacts by resources category reveals that it is the oil rent (Figure 9), whose significant impacts range from \$9.78 (OLS) to \$13.97 (DOLS), that explains the positive result of total resources on their GDP *per capita*. The observation of the impacts of coal (Figure 5) and forestry (Figure 6) rents ranging significantly from −\$134.2 (D-OLS) to \$213.19 and from −\$99.63 (D-OLS) to \$18.55 (LSDV) could have erased the overall positive effect observed (the gas and mining rents not being significant). However, it should be remembered that total rents from natural resources account for 1.06% of the average GDP *per capita* of high-income countries (see Table 3). Oil rents account for more than 78% (0.83/1.06 or 1123/1436 if we reason from the « Sum » line of Table 3) of these total rents. According to Table 3, oil rents are the main source of total rents (57.4%, i.e., 0.66%/1.15% or 2586/4473 based on the « Sum » line). These oil rents are also the most substantial in high-income countries, which can be verified from the « Sum » line for the GDPPC variable and the "Average" line for OILRPC (with a *per capita* oil rent of \$90,116.21 or 46,658,990*0.83%).

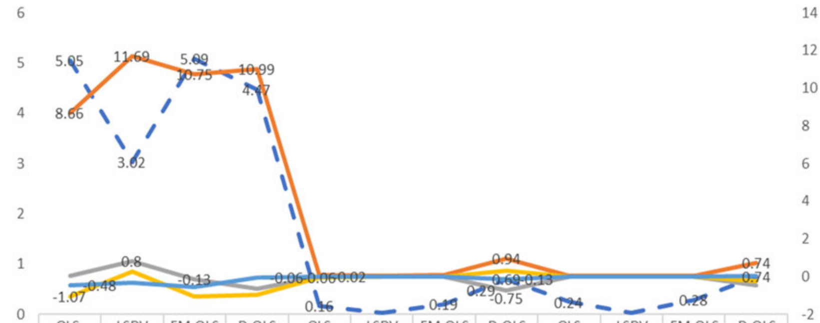
The econometric results must therefore be reconciled with the descriptive data if we want to understand why oil rents are decisive in the final positive result of natural resource rents on GDP *per capita* within high-income countries on the one hand (see 78% above) and within the full sample, on the other (see 57.4% and \$90,116.21 above).

This suggests a main explanation: the importance of a given rent in the total rents of the country or group of countries, the importance of a given rent in the total global rents, and the importance of a given rent in one country (or group of countries) relative to the same rent in other countries (or groups of countries) are 3 characteristics that should be associated with the econometric result on global influence of natural resource rents on GDP *per capita*.

This main explanation of the global positive result of natural resource rents on GDP can also be complemented by the rents per given component by examining the positive contributions of the components from the other categories of countries (UMI, LMI, and LI). We will let readers combine the following econometric and statistical results as was done above for HI countries. This will allow us to deduce the role of each resource category in each group of countries in the final result of the global impact of resource rents (hence this impact in the full sample).

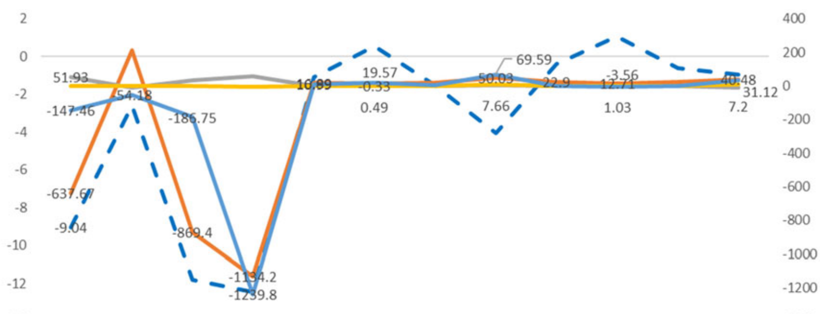
Let us now look, as we just did for HI countries, at how each component may have played into the outcome of the impact of total rents on GDP *per capita* in each country group (the three remaining sub-samples).

In the upper-middle-income countries (UMI), the role of total resource rents is very mixed. While the LSDV estimate (Figure 4) reveals that when they increase by 1%, they contribute significantly \$0.8 to GDP *per capita* in these countries, the FM-OLS estimate indicates a result significantly close to 0 (−\$0.13), both of which are less economically significant than in the full sample or the high-income sample. The results for the other two estimations (OLS and DOLS) are not significant. A detailed examination of the previous



	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS
	TOTALNRRPC ($)				TOTALNRRPC*RULAW ($)				TOTALNRRPC*CONTCOR ($)			
Global	5.05	3.02	5.09	4.47	0.16	0.02	0.19	0.69	0.24	0.02	0.28	0.74
HI	8.66	11.69	10.75	10.99	0.07	0.03	0.06	0.94	0.05	0.04	0.05	0.74
UMI	0.05	0.8	-0.13	-0.67	0	0.01	-0.01	-0.75	0	0.01	-0.03	-0.47
LMI	-1.07	0.25	-1.06	-0.95	-0.06	-0.01	-0.01	0.29	-0.01	0	-0.03	-0.26
LI	-0.48	-0.34	-0.58	-0.06	-0.02	-0.01	-0.02	-0.13	-0.01	-0.01	-0.02	0.02

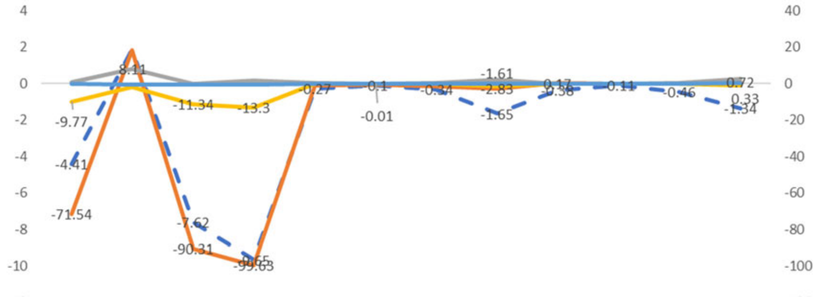
Figure 4. Impact of total natural resource rents and their interactions with institutional variables on GDP *per capita* – Full (for recall) and sub-samples.
Source: Author



	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS
	COALRPC ($)				COALRPC*RULAW ($)				COALRPC*CONTCOR ($)			
Global	-9.04	-2.59	-11.78	-12.43	-1.1	0.54	-1.51	-4.04	-0.41	1.06	-0.63	-0.96
HI	-637.67	213.19	-869.4	-1134.2	16.89	11.78	17.4	50.03	22.9	12.71	26.21	40.48
UMI	51.93	-8.32	31.92	59.84	-0.84	-0.33	-1.39	5.32	-1.4	-2.01	-1.66	-8.7
LMI	-1.47	-0.91	-1.63	-5.99	-0.03	0.49	-0.12	7.66	0.13	1.03	-0.06	7.2
LI	-147.46	-54.18	-186.75	-1239.8	10.99	19.57	6.35	69.59	-2.49	-3.56	-0.41	31.12

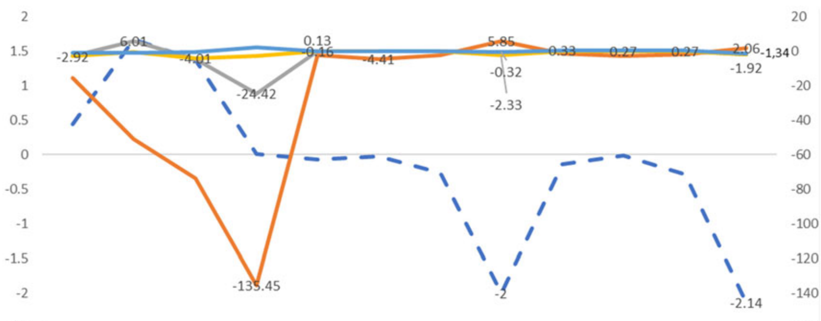
Figure 5. Impact of coal rent and its interaction with institutional variables on GDP *per capita* – Full (for recall) and sub-samples.
Source: Author.

graphs shows that the LSDV technique assigns a significantly positive role to gas rent (nearly \$115, Figure 8) and a significantly positive role to forestry (\$8.11, Figure 6) and mining (\$6.01, Figure 7) rents. At the same time, the other techniques provide either insignificant or significantly negative impacts. The same but longer-term (FM-OLS) examination of this relationship indicates that the −\$0.13 figure is explained by impacts that are all insignificant, sometimes positive and sometimes negative, but with p-values



	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS
	FORRPC ($)				FORRPC*RULAW ($)				FORRPC*CONTCOR ($)			
Global	-4.41	1.88	-7.62	-9.65	-0.27	-0.1	-0.34	-1.65	-0.38	-0.11	-0.46	-1.34
HI	-71.54	18.55	-90.31	-99.63	-0.88	-0.56	-1.6	-2.83	0.17	-0.19	-0.13	0.72
UMI	0.75	8.11	-0.08	1.83	0.19	0.1	0.28	1.95	0.09	-0.04	0.18	2.63
LMI	-9.77	-2.07	-11.34	-13.3	-0.03	0.05	-0.02	-1.61	0.02	0.03	-0.01	-1
LI	-0.28	-0.43	-0.57	-0.53	-0.01	-0.01	-0.02	0	0	-0.01	0.02	0.33

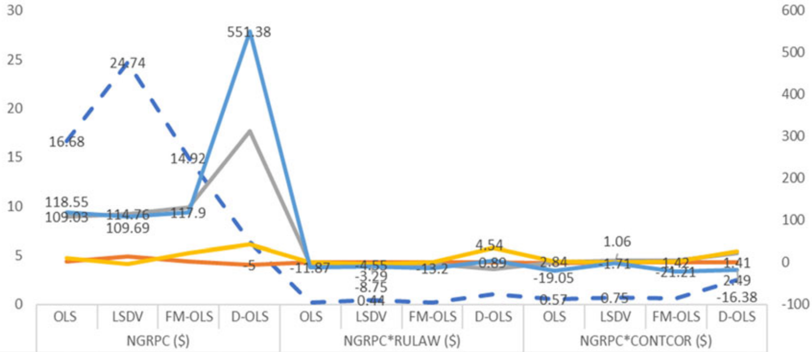
Figure 6. Impact of forest rent and its interaction with institutional variables on GDP *per capita* – Full (for recall) and sub-samples.
Source: Author.



	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS
	MINRPC ($)				MINRPC*RULAW ($)				MINRPC*CONTCOR ($)			
Global	0.44	1.67	1.38	0.01	-0.07	-0.02	-0.26	-2	-0.14	-0.01	-0.29	-2.14
HI	-15.31	-50.89	-73.59	-135.45	-2.3	-4.41	-2.46	5.85	-1.51	-2.68	-2.01	2.06
UMI	-2.85	6.01	-4.61	-24.42	0	0	0	-1.02	0.08	0.27	0.02	-1.8
LMI	-2.92	-0.63	-4.01	-2.65	-0.16	-0.03	-0.2	-2.33	-0.1	-0.04	-0.11	-1.92
LI	-0.87	-0.97	-0.29	2.39	0.13	0.11	0.15	-0.32	0.33	0.34	0.27	-1.34

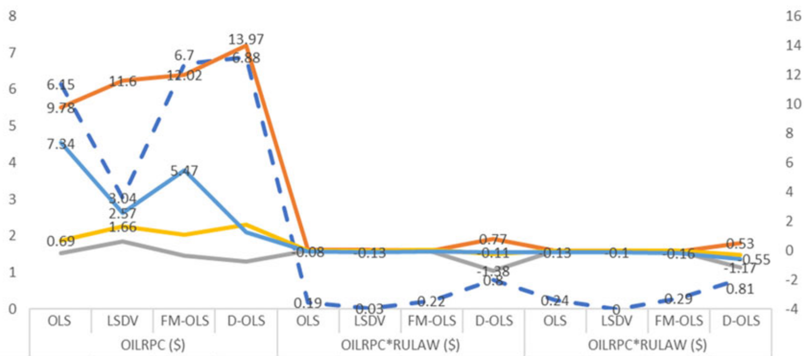
Figure 7. Impact of mining rent and its interaction with institutional variables on GDP *per capita* – Full (for recall) and sub-samples.
Source: Author.

(probability-values) sometimes close to 10%. The share of each of the 5 rents in the total rent as provided in Table 3 can be combined with the econometric estimates to understand the overall impact of −$0.13 obtained for these countries (just as for the figure of $0.8, even if, in this case, the result is more clearly understood in view of the 3 significantly positive rents above).



	NGRPC ($)				NGRPC*RULAW ($)				NGRPC*CONTCOR ($)			
	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS
Global	16.68	24.74	14.92	6.36	0.18	0.44	0.18	1.05	0.57	0.75	0.65	2.49
HI	1.77	14.56	2.51	-5	0.28	0.01	0.66	0.89	-1.51	1.06	1.42	1.41
UMI	109.03	114.76	130.04	312.3	-2.79	-4.55	-3.82	-14.36	0.34	5.11	4.07	22.79
LMI	10.29	-2.5	23.57	43.6	-0.01	-3.29	-0.18	35.01	2.84	-0.13	2.29	26.4
LI	118.55	109.69	117.9	551.38	-11.87	-8.75	-13.2	4.54	-19.05	-1.71	-21.21	-16.38

Figure 8. Impact of gas rent and its interaction with institutional variables on GDP *per capita* – Full (for recall) and sub-samples.
Source: Author.



	OILRPC ($)				OILRPC*RULAW ($)				OILRPC*RULAW ($)			
	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS	OLS	LSDV	FM-OLS	D-OLS
Global	6.15	3.04	6.7	6.88	0.19	0.03	0.22	0.8	0.24	0	0.29	0.81
HI	9.78	11.6	12.02	13.97	0.05	0.03	0	0.77	-0.02	-0.02	-0.04	0.53
UMI	-0.16	0.63	-0.35	-0.76	-0.02	0	-0.04	-1.38	-0.03	-0.02	-0.06	-1.17
LMI	0.69	1.66	1.1	1.74	0.02	-0.01	0.03	-0.25	0	-0.02	0.01	-0.28
LI	7.34	2.57	5.47	1.27	-0.08	-0.13	-0.08	-0.11	-0.13	-0.1	-0.16	-0.55

Figure 9. Impact of oil rent and its interaction with institutional variables on GDP *per capita* – Full (for recall) and sub-samples.
Source: Author.

In low-middle-income (LMI) countries, the impact results (Figure 4) range from −\$1.07 (OLS) to \$0.25 (LSDV). Overall, the results are economically weak and econometrically insignificant. Only the result for the OLS estimate is significant. Here, as before, the result for each of the 4 techniques is the sum of the influences of the rent of each of the 5 components, significant or not, sometimes positive and sometimes negative with p-values more or less close to 10%. For e.g., according to OLS, forestry rent (Figure 6) has a significant negative impact (−\$9.77) on the GDP *per capita* of these countries. According to LSDV, it is not significant but negative (−\$2.07). In the longer term, the OLS result is confirmed and amplified (−$11.34 for FM-OLS and even −$13.3 for DOLS). The mining rent (Figure 7) presents a similar profile but of lesser economic importance. All four techniques produce negative results of similar magnitude, but only OLS (−$2.92) and FM-OLS (−$4.01) are significant.

In low-income countries (Li), the impact results (Figure 4), all negative and with low economic magnitude, range from −$0.58 (FM-OLS) to −$0.06 (DOLS). However, they are only significant for OLS (−$0.48) and DOLS. The observation of the rents by component, which can contribute to the explanation of this very weakly negative global result, shows that the coal rent (Figure 4) has a significantly negative influence (−$147.46 for OLS and −$1239.8 for DOLS). This rent is counterbalanced by the significantly positive gas rent (Figure 8) ($118.55 for OLS and $551.38 for DOLS) and to a lesser extent by the oil rent in Figure 9 ($7.34 for OLS and $1.27 but not significant for DOLS).

Results of the two models with "resource category-institutions" interaction

Concerning the interaction terms, for each of the four estimation techniques, we can first re-examine the influence of each "total resources-institutions" pair in each country category on GDP *per capita* in the full sample. At a second level, we can also look at how each "resource category-institutions" may have influenced the impact of the "total resources-institutions" interaction on GDP *per capita* in each of the four country groups.

On the first scale, the interaction terms are significantly slightly positive for both the "total resources-rule of law" interaction and the "total resources-control of corruption" interaction for all estimation techniques except LSDV, where they are practically zero and not significant. The orders of magnitude (see Figure 4) of the impact on GDP *per capita* that the two institutional indicators add to the rents *per capita* from natural resources range from $0.16 (« total natural resource rents-rule of law», OLS technique) to $0.74 (« total natural resource rents-control of corruption », DOLS technique). The orders of magnitude are extremely close for the same technique between the two institutional variables, with a few cents more in favor of the "total natural resource rents-control of corruption" interaction. These figures, which are significant and slightly positive, are not explained by what is happening in any particular country group.

All estimation techniques considered, they result from the combination of significantly or non-significantly positive or negative results of the « total resources-institutions » interactions in each of the 4 country groups. We note that DOLS reveals the greatest number of significant (positive or negative) "total resources-institutions" interactions.

On the second scale, the estimated results (see Figure 4) of the influence on GDP *per capita* of the interaction between total resource rents and institutions range from −0.75 (« total resources-rule of law » interaction, UMI countries, DOLS technique) to $0.94 (« total resources-rule of law interaction », HI category, DOLS technique). The figure for the « total resources-corruption control » interaction is $0.74 for HI countries, suggesting that it is relevant to test the interaction terms in these countries. However, this relevance is almost exclusively limited to the DOLS estimation technique and to the "total resources-rule of law" interaction (excluding the "total resources-control of corruption" interaction in the HI category). In general, however, the DOLS technique generates different results from the other three techniques. However, because of the lags and leads it adds to the estimated variables, the specifications of the models with interactions reach such a large size that it becomes difficult not to be cautious about the economic significance of the econometric estimates performed with this technique. The results mentioned above are the combination of the results of the "natural resource category-institutions" interactions, positive or negative, significant or not, obtained within each category of countries.

We conclude by mentioning two remarkable results from the other three estimation techniques. These are the interaction, in low-income countries, between the coal rent and the rule of law, which is significantly positive ($11 for OLS, $20 for LSDV and $6.35 but not significant for FM-OLS). Still in this group of countries, we note that the results with OLS, LSDV and FM-OLS relative to the interactions between gas rent and rule of law and between gas rent and control of corruption are respectively −$11.87, −$8.75, −$13.2, −$19.05, −1.71 and −$21.21. However, only the positive and significant results of $11 and $20 can validated. This is because the condition for switching from model (6) to interaction models – that is, the coefficient of the interaction terms in models (7) or (8) must be lower than that of the isolated term, i.e., the component included in the interaction, in accordance with the interpretation of the interaction terms seen in section "Full sample with aggregated TOTALNRRPC" before Table 5 – is met only for these two figures.

Conclusion

Using data primarily from the World Bank (WDI, 2022) and Penn World Tables, PWT 10.0 (Feenstra et al. 2015), a global sample of 130 countries was compiled between 1990 and 2019 and then subdivided into 4 subsamples according to the countries' level of GDP *per capita*.

While the literature focuses on the weak blessing/curse of resources, this paper sought to econometrically examine the strong blessing/curse issue, i.e., the influence of natural resource rents *per capita* TOTALNRRPC (aggregated and then disaggregated) not on growth (weak blessing/curse) but the level of GDP. It also has a methodological dimension, since it applies the same econometric techniques to both the full sample and 4 sub-samples.

The equation estimated using four econometric techniques (OLS, LSDV, FM-OLS, DOLS) is theoretically based on a combination of variables (i) from the development accounting framework and (ii) institutional variables (Rule of Law, RULAW and Control of Corruption, CONTCOR) considered separately then in interaction with the variable of interest TOTALNRRPC as recommended by the meta-analytic literature, and iii) control variables that are usual in the literature or new (Income inequality, GINI and Current account balance *per capita*, CURBOPC) and finally iv) country and time specific effects. The same equation was also estimated in disaggregated form, i.e., with TOTALNRRPC decomposed, this time, into 5 natural resource categories (coal, forestry, gas, mining, and oil).

Thus, the question of the natural resources-economic development link is addressed in a way that considers several possible sources of discrepancy that may influence the meaning, magnitude, and significance of the results. In its findings, the meta-analysis literature on the natural resource-growth nexus observed that variables play a decisive role in this relationship. Thus, the capital stock, the role of institutions separately and in their interaction with natural resources (considered here for both total natural resources and resource categories), or the presence of control variables were considered here.

In this conclusion, only the full sample results are presented. This presentation with the 4 econometric methods follows the pattern ordered this way: for each of the 4 methods we examine the impact of the variable of interest (total resource rents *per capita* and then decomposed by resource rent categories *per capita*), separately or in interaction with the 2 institutional variables. Section "Results of the econometric estimations in the sub-samples" follows the same pattern but for the sub-samples. It is richly detailed for readers who want to understand how the sub-sample results combine to explain the global results, or who are simply interested in the results for a particular category of countries by their level of GDP *per capita*.

In the full sample, therefore, and for the 4 econometric methods, the observation of models without « resources-institutions » interactions shows a positive relationship between natural resources and GDP *per capita*. This result is almost identical between OLS, FM-OLS, and DOLS around \$5. It is weaker for panel estimate (LSDV), around \$3.

In all 4 specifications but this time with « natural resources-institutions » interactions, institutional variables significantly mitigate the negative effect of natural resources on long-term development (FM-OLS, DOLS) or reinforce the positive effect of these resources on development (OLS, LSDV).

The decomposition of rents from total resources into rents by resource category revealed 2 groups according to the OLS estimate of the full sample. The group with the categories that positively influence GDP *per capita* are, in order of importance: The *per capita* rents from natural gas (NGRPC with an influence of \$16.7), those from crude oil before refining (OILRPC with \$6.15), while those from mineral resources (MINRPC) – but for which it has been mentioned that the list of components currently retained by the World Bank does not exhaust all the existing resources – have a weak (\$0.44) and non-significant but positive influence. The second group consists of *per capita* rents from coal (COALRPC) and forestry rents (FORRPC) from roundwood, before industrial processing, whose significantly negative influences on *per capita* GDP are respectively −\$9.04 and −\$4.42.

For the specifications with interaction terms this time, only forest rents escape the generally favorable mechanism of institutional quality on resources. The results obtained for the other 4 resource categories are more intuitive and thus highlight the positive role of institutional variables in the positive (not always significant) influence that natural resources exerts on GDP. For e.g., crude oil rent have a negative impact on GDP *per capita* of about \$3 when RULAW is neutralized. However, this negative effect is mitigated by \$0.2 each time institutional quality captured by RULAW improves by 1%. This also explains the positive influence of oil rent in the model without interaction.

When individual and time-fixed effects are considered (LSDV), the results for the group of variables positively influencing GDP *per capita* (NGRRPC, OILRPC, and MINRPC) continue to play the same role. However, the magnitude of this role changes. Thus, rents from natural gas rise from \$16.7 to about \$25, while those from crude oil fall from \$6.15 to \$3.04. The mining rent, still not significant, is more positive, rising from \$0.44 to \$1.67.

For this group, the comparison between the model without and with interactions shows that the institutional variables RULAW and CONTCOR are relevant in the reinforcing role of the effects of natural resources on GDP *per capita*. As an illustration, a 1% increase in the control of corruption indicator reinforces the influence of gas rent by \$0.75. This positive role of institutions is stronger than with OLS.

For the group of resources that negatively influenced GDP *per capita* with OLS, namely COALRPC and FORRPC, these are no longer significant but FORRPC is now positive while COALRPC keeps a negative influence.

In the long term, results with FM-OLS can still be interpreted from the 2 groups of results from OLS and LSDV. There is a closeness with the results obtained with OLS and to a lesser degree with LSDV. In particular, in the group of resources with a positive influence on GDP *per capita*, gas rents contribute significantly \$14.92 to GDP *per capita* (\$16.68 with OLS and \$24.74 with LSDV), while oil rents have a \$6.7 influence here (\$6.15 with OLS and \$3.04). Mining rents remain insignificant but positive and of a higher amount with \$1.38 versus \$0.44 with OLS or \$1.67 with LSDV. Our simulations with the DOLS method reveal a difference, however, since the gas rent still appears positive but by a smaller amount and is non-significant (\$6.36). On the other hand, the oil rent remains positive and significant (\$6.88) while mining rent is still insignificant and intermediate (\$0.9) between OLS and FM-OLS.

When we look at the negative influence group, the coal rent continues to have a negative impact (−\$11.78), close to that of OLS (−\$9.04 and significant) but is no longer significant. The impact of forest rent is significantly negative (−\$7.62) and of a higher amount than with OLS (−\$4.41). In the LSDV estimation, these two types of resources did not significantly impact GDP *per capita*. The results of the long-term estimation in DOLS can be reconciled with FM-OLS since the influence of coal rent is negative at −\$12.43 without being significant while forest rent has a significantly negative influence of \$9.65 (compared to −\$7.62 above).

In the case of models with "total natural resources-institution" interactions, the results show that, for the group of resources with a significantly positive influence (NGRPC and OILRPC), the RULAW and CONTCOR variables reinforce the positive effects of resources on GDP *per capita* and attenuate the negative effects. It should be noted that this positive effect is not significant for the particular case of gas rent. When the results of the DOLS estimation are used, this last positive effect is indeed significant.

In contrast, the results of the models with interactions suggest that the use of RULAW and CONTCOR is not the most appropriate for studying « natural resources-institution » interactions in the case of coal and forestry or even mining rents. In other words, the variables included in the interaction are independent and it is appropriate to stick with the model without interactions for these resource categories. An indicator reflecting institutional quality that is more specific to these activities might therefore be more appropriate.

Finally, the link between dependence on natural resources and the level of GDP *per capita* that has been studied here, thanks to the proposed model, can of course be replicated as a new research direction. The more the replication follows the methodology proposed here – both on full and sub-samples – the more relevant the comparability and lessons learned. In particular, other econometric techniques would also be welcome in this sense.

Data availability statement. The author confirms that all data generated or analyzed during this study are publicly available. All other data required for final calculations and/or econometric simulations can be provided upon request.

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