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Structural Breaks and Oil-Economy Sustainability

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This study examines the impact of economic policy uncertainty (EPU) on environmental degradation in oil-producing African economies from 1990 to 2022, controlling for GDP and globalization. Using advanced panel tests and Granger non-causality analysis, the study finds that higher EPU reduces environmental harm, while globalization has no significant effect. It recommends economic diversification to lessen reliance on oil and mitigate environmental risks, offering key insights for policymakers.

I. Introduction

Economic policy uncertainty (EPU) significantly influences macroeconomic fundamentals, including research and development (R&D), energy consumption, and overall economic activity. It affects various sectors, including businesses, households, and governments. In terms of environmental degradation, EPU plays a dual role. On the one hand, it can reduce environmental harm by decreasing consumption and investment activities that contribute to ecological damage. On the other hand, EPU can hinder investments in clean energy and R&D, which are essential for long-term environmental sustainability (Adebayo et al., 2022; Akadiri et al., 2020; Olasehinde-Williams, 2020; Osodi & Olasehinde-Williams, 2024).

Despite its significance, the relationship between EPU and environmental outcomes is underexplored, particularly in African oil-producing nations. These countries face unique challenges, including weak enforcement of environmental standards by multinational oil companies, poor waste management, and agricultural practices that worsen environmental degradation. Additionally, the global energy transition and the volatility of oil prices further complicate the environmental impact of EPU in these economies (Abubakar & Akadiri, 2022; Akadiri et al., 2020).

This study explores the connection between EPU and environmental degradation in oil-producing African economies from 1990 to 2022. It seeks to understand how EPU affects environmental outcomes, accounting for structural breaks and data complexities that are typical of African economies. The study's theoretical framework posits that EPU has a dual effect on environmental degradation. While it may reduce environmental harm by low-

ering investment and production activities, it also hinders investments in clean energy and environmental protection, complicating efforts toward sustainability.

This study uniquely addresses the structural and data-related challenges faced by African economies, providing a more accurate analysis of EPU's impact on environmental outcomes. The findings offer valuable insights for policymakers and stakeholders, highlighting the need for economic diversification to mitigate the environmental effects of oil production and economic fluctuations.

The rest of the paper is organised as follows. Section II discusses data and methodology. Section III presents discussion on empirical findings and the final section concludes the paper.

II. Data and Methodology

A. Data

This study examines the impact of *EPU* on environmental degradation in Africa's top oil-producing countries—specifically Nigeria, Algeria, Libya, Angola, and Gabon—over the period from 1990 to 2021. *EPU* is quantified using the Uncertainty Index developed by Ahir et al. (2022). Environmental degradation is measured by carbon emissions (metric tonnes per capita), while economic growth (*Y*) is assessed through real GDP per capita (in US dollars), with both data sets sourced from the World Development Indicators (WDI). Additionally, the study employs the globalization index (*GLO*) developed by Dreher (2006).

B. Methodology

Given that the analysis period is characterized by developments such as the 2007/2008 Global Financial Crisis (GFC) and the COVID-19 pandemic, structural changes in the variables are likely. Hence, this study adopts Karavias & Tzavalis (2021) panel unit root test and the Ditzen et al. (2021) test to account for structural breaks in unit root and cointegration tests that allow for multiple breaks, respectively. The confirmation of unit root and cointegration is followed by the test for causality based on the innovative Granger non-causality test of Juodis, Karavias, & Sarafidis (2021). The test begins with the following specification:

$$Y_{i,t} = \theta_{0,i} + \sum_{p=1}^P \theta_{p,i} Y_{i,t-p} + \sum_{q=1}^Q \delta_{q,i} X_{i,t-q} + \varepsilon_{i,t} \quad (1)$$

For $t = 1, \dots, T$ and $I = 1, \dots, N$, where $\theta_{0,i}$ represents the individual fixed effects, $\theta_{p,i}$ captures the heterogeneous autoregressive coefficients, $\delta_{q,i}$ indicates the Granger causation parameters or heterogeneous feedback coefficients, and $\varepsilon_{i,t}$ denotes the error term for individual i at time t . Using the assumption that $Y_{i,t}$ is an ARDL (P, Q) process, generally, $Y_{i,t}$ can be seen as one of the equations of a joint VAR model for $(Y_{i,t}, X_{i,t})'$. The bivariate system can be extended to a multivariate model.

The null hypothesis of the test states that series $X_{i,t}$ does not Granger-cause series $Y_{i,t}$. The formulation involves imposing a set of restrictions on the δ 's in Equation (1):

$$H_0 : \delta_{q,i} = 0, \text{ for all } 1 \text{ and } q \quad (2)$$

On the other hand, the alternative hypothesis is expressed in Equation (2)

$$H_1 : \delta_{q,i} = 0, \text{ for some } i \text{ and } q \quad (3)$$

The rejection of the null hypothesis based on the chosen level of statistical significance implies that series $X_{i,t}$ Granger-causes $Y_{i,t}$.

III. Empirical Results

We implement the Karavias & Tzavalis (2021) panel unit root test and report the outcome in Table 1. Our assessment commences with CO_2 , wherein we accommodate the possibility of an unknown break date determined by the data. The selection of critical values utilized the default parameters, encompassing 1,000 bootstrap samples for robustness check.¹

The test reveals that some or all the panel time series are stationary. A disaggregated analysis shows that EPU , Y , GLO , and CO_2 emissions, with p -values of 0.000, are statistically significant at the first difference. We proceed with

the cointegration techniques that account for panel structural breaks and report results in Table 2. The panel series are cointegrated; that is, there exists a long-run equilibrium relationship among the series, having accounted for potential structural breaks.

The Ditzen, Karavias, & Westerlund (2021) test identifies two structural breaks in 1993 and 2008, linked to global oil price fluctuations, OPEC's production cuts, and the global financial crisis. These breaks influenced environmental outcomes in African oil-producing economies. The Granger non-causality test reveals significant dynamics between CO_2 emissions, EPU , output, and globalization, emphasizing the role of structural breaks and economic events in shaping environmental impacts.

The analysis reveals significant insights into the relationship between EPU and CO_2 emissions. While the first lag shows no significant Granger causality from EPU to CO_2 emissions, the second and third lags indicate a Granger-causal link, suggesting a negative association between EPU and CO_2 emissions. This finding contrasts with previous studies by Anser et al. (2021), Chu & Le (2022), Udeagha & Muchapondwa (2022), Zhang et al. (2022), and Farooq et al. (2023), which documented a positive correlation between EPU and environmental degradation. Our study emphasizes the delayed impact of EPU on the environment, highlighting the potential for eventual detrimental consequences for the planet and its inhabitants.

Further examination reveals the influence of variable Y on CO_2 emissions. In the first lag, Y shows a positive Granger-causal relationship with CO_2 emissions, while the second lag reveals a negative relationship, indicating a nuanced and evolving impact over time. By the third lag, the Granger causality between Y and CO_2 is no longer statistically significant, suggesting that the immediate effect of Y diminishes over time. This pattern aligns with the Kuznets environmental curve, which supports the theory's applicability in our study, potentially due to factors like commodity volatility and external shocks in commodity-exporting economies. Additionally, GLO does not cause CO_2 emissions in any period examined, despite exhibiting a negative relationship, which contrasts with Akadiri et al. (2020), who found a long-term negative association between globalization and CO_2 emissions. However, globalization remains relevant in explaining environmental degradation within the model.

The study underscores the significant environmental implications for economies dependent on oil production, particularly during uncertain times. Faced with macroeconomic challenges, nations may focus on short-term goals, leading to intensified exploration activities. This can have detrimental consequences, including the destruction of aquatic ecosystems, soil degradation, and ecological imbalance. Additionally, economic pressures might drive govern-

¹ To mitigate the potential influence of break dates on our empirical results, we subjected the break date to a CHOW test. Our analysis revealed that the break date did not exert a significant impact on the model. As a result, we have chosen to proceed with our results without incorporating the break dates into the analysis.

Table 1. Panel unit root result

Variables	Statistics	Bootstrap CV	p-Value	Break Date
CO ₂	-6.930***	-3.917	0.000	2005
EPU	-16.653***	1.719	0.000	1991
Y	-11.906***	-0.067	0.000	1998
GLO	-18.587***	6.809	0.000	2021

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, while CV indicates critical values.

Table 2. Panel cointegration results with structural breaks

	Test Stat.	1% CV	5% CV	10% CV
F(1 0)	2.35	6.09	4.66	4.03
F(2 1)	5.41**	6.59	5.24	4.64
F(3 2)	5.04	6.92	5.61	4.99
F(4 3)	1.41	7.33	5.87	5.23
F(5 4)	1.02	7.49	6.05	5.45
#	Index	Date	[95% Conf. Interval]	
1	4	1993	1992	1994
2	19	2008	2007	2009

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 3. Panel granger causality results

Variables	Lags	Coefficient	Std. err	Z	p-value
EPU	1	-0.024	0.059	-0.41	0.685
	2	-0.059**	0.025	-2.31	0.021
	3	-0.057***	0.021	-2.60	0.009
Y	1	0.00003***	4.480	8.40	0.000
	2	-0.00009***	0.0002	-8.44	0.000
	3	0.00001	9.490	1.55	0.120
GLO	1	-0.009	0.006	-1.35	0.177
	2	-0.013	0.033	-0.40	0.686
	3	0.006	0.022	0.31	0.757

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

ments to implement austerity measures, reducing funding for environmental agencies and initiatives. This resource reduction could weaken environmental regulations and oversight, potentially increasing environmental violations and pollution. Consequently, setbacks in environmental compliance with established regulations are likely, highlighting the need for a balanced approach that considers economic and environmental factors to ensure sustainable development and the preservation of natural resources.

This further illustrates the complex dynamics between oil production and environmental impact. In periods of increased oil production, the environment often suffers due to habitat destruction, pollution, and ecosystem disruption. However, the negative environmental impact might be exacerbated during economic uncertainty as short-term economic stability takes precedence over environmental concerns. Governments and oil companies may reduce

investments in the sector, although adopting new technologies aligned with global environmental regulations could mitigate some negative impacts. This shift towards cleaner technologies indicates the industry's recognition of environmental challenges. The study also emphasizes the role of globalization, which, while facilitating economic diversification and technological advancement, can contribute to the spread of pollution. The mixed outcomes of globalization reflect its dual nature, necessitating a balance between economic growth and responsible environmental practices to achieve sustainability goals.

IV. Conclusion

This study investigates the impact of EPU on environmental degradation in African oil-producing economies from 1990 to 2022, considering output and globalization. It

recommends that policymakers prioritize economic diversification, promote sustainable technologies, enforce robust environmental regulations, and balance economic growth with conservation. Emphasizing renewable energy investments can reduce dependence on fossil fuels and mitigate environmental harm, fostering sustainable development in these economies.

In addition, policymakers should foster international collaboration on environmental protection, technology transfer, and sustainable practices, while addressing the negative impacts of economic growth. The limited effect of globalization highlights the need for capacity building, skill development, and infrastructure enhancement to create a diversified industrial base. Governments should design resilient policies that prioritize environmental protection during economic shocks. Lastly, public awareness and

education initiatives, along with international collaboration, are crucial for achieving a sustainable and balanced approach to economic growth and environmental conservation.

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