NATURAL RESOURCE REVENUE AND INFRASTRUCTURE IN SUB-SAHARAN AFRICA

Nosakhare Liberty Arodoye and Eseosa Joy Sowemimo

Department of Economics, University of Benin, Benin City, Nigeria

ABSTRACT

This study investigated the impact of total natural resource rents on aggregate infrastructure as well as various infrastructure types taking into account institutional and political environments in forty SSA countries for periods ranging from 2005 to 2018 using both the two-step system GMM and the panel data version of the FMOLS. Arising from the empirical assessments, the study revealed that natural resource rents exert negative and not significant impact on aggregate infrastructure, but, this impact exhibits mixed findings across various infrastructure types and across the various sub-regions of SSA, but with the interaction of natural resource rents and governance factors, it exerted negative and significant effect on aggregate infrastructure. Given the empirical outcomes, governments in the SSA countries should focus on building strong and efficient institutions to allow natural resource rents transmit into building strong and resilient infrastructure for the various sub-regions of the SSA.

Keywords: Natural Resources, Infrastructure, Institutions, Panel Data, Sub-Saharan Africa

JEL classification: N57, H54, O43, C33

1. Introduction

The development of infrastructure in sub-Saharan Africa is critical for fostering economic growth and improving living standards in the continent. This is because the construction of roads, rails and bridges, the installation of reliable power sources and the provision of clean water tend to transform the lives of citizens while providing business opportunities and allowing economies to thrive (Africa Development Bank, AfDB , 2018).

The Africa Infrastructure Development Index (AIDI) (AfDB, 2018) shows that the average transport composite index for the continent was 10.6 in 2000 but fell to 10.4 a decade later. The average ICT composite index on the other hand rose from 0.8 in 2000 to 14.0 in 2010. Similarly, the average electricity index (KWh) was 421.9 in 2000 and rose to 529.8 in 2010. Finally, the water and sanitation composite index was an average of 45.1 in 2000 and improved to 51.9 in 2010. More recent data show that there have been considerable improvements in investments in infrastructure; this is according to the AIDI for the period 2016 - 2018. The AIDI scores for the African continent rose from 27.12 in 2016 to 28.44 in 2018.

Global Infrastructural Outlook (2020) asserted that the global need for infrastructural investment is expected to reach $94 trillion by 2040. An additional $3.5 trillion is required to meet the SDGs' needs for water and electricity. Specifically, in Africa, the African Development Bank's African Economic Outlook (2018) estimated that the annual infrastructural deficit in the continent was $108 billion as at 2018. It further estimated that the investment gap in Africa is 1.7% of the gross domestic product (GDP) compared to the global average of 0.6%. More generally, it forecast that the investment gap would rise to 3.4% of GDP if investment needs incorporate the Sustainable Development Goals. The World Bank, however, estimates that if sub-Saharan Africa closes the infrastructural gap both in quantitative and qualitative terms, the region could potentially raise her GDP growth per head by 2.6% per year (The Economist Intelligent Unit, 2019). On the other hand, the AfDB (2018) puts the infrastructure needs at $130-$170 billion a year, with a financing gap that ranges between $68 and $108 billion.

These infrastructural deficits have imposed an additional cost on businesses in Africa, reducing international competitiveness and economic productivity. Various reasons has been adduced for the widening infrastructural gap and the urgent need to bridge the gap; from rapid urbanization (50% of Africans are expected to reside in urban areas by 2035), which has put a strain on existing utilities, to expanding population (population in Africa is expected to grow from 1.2 billion in 2019 to 2.5

billion in 2050), and the need to build climate change and resilient infrastructure as well as overall pursuit of economic growth (African Union Commission/Organisation for Economic Cooperation and Development (AUC/OECD), 2018).

There is low level of public capital in Africa but its role in boosting the needed economic growth in the region cannot not be undermined, and natural resource rents serve as an opportunity to scale-up the infrastructural development of the region, and this is expected to depend heavily on the quality of institutions, hence, this study seeks to investigate the effect of natural resource rents on infrastructure, and assess the effect of the interaction of natural resource rents with institutions on aggregate infrastructure as well as infrastructure types for forty SSA countries and across four regions (West Africa, Southern Africa, Central Africa and East Africa, and North Africa) for the period 2005 to 2018. This period was considered because of the paucity of dataset for the various components of aggregate infrastructure.

The present study is particularly germane because there are few or no known studies to the best of the researchers' knowledge that has linked natural resource rents to infrastructure and its varying components such as transport, electricity, ICT, and water and sanitation across the various sub-regions of SSA. However, there are scanty studies that link natural resource revenue to economic growth (such as, Karimu et al., 2016; Fuss et al., 2016) but there is no recognizable literature linking natural resource revenue to infrastructure in SSA.

This study breaks out of the mode by investigating the impact of natural resource revenue on aggregate infrastructure and its components across the various sub-region of the SSA. Also, considering the pertinent roles institutions play in fiscal revenue management, there are no known extant literature to the best of the researcher's knowledge that has examined the interaction of natural resource rents with governance indicators and their impact on aggregate infrastructure and infrastructure types in SSA. The current study stands out by linking natural resource rent with governance index to reveal the impact of natural resource revenue under a given institutional or political environment. This study will provide a dependable platform for critical public policy dialogue, design, formulation and implementation of policies as well as useful information for the sustainable management of critical natural resource endowments and rents in SSA countries in order to escape the natural resource curse syndrome.

2. Review of Relevant Literature

2.1 Theoretical literature review

The theoretical foundations of the relationship between natural resource revenue and physical capital are rooted in the debate about the substitutability of natural resources with physical capital. One of the earliest authors who created the nexus between natural resource rent and physical capital was Hartwick (1977) who affirmed reinvesting resource rents in reproducible capital so that the value of net investments would always be zero. In addition to the natural resource rent-physical capital nexus, other studies (for example, Barbier, 1999; Thompson, 2012) modified the neoclassical growth model to accommodate the role of non-renewable resources. Surprisingly, some authors (Sachs and Warner, 1997; 2001; Kaldor, Karl, and Said, 2007; Ross 2001; Sala-i-Martin and Subramanian, 2003) asserted that existing empirical literature from most developing countries show that resource rich countries tend to grow more slowly than countries without natural resources – This is the resource curse experience.

Another theory that has been put forward in the literature is the institutional model. The literature is divided on how institutions affect resource-rich countries. The first hypothesis suggests that natural resource revenue impacts an economy in varying ways, depending on pre-existing institutions. Conversely, the second hypothesis argues that it is the natural resources themselves that modify institutions. This then has the effect of transforming the developmental trajectory of the economy (Moreen, 2006). These arguments notwithstanding, it is obvious that the state of institutions is an important consideration in the wellbeing of resource-rich countries, especially as it relates to the allocation of resource revenue.

2.2 Empirical literature review

The empirical investigations that examine the relationship between natural resource revenue and infrastructure follow similar arguments as those that highlight the resource curse thesis. For instance, Foster & Briceno-Garmendia (2010) posit that institutional competence and capacity are important determinants of the performance of infrastructural provision across sectors in a country. Hence, countries may perform well in one sector and not in the other. Their findings suggest that sector-specific constraints may be as important as country-specific constraints.

Gylfason and Zoega (2001) examined the nexus between natural capital and physical capital for 85 countries from 1965 to 1980 and revealed that rising natural resource capital may hamper physical capital and economic growth, and that resource richness can hinder savings and investment indirectly by impeding the width and depth of the country's financial system. However, they argue that economic and structural reforms can overcome the adverse effect of resource abundance as evidenced by some formerly resource-dependent economies. Vandycke (2013) considered data from Eurasia and found that low accumulation of physical capital was propelled by weak institutions and economic policies based on resource rents, coupled with inadequate process of public investment management.

Karimu et al. (2016) examined the impact of natural resource rent on public physical investment for natural resource-endowed SSA countries for the period 1990 to 2013, employing a panel data estimation technique. Their empirical outcomes reveal that natural resource rents exert significant influence on public investment in SSA under considerable institutional and political conditions, and by extension, that physical capital exerts a positive effect on the overall economic growth of SSA countries. However, natural resource rents exert negative influence on some components of public investment expenditure like education and health. In a more recent study, Ali and Bhuiyan (2022) assessed the roles of governance in developing physical infrastructure through the utilization of natural resource rent and that the latter is highly significant in ensuring the infrastructural development of Middle East and North Africa countries.

3. Methodology

This study employs panel data of forty (40) SSA countries over the period 2005 to 2018. The study employs a dynamic panel data methodology to investigate the relationship between natural resource rents and infrastructure, and by extension, assesses the effects of the interaction of natural resource rents and institutional qualities on infrastructure. However, the governance index is estimated from six institutional indicators (voice and accountability, government effectiveness, control of corruption, rule of law, regulatory quality, and absence of violence and political stability) using the Principal Component Analysis (PCA) for panel data to avoid the likelihood of multicollinearity.

This study employs the system Generalized Method of Moments (s-GMM) estimator to examine the relationship between natural resource rents and infrastructure as well as the interaction terms for the full sample. The s-GMM approach was found appropriate for this study because it can tackle the likelihood of endogeneity, simultaneity bias, and reverse causality among the regressors. For the dynamic relationship between natural resource rents and aggregate and various components of infrastructures, the inclusion of many explanatory variables implies that the problem of endogeneity and heterogeneity cannot be de-emphasized as there are possible feedback effects between infrastructure, institutions and natural resource rents. Hence, under the conditions of endogeneity and likely heterogeneity, this study adopts the system GMM estimators as earlier stated. However, the consistency of the s-GMM estimator depends on the validity of the instruments used in the model as well as the assumption that error term does not exhibit serial correlation.

This study employed instruments chosen from the lagged endogenous variables (for example, lagged aggregate infrastructure) and explanatory variables (for example, lagged natural resource rent, institutional quality variables, government consumption expenditure, financial development variable (M2_gdp), gross fixed capital formation, population growth), and the s-GMM's over-identifying restrictions is performed via the famous J-statistics proposed by Hansen (1982). Our choice of a two-step s-GMM estimator is because of its asymptotic efficiency. The general s-GMM model to be followed by the study is:

$$y_{it} = \alpha_0 + y_{it-1} + \beta_i \sum_{i=1}^{n} \chi_{it} + \tau_i + \eta_j + \varepsilon_{it} \quad (1)$$

Drawing from the neoclassical growth model as modified by Thompson (2012) to take account of the depletion of natural resources of the non-renewable kind and the public investment model of Karimu et al. (2016), we present the baseline model for the study;

$$ag\_\inf_{it} = \alpha_0 + ag\_\inf_{it-1} + \beta_i \sum_{i=1}^{n} \chi_{it} + \tau_i + \eta_j + \varepsilon_{it} \quad (2)$$

where:

ag_infr_{it} = aggregate infrastructure

ag_infr_{it-1} = one period lag of aggregate infrastructure.

The aggregate infrastructure index is made up of the following composite indices, which we regard as infrastructure types in this study. They include:

(i) *transport composite index*: that is indicated by the total paved roads (km per 10,000 inhabitants), total road network in kilometres;

(ii) *electricity index:* net generation (kwh per inhabitants), that is, the total production of electricity of a given country, including energy imported from abroad;

(iii) *ICT composite index:* (total phone subscriptions (per 100 inhabitants), number of internet users (per 100 inhabitants), fixed–wired broadband internet subscribers (per 100 inhabitants) and international internet bandwidth (mbps);

(iv) *water and sanitation composite index*: improved water source (% of population with access), improved sanitation facilities (% of population with access.

X_{it} = vector of natural resource rents (sum of rents from oil, natural gas, coal, minerals, and forest resources according to the World Bank) as a percent of gdp,(natr_gdp); interactive term of governance index and natural resource rents is (inst_natr).

Guided by relevant and related empirical literature (for example, Albino-War et al., 2014; Stum and de Haan, 1998; Tanzi and Davoodi**,** 1997), this study controls for other critical variables that are potential drivers of infrastructural development in the estimated model, and these variables include: *gov_index*=governance index; *gdppc*=real gross domestic product per capita; *gfc_gdp*=general government final consumption expenditure (percent of gdp); *m*2*_gdp*=broad money (percent of gdp); *gfcf_gdp*=gross fixed capital formation (percent of gdp); *trd_gdp*=trade(percent of gdp) and *pop_gr*=population growth(annual percent). The random error term is denoted by ε_{it}; τ_i is a period specific effect common to the forty countries while η_j is the unobserved country-specific effects.

To address the question of the nature of the link between natural resource revenue and various infrastructural types, the study specified the following investment-type model:

$$Z_{it} = \alpha_0 + \beta_i \sum_{i=1}^{n} Z_{it-1} + \delta_i \sum_{i=1}^{n} \chi_{it} + \tau_i + \eta_j + \varepsilon_{it} \qquad (3)$$

where:

Z = Vector of various infrastructure types (e.g., transport, electricity, ICT, water and sanitation),

X = Vector of natural resource revenue, interactive term of natural resource revenue and governance index, and other control variables.

For a deeper assessment and expressive understanding of the effects of natural resource rents on infrastructure, this study categorized the 40 SSA countries into different geographical sub-regions across different infrastructural types. The effects of natural resource rents on aggregate infrastructure and infrastructure types across the sub-regions were analysed using the panel fully-modified ordinary least squares (PFMOLS) because it can accommodate the limited sample sizes of the sub-regions, and it has the capacity to preclude issues of serial correlation, heterogeneity and endogeneity among the regressors, taking into account period fixed effects. The PFMOLS model is estimated based on the following cointegrated system panel time series model (Pedroni, 2000) thus:

$$y_{it} = \alpha_0 + \alpha_{it}\beta + \varepsilon_{it} \qquad (4)$$

$$\chi_{it} = \chi_{it} + \varepsilon_{it}$$

To address the question of the nature of the link between natural resource rents and various infrastructural types across the SSA region as a unit as well as across the five regions of sub-Saharan Africa, the study specified the following panel FMOLS model:

$$y_{it} = \alpha_0 + \beta_i \sum_{i=1}^{n} \chi_{it} + \varepsilon_{it} \qquad (5)$$

In terms of apriori expectations, it is expected that natural resource rent is positively related to aggregate infrastructure as well as the various infrastructure types. The interactive term of governance and natural resource rents will either be positive or negative depending on the signs of the individual variables in the interactive term. If institutions are weak, they are expected to exert a negative effect on infrastructural development. Therefore, interacting such poor governance factor on natural resource rent will have an overall negative effect on infrastructure. If on the other hand, a nation has strong institutions, it should have a positive and significant impact on infrastructure so that the overall impact will be positive. The hypothesized signs are based on the empirical literature. For instance, Van der Ploeg and Poelhekke (2008), Van der Ploeg and Venebles (2011), Vandycke (2013), and Karimu et al. (2016) found evidence that resource rent boosts public investment but the level of investment specifically and growth generally depend on the quality of political institutions.

With regard to the various control variables in the model, governance index is hypothesized to have a positive or negative effect on infrastructure depending on the quality of institutions. Real gross domestic product per capital, broad money, gross fixed capital formation and trade should be positively related to infrastructure, while the general government final consumption expenditure and population growth should be negatively related to infrastructural development.

Data for the study were sourced from the World Development Indicators (WDI) 2019 and the African Development Bank's (2019) Africa Infrastructure Development Index (AIDI) and the dataset spans the period 2005 to 2018.

4. Empirical Analysis

4.1 Pre-estimation test result

4.1.1 *Descriptive Statistics*

Table 1 presents the summary statistics of the relevant variables employed in assessing the relationship between natural resource revenue, institutional quality and infrastructure in SSA. From the study, it can be observed that the average value of aggregate infrastructure index is about 18.512, ranging from a minimum value of 2.815 to a maximum of 94.324, with a standard deviation of about 15.876 in SSA. The implication of the low average value of aggregate infrastructure index in SSA countries is that progress in the infrastructural development of most of the SSA countries is slow although there were noticeable improvements in some of the sub-regions, like in the Southern and East Africa sub-regions. The mean value of total natural resources rents as a percentage of GDP is about 13.435% ranging from 0.001% to 59.604% with a standard deviation of 12.865. The implication of these figures is that infrastructural development in most of the SSA sub-regions grows in sync with the progress in the value added of natural resources rent of the various sub-regions.

Table 1. Descriptive Statistics

Variables	No. of obs	Mean: SSA	Mean: West Africa	Mean: Southern Africa	Mean: Central Africa	Mean: East Africa	Mean: North Africa	std dev.	min	max.
aggregate infrastructure development index	560	18.512	13.099	25.951	12.843	24.334	11.408	15.876	2.815	94.324
transport composite index	560	9.272	5.893	12.759	4.869	15.516	5.339	9.816	1.091	53.309
electricity composite index	560	7.503	1.863	15.736	4.921	9.041	3.220	15.455	0.000	82.376
ICT composite index	560	5.426	4.064	7.889	3.794	5.998	4.852	9.090	-0.792	63.445
water and sanitation composite index	560	55.570	51.693	61.457	51.250	58.940	51.757	18.790	7.546	99.788
total natural resources rents (% of GDP)	560	13.435	12.432	8.396	27.398	7.422	27.262	12.865	0.001	59.604
governance index	560	-0.254	-0.163	1.438	-2.192	0.337	-0.548	2.200	-3.868	5.769
control of corruption	560	-0.651	-0.718	-0.268	-1.236	-0.521	-0.742	0.607	-1.826	1.160
government effectiveness	560	-0.758	-0.872	-0.357	-1.293	-0.613	-0.858	0.615	-1.848	1.057
political stability and absence of violence	560	-0.494	-0.638	0.046	-0.948	-0.571	-0.673	0.815	-2.699	1.200
regulatory quality	560	-0.632	-0.641	-0.355	-1.136	-0.540	-0.678	0.567	-2.236	1.127
rule of law	560	-0.683	-0.743	-0.312	-1.255	-0.553	-0.829	0.604	-1.852	1.029
voice and accountability	560	-0.529	-0.396	-0.213	-1.268	-0.503	-0.872	0.665	-2.000	0.941
real GDP per capita (US dollars)	560	2559.8	924.69	3630.004	4436.174	2398.157	1677.072	3579.1	210.8	20532.950
government final consumption expenditure	560	14.811	12.599	19.799	10.928	15.439	13.718	6.532	2.047	41.888
broad money (% of GDP)	560	29.873	26.379	42.397	17.329	30.716	22.947	18.461	4.530	115.302
gross fixed capital formation (% of GDP)	560	21.832	19.437	21.331	23.870	23.216	36.918	7.969	2.000	54.304
trade (% of GDP)	560	76.393	67.848	89.271	83.480	63.919	92.061	38.893	20.723	311.354
population growth (annual %)	560	2.505	2.778	1.773	2.978	2.582	2.887	0.938	-2.629	4.655

Source: Authors' computation.

governance index: computed using the panel principal component analysis using governance indicators(control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law and voice and accountability). Obs=observations; std=stanradr deviation; min=minimum and max=maximum. SSA=sub-Saharan Africa

4.1.2 *Check for Cross-Section Dependence in Panel Dataset*

This study checked for the cross-section dependence in order to ascertain the spatial effects on the various residuals employing the Breuch-Pegan, Peseran Scaled, Bias-corrected scaled LM and Pesaran CD estimators, the estimators provided evidence for cross-section dependence in the panel data structure at 1 and 5 percent significance levels, thus rejecting the null hypothesis of no cross-section dependence in residuals of the panel data series employed. This result provides sufficient background for the our choice of unit root and co integration tests (see appendix) and the adoption of the FMOLS for this study, and the FMOLS is suitable to examining long run relationship of natural resource rents and aggregate infrastructure as well as its various components because of its ability to address issues of serial correlation and endogeneity that may be present in the model, and it allows for country-specific effects to be heterogeneous while estimating a long run relationship.

Table 2. Residual Cross-Section Dependence Test

Test	Statistic	Probability
Breusch-Pagan LM	2497.841*	0.0000
Pesaran scaled LM	43.49314*	0.0000
Bias-corrected scaled LM	41.95468*	0.0000
Pesaran CD	2.205521**	0.0274

Source: Author

** = 1 percent significance level ** = 5% significance level*

4.2 Estimation results

The empirical results from Table 3 show the absence of second-order serial correlation, hence, the acceptance of the null hypothesis of no autocorrelation. and the Hensen J-statistics show the validity of the various instruments employed across the myriad of regression analyses, and hence no problem of instrument over-identification. From Table 2, natural resource rents had negative but no significant impact on aggregate infrastructure in SSA countries, while in terms of infrastructure types, the results show that natural resource rents had positive and significant impact on transport at 1% significant level, while natural resource rents exerted negative and significant impact on electricity infrastructure at 1% significant level. With regard to ICT and water and sanitation infrastructure, natural resource revenue showed positive effect on the former and negative effect on the latter. In summary, the effect of natural resource rents on infrastructure across various infrastructure types presented mixed findings, and this may not be unconnected with the differences in the quality of institutional settings across sectors housing the various infrastructure types.

The results of the interaction of natural resource rent with institutional quality indicate that the interaction term is negative and significant in the case of aggregate infrastructure, transport and ICT infrastructure types – indicating the presence of the natural resource curse, but positive but not significant on electricity and water and sanitation infrastructure types. The findings are mixed and they simply imply that the allocation of natural resource revenues to various components of the aggregate infrastructure is conditional on institutional qualities. The empirical results obtained from the impact of the interaction of natural resource revenue with governance index on infrastructure also imply that the impact of natural resource rents on aggregate infrastructure depends largely on policies that ensure better institutional qualities for the various SSA countries. Moreover, infrastructural development thrives with abundance of natural resource revenue under a government that enjoys better quality of institutions, that is, natural resource rents promote infrastructural development where institutions are efficient. The empirical outcome revealing the negative effect of natural resource rents on infrastructure under varying political and institutional environments suggests, among other things, weakness of existing institutions, and that the public spending of natural resource rents may have been directed to other infrastructure investments.

In terms of control variables, the growth in the economy proxied by real GDP per capita exerts positive and significant effect on aggregate infrastructure, and maintains such impacts on other infrastructure types except for transport infrastructure. Gross fixed capital formation (proxy for domestic investment) exerts a positive impact on aggregate infrastructure while trade openness exerts positive and significant influence on aggregate infrastructure and most infrastructure types (except that of water and sanitation infrastructure), and this implies that trade openness complements the infrastructural development of SSA countries.

Table 3. Empirical Relationship between Natural Resource Revenue and Infrastructure in SSA

	Aggregate infrastructure	Transport infrastructure	Electricity infrastructure	ICT infrastructure	Water and sanitation infrastructure
Variables	system-GMM	system- GMM	system- GMM	system-GMM	system- GMM
log(aaidi)(-1)	0.909* (48.013)	0.657* (34.510)	0.438* (14.451)	0.801* (46.234)	0.926* (114.568)
log(natr_gdp)	-0.005 (-0.837)	0.011* (4.592)	-0.102* (-5.499)	0.015 (0.110)	-0.002 (-0.046)
inst_natr	-0.004* (-4.335)	-0.001* (-2.491)	0.001 (0.714)	-0.013* (-3.836)	0.010 (0.073)
log(gdppc)	0.063* (3.725)	-0.053* (-3.413)	0.033 (0.314)	1.622* (3.474)	0.015* (5.269)
log(gfc_gdp)	-0.012 (-0.877)	0.022* (3.124)	-0.048 (-0.836)	-0.012 (-0.105)	-0.001 (-0.716)
log(m2_gdp)	0.088* (6.721)	-0.017* (-3.381)	0.369* (3.181)	2.108* (7.979)	0.010* (4.596)
log(gfcf_gdp)	0.005 (0.474)	0.002 (0.323)	-0.086 (-1.468)	0.119 (0.593)	-0.001 (-0.897)
log(trd_gdp)	0.028** (2.007)	0.035* (4.715)	0.159* (3.247)	0.565* (3.370)	-0.001 (-1.284)
pop_gr	-0.002 (-0.837)	-0.002 (-0.609)	-0.017 (-1.417)	-0.310* (-5.459)	-0.001 (-1.099)
J- Statistics	32.756	29.059	31.549	38.006	26.582
AR(1)	-0.667*	-0.524*	-0.133*	-0.276*	-0.581*
AR(2)	0.054	0.080	0.689	0.345	0.105
No. of observations	520	520	520	520	520

Source: Authors.

** /** /*** = 1, 5 and 10 percent significant levels*

inst_natr = interactive term of governance index and natural resources rents; ICT= Information and Communication Technology; natr_gdp=total natural resource rent(percent of gdp; gov_index=governance index; gdppc=real gross domestic product per capita;gfc_gdp=general government final consumption expenditure(percent of gdp); m2_gdp=broad money(percent of gdp);gfcf_gdp=gross fixed capital formation(percent of gdp);trd_gdp=trade(percent of gdp) and pop_gr=population growth(annual percent). T-statistics are in parenthesis.

In order to ensure the robustness of our baseline estimation in Table 4, this study used an alternative estimator, i.e. panel FMOLS, in Table 5. The regression results in Table 4 show that natural resource rents exert negative and significant influence on aggregate infrastructure, and the interaction term exerts negative and significant influence on infrastructure. This result further validated the presence of the natural resource curse in SSA countries, and mixed findings across the infrastructure types.

For sub-regional analysis, in West Africa, natural resource rents had negative and significant effects on aggregate infrastructure, and the interaction of natural resource revenue and institutional quality exerted negative and significant effects on aggregate infrastructure. However, the findings on the effect of natural resource revenue on the various infrastructure components were mixed while the interaction terms maintained the same results. For example, natural resource revenue exerted positive and significant effect on transport and the ICT infrastructures, while the effect on electricity and water and sanitation infrastructure was negative and significant in the sub-region.

In the case of Southern African countries, natural resource rents exerted negative and significant influence on aggregate infrastructure at one percent significant level. However, the findings across infrastructure types were mixed. For example, natural resource revenue exhibited positive and significant influence on water and sanitation infrastructure at one percent significant level. Moreover, the interaction of institutional quality with natural resource rents exhibited a negative and significant influence on aggregate infrastructure and other infrastructure types at one percent significant level.

In the case of Central African countries, natural resource rents indicated a negative and significant effect on aggregate infrastructure at one percent significant level. Again, like other sub-regions, mixed findings were experienced among the infrastructure types. For example, natural resource revenue exerted positive and significant influence on transport and electricity infrastructure, while in terms of the impact of the interaction of natural resource rents and institutional quality on infrastructure, a negative and significant influence was exerted on aggregate infrastructure while mixed findings were observed across the various infrastructure types.

For East African countries, natural resource rents exerted positive and significant effects on aggregate infrastructure as well as other infrastructure types, though, no significant impact was exerted on electricity infrastructure. This attendant positive impact of natural resource revenue may not be surprising within the said period, taking into account the high infrastructural needs of the region in the 2016, 2017 and 2018 infrastructure development rankings by the African Development Bank (AfDB). The region scored 13.52, 14.00 and 14.60 respectively for 2016, 2017 and 2018, compared to those of North Africa, Southern Africa and West Africa with 71.63, 71.62, 72.96; 33.47, 34.97, 35.46; and 18.92, 19.76, and 20.47 respectively (AfDB, 2018). With the low infrastructure in the region, there is a high tendency for natural resource revenue to promote the infrastructural development of the region.

In terms of infrastructure types, the empirical results indicate a positive and significant impact of natural resource revenue on the various infrastructure types, except for electricity which had a positive but not significant impact. However, mixed findings were revealed in the impact of the interaction of natural resource revenue and governance index on infrastructure. For example, the interaction term exerted a negative and non-significant effect on aggregate infrastructure while the interaction term showed a positive impact on transport, electricity and ICT infrastructures and a negative and significant influence on water and sanitation infrastructure.

As a result of data paucity, this study represented the North African region with a single country – Mauritania, and this was done to have a fair representation of all the geographical sub-regions of Africa. The analysis was conducted with the time series version of the FMOLS. The empirical findings show that natural resource revenue exerted negative and significant effect on aggregate infrastructure. However, mixed findings were obtained across the various infrastructure types. In terms of the impact of interaction of natural resource revenue with governance index on infrastructure, the interaction term exerted a negative and significant influence on aggregate infrastructure as well as other infrastructure types.

Table 4. Empirical Relationship between Natural Resource Revenue and Infrastructure in SSA (Robustness check)

Variables	Aggregate infrastructure		Transport infrastructure		Electricity infrastructure		ICT infrastructure		Water and sanitation infrastructure	
	pFMOLS		pFMOLS		pFMOLS		pFMOLS		pFMOLS	
log(natr_gdp)	-0.042* (-11.406)	-0.041* (-11.405)	0.017* (3.734)	0.018* (3.721)	-0.230* (-12.917)	-0.231* (-12.979)	-0.388* (-7.121)	-0.385* (-7.097)	0.006* (3.952)	0.006* (4.039)
inst_natr	-0.001* (-9.362)	-0.001* (-9.591)	-0.001* (-8.128)	-0.001* (-8.171)	0.003* (6.110)	0.003* (6.110)	-0.018* (-11.364)	-0.018* (-11.517)	-0.001* (-29.436)	-0.001* (-29.692)
log(gdppc)	0.946* (78.287)	0.945* (79.109)	0.038* (2.419)	0.037* (2.364)	0.331* (5.587)	0.331* (5.614)	14.411* (79.754)	14.409* (80.042)	0.479* (97.138)	0.479* (97.621)
log(gfc_gdp)	-0.148* (-26.332)	-0.148* (-26.641)	0.029* (3.909)	0.029* (3.913)	-0.175* (-6.321)	-0.176* (-6.393)	0.095 (1.131)	0.104 (1.238)	-0.043* (-18.844)	-0.043* (-18.906)
log(m2_gdp)	0.601* (89.072)	0.600* (89.916)	-0.101* (-11.529)	-0.101* (-11.534)	0.578* (17.435)	0.575* (17.424)	9.250* (91.674)	9.242* (91.929)	0.322* (116.841)	0.321 (117.308)
log(gfcf_gdp)	-0.050* (-9.522)	-0.049* (-9.390)	0.043* (6.247)	0.043* (6.266)	-0.303* (-11.651)	-0.299* (-11.590)	-0.676* (-8.535)	-0.667* (_8.455)	-0.002 (-0.961)	-0.002 (-0.834)
log(trd_gdp)	-0.082* (-10.753)	-0.082* (-10.887)	-0.044* (-4.446)	-0.045* (-4.469)	0.198* (5.271)	0.199* (5.316)	-0.556* (-4.855)	-0.566* (-4.960)	0.031* (10.023)	0.031* (10.024)
pop_gr	0.094* (-26.301)	-0.094* (-26.552)	-0.044* (-9.461)	-0.044* (-9.496)	-0.059* (-3.347)	-0.059* (-3.379)	-1.281* (-23.838)	-1.276* (-23.830)	-0.022* (-15.318)	-0.022* (-15.367)
R squared	0.952	0.952	0.981	0.981	0.955	0.955	0.681	0.681	0.934	0.934
adj. R squared	0.947	0.947	0.979	0.979	0.950	0.950	0.649	0.649	0.928	0.928
No. of observations	520	520	520	520	519	519	520	520	520	520
Period fixed effects included	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Source: Authors.

** /** /*** = 1, 5 and 10 percent significant levels; inst_natr = interactive term of governance index and natural resources rents.*
t-statistics are in parenthesis.

Table 5. Empirical Relationship between Natural Resource Revenue and Infrastructure in West Africa

	Aggregate infrastructure		Transport infrastructure		Electricity infrastructure		ICT infrastructure		Water and sanitation infrastructure	
Variables	pFMOLS		pFMOLS		pFMOLS		pFMOLS		pFMOLS	
log(natr_gdp)	-0.074* (-7.599)	-0.071* (-7.529)	0.054* (4.490)	0.054* (4.524)	-0.204* (-5.081)	-0.198* (-5.052)	1.075* (7.968)	1.094* (8.148)	-0.051* (-14.761)	-0.050* (-14.968)
inst_natr	-0.005* (-11.747)	-0.005* (-12.031)	-0.003* (-5.929)	-0.003* (-5.974)	-0.004* (-3.029)	-0.005* (-3.069)	-0.015* (-2.836)	-0.015* (-2.825)	-0.003* (-18.734)	-0.003* (-19.240)
log(gdppc)	1.537* (49.040)	1.536* (50.129)	0.408* (10.488)	0.409* (10.496)	1.029* (7.945)	1.027* (8.102)	15.510* (35.551)	15.488* (35.644)	0.632* (57.083)	0.633* (58.444)
log(gfc_gdp)	-0.004 (-0.323)	-0.004 (-0.268)	0.071* (4.181)	0.071* (4.192)	-0.297* (-5.280)	-0.294* (-5.329)	0.398** (2.095)	0.401** (2.121)	0.024* (5.034)	0.025* (5.231)
log(m2_gdp)	0.518* (37.852)	0.517* (38.673)	-0.209* (-12.284)	-0.209* (-12.293)	0.280* (4.928)	0.280* (5.048)	8.517* (44.691)	8.524* (44.914)	0.288* (59.604)	0.288* (60.943)
log(gfcf_gdp)	0.003 (0.305)	0.005 (0.425)	-0.056* (-3.974)	-0.056* (-3.976)	-0.181* (-3.829)	-0.178* (-3.849)	1.509* (9.494)	1.516* (9.573)	0.017* (4.258)	0.018* (4.445)
log(trd_gdp)	-0.028** (-2.001)	-0.032** (-2.323)	-0.077* (-4.365)	-0.078* (-4.437)	0.346* (5.886)	0.335* (5.822)	-0.875* (-4.446)	-0.910* (-4.647)	0.029* (5.948)	0.029* (5.924)
pop_gr	-0.126* (-10.810)	-0.123* (-10.769)	-0.037* (-2.528)	-0.035* (-2.429)	-0.013 (-0.272)	-0.003 (-0.070)	-1.254* (-7.734)	-1.225* (-7.584)	-0.033* (-8.002)	-0.032* (-7.891)
R squared	0.936	0.936	0.950	0.950	0.933	0.932	0.818	0.818	0.954	0.953
adj. R squared	0.928	0.928	0.944	0.944	0.923	0.924	0.794	0.794	0.948	0.948
No. of observations	182	182	182	182	181	181	182	182	182	182
Period fixed effects included	*No*	*Yes*	*No*	*Yes*	*No*	*yes*	*No*	*Yes*	*No*	*Yes*

Source: Authors.

** /** /*** = 1, 5 and 10 percent significant levels. t-statistics are in parenthesis. pFMOLS=panel Fully Modified Ordinary Least Squares*

inst_natr = interactive term of individual institutional quality indicators and natural resources rents.

Table 6. Empirical Relationship between Natural Resource Revenue and Infrastructure in Southern Africa

Variables	Aggregate infrastructure		Transport infrastructure		Electricity infrastructure		ICT infrastructure		Water and sanitation infrastructure	
	pFMOLS		pFMOLS		pFMOLS		pFMOLS		pFMOLS	
log(natr_gdp)	-0.017*	-0.017*	-0.024*	-0.024*	-0.239*	-0.243*	-0.083	-0.087	0.080*	0.081*
	(-5.246)	(-5.195)	(-4.381)	(-4.394)	(-6.719)	(-6.872)	(-1.029)	(-1.104)	(48.651)	(48.467)
inst_natr	-0.001*	-0.001*	-0.001*	-0.001*	-0.004*	-0.004*	-0.034*	-0.035*	-0.003*	-0.003*
	(-6.664)	(-6.859)	(-4.420)	(-4.431)	(-2.736)	(-2.779)	(-9.846)	(-10.299)	(-40.878)	(-40.781)
log(gdppc)	0.829*	0.828*	-0.251*	-0.251*	-0.078	-0.069	19.952*	19.867*	0.714*	0.714*
	(44.874)	(44.923)	(-8.132)	(-8.142)	(-0.386)	(-0.347)	(43.889)	(44.709)	(76.067)	(75.709)
log(gfc_gdp)	-0.124*	-0.124*	0.058*	0.057*	-0.260*	-0.266*	-1.441*	-1.401*	-0.196*	-0.196*
	(-16.694)	(-16.670)	(4.677)	(4.626)	(-3.209)	(-3.301)	(-7.862)	(-7.819)	(-51.719)	(-51.437)
log(m2_gdp)	0.401*	0.401*	-0.108*	-0.109*	0.749*	0.755*	4.989*	4.908*	0.406*	0.406*
	(43.276)	(43.414)	(-6.946)	(-7.041)	(7.420)	(7.519)	(21.856)	(22.264)	(86.100)	(85.705)
log(gfcf_gdp)	-0.086*	-0.085*	0.039*	0.039*	-0.132**	-0.137**	-0.620*	-0.613*	0.134*	0.135*
	(-14.375)	(-14.301)	(3.876)	(3.904)	(-2.033)	(-2.119)	(-4.226)	(-4.271)	(44.402)	(44.231)
log(trd_gdp)	-0.181*	-0.181*	0.064*	0.064*	-0.387*	-0.388*	-3.676*	-3.716*	0.013**	0.013**
	(-16.784)	(-16.869)	(3.534)	(3.574)	(-3.302)	(-3.306)	(-13.856)	(-14.293)	(2.365)	(2.300)
pop_gr	-0.152*	-0.152*	0.018	0.018	0.176**	0.175**	-1.046*	-1.030*	-0.061*	-0.061*
	(-21.994)	(-22.073)	(1.591)	(1.553)	(2.331)	(2.336)	(-6.139)	(-6.185)	(-17.346)	(-17.227)
R squared	0.962	0.962	0.993	0.993	0.897	0.897	0.683	0.684	0.948	0.948
adj. R squared	0.957	0.957	0.992	0.992	0.882	0.883	0.638	0.638	0.940	0.940
No. of observations	143	143	143	143	143	143	143	143	143	143
Period fixed effects included	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*

Source: Authors.

** /** /*** = 1, 5 and 10 percent significant levels. t-statistics are in parenthesis*

inst_natr = interactive term of individual institutional quality indicators and natural resources rents.

Table 7. Empirical Relationship between Natural Resource Revenue and Infrastructure in Central Africa

Variables	Aggregate infrastructure		Transport infrastructure		Electricity infrastructure		ICT infrastructure		Water and sanitation infrastructure	
	pFMOLS		pFMOLS		pFMOLS		pFMOLS		pFMOLS	
log(natr_gdp)	-0.093*	-0.093*	0.031**	0.031**	0.031**	0.031**	-0.089*	-0.799*	-0.031*	-0.031*
	(-8.277)	(-8.531)	(2.326)	(2.318)	(2.326)	(2.318)	(-4.184)	(-4.189)	(-6.566)	(-6.831)
inst_natr	-0.001*	-0.001*	0.001*	0.001*	0.001*	0.001*	-0.029*	-0.029*	0.001***	0.001***
	(-4.721)	(-4.766)	(2.988)	(2.950)	(2.988)	(2.954)	(-11.096)	(-11.206)	(1.714)	(1.764)
log(gdppc)	0.164*	0.162*	-0.295*	-0.297*	-0.295*	-0.297*	6.651*	6.601*	-0.034*	-0.035*
	(6.116)	(6.223)	(-9.213)	(-9.266)	(-9.213)	(-9.266)	(14.385)	(14.469)	(-3.303)	(-3.233)
log(gfc_gdp)	-0.239*	-0.239*	0.004	0.004	0.004	0.004	-0.092	-0.112	-0.073*	-0.073*
	(-20.293)	(-21.003)	(0.302)	(0.286)	(0.302)	(0.286)	(-0.457)	(-0.559)	(-14.655)	(-15.343)
log(m2_gdp)	0.664*	0.662*	-0.083*	-0.082*	-0.083*	-0.082*	11.678*	11.669*	0.199*	0.198*
	(49.997)	(51.410)	(-5.206)	(-5.208)	(-5.206)	(-5.208	(51.103)	(51.749)	(35.626)	(37.080)
log(gfcf_gdp)	-0.023**	-0.022**	0.095*	0.096*	0.096*	0.096*	-0.714*	-0.703*	-0.005	-0.004
	(-2.114)	(-2.097)	(7.255)	(7.215)	(7.255)	(7.275)	(-3.759)	(-3.753)	(-1.042)	(-0.999)
log(trd_gdp)	0.029	0.030	0.194*	0.195*	0.194*	0.195*	-0.787**	-0.779**	0.061*	0.062*
	(1.449)	(1.511)	(8.195)	(7.275)	(8.195)	(8.236)	(-2.307)	(-2.314)	(7.334)	(7.714)
pop_gr	-0.086*	-0.087*	0.001	0.001	0.001	0.001	-1.418*	-1.453*	-0.060*	-0.062*
	(-11.404)	(-12.004)	(0.088)	(0.036)	(0.088)	(0.036)	(-10.977)	(-11.397)	(-19.071)	(-20.396)
R squared	0.967	0.967	0.988	0.988	0.988	0.988	0.787	0.787	0.994	0.994
adj. R squared	0.961	0.961	0.986	0.986	0.986	0.986	0.748	0.748	0.993	0.993
No. of observations	91	91	91	91	91	91	91	91	91	91
Period fixed effects included	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*

Source: Authors.

** /** /*** = 1, 5 and 10 percent significant levels. t-statistics are in parenthesis*

inst_natr = interactive term of individual institutional quality indicators and natural resources rents.

Table 8. Empirical Relationship between Natural Resource Revenue and Infrastructure in East Africa

Variables	Aggregate infrastructure		Transport infrastructure		Electricity infrastructure		ICT infrastructure		Water and sanitation infrastructure	
	pFMOLS		pFMOLS		pFMOLS		pFMOLS		pFMOLS	
log(natr_gdp)	0.048* (3.201)	0.050* (3.421)	0.081* (3.232)	0.080* (3.203)	0.002 (0.055)	0.006 (0.194)	0.602* (3.547)	0.609* (3.604)	0.081* (11.658)	0.081* (11.760)
inst_natr	-0.001 (-1.025)	-0.001 (-1.412)	0.001 (0.298)	0.001 (0.292)	0.016* (11.008)	0.015* (11.097)	0.135* (18.478)	0.134* (18.414)	-0.002* (-6.344)	-0.002* (-6.548)
log(gdppc)	1.695* (43.348)	1.690* (44.625)	0.294* (4.544)	0.289* (4.479)	2.368* (27.922)	2.354* (28.698)	25.728* (58.743)	25.756* (58.940)	1.216* (68.056)	1.216* (68.373)
log(gfc_gdp)	-0.161* (-7.788)	-0.160* (-7.993)	-0.015 (-0.544)	-0.015 (0.453)	0.315* (7.035)	0.311* (7.184)	-2.239* (-9.694)	-2.226* (-9.659)	0.041* (4.381)	0.042* (4.450)
log(m2_gdp)	0.093* (3.865)	0.094* (4.005)	-0.113* (-2.842)	-0.112* (-2.805)	0.063 (1.209)	0.068 (1.338)	2.733* (10.118)	2.730* (10.129)	-0.150* (-13.598)	-0.150* (-13.701)
log(gfcf_gdp)	-0.245* (-9.661)	-0.240* (-9.766)	-0.006 (-0.138)	-0.004 (-0.107)	-0.289* (-5.254)	-0.277* (-5.201)	-7.493* (26.383)	-7.482* (-26.404)	-0.329* (-28.428)	-0.328* (-28.476)
log(trd_gdp)	-0.464* (-18.377)	-0.463* (-18.941)	-0.469* (-11.243)	-0.469* (-11.232)	0.242* (4.423)	0.242* (4.571)	0.248 (0.878)	0.241 (0.853)	-0.102* (-8.813)	-0.102* (-8.894)
pop_gr	-0.004 (-0.820)	-0.005 (-1.021)	-0.047* (-5.387)	-0.047* (-5.403)	0.065* (5.633)	0.063* (5.633)	-0.231* (-3.881)	-0.234* (-3.944)	0.029* (11.814)	0.029* (11.807)
R squared	0.976	0.976	0.959	0.959	0.991	0.991	0.764	0.764	0.931	0.931
adj. R squared	0.971	0.971	0.952	0.952	0.989	0.989	0.720	0.721	0.918	0.918
No. of observations	91	91	91	91	91	91	91	91	91	91
Period fixed effects included	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*

Source: Authors.
** /** /*** = 1, 5 and 10 percent significant levels. t-statistics are in parentheses*
inst_natr = interactive term of individual institutional quality indicators and natural resources rents.

5. Policy Implications, Recommendations and Conclusion

The core objective of this paper was to examine the effect of resource revenue on aggregate infrastructure. The study particularly focused on three pertinent policy areas as they relate on the role of natural resource revenue as a source of finance for public investment. The study started by investigating the nature of the relationship between natural resource rent and infrastructure. Then it progressed to examining this relationship across various infrastructural types. The paper also interacted natural resource revenue with governance indicators to determine the interactive effects on infrastructure and infrastructure types in SSA.

The study employed panel data of forty (40) SSA countries covering the period 2005 to 2018. A dynamic panel data methodology was employed to investigate the relationship between natural resource rents and infrastructure, and by extension assess the effects of the interaction of natural resource revenue and institutional qualities on infrastructure. The variables included in the study were aggregate infrastructure, total natural resource rent, interactive term of governance index and natural resources rents. The control variables utilized in the study include real gross domestic product per capita; general government final consumption expenditure, broad money, gross fixed capital formation, trade, and population growth.

The study utilized both the two-step system GMM and the panel FMOLS. Evidence from the study indicates that the allocation of natural resource revenues to various components of aggregate infrastructure is conditional on institutional qualities. In other words, infrastructural development thrives with the abundance of natural resource revenue under a government that enjoys better quality of institutions, that is, natural resource rent promotes infrastructural development where institutions are efficient.

With regard to policy direction, findings from the study imply that resource rent is a veritable source of finance for infrastructural development but the transmission mechanism would only work effectively if institutional quality is top notch. Hence, government in SSA should focus on developing strong and efficient institutions which should ultimately allow for resource revenue to be channeled to building strong and resilient infrastructure.

References

Albino-War, M., Cerovic, S., Grigoli, F., Flores, J.C., Kapsoli, J., Qu, H., Said, Y., Shukurov, B., Sommer, M. & Yoon, S. (2014). Making the most of public investment in MENA and CCA oil-exporting countries. IMF Staff Discussion Note SDN/14/10. Washington, DC: International Monetary Fund (IMF). Available at: https://www.imf.org/external/pubs/ft/sdn/2014/sdn1410.pdf (accessed 15 March 2016).

Ali, H.E., & Bhuiyan, S. (2022). Governance, natural resources rent and infrastructure development: Evidence from the Middle East and North Africa. Political Policy. https://doi.org/10.1111/polp.12451

AfDB. (2018). The Africa infrastructure development index 2018.

AfDB (2019). The Africa infrastructure development index 2019.

AfDB (2018). Financing Infrastructure: Strategies and Instruments. African Economic Outlook.

AUC/OECD. (2018). *Africa's Development Dynamics 2018. Growth, Jobs and Inequalities*. Paris: OECD Publishing. https://doi.org/10.1787/9789264302501-en

Barbier, E.B. (1999). Endogenous growth and natural resource scarcity. *Environmental and Resource Economics, 14*(1), 55 -74.

Foster, V., & Briceno-Garmendia, C. (2010). Africa's infrastructure: A time for transformation. Africa Development Forum. Washington DC. The World Bank.

Fuss, S., Chen, C., Jakob, M., Marxen, A., Rao, N.D., & Edenhofer, O. (2016). Could resource rents finance universal access to infrastructure? A first exploration of needs and rents. *Environment and Development Economics*, Available on CJO 2016 doi:10.1017/S1355770X16000139

Global Infrastructure Outlook. (2020). *Infrastructure investment need in the compact with Africa countries*. Global Infrastructure Hub. Oxford Economics.

Gylfason, T., & Zoega, G. (2001). *Natural resource and economic growth: the role of investment*. No 01-02. EPRU Working Paper series, University of Copenhagen, Department of Economics.

Hansen, L.P. (1982). Large sample properties of generalized method of moments estimators. *Econometrica*, *50*(4), 1029 -1054.

Hartwick, J.M. (1977). Intergenerational equity and the investing of rents from exhaustible resources. *American Economic Review*, *16*: 131-151.

Kaldor, M., Karl, T.L., & Said, Y. (2007). *Oil wars*. Ann Arbor, MI: Pluto Press.

Karimu, G.A., Marbuah, G., Mensah, J.T., & Amuakwa-Mensah, F. (2016). Natural resource revenues and public investment in resource-rich economies in sub-Saharan Africa. WIDER Working Paper 2016/24.

Moreen, A.L. (2006). *Overcoming the "resource curse" prioritizing policy interventions in countries with large extractive industries*. Santa Monica. CA.: Pardee Rand Graduate School.

Pedroni, P. (2000). Fully modified OLS for heterogenous cointegrated panels. Nonstationary panels, panel cointegration and dynamic panels. *Advances in Economics*, *15*, 93 -130.

Ross, M. (2001). Does oil hinder democracy? *World Politics*, *53*, 325-61.

Sachs, J.D., & Warner, A.M. (1997). *Natural resource abundance and economic growth*. Center for International Development and Harvard Institute for International Development.

Sala-i-Martin, X., & Subramanian, A. (2003). *Addressing the natural resource curse: an illustration from Nigeria*. Natl. Bur. Econ. Res. (NBER), (Working Paper 9804).

Sturm, J.-E., & de Haan, J. (1998). Public capital spending in the Netherlands: Developments and explanations. *Applied Economics Letters*, *5*(1): 5–10.

Tanzi, V., & Davoodi, H.R. (1997). Corruption, public investment, and growth. IMF Working Paper WP/97/139. Washington, DC: International Monetary Fund (IMF). Available at: https://www.imf.org/external/pubs/ft/wp/wp97139.pdf (accessed 15 March 2016).

The Economist Intelligence Unit. (2019). The Critical Role of Infrastructure for the Sustainable Development Goals.

Thompson H. (2012). Economic growth with a non-renewable resource. *Journal of Energy and Development*. Auburn University.

Vandycke N. (2013). *Natural resources, physical capital and institutions: Evidence from Eurasia.* Policy Research Working Paper; No. 6586. Washington DC.: World Bank.

Van der Ploeg, F., & Poelhekke, S. (2008). *Volatility and Natural Resource Curse*. OxCarre Research Paper. No.2008-3, University of Oxford.

Van der Ploeg, F., & Venebles, A.J. (2011). Harnessing windfall revenues: optimal policies for resources-rich developing economies. *The Economic Journal*, *121*(551), 1-30.

World Bank. (2019). World Development Indicators. Available at: http://data.worldbank.org/news/ release-of-world-development-indicators-2019.

APPENDIX

Homogeneous and Heterogeneous Panel Unit Root Tests

	Homogeneous		***Heterogeneous***		
	LLC	***BRT***	***IPS***	***ADF***	
			Levels		
aaidi	-0.773	3.289	-0.568	83.415	65.976
natr_gdp	-1.974**	5.206	0.105	83.447	85.832
gov_index	-2.989*	0.701	-1.678**	104.056**	183.341*
gdppc	-7.179*	2.471	0.119	84.225	62.452
m2_gdp	-4.149*	1.676	0.757	79.919	84.619
trd_gdp	-4.692*	-0.807	-0.568	84.698	108.156*
gfc_gdp	-10.982*	-1.101	-3.576*	139.751*	145.523*
gfcf_gdp	-4.347*	-0.176	0.335	72.901	70.369
	Homogeneous		***Heterogeneous***		
	LLC	***BRT***	***IPS***	***ADF***	
			First Difference		
Aaidi	-3.770*	1.614	-1.225	96.176	141.990*
natr_gdp	-12.363*	2.222	-4.112*	146.537*	273.501*
gov_index	-7.299*	-1.871**	-4.997*	163.782*	381.906*
Gdppc	-10.745*	-5.821*	-4.311*	144.873*	211.053*
m2_gdp	-6.423*	-2.624*	-2.426*	112.273*	313.762*
trd_gdp	-6.695*	-4.723*	-2.917*	119.44*	305.639*
gfc_gdp	-11.435*	-3.599*	-6.681*	179.745*	412.875*
gfcf_gdp	-10.444*	-4.810*	-4.466*	148.511*	365.582*

*LLC=Levin Lee and Chu, BRT= Breitung, IPS = Im, Pasaran and Shin, ADF = Augmented Dickey Fuller, PP= Phillip Peron. */**/ = 1% and 5% significance levels.*

Note: All variables were stationary after first difference at 1% significance level.

Kao Residual Cointegration Test

	t-Statistics	Probability
ADF	0.808	0.209
Residual Variance	2.215	
HAC Variance	3.354	

There is no evidence of cointegration with the homogeneous panel cointegration approach

Pedroni Residual Cointegration Test

Within Dimension		
	Statistics	Probability
Panel V-statistics	8.073*	0.000
Panel rho –statistics	7.220	1.000
Panel PP – Statistics	-31.259*	0.000
Panel ADF – Statistics	-0.227	0.410

Between Dimension		
	Statistics	Probability
Group rho-statistics	10.309	1.000
Group PP-Statistics	-31.600*	0.000
Group ADF-Statistics	-1.081	0.140

** = 1% significance level..* ***There was evidence of co integration at 1% significance level.***