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Resource Rents and Economic Growth: Governance and Infrastructure Thresholds

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Abstract

This study investigates how governance and infrastructure modulate the effect of natural resource rents on economic growth in a sample of 110 countries for the period 2000-2018. The empirical evidence is based on Panel Smooth Transition Regressions (PSTR). The following findings are established. First, the nexus between economic growth and natural resources is not linear and the underlying non-linearity is contingent on existing infrastructural and governance levels. Second, evidence of a "natural resource curse" is apparent in countries with extremely low levels of governance and infrastructural development. Third, the favorable effect of natural resources on economic growth requires a governance threshold of -1.210 and an infrastructure threshold of 2.583 indicating that countries with governance and infrastructure level higher than these values tend to benefit much more from the wealth of natural resources. With high levels of the transition variables (governance and infrastructure), the established thresholds are low and situated between the 5^{th} and the 10^{th} percentiles. Countries identified below the established thresholds are mainly from Africa. Policy implications are discussed with specific emphasis on African countries.

JEL Codes: H10;Q20; Q30; O11; O55

Keywords: Natural Resources; Economic Growth; Governance; Infrastructure; Threshold

1. Introduction

Since the influential work of Sachs and Warner (1995), the economic growth-natural resource nexus has been widely debated. As argued by Havranek *et al*. (2016), there is no strong consensus on the effect of natural resource wealth on economic growth and the mechanism underlying this effect. With the collection of 43 econometric studies which report 605 regression estimates of the effect of natural resources on economic growth, their results show a contradictory picture: roughly 40% of the empirical papers find a negative effect (commonly known as 'natural resource curse'), 40% establish no effect and 20% find a positive effect of natural resources on economic growth.

Within the framework of this study, we re-examine the impact of natural resource rents on economic growth contingent on governance and infrastructure levels[1]. This work contributes to the existing literature on the 'natural resource' - 'economic growth' nexus in several ways. First, it overcomes some limitations of the previous literature pertaining to the econometric approach (Mehlum *et al*., 2006; Brunnschweiler, 2008; Torvik, 2009; Mavrotas *et al*., 2011). In effect, in this paper, we use a methodology which allows us to capture the fact that natural resources are not linearly connected to growth, but rather conditional on the position in the distribution of the transition variable (i.e. the governance or infrastructure level). Secondly, we go beyond the existing studies which estimate the link between natural resource and economic growth in a context of homogeneity and allow the coefficients of the model to vary with respect to countries and time. Thirdly, in comparison to the existing literature that extensively uses institutional quality as a mechanism (Brunnschweiler, 2008; Sachs & Warner, 1995; Mehlum *et al*., 2006; Torvik, 2009; Mavrotas *et al*., 2011; Sarmidi *et al*., 2014), this study analyses the effect of natural resources on economic growth by also controlling for the infrastructure levels of sampled countries. According to Soumaila (2015) and Levy (2007), public investment can be considered as a tool with which to reverse Dutch disease. In effect, natural resource extraction interacts with the agriculture, manufacturing and industry sectors. The relevance of infrastructure (development of road network, water access, education, information and communication technology (ICT) and innovation, affordable energy, *inter alia*) linked to natural resource abundance could improve productivity and therefore economic growth. Thus, in the same way that the quality of institutions mitigates the negative effects of resource rents, the relevance of infrastructure could also dampen the Dutch

[1]"Natural resources" and "natural resource rents" are used interchangeably throughout the study. Growth and economic growth are also used interchangeably throughout the study.

disease.

In recent years, most of the literature has been oriented towards the mechanisms through which natural resources affect growth, the difference between resource dependence and abundance and distinction between different types of natural resources. Concerning the mechanisms, there is a large body of work on the quality of institutions (Robinson *et al.*, 2006; Mehlum *et al.*, 2006; Tella & Ades, 1999; Barro, 1999; Ross, 2001; Jensen & Wantchekon, 2004; Collier & Hoeffler, 2005; Boschini *et al.*, 2007; Horvath & Zeynalov, 2014; Frankel, 2012). In contrast to the claims of Sachs and Warner that institutions do not play a role, Mehlum *et al.* (2006) confirm that institutions are decisive in the resource curse. In effect, countries with good institutional quality are found to benefit from the natural resources and achieve high standards of living. Collier and Hoeffler (2009) find that in developing countries the combination of high natural resource rents and open democratic systems has been growth-reducing while checks and balances offset this adverse effect.

Bhattacharyya and Hodler (2010) study how natural resources can feed corruption as well as how the underlying effect depends on the quality of democratic institutions. Using a panel of 124 countries covering the period 1980-2004, their estimates confirm that the relationship between resource rents and corruption depends on the quality of democratic institutions. In particular, resource abundance is positively associated with corruption only in countries that have endured an undemocratic regime for more than 60 percent of the years since 1956. Recently, Moshiri (2015) has tested if oil shocks have asymmetric effects on economic growth in oil-exporting countries and shown how the effect depends on institutional quality. In oil-exporting countries with good institutional quality, oil shocks do not have a major effect on growth. However, in countries with weak institutional quality, negative oil shocks deteriorate economic performance, but positive oil shocks do not generate long-run growth. Besides the control for institutional quality, some authors deal with the effect of natural resources by controlling for the level of investment activity or human capital. The main theoretical underpinning is that the effects of natural resources on economic growth is not equal and it could be modulated or moderated by economic characteristics such us financial development, investment, human capital, *inter alia*. For example, Bhattacharyya and Hodler (2014) provide an empirical support for the hypothesis that resources revenues hinder financial development in countries with poor political institutions but not in countries with better political institutions. In the same vein, Gylfason (2001) discussed the four main channels of transmission from abundant natural resources to sluggish economic growth. The four channels are: the Dutch disease, rent seeking, overconfidence and neglect of education. Indeed, Atkinson and Hamilton (2004) found that natural resources crowd-out physical capital and consequently affect economic growth negatively.

The positioning of the above study departs from contemporary economic growth literature which has largely focused on *inter alia*: the importance of information technology in economic growth (Vu, 2019; Asongu & Odhiambo, 2020a); nexuses between financial development and economic growth (Adam *et al*., 2017; Assefa & Mollick, 2017); dynamic linkages between economic output and inflation (Bonga-Bonga & Simo-Kengne, 2018); the connection between economic growth volatility and financial development (Muazu & Alagidede, 2017); relationships between aid, aid volatility and sectoral growth (Kumi *et al*., 2017); thresholds of insurance penetration for economic growth (Asongu & Odhiambo, 2020b); the relationship between innovation and volatility in economic growth (Yaya & Cabral, 2017) and dynamics of government expenditure in economic growth (Onifade *et al*., 2020)[2].

The remainder of the paper is organized as follows. Section 2 discusses underpinnings for the infrastructure and governance mechanisms in the nexus between natural resources and economic growth while Section 3 presents the data and describes the econometric methodology employed. Section 4 outlines and discusses the empirical findings. Section 5 concludes with implications and future research directions.

2. The resource curse and underpinnings for infrastructure and governance channels

Consistent with the problem statement of the study which is based on using governance and infrastructure as transition variables, it is relevant to clarify the choice of the attendant modulating variables within the framework of the nexus between natural resources and economic growth. The role of the transition variable is to depict how it modulates the relationship between natural resource abundance and economic growth. In effect, it is plausible that governance and infrastructure are channels through which resource rents

[2]The paragraph is meant to clarify that the focus of the study departs from extant contemporary economic growth literature that has not directly focused on the problem statement being examined. Therefore, the paragraph is meant to articulate that the extant contemporary literature has not focused on the problem statement being examined in the present study.

positively affect economic growth. Moreover, using transition variables allows us to know the mediating factors when explaining the natural resource-growth nexus. In line with Badeep *et al*. (2017), studies on the resource curse should not be limited to estimating the relationship between natural resources and economic development, but should go a step further to substantiate transition mechanisms by which the relationship withstands empirical scrutiny. According to the attendant literature, the two main transition variables which are economic and political are captured in this study in terms of infrastructure and governance, respectively. The two perspectives are discussed in what follows.

First, on the infrastructural front, the attendant literature (Gylfason, 2001; Gylfason *et al*., 1999; Iimi, 2007; Badeep *et al*., 2017) argues that infrastructural issues are largely associated with natural resources because income from natural resources can motivate policy makers to become overconfident about prospects of their economies and by extension, such constant availability of rents from natural resources decreases the government's tendency to collect taxes from other sources (Ross, 2007). Accordingly, tax income from other sources (i.e. non-resource taxes) has been documented to be associated with fiscal discipline and more demand for investment in economic infrastructure by the taxpayers (Eubank, 2012). Accordingly, people and corporations largely making-up the non-resources tax prospects are only prepared to pay taxes in exchange for better infrastructural development and macroeconomic management standards (Asongu, 2015).

While the above narrative is associated with the resource curse, this study argues that such a resource curse can be curbed by investing in infrastructure in order to improve the management and associated positive externalities of such natural resources. Accordingly, it has been documented that good infrastructure (which includes, *inter alia*, transportation networks, information technology) enhances the relevance of natural resources in economic development (Bodin & Crona, 2009; Kodila-Tedika, 2018). Good governance is also relevant for natural resource rents to positively affect economic development.

Second, with respect to the governance transition variable, two main points are worth emphasising from a survey of the attendant literature (Badeep *et al*., 2017). On the one hand, rents from natural resources have an unfavourable incidence on the quality of governance. On the other hand, the quality of governance can mediate the resource curse hypothesis in order to induce a favourable effect of natural resources on economic development. While this study is more focused on this latter perspective, both are discussed in what follows.

There is a bulk of literature that is sympathetic to the position that resource rents are associated with a plethora of negative economic and institutional externalities such as conflicts and poor governance (Hodler, 2006; Iimi, 2007; Frankel, 2012). For instances: (i) it is established by Sala-i-Martin and Subramanian (2003) that because natural resources have a negative incidence on institutional quality, they also indirectly exert a negative incidence on economic prosperity. (ii) Arezki and Galyfason (2011) corroborate the Nigerian experience of Sala-i-Martin and Subramanian (2003) in a sample of 29 countries in Sub-Saharan Africa. (iii) Bhattacharyya and Hodler (2010) conclude that in non-democratic states, natural resource rents boost corruption, which is broadly consistent with Arezki and Brückner (2011) who use a panel of 31 oil-exporting countries to establish that oil rents fuel political instability and corruption.

Despite some positions in the literature that institutions do not have a significant causal incidence on resource rents and by extension, do not play a fundamental role in the outcome of the resources curse (Brunnschweiler, 2008; Sachs & Warner, 1995), a strand of the literature contents that institutions play a critical role in determining the incidence of natural resource rents on economic development outcomes (Mehlum *et al*., 2006; Torvik, 2009; Mavrotas *et al.*, 2011; Sarmidi *et al*., 2014). In essence, Torvik (2009) and Sarmidi *et al*. (2014) opine that, with the enhancement of institutional quality, the unfavourable impact of natural resources on economic growth is mitigated. This is consistent with Mavrotas *et al*. (2011) and Mehlum *et al*. (2006) who argue that growth performance in resource abundant countries is contingent on the manner in which rents from the attendant countries are distributed via institutional frameworks. Overall, these studies just include interactive terms between resource abundance and institutional quality to test the Dutch disease hypothesis. Moreover, while the corresponding methodology enables the studies to capture the mitigating role of institutional quality, it does not take into account the non-linearity between economic conditions and natural resources, contingent on transitional factors. Another limit of these studies is that only institutional quality is used as a moderating variable. In this paper, we provide a non-linear model with institutions and infrastructure as transition factors.

3. Data and methodology

In this section, we present the data and the methodology used to assess the transition effect of governance and infrastructure in the relationship between economic growth and natural resources.

3.1 Data

We use annual data obtained from the World Bank's World Development Indicators (WDI) and World Governance Indicators (WGI), covering the period 2000-2018. In Table 1, we present the description of variables. Economic growth which is our dependent variable is GDP growth (gdpgr). In this work, the independent variable of interest is natural resources (natural_resource). The natural resources represent total natural resources rents (% of GDP). Following Bhattacharyya and Hodler (2014), this variable is a preferred measure of natural resources for many reasons. First, it is able to capture the notion of natural resource revenues in the theoretical context. The second argument is that it avoids the risk of sample selection bias because it is fairly wide in terms of country coverage. Third, this variable has been used ina number of works (Collier & Hoeffler, 2009; Bhattacharyya & Hodler, 2010). We use two factors for the transition. The first isgovernance and the second is infrastructure. Following Asongu (2016), infrastructure is proxied by mobile phone per 100 people. This choice is alsojustified by data availability constraints. In our sample, we introduce some countries (mostly African countries) which are characterised by a serious problem of data availability for a proxy of infrastructure. That is why in the present paper, we use mobile phone subscriptions. Using mobile phone to proxy for infrastructure is in line with the existing literature (Asongu& Odhiambo, 2018; Asiedu, 2002; Sekkat & Veganzones-Varoudakis, 2007, *inter alia*). Accordingly, other variables could not be used owing to substantial missing observations. These include variables such as logistics quality and competence, logistics performance index and energy access or energy intensity. The concern of endogeneity is addressed in the section on robustness checks.

In addition to the transition variables and the independent variable of interest, the control variables include: foreign direct investment (fdi), trade of merchandise (trade), consumption price index (cpi), population growth (popgr) and interactions between the transition variables (i.e. Governance & Mobile) and natural resource (i.e. Governance & natural_resource, Mobile & natural_resource). These selected control variables are consistent with economic growth theory and the determinants of growth. We assume that FDI and economic growth are positively linked through the direct spillover effect on economic growth. FDI is widely considered as a driver of economic growth. High inflation (consumer price index) has a potential negative impact on economic growth given that low and stable inflation is conductive for a positive economic outlook (Asongu, 2013). Trade openness as a determinant of economic growth is also justified. In effect, several empirical studies have found that trade openness positively and significantly affect economic growth (Were, 2015; Lewer & Van den

Berg, 2013; Frankel & Romer, 1999, *inter alia*). The selection of population growth is also justified on the basis of the neoclassical growth theory which is focused on the role that this variable plays in generating macroeconomic growth (Solow, 1956; Swan, 1956). The summary statistics is provided in Table 2.

3.2 Methodology

In this section, we first present the Panel Principal Component Analysis (PPCA) used to construct the overall governance index before describing the Panel Smooth Transition Regression (PSTR) used to estimate the econometric model.

3.2.1 Panel Principal Component Analysis (PPCA)

In this paper, we use the World Governance Indicators (WGI) of the World Bank as proxies for governance, in accordance with recent governance literature (Ajide & Raheem, 2016a, 2016b; Andrés *et al*., 2015; Amavilah *et al*., 2017). We apply the PPCA to construct the overall governance index. This choice is justified by the fact that with this method, we can summarize a set of variables without losing the important variability in the original data (Tchamyou, 2017, 2020; Diop & Asongu, 2020). The objective of PPCA is to explain the variance of the observed data through a few linear combinations of the original data. In a panel framework, we have a multidimensional data vector:

$$X_{T\times Q} = \left(x_1^t, x_2^t, \dots, x_Q^t\right), t \in T$$

where t is the number of periods and Q is the number of variables.

Let $\Sigma_{Q\times Q}$ the correlation matrix of the variables $X_{Q\times T}$. The principal component $Z_i^t, i = 1,2, \dots, Q$ is defined as:

$$\begin{cases} Z_1^t = a_{11}x_1^t + a_{12}x_2^t + \cdots + a_{1Q}x_Q^t \\ Z_2^t = a_{21}x_1^t + a_{22}x_2^t + \cdots + a_{2Q}x_Q^t \\ \quad \vdots \\ Z_Q^t = a_{Q1}x_1^t + a_{Q2}x_2^t + \cdots + a_{QQ}x_Q^t \end{cases}$$

Or in a matrix form, $Z = A'X_{Q\times T}$, where $A = \left(a_1, a_1, \dots, a_Q\right)$. The coefficient matrix A maximizes the variance of $Z = E(ZZ') = A'\Sigma A$ subject to the following constraints:

$$a_1'a_1 = a_2'a_2 = \cdots = a_Q'a_Q = 1 \text{ and } cov\left(a_i'x, a_j'x\right) = 0, i \neq j$$

The solution to the eigenvalue-eigenvector problem resulting from of this optimization program is λ_i which is equal to the variance of Z, with $\lambda_1 > \lambda_2 > \cdots > \lambda_Q$.

We can now use the loadings we obtain from the PPCA to compute the different weights. In the first step, we apply the PPCA on the six indicators in order to obtain the different weights. Once the weights are obtained, we are able to compute the overall index of governance as:

$$Governance = \sum_{i=1}^{6} w_i I_i$$

where w_i is the weight obtained through the PPCA and I_i represents each of the six indicators.

It is also relevant to clarify why variables derived from PPCA can be used in subsequent regressions. Consistent with Asongu *et al*. (2018), the associated concerns pertain to efficiency, consistency and validity of estimated coefficients. In the light of Pagan (1984), efficiency and consistency can be associated with principal component augmented variables. However, according to the authors, only few valid inferences can be made from the estimated coefficients. These concerns which relate to *two-step* estimations are in line with the attendant literature on the subject, *inter alia*: Oxley and McAleer (1993), McKenzie and McAleer (1997), Stock and Watson (2002), Bai (2003), Pesaran (2006), Ba and Ng(2006), Bai (2009), Greenaway-McGrevy *et al*. (2012) and Westerlund and Urbain (2013a).

Narrowing the perspective to this study, PPCA-augmented variables provide consistent and efficiency estimates as well as estimates that are characterised by inferential validity. These claims are valid because according to the attendant literature (Westerlund & Urbain, 2013b, 2015), while such estimates are consistent and efficient, inferential validity is also worthwhile as long as the attendant estimated coefficients converge to their true values at the rate $\sqrt{NT}$, (where T is the number of time series and N denotes the number of cross-sections). This study: (i) focuses on 110countries for the period 2000-2018 and (ii) the N and T values in the study are much higher than corresponding values in the literature using PPCA to derive independent variables (Asongu & Nwachukwu, 2016a, 2016b; Tchamyou, 2017, 2020).

3.2.2 Panel Smooth Transition Regression (PSTR)

In this paper, we adopt the PSTR approach developed by Gonzalez *et al*. (2005) to detect the non-linearity between economic growth and natural resources using governance and infrastructure levels as transition factors. As far as we know, this methodology has never been used to address the natural resource-economic growth nexus in the presence of different levels of governance and infrastructure. The PSTR has several advantages compared to the regression with interactive term or the Panel Threshold Regression (PTR) proposed by Hansen (1999). Firstly, it deals with the problem of heterogeneity in anon-linear framework and the coefficients vary across individuals over time. Secondly, the PSTR is appropriate to capture the non-linearity of the nexus between resource rents and economic growth when we consider some transition variables such as governance and infrastructure. More specifically, it enables the sensitivity of economic growth to resource rents to vary over time and space depending on the level of governance and infrastructure. Thus, the PSTR approach takes into account the heterogeneity of the relationship between the dependent variable, the explanatory variable and the transition variable. The transition variables show how resource rents affect economic growth depending on the levels of governance and infrastructure. For example, we assume that in countries with low governance and infrastructure levels, the Dutch disease cannot be reversed and vice versa.

A PSTR model with two extreme regimes and a single transition function is defined as:

$$y_{it} = \mu_i + \lambda_t + \beta_0' x_{it} + \beta_1' x_{it} g(q_{it}; \gamma, c) + u_{it}$$

where $i = 1, \cdots, N$, and $t = 1, \cdots, T$, where N and T are respectively, the cross section and time dimensions of the panel, y_{it} is the dependent variable which represents economic growth, x_{it} is a k-dimensional vector of time varying exogenous variables (natural resources, foreign direct investment, cpi, mobile, *inter alia*), q_{it} is the transition variable (governance or infrastructure), c is the threshold parameter (governance threshold or infrastructure threshold), γ is the slope parameter which denotes the smoothness of the transition from one regime to the other, μ_i and λ_t are respectively the country fixed and time fixed effects, and u_{it} represents the residual term.

$g(q_{it}; \gamma, c)$ is the transition function. It is a continuation of the transition variable that is normalized to be bounded between zero and one. These two extreme values are associated with the regression coefficients β_0 and $\beta_0 + \beta_1$. Indeed, the value of the transition variable q_{it} determine $g(q_{it}; \gamma, c)$ and therefore the regression coefficient for an individual i at time t :

$$e_{it} = \frac{\Delta y_{it}}{\Delta x_{it}} = \beta_0 + \beta_1 g(q_{it}; \gamma, c)$$

with

$$g(q_{it}; \gamma, c) = \left(1 + exp\left(-\gamma \prod_{j=1}^{m} \left(q_{it} - c_j\right)\right)\right)^{-1}$$

with

$$\gamma > 0 \text{ and } c_1 < c_2 < \cdots < c_m$$

Two problems need to be resolved before estimating the PSTR model. The first is the test of linearity and the second is the number of regimes (*m*). The PSTR model is reduced to a linear model by imposing either $\gamma = 0$ or $\beta_1 = 0$. Therefore, testing the homogeneity of coefficients is equivalent to testing the null hypothesises as follow:

$$H_0: \gamma = 0 \text{ or } H_0': \beta_1 = 0$$

However, these tests are non-standard because under either null hypothesis, the PSTR model contains the unidentified nuisance parameter c (Hansen, 1996; Luukonen *et al.*, 1988; Gonzalez *et al.*, 2005). We adopt the solution proposed by Luukonen *et al.* (1988) and Gonzalez *et al.* (2005) within the framework of panel data analyses. We replace $g(q_{it}; \gamma, c)$ by the first order Taylor expansion around $\gamma = 0$. After reparameterization, this leads to the following auxiliary equation:

$$y_{it} = \mu_i + \lambda_t + \beta_0' x_{it} + \beta_1'^{*} x_{it} q_{it} + \cdots + \beta_m'^{*} x_{it} q_{it} + u_{it}^{*}$$

According to the Taylor expansion, the parameters $\beta_1^*, \cdots, \beta_m^*$ are multiples of γ. Therefore, testing $\gamma = 0$ is equivalent to testing the following null hypothesis[3]:

$$\beta_1^* = \cdots = \beta_m^* = 0$$

4. Empirical findings

The criterion used to retain the number of factors from the PPCA is from Kaiser, in accordance with the attendant literature (Tchamyou, 2017, 2020; Diop & Asongu, 2020). The author recommends the retention of principal components with an eigenvalue higher than one. Table 3 reports the PPCA results. As we can see, only the first component has an eigenvalue higher than one (5.328) and this component or composite governance (hence governance)explains 88.8% of the total variance. Hence, we can group the six indicators into a single component. Taking into account all 110 countries covering the period 2000-2018, the highest weight (0.185) is allocated to the rule of law while the lowest weight (0.136) is assigned to political stability. Government effectiveness, regulation quality and corruption control indicators have the same weights (0.176).

The homogeneity tests are reported in Table 4. The null hypothesis that the model is linear is strongly rejected for governance and infrastructure. This result implies that the relationship between economic growth and natural resources is not linear. This non linearity is contingent on the governance and infrastructure levels. With regard to the number of regimes,

[3] For more details on linearity tests and the selection of the number of regimes, the interested reader can consult Gonzalez *et al.* (2005) and Colletaz and Hurlin (2006).

the results of the homogeneity test indicate that at a 1% significance level, the null hypothesis of a PSTR model with a threshold (two regimes: regime 1 and regime 2) cannot be rejected. The estimated threshold is -1.210 for governance and 2.583 for infrastructure (see Table 5). This implies that for governance and infrastructure below or equal to -1.210 and 2.583, respectively (regime 1), we should expect a different sensitivity of economic growth to governance and infrastructure compared to the corresponding values of the second regime which are higher.

The results of the PSTR estimations are presented in Table 5. Both the slope and the threshold coefficients are significant at the 1% level. In line with expectations of the study, natural resources are not significant in the first extreme regime when governance is used as a transition variable. This result suggests that the effects of natural resources on economic growth are not statistically significant when governance is below the threshold level of -1.210. Contrary to the first regime, the coefficient associated to the natural resources is positive and statistically significant at 10% in the high governance regime. We also note that the point estimate $\hat{c} = -1.210$, is in-between the 5th and the 10th percentiles of the empirical distribution of the transition variable (i.e. governance) in Table 2. In effect, the model identifies countries with very weak governance, signalled by their low governance levels. If we look more closely at the data, it is apparent that there are countries with governance levels lower than this threshold during all (or almost) the sample period (Zimbabwe, Sudan, Iraq, Equatorial Guinea, Congo Democratic Republic, Chad, Central African Republic, Burundi, Yemen Republic and Libya) while other countries are below the attendant threshold only at the beginning of the period, namely: Angola, Congo Republic, Cote d'Ivoire (during the political crisis), Guinea, Liberia, Nigeria, Sierra Leone and at the end of the sample, Guinea Bissau. Hence, these findings show that the 'natural resources curse' exist only in countries where the average level of governance is extremely low. Thus, economies with fair or better governance standards tend to benefit much more from the wealth of natural resources.

When mobile phone penetration is used as a proxy for the level of infrastructure, the slope and the threshold are positive and significant at the 1% level. It is apparent that the estimate of the coefficient of natural resources is negative but statistically insignificant for low infrastructure while it is positive and significantly different from zero for the high infrastructure regime. This means that in countries with a high level of infrastructure, natural resources boost economic growth contrary to countries where the attendant infrastructure is weak. Concerning the threshold, the same results are noted as for the governance transition variable. Once again, the estimated threshold (2.583) is very low and is in-between the 5th and the 10th percentiles. As expected, countries below this threshold are mainly in the African continent. Moreover, this tendency is only relevant to the years at the beginning of the sample (i.e.2000-2008) since the number of mobile phones per 100 people has considerably increased. These results show that the infrastructure level required for natural resources to have a positive and significant impact on economic growth is not quite high. However, this inference does not negate the fact that enhanced mobile phone penetration and by extension, information technology could further improve the positive externalities associated with the relevance of mobile technologies in reversing the resource curse, especially in countries where exiting information technology penetration levels are comparatively low.

In order to check for the robustness of the PSTR and corresponding findings, we estimate a Generalized Method of Moments (GMM) to address some econometric issues such as the reverse causality concern of endogeneity. In effect, governance or infrastructure and resource rents could be mutually reinforcing in a reciprocal pattern. For the validation of the estimation, we perform two tests. Firstly, we test the hypothesis that the differenced error term is second order serially correlated. Secondly, we implement the Hansen test to check the validity of the instruments. Table 6 shows the corresponding results. The findings we obtain confirm the PSTR estimations. In effect, the coefficient of natural resource is positive while the interactive term (both for governance and infrastructure) is also positive and significant. This result confirms those obtained with the PSTR estimation that the negative effect of natural resources could be mitigated by high levels of governance and infrastructure. We also introduce an interaction between Africa (1 if an African country and 0 otherwise) to take into account the specificity of the continent. The findings show that the Dutch disease is a reality in African countries. More precisely the negative effects of resource abundance are more apparent in the continent.

5. Concluding implications and future research directions

The study complements existing literature by assessing the nexus between natural resources and economic growth, contingent on governance and infrastructural development. Hence, the study investigates how governance and infrastructure modulate the effect of natural resources on economic growth. To make this assessment, thresholds of governance and infrastructure are examined in a sample of 110countries for the period 2000-2018. The following findings are established. First, the nexus between economic growth and natural resources is not linear and the underlying non-linearity is contingent on existing infrastructural and governance levels. Second, evidence of a "natural resource curse" is apparent in countries with extremely low levels of governance and infrastructural development. Third, the effect of natural resources on economic growth is not statistically significant when governance is below the threshold level of -1.210. Fourth, the positive effect of natural resources on economic growth requires an infrastructure threshold of 2.583. With high levels of the transition variables, the established thresholds are low and situated between the 5thand the 10th percentiles. Countries identified below the established thresholds are mainly in Africa.

Before discussing attendant policy implications that should be more specific to African countries in the light of the fact that these countries are comparatively characterised by low levels of infrastructure and governance, it is worthwhile to connect the findings with some debates in the literature. Accordingly, the findings in this study are contrary to the strand of literature which suggests that institutions do not modulate natural resource rents for significant macroeconomic outcomes (Brunnschweiler, 2008; Sachs & Warner, 1995). Hence, the findings are consistent with the strand of literature supporting the position that institutions are worthwhile in significantly modulating natural resources to induce a positive incidence on macroeconomic outcomes such as economic growth (Mehlum *et al*., 2006; Torvik, 2009; Mavrotas*et al*., 2011; Sarmidi *et al*., 2014). It is also important to note that, in the light of the motivation of the study in the introduction, the modulating incidence of infrastructure employed in this study cannot be compared with findings from the extant literature because this is the first study, to the best of knowledge to engage the infrastructure dimension, in view of improving the extant literature. Policy implications are discussed in what follows.

First, because information technology used to proxy for infrastructure still has a high potential for penetration in Africa (Uduji & Okolo-Obasi, 2018; Tchamyou *et al*., 2019a, 2019b), policies should be designed to improve its access as well as other dynamics of infrastructure that are relevant in the management of natural resources and the equitable distribution of the rents associated with attendant resource management. On the front of information technology, it can be increased by the government boosting information technology infrastructure and availability through, *inter alia*: sharing schemes, universal access mechanisms and low pricing networks.

Second, on the governance front, in line with Asongu and Odhiambo (2021), it is important to boost all dynamics of governance in order to optimally enhance targeted macroeconomic outcomes. Given that a composite measureof political, economic and institutional governance is used as proxy for governance in this study, all constituent components should be improved. Political governance can be improved by ameliorating conditions for the replacement and election of political leaders. Economic governance can be enhanced by improving the formulation and implementation of policies that deliver public commodities especially as it pertains to the arrangement for the equitable distribution of resource rents. Institutional governance can be improved by boosting arrangements that enable both the State and citizens to respect institutions that govern interactions between them.

Future research directions that can be considered to improve the extant knowledge include the imperative of considering other policy measures or transition variables by which the resource curse can be mitigated. Moreover, the analysis can be replicated within the framework of corporate governance data. This latter recommendation is premised on the potential managerial implications of the findings given that the decisions' of both investors and managers depend on how corporate governance and social responsibility (i.e. corporate investment in infrastructure) affect the resource curse and the relevance of natural resource rents in both human and socio-economic developments of resource-rich countries.

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Table 1: Definitions of variables

Variables	Definitions	Sources
Voice_accountability	"Voice and accountability (estimate): measures the extent to which a country's citizens are able to participate in selecting their government and to enjoy freedom of expression, freedom of association and a free media"	WGI
Political_stability	"Political stability/no violence (estimate): measured as the perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional and violent means, including domestic violence and terrorism"	WGI
Governance_effectiveness	"Government effectiveness (estimate): measures the quality of public services, the quality and degree of independence from political pressures of the civil service, the quality of policy formulation and implementation, and the credibility ofgovernments' commitments to such policies".	WGI
Regulation_quality	"Regulation quality (estimate): measured as the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development".	WGI
Rule_law	"Rule of law (estimate): captures 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, the courts, as well as the likelihood of crime and violence"	WGI
Control_corruption	"Control of corruption (estimate): captures 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".	WGI
Governance	Overall governance indicator obtained from PPCA	Own calculations
Fdi	Foreign direct investment, net inflows (in current U.S. dollars) refers to direct investment equity flows in the reporting economy.	WDI
Natural_resource	total natural resources rents (% of GDP). The total natural resources rents are the	WDI

	sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	
Trade	Merchandise trade. Merchandise trade as a share of GDP is the sum of merchandise exports and imports divided by the value of GDP, all in current U.S. dollars.	WDI
Mobile	Mobilecellularsubscription(per 100 people)	WDI
Gdpgr	GDP Growth(annual %)	WDI
Consumer_price	Consumer Price Index(annual %)	WDI
Population_growth	population growth. Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage.	WDI
Governance≠Mobile	Interaction between governance and infrastructure	Own calculations
Governance≠Natural_resource	Interaction between governance and natural resources	Own calculations
mobile≠natural_resource	Interaction between infrastructure and natural resources	Own calculations
Governance≠Mobile	Interaction between governance and infrastructure	Own calculations

Sources: authors

Note: WDI: World Development Indicators of the World Bank. WGI: World Governance Indicators of the World Bank.

Table 2: Summary statistics

	Mean	Std.Dev	5%	10%	25%	50%	75%	90%
Natural_resource	9.394	12.887	0.019	0.083	0.890	4.052	12.361	28.337
Fdi	1.41e+10	4.57e+10	-1.4e+07	1.05e+07	1.89e+08	1.21e+09	8.20e+09	3.57e+10
Trade	61.475	36.688	24.118	28.624	38.884	52.730	73.3461	102.739
Mobile	72.003	47.345	1.133	4.333	27.712	76.648	110.537	131.074
Population_growth	1.632	1.474	-0.315	0.055	0.589	1.458	2.618	3.124
Governance	0.013	0.996	-1.389	-1.144	-0.776	-0.217	0.799	1.606

Note: the table presents the mean, standard deviation (Std.Dev) and selected percentiles of the variables for a panel of 110 countries covering the period 2000-2018.

Table 3: Panel PCA for weights calculation

	Voice_accountability	Political_stability	Governance_effectiveness	Regulation_quality	Rule_law	Control_corruption
	1	2	3	4	5	6
Eig. val.	**5.328**	0.319	0.222	0.071	0.035	0.025
Prop.	**0.888**	0.053	0.037	0.012	0.006	0.004
Cum	**0.888**	0.941	0.978	0.990	0.996	1.000
			Squared loadings			
Variables	Voice_accountability	Political_stability	Governance_effectiveness	Regulation_quality	Rule_law	Control_corruption
F1	0.153	0.136	0.176	0.176	0.185	0.176
			Weights			
Weights	0.153	0.136	0.176	0.176	0.185	0.176

Source: authors

Table 4: Linearity tests

	LM_{χ}		LM_F	
Variable de transition	Test	p-value	Test	p-value
Gov	28.710	0.000	9.012	0.000
Mobile	38.920	0.000	12.220	0.000
Gov≠Mobile	3.787	0.150	1.785	0.168

Source: authors

Table 5: PSTR Model estimations. Dependent variable: growth

	Gov		Mobile	
Variables	Estim.	Std. err	Estim	Std. err
Parameter estimates in the linear part (first extreme regime)				
Natural_resource	0.578	0.370	-0.052	0.078
Fdi	0.000	0.000	0.000	0.000
Trade	**0.068*** **	0.029	**0.065*** **	0.026
Cpi	**-0.015* **	0.009	-0.011	0.005
Governance	**7.184*** **	1.610	**3.664*** **	1.190
Governance ≠Natural_resource	0.159	0.236	---	---
Mobile	**-0.014*** **	0.004	-1.024	0.730
Population_growth	**0.757*** **	0.290	**0.738*** **	0.282
Mobile≠Natural_resource	---	---	**0.257*** **	0.098
Governance≠Mobile	-0.004	0.006	-0.003	0.008
Parameter estimates in the second extreme regime				
Natural_resource	**0.084* **	0.047	**0.146*** **	0.004
Governance	2.852***	1.157	---	---
Governance≠Natural_resource	-0.006	0.048	---	---
Mobile	---	---	**-0.016*** **	0.006
Mobile≠Natural_resource	---	---	0.000	0.000
Non-linear parameter estimates				
Gamma (slope)	**27.035*** **	11.185	**16.747*** **	7.338
C (threshold)	**-1.210*** **	0.048	**2.583*** **	0.038
ESDRE		4.945		
≠ of observations		2090		

Sources: authors.*,** and *** denote significance of the 10%, 5% and 1% level respectively
ESDR: Estimated Standard Deviation of the Residuals

Table 6: Robustness checks (GMM estimations)

	(1)	(2)	(3)	(4)
Natural_resource	-0.109* (0.063)	-0.084* (0.045)	-0.071 (0.063)	-0.105* (0.059)
Fdi	0.000** (0.000)	0.000** (0.000)	0.000** (0.000)	0.000** (0.000)
Trade	0.074** (0.034)	0.079** (0.027)	0.080** (0.031)	0.081*** (0.021)
Cpi	-0.019* (0.012)	-0.056 (0.049)	-0.090 (0.082)	-0.103 (0.082)
Governance	10.145*** (2.763)	6.745*** (1.923)	8.510*** (1.643)	9.223*** (2.463)
Governance≠Natural_resource	0.223** (0.112)		0.121** (0.124)	0.225** (0.122)
Mobile	0.021*** (0.007)	0.075*** (0.021)	0.061** (0.032)	0.066** (0.032)
Population_growth	0.734* (0.404)	0.789* (0.432)	0.812* (0.503)	0.645* (0.393)
Mobile≠Natural_resource		0.219*** (0.071)	0.413*** (0.044)	0.243*** (0.084)
Governance≠Mobile				2.613*** (0.076)
Africa≠narural_resource				-0.116** (0.058)
Hansen P-value	0.886	0.654	0.878	0.884
AR (2) P-value	0.762	0.787	0.675	0.597
≠ of observations	2090	2090	2090	2090

Sources: Authors. *,** and *** denote significance of the 10%, 5% and 1% level respectively