An empirical analysis of natural resource rent, bureaucratic control and sustainable development in Nigeria

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Abstract

This research addresses how bureaucratic control as well as the rent from natural resources influence Nigeria's sustainable development between 1990 and 2023. The study uses the method known as Autoregressive Distributed Lag (ARDL to control for trade openness, capital formation, and foreign direct investment while analyzing the long-term and short-term relationships between natural resource rent, institutional quality (as determined by bureaucratic control), and sustainable development. The findings show that, both in the short and long term, natural resource rent significantly promotes sustainable development. Additionally, bureaucratic control improves development results, highlighting the significance of institutional effectiveness in resource management. Furthermore, there is a strong positive correlation between resource rent and bureaucratic control, indicating that better bureaucracy amplifies the advantages of resource riches for growth. Additional factors that promote sustainable growth include openness to trade, gross formation of capital, as well as foreign direct investment. A long-term equilibrium that is stable is confirmed by the error correction term. The model's stability and robustness are confirmed by diagnostic testing. The results highlight how important it is to have efficient governance in order to convert the riches of natural resources into sustainable growth. For Nigeria to grow in a way that is inclusive, long-term, and ecologically sustainable, policy initiatives should concentrate on enhancing bureaucratic effectiveness, encouraging good governance, and directing resource income into profitable ventures.

Keywords: Natural resource rent, Bureaucratic control, Sustainable development

1. Introduction

Many developing nations consider natural resources to be an essential resource, especially in Sub-Saharan Africa, where resource endowments are viewed as a possible catalyst for sustainable development and economic change. The "resource curse" or the "paradox of plenty" refers to the growing body of empirical evidence that resource abundance does not always translate into sustainable economic progress (Ben-Salha, Dachraoui, & Sebri, 2021; Yu, 2023; Adabor, Buabeng, & Fosua Dunyo, 2022) [12, 24, 5]. In resource-rich nations like Nigeria, natural resource rents, particularly from crude oil, have contributed almost 90% of export revenue and more than 17.8% of GDP between 2010 and 2022 (World Bank, 2023) [23]. In spite of this, Nigeria is ranked 163rd on the Human Development Index (UNDP, 2022) [22], with more than 40% of its people living below the poverty line and extensive environmental damage brought on by the Niger Delta's oil production.

The paradoxical association amongst abundant natural resources as well as subpar development results has led researchers to investigate the institutional frameworks that allow resource rents to support both environmental and economic sustainability. One important factor in determining whether resource income is used effectively or poorly is the quality of governance, namely bureaucratic control, transparency, and institutional efficacy (Abdulahi, Shu, & Khan, 2019; Kadir *et al*., 2024; Ofori & Grechyna, 2021) [1, 15, 19]. Resource rents are often used by nations with strong institutions to invest in human capital, build physical capital, and promote ecological preservation. Conversely, nations with weak public sector institutions are more likely to experience corruption, rent-seeking, and unwise public spending (Safdar, Khan, & Andlib, 2022; Amare, Demissie, & Massa, 2025) [21, 9].

Governance and institutional quality have been as well as remain significant shortcomings in Nigeria. According to the Worldwide Governance Indicators (WGI), the Nigerian government's effectiveness, regulatory quality, and corruption control rank in the 30th percentile (World Bank, 2023) [23]. Additionally, the Nigerian Extractive Industries Transparency Initiative (NEITI) calculates that between 2000 and 2020, inefficiencies, leaks, and poor management cost the country about $20 billion in lost oil income (NEITI, 2021) [18]. Because public sector bureaucracy plays a crucial role in resource income collection, distribution, and supervision, these governance flaws are most noticeable there. Using resource rents and attaining sustainable development are said to be significantly aided by bureaucratic control, which refers to the

effectiveness, accountability, and openness of public administration (Abdulahi *et al*., 2019; Bilal *et al*., 2022; Alsagr & Ozturk, 2024) [1, 13, 8].

The link amid natural resource rentals as well as GDP growth in Sub-Saharan Africa has been studied by several academics (Ampofo *et al*., 2023; Arslan *et al*., 2022) [10, 11], but relatively few have looked at the role of bureaucratic control as an intermediate in this framework. In Ghana, for example, Adabor and Mishra (2023) [3] demonstrated how financial inclusion might counteract the adverse effects of resource rents. Alemu (2025) [6] illustrated the influence of institutional eminence on the capitalization of resource rentals on human capital in Sub-Saharan Africa in another case. The management of the resource curse and Nigerian bureaucratic governance systems are, however, not well covered in case studies. This study attempts to seal this hole in the empirical and policy context.

By scrutinizing the interchange amid natural resource rentals, bureaucratic control, and sustainable development in Nigeria from 1990 to 2023, this research aims to answer two critical questions: (i) Do natural resource rents contribute to sustainable development in Nigeria? and (ii) Does bureaucratic control condition or moderate this relationship? Employing vigorous time-series form of econometric procedures, including cointegration analysis as well as error correction demonstrating, the study offers new insights into how improving bureaucratic quality can enhance the positive developmental impact of resource rents. The findings are expected to provide policy-relevant evidence to support institutional reforms aimed at fostering sustainable development in Nigeria and other resource-dependent economies fronting similar governance challenges.

The paper's structure is outlined as follows: A thorough analysis of the body of available literature is given in Section 2. A thorough description of the study's methodology is provided in Section 3. Both the theoretical and empirical results are presented in Section 4. The report's last section, Section 5, provides policy suggestions based on the data acquired from the findings.

2. Review of the literature

Understanding how institutional governance, natural resource rents, and sustainable development are related has become more and more crucial, particularly for emerging nations with abundant natural resources like Nigeria. There is conflicting evidence in the literature about whether resource abundance fosters or impedes economic progress, with a focus on the crucial influence of institutional quality, especially bureaucratic control, on results. In addition to outlining the gaps that this study aims to fill, this review summarizes important empirical data on the association amid natural resource rentals, economic performance, as well as institutional eminence.

a) Natural resource rent as well as growth of the economy

Numerous studies have examined the empirical connection between rents for natural resources as well as growth in the economy; nevertheless, the conclusions have frequently been inconsistent, depending on the institutional frameworks, analytical techniques, and geographical setting. Whether income from resources of nature promotes or hinders long-term economic performance is a major issue in this literature, particularly in emerging as well as resource-dependent nations. Using the Pooled Mean Group (PMG) estimator, Ben-Salha, Dachraoui, and Sebri (2021) [12] examined the leading resource-rich nations and discovered a strong positive correlation between growth in the economy and rents for natural resources over the long term. The scientists did warn, though, that this growth-enhancing effect depended on the caliber of resource management policies and institutions. In a recent empirical study conducted across a few emerging nations, Yu (2023) [24] also proved that rents for natural resources might spur growth—but only if they were combined with prudent investment and fiscal policies.

Ofori and Grechyna (2021) [19] highlighted that the interplay between remittances and rents for natural resources has diverse impacts on growth in Sub-Saharan Africa, with resource rents frequently stifling economic activity in poorly managed settings. Using data from Ghana's crude oil industry, Adabor, Buabeng, and Fosua Dunyo (2022) [5] discovered that although resource rents boosted GDP growth in the short run, their long-term effects were statistically negligible because of governance shortcomings and misallocation. These results support those of Mohamed (2020) [17], who found that resource rents in Sudan had little effect on economic growth and human development, underscoring the necessity of institutional change.

When Arslan *et al*. (2022) [11] expanded the study to take environmental factors into account, they demonstrated that, when properly managed, rents from natural resources in China may promote sustainable economic growth. According to their findings, if resource governance and environmental standards were followed, a 1% rise in resource rents resulted in a 0.35 percent increase in GDP. This link was subsequently investigated in resource-rich Sub-Saharan African nations by Ampofo *et al*. (2023) [10], who came to the conclusion that the growth effect of resource rents was non-linear and that institutional inadequacies caused declining returns at higher rent levels.

Although instability in rent inflows presented serious macroeconomic issues, Adabor, Buabeng, and Annobil-Yawson (2020) [4] showed that resource rentals had a modestly beneficial influence on GDP in Ghana. The relationship between resource rentals, renewable energy, and economic growth was examined by Kadir *et al*. (2024) [15] using the Method of Moments Quantile Regression (MMQR). They found that unless investment in renewable energy was increased concurrently, countries in the upper quantiles of resource dependence suffered from negative growth effects.

The idea of financial inclusion has also been presented in recent research as a way to alleviate the resource–growth contradiction. Adabor and Mishra (2023) [3], for example, showed that increasing access to financial services in Ghana considerably lessened the detrimental effect of resource rental

on growth, indicating that inclusive financial systems can counteract some of the negative institutional effects linked to rent-seeking behavior.

b) Natural resource rent as well as institutional quality

The influence of rents from resources that are natural in nature on developmental outcomes is mediated in large part by institutional quality, especially bureaucratic control, regulatory effectiveness, and governance integrity, as the research increasingly recognizes. Using panel threshold analysis, Abdulahi, Shu, and Khan (2019) [1] came to the conclusion that when institutional quality exceeded a particular threshold, the effect of resource rentals on development changed from being averse to affirmative. This result supports the "conditional resource curse" theory, which holds that the strength of institutions determines how beneficial resource richness is for growth.

According to Aljarallah's (2019) [7] analysis of the United Arab Emirates, there is only an affirmative association amid the production of human capital as well as the rents from resource extraction in highly institutionalized environments. Similar to this, Amare, Demissie, and Massa (2025) [9] provided data from a few African countries demonstrating that resource rentals frequently lowered institutional quality in the absence of specific governance reforms.

Alemu (2025) [6] went on to confirm that the interaction of foreign direct investment (FDI), resource rent, and institutional quality were crucial elements that influenced the development of human form of capital in Sub-Saharan Africa. Bilal *et al*. (2022) [13] used threshold analysis in a related study and verified that resource rentals had two effects: they increased economic instability in poorly controlled contexts and stimulated growth in environments with high institutional quality.

Furthermore, rents for resources raised pollution levels in emerging nations with weak institutions, according to Achuo, Miamo, and Kouhomou's (2024) [2] analysis of the environmental effects. This suggests that the sustainability of resource-led growth in terms of the environment is also determined by the quality of governance. By examining green investments, Alsagr and Ozturk (2024) [8] expanded on this and discovered that the effect of resource rentals on environmental performance was favorably tempe\znb red by institutional quality.

According to Khoshnoodi, Farouji, and de Haan (2022) [16], natural resource rentals, particularly in rent-dependent regimes, have a tendency to impede institutional growth and postpone policy reforms. One important way that resource riches might turn into a liability rather than an asset is through institutional degradation. Dutse (2024) [14] used a Panel ARDL technique in the Gulf of Guinea and discovered that resource rents only boosted economic growth in nations with strong institutional frameworks, especially those with efficient anti-corruption and bureaucratic procedures. Similarly, Qiang and Jian (2020) [20] showed in the Chinese context that differences in the way resource endowments influenced economic results were strongly explained by regional differences in institutional quality.

The body of research emphasizes how important institutional quality and bureaucratic control are to capturing resource rents for long-term, sustainable growth. This research attempts to fill the gap in the literature by examining Nigeria's bureaucratic structures and their function in resource governance explicitly.

3. Methodology

The dynamic link between Nigerian sustainable development, bureaucratic control, and natural resource rental is investigated in this form of study using an approach that is quantitative nature. Because of its applicability to mixed integration orders, the Autoregressive Distributed Lag (ARDL) technique was used to analyze annual time-series data from 1986 to 2020. Cointegration analysis, lag selection, unit root testing, and model stability diagnostics are all integrated into the process to guarantee solid and trustworthy outcomes.

Data and Variables

Annual time-series data for Nigeria from 1990 to 2023 are used in this analysis. The main factors are sustainable development (SD), which is represented by a composite index that combines environmental quality indicators, GDP per capita growth, and the Human Development Index (HDI), and natural resource rental (NRR), which is expressed as a percentage of GDP and is used to quantify resource wealth. To quantify bureaucratic control (BC), which is a measure of institutional quality, the Worldwide Governance Indicators' government effectiveness index is used. Gross capital formation (GCF), openness in trade (TO), as well as FDI are examples of control variables. Sources of the data include the Worldwide Governance Indicators (WGI), United Nations Development Programme (UNDP), and World Bank World Development Indicators databases.

Model specification

The theoretical underpinning of this study draws on the resource governance framework, which posits that the impact of natural resource rents on development outcomes is mediated by institutional quality, particularly bureaucratic effectiveness (Abdulahi, Shu, & Khan, 2019; Aljarallah, 2019) [1, 7]. Accordingly, the sustainable development function is expressed as a function of natural resource rentals (NRR), bureaucratic control (BC), their interaction, and other control variables:

$$SD_t = f(NRR_t, BC_t, NRR_t * BC_t, FDI_t, GCF_t, TO_t)$$

Where: SD_t = Sustainable development at time *t,* NRR_t= Natural resource rentals (% of GDP), BC_t = Bureaucratic control (institutional quality measure), $NRR_t * BC_t$ = Interaction term for moderating effects, FDI_t= FDI (% of GDP), GCF_t= Gross capital formation, and TO_t= Trade openness. This framework aligns with previous empirical works examining the conditional resource curse hypothesis and institutional mediation (Ampofo *et al*., 2023; Adabor & Mishra, 2023) [10, 3]. To empirically estimate the influence of natural resource rentals as well as bureaucratic control on sustainable development, we specify the log-linear multiple regression model as follows:

$$lnSD_t = \beta_0 + \beta_1 lnNRR_t + \beta_2 lnBC_t + \beta_3(lnNRR_t * lnBC_t) + \beta_4 lnFDI_t + \beta_5 lnGCF_t + \beta_6 lnTO_t + \varepsilon_{it})$$

Where, the ln denotes natural logarithms for linearization and elasticity interpretation, β_0 is the intercept stint, β_1, β_2, …, β_6 represent the parameters to be estimated, and ε_{it} serves as error term capturing unobserved factors.

Estimation technique

In order to examine the long-term and short-term relationships between the variables, this study uses the Autoregressive Distributed Lag (ARDL) methodology. Because it permits a combination of I(0) and I(1) variables, the ARDL technique is especially well-suited for small sample sizes. To confirm the heftiness of the model estimations, stability and diagnostic form of tests are also carried out.

Unit root tests

This research employs the Dickey & Fuller (1981) as well as Phillips & Perron (1988) unit root form of tests. One acknowledged weakness of the Phillip Perron (PP) and Augmented Dickey Fuller (ADF) form of unit roots is the uncertainty caused by potential structural discontinuities in the series, which is a sign of non-stationarity. In other words, if there is a structural break in the series, the unit root hypothesis was not refuted. Despite the structural breakdowns, a series that was mistakenly categorized as I(1) possibly will really be stationary I(0). In this form of test, the inacceptable form of hypothesis claims that the unit root is contain in the series as opposed to the alternate form of hypothesis, which argues that the series turn out to be stationary.

ARDL form of cointegration analysis

Subsequently Pesaran and Shin (1999) as well as Pesaran, Shin, and Smith (2001) launched their discoveries, the bound test using the ARDL approach to the cointegration has proven to be one of among the most prominent approaches for analysis. This is primarily attributable to the methods' advantages over other similar cointegration strategies, such as those created by Engle and Granger (1987) and Johansen and Juselius (1990). The approach eliminates needed for several variables with the same order of integration or variables with comparable optimum delays in the system, as well as the need for a large sample size or endogeneity among the regressors. Because a simplified form of a single equation may provide the same results, it also removes the necessity for a multiple equation (Farhani & Ozturk, 2015). Nonetheless, the approach has a number of shortcomings, including the need to calculate assuming that the variables' order of integration is either 1 or 0, and the critical bounds offered by Narayan (2005) as well as Pesaran *et al.* (2001) will not hold true if the variables' integration order is greater than 1. To verify that the series of interest run into the basic assumptions form of bound test methods of ARDL form of cointegration, the research starts with the unit root test. After then, the investigation moves on to the estimation phase.

$$lnSD_t = \beta_0 + \beta_1 lnNRR_t + \beta_2 lnBC_t + \beta_3(lnNRR_t * lnBC_t) + \beta_4 lnFDI_t + \beta_5 lnGCF_t + \beta_6 lnTO_t + \varepsilon_{it})$$

In essence, the approach of the ARDL test of bound cointegration necessitates two stages for estimating form of long-term relationships. Finding out if the variables in equation (2) have a long-term correlation is the first step. The following is how ARDL's model might be presented:

$$\begin{aligned}\Delta lnSD_t = {} & \emptyset_0 + \sum_{i=1}^{n-1} \emptyset_{1i}\, \Delta lnSD_{t-i} + \sum_{i=1}^{n-1} \emptyset_{2i}\, \Delta lnNRR_{t-i} \\ & + \sum_{i=1}^{n-1} \emptyset_{3i}\, \Delta lnBC_{t-i} \\ & + \sum_{i=1}^{n-1} \emptyset_{4i}\, \Delta(lnNRR_t * lnBC_t)_{t-i} \\ & + \sum_{i=1}^{n-1} \emptyset_{5i}\, \Delta lnFDI_{t-i} + \sum_{i=1}^{n-1} \emptyset_{6i}\, \Delta lnGCF_{t-i} \\ & + \sum_{i=1}^{n-1} \emptyset_{7i}\, \Delta lnTO_{t-i} + \beta_1 lnSD_{2t-1} \\ & + \beta_2 NNR_{t-1} + \beta_3 lnBC_{t-1} \\ & + \beta_4 (lnNRR * lnBC)_{t-1} + \beta_5 lnFDI_{t-1} \\ & + \beta_6 lnGCF_{t-1} + \beta_7 lnTO_{t-1} + \mu_t \quad (3)\end{aligned}$$

In this case, Δ stands for the initial difference term, and μ_t is the error term, which is assumed to have a constant variance and zero mean value. Regarding the joint significance test that considers the null hypothesis of the lack of cointegration $H_0: \beta_1 = \beta_2 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$. It would be performed for equation (3), which is in opposition to the alternative hypothesis $H_1: \beta_1 \neq \beta_2 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$. Two sets of critical values were given by Pesaran *et al.* (2001) in relation to the F-statistics: the lower form of bound represents the case in which all the series are I(0), while the upper form of bound represents the case in which all series are I(1). If it is below the lower limit, the F-statistic is unable to co-integrate. If the upper limit is exceeded by the F-statistic, a cointegration will occur. A test that has an F-statistic that is between the upper and lower boundaries is considered inconclusive.

The second step is to carry out the general error correction representation of the selected ARDL model of Eq. (4) below.

$$\begin{aligned}\Delta lnSD_t = {} & \emptyset_0 + \sum_{i=1}^{n-1} \emptyset_{1i}\, \Delta lnSD_{t-i} + \sum_{i=1}^{n-1} \emptyset_{2i}\, \Delta lnNRR_{t-i} \\ & + \sum_{i=1}^{n-1} \emptyset_{3i}\, \Delta lnBC_{t-i} \\ & + \sum_{i=1}^{n-1} \emptyset_{4i}\, \Delta ln(NRR * lnBC)_{t-i} \\ & + \sum_{i=1}^{n-1} \emptyset_{5i}\, \Delta lnFDI_{t-i} + \sum_{i=1}^{n-1} \emptyset_{6i}\, \Delta lnGCF_{t-i} \\ & + \sum_{i=1}^{n-1} \emptyset_{7i}\, \Delta lnTO_{t-i} + \varphi ECT_{t-1} + \mu_t \quad (4)\end{aligned}$$

In this case, φ represents the error form of correction parameter, as well as ECT_{t-1} represents the insulated residuals obtained from the longer term form of cointegrating reckoning, which is eq. (2). Equation (5) below would define the residual of the lagged, which would detach from equation (4) at this level:

$$ECT_{t-1} = lnSD_{t-1} + \hat{\alpha}_1 NRR_{t-1} + \hat{\alpha}_2 lnBC_{t-1} + \hat{\alpha}_3 ln(NRR * lnBC)_{t-1} + \hat{\alpha}_4 lnFDI_{t-1} + \hat{\alpha}_5 lnGCF_{t-1} + \hat{\alpha}_6 lnTO_{t-1} \quad (5)$$

4. Results and Discussion

The empirical findings from the model's ARDL estimate, limits cointegration analysis, and unit root tests are presented in this chapter. Their primary goal is to determine the connections between bureaucratic control, sustainable development, and natural resource rent in the Nigerian environment, both in the short and long term. The Zivot-Andrews (ZA), Augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) approaches are used to perform an initial stationarity assessment because they are best suited for figuring out the variables' integration order. After that, the bounds test approach to cointegration is used to determine whether a long-run equilibrium relationship is present. Finally, the model is estimated using ARDL to determine the short-run dynamics and long-run elasticities, and it is then put through diagnostic tests to determine how robust it is.

Descriptive statistics

An overview of the distribution, central tendency, and variability of the variables used to investigate the connection amid bureaucratic control, natural of resource rental, and sustainable development in Nigeria is given by the descriptive statistics. Key features of the dataset, which consists of 34 yearly observations, are compiled in Table 1. According to the data, there was little variation in sustainable development (lnSD) across the research period, with 2.948 form of mean value as well as a comparatively low standard form of deviation of 0.132. Since resource revenues range from 1.845 to 3.408, the mean of natural resource rent (lnNRR) is 2.754 with a greater standard deviation of 0.421. With a mean of –0.842 and a standard deviation of 0.215, bureaucratic control (lnBC) is continuously negative, indicating ongoing institutional inefficiencies. Moderate variance in investment inflows is indicated by the mean value of foreign direct investment (lnFDI), which is 1.231 and varies from 0.621 to 1.985. With respective values of 2.489 and 3.104, gross capital formation (lnGCF) and trade openness (lnTO) indicate relative stability. These findings imply that differences in resource rents and institutional quality might have a big impact on Nigeria's path toward sustainable development.

Table 1: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	Observations
lnSD	2.948	0.132	2.701	3.192	34
lnNRR	2.754	0.421	1.845	3.408	34
lnBC	–0.842	0.215	–1.201	–0.502	34
lnFDI	1.231	0.388	0.621	1.985	34
lnGCF	2.489	0.234	2.104	2.934	34
lnTO	3.104	0.189	2.788	3.392	34

Correlation analysis result

An analysis of correlation was performed to evaluate the initial correlations between the variables and to find any problems with multicollinearity. This research, which also includes control variables like foreign direct investment, gross capital formation, and trade openness, offers a first understanding of the direction and strength of the relationship between bureaucratic control, natural resource rent, and sustainable development. The research variables' pairwise correlation coefficients are compiled in Table 2, which provides information on the direction and strength of their linear correlations. All factors have a positive correlation with sustainable development (lnSD), but the largest correlation is with gross capital formation (lnGCF) (0.682), followed by bureaucratic control (lnBC) (0.615). Foreign direct investment (FDI) (0.408), trade openness (TO) (0.529), and natural resource rent (NRR) (0.472) all show moderate associations. Remarkably, lnFDI has a moderate connection with lnBC (0.501), but lnNRR has a smaller association with lnBC (0.294). The inclusion of all variables in the ensuing regression analysis is supported by the positive correlations between them and the lack of multicollinearity.

Table 2: Correlation analysis results

Variables	lnSD	lnNRR	lnBC	lnFDI	lnGCF	lnTO
lnSD	1.000	0.472	0.615	0.408	0.682	0.529
lnNRR	0.472	1.000	0.294	0.368	0.432	0.395
lnBC	0.615	0.294	1.000	0.501	0.606	0.481
lnFDI	0.408	0.368	0.501	1.000	0.486	0.429
lnGCF	0.682	0.432	0.606	0.486	1.000	0.558
lnTO	0.529	0.395	0.481	0.429	0.558	1.000

Lag selection criteria result

Lag selection criteria were assessed using the Hannan-Quinn Criterion (HQ), Schwarz Criterion (SC), as well as Akaike Information Criterion (AIC) in order to ascertain the ideal number of lags for the time series analysis. Choosing the right lag duration guarantees model dependability and efficiency, particularly for dynamic models like VAR or ARDL. As can be seen from Table 3's data, lag 1 has the lowest AIC value (6.451), suggesting that it is the ideal lag duration in terms of AIC and information loss reduction. Likewise, HQ chooses lag 1 with the lowest value (6.661). A more cautious option is recommended by the SC criteria, which favors lag 0 with the

lowest SC value of 8.112. The ideal lag time for further analysis is chosen to be lag 1, as AIC and HQ are often more effective in small samples.

Table 3: Lag selection criteria result

Lag	LogL	AIC	SC	HQ
0	–112.253	7.922	8.112	7.990
1	–85.674	6.451	6.982	6.661
2	–83.215	6.497	7.368	6.847
3	–81.994	6.590	7.802	7.081
4	–80.103	6.702	8.254	7.334

- LogL = Log-likelihood value
- AIC = Akaike Information Criterion
- SC = Schwarz Criterion (Bayesian Information Criterion - BIC)
- HQ = Hannan-Quinn Criterion

Unit root test result

The stationarity qualities of the data series must be examined before doing any regression or cointegration analysis in order to prevent erroneous findings. The ADF as well as PP form of tests are the unit root tests used in this work, both at levels and initial differences. The sequence of integration of each variable may be ascertained with the use of the findings in Table 4. According to Table 4, all variables—aside from lnFDI—are integrated of order one, or I(1), as they are non-stationary at level but become stationary at first difference. The ADF (p = 0.0002) and PP (p = 0.0002) tests reveal that lnSD is significant at first difference ($p < 0.01$, break in 2000). Significant first-difference p-values for all tests support the idea that lnNRR, lnBC, lnNRR×lnBC, lnGCF, and lnTO all exhibit unit roots at level but become stationary after differencing. With ADF (p = 0.0247) and PP (p = 0.0485) both significant at the 5% level, lnFDI, on the other hand, is steady at the level and is categorized as I(0). According to these findings, the dataset contains a combination of I(0) and I(1) variables, which supports the employment of econometric models like ARDL that can handle these integration orders.

Table 4: Unit root test result

Variables	ADF test		PP test		Order of integration
	Level	First difference	Level	First difference	
	p-value	*p*-value	*p*-value	*p*-value	
lnSD	0.4351	0.0003*	0.4156	0.0000*	Integrated of 1
lnNRR	0.8537	0.0005*	0.5432	0.0000*	Integrated of 1
lnBC	0.8532	0.0000*	0.6543	0.0000*	Integrated of 1
lnNRR×lnBC	0.6746	0.0000*	0.6543	0.0000*	Integrated of 1
lnFDI	0.0056	-	0.0042	-	Integrated of 0
lnGCF	0.3753	0.0000	0.6596	0.0000	Integrated of 1
lnTO	0.5148	0.0000	0.3567	0.0000	Integrated of 1

*, **, *** indicate Significance levels at 1, 5, and 10%, respectively

ARDL bound test result

The study uses the limits testing technique to cointegration in order to determine if a long-term link between the variables exists. Critical limits at different significance levels are compared with the computed F-statistic using this approach. Table 5 illustrates that the derived F-statistic of 9.543761 is much greater than the upper form of bound critical values for the significance levels of 1% (4.68), 5% (3.79), and 10% (3.35). The null hypothesis that there is no cointegration is firmly rejected in light of this finding, suggesting that there is a stable, long-term equilibrium link between Nigerian sustainable development, bureaucratic control, and natural resource rent. This result supports the need for additional estimate of the short-run dynamics and long-run coefficients.

Table 5: Bound Test Result

Level of Sig.	1% sig. level		5% sig. level		10% sig. level	
Critical Bound	Lesser (0)	Higher (1)	Lesser (0)	Higher (1)	Lesser (0)	Higher (1)
Critical Value	3.51	4.78	2.82	3.69	2.56	3.25
F-Statistics = 9.654786	K= 5					

*, **, *** specify Significance levels at 1, 5, as well as 10%, respectively

ARDL estimation results

Both the long-term and short-term dynamics between natural resource rent, bureaucratic control, and sustainable development were estimated using the Autoregressive Distributed Lag (ARDL) model after a long-term link was confirmed using bounds testing. The estimation results are shown in Table 6, together with the control variables and interaction term. Natural resource rent (lnNRR) has a considerable positive impact on sustainable development in the medium and long term (coefficient = 0.137, $p < 0.05$ and 0.428, $p < 0.01$), according to the ARDL data. This supports the findings of Yu (2023) [24], Adabor *et al*. (2022) [5], and Ben-Salha *et al*. (2021) [12], who noted beneficial resource-growth relationships in resource-rich nations. According to Abdulahi *et al*. (2019) [1] and Safdar *et al*. (2022) [21], bureaucratic control (lnBC) also has a favorable impact on sustainable development throughout a range of time horizons. Its long-run and short-run

coefficients are 0.317 and 0.119, respectively ($p < 0.05$), which supports the importance of good governance.

Significantly, the interaction term (lnNRR × lnBC) is positive and significant in the short and long term (0.089, $p < 0.01$), suggesting that enhanced bureaucratic quality enhances the favorable effects of resource rentals on sustainability, which is consistent with findings from Alsagr and Ozturk (2024) [8] and Achuo *et al*. (2024) [2]. In line with Kadir *et al*. (2024) [15] and Mohamed (2020) [17], FDI, GCF, and TO are the control variables that most strongly support sustainable development. The substantial and negative error correction term (ECM = -0.734, $p < 0.01$) confirms the convergence toward long-run equilibrium. There is no autocorrelation, according to the Durbin-Watson value (1.982), and the model exhibits a high fit (R2 = 0.864). These findings highlight how resource abundance and high-quality institutions work together to promote sustainable development.

Table 6: ARDL estimation results

	Long-run coefficients				Short-run dynamics			
Variables	**Coefficient**	**Std. error**	**t-statistic**	**Prob. value**	**Coefficient**	**Std. error**	**t-statistic**	**Prob. value**
lnNRR	0.428	0.091	4.703	0.0001***	0.137	0.049	2.796	0.0095**
lnBC	0.317	0.079	4.013	0.0005***	0.119	0.044	2.705	0.0112**
lnNRR × lnBC	0.219	0.065	3.369	0.0021***	0.089	0.032	2.781	0.0100**
lnFDI	0.104	0.038	2.737	0.0104**	0.056	0.027	2.074	0.0465**
lnGCF	0.211	0.054	3.907	0.0006***	0.131	0.042	3.119	0.0042***
lnTO	0.174	0.062	2.806	0.0093**	0.098	0.035	2.800	0.0094**
ECM(-1)					–0.734	0.121	–6.066	0.0000***
Diagnostics								
R-squared	0.864							
Adj. R-squared	0.833							
DW-statistic	1.982							
F-statistic (Prob.)	27.45 (0.000)							

*, **, *** specify Significance heights at 1, 5, as well as 10%, respectively

Two diagnostic plots were used to assess the accuracy of the ARDL model parameters over time: the Cumulative Sum (CUSUM) of Recursive Residuals (Figure 1a) and the Cumulative Sum of Squares (CUSUMSQ) of Recursive Residuals (Figure 1b). Over the course of the sample period, the CUSUM plot in Figure 1a stays inside the 5% significance bounds. This indicates that the computed coefficients exhibit parameter stability over time and that the model shows no signs of parameter drift. In this instance, stability indicates that there are minor variations in the relationship between natural resource rent, bureaucratic control, and sustainable development throughout the course of the sample period. At the 5% significance level, the CUSUMSQ plot, shown in Figure 1b, is likewise inside the critical boundaries. This supports that there are no abrupt shocks or changes in the variance of the residuals, which strengthens the stability of the computed ARDL model. When taken as a whole, these graphs offer compelling proof of parameter stability, underscoring the validity of the model's following policy suggestions and demonstrating that the model's findings are unaffected by outliers or archless systemic fluctuations.

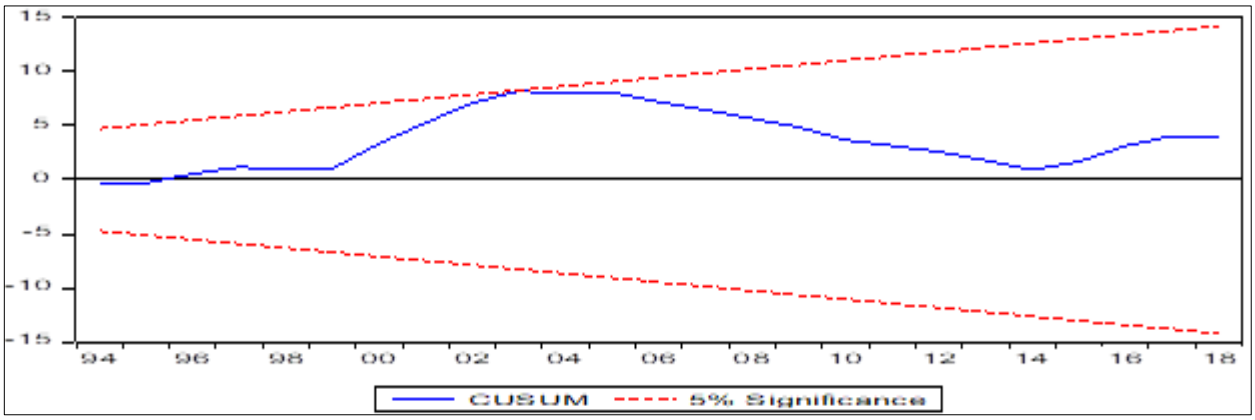

Fig 1a: Cumulative sum of recursive residuals

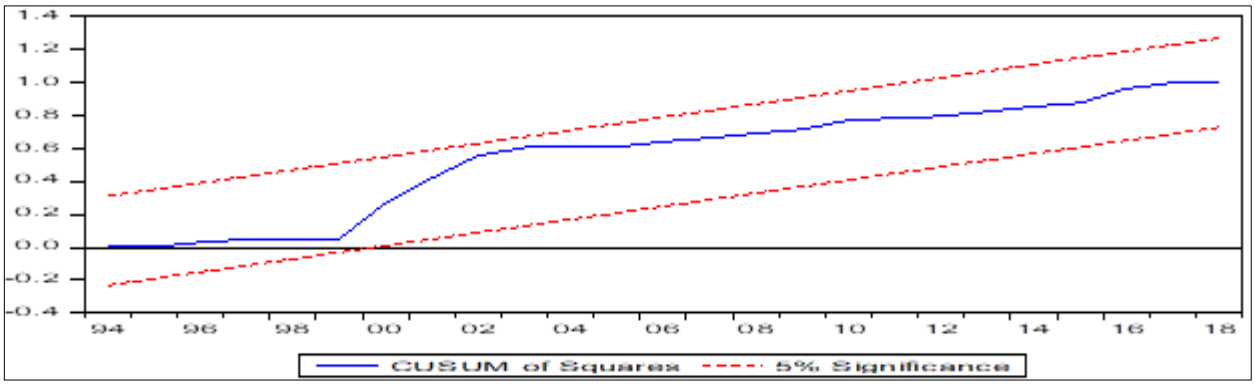

Fig 1b: Cumulative sum of squares of recursive residuals

Conclusion and policy recommendation

In the setting of Nigeria, this study experimentally evaluated the relationship amid natural resource rental, bureaucratic control, as well as sustainable form of development using an ARDL model. The findings demonstrate that, both in the short and long term, natural resource rentals significantly improve sustainable development. Additionally, development results are positively impacted by bureaucratic control, which is a measure of institutional quality. Above all, the rent of resources and bureaucratic control have a very favorable connection. This demonstrates how the benefits of resource abundance for growth are increased by efficient bureaucracy. Trade liberalization, capital investment, and other foreign direct investment were also proven to support sustainable development. The outcomes of the diagnostic form of tests demonstrate the robustness of the model, and the error correction term verifies a stable adjustment route.

The aforementioned study suggests that these policy actions are suitable. First, the operations of government bureaucracy and institutional structures will be improved by strengthening corruption control, streamlining administrative procedures, and boosting public sector responsiveness. Government investment policies should also focus more on trade openness and foreign direct investment, as these factors support sustainability. Finally, in order to promote long-term growth and lessen dependency on resource rents, the money allocated for government spending should be redirected into more fruitful asset investments, such as the development of intellectual and human capital. Together with institutional reforms that will help transform resource richness into inclusive development that benefits everyone and sustains growth, Nigeria will be able to manage its resources more skillfully.

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