Sectoral Activities, Energy Use and Environmental Quality in Nigeria

Busayo Victor Osuntuyi
Department of Economics, Adekunle Ajasin University,
Akungba-Akoko, Ondo State, Nigeria

Abstract
Nigeria faces escalating environmental challenges that threaten ecosystems, public health, and climate stability. Despite various policy efforts, environmental degradation persists, driven largely by unsustainable energy use and sectoral activities. This study examines the long-run impacts of sectoral activities (agriculture, industry, and services) and energy use on environmental degradation in Nigeria, using secondary data from credible sources. Fully Modified Ordinary Least Squares (FMOLS) and Canonical Cointegrating Regression (CCR) techniques were employed to estimate long-run relationships. The results found that agricultural output significantly worsens environmental conditions, with a 1% increase associated with a 0.076% rise in carbon emissions and a 0.63% increase in ecological footprint. Conversely, the service sector helped mitigate environmental degradation, reducing CO2 emissions by 0.068% and ecological footprint by 0.26% per 1% increase in output. Energy use is the most critical driver, with a 1% increase resulting in a 0.975% rise in carbon emissions and a 0.20% increase in ecological footprint. Industrial output showed no statistically significant environmental impact. The study concluded that sectoral activities and energy use are central to Nigeria's environmental degradation and recommended promoting sustainable agriculture, diversifying the energy mix, and adopting green technologies to address these challenges.

Keywords: Carbon emissions, ecological footprint, sectoral activities, energy use

Introduction

Environmental degradation has emerged as one of the most pressing global challenges in recent decades (Nuță et al., 2024). In response, international frameworks such as the Kyoto Protocol and the Paris Agreement, central to achieving the Sustainable Development Goals (SDGs), have aimed to limit global warming to below 2°C (Pengcheng et al., 2024; Zhang et al., 2019). Despite these initiatives, rising global emissions, particularly from energy use, continue to undermine progress toward environmental sustainability (Bekele et al., 2024). The persistent reliance on fossil fuels remains a critical barrier, as energy production and economic expansion continue to drive greenhouse gas (GHG) emissions (Wang & Azam, 2024). Nonetheless, opportunities for transitioning to carbon neutrality exist through the adoption of renewable energy sources and more efficient production practices (Ehigiamusoe et al., 2023).

Sectoral activities (agriculture, industry, and services) play a dual role in this context. While they drive economic growth, they also contribute significantly to environmental degradation due to increased energy demands and resource exploitation (Danish et al., 2019; Ehigiamusoe et al., 2022). In Nigeria, all major sectors are heavily dependent on fossil fuels, contributing not only to GDP but also to environmental pressures through carbon emissions (Tunde et al., 2022). For instance, agriculture, which remains the backbone of the Nigerian economy, is responsible for about one-third of global GHG emissions (FAO, 2016; Agboola &

Bekun, 2019). The sector has undergone significant growth since the 1980s, especially during the 1990s and early 2000s, but this expansion has come with increased energy use and emissions (CBN, 2023; Sadowski et al., 2024).

Similarly, Nigeria's industrial sector has experienced structural fluctuations, with periods of growth and decline over the past four decades. While it has contributed to economic development, industrialisation has also led to increased emissions, particularly from oil and gas activities, mining, cement production, and waste disposal (Inah et al., 2022; Matthew et al., 2019). The service sector, once considered less environmentally intensive, now significantly contributes to pollution due to its growing energy and material demands (Hashmi et al., 2020). Despite these environmental impacts, the sector has shown consistent resilience and growth, particularly post-2000s, making it a key driver of Nigeria's economic development (CBN, 2023). Also, energy use in Nigeria has followed an upward trend since the 1980s, with notable surges in the early 2000s. This increase correlates with rising CO2 emissions and an expanding ecological footprint, two key indicators of environmental quality (EIA, 2023; GEF, 2023). While emissions and ecological footprint have fluctuated over the years, the overall trend indicates increasing environmental pressure, driven largely by sectoral activities and energy use.

Despite the implementation of several environmental policies, Nigeria continues to face rising temperatures, CO2 emissions, and ecological degradation (Federal Ministry of Environment, 2021). This underscores the need for a comprehensive understanding of how sectoral activities and energy use affect environmental outcomes. While previous studies (e.g., Aladejare, 2022; Ezaal & Owede, 2022; Mehboob et al., 2023; Osuntuyi & Lean, 2023; Yusuf, 2023) have examined various determinants of environmental degradation, the role of sectoral activities remains underexplored in the Nigerian context. This study addresses this gap by investigating the environmental impacts of sectoral activities and energy use in Nigeria from 1981 to 2022. Unlike prior research that relied solely on CO2 emissions, this study adopts both CO2 emissions and the ecological footprint as comprehensive environmental indicators, offering a broader perspective on environmental degradation (Bashir et al., 2020; Chidiebere-Mark et al., 2022; Zhao et al., 2022). By exploring the nexus between sectoral activities, energy use, and environmental outcomes, the study aims to inform policy interventions geared toward sustainable development.

Empirical Literature

The structural change theory suggests that economic development progresses through phases: from low-pollution agricultural sectors to high-pollution industrial sectors, and eventually to lower-pollution service sectors (Marsiglio et al., 2016). Numerous studies have explored how transitions across these sectors influence environmental quality. Literature on agriculture's environmental impact presents both conflicting (win-lose) and synergistic (win-win) narratives. The win-lose view sees agriculture degrading the environment or being constrained by environmental policies, while the win-win perspective supports sustainable agricultural productivity (Adekoya et al., 2022).

Several studies confirm agriculture's negative environmental effects. Snyder et al. (2009) and Gokmenoglu and Taspinar (2018) identify agriculture as a major source of greenhouse gas emissions. Arshad et al. (2020) link deforestation to pollution in South and Southeast Asia, while Parajuli et al. (2019) stress forest conservation's role in emission reduction. In BRICS and other countries, agricultural output increases pollution (Balsalobre-

Lorente et al., 2019; Eyuboglu & Uzar, 2020). Similarly, studies by Uddin (2020), Ganda (2021), Adedoyin et al. (2021), Usman and Makhdum (2021), and Adekoya et al. (2022) show that agriculture exacerbates environmental degradation, especially in low-income and BRICS-T nations. Factors such as fertiliser use and livestock also heighten emissions (Chidiebere-Mark et al., 2022; Warsame et al., 2023).

Some studies suggest this impact varies by income level (Olanipekun et al., 2019), with wealthier nations better equipped to offset damage. The Environmental Kuznets Curve (EKC) has mixed support, validated in agriculture by Agboola and Bekun (2019) for Nigeria but rejected in the short run by Falade and Adeyemi (2022). Other studies show that agriculture worsens environmental quality in Sub-Saharan Africa and elsewhere (Omotoso & Omotayo, 2024; Yurtkuran, 2021; Pata, 2021). However, renewable energy use in agriculture shows potential for mitigating degradation (Maji & Adamu, 2021). In contrast, a stream of research finds that agriculture can reduce environmental harm. For example, agricultural value-added is linked to lower emissions in China (Jiang et al., 2021) and globally (Rafiq et al., 2016; Anwar et al., 2020; Rudolph & Figge, 2017). Studies in Turkey (Dogan, 2016), Saudi Arabia (Mahmood et al., 2019), and Indonesia (Prastiyo et al., 2020) also support this mitigation role. Sadowski et al. (2024) advocate for modernising agriculture with sustainable techniques to reduce environmental costs.

The industrial sector is widely recognised as a major contributor to pollution. Industrialisation raises economic output but often compromises environmental efficiency through increased energy use (Naeem et al., 2023). While industrial restructuring can reduce emissions (Chang, 2015; Zhu et al., 2021), its success depends on systemic reform and technological advancement (Tian et al., 2014; Muhammad et al., 2022). Nations relying on resource-intensive industries risk falling into a “resource curse,” with heightened pollution and stunted development (Wu et al., 2018). Studies underscore the role of industrial upgrading in improving eco-efficiency (Han et al., 2021; Zhao et al., 2022), though some find limited impact (Zhang et al., 2020). Technological innovation and efficient resource use are identified as key to reducing emissions (Chuai & Feng, 2019; Nureen et al., 2023). Empirical evidence from multiple countries confirms industrial output’s harmful environmental effects (Zhang & Lin, 2012; Li & Lin, 2015; Samargandi, 2017; Sohag et al., 2017; Anwar et al., 2020). Others, like Ehigiamusoe (2020), observe pollution-reducing effects in certain contexts (ASEAN and China). Studies also highlight regional and sectoral differences (Han & Chatterjee, 1997; Rahman & Kashem, 2017; Yang et al., 2018; Liang et al., 2019; Wang et al., 2019; Chen et al., 2018).

The environmental impact of the service sector remains debated. Some studies link services to reduced emissions, especially in high-income nations where energy intensity is lower (Zaman & Moemen, 2017; Hashmi et al., 2020). Others reveal a positive association between service output and pollution, especially in countries lagging in clean energy innovation (Poumanyvong & Kaneko, 2010; Jebli & Kahia, 2020). Comparative studies show that transitioning to services, as in Japan, results in better environmental outcomes than in countries still industrialising, like China (Li et al., 2017).

Sohag et al. (2017) and Falade and Adeyemi (2022) present mixed findings, while services and agriculture sometimes reduce emissions, the industrial sector tends to increase them. Bashir et al. (2020) report similar patterns for Pakistan, where agricultural and service outputs lower emissions, unlike the industrial sector. Overall, the literature reveals sectorspecific and context-dependent environmental outcomes. Agriculture and services can either mitigate or worsen pollution, while industry consistently poses environmental risks unless offset by innovation, restructuring, and stringent regulation. Institutional quality, energy mix, and economic development levels further moderate these relationships (Adekoya et al., 2022).

Methodology

Theoretical Framework

This study is grounded in the Environmental Kuznets Curve (EKC) hypothesis, which posits an inverted U-shaped relationship between economic growth and environmental degradation. Initially proposed by Grossman and Krueger (1995), the EKC suggests that environmental degradation increases with economic growth up to a certain threshold, after which it declines. To quantify this relationship, Grossman and Krueger (1995) introduced a generalized functional form incorporating a quadratic term of income. The model is specified as follows:

$$ENV = f\left(GDP, GDP^2, X\right) \qquad (3.1)$$

Econometrically, the model can be specified as follows:

$$ENV = a_0 + a_1 GDP_t + a_2 GDP_t^2 + X_t + \varepsilon_t \qquad (3.2)$$

Where ENV is a measure of the environment, GDP is a gross domestic product, which measures economic growth, X represents a vector of other variables, while ε is the normally distributed stochastic term.

3.2 Model Specification

We slightly modified the EKC model by excluding the square of GDP from the model, as our goal is not to examine the EKC hypothesis. We disaggregate the GDP in equation 3.2 into outputs from different sectors. Also, we incorporate energy use into the model. Therefore, following the studies of Bashir et al. (2020) and Adekoya et al. (2022), the model for this study is specified as follows:

$$ENV = a_0 + a_1 AGR_t + a_2 IND_t + a_3 SER_t + a_4 ENG_t + \varepsilon_t \qquad (3.3)$$

where: ENV denotes a measure of the environment, AGR is agriculture output, IND is industrial output, SER is service output, ENG is energy use and ε is the model's error term representing other factors. However, ENV is measured using two proxies: CO2 and ecological footprint (EFP). Therefore, the first part of the model, where CO2 is employed as the measure of environmental degradation, is specified as follows:

$$CO2 = a_0 + a_1 AGR_t + a_2 IND_t + a_3 SER_t + a_4 ENG_t + \varepsilon_t \qquad (3.4)$$

The variables are converted into their logarithmic form to ensure smoother and more consistent results.
The log-linearised form of equation 3.4 is as follows:

$$InCO2 = a_0 + a_1 InAGR_t + a_2 InIND_t + a_3 InSER_t + a_4 InENG_t + \varepsilon_t \qquad (3.5)$$

The second part of the model, where EFP is employed as the measure of environmental degradation, is specified as follows:

$$InEFP = \beta_0 + \beta_1 InAGR_t + \beta_2 InIND_t + \beta_3 InSER_t + \beta_4 InENG_t + \varepsilon_t \quad (3.6)$$

The coefficients range from a_1 to a_4 and β_1 to β_4 are the coefficients of agriculture output, industrial output, service output and energy use, respectively.

A priori Expectation

Based on theoretical insights and empirical evidence, the environmental impact of agricultural, industrial, and service sector outputs may be either positive or negative, depending on their respective contributions to overall GDP and the nature of their activities. In contrast, energy use is expected to exert a positive effect on environmental degradation. This is because most energy sources, particularly fossil fuels, emit substantial amounts of greenhouse gases (GHGs) and other pollutants when combusted, thereby increasing both carbon emissions and the ecological footprint.

Estimation Techniques

The analysis begins with preliminary tests, including summary statistics, stationarity, and cointegration assessments. Stationarity is examined using the Augmented Dickey-Fuller (ADF) test, while the Johansen (1988) cointegration test is employed to determine the existence of long-run relationships among the variables. Johansen's approach utilizes two likelihood ratio tests, the trace statistic and the maximum eigenvalue test. To estimate these long-run relationships, the study uses the Fully Modified Ordinary Least Squares (FMOLS) method developed by Phillips and Hansen (1990), which corrects for endogeneity and serial correlation by applying a semi-parametric adjustment. For robustness, the Canonical Cointegrating Regression (CCR) technique proposed by Park (1992) is also employed.

Measurement and Sources of Data

This study relies on secondary data from reputable sources. Carbon dioxide (CO_2) emissions, measured in metric tons, and energy use, measured in British thermal units (BTUs), are both obtained from the U.S. Energy Information Administration (EIA, 2023). The ecological footprint (EFP), expressed in global hectares (gha), is sourced from the Global Footprint Network (GEF, 2023). Sectoral activities: agriculture (AGR), industry (IND), and services (SER), are measured in 2010 constant basic prices, with data drawn from the Central Bank of Nigeria (CBN, 2023).

Discussion of Results

This section presents the data analysis, interprets the results, and discusses the findings in line with the study's objectives.

Descriptive Statistics

Table 4.1 Descriptive Statistics Results

	InCO2	InEFP	InAGR	InIND	InSER	InENG
Mean	4.075292	18.68666	8.824091	9.393740	9.508555	9.117006
Median	3.951101	18.73447	8.743078	9.370706	9.270004	9.007061
Maximum	4.776593	19.02504	9.856976	9.725685	10.62990	9.837135
Minimum	3.484401	18.24348	7.742187	9.018666	8.585330	8.513584
Std. Dev.	0.388123	0.276470	0.736539	0.207311	0.742957	0.405121
Skewness	0.416401	-0.269578	0.031427	-0.164590	0.264467	0.435713
Kurtosis	2.082584	1.423067	1.424274	1.878604	1.444026	2.006545
Jarque-Bera	2.686622	4.860461	4.352012	2.390302	4.726446	3.056091
Probability	0.260980	0.088017	0.113494	0.302658	0.094116	0.216959
Sum	171.1623	784.8396	370.6118	394.5371	399.3593	382.9143
Sum Sq. Dev.	6.176223	3.133868	22.24207	1.762094	22.63136	6.729041
Observations	42	42	42	42	42	42

Source: Author's computation (2024) using Eviews 10

Table 4.1 presents the descriptive statistics for the study variables across 42 observations. CO2 emissions have a mean of 4.08 and a median of 3.95, indicating a mildly right-skewed distribution. The standard deviation of 0.39 reflects moderate variability, and the Jarque-Bera (JB) test suggests the distribution is approximately normal. The ecological footprint (EFP) shows a mean of 18.69 and a closely aligned median of 18.73, indicating near symmetry. With a low standard deviation of 0.28 and a slight negative skew, EFP has the least variability among the variables. The JB statistic indicates mild deviation from normality but not enough to reject the null hypothesis. Agricultural output (AGR) has a mean of 8.82 and a median of 8.74, with a standard deviation of 0.74, the highest among the variables, indicating substantial dispersion. The near-zero skewness suggests a symmetric distribution, and the JB test supports normality. Industrial output (IND) is the most stable variable, with a low standard deviation of 0.21 and a narrow range. It shows a slight negative skew, a flat distribution, and a JB p-value of 0.30, indicating normality. Service output (SER) has a mean of 9.51 and a median of 9.27, reflecting a slight right skew and considerable variability. Its JB test suggests a marginal deviation from normality, but not statistically significant. Energy use (ENG) has a mean of 9.12 and a median of 9.01, with moderate variability and a modest right skew. The JB statistic confirms an approximately normal distribution.

Stationarity Test

Table 4.2 ADF Stationarity Test Results

Variable	@ Level		@ First Difference		Order of Integration
	Test Statistic	5% Critical Value	Test Statistic	5% Critical Value	
InCO2	-0.599576	-2.935001	-7.730679	-2.936942	I(1)
InEFP	-0.679164	-2.935001	-7.020176	-2.936942	I(1)
InAGR	-0.380378	-2.935001	-6.059542	-2.936942	I(1)
InIND	-0.851619	-2.935001	-5.438038	-2.936942	I(1)
InSER	-0.390026	-2.935001	-3.241297	-2.936942	I(1)
InENG	-0.697522	-2.935001	-7.996049	-2.936942	I(1)

Source: Author's computation (2024) using Eviews

The unit root test results presented in Table 4.2 show that all variables become stationary after first differencing. The Augmented Dickey-Fuller (ADF) test is used to evaluate the presence of unit roots, and the results indicate that, at the 5% significance level, the null hypothesis of a unit root is rejected for all variables. This confirms that the variables are integrated of order one, I(1), and are thus suitable for subsequent econometric analysis.

Cointegration Test

Table 4.3 Johansen Cointegration Test Results.

Hypothesis	Eigenvalue	Trace Statistic	5% Critical Value	Max-Eigen Statistic	5% Critical Value
R =0	0.667974	100.2178*	69.81889	44.10173*	33.87687
R ≤1	0.506200	56.11610*	47.85613	28.22497*	27.58434
R ≤2	0.361912	27.89114	29.79707	17.97117	21.13162
R ≤3	0.210442	9.919966	15.49471	9.451277	14.26460
R ≤4	0.011649	0.468689	3.841466	0.468689	3.841466

Source: Author's computation (2024) using Eviews 10.

The test indicates 2 cointegrating eqn(s) at the 5% level. *denotes rejection of the hypothesis at the 5% level

Table 4.3 reports the results of the cointegration test, which confirm the existence of a long-run equilibrium relationship among the variables. The test statistics provide sufficient evidence of cointegration, indicating that the variables move together over time despite short-term fluctuations. Based on this result, the study proceeds to estimate the long-run relationships.

Long-run Estimations

We estimate the models based on the objectives of the study. Table 4.4 presents the results of the long-run estimation.

Table 4.4 Long-Run Estimation Results

	Dependent Variable = CO2		Dependent Variable = EFP	
Variable	**FMOLS**	**CCR**	**FMOLS**	**CCR**
InAGR	0.076078*	0.071394*	0.629722***	0.629910***
	(0.038334)	(0.036280)	(0.134020)	(0.124900)
InIND	-0.048092	-0.045511	0.367111	0.376177
	(0.064879)	(0.055217)	(0.226828)	(0.229518)
InSER	-0.068375*	-0.065046*	-0.263124**	-0.260388**
	(0.036447)	(0.035884)	(0.127425)	(0.127425)
InENG	0.974587***	0.976186***	0.204590**	0.217377**
	(0.026817)	(0.027866)	(0.093757)	(0.099876)
Constant	-4.377761***	-4.406450***	14.04199***	14.04536***
	(0.443681)	(0.383877)	(1.551179)	(1.336062)
R-squared	0.995283	0.995247	0.946779	0.946412
Adjusted R-squared	0.994759	0.994719	0.940865	0.940458
S.E. of regression	0.027610	0.027716	0.066779	0.067008
Long-run variance	0.000686	0.000686	0.008389	0.008389
Diagnostic Tests				
Serial correlation	4.824642		5.685053	
	[0.0896]		[0.0583]	
Homoscedasticity	7.251511		4.450584	
	[0.1232]		[0.3484]	
Normality	2.973695		0.657705	
	[0.226084]		[0.719749]	

Source: Author's computation (2024) using Eviews 10

Note: ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively. Standard errors in parenthesis (in the main results), while P-values in square bracket [in the diagnostic tests]. The FMOLS is the main technique of analysis while the CCR serves as a robustness check.

Table 4.4 presents the results of the FMOLS and CCR estimations addressing the second objective. Columns 2 and 3 report results for CO2 as the dependent variable, while columns 4 and 5 report estimates for EFP. When CO2 is the dependent variable, the results show that agricultural output (InAGR) and energy use (InENG) significantly increase emissions, with coefficients of 0.076 and 0.975, respectively. In contrast, service output (InSER) significantly reduces emissions (−0.068), while industrial output (InIND) has a negative but statistically insignificant effect. For EFP, InAGR, InIND, and InENG all show positive associations, while InSER is negatively related. Specifically, InAGR increases EFP by 0.63%, and InENG by 0.21%, while InSER reduces it by 0.26%. InIND, however, remains statistically insignificant. Both models exhibit high R-squared values, low standard errors, and pass diagnostic tests for serial correlation, heteroskedasticity, and normality, affirming model robustness and reliability for policy inference. The positive effects of agriculture on CO2 and EFP suggest that Nigerian agriculture is environmentally unsustainable, largely due to land clearing, poor soil management, and inefficient energy use (FAO, 2021; Mongabay, 2020; IFPRI, 2019; World Bank, 2020; IPCC, 2019; UNEP, 2021). These findings align with studies by Adekoya et al. (2022), Adedoyin et al. (2021), Ganda (2021), and Warsame et al. (2023), but contrast with Anwar et al. (2020), Dogan (2016), and Rafiq et al. (2016).

Energy use is the strongest driver of environmental degradation, given Nigeria's fossil fuel-dependent energy mix. The combustion of oil and gas contributes heavily to greenhouse gas emissions and ecological damage (Oyedepo, 2014; OPEC, 2020; IEA, 2021). This aligns with findings by Osuntuyi and Lean (2022), Wang et al. (2024), and Adekoya et al. (2022). The negative impact of the service sector on CO2 and EFP reflects its lower resource intensity and emissions compared to agriculture and industry. Sectors such as finance, telecoms, and education are less polluting and increasingly digitised, reducing environmental stress (World Bank, 2020; UNEP, 2019; OECD, 2018). This supports Bashir et al. (2020) and Zaman and Moemen (2017), but diverges from Jebli and Kahia (2020). Finally, the industrial sector shows no significant environmental effect, possibly due to underdevelopment, inefficiencies, or structural challenges such as poor infrastructure and low energy intensity (Adewuyi & Oyejide, 2019; NBS, 2021; World Bank, 2020). These findings contradict those of Anwar et al. (2020) and Zhang and Lin (2012), who found industry to be a major polluter.

Conclusion and Recommendations

This study finds that sectoral activities and energy use have significantly driven environmental degradation in Nigeria over the past four decades. Agriculture contributes most to carbon emissions and ecological footprint due to unsustainable practices and heavy reliance on non-renewable energy. Fossil fuel-driven energy use emerges as the primary environmental threat. While the service sector has a relatively lower impact, its growing energy demands, along with inefficiencies in the industrial sector, further strain the environment. These findings highlight the urgent need for sustainable practices, improved energy efficiency, and cleaner technologies.

To address the environmental impacts of agriculture, policymakers should promote sustainable farming methods such as agroforestry, crop rotation, organic fertilisers, and reduced land-clearing practices like slash-and-burn. Reducing fossil fuel dependence is also critical. Investment in renewable energy should be prioritised, alongside incentives for adopting energy-efficient technologies across all sectors. As the service sector grows, efforts should focus on greening energy-intensive activities, especially telecommunications and transport. This includes expanding renewable energy use in data centres, promoting electric mobility, and raising awareness about energy-efficient digital practices. Finally, an integrated, cross-sectoral policy approach is essential. Collaboration among the government, private sector, and civil society can drive sustainable development by incentivising cleaner production, enhancing resource efficiency, and aligning economic growth with environmental conservation.

References

Adedoyin, F. F., Bein, M. A., Gyamfi, B. A., & Bekun, F. V. (2021). Does agricultural development induce environmental pollution in E7? A myth or reality. *Environmental Science and Pollution Research*, *28*(31), 41869–41880. https://doi.org/10.1007/s11356-021-13586-2

Adekoya, O. B., Ajayi, G. E., Suhrab, M., & Oliyide, J. A. (2022). How critical are resource rents, agriculture, growth, and renewable energy to environmental degradation in the resource-rich African countries? The role of institutional quality. *Energy Policy*, *164*(January), 112888. https://doi.org/10.1016/j.enpol.2022.112888

Agbenyo, J. S. (2020). The structural change theory –An analysis of success and failures of technology. *International Journal of Research and Innovation in Social Science*, *4*(1), 2454–6186.

Agboola, M. O., & Bekun, F. V. (2019). Does agricultural value added induce environmental degradation? Empirical evidence from an agrarian country. *Environmental Science and Pollution Research*, *26*(27), 27660–27676. https://doi.org/10.1007/s11356-019-05943-z

Aladejare, S. A. (2022). Natural resource rents, globalisation and environmental degradation: New insight from 5 richest African economies. *Resources Policy*, *78*(July), 102909. https://doi.org/10.1016/j.resourpol.2022.102909

Anwar, A., Ahmad, N., & Madni, G. R. (2020). Industrialization, freight transport and environmental quality: Evidence from belt and road initiative economies. *Environmental Science and Pollution Research*, *27*(7), 7053–7070. https://doi.org/10.1007/s11356-019-07255-8

Arshad, Z., Robaina, M., Shahbaz, M., & Veloso, A. B. (2020). The effects of deforestation and urbanization on sustainable growth in Asian countries. *Environmental Science and Pollution Research*, *27*(9), 10065–10086. https://doi.org/10.1007/s11356-019-07507-7

Ayres, R. U. (1998). Technological progress: A proposed measure. *Technological Forecast Social Change*, *59*, 213–233. https://doi.org/10.4337/9781788974912.T.6

Balsalobre-Lorente, D., Driha, O. M., Bekun, F. V., & Osundina, O. A. (2019). Do agricultural activities induce carbon emissions? The BRICS experience. *Environmental Science and Pollution Research*, *26*(24), 25218–25234. https://doi.org/10.1007/s11356-019-05737-3

Bashir, F., Chaudhry, I. S., Ahmad, R., & Habib, F. (2020). An econometric investigation of sectoral output and environmental Degradation in Pakistan. *Review of Education, Administration & LAW*, *3*(3), 443–456. https://doi.org/10.47067/real.v3i3.90

Bekele, M., Sassi, M., Jemal, K., & Ahmed, B. (2024). The dynamic linkage between renewable energy use and environmental sustainability in Sub-Saharan African countries: Heterogeneous macro-panel data analysis. *Cogent Economics and Finance*, *12*(1). https://doi.org/10.1080/23322039.2023.2285188

Bekhet, H. A., & Othman, N. S. (2017). Impact of urbanization growth on Malaysia CO2 emissions : Evidence from the dynamic relationship. *Journal of Cleaner Production*, *154*, 374–388. https://doi.org/10.1016/j.jclepro.2017.03.174

Ben Jebli, M., & Kahia, M. (2020). The interdependence between CO2 emissions, economic growth, renewable and non-renewable energies, and service development: evidence from 65 countries. *Climatic Change*, *162*(2), 193–212. https://doi.org/10.1007/s10584-020-02773-8

Central Bank of Nigeria. (2023). *Annual Statistical Bulletin*. https://www.cbn.gov.ng/documents/Statbulletin.asp

Chang, N. (2015). Changing industrial structure to reduce carbon dioxide emissions: A Chinese application. *Journal of Cleaner Production*, *103*, 40–48. https://doi.org/10.1016/j.jclepro.2014.03.003

Chen, D., Chen, S., & Jin, H. (2018). Industrial agglomeration and CO2 emissions: Evidence from 187 Chinese prefecture-level cities over 2005–2013. *Journal of Cleaner Production*, *172*, 993–1003. https://doi.org/10.1016/j.jclepro.2017.10.068

Chidiebere-Mark, N. M., Onyeneke, R. U., Uhuegbulem, I. J., Ankrah, D. A., Onyeneke, L. U., Anukam, B. N., & Chijioke-Okere, M. O. (2022). Agricultural production, renewable energy use, foreign direct investment, and carbon emissions: New evidence from Africa. *Atmosphere*, *13*(12), 1–24. https://doi.org/10.3390/atmos13121981

Chuai, X., & Feng, J. (2019). High resolution carbon emissions simulation and spatial heterogeneity analysis based on big data in Nanjing City, China. *Science of the Total Environment*, *686*, 828–837. https://doi.org/10.1016/j.scitotenv.2019.05.138

Danish, Baloch, M. A., Mahmood, N., Zhang, J. W., Baloch, Muhammad Awais Mahmood, N., & Zhang, J. W. (2019). Effect of natural resources, renewable energy and economic development on CO2 emissions in BRICS countries. *Science of the Total Environment*, *678*, 632–638. https://doi.org/10.1016/j.scitotenv.2019.05.028

Dogan, N. (2016). Agriculture and environmental kuznets curves in the case of Turkey: Evidence from the ARDL and bounds test. *Agricultural Economics (Czech Republic)*, *62*(12), 566–574. https://doi.org/10.17221/112/2015-AGRICECON

Ehigiamusoe, K. U. (2020). The drivers of environmental degradation in ASEAN + China: Do financial development and urbanization have any moderating effect? *Singapore Economic Review*, 1–44. https://doi.org/10.1142/S0217590820500241

Ehigiamusoe, K. U., Lean, H. H., & Smyth, R. (2020). The moderating role of energy use in the carbon emissions-income nexus in middle-income countries. *Applied Energy*, *261*(December 2019), 1–13. https://doi.org/10.1016/j.apenergy.2019.114215

Ehigiamusoe, K. U., Lean, H. H., & Somasundram, S. (2022). Unveiling the non-linear impact of sectoral output on environmental pollution in Malaysia. *Environmental Science and Pollution Research*, *29*(5), 7465–7488. https://doi.org/10.1007/S11356-021-16114-4/TABLES/7

Ehigiamusoe, K. U., Ramakrishnan, S., Lean, H. H., & Somasundram, S. (2023). Role of energy use on the environmental impact of sectoral growth in Malaysia. *SAGE Open*, *13*(3), 1–17. https://doi.org/10.1177/21582440231184044

EIA. (2023). *U.S. Energy Information Administration*. https://www.eia.gov/international/data/world

Eyuboglu, K., & Uzar, U. (2020). Examining the roles of renewable energy use and agriculture on CO2 emission in lucky-seven countries. *Environmental Science and Pollution Research*, *27*(36), 45031–45040. https://doi.org/10.1007/s11356-020-10374-2

Ezaal, O., & Owede, M. (2022). Fossil fuel consumption, economic growth, and environmental degradation: Is the "energy use-growth" nexus sustainable in Nigeria? *IOSR Journal of Economics and Finance*, *13*(2), 51–68. https://doi.org/10.9790/5933-1302025168

Falade, O. E., & Adeyemi, W. O. (2022). The effect of sectorial contributions to GDP on environmental degradation: A verification of the environmental Kuznets curve hypothesis in Nigeria. *Journal of Economics and Behavioral Studies*, *14*(4), 1–10.

FAO. (2016). The state of food and agriculture. In *Food and Agriculture Organization of the United Nations* (Vol. 59, Issue 2).

Federal Ministry of Environment. (2021). *National climate change policy for Nigeria: 2021-2030*.

Gabardo, F. A., Pereima, J. B., & Einloft, P. (2017). The incorporation of structural change into growth theory: A historical appraisal. *EconomiA*, *18*(3), 392–410. https://doi.org/10.1016/j.econ.2017.05.003

Ganda, F. (2021). The influence of growth determinants on environmental quality in Sub-Saharan Africa states. *Environment, Development and Sustainability*, *23*(5), 7117–7139. https://doi.org/10.1007/s10668-020-00907-7

Global Ecological Footprint. (2023). *Ecological footprint*. https://data.footprintnetwork.org/?_ga=2.21323262.499052044.1715079746-2060393916.1701616347#/countryTrends?type=BCtot,EFCtot&cn=159

Gokmenoglu, K. K., Olasehinde-Williams, G. O., & Taspinar, N. (2019). Testing the Environmental Kuznets Curve hypothesis: The role of deforestation. *Green Energy and Technology*, 61–83. https://doi.org/10.1007/978-3-030-06001-5_3

Gokmenoglu, K. K., & Taspinar, N. (2018). Testing the agriculture-induced EKC hypothesis: the case of Pakistan. *Environmental Science and Pollution Research*, *25*(23), 22829–22841. https://doi.org/10.1007/s11356-018-2330-6

Grossman, G., & Krueger, A. (1991). Environmental impacts of a North American free trade agreement. In *NBER working papers series* (Issue 3914). https://doi.org/10.3386/w3914

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics*, *110*(2), 353–377. https://doi.org/10.2307/2118443

Han, X., & Chatterjee, L. (1997). Impacts of growth and structural change on CO2 emissions of developing countries. *World Development*, *25*(3), 395–407. https://doi.org/10.1016/s0305-750x(96)00110-6

Han, Y., Zhang, F., Huang, L., Peng, K., & Wang, X. (2021). Does industrial upgrading promote eco-efficiency? —A panel space estimation based on Chinese evidence. *Energy Policy*, *154*(April 2020), 112286. https://doi.org/10.1016/j.enpol.2021.112286

Hao, Y. (2022). The relationship between renewable energy use, carbon emissions, output, and export in industrial and agricultural sectors: Evidence from China. *Environmental Science and Pollution Research*, 63081–63098. https://doi.org/10.1007/s11356-022-20141-0

Hashmi, S. H., Hongzhong, F., Fareed, Z., & Bannya, R. (2020). Testing non-linear nexus between service sector and CO2 emissions in Pakistan. *Energies*, *13*(526), 1–29.

Inah, O. I., Abam, F. I., & Nwankwojike, B. N. (2022). Exploring the CO2 emissions drivers in the Nigerian manufacturing sector through decomposition analysis and the potential of carbon tax (CAT) policy on CO2 mitigation. *Future Business Journal*, *8*(1). https://doi.org/10.1186/s43093-022-00176-y

Jiang, Q., Khattak, S. I., & Rahman, Z. U. (2021). Measuring the simultaneous effects of electricity consumption and production on carbon dioxide emissions (CO2e) in China: New evidence from an EKC-based assessment. *Energy*, *229*, 120616. https://doi.org/10.1016/j.energy.2021.120616

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, *12*(2–3), 231–254. https://doi.org/10.1016/0165-1889(88)90041-3

Khan, A. N., En, X., Raza, M. Y., Khan, N. A., & Ali, A. (2020). Sectorial study of technological progress and CO2 emission: Insights from a developing economy. *Technological Forecasting and Social Change*, *151*(November 2019), 119862. https://doi.org/10.1016/j.techfore.2019.119862

Khan, R., Zhuang, W., Najumddin, O., Butt, R. S., Ahmad, I., & Al-Faryan, M. A. S. (2022). The impact of agricultural intensification on carbon dioxide emissions and energy use: A comparative study of developing and developed nations. *Frontiers in Environmental Science*, *10*(December). https://doi.org/10.3389/fenvs.2022.1036300

Li, K., & Lin, B. (2015). Impacts of urbanization and industrialization on energy use/CO2 emissions: Does the level of development matter? *Renewable and Sustainable Energy Reviews*, *52*, 1107–1122. https://doi.org/10.1016/j.rser.2015.07.185

Liang, W., Gan, T., & Zhang, W. (2019). Dynamic evolution of characteristics and decomposition of factors influencing industrial carbon dioxide emissions in China: 1991–2015. *Structural Change and Economic Dynamics*, *49*, 93–106. https://doi.org/10.1016/j.strueco.2018.09.009

Mahmood, H., Alkhateeb, T. T. Y., Al-Qahtani, M. M. Z., Allam, Z., Ahmad, N., & Furqan, M. (2019). Agriculture development and CO2 emissions nexus in Saudi Arabia. *PLoS ONE*, *14*(12), 1–15. https://doi.org/10.1371/journal.pone.0225865

Maji, I. K., & Adamu, S. (2021). The impact of renewable energy use on sectoral environmental quality in Nigeria. *Cleaner Environmental Systems*, *2*(December 2020), 100009. https://doi.org/10.1016/j.cesys.2021.100009

Marsiglio, S., Ansuategi, A., & Gallastegui, M. C. (2016). The Environmental Kuznets Curve and the Structural Change Hypothesis. *Environmental and Resource Economics*, *63*(2), 265–288. https://doi.org/10.1007/s10640-015-9942-9

Matthew, O., Osabohien, R., Olawande, T., & Urhie, E. (2019). Manufacturing industries and construction emissions in Nigeria: Examining the effects on health conditions. *International Journal of Civil Engineering and Technology*, *10*(1), 2401–2414.

Mehboob, M. Y., Ma, B., Mehboob, M. B., & Zhang, Y. (2023). Does green finance reduce environmental degradation? The role of green innovation, environmental tax, and geopolitical risk in China. *Journal of Cleaner Production*, *435*(December 2023), 140353. https://doi.org/10.1016/j.jclepro.2023.140353

Muhammad, S., Pan, Y., Agha, M. H., Umar, M., & Chen, S. (2022). Industrial structure, energy intensity and environmental efficiency across developed and developing economies: The intermediary role of primary, secondary and tertiary industry. *Energy*, *247*, 123576. https://doi.org/10.1016/j.energy.2022.123576

Naeem, M. A., Appiah, M., Karim, S., & Yarovaya, L. (2023). What abates environmental efficiency in African economies? Exploring the influence of infrastructure, industrialization, and innovation. *Technological Forecasting and Social Change*, *186*(PB), 122172. https://doi.org/10.1016/j.techfore.2022.122172

Nureen, N., Sun, H., Irfan, M., Nuta, A. C., & Malik, M. (2023). Digital transformation: fresh insights to implement green supply chain management, eco-technological innovation, and collaborative capability in manufacturing sector of an emerging economy. *Environmental Science and Pollution Research*, *30*(32), 78168–78181. https://doi.org/10.1007/s11356-023-27796-3

Nuţă, F. M., Sharafat, A., Abban, O. J., Khan, I., Irfan, M., Nuţă, A. C., Dankyi, A. B., & Asghar, M.

(2024). The relationship among urbanization, economic growth, renewable energy use, and environmental degradation: A comparative view of European and Asian emerging economies. *Gondwana Research*, *128*(November), 325–339. https://doi.org/10.1016/j.gr.2023.10.023

Omotoso, A. B., & Omotayo, A. O. (2024). The interplay between agriculture, greenhouse gases, and climate change in Sub-Saharan Africa. *Regional Environmental Change*, *24*(1), 1–13. https://doi.org/10.1007/s10113-023-02159-3

Osuntuyi, B. V. (2018). Energy use, urbanization and carbon emissions: Implications for sustainable growth and development in Nigeria. *The Social and Management Scientist*, *10*(November), 1–12.

Osuntuyi, B. V., & Lean, H. H. (2022). Economic growth, energy use and environmental degradation nexus in heterogeneous countries : Does education matter? *Environmental Sciences Europe*, *34*(48), 2–16. https://doi.org/10.1186/s12302-022-00624-0

Osuntuyi, B. V., & Lean, H. H. (2023). Environmental degradation, economic growth, and energy use: The role of education. *Sustainable Development*, *November 2022*, 1–12. https://doi.org/10.1002/sd.2480

Osuntuyi, B. V., & Mobosi, I. A. (2017). Growth, fossil fuel energy use and carbon emissions in Nigeria. *Maghreb Review of Economics and Management*, *4*(1), 57–70. https://doi.org/10.12816/0037721

Parajuli, R., Joshi, O., & Maraseni, T. (2019). Incorporating forests, agriculture, and energy use in the framework of the environmental Kuznets Curve: A dynamic panel data approach. *Sustainability (Switzerland)*, *11*(9). https://doi.org/10.3390/su11092688

Pata, U. K. (2021). Linking renewable energy, globalization, agriculture, CO2 emissions and ecological footprint in BRIC countries: A sustainability perspective. *Renewable Energy*, *173*, 197–208. https://doi.org/10.1016/j.renene.2021.03.125

Pengcheng, L., Abbas, J., Balsalobre-Lorente, D., Qingren, W., Zhang, Q., & Shah, S. A. R. (2024). Impact of Sectoral Mix on Environmental Sustainability: How is Heterogeneity addressed? *Gondwana Research*, *128*(April), 86–105. https://doi.org/10.1016/j.gr.2023.09.018

Pokrovski, V. N. (2003). *Energy in the theory of production*. *28*, 769–788. https://doi.org/10.1016/S0360-5442(03)00031-8

Poumanyvong, P., & Kaneko, S. (2010). Does urbanization lead to less energy use and lower CO2 emissions? A cross-country analysis. *Ecological Economics*, *70*(2), 434–444. https://doi.org/10.1016/j.ecolecon.2010.09.029

Prastiyo, S. E., Irham, Hardyastuti, S., & Jamhari. (2020). How agriculture, manufacture, and urbanization induced carbon emission? The case of Indonesia. *Environmental Science and Pollution Research*, *27*(33), 42092–42103. https://doi.org/10.1007/s11356-020-10148-w

Rafiq, S., Salim, R., & Apergis, N. (2016). Agriculture, trade openness and emissions: an empirical analysis and policy options. *Australian Journal of Agricultural and Resource Economics*, *60*(3), 348–365. https://doi.org/10.1111/1467-8489.12131

Rahman, M. M., & Kashem, M. A. (2017). Carbon emissions, energy use and industrial growth in Bangladesh: Empirical evidence from ARDL cointegration and Granger causality analysis. *Energy Policy*, *110*(September), 600–608. https://doi.org/10.1016/j.enpol.2017.09.006

Ramzan, M., Razi, U., Usman, M., Sarwar, S., Talan, A., & Mundi, H. S. (2024). Role of nuclear energy, geothermal energy, agriculture, and urbanization in environmental stewardship. *Gondwana Research*, *125*(January), 150–167. https://doi.org/10.1016/j.gr.2023.08.006

Rudolph, A., & Figge, L. (2017). Determinants of ecological footprints: What is the role of globalization? *Ecological Indicators*, *81*(April), 348–361. https://doi.org/10.1016/j.ecolind.2017.04.060

Sadowski, A., Wojcieszak-Zbierska, M. M., & Zmyślona, J. (2024). Agricultural production in the least developed countries and its impact on emission of greenhouse gases – An energy approach. *Land Use Policy*, *136*(August 2023), 106968. https://doi.org/10.1016/j.landusepol.2023.106968

Samargandi, N. (2017). Sector value addition, technology and CO2 emissions in Saudi Arabia. *Renewable and Sustainable Energy Reviews*, *78*(May), 868–877. https://doi.org/10.1016/j.rser.2017.04.056

Sarkodie, S. A., & Strezov, V. (2018). Empirical study of the environmental Kuznets curve and environmental sustainability curve hypothesis for Australia, China, Ghana and USA. *Journal of Cleaner Production*, *201*, 98–110. https://doi.org/10.1016/j.jclepro.2018.08.039

Sinha, A., & Shahbaz, M. (2018). Estimation of Environmental Kuznets Curve for CO2 emission: Role of renewable energy generation in India. *Renewable Energy*, *119*, 703–711. https://doi.org/10.1016/j.renene.2017.12.058

Sirag, A., Matemilola, B. T., Law, S. H., Bany-Ariffin, & A. N., Tunde Matemilola, B., & Bany-Ariffin, A. N. (2018). Does environmental Kuznets curve hypothesis exist? Evidence from dynamic panel threshold. *Journal of Environmental Economics and Policy*, *7*(2), 145–165. https://doi.org/10.1080/21606544.2017.1382395

Snyder, C. S., Bruulsema, T. W., Jensen, T. L., & Fixen, P. E. (2009). Review of greenhouse gas emissions from crop production systems and fertilizer management effects. *Agriculture, Ecosystems and Environment*, *133*(3–4), 247–266. https://doi.org/10.1016/j.agee.2009.04.021

Sohag, K., Al Mamun, M., Uddin, G. S., & Ahmed, A. M. (2017). Sectoral output, energy use, and CO2 emission in middle-income countries. *Environmental Science and Pollution Research*, *24*(10), 9754–9764. https://doi.org/10.1007/s11356-017-8599-z

Stern, D. I. (2004). Economic growth and energy. *Encyclopedia of Energy*, *2*, 35–51. https://doi.org/10.4324/9781315095745-2

Stern, D. I. (2010). The role of energy in economic growth. *Crawford School Centre for Climate Economics & Policy*, *3*(10), 1–50. https://doi.org/http://dx.doi.org/10.2139/ssrn.1878863

Tian, X., Chang, M., Shi, F., & Tanikawa, H. (2014). How does industrial structure change impact carbon dioxide emissions? A comparative analysis focusing on nine provincial regions in China. *Environmental Science and Policy*, *37*, 243–254. https://doi.org/10.1016/j.envsci.2013.10.001

Tunde, O. L., Adewole, O. O., Alobid, M., & Szucs, I. (2022). *Sources and Sectoral Trend Analysis of CO 2 Emissions Data in*.

Uddin, M. M. M. (2020). What are the dynamic links between agriculture and manufacturing growth and environmental degradation? Evidence from different panel income countries. *Environmental and Sustainability Indicators*, *7*(April), 100041.

https://doi.org/10.1016/j.indic.2020.100041

United Nations. (2021). *New FAO analysis reveals carbon footprint of agri-food supply chain*. The United Nations Office at Geneva. https://www.ungeneva.org/en/news-media/news/2021/11/70266/new-fao-analysis-reveals-carbon-footprint-agri-food-supply-chain

Usman, M., & Makhdum, M. S. A. (2021). What abates ecological footprint in BRICS-T region? Exploring the influence of renewable energy, non-renewable energy, agriculture, forest area and financial development. *Renewable Energy*, *179*, 12–28. https://doi.org/10.1016/j.renene.2021.07.014

Wang, J., & Azam, W. (2024). Natural resource scarcity, fossil fuel energy use, and total greenhouse gas emissions in top emitting countries. *Geoscience Frontiers*, *15*(2), 101757. https://doi.org/10.1016/j.gsf.2023.101757

Wang, L., Wei, C., Liu, J., & Dong, Y. (2024). Sustainable development or smoke ?: The role of natural resources , renewable energy , and agricultural practices in China. *Resources Policy*, *88*(May 2023), 104512. https://doi.org/10.1016/j.resourpol.2023.104512

Wang, Q., Zhao, M., & Li, R. (2019). Decoupling sectoral economic output from carbon emissions on city level: A comparative study of Beijing and Shanghai, China. *Journal of Cleaner Production*, *209*, 126–133. https://doi.org/10.1016/j.jclepro.2018.10.188

Warsame, A. A., Mohamed, J., & Mohamed, A. A. (2023). The relationship between environmental degradation, agricultural crops, and livestock production in Somalia. *Environmental Science and Pollution Research*, *30*(3), 7825–7835. https://doi.org/10.1007/s11356-022-22595-8

Wu, S., Li, L., & Li, S. (2018). Natural resource abundance, natural resource-oriented industry dependence, and economic growth: Evidence from the provincial level in China. *Resources, Conservation and Recycling*, *139*(29), 163–171. https://doi.org/10.1016/j.resconrec.2018.08.012

Yang, L., Yang, Y., Zhang, X., & Tang, K. (2018). Whether China's industrial sectors make efforts to reduce CO2 emissions from production? - A decomposed decoupling analysis. *Energy*, *160*, 796–809. https://doi.org/10.1016/j.energy.2018.06.186

Yurtkuran, S. (2021). The effect of agriculture, renewable energy production, and globalization on CO2 emissions in Turkey: A bootstrap ARDL approach. *Renewable Energy*, *171*, 1236–1245. https://doi.org/10.1016/j.renene.2021.03.009

Yusuf, A. (2023). Dynamic effects of energy use, economic growth, international trade and urbanization on environmental degradation in Nigeria. *Energy Strategy Reviews*, *50*(September), 101228. https://doi.org/10.1016/j.esr.2023.101228

Zaman, K., & Moemen, M. A. el. (2017). Energy use, carbon dioxide emissions and economic development: Evaluating alternative and plausible environmental hypothesis for sustainable growth. *Renewable and Sustainable Energy Reviews*, *74*(March), 1119–1130. https://doi.org/10.1016/j.rser.2017.02.072

Zhang, C., & Lin, Y. (2012). Panel estimation for urbanization, energy use and CO 2 emissions: A regional analysis in China. *Energy Policy*, *49*, 488–498. https://doi.org/10.1016/j.enpol.2012.06.048

Zhang, F., Deng, X., Phillips, F., Fang, C., & Wang, C. (2020). Impacts of industrial structure and technical progress on carbon emission intensity: Evidence from 281 cities in China. *Technological Forecasting and Social Change*, *154*(January), 119949.

https://doi.org/10.1016/j.techfore.2020.119949

Zhang, L., Pang, J., Chen, X., & Lu, Z. (2019). Carbon emissions, energy use and economic growth: Evidence from the agricultural sector of China's main grain-producing areas. *Science of the Total Environment*, *665*(222), 1017–1025. https://doi.org/10.1016/j.scitotenv.2019.02.162

Zhao, J., Jiang, Q., Dong, X., Dong, K., & Jiang, H. (2022). How does industrial structure adjustment reduce CO2 emissions? Spatial and mediation effects analysis for China. *Energy Economics*, *105*(November 2021), 105704. https://doi.org/10.1016/j.eneco.2021.105704

Zhu, W., Zhu, Y., Lin, H., & Yu, Y. (2021). Technology progress bias, industrial structure adjustment, and regional industrial economic growth motivation —— Research on regional industrial transformation and upgrading based on the effect of learning by doing. *Technological Forecasting and Social Change*, *170*(November 2020), 4–12. https://doi.org/10.1016/j.techfore.2021.120928