A G D I Working Paper

WP/22/094

Natural Resources, Renewable Energy, and Governance: A path towards sustainable development

Forthcoming: Sustainable Development

Tii N. Nchofoung
(Corresponding author)
University of Dschang, Cameroon
&
Ministry of Trade, Cameroon
E-mail: ntii12@yahoo.com

Nathanael Ojong
York University, 324 Founders College, 4700 Keele Street,
Toronto, ON M3J 1P3, Canada
E-mail: nojong@yorku.ca

Research Department

Natural Resources, Renewable Energy, and Governance: A path towards sustainable development

Tii N. Nchofoung & Nathanael Ojong

Abstract

Based on data for 48 African countries for the period 2000–2020, we analyse the effects of natural resources on renewable energy development and the mediating effects of governance on that relationship. For this purpose, the Ordinary Least Squares method was used to develop a baseline regression model, and the Generalized Method of Moments (GMM) approach was used for the dynamic model regression. Quantile regression was used for robustness checking across the various distributions of renewable energy. First, we find that natural resources enhance renewable energy development in Africa and that the results are robust across alternative specifications of natural resources and governance, except for forest resources, which have a negative effect on renewable energy development. When robustness is checked through a quantile regression analysis, the results show that the positive effect depends on the conditional distribution of natural resources and the type of natural resource under consideration. The negative effect of total natural resources becomes weaker as we move towards higher quantiles. Second, governance interacts with natural resource rents to generate positive effects across different governance specifications and natural resources, except for coal rent. We thereby derive some relevant implications for renewable energy financing in African countries.

Keywords: Sustainable development, renewable energy, natural resources, governance, Africa, SDG7
JEL Codes: C23; Q33; Q48

1. Introduction

Global efforts to achieve the sustainable development agenda are challenged by several factors, among which is the persistent increase in environmental degradation. To address this issue, renewable energy is increasingly regarded as essential to reducing greenhouse gas emissions and mitigating climate change (Fotis and Polemis, 2018; Kuriqi et al., 2019;Lohani et al., 2022;Lu et al., 2020; Mazzucato and Semieniuk, 2018;Tabrizian, 2022).An increase in renewable energy consumption can foster energy security, sustainable economic development, and economic growth (Alper and Oguz, 2016; Destek, 2016; Destek and Aslan, 2017; Ojong, 2022a; Okumus et al., 2021; Rafindadi and Ozturk, 2017a).It also has a major role to play in tackling energy poverty in Africa (Akella et al., 2009; Kaygusuz, 2011; Ojong, 2021; Szabó et al., 2013) as well as counteracting negative shocks, especially in the agricultural sector (Nchofoung, 2022; Tiwari et al., 2022). Renewable energy contributes to different facets of sustainability in relation to the economy, energy, environment, and society, and therefore an increase in renewable energy consumption is necessary in contemporary Africa (Destek et al., 2022; Hosseini, 2022; Kalair et al., 2021; Kuriqi et al., 2017; Rafindadi, 2016a; Rafindadi et al., 2018; Riti et al., 2018).

Natural resources have a crucial role to play in renewable energy development, and Africa is endowed with rich natural resources such as minerals, arable land, forests, freshwater, oil, and natural gas (Byaro et al., 2022; Erdoğan et al., 2021). The continent is a key player in oil production (Graham and Ovadia, 2019), and it is estimated that 100 billion barrels of oil await discovery offshore (Rotimi and Ngalawa, 2017). Africa’s forests account for approximately 21% of its total land area (Hetemäki et al., 2021). The continent is also home to the world's largest arable landmass, accounts for about 30% all global mineral reserves (AfDB, 2016), and possesses deposits of minerals (e.g., iron, cobalt, manganese, aluminium, and copper) that are vital for the renewable energy sector (Ojong, 2022b). In fact, minerals account for an average of 70% of total exports from the continent (AfDB, 2016). Thus, in theory, natural resource rents could be used to finance renewable energy projects.

However, studies have noted that multiple African countries suffer from the natural resource curse (Carbonnier, 2013; Collier and Hoeffler, 2005; Isham et al., 2005; Leite and Weidmann, 1999), and some studies argue that rent-seeking might discourage entrepreneurship (Mehlum et al., 2006; Tornell and Lane, 1998), increase corruption (Bhattacharyya and Hodler, 2010), and cause conflicts or civil wars (Caselli and Coleman, 2013; Collier and Hoeffler, 1998), especially when these resources are not evenly distributed (Lessmann and Steinkraus, 2019). Other studies, however, contend that the natural resource curse in Africa may be attributed to weak institutions and the mismanagement of natural resource rents (Badeed et al., 2017; Mlachila & Ouedraogo, 2019). Others argue that the lack of appropriate governance structure is responsible for the phenomenon (Germond-Duret, 2014; Humphreys et al., 2007).

Governance is defined as "the traditions and institutions by which authority in a country is exercised", which includes "(a) the process by which governments are selected, monitored and replaced"; "(b) the capacity of the government to effectively formulate and implement sound policies"; and finally,"(c) the respect of citizens and the state for the institutions that govern economic and social interactions among them" (Kaufmann et al., 2011, p. 222). Focusing on public sector management, the World Bank states that the concept of governance captures "the manner in which power is exercised in the management of a country's economic and social resources for development" (World Bank, 1992, p. 1). Clearly, good governance is vital to improving environmental and socio-economic outcomes in Africa (Asongu and Odhiambo, 2019).

Despite the crucial role of governance in socio-economic development, there is a blind spot in the scholarly literature regarding its mediating role in the natural resource endowment–renewable energy development nexus. Researchers have examined the nexus between natural resources and environmental degradation (Shittu et al., 2021; Wang et al., 2021), the nexus between CO_2 emissions and resource rent (Bekun et al., 2019), the relationship between natural resources and ecological footprints (Nathaniel et al., 2021), the association between renewable energy consumption and carbon dioxide emissions (Bhattacharya et al., 2017; Salim and Rafiq, 2012), the influence of renewable energy and natural resources on environmental quality (Li et al., 2022; Zafar et al., 2021), and the long-run and causal effect of financial development and renewable energy consumption on environmental sustainability (Kirikkaleli and Adebayo, 2021). However, those studies did not investigate the mediating role of governance in the relationship between natural resource endowment and renewable energy development. While Ahmadov and van der Borg (2019) investigated the relationship between natural resources and renewable energy production, their study only focused on the European Union.

Thus, the objectives of this paper are to examine the effect of natural resource abundance on renewable energy development in Africa and the mediating effect of governance in this relationship. It does so by using data for 48 African countries for the period 2000–2020. The study is driven by the following research questions: (i) What is the effect of natural resources on renewable energy development in Africa? and (ii) What is the mediating effect of governance in this situation? Examining the relationship between natural resources and renewable energy is of particular importance for the sustainable development agenda in Africa, especially regarding the United Nations' Sustainable Development Goal 7 (SDG7), which has the aim of ensuring access to affordable, reliable, sustainable and modern energy for all (UNDP, 2015). However, the transition from fossil fuels to renewable energy has been slow, and concerted efforts and policies are required to speed up this transition (Hosseini, 2022).

This study makes three core contributions to the literature. First, to our knowledge, this is one of the first empirical studies on the mediating role of governance in the natural resource–renewable energy nexus in Africa. We advance the literature on the natural resource–renewable energy nexus by examining the mediating role of governance, and the corresponding thresholds needed for efficient policies are provided. The closest studies on this issue are those by Ahmadov and van der Borg (2019) and Baye et al. (2022) and however, these studies did not take into consideration the role of governance in establishing the determinants of renewable energy outputs. Also, both studies examined the direct effects, while our study investigates both the direct and indirect effects. Additionally, Baye et al. (2022) used a non-dynamic panel methodology, while Ahmadov and van der Borg (2019) applied a multivariate panel method.Our study departs from the methods used in both studies, as we use a dynamic panel model and integrate key initial economic conditions in the analysis. Second, unlike the significant proportion of research on financing renewable energy development, we argue that African countries could use resource rents to finance renewable energy development. Third, by examining the mediating role of governance, we bring to the fore the need for policymakers to tackle the thorny issue of governance on the continent, as this has implications for renewable energy development. Addressing governance issues is necessary to achieve SDG 7. Put differently, this study contributes to the policy debates in Africa regarding factors that influence renewable energy development.

Building on this foundation, the next section reviews the literature and provides theoretical grounding, while the third section describes our research methodology and the variables and data sources used in our analysis. The fourth section presents and discusses the results, while the fifth section provides concluding remarks and policy implications.

2. Literature Review

The theoretical foundation of this study is based on Hartwick's (1977) work, which showed that natural resource rents represent available capital, and that capital stock obtained from natural resource rents could be invested into different sectors, including the energy sector

(Hartwick, 1977). This aligns with the argument that resource rents can be invested towards the sustainable development of natural resources-rich countries (Thampapillai et al., 2014; Van der Ploeg, 2011).

However, while overall natural resource wealth can be a good source of financing for renewable energy development, specific natural resources such as oil can be harmful due to their potentially corrosive effect on governance and the economy (Ahmadov and van der Borg, 2019). One of the principal factors that encourage investment in an economy is economic performance; however, studies argue that natural resources degrade the quality of institutions, leading to poor economic performance (Dwumfour and Ntow-Gyamfi, 2018; Henri, 2019; Isham et al., 2005; Leite and Weidmann, 1999).

The empirical literature is divided into four strands. The first strand examines sources of financing renewable energy, and the second analyses the effects of governance on economic investments in general and in the energy sector in particular. The third strand investigates the effect of natural resources on economic development and investment, and the last strand deals with the mediating effect of governance in the natural resources–renewable energy nexus. Regarding the first strand, several sources of financing for renewable energy have been discussed in the literature, with financial globalization being considered one such source (Das et al., 2021; Doytch and Narayan, 2016; Fotio et al., 2022;Haque and Rashid, 2022; Kim, 2018; Koengkan et al., 2020; Roberts et al., 2009;Samour et al., 2022). Foreign direct investment inflows enhance renewable energy consumption becauseas a source of financing, they foster innovation and energy efficiency (Doytch and Narayan, 2016). Also, as a component of foreign capital flows, foreign aid enhances renewable energy capacity (Haque and Rashid, 2022).

Another source of financing for renewable energy explored in the literature is the development of the domestic financial sector (Anton and Nucu, 2020; Eren et al., 2019; He et al., 2019; Kim and Park, 2016; Rafindadi, 2016b; Rafindadi and Ozturk, 2016,2017b;Raza et al., 2020; Shahbaz et al., 2021). It has been argued that financial development increases the demand for renewable energy (Anton and Nucu, 2020; Shahbaz et al., 2021); however, other studies found a negative effect of financial development on renewable energy (He et al., 2019; Shahbaz et al., 2016), and others found no causality between financial development and renewable energy (Altay and Topcu, 2015; Burakov and Freidin, 2017; Çoban and Topcu, 2013; Rafindadi, 2015).Further, Raza et al. (2020) argue that the relationship is non-linear.

Additionally, some studies argue that government subsidies and taxes represent sources of financing for renewable energy (Bashir et al., 2021; El-Karmi and Abu-Shikhah, 2013; Yahya and Rafiq, 2019; Yang et al., 2019a). In this respect, Yang et al. (2019a) argue that government subsidies enhance renewable energy investment, with the effect of tax subsidies being greater than that of monetary subsidies, while El-Karmi and Abu-Shikhah (2013) argue that introducing financial incentives in the economy to promote green electricity production spurs financial development, which in turn stimulates renewable energy investment. Meanwhile, Lee et al. (2021) contend that during natural disasters, the consumption of both oil and renewable energy are affected.

Regarding the second strand, governance is viewed as a determinant of economic development in general and renewable energy investment in particular. Cowell et al. (2017) contend that rescaling governance for efficient renewable energy development is feasible, and note that government devolution creates new renewable energy initiatives. Bellakhal et al. (2019) posit that bad governance is detrimental to renewable energy investment, and state that this effect is moderated by trade openness, which has a positive effect on renewable energy investment even in countries with low institutional quality. Other researchers have highlighted the role of a country's legal system. On this point, it is argued that limited renewable energy development in a country may also be due to its legal system, which shapes regulatory and business policies and hence determines the investment trajectory (Liu et al., 2021).

The third strand, which is still emerging, examines the use of natural resource rents to finance renewable energy projects. Natural resources have varying effects on economic development. For example, Kim and Lin (2017) argue that countries endowed with natural resources tend to develop slowly compared to non-resource-endowed economies due to the resource curse. However, Havranek et al. (2016) argue that the resource curse hypothesis is weak unless the analysis controls for differences in institutional quality, level of investment, and different types of natural resources, and differentiates between natural resource dependence and abundance. Ahmadov and van der Borg (2019) show that the actual economic impact of natural resource abundance on renewable energy depends on the type of natural resource under consideration. While in general, natural resource abundance is beneficial for renewable energy production, specific natural resources such as oilare detrimental to renewable energy (Ahmadov and van der Borg, 2019). Baye et al. (2022) show a negative effect of natural resources on renewable energy in Sub-Saharan Africa, and also posit that negative oil price shocks are detrimental to renewable energy outputs on the continent (Baye et al., 2022). Using Pakistan as an example, Lee et al. (2022) argue that coal enhances green technology implementation particularly during energy shortfalls, because industries move towards renewable resources during such shortfalls. Hassan et al. (2021) show that the use of natural resources leads to environmental degradation, and recommend the implementation of energy-saving technologies as a way to fight environmental degradation.

We develop our first hypothesis from the above discussion.

Hypothesis 1:

Natural resources significantly enhance renewable energy investment in Africa.

The last strand examines the mediating role of governance in the relationship between natural resources and renewable energy. In this regard, Asiamah et al. (2022) argue that natural resource wealth has a negative effect ongovernance in Africa, and to reduce rent-seeking and guarantee the independence and quality of institutions, they recommend a natural resources policy which stresses sustainable use in order to turn the resource curse into a blessing. (Asiamah et al., 2022). Similarly, Busse and Gröning (2013) show that natural resource wealth is a driver of corruption, but Caselli and Tesei (2016) argue that oil wealth has no effect in democracies, while the effect on autocracies is heterogeneous. Also, Acheampong et al. (2022) posit that democracy moderates the consumption of non-renewable energy sources, which degrades the environment, and call for the use of renewable energy sources to tackle environmental degradation.

We derive our second hypothesis from the above discussion.

Hypothesis 2:

Governance is the mediating channel through which natural resources affect renewable energy in Africa.

3. Methods

3.1 Data Sources

The data for renewable energy were obtained from the International Renewable Energy Agency (IRENA); those related to governance were sourced from the Worldwide Governance Indicator (World Bank); and the other variables were obtained from the World Development Indicators database (World Bank).The study is based on data for 48 African countries for the period 2000–2020.[1] The choice of countries and study period is based principally on data availability.

[1] Algeria, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo Dem. Rep., Congo Rep., Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia,

3.2Dependent and independent variables

In this study, renewable energy development (RE) is the dependent variable, and total renewable energy electricity generation (GWh), renewables (% equivalent primary energy), and total renewable energy generated hydropower (in GWh) are used as proxies.

3.2.1 Independent variables

The first independent variable of interest is natural resource rents, which is measured by taking into consideration total natural resource rents (%GDP), and subsequently taking into consideration forest rents (%GDP), oil rents (%GDP), mineral rents (%GDP), coal rents (%GDP), and gas rents (%GDP). Ahmadov and van der Borg (2019) argue that overall natural resource abundance is beneficial to renewable energy development, while specific natural resources (e.g., oil) are detrimental to renewable energy. Therefore, a positive or negative result depends on the proxy used.

The second independent variable of interest is governance, which is considered here as the average of the six governance indicators espoused by Kaufmann et al. (2011), and in accordance with the literature (Ngouhouo et al., 2021). These six indicators, which are further integrated into the model individually, are: control of corruption, political stability and absence of violence, rule of law, government effectiveness, voice and accountability, and regulatory quality. Asongu and Odhiambo (2021) argue that governance is detrimental to renewable energy consumption in sub-Saharan Africa. Also, Bellakhal et al. (2019) posit that bad governance is detrimental to renewable energy investment and that this effect is moderated by trade openness, which has positive effects on renewable energy investment even in countries with low institutional quality. Governance could therefore produce either a

---

Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Zimbabwe positive or negative outcome. Figure 1 shows the perceived effect of the variables of interest on renewable energy.

[Insert Figure 1 here]

3.2.2Control variables

The first control variable is trade openness, proxied by the trade share (%GDP). This is integrated into the model in accordance with Bellakhal et al.'s (2019) study, which notes a positive effect of trade openness on renewable energy investment. This variable is therefore hypothesized as producing a positive result. The subsequent control variable is foreign direct investment inflows (%GDP), which is also hypothesized as producing a positive result. The next variable is foreign aid, which is proxied as net official development assistance received (%GNP), and is expected to generate a positive outcome, in accordance with Haque and Rashid (2022). This is attributed to the fact that a significant proportion of development aidis sector-oriented, and in some developing economies, a part of development aid is earmarked for the development of the renewable energy sector. The last control variable integrated into the model is financial development, proxied by domestic credit to the private sector (%GDP). The result of this maybe positive or negative, in line with Raza et al. (2020), who argue that the relationship is non-linear with renewable energy. Table 1 presents the summary statistics, while the corresponding correlation matrix is given in the appendix.

[insert Table 1 here]

3.3Model specification and regression methodology

Based on recent literature on the determinants of renewable energy investment (Ahmadov and van der Borg, 2019; Haque and Rashid, 2022), the following model is specified:

$$RE_{it} = \beta_0 + \beta_1 Natural\_Resource_{it} + \beta_2 Governance_{it} + \nabla X_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

where RE is renewable energy investment, Natural_Resource is natural resource rents, Governance is governance quality, X is the vector for the control variables, β_i is the coefficient attached to the variables of interest,∇ is the coefficient of the control variables,μ is the individual effect, and ε is the stochastic error term.

When the indirect effect of governance is considered, the interactive term between governance and natural resources is introduced in 1 to give (2):

$$RE_{it} = \beta_0 + \beta_1 Natural\_Resource_{it} + \beta_2 Governance_{it} + \beta_3 (Governance_{it} * Natural_{Resource_{it}}) + \nabla X_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

In light of the above, the coefficients β_1 *and* β_3 in (2) could all be significant and identical in sign, in which case we suggest a positive effect. However, if the signs of the stated coefficients are opposing and all significant, then there exists a net effect in the regression outcome, in which case the net effect is computed as in (3):

$$Net\ effect = (\beta_1 * \beta_3) + \overline{Governance} \quad (3)$$

where the value $\overline{Governance}$, which is fixed, is the mean of the governance variable in the sample considered.

The correlation between the main dependent variable and its first period lag reflects a lag in value of 0.9952, which indicates the importance of integrating the initial condition in our analysis (Bolt, 2010; Nchofoung et al., 2022a). Therefore, (2) can be specified as in (4).

$$RE_{it} = \beta_0 + \beta_1 RE_{i(t-1)} + \beta_2 Natural\_Resource_{it} + \beta_3 Governance_{it} + \beta_3 (Governance_{it} * Natural_{Resource_{it}}) + \nabla X_{it} + \mu_i + \omega_t + \varepsilon_{it} \quad (4)$$

where ω_t is the period fixed effect. The presence of the lagged dependent variable in this model is likely to correlate with specific country effects, thereby generating an endogeneity bias (Nickell, 1981). The Generalized Method of Moments (GMM)approach is used in this study to correct this bias. Several reasons motivate the choice of GMM over other possible estimators that could equally correct this bias, including the fact that the time dimension (i.e., 21 years) is less than the cross-sectional dimension (i.e.,48 countries), which is one of the conditions necessary for the application of a GMM regressor (Roodman, 2009). We employ the GMM because Blundell and Bond (1998) showed, using Monte Carlo simulations, that the GMM estimator in the first set generates biased results in finite samples when the instruments are weak.

The GMM faces several problems, including identification, simultaneity, and exclusion restrictions (Nchofoung et al., 2022b; Nchofoung and Asongu, 2022), which we assume affect our model. To resolve these problems, all explanatory variables are presumed to be potential sources of endogeneity and are treated as such. Also, the selected instruments are exogenous. In this respect, we retained the second lag of the explanatory variables as instruments, in line with the literature (Kiviet, 2022). Additionally, the forward orthogonal deviation is adopted, and the instruments are collapsed to limit their proliferation. Hayakawa (2009) shows that the forward orthogonal deviation performs better than differencing, especially when the instruments are from the backward orthogonal deviations in a panel with a large time dimension. Furthermore, Hayakawa (2009) shows that the forward orthogonal deviation corrects unobserved individual effects in the panel. The validity of the instruments retained is examined by using the difference in Hansen's test for instrument exogeneity under the null hypothesis of exogeneity of instruments. Moreover, the number of instruments should be less than the number of cross-sections. Also, the regressions are valid in the absence of second-order autocorrelation, under the null hypothesis, in the absence of second-order autocorrelation of residuals.

4. Empirical Results

The acquisition of results begins with a baseline regression of model (1). This is done using the Ordinary Least Squares (OLS) method, and then the dynamic model regression is done using the GMM, as highlighted in the previous section. Finally, robustness is determined across the various distribution of renewable energy by using quantile regression.

4.1 Dynamic model regression

Table 2 shows the results based on the GMM regression. Overall, natural resources and governance show enhancing effects on renewable energy investments, with the same results when alternative measures of natural resources are used. The exception is forest resource rents, which show a negative effect. Regarding the control variables, trade openness, foreign aid, and foreign direct investment have negative effects on renewable energy investment, while financial development has a positive effect.

The positive effect of natural resources on renewable energy corroborates the results of Ahmadov and van der Borg (2019), who argue that the actual economic impact of natural resource abundance on renewable energy depends on the type of natural resource under consideration. Overall, although natural resource abundance has a positive effect on renewable energy development, some specific natural resources, such as forest rents, are detrimental to renewable energy. Natural resource rents, as available capital in the economy, can increase the capital stock, and that can be invested into different sectors, including the energy sector (Hartwick, 1977). Most African economies depend largely on natural resources, with about 70% of the continent's export based on minerals, which have attracted foreign direct investment onto the continent (Bokpin et al., 2015). At the same time, foreign direct investment is a source of financing that promotes innovation as well as energy efficiency (Doytch and Narayan, 2016).

The positive effect of natural resources on renewable energy is not a given. This is because of the natural resource curse, which is a problem in most natural resource-rich countries in Africa. For natural resources to have a positive effect on renewable energy development, it is vital to identify and minimise the risk of this curse. Recent studies show that institutionalisation (Tiba and Frikha, 2019; Yang et al., 2019b) and increasing human capital accumulation could help in tackling the resource curse problem (Erdoğan et al., 2021; Shahbaz et al., 2019). The point we are emphasising here is that by identifying and addressing the resource curse problem, natural resource rents would have a positive effect on renewable energy development.

As noted earlier, our study shows that forest rents have a negative effect on renewable energy investment. An increase in forest rents implies an increase in the use of forest resources, which leads to deforestation. Additionally, forests are a source of wood used for fuel, which is a non-renewable energy source widely used in Africa. Therefore, increasing the demand for wood-based energy will reduce demand for renewable energy sources (Favero et al., 2020).

[Insert Table 2 here]

The positive effect of governance is in line with the results of Bellakhal et al. (2019), who found an enhancing effect of good governance on renewable energy. This positive effect can be explained by the fact that good governance attracts foreign investors into various economic sectors, including the energy sector. This is because in the presence of good governance, property rights are secured and the rule of law is guaranteed, thereby increasing the credibility of the economy in the eyes of foreign investors. Moreover, economic development is driven by a stable political environment. Likewise, in the absence of corruption, public resources are better allocated for productive investments. These investments include those in the energy sector, and in recent years, most African governments have opted to invest more into hydropower.

Regarding the control variables, the negative effect of trade on renewable energy is reflected in the results from Wang and Zhang (2021), who argue that trade negatively affects renewable energy development in lower- and middle-income economies. Trade openness increases competition within the economy, and as a result, firms invests in cheaper sources of energy to maximize profits. In this respect, non-renewable sources of energy are often opted for by these firms over renewable energy sources.

Moreover, our results show that financial development enhances renewable energy development, which corroborates the results of Shahbaz et al. (2021), as increased financial development means availability of financial institutions for the financing of investment projects, including energy projects.

The positive effect of the first period lag of renewable energy highlights the importance of initial economic conditions for the development of the renewable energy sector in Africa (Bolt, 2010; Nchofoung et al., 2022a), meaning that there is a need to keep the development of the renewable energy sector in Africa on a growth trajectory. This further corroborates the catch-up effect posited by Barro and Sala-i-Martin (1992), implying that economic development is driven by the accumulation of physical capital until an optimal threshold is attained. In this respect therefore, the use of renewable energy technologies will continue to increase in the economy until an optimum level is reached, at which point the entire economy will enjoy the same level of renewable energy endowment with respect to its proportion of their total energy.

The results of external financial inflows (foreign direct investments and foreign aid) are counter-intuitive, producing negative relationships with renewable energy development. However, Fotio et al. (2022) argue that the actual effect of financial integration on renewable energy is heterogeneous across the distribution of renewable energy capacity. The negative relationship occurs because financial integration increases economic activity, leading to higher energy demand (Fotio et al., 2022). To respond to this demand and stay competitive, firms tend to invest in non-renewable energy, which is cheaper than renewable energy.

4.2 Robustness Checks

To confirm the results, robustness checking was done, first across alternative measures of governance, and second across an alternative regression methodology. Table 3 presents the results across alternative specification of governance, while Table 4presents those across an alternative methodology.

Table3 shows that across different specifications of governance, natural resources robustly enhance renewable energy development in Africa. This further strengthens the results shown in Table 2 and corroborates existing literature on the effect of institutional governance on renewable energy. Amoah et al. (2021) argue that corruption is inimical to renewable energy in Africa. In the renewable energy financing literature, Wiser and Pickle (1998) emphasise the importance of effective policy design for efficient investment in renewable energy. In this respect, policies that have negative secondary impacts on investment decisions will increase financing costs, sometimes dramatically reducing the effectiveness of renewable energy development.

[Insert Table 3 here]

[Insert Table 4 here]

Table 4 shows that the effect of natural resources on renewable energy depends on the type of natural resources and the distribution of such energy across the economy. While the positive effect of natural resources is apparent only in the 90th percentile, forest resources, mineral resources, and natural gas resources enhance renewable energy across the entire distribution.

The negative effect is thus attributed to the negative effect of oil and coal resources in most of the quantiles; however, the negative effect of total natural resources becomes weaker towards the higher quantiles. This corroborates the results of Ahmadov and van der Borg (2019), who established that the actual economic impact of natural resource abundance on renewable energy depend on the type of natural resource under consideration. Moreover, the resource curse hypothesis is validated for oil and coal resources. What is worth noting is that unlike the GMM approach discussed earlier, the quantile regression method does not correct possible sources of endogeneity, which gives more credibility to the economic interpretation linked to the GMM.

4.3 Indirect effects

Tables 5 and 6 present the indirect effects of the mediatory role of governance in the natural resources-renewable energy nexus.

[Insert Table 5 here]

[Insert Table 6 here]

Table 5 shows that governance interacts with natural resource rents to produce positive effects on renewable energy across the different types of governance measures considered. Table 6shows a similar result across different types of natural resources, and yields positive net effects except for coal rents, which produce a positive direct effect and negative indirect effect with governance, leading to a positive net effect. Mawejje (2021) stresses that improving governance and transparency in the management of natural resource revenue is essential in moderating the negative outcomes that epitomize resource-rich countries. Therefore, it is of paramount importance to enhance institutional governance through the effective management of resource wealth in order for efficient investment in the renewable energy sector. This also entails improving the quality of institutions and fighting against corruption at various levels. Most natural-resource-rich countries, especially those rich in oil and gas, have weak institutions, and corruption is endemic. For example, oil-rich South Sudan was ranked the most corrupt country in the 2021 Corruption Perception Index, occupying the 180th position out of the 180 countries considered (Transparency International 2022), and its score of 11 out of 100 indicates serious levels of public sector corruption (Transparency International 2022).[2]

Corruption was equally pervasive in other oil and gas- or mineral-rich African countries, including Libya (172nd/180, Democratic Republic of Congo (169th/180), Chad (164th /180), Republic of Congo (162nd/180), Nigeria (154th/180), Mozambique (147th/180), Cameroon (144th/180), and Angola (136th/180). All of these countries had scores of less than 30 out of 100, indicating serious levels of public sector corruption. These countries also had poor scores in terms of the health of their institutions. For instance, concerning judicial independence, in 2019, Chad had a score of 2.5 out of 7, indicating that its judicial system is seriously influenced by members of the government, private citizens, and firms (World Economic Forum 2019).[3]Also in 2019, it was ranked 137 (out of 141 countries) on one of the Global Competitive Index components, i.e., institutions (World Economic Forum, 2019). This ranking is indicative of chronic corruption and weakness of the country's laws and institutions. Most of the natural-resource-rich countries on the continent therefore have to improve the quality of their institutions as well as tackle governance issues in order for natural resource rents to have a positive effect on renewable energy development.The current environment explains why, despite the abundance of natural resources and rents generated on the continent, renewable energy investment is still lagging that of other regions.

[2] According to Transparency International, the source of the Corruption Perceptions Index, scores range from 0 (highly corrupt) to 100 (very clean).
[3]Scores range from 1 (heavily influenced) to 7 (entirely independent).

5. Conclusions and Policy Implications

Renewable energy is increasingly considered as having a crucial role to play in fostering sustainable development. This paper investigates the effect of natural resources on renewable energy development in Africa and the mediating effect of governance. Based on data for 48 African countries for the period 2000–2020, and utilizing the Generalized Method of Moments (GMM) approach in addition to quantile regression methodologies, the results show that natural resources enhance renewable energy development in Africa, and that these results are robust across alternative specifications of natural resources and governance. When robustness is checked through quantile regression, the results indicate that the positive effect depends on the conditional distribution of natural resources and the type of natural resource under consideration. Meanwhile, the indirect effect results showed that governance interacts with natural resource rents to produce positive effects across different governance and natural resource specifications, except for coal rents, which produced a net positive effect from the negative indirect and positive direct effects.

These results have implications for policymakers and researchers. The finding that governance interacts with natural resource rents, except for coal rents, to generate positive effects across different governance specifications and natural resources, highlights a problem particularly for countries with significant investments in coal. Policymakers in such countries should put in place regulations which prevent the expansion of coal-related activities and investment, and additionally, a special tax should be levied on coal companies and coal-related activities. The purpose of such a tax is twofold; first, it would render investment in the sector less attractive, leading to a gradual decline in such activities, and second, the tax collected can be channelled toward development of the renewable energy sector. Moving beyond coal would also be good for the relevant countries' sustainable development agendas, as the coal sector is one of the key drivers of carbonisation. In other words, such policies would contribute strongly to the fight against climate change. Additionally, the finding that governance interacts with natural resource rents to generate positive effects across different governance specifications highlights the importance of governance and quality institutions in the development of the renewable energy sector. These issues are often neglected in discussions on how to enhance the growth of that sector. Policymakers should also improve governance, especially in the management of natural resource rents, by embracing digitalisation. Digitalisation will ensure transparency and accountability as well as increase efficiency in the management of natural resource rents. This will ensure that funds earmarked for the development of the renewable energy sector are used for their intended purposes.

Regarding future research, work should be done toward integrating the Extractive Industries Transparency Initiative (EITI) into an analysis of the role of governance in renewable energy development. Empirical research in this area is particular important, since the EITI aims to support improved governance and transparency in resource-rich countries through the full publication and verification of company payments and government revenues from oil, gas, and mining activities.

Acknowledgments

We are grateful to the editor and nine anonymous reviewers for their constructive comments and suggestions. The usual disclaimer applies.

References

Acheampong, A. O., Opoku, E. E. O., & Dzator, J. (2022). Does democracy really improve environmental quality? Empirical contribution to the environmental politics debate. *Energy Economics*, *109*, 105942.

Adebayo, T. S., Akadiri, S. S., Adedapo, A. T., & Usman, N. (2022). Does interaction between technological innovation and natural resource rent impact environmental degradation in newly industrialized countries? New evidence from method of moments quantile regression. *Environmental Science and Pollution Research*, *29*(2), 3162-3169.

African Development Bank [AfDB]. (2016). Catalyzing growth and development through effective natural resources management. African Natural Resources Center, African Development Bank: Abidjan. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/anrc/AfDB_ANRC_BROCHURE_en.pdf (accessed 27 October 2022)

Ahmadov, A. K., & van der Borg, C. (2019). Do natural resources impede renewable energy production in the EU? A mixed-methods analysis. *Energy Policy*, *126*, 361-369.

Akella, A., Saini, R and M.P. Sharma, M.P. 2009. Social, economical and environmental impacts of renewable energy systems. *Renewable Energy*, 34, 390-396.

Alper, O and Oguz, O. 2016. The role of renewable energy consumption in economic growth: evidence from asymmetric causality. *Renew. Sust. Energ. Rev*., 60 (2016), pp. 953-959.

Altay, B., & Topcu, M. (2015). Relationship between financial development and energy consumption: The case of Turkey. *Bulletin of Energy Economics (BEE)*, *3*(1), 18-24.

Amoah, A., Asiama, R. K., Korle, K., & Kwablah, E. (2022). Corruption: Is it a bane to renewable energy consumption in Africa?. *Energy Policy*, *163*, 112854.

Anton, S. G., & Nucu, A. E. A. (2020). The effect of financial development on renewable energy consumption. A panel data approach. *Renewable Energy*, *147*, 330-338.

Asiamah, O., Agyei, S. K., Bossman, A., Agyei, E. A., Asucam, J., & Arku-Asare, M. (2022). Natural resource dependence and institutional quality: Evidence from Sub-Saharan Africa. *Resources Policy*, *79*, 102967.

Asongu, S., & Odhiambo, N. M. (2021). Governance and renewable energy consumption in Sub-Saharan Africa. *International Journal of Energy Sector Management*.

Asongu, S. A., & Odhiambo, N. M. (2019). Inclusive development in environmental sustainability in sub-Saharan Africa: Insights from governance mechanisms. *Sustainable Development*, 27(4), 713-724.

Barro, R. J., & Sala-i-Martin, X. (1992). Convergence. *Journal of political Economy*, *100*(2), 223-251.

Bashir, M. F., Ma, B., Bashir, M. A., Radulescu, M., & Shahzad, U. (2021). Investigating the role of environmental taxes and regulations for renewable energy consumption: evidence from developed economies. *Economic Research-Ekonomska Istraživanja*, 1-23.

Baye, R. S., Ahenkan, A., & Darkwah, S. (2021). Renewable energy output in sub Saharan Africa. *Renewable Energy, 174*, 705-714.

Badeeb, R. A., Lean, H. H., & Clark, J. (2017). The evolution of the natural resource curse thesis: A critical literature survey. *Resources Policy*, 51, 123–134.

Bayer, P., Dolan, L., & Urpelainen, J. (2013). Global patterns of renewable energy innovation, 1990–2009. *Energy for Sustainable Development*, *17*(3), 288-295.

Bekun, F., Alola, A.A and Sarkodie, S.A. Toward a sustainable environment: Nexus between CO2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries. *Science of the Total Environment*, 657 (2019), pp. 1023-1029

Bellakhal, R., Kheder, S. B., & Haffoudhi, H. (2019). Governance and renewable energy investment in MENA countries: How does trade matter?. *Energy Economics*, *84*, 104541.

Bhattacharya, M., Churchill, S.A and S.R. Paramati, S.R. (2017). The dynamic impact of renewable energy and institutions on economic output and CO2 emissions across regions. Renew. *Energy*, 111, 157-167.

Bhattacharyya, S., & Hodler, R. (2010). Natural resources, democracy and corruption. *European Economic Review*, *54*(4), 608-621.

Bokpin, G. A., Mensah, L., & Asamoah, M. E. (2015). Foreign direct investment and natural resources in Africa. *Journal of Economic Studies*. 42 (4), 608-621.

Bolt, J. (2010). *Explaining long-run economic development in Africa: do initial conditions matter?* (Doctoral dissertation, University of Groningen).

Burakov, D. (2017). Financial development, economic growth and renewable energy consumption in Russia.

Busse, M., & Gröning, S. (2013). The resource curse revisited: governance and natural resources. *Public choice*, *154*(1), 1-20.

Byaro, M., Nkonoki, J. & Mafwolo, G. Exploring the nexus between natural resource depletion, renewable energy use, and environmental degradation in sub-Saharan Africa. Environ Sci Pollut Res (2022). https://doi.org/10.1007/s11356-022-23104-7

Carbonnier, G. 2013. La malédiction des ressources naturelles et ses antidotes Rev. Int. Et. Strat., 3 (91), pp. 38-48.

Caselli, F., & Tesei, A. (2016). Resource windfalls, political regimes, and political stability. *Review of Economics and Statistics*, *98*(3), 573-590.

Caselli, F., Cunningham, T. (2009). Leader behaviour and the natural resource curse. *Oxford Economic Papers*, 61 (4), 628–650.

Çoban, S., & Topcu, M. (2013). The nexus between financial development and energy consumption in the EU: A dynamic panel data analysis. *Energy Economics*, *39*, 81-88.

Collier, P and Hoeffler, A. (2005). Resource rents, governance, and conflict. J. Confl. Resolut., 49 (4), 625-633.

Collier, P., Hoeffler, A. (1998). On economic causes of civil war. Oxf. Econ. Pap. 50 (4), 563–595.

Cowell, R., Ellis, G., Sherry-Brennan, F., Strachan, P. A., & Toke, D. (2017). Rescaling the governance of renewable energy: lessons from the UK devolution experience. *Journal of Environmental Policy & Planning*, *19*(5), 480-502.

Daniele, V. (2011). Natural resources and the ‘quality’of economic development. *the Journal of Development studies*, *47*(4), 545-573.

Das, A., McFarlane, A., & Carels, L. (2021). Empirical exploration of remittances and renewable energy consumption in Bangladesh. *Asia-Pacific Journal of Regional Science*, *5*(1), 65-89.

Destek, M. A. (2016). Renewable energy consumption and economic growth in newly industrialized countries: Evidence from asymmetric causality test. *Renewable Energy*, 95, 478-484.

Destek, M. A., Manga, M., Cengiz, O., & Destek, G. (2022). Investigating the potential of renewable energy in establishing global peace: Fresh evidence from top energy consumer countries. *Renewable Energy*, 197, 170-177.

Destek, M. A and Aslan, A. (2017). Renewable and non-renewable energy consumption and economic growth in emerging economies: Evidence from bootstrap panel causality, *Renewable Energy* 111, 757-763.

Doytch, N., & Narayan, S. (2016). Does FDI influence renewable energy consumption? An analysis of sectoral FDI impact on renewable and non-renewable industrial energy consumption. *Energy Economics*, *54*, 291-301.

Dwumfour, R. A., & Ntow-Gyamfi, M. (2018). Natural resources, financial development and institutional quality in Africa: is there a resource curse?. *Resources Policy*, *59*, 411-426.

El-Karmi, F. Z., & Abu-Shikhah, N. M. (2013). The role of financial incentives in promoting renewable energy in Jordan. *Renewable Energy*, *57*, 620-625.

Erdoğan, S, Çakar, ND, Ulucak, R, Danish, , Kassouri, Y. The role of natural resources abundance and dependence in achieving environmental sustainability: Evidence from resource-based economies. *Sustainable Development*. 2021; 29: 143– 154.

Eren, B. M., Taspinar, N., & Gokmenoglu, K. K. (2019). The impact of financial development and economic growth on renewable energy consumption: Empirical analysis of India. *Science of the Total Environment*, *663*, 189-197.

Favero, A., Daigneault, A., & Sohngen, B. (2020). Forests: Carbon sequestration, biomass energy, or both?. *Science Advances*, *6*(13), eaay6792.

Fotio, H. K., Nchofoung, T. N., & Asongu, S. A. (2022). *Financing renewable energy generation in SSA: Does financial integration matter?* (No. 22/016). African Governance and Development Institute.

Fotis, P., & Polemis, M. (2018). Sustainable development, environmental policy and renewable energy use: A dynamic panel data approach. *Sustainable Development*, 26(6), 726-740.

Germond-Duret, C. (2014). Extractive industries and the social dimension of sustainable development: Reflection on the Chad–Cameroon pipeline. *Sustainable Development*, 22(4), 231-242.

Graham, E and Ovadia, J. S. (2019). Oil exploration and production in Sub-Saharan Africa, 1990-present: Trends and developments, *The Extractive Industries and Society* 6(2), 593-609.

Haque, N., & Rashid, S. (2022). Effects of cumulative energy aid projects on renewable energy generation capacity. *Environmental Development*, *42*, 100692.

Hartwick, J. M. (1977). Intergenerational Equity and the Investing of Rents from Exhaustible Resources. American economic review, v. 67, n. 5.

Havranek, T., Horvath, R., & Zeynalov, A. (2016). Natural resources and economic growth: A meta-analysis. *World Development*, *88*, 134-151.

Hayakawa, K. (2009). First difference or forward orthogonal deviation-which transformation should be used in dynamic panel data models?: A simulation study. *Economics Bulletin*, *29*(3), 2008-2017.

He, L., Liu, R., Zhong, Z., Wang, D., & Xia, Y. (2019). Can green financial development promote renewable energy investment efficiency? A consideration of bank credit. *Renewable Energy*, *143*, 974-984.

Henri, P. A. O. (2019). Natural resources curse: A reality in Africa. *Resources policy*, *63*, 101406.

Hosseini, S. E. (2022). Transition away from fossil fuels toward renewables: lessons from Russia-Ukraine crisis. *Future Energy*, *1*(1).

Hetemäki, L., Palahi, M and White, L. (2021). How to preserve Africa's forests and build a green economy. World Economic Forum, Geneva. https://www.weforum.org/agenda/2021/06/preserve-africa-forests-green-economy/ (accessed 27 October 2022)

Humphreys, M., Sachs, J and Stiglitz, J. (2007). (eds). *Escaping the Resource Curse. Initiative for Policy Dialogue*. Columbia University Press: New York.

Isham, J., Woolcock, M., Pritchett, L and Busby, G. 2005. The varieties of resource experience: natural resource export structures and the political economy of economic growth World Bank Econ. Rev., 19 (2), 141-174.

Kalair, A., Abas, N., Saleem, M. S., Kalair, A. R., & Khan, N. (2021). Role of energy storage systems in energy transition from fossil fuels to renewables. *Energy Storage*, *3*(1), e135.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The worldwide governance indicators: methodology and analytical issues1. *Hague journal on the rule of law*, *3*(2), 220-246.

Kaygusuz, K. (2011). Energy services and energy poverty for sustainable rural development Renew. Sust. Energ. Rev., 15 (2011), 936-947.

Kim, D. H., & Lin, S. C. (2017). Natural resources and economic development: new panel evidence. *Environmental and resource economics*, *66*(2), 363-391.

Kim, J. E. (2018). Technological capacity building through energy aid: Empirical evidence from renewable energy sector. *Energy policy*, *122*, 449-458.

Kim, J., & Park, K. (2016). Financial development and deployment of renewable energy technologies. *Energy Economics*, *59*, 238-250.

Kirikkaleli, D., & Adebayo, T. S. (2021). Do renewable energy consumption and financial development matter for environmental sustainability? New global evidence. *Sustainable Development*, 29(4), 583-594.

Kiviet, J. F. (2022). Instrument-free inference under confined regressor endogeneity and mild regularity. *Econometrics and Statistics*. https://doi.org/10.1016/j.ecosta.2021.12.008

Koengkan, M., Poveda, Y. E., & Fuinhas, J. A. (2020). Globalisation as a motor of renewable energy development in Latin America countries. *GeoJournal*, *85*(6), 1591-1602.

Kuriqi, A., Pinheiro, A., Sordo-Ward, A and Garrote, L. 2017. Trade-off between Environmental Flow Policy and Run-of-River Hydropower Generation in Mediterranean Climate

Kuriqi, A., Pinheiro, A., Sordo-Ward, A and Garrote, L. 2019. Influence of hydrologically based environmental flow methods on flow alteration and energy production in a run-of-river hydropower plant. *Journal of Cleaner Production*, 232, 1028-1042.

Lee, C. C., Hussain, J., & Chen, Y. (2022). The optimal behavior of renewable energy resources and government's energy consumption subsidy design from the perspective of green technology implementation. *Renewable Energy*, *195*, 670-680.

Lee, C. C., Wang, C. W., Ho, S. J., & Wu, T. P. (2021). The impact of natural disaster on energy consumption: International evidence. *Energy Economics*, *97*, 105021.

Leite, C. and Weidmann, J. (1999). Does Mother Nature Corrupt - Natural Resources, Corruption, and Economic Growth. IMF Working Paper, 34.

Lessmann, C., & Steinkraus, A. (2019). The geography of natural resources, ethnic inequality and civil conflicts. *European Journal of Political Economy*, *59*, 33-51.

Li, Y., Alharthi, M., Ahmad, I., Hanif, I and Hassan, M. (2022). Nexus between renewable energy, natural resources and carbon emissions under the shadow of transboundary trade relationship from Southeast Asian economies, *Energy Strategy Reviews*, 41, 100855.

Liu, J., Zhang, D., Cai, J., & Davenport, J. (2021). Legal systems, national governance and renewable energy investment: evidence from around the world. *British Journal of Management*, *32*(3), 579-610.

Lohani, S. P., Gurung, P., Gautam, B., Kafle, U., Fulford, D., & Jeuland, M. (2022). Current status, prospects, and implications of renewable energy for achieving sustainable development goals in Nepal. *Sustainable Development*. https://doi.org/10.1002/sd.2392

Lu, J., Ren, L., Yao, S., Rong, D., Skare, M., & Streimikis, J. (2020). Renewable energy barriers and coping strategies: Evidence from the Baltic States. *Sustainable Development*, 28(1), 352-367.

Mawejje, J. (2019). Natural resources governance and tax revenue mobilization in sub saharan Africa: The role of EITI. *Resources Policy*, *62*, 176-183.

Mazzucato, M., & Penna, C. C. (2016). Beyond market failures: The market creating and shaping roles of state investment banks. *Journal of Economic Policy Reform*, *19*(4), 305-326.

Mazzucato, M., & Semieniuk, G. (2018). Financing renewable energy: Who is financing what and why it matters. *Technological Forecasting and Social Change*, *127*, 8-22.

Mehlum, H., Moene, K., Torvik, R. (2006). Institutions and the resource curse. Econ. J.116 (508), 1–20.

Mlachila, M., & Ouedraogo, R. (2019). Financial development curse in resource-rich countries: The role of commodity price shocks. *Quarterly Review of Economics and Finance,* 76, 84–96.

Nathaniel, S.P., Yalçiner, K and Bekun, F. (2021). Assessing the environmental sustainability corridor: Linking natural resources, renewable energy, human capital, and ecological footprint in BRICS,*Resource Policy*, 70, 101924

Nchofoung, T. N., & Asongu, S. A. (2022). Effects of infrastructures on environmental quality contingent on trade openness and governance dynamics in Africa. *Renewable Energy*, *189*, 152-163.

Nchofoung, T. N., Achuo, E. D., & Asongu, S. A. (2021). Resource rents and inclusive human development in developing countries. *Resources Policy*, *74*, 102382.

Nchofoung, T. N., Asongu, S. A., Njamen Kengdo, A. A., & Achuo, E. D. (2022 b). Linear and non-linear effects of infrastructures on inclusive human development in Africa. *African Development Review*, *34*(1), 81-96.

Nchofoung, T., Asongu, S., & Tchamyou, V. (2022 a). *Tourism, ICT and inclusive development: global evidence* (No. 22/037). European Xtramile Centre of African Studies (EXCAS).

Ngouhouo, I., Nchofoung, T., & Njamen Kengdo, A. A. (2021). Determinants of trade openness in sub-Saharan Africa: do institutions matter? *International Economic Journal*, *35*(1), 96-119.

Nwani, C., & Adams, S. (2021). Environmental cost of natural resource rents based on production and consumption inventories of carbon emissions: assessing the role of institutional quality. *Resources Policy*, *74*, 102282.

Ojong, N. (2022a). Fostering Human Wellbeing in Africa through Solar Home Systems: A Systematic and a Critical Review. *Sustainability*, 14(14), 8382.

Ojong, N. (2022b). "Off-Grid Solar Electrification on the Rise in Africa, But Where to?" In: Ojong, N (ed) *Off-Grid Solar Electrification in Africa: A Critical Perspective*. Palgrave Macmillan Cham, London.

Ojong, N. (2021). The rise of solar home systems in sub-Saharan Africa: Examining gender, class, and sustainability. *Energy Research & Social Science*, 75, 102011.

Okumus, I., Guzel, A.E. & Destek, M.A. (2021). Renewable, non-renewable energy consumption and economic growth nexus in G7: fresh evidence from CS-ARDL. *Environmental Science and Pollution Research*, 28, 56595–56605.

Opoku, E. E. O., Kufuor, N. K., & Manu, S. A. (2021). Gender, electricity access, renewable energy consumption and energy efficiency. *Technological Forecasting and Social Change*, *173*, 121121.

Qamruzzaman, M., & Jianguo, W. (2020). The asymmetric relationship between financial development, trade openness, foreign capital flows, and renewable energy consumption: Fresh evidence from panel NARDL investigation. *Renewable Energy*, *159*, 827-842.

Rafindadi, A. A. (2015). Econometric prediction on the effects of financial development and trade openness on the German energy consumption: a startling revelation from the data set. *International Journal of Energy economics and policy*, *5*(1), 182-196.

Rafindadi, A. A. (2016a). Revisiting the concept of environmental Kuznets curve in period of energy disaster and deteriorating income: Empirical evidence from Japan. *Energy Policy*, *94*, 274-284.

Rafindadi, A. A. (2016b). Does the need for economic growth influence energy consumption and CO2 emissions in Nigeria? Evidence from the innovation accounting test. *Renewable and Sustainable Energy Reviews*, *62*, 1209-1225.

Rafindadi, A. A., & Ozturk, I. (2016). Effects of financial development, economic growth and trade on electricity consumption: Evidence from post-Fukushima Japan. *Renewable and Sustainable Energy Reviews*, *54*, 1073-1084.

Rafindadi, A. A., & Ozturk, I. (2017a). Dynamic effects of financial development, trade openness and economic growth on energy consumption: Evidence from South Africa. *International Journal of Energy Economics and Policy*, *7*(3), 74-85.

Rafindadi, A. A., & Ozturk, I. (2017b). Impacts of renewable energy consumption on the German economic growth: Evidence from combined cointegration test. *Renewable and Sustainable Energy Reviews*, *75*, 1130-1141.

Rafindadi, A. A., Muye, I. M., & Kaita, R. A. (2018). The effects of FDI and energy consumption on environmental pollution in predominantly resource-based economies of the GCC. *Sustainable Energy Technologies and Assessments*, *25*, 126-137.

Raza, S. A., Shah, N., Qureshi, M. A., Qaiser, S., Ali, R., & Ahmed, F. (2020). Non-linear threshold effect of financial development on renewable energy consumption: evidence from panel smooth transition regression approach. *Environmental Science and Pollution Research*, *27*(25), 32034-32047.

Riti, J. S., Song, D., Shu, Y., Kamah, M., & Atabani, A. A. (2018). Does renewable energy ensure environmental quality in favour of economic growth? Empirical evidence from China's renewable development. *Quality & Quantity*, 52(5), 2007– 2030.

Roberts, J. T., Parks, B. C., Tierney, M. J., & Hicks, R. L. (2009). Has Foreign Aid Been Greened?. *Environment: Science and Policy for Sustainable Development*, *51*(1), 8-21.

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *The stata journal*, *9*(1), 86-136.

Rotimi, Mathew Ekundayo, and Harold Ngalawa. 2017. Oil price shocks and economic performance in Africa’s oil exporting countries. Acta Universitatis Danubius. *Œconomica* 13: 169–188.

Salim, R. and S. Rafiq, S. 2012. Why do some emerging economies proactively accelerate the adoption of renewable energy? *Energy Econ.*, 34 (4), 1051-1057.

Samour, A., Baskaya, M. M., & Tursoy, T. (2022). The impact of financial development and FDI on renewable energy in the UAE: a path towards sustainable development. *Sustainability*, *14*(3), 1208.

Schapiro, M. G. (2012). Rediscovering the developmental path? Development Bank, Law, and Innovation Financing in the Brazilian economy. *Development Bank, Law, and Innovation Financing in the Brazilian Economy (January 17, 2012)*.

Schumpeter, J. A. (1939). *Business cycles* (Vol. 1, pp. 161-174). New York: Mcgraw-hill.

Shahbaz, M., Mallick, H., Mahalik, M. K., & Sadorsky, P. (2016). The role of globalization on the recent evolution of energy demand in India: Implications for sustainable development. *Energy Economics*, *55*, 52-68.

Shahbaz, M., Destek, M. A., Okumus, I., & Sinha, A. (2019). An empirical note on comparison between resource abundance and resource dependence in resource abundant countries. *Resources Policy*, 60, 47-55.

Shahbaz, M., Topcu, B. A., Sarıgül, S. S., & Vo, X. V. (2021). The effect of financial development on renewable energy demand: The case of developing countries. *Renewable Energy*, *178*, 1370-1380.

Shittu, W., Adedoyin, F., Shah, M. I and H.O. Musibau, H.O. 2021. An investigation of the nexus between natural resources, environmental performance, energy security and environmental degradation: evidence from Asia. *Resources Policy*, 73, p. 102227.

Szabó S, Bódis K, Huld T and Moner-Girona M .2013. Sustainable energy planning: leapfrogging the energy poverty gap in Africa Renew. Sustain. Energy Rev. 28, 500–9.

Hassan, S.T., Xia, E., & Lee, C. C. (2021). Mitigation pathways impact of climate change and improving sustainable development: The roles of natural resources, income, and CO2 emission. *Energy & Environment*, *32*(2), 338-363.

Tabrizian, S. (2019). Technological innovation to achieve sustainable development—Renewable energy technologies diffusion in developing countries. *Sustainable Development*, 27(3), 537-544.

Thampapillai, D., Hansen, J and Bolat, A. (2014). Resource rent taxes and sustainable development. *Energy Policy*, 71, 169-179.

Tiba, S., & Frikha, M. (2020). Africa is rich, Africans are poor! A blessing or curse: an application of cointegration techniques. *Journal of the knowledge economy*, *11*(1), 114-139.

Tiba, S and Frikha, M. 2019. The controversy of the resource curse and the environment in the SDGs background: the African context. *Resource Policy* 62, 437-452.

Tiwari, A. K., Abakah, E. J. A., Adewuyi, A. O., & Lee, C. C. (2022). Quantile risk spillovers between energy and agricultural commodity markets: Evidence from pre and during COVID-19 outbreak. *Energy Economics*, *113*, 106235.

Tornell, A., Lane, P.R. (1998). Are windfalls a curse? a non-representative agent model of the current account. J. Int. Econ. 44 (1), 83–112.

Transparency International. 2022. Corruption Perception Index 2021. Berlin: Transparency International.

UNDP. (2015a). Transforming out world: The 2030 Agenda for Sustainable Development: United Nations Development Programme.

Van der Ploeg, F. (2011). Natural resources: curse or blessing? *Journal of Economic Literature*, 49(2), 366-420.

Wang Y, Uddin I, Gong Y (2021) Nexus between natural resources and environmental degradation: Analysing the role of income inequality and renewable energy. *Sustainability*, 13.

Wang, Q., & Zhang, F. (2021). Free trade and renewable energy: A cross-income levels empirical investigation using two trade openness measures. *Renewable Energy*, *168*, 1027-1039.

Wiser, R. H., & Pickle, S. J. (1998). Financing investments in renewable energy: the impacts of policy design. *Renewable and Sustainable Energy Reviews*, *2*(4), 361-386.

World Bank. 1992. Governance and Development (Washington, DC: The World Bank)

World Economic Forum. (2019). The Global Competitiveness Report 2019. World Economic Forum: Geneva.

Yahya, F., & Rafiq, M. (2019). Unraveling the contemporary drivers of renewable energy consumption: Evidence from regime types. *Environmental Progress & Sustainable Energy*, *38*(5), 13178.

Yang, X., He, L., Xia, Y., & Chen, Y. (2019). Effect of government subsidies on renewable energy investments: The threshold effect. *Energy Policy*, *132*, 156-166.

Yang, S., Abdulahi, E., Haider, M. and Khan, M.A. (2019b). Revisiting the curse: resource rent and economic growth of sub-Saharan African countries. Int. J. Econ. Financ. Issues, 9 (1), 121.

Yıldırım, S., Gedikli, A., Erdoğan, S., & Yıldırım, D. Ç. (2020). Natural resources rents-financial development nexus: Evidence from sixteen developing countries. *Resources Policy*, *68*, 101705.

Zafar, M. W., Saeed, A., Zaidi, S. A. H., & Waheed, A. (2021). The linkages among natural resources, renewable energy consumption, and environmental quality: A path toward sustainable development. *Sustainable Development*, 29(2), 353-362.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Control of corruption	1082	-.628	.607	-1.905	1.23
Government effectiveness	1081	-.73	.618	-2.475	1.057
Political stability	1081	-.556	.869	-2.699	1.282
Regulatory quality	1081	-.684	.608	-2.347	1.127
Rule of law	1081	-.674	.622	-2.009	1.077
Voice and accountability	1040	-.557	.75	-2.226	1.324
Governance	1029	-.639	.579	-1.958	.88
Renewables share in primary energy	84	2.64	2.419	.052	7.634
Total Renewable energy	982	4.631	2.61	-4.423	9.161
Renewable hydropower	840	5.245843	2.072124	-.6931472	8.311712
Coal rents	1063	.578	3.321	0	48.689
Financial development	974	21.34	23.525	0	142.422
Foreign direct investment	1065	4.281	7.811	-11.199	103.337
Forest rents	1070	4.963	5.676	0	40.408
Mineral rents	1070	1.16	2.879	0	24.834
Natural gas rents	1060	.273	.795	0	5.601
Foreign aid	1059	7.653	8.468	-.251	92.141
Oil rents	1066	5.186	12.09	0	66.685
Trade openness	988	71.463	39.209	.785	347.997

Table 2. Dynamic regression (GMM)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Dependent variable: Total Renewable Energy					
L.Total Renewables	0.862***	0.810***	0.981***	0.978***	0.985***	0.857***
	(0.00597)	(0.0198)	(0.00323)	(0.00298)	(0.00318)	(0.0117)
Natural resource rents	0.00181***					
	(0.000656)					
Governance	0.00145	0.0257	0.0533***	0.0568***	0.0662***	0.0706
	(0.0293)	(0.0446)	(0.00911)	(0.0113)	(0.00960)	(0.0429)
Trade openness	-0.000641**	-0.00153***	-0.000439**	-0.000584***	-0.000440***	-0.000948*
	(0.000259)	(0.000485)	(0.000168)	(0.000119)	(0.000130)	(0.000487)
Foreign aid	-0.00233**	-0.00109	-0.00366***	-0.00333***	-0.00213***	-0.00149
	(0.00105)	(0.00214)	(0.000700)	(0.000554)	(0.000559)	(0.00295)
Foreign direct investment	-0.00385***	-0.00350**	-0.000644	-0.00196***	-0.000998*	-0.00304*
	(0.000548)	(0.00136)	(0.000388)	(0.000526)	(0.000546)	(0.00177)
Financial development	0.00703***	0.00692**	0.000123	1.37e-05	8.05e-05	0.00717***
	(0.00128)	(0.00279)	(0.000179)	(0.000254)	(0.000232)	(0.00248)
Forest rents		-0.00465*				
		(0.00263)				
Mineral rents			0.00354**			
			(0.00161)			
Natural gas rents				0.0300***		
				(0.00349)		
Oil rents					0.00202***	
					(0.000449)	
Coal rents						0.00462***

						(0.000348)
Constant	0.627***	1.018***	0.240***	0.262***	0.216***	0.751***
	(0.0484)	(0.0847)	(0.0275)	(0.0210)	(0.0219)	(0.0789)
Observations	735	735	676	672	676	735
Number of countries	48	48	48	48	48	48
Prop>AR1	0.00978	0.0103	0.0102	0.0106	0.0104	0.0100
Prop>AR2	0.356	0.338	0.322	0.318	0.340	0.332
Instruments	36	29	36	36	36	22
Prop>Hansen	0.400	0.462	0.209	0.194	0.225	0.128
Fisher	7368***	762.6***	70892***	57606***	74504***	16221***

Notes: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Robustness through alternative specifications of governance

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Dependent variable: Total Renewable Energy					
L. Total Renewables	0.876***	0.986***	0.987***	0.986***	0.989***	0.987***
	(0.00830)	(0.00293)	(0.00406)	(0.00310)	(0.00298)	(0.00334)
Natural resource rents	0.00109*	0.00456**	0.00240*	0.00458**	0.00606***	0.00452***
	(0.000586)	(0.00196)	(0.00134)	(0.00207)	(0.00147)	(0.00146)
Trade openness	-0.000331	-0.000475***	-0.000559***	-0.000420**	-0.000459**	-0.000263
	(0.000233)	(0.000148)	(0.000199)	(0.000159)	(0.000184)	(0.000187)
Foreign aid	-0.00320***	-0.00156	-0.00170**	-0.00189**	-0.00168	-0.00212***
	(0.000960)	(0.00103)	(0.000783)	(0.000936)	(0.00104)	(0.000778)
Foreign direct investment	-0.00332***	-0.000728	-0.000449	-0.000921	-0.00187**	-0.00193**
	(0.000643)	(0.00105)	(0.000841)	(0.00110)	(0.000899)	(0.000853)
Financial development	0.00544***	0.000172	0.000783***	0.000414	0.000593***	0.000959***
	(0.00125)	(0.000282)	(0.000212)	(0.000336)	(0.000183)	(0.000182)
Control of corruption	0.0477*					
	(0.0257)					
Government effectiveness		0.0734***				
		(0.0216)				
Political stability			0.0302***			
			(0.0101)			
Regulatory quality				0.0648*		
				(0.0327)		
Rule of law					0.0716***	
					(0.0160)	
Voice and accountability						0.0414***
						(0.0123)

Constant	0.621***	0.173***	0.147***	0.157***	0.131***	0.115***
	(0.0431)	(0.0311)	(0.0376)	(0.0290)	(0.0286)	(0.0307)
Observations	769	671	671	671	671	637
Number of countries	48	48	48	48	48	48
Prop>AR1	0.00960	0.0103	0.0105	0.0103	0.0103	0.0101
Prop>AR2	0.365	0.384	0.341	0.377	0.383	0.369
Instruments	36	22	22	22	29	29
Prop>Hansen	0.489	0.135	0.134	0.116	0.205	0.204
Fisher	2953***	32048***	28006***	24004***	36355***	24257***

Notes: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Quantile Regression

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Total Renewable Energy				
VARIABLES	q10	q25	q50	q70	q90
Natural resource rents	0.00352	-0.0489***	-0.0347**	-0.0313***	0.0405***
	(0.00917)	(0.0111)	(0.0176)	(0.00923)	(0.0137)
Control variables	yes	yes	yes	yes	yes
Forest rents	0.144**	0.147***	0.0893***	0.103**	0.0859***
	(0.0670)	(0.0553)	(0.0270)	(0.0434)	(0.0244)
Control variables	yes	yes	yes	yes	yes
Mineral rents	0.280*	0.295***	0.160***	0.214***	0.159***
	(0.167)	(0.0680)	(0.0577)	(0.0633)	(0.0452)
Control variables	yes	yes	yes	yes	yes
Natural gas rents	0.588**	0.689***	-0.000476	0.484**	0.256***
	(0.292)	(0.152)	(0.131)	(0.196)	(0.0930)
Control variables	yes	ye	yes	yes	yes
Oil rents	0.00360	-0.0750***	-0.0631***	-0.0405***	-0.0333***
	(0.00978)	(0.0130)	(0.0165)	(0.0101)	(0.0108)
Control variables	yes	yes	yes	yes	yes
Coal rents	-0.0578**	-0.0862***	-0.0616***	-0.0927***	-0.107***
	(0.0289)	(0.0334)	(0.0156)	(0.0207)	(0.0258)

Control variables	yes	yes	yes	yes	yes

Notes: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5. Indirect effect through governance indicators

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Dependent: Total Renewable Energy						
L. Total Renewables	0.977***	0.978***	0.977***	0.976***	0.978***	0.975***	0.969***
	(0.00523)	(0.00546)	(0.00519)	(0.00400)	(0.00471)	(0.00432)	(0.00210)
Natural resources (A)	0.0101***	0.00871***	0.0108***	0.00732***	0.00259***	0.00781***	0.00386***
	(0.00233)	(0.00218)	(0.00226)	(0.00148)	(0.000887)	(0.000987)	(0.000435)
Trade openness	-0.000599**	-0.000469*	-0.000560**	-0.000664***	-0.000856***	-0.000654***	-0.000606***
	(0.000272)	(0.000260)	(0.000213)	(0.000167)	(0.000246)	(0.000182)	(0.000162)
Foreign aid	-0.00242*	-0.00300**	-0.00205	-0.00341***	-0.00349***	-0.00287***	-0.00410***
	(0.00128)	(0.00138)	(0.00122)	(0.000908)	(0.000826)	(0.00104)	(0.000635)
Foreign direct investment	-0.00162*	-0.00119	-0.00138	-0.000962	-0.000402	-0.000518	-0.000269
	(0.000930)	(0.00102)	(0.000884)	(0.000632)	(0.000869)	(0.000790)	(0.000422)
Financial development	0.00105***	0.00102***	0.000929**	0.000679***	0.000852***	0.000437***	0.000727***
	(0.000333)	(0.000267)	(0.000357)	(0.000213)	(0.000228)	(0.000142)	(0.000120)
Governance	-0.0397						
	(0.0283)						
Governance*A	0.00826***						
	(0.00214)						
Control of corruption		-0.0457**					
		(0.0226)					

Control of corruption*A		0.00737***					
		(0.00182)					
Government effectiveness			-0.0270				
			(0.0222)				
Government effectiveness*A			0.00854***				
			(0.00187)				
Regulatory quality				0.0119			
				(0.0232)			
Regulatory quality*A				0.00466***			
				(0.00124)			
Political stability					0.00983		
					(0.0166)		
Political stability*A					0.00122*		
					(0.000669)		
Rule of law						0.00927	
						(0.0136)	
Rule of law*A						0.00567***	
						(0.000731)	
Voice & accountability							0.0196**
							(0.00843)
Voice & accountability*A							0.00183***
							(0.000323)
Constant	0.155***	0.140***	0.154***	0.208***	0.224***	0.212***	0.252***
	(0.0570)	(0.0507)	(0.0461)	(0.0365)	(0.0495)	(0.0397)	(0.0201)
Observations	637	671	671	671	671	671	637
Number of countries	48	48	48	48	48	48	48
Prop>AR1	0.0100	0.0100	0.00991	0.0103	0.0103	0.0103	0.00993
Prop>AR2	0.305	0.301	0.308	0.337	0.317	0.314	0.338
Instruments	24	24	24	32	24	32	40
Prop>Hansen	0.103	0.173	0.254	0.212	0.147	0.269	0.220
Fisher	13591***	16238***	15430***	18418***	13019***	34496***	64917***

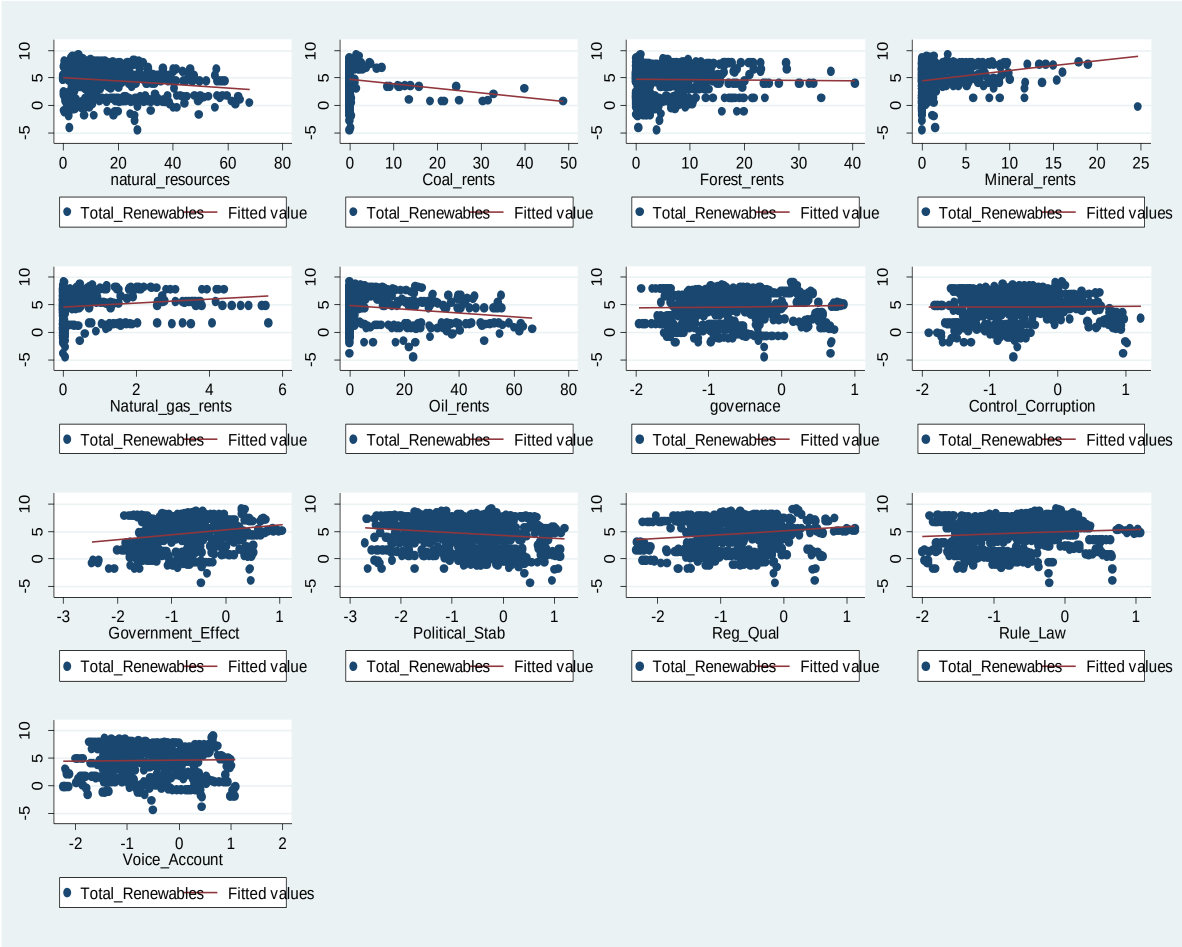
Notes: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6. Indirect effect by specification of different natural resources

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Dependent variable: Total Renewable Energy				
L. Total Renewables	0.974***	0.942***	0.972***	0.947***	0.983***
	(0.00265)	(0.00890)	(0.00389)	(0.00574)	(0.00349)
Governance (B)	0.0532***	0.156***	0.0181**	0.112***	0.0396**
	(0.0137)	(0.0347)	(0.00757)	(0.0194)	(0.0163)
Trade	-0.000757***	-0.000867**	-0.000530**	-0.000936***	-0.000487**
	(0.000173)	(0.000422)	(0.000204)	(0.000215)	(0.000185)
Foreign aid	-0.00316***	-0.00300**	-0.00301***	-0.00137	-0.00107
	(0.000961)	(0.00141)	(0.000741)	(0.00106)	(0.000655)
Foreign direct investment	-0.00107	-0.00174*	-0.000114	-0.00374***	-0.000825*
	(0.000796)	(0.000992)	(0.000501)	(0.000885)	(0.000440)
Financial development	-9.59e-05	0.00143	0.000441**	0.000659	0.000575***
	(0.000238)	(0.00132)	(0.000191)	(0.000511)	(0.000203)
Coal rents	0.00908***				
	(0.00105)				
Coal rents*B	-0.00731***				
	(0.00132)				
Forest rents		-0.00630			
		(0.00701)			
Forest rents*B		-0.00803			
		(0.00543)			
Mineral rents			0.0259***		
			(0.00617)		
Mineral rents*B			0.0233***		
			(0.00430)		
Natural gas rents				0.0950***	

				(0.0234)	
Natural gas rents*B				0.0384**	
				(0.0181)	
Oil rents					0.00653***
					(0.00164)
Oil rents*B					0.00453***
					(0.00144)
Constant	0.300***	0.517***	0.248***	0.458***	0.193***
	(0.0256)	(0.0620)	(0.0293)	(0.0313)	(0.0299)
Net effect	0.00485	--	---	---	---
Observations	637	735	637	733	637
Number of countries	48	48	48	48	48
Prop>AR1	0.0106	0.0105	0.0101	0.0114	0.0105
Prop>AR2	0.327	0.323	0.328	0.316	0.325
Instruments	32	32	40	40	32
Prop>Hansen	0.186	0.228	0.246	0.489	0.306
Fisher	147455***	5020***	27498***	19574***	47206***

Notes: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1



NB:Government_Effect is government effectiveness, Political_Stab is political stability, Req_qual is regulatory quality, rule_law is rule of law

Figure 1. Fitted scatted plot

Appendix

A1. Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
(1) control of corruption	1.000																		
(2) government effectiveness	0.942	1.000																	
(3) political stability	0.858	0.884	1.000																
(4) regulatory quality	0.854	0.872	0.832	1.000															
(5) rule of law	0.902	0.936	0.922	0.911	1.000														
(6) voice and account	0.884	0.892	0.819	0.879	0.856	1.000													
(7) governance	0.949	0.966	0.928	0.944	0.964	0.945	1.000												
(8) renewables share in primary energy	-0.065	-0.183	0.132	0.066	0.076	-0.102	-0.016	1.000											
(9) total renewables	0.572	0.624	0.759	0.622	0.727	0.604	0.683	0.443	1.000										
(10) renewable hydropower	0.513	0.514	0.657	0.625	0.678	0.378	0.580	0.622	0.750	1.000									
(11) coal rents	0.112	0.261	0.299	0.301	0.387	0.397	0.371	-0.313	0.325	0.136	1.000								
(12) financial development	0.465	0.434	0.452	0.362	0.457	0.242	0.145	0.209	0.772	0.628	0.020	1.000							
(13) foreign direct investment	0.148	0.174	0.221	0.209	0.255	-0.007	0.164	0.263	0.222	0.469	0.092	0.235	1.000						
(14) forest rents	0.208	0.032	0.139	0.279	0.146	0.367	0.222	0.502	0.168	0.195	0.130	0.033	-0.047	1.000					
(15) mineral rents	0.206	0.289	0.482	0.338	0.433	0.079	0.307	0.369	0.450	0.701	0.108	0.477	0.487	-0.117	1.000				
(16) natural gas rents	-0.717	-0.706	-0.858	-0.781	-0.832	-0.721	-0.808	-0.489	-0.838	-0.820	-0.476	-0.809	-0.273	-0.430	-0.525	1.000			

(17) foreign aid	-0.101	-0.186	0.066	0.091	0.056	-0.156	-0.043	0.823	0.297	0.628	-0.317	-0.026	0.383	0.423	0.501	-0.421	1.000		
(18) oil rents	-0.443	-0.338	-0.390	-0.331	-0.468	-0.385	-0.348	-0.506	-0.810	-0.789	-0.447	-0.258	-0.245	-0.482	-0.488	0.960	-0.441	1.000	
(19) trade openness	-0.321	-0.261	-0.091	-0.273	-0.134	-0.552	-0.308	0.286	0.027	0.274	-0.376	-0.099	0.406	-0.332	0.428	0.141	0.305	0.212	1.000