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Renewable Energy and Economic Growth: An Empirical Analysis of the Relationship between Solar Power and GDP

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ABSTRACT

This study investigated the effect of renewable energy on economic growth particularly it empirically analysed the relationship between solar power and GDP. The study used an ex post facto research design and the model formulated was estimated using the ordinary least squares regression technique. The data were sourced from World Bank's world development indicator and covered the period between 1990 and 2023. The findings of the study showed that renewable energy consumption which is a proxy for solar power have a positive and insignificant impact on economic growth. Carbon emission have a positive and significant effect on economic growth. Foreign direct investment have positive and significant effect of economic growth. Trade balance also displayed a positive impact on economic growth but it is not statistically significant. Also, solar power consumption does not have a statistically significant causal effect on GDP, GDP does Granger-cause solar power consumption while carbon emission and GDP have bidirectional causality. Based on these findings, the study recommends that the government should; increase investment in solar infrastructure, encourage policies that promote a gradual shift to renewable energy sources, combined with carbon mitigation strategies, create an investor-friendly environment-such as tax incentives, streamlined regulatory.

Keywords: Solar power, Carbon emission, economic growth, Granger causality.

I. Introduction

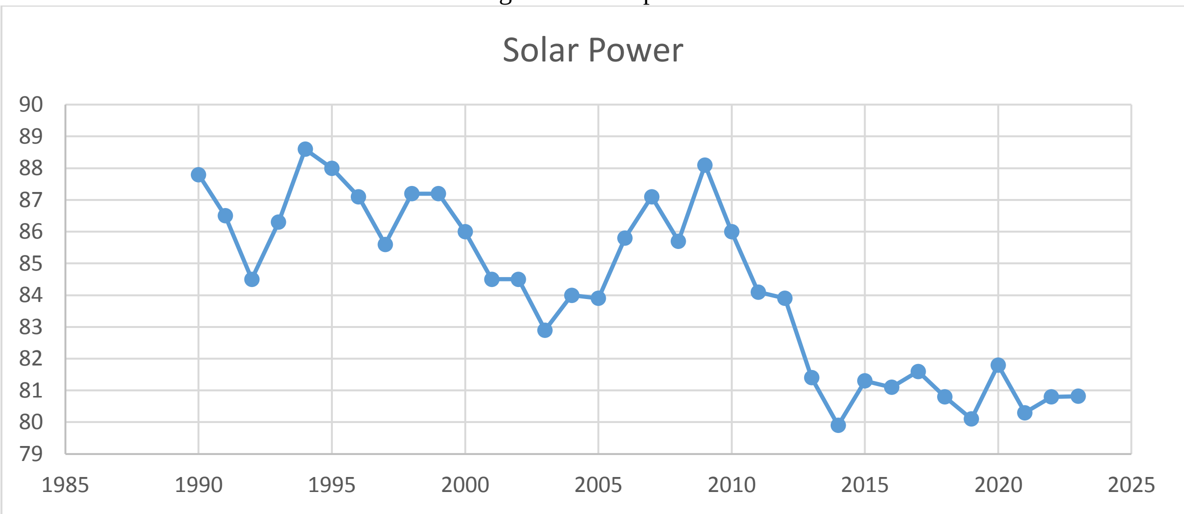
The consumption of non-renewable energy may produce output and foster economic development, but undoubtedly it is not only a significant source of carbon emission but also contributes to environmental degradation (Awodumi and Adewuyi 2020). The use of non-renewable energy sources put countries in a dilemma in policy priority between pollution reduction and economic growth. Thus, whether renewable or nonrenewable, the energy should be used carefully and efficiently as its sources are limited. Fossil fuels as an energy source as contributed immensely in the development of the world's economy over the past decades (Apergis and Payne, 2014). The impact of fossil fuel on environmental quality and climate change however, has caused stakeholders and policymakers to worry about the sustainability of the environment. Global warming is a result of the over-reliance on fossil fuels which has resulted in high carbon emissions (Sarkodie, 2020).

Renewable energy is however considered to be a more sustainable energy source to opt for instead of fossil fuels. In the view of Maji et al (2019), renewable energy does not emit carbon emissions during production unlike fossil fuel. Abokyi et al (2019), further attributed the high emission of greenhouse gas in the world to the combustion of fossil fuel. Removing fossil fuel from the equation for economic growth raises the issue of continuity and prosperity since renewable energy has the potential to minimize carbon emissions. However, the improper use of renewable energy could lower productivity and have a detrimental impact on the economy (Gyimah et al 2022).

Due to the higher cost of implementing and maintaining, cost-benefit analysis, and other external-internal factors, renewable energy is still under consideration to entirely depend on the energy source (Bhuiyan et al, 2022). Thus, this is a burning question for the researchers, policy makers, and related organizations whether introducing the renewable energy source would hinder or slow down the economic growth. Many researchers are trying to answer for their respective country or region of interest (Bhuiyan et al, 2022). Despite the revolutionary attempt to adopt renewable energy technologies, some industrial countries are still firm on the consumption of fossil fuels energies with the aim of recording faster and more impressive economic growth (Shrinkhal, 2019; Islam et al., 2021).

Hence, due to climate change and global warming situation, renewable energy could be the most attractive alternative to fossil fuel, reducing the CO_2 emission process. However, introducing new renewable energy technologies, consuming, and making them available for the citizens, is very time-consuming and costly. On the other side, countries struggle to maintain economic growth and development. The rest of the research is structured thus; section two contains the literature review, methodology is presented in section three, the results are presented in section four and the conclusion and recommendations are presented in section five.

Figure 1: Solar power



Source: WDI, 2024

II. Literature Review

Empirical review

Gyimah et al (2023) explored the direct and indirect effects of renewable energy on economic growth and carbon emissions by employing Partial Least Square Structure Equation Modeling and Granger Causality Test with data from 1990 to 2021. The results from the Partial Least Squares Structure Equation Modeling indicated that renewable energy consumption causes carbon emissions and has no effect on economic growth. Financial inclusion and foreign direct investment have positive effects on carbon emissions. However, renewable energy has an indirect negative effect on carbon emissions through economic growth. Foreign direct investment affects economic growth positively. Furthermore, the results from the Granger causality test indicate that renewable energy has a unidirectional causality relationship with financial inclusion and foreign direct investment and has a feedback causality relationship with economic growth.

Xie et al (2023) investigated the issue, this study analyzes renewable energy led economic growth hypothesis in the Next-11 economies over the period 1990–2020. Also, the study examined the influence of industry value added, gross national expenditure, and trade openness on economic growth of these economies. Along with the second-generation panel unit root test, this study employed the nonparametric panel data approach, i.e., quantile method of moments regression. The estimated results reveal the slopes coefficients are heterogeneous and cross-sectional dependency is present in the panel. The non-parametric approach reveals that validity of renewable energy led growth hypothesis. Also, the industry value added, gross national expenditure, and trade openness are found positively affecting economic growth of these economies. The panel causality test gives indication of the two way causal association between the variables. Jia et al (2023) investigated the direct and indirect effects of renewable energy consumption on economic growth, utilizing panel data from 90 countries along the Belt and Road between 2000 and 2019. Employing Granger causality tests and mediating effect models, they detected a bidirectional causal relationship between renewable energy consumption and economic growth, further affirming the feedback hypothesis. Our findings show that renewable energy consumption directly contributes to economic growth. Additionally, they found that renewable energy consumption has an indirect influence on economic growth via its impact on gross capital formation and trade. Raihan and Tuspekova (2022) examined the dynamic effects of economic growth, renewable energy use, urbanization, industrialization, tourism, agricultural productivity, and forest area in Turkey to accomplish environmental sustainability by lowering carbon dioxide emissions. The Dynamic Ordinary Least Squares method was used to analyze time series data from 1990 to 2020. The results disclosed that economic growth, urbanization, industrialization, and tourism have a positive impact on carbon dioxide emissions in Turkey. Furthermore, renewable energy consumption, agricultural productivity, and forest area have negative impact on carbon dioxide emissions. Doytch and Narayan (2021) estimated the effects of non-renewable and renewable energy consumption on manufacturing and services growth. They found that renewable energy enhances growth in high-growth sectors, that is, the services sector in high-income economies and the manufacturing sector in middle-income economies. Acheampong et al. (2021) investigated the causal relationship between renewable energy, CO_2 emission, and economic growth for 45 African (sub-Saharan) countries over 57 years (1960-2017). Using the GMM-PVAR method, they concluded that a bidirectional causal relationship exists between economic growth and renewable energy. Furuoka (2017) studied the relationship between renewable electricity consumption and economic development in Estonia, Latvia, and Lithuania between 1992 and 2011 and found that economic growth leads to the expansion of renewable electricity consumption, but not vice versa. Boontome et al. (2017) in their study on Thailand, on the other hand, considered the impact of non-renewable energy consumption and per capita CO_2 and found that renewable energy consumption can lead to a greener economy. Chen et al. (2020) considered labor variables in a study of 103 OECD countries from 1995 to 2015 and showed that the consumption of renewable energy has no effect on economic growth in developed countries and has a threshold effect on developing countries. Apergis and Danuletiu (2014) examined for the first time the relationship between renewable energy and economic growth for 80 countries under the Canning and Pedroni (2008) long-run causality test, which indicated that there is long-run positive causality running from renewable energy to real GDP for the total sample as well as across regions. The empirical findings provided strong evidence that the interdependence between renewable energy consumption and economic growth indicates that renewable energy is important for economic growth and likewise economic growth encourages the use of more renewable energy source. Chang and Fang (2022) examined the presence of the said hypothesis in BRICS economies. They applied Methods of moments Quantile regressions and panel estimations from the year 1995 to the year 2019. The empirical results confirmed the growth hypothesis in BRICS countries. Mohsin et al. (2021) found bi-directional causality in 25 Asian countries from 2000 to the year 2016. The findings portrayed that there is a positive association between renewable energy usage and economic growth. They also analyzed the rise in renewable energy usage decreases the harmful carbon dioxide emissions. Bouyghrissi et al. (2021) examined the renewable energy association with economic growth in Morrocco from the period 1990 to 2014. The empirical findings were consistent with the prevailing literature that it has a positive impact on economic sustainable development because of renewable energy consumption. Namahoro et al. (2021) examined the renewable energy and economic growth nexus in a sample of 75 low-income, middle-income, and upper-income countries from the period 1980 to 2016. They applied recent CS-DL and CCEMG novel techniques and found mixed impacts across the income regions/groups. While overall there is a significant and positive association at the global level. Okumus et al. (2021) investigated the influence of renewable energy (REN) and non-renewable energy (nonREN) consumption on the economic growth in G7 economies from 1980 to 2016 employing bootstrap Granger causality analysis. The resultant coefficients are positive and statistically noteworthy for both REN consumption and non-REN consumption. The empirical findings depicted that the growth hypothesis is only valid for renewable energy consumption on economic growth in Canada, the United States, and Italy. While neutrality exists in renewable energy consumption in France, the United Kingdom, and Japan. Additionally, Germany supports the feedback hypothesis for renewable energy consumption and economic growth. Chen et al. (2020) scrutinized the casual association of renewable energy and economic growth in 103 world countries from the year 1995 to 2015. The developing and non-OECD economies depicted a positive influence of renewable energy on economic growth when they outdo a certain level of threshold. If the economies utilize renewable energy below that certain threshold level then the impact is negative. Whereas the OECD economies showed a positive association of renewable energy and economic growth nexus and the developed economies showed no significant response.

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Theoretical review

The theoretical background that explains the relationship between energy, economic growth, and carbon emissions is the Environmental Kuznets Curve hypothesis. The EKC hypothesis argues how economic growth influences the environment at each stage of development. According to the hypothesis, at the initial stage of economic development, the energy use and the economic activities put the environment at risk but the will be a turnover when a certain level of growth is attained (Gyimah and Yao, 2022). Several studies have used this hypothesis to explain the effect on economic growth and energy use on carbon emissions (Tachega, et al (2021), Nyantakyi, et al 2023). As the world is in the era of industrial revolution, many countries especially those in developing countries are putting measures in place to meet with the global growth of development. This situation puts many countries in a place to use energies that are not environmentally friendly. As the world is fighting against climate change, it is of relevant to explore how the type of energy use contributes to economic development and environmental quality.

III. Methodology

The data for the study is gotten from the World Bank's Development Indicators and ranges from 1990 to 2023. The dependent variable of the study is economic growth while the independent variables are; renewable energy consumption, carbon emission, foreign direct investment, and trade balance.

The study is modelled after that of Jia et al (2023) and Gyimah et al, (2023) with some modifications.

The functional form of the model used in the study is given as;

GDP = *f* (SP, FDI, EMS, TRD)

$$GHG = \beta_0 + \beta_1 SP + \beta_2 FDI + \beta_3 EMS + \beta_4 TRD + \mu$$

Where; GDP is economic growth, SP is solar power proxy by Renewable energy consumption (% of total final energy consumption), FDI is foreign direct investment, EMS is carbon emission (Carbon dioxide (CO_2) emissions from Power Industry (Energy) (Mt CO_2e)) and TRD is trade balance. β_0, β_1, β_2, β_3, β_4 and μ are the intercept parameter, parameters of the explanatory variables and the unobserved terms in the model.

IV. Result and Discussion

4.1: Descriptive Statistics

	GDP	SP	EMS	FDI	TRD
Mean	2.59E+11	85.39167	7.624821	1.638773	27.36532
Median	2.28E+11	85.75000	6.909050	1.673695	27.19583
Maximum	4.80E+11	88.60000	13.57420	2.900249	30.22844
Minimum	1.53E+11	79.90000	4.959400	0.233794	24.72208
Std. Dev.	1.09E+11	2.138451	2.378164	0.753860	1.660310
Skewness	0.651219	-0.704634	1.005008	-0.375076	-0.081769
Kurtosis	2.038587	3.232968	3.069315	2.498466	1.839915
Jarque-Bera	2.620660	2.040313	4.044968	0.814264	1.372541
Probability	0.269731	0.360539	0.132326	0.665556	0.503450
Observations	34	34	34	34	34

Source: Author's computation with EVIEWS

The result of descriptive statistics for five variables: economic growth (GDP), solar power (SP), carbon emission (EMS), foreign direct investment (FDI), and trade balance (TRD) are presented in table 4.1. The economy on average recorded a 2.5 percent growth during the period of the study, for solar power the mean was 85.39 percent of renewable energy was used. On the average 7.62 (Mt CO_2e) was emitted. FDI have a mean of 1.64 which suggests that the average value of Foreign Direct Investment as a percentage of GDP was 1.64 percent. TRD have an average value of 27.37. GDP and carbon emission both have a positive skewness signifying that the data is slightly skewed to the right, with a longer tail on the higher side of the distribution. Solar power, FDI and TRD all have negative skewness which indicates a leftward skewness, with a longer tail on the lower side. GDP, FDI and TRD all have a distribution that is platykurtic (flatter than a normal distribution), while carbon emission and solar power both indicates a mesokurtic distribution (more peaked than normal). The Jarque-Bera statistic suggests that the data of the variables employed in the study are normally distributed based on their probability values.

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Table 4.2: OLS Output

Dependent Variable: LGDP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LSP	1.340452	1.290668	1.038573	0.3120
LEMS	1.332738	0.207051	6.436758	0.0000
LFDI	0.063725	0.033717	1.889974	0.0741
LTRD	0.296613	0.878382	0.337682	0.7393
C	16.58754	6.191530	2.679070	0.0148

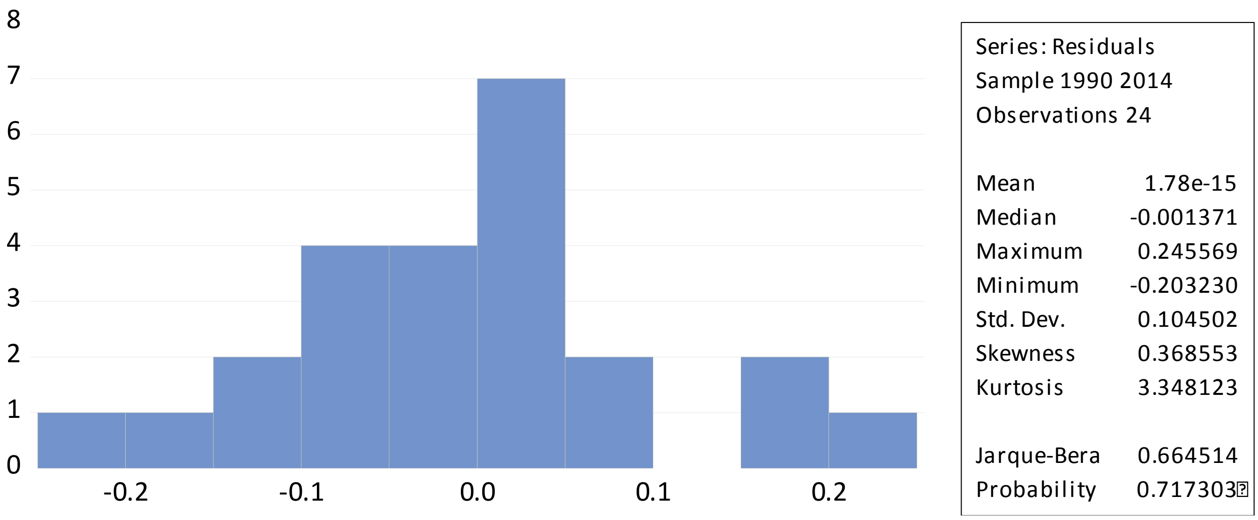
R-squared	0.933394	Mean dependent var	26.20108
Adjusted R-squared	0.919372	S.D. dependent var	0.404922
F-statistic	66.56527	Durbin-Watson stat	1.422165
Prob(F-statistic)	0.000000		

Source: Author's computation with EVIEWS

Renewable energy consumption which is a proxy for solar power have a positive and insignificant impact on economic growth. The coefficient of 1.340452, mean that a 1% increase in solar power use is associated with an approximately 1.34% increase in economic growth. Carbon emission have a positive and significant effect on economic growth, the coefficient of 1.332738, suggests that a 1% increase in carbon emission corresponds to an approximately 1.33% increase in GDP. Foreign direct investment have positive and significant effect of economic growth. The **c**oefficient of 0.063725, means that a 1% increase in FDI is associated with an approximately 0.06% increase in GDP. Trade balance also displayed a positive impact on economic growth but it is not statistically significant, the coefficient of 0.296613, means that a 1% increase in TRD would increase GDP by approximately 0.30%. The Adjusted R-squared of 0.9194 shows that the variables of the model (economic growth, solar power, carbon emission, foreign direct investment, and trade balance) explains about 92% confirming the model's strong explanatory power. A high F-statistic with a p-value of 0.0000 indicates that the model as a whole is statistically significant, implying that at least one of the predictors significantly explains variations in economic growth. Durbin-Watson statistic of 1.4 shows that the model is free from autocorrelation.

Model Diagnostic

Figure 2: Normality test



The Jarque-Bera statistic was used to test for the normality of the residuals, the probability value of 0.717303 which is greater than 5%, showed that the model's residuals are normality distributed.

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Table 4.3: Test for Autocorrelation

F-Statistics	1.375641
P-value	(0.2561)

Source: Author's computation with EVIEWS

From the table 4.3, it is evident that the model formulated and estimated for the study is robust and devoid of autocorrelation based on the probability values of 0.5118 which is clearly greater than the 5% level. The null hypothesis of the presence of serial correlation is therefore rejected.

Table 4.4: Test for Heteroskedasticity

F-Statistics	1.175672
P-value	(0.3529)

Source: Author's computation with EVIEWS

From the table 4.4, it is evident that the model formulated and estimated for the study is robust and devoid of Heteroskedasticity based on the probability values of 0.3124 which is clearly greater than the 5% level. The null hypothesis of the presence of Heteroskedasticity is therefore rejected.

Table 4.5: Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
SP does not Granger Cause GDP	33	1.84588	0.1844
GDP does not Granger Cause SP		5.86049	0.0217
EMS does not Granger Cause GDP	33	5.15327	0.0306
GDP does not Granger Cause EMS		23.5344	4.E-05
FDI does not Granger Cause GDP	33	8.11243	0.0079
GDP does not Granger Cause FDI		1.93630	0.1743
TRD does not Granger Cause GDP	33	2.80520	0.1103
GDP does not Granger Cause TRD		5.28574	0.0330

Source: Author's computation with EVIEWS

From the Granger causality test presented in table 4.5, solar power (SP) does not have a statistically significant causal effect on GDP at the 5% significance level. GDP does Granger-cause SP at the 5% significance level, indicating that past values of GDP can be used to predict SP. EMS does Granger-cause GDP, GDP also Granger-causes EMS. This bidirectional causality implies that GDP and EMS can predict each other, suggesting a potentially strong interdependence between the two. FDI Granger-causes GDP, GDP does not Granger-cause FDI. TRD does not Granger-cause GDP at the 5% significance level. GDP does Granger-cause TRD.

V. Conclusion and Recommendations

This study analyzed the relationship between renewable energy consumption (specifically solar power) and economic growth, using carbon emissions, foreign direct investment (FDI), and trade balance as additional factors influencing growth. Findings revealed that renewable energy consumption, though positively associated with economic growth, has an insignificant effect, suggesting that while solar power can potentially support economic growth, its current scale and utilization do not yet substantially drive economic performance. Carbon emissions have a positive and significant impact on economic growth. This may indicate that traditional energy sources, often carbon-intensive, continue to play a dominant role in economic activities, which could present environmental challenges. Foreign direct investment (FDI) shows a positive and significant impact on economic growth, underscoring the importance of capital inflow and investments in fostering economic development. Trade balance, while also positive, is not statistically significant for economic growth, suggesting that trade dynamics may not strongly influence the economy in the current context, or that trade impacts require a more nuanced or sector-specific analysis.

Based on the finding the following recommendations are made; government should increase investment in solar infrastructure. This includes government incentives, subsidies, and public-private partnerships aimed at expanding solar energy production and consumption. Policies encouraging a gradual shift to renewable energy sources, combined with carbon mitigation strategies, would allow for sustainable growth. Policies that create an investor-friendly environment-such as tax incentives, streamlined regulatory frameworks, and infrastructure improvements-should be encouraged.

Specific incentives could target renewable energy projects, aligning FDI with sustainability goals. Encouraging trade in renewable technology, parts, and expertise could stimulate growth within the solar energy sector and foster innovation.

References

[1]. Abokyi, E., Appiah-Konadu, P., Abokyi, F. & Oteng-Abayie, E., F. (2019). Industrial growth and emissions of CO2 in Ghana: The role of financial development and fossil fuel consumption. Energy Reports, 5, 1339–1353.

[2]. Acheampong, A. O., Dzator, J., & Savage, D. A. (2021). Renewable Energy, CO_2 Emissions and Economic Growth in Sub-saharan Africa: Does Institutional Quality Matter? Journal of Policy Model, 43(5), 1070-1093. doi:10.1016/j.jpolmod.2021.03.011

[3]. Apergis, N. & Danuletiu, D., C. (2014). Renewable Energy and Economic Growth: Evidence from the Sign of Panel Long-Run Causality. International Journal of Energy Economics and Policy, 4(4), 578-587.

[4]. Apergis, N. & Payne, J., E. (2014). Renewable energy, output, CO2 emissions, and fossil fuel prices in Central America: Evidence from a nonlinear panel smooth transition vector error correction model. Energy Economics, 42, 226–32.

[5]. Awodumi, O. B., & Adewuyi, A. O. (2020). The Role of Non-renewable Energy Consumption in Economic Growth and Carbon Emission: Evidence from Oil Producing Economies in Africa. Energy Strategy Review, 27 (January), 100434. doi:10.1016/j.esr.2019.100434

[6]. Bhuiyan, M. A., Zhang, Q., Khare, V., Mikhaylov, A., Pinter, G. & Huang, X. (2022). Renewable Energy Consumption and Economic Growth Nexus-A Systematic Literature Review. Frontiers in Environmental Science, 10, 878394. doi: 10.3389/fenvs.2022.878394

[7]. Boontome, P., Therdyothin, A. & Chontanawat, J. (2017). Investigating the Causal Relationship between Non-Renewable and Renewable Energy Consumption, CO_2 Emissions and Economic Growth in Thailand. Energy Procedia, 138, 925-930.

[8]. Bouyghrissi, S., Berjaoui, A., & Khanniba, M. (2021). The nexus between renewable energy consumption and economic growth in Morocco. Environmental Science and Pollution Research International, 28(5), 5693–5703. https://doi.org/10.1007/s11356-020-10773-5

[9]. Canning, D. & Pedroni, P. (2008). Infrastructure, long-run economic growth and causality tests for cointegrated panels, The Manchester School, 76, 504-527.

[10]. Chang, C. L., & Fang, M. (2022). Renewable energy-led growth hypothesis: New insights from BRICS and N-11 economies. Renewable Energy, 188, 788-800. https://doi.org/10.1016/j.renene.2022.02.052

[11]. Chen, C., Pinar, M. & Stengos, T. (2020). Renewable Energy Consumption and Economic Growth Nexus: Evidence from a Threshold Model. Energy Policy, 139, 111295.

[12]. Chen, C., Pinar, M., & Stengos, T. (2020). Renewable energy consumption and economic growth nexus: Evidence from a threshold model. Energy Policy, 139, 111295. https://doi.org/10.1016/j.enpol.2020.111295

[13]. Doytch, N., & Narayan, S. (2021). Does Transitioning towards Renewable Energy Accelerate Economic Growth? An Analysis of Sectoral Growth for a Dynamic Panel of Countries. Energy 235, 121290. doi:10.1016/j.energy.2021.121290

[14]. Furuoka, F. (2017). Renewable Electricity Consumption and Economic Development: New Findings from the Baltic Countries. Renew. Sustain. Energy Rev., 71, 450-463.

[15]. Gyimah, J. & Yao, X. (2022). Globalisation and renewable energy impact on carbon emissions in Ghana. International Journal of Global Warming, 28(2), 113–21.

[16]. Gyimah, J., Fiati, M. K., Nwigwe, U. A., Vanessa, A., E. & Yao, X. (2023). Exploring the impact of renewable energy on economic growth and carbon emissions: Evidence from partial least squares structural equation modeling. PLoS ONE 18(12), 1-24. e0295563. https://doi.org/10.1371/journal.pone.0295563

[17]. Gyimah, J., Yao, X., Tachega, M. A., Hayford, S., I. & Opoku-Mensah, E. (2022). Renewable energy consumption and economic growth: New evidence from Ghana. Energy. 2022; 248.

[18]. Islam, M. M., Irfan, M., Shahbaz, M., & Vo, X., V. (2022). Renewable and Nonrenewable Energy Consumption in Bangladesh: The Relative Influencing Profiles of Economic Factors, Urbanization, Physical Infrastructure and Institutional Quality. Renewable Energy 184, 1130-1149. doi:10.1016/j.renene.2021.12.020

[19]. Jia, H., Fan, S. & Xia, M. (2023). The Impact of Renewable Energy Consumption on Economic Growth: Evidence from Countries along the Belt and Road. Sustainability 2023, 15, 8644. https://doi.org/10.3390/su15118644
[20]. Maji, I. K., Sulaiman, C. & Abdul-Rahim, A., S. (2019). Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. Energy Reports, 5, 384-392.
[21]. Mohsin, M., Kamran, H. W., Nawaz, M. A., Hussain, M. S., & Dahri, A. S. (2021). Assessing the impact of transition from nonrenewable to renewable energy consumption on economic growth-environmental nexus from developing Asian economies. Journal of Environmental Management, 284, 111999. https://doi.org/10.1016/j.jenvman.2021.111999
[22]. Namahoro, J. P., Nzabanita, J., & Wu, Q. (2021). The impact of total and renewable energy consumption on economic growth in lower and middle-and upper-middle-income groups: Evidence from CS-DL and CCEMG analysis. Energy, 237, 121536. https://doi.org/10.1016/j.energy.2021.121536
[23]. Nyantakyi, G., Gyimah, J., Sarpong, F., A. & Sarfo, P., A. (2023). Powering Sustainable growth in West Africa: exploring the role of environmental tax, economic development, and financial development in shaping renewable energy consumption patterns. Environ Sci Pollut Res Int. 2023. https://doi.org/10.1007/s11356023-30034-5PMID: 37770735
[24]. Okumus, I., Guzel, A. E., & Destek, M. A. (2021). Renewable, non-renewable energy consumption and economic growth nexus in G7: Fresh evidence from CS-ARDL. Environmental Science and Pollution Research International, 28(40), 56595–56605. https://doi.org/10.1007/s11356-02114618-7
[25]. Raihan, A. & Tuspekova, A. (2022). Dynamic impacts of economic growth, renewable energy use, urbanization, industrialization, tourism, agriculture, and forests on carbon emissions in Turkey. Carbon Research, 1(20), 1-14.
[26]. Sarkodie, S. A., Adams, S., Owusu, P. A., Leirvik, T. & Ozturk, I. (2020). Mitigating degradation and emissions in China: The role of environmental sustainability, human capital and renewable energy. Science Total Environment, 719, 137530. https://doi.org/10.1016/j.scitotenv.2020.137530 PMID: 32143100
[27]. Shrinkhal, R. (2019). Economics, Technology, and Environmental Protection, in Phytomanagement of Polluted Sites (Amsterdam: Elsevier), 569–580. doi:10.1016/B978-0-12-813912-7.00022-3
[28]. Tachega, M. A., Yao, X., Liu, Y., Ahmed, D., Ackaah, W. & Gabir, M. (2021). Income Heterogeneity and the Environmental Kuznets Curve Turning Points: Evidence from Africa. Sustainability, 13(10).
[29]. Xie, P., Zhu, Z., Hu, G. & Huang, J. (2023). Renewable energy and economic growth hypothesis: Evidence from N-11 countries. Economic Research Ekonomska Istraživanja, 36(1), 2121741, DOI:10.1080/1331677X.2022.2121741