

Economic Growth, Globalization and The Environment In Nigeria

R. Santos Alimi

Economics Department, Adekunle Ajasin University
Akungba Akoko, Ondo State, Nigeria
+234 705 046 7385.

Email: rasaq.alimi@aaua.edu.ng, rsantos.alimi@gmail.com
ORCID: 0000-003-2450-3078

Abstract

In recent times more attention is given to the interrelationship among economic growth, globalization and environmental quality such as Carbon Dioxide (CO₂) emissions in quest to ensure Sustainable Development and the challenge posed by climate change. Prior studies have focused on how trade component in globalization influences the environment. However, recent studies posit that other aspect of globalization such as economic, social, and political are also important, the integration of which needs to be considered in sustainable development. Thus, this paper enriches current literature by providing new evidence derived from a comprehensive globalization index to confirm the long- and short-term relationship among economic growth, globalization and the environment in Nigeria. This study used the KOF globalization index as the proxy for globalization, per capita GDP as proxy for economic growth and CO₂ emissions as the proxy for the environment. The data on globalization index was retrieved from KOF Swiss Economic Institute while those of per capita GDP and CO₂ emissions were obtained from the World Bank for the period 1990 to 2023 and employed autoregressive distributed lags (ARDL) estimation technique. The empirical results indicate that the nexus among economic growth, globalization and the environment is cointegrated in the long-term. In the short - and long - run, the study found that economic growth and globalization improve the environment i.e causing reduction in environmental degradation. The finding also showed that consumption of renewable energy, adherence to rule of law and international price of crude oil as determinants of environmental quality in Nigeria. The study recommends that government should be concerned about environmental development when promoting globalization through economic and social activities. Moreso, policymakers should continue to encourage investment in renewable energy as energy-intensive industries are the major source of CO₂ emissions in Nigeria.

Keywords: globalization, economic growth and CO₂ emissions, renewable energy

INTRODUCTION

The goal of many nations is to increase economic growth through increased output, experience a low and stable inflation rate, increase the standard of living and maintain a favourable balance of payment. In 2015, United Nations adopted 17 goals of sustainable development goals (SDGs) which hovers around three important components – ***the environment, the economy and the People***. In order to achieve these goals (either national macroeconomics objectives or SDGs) the environment plays a key role. As a matter of emphasis, 10 out of 17 SDGs (SDG 6, 7, 8, 9, 11, 12, 13, 14, 15 & 17) are about the environment which is pivotal to achieving the broad objectives of SDGs, these are; support human well-being and health, promote economic growth and development, ensure resource availability for future generations and mitigate climate change and its impacts.

Globalization in simple term is *the increased interconnectedness and interdependence of peoples and countries*. It is the increasing integration of economies, societies and cultures through international trade, investment and technological advancement. Although globalization has brought a number of positive developments such as economic development, good governance, technological progress, religious and ethnic tolerance, it has also led to inequality between countries, religious and ethnic tensions, and environmental problems such as degradation (Shahzadi, Yaseen, & Anwar, 2019). Globalization brings

faster access to technologies, improved communication networks, and innovation that lead to industrialization and industry concentration, which negatively affects the environment.

Today, one of the major problems the world is currently facing is climate change. The problem of global warming is of an ecological nature and affects many vital functions of the planet Earth and the inhabitants. According to United Nations, fossil fuels are the largest contributor to global climate change, accounting for over 75% of global greenhouse gas emissions and nearly 90% of all carbon dioxide emissions, in the atmosphere in several countries of the world, which Nigeria is not exempted from. Although Nigeria's contribution to global CO₂ emissions is low at 0.32 percent, it is far lower than China's 32.8 %, USA's 12.6%, Indian's 6.99% and Russia's 4.96% of world share of carbon dioxide, it's however fourth major contributor in Africa after South Africa, Egypt and Algeria.

Nigeria is rich in both natural and human resources. As such, globalization makes it possible for many multinational organizations to operate in Nigeria to explore and exploit her natural resources while most industrialized nations exports finished products to the country space because of the size of the Nigerian market. These activities have both positive and negative consequences for the environment (Ejovi, Sunday & Akpokighe, 2014). Among the environmental problems facing Nigeria aside global warming and ozone layer depletion are environmental pollutions, destruction of aquatic lives, desertification of farm lands and flooding; these have pose serious environmental challenges for host communities and the nation at large (Ejovi, Sunday & Akpokighe, 2014). The Nigerian environment is also polluted through the burning of fossil fuels to power generators (for personal or business use) and run automobile (especially large volume of used cars on Nigerian road), these have contributed enormous greenhouse gases to the earth's atmosphere.

Globalization and the environment are closely linked, with complex interactions and impacts. Evidence from empirical literature suggests that globalization could be a cause or a cure to the issues of environmental degradation since it has both mitigating and exacerbating effects on environmental quality. For instance, globalization creates and increases national/corporate wealth through transfer of technology, global cooperation, movement of capital, manpower, idea and information, therefore host countries will be able to afford the efficient technologies that are eco-friendly and increase budgetary allocation to education, thereby disseminating knowledge, with ease, about the need to protect the environment through adherence to environmental friendly practices such as shift from fossil fuel to renewable energy source (Lee & Min (2014), Dogan & Turkecul (2016), Shahbaz , Bhattacharya & Ahmed (2016), Akadiri, Adebayo, Nakorji, Mwakapwa, Inusa & Izuchukwu (2022), Çetin, Sarigül, Topcu, Alvarado & Karataser (2023)).

On the other hand, globalization increases global demand for goods and services which in turn increase economic activities and output, as a consequence exerts negative environmental externalities such as health problems pollution and waste, resource depletion, transportation emissions, loss of biodiversity, etc. (Yameogo, Omojolaibi & Dauda (2021), Wen, Mughal, Zhao, Shabbir, Niedbała, Jain & Anwar (2021)). According to Grossman and Krueger (1991) and Panayotou (1997), they studies posit modified Environment Kuznet Curve (EKC) as theoretical framework for explaining globalization and environmental degradation interrelationship and that the environmental outcomes are dependent on distinct stages or degrees of globalization. Thus, determining the effects of globalization on the environment becomes an empirical issue.

As depicted in the study, globalization has far-reaching consequences for sustainable development. In recent times more attention is given to the interrelationship between globalization and environmental quality such as Carbon Dioxide (CO₂) emissions in quest to ensure Sustainable Development and the challenge posed by climate change. Prior studies , such as Dogan and Turkecul (2016), Enyinna Emmanuel, and Ejike (2020), Akadiri, Adebayo, Nakorji, Mwakapwa, Inusa & Izuchukwu (2022) and Çetin, Sarigül, Topcu, Alvarado and Karataser (2023) have focused on how trade component in globalization influences the environment. However, recent studies (Akbulut & Çoban (2023); Al-Malkia, Abidb, Sekrafic & Alnor, 2024) posit that other aspect of globalization such as economic, social, and political are also important, the integration of which needs to be considered in sustainable development. Thus, this paper enriches current literature by providing new evidence derived from a recent comprehensive KOF index of globalization to re-examine the long- and short-term globalization - environment nexus in Nigeria.

2. DATA AND METHODS

The study specified a linear model to establish the relationship between economic growth, globalization and the environment using yearly observations between 1990 and 2022. The recently developed globalization index was employed as a proxy of globalization - KOF globalization indices which provide a more comprehensive measure of globalization in general. KOF index of globalization combines three sub-indices of globalisation – economic, social and political - into an overall index of globalization. The economic globalization index combines information on actual trade flows, foreign direct investment, income payments to foreign nationals and restrictions on trade and capital. The social globalization index combines data on personal contact with people, information flows and international cultural integration. The political globalization index combines information on international political integration of countries involving embassies in country, membership in international organisations, participation in U.N. Security Council missions and international treaties. The aggregated index of KOF data was employed in the study. All index ranges between 0 (not globalized) and 100 (globalized) – see Appendix I for Structure, variables and weights of KOF index of globalization. (Dreher, 2006; Gygli, Haelg, Potrafke, Sturm (2019).

CO₂ is the most important greenhouse gas and it primarily comes from transportation (Shapiro and Walker 2018). CO₂ emissions were used as a measure of the environment and were measured in kilograms in terms of GDP based on the 2010 constant price. As suggested in the literature (Samour, Tawfik, Radulescu & Baldan, 2023), the study included rule of law, renewable energy, population growth rate and price of crude oil as control variables. The data on the globalization index was drawn from the KOF Swiss Economic Institute while those of CO₂ emissions, per capita GDP, renewable energy, population growth and price of crude oil were obtained from the World Bank. Data on rule of law reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts; and it was elicited from the Worldwide Governance Indicators. Renewable energy consumption is the share of renewable energy in total final energy consumption, population growth in percentage while crude oil price is given in US dollar.

The model for the environmental effects of economic growth and globalization is thus presented;

$$co2 = \Omega_0 + \Omega_1 income + \Omega_2 glob_t + \Omega_3 rolaw + \Omega_4 renergy_t + \Omega_5 popr_t + \Omega_6 oilp_t + ut \quad (1)$$

Where:

- co2 - environmental quality proxied by carbon emission (CO₂).
- income - defined as per capita expressed in constant 2010 US dollars
- glob - KOF globalization index
- rolaw - rule of law
- renergy - renewable energy
- popr - population growth rate
- oilp - international price of crude oil in dollar

The study first applied unit root tests to check for the order of integration of the data series using augmented Dickey-Fuller, ADF (Dickey and Fuller, 1981), Modified Dickey-Fuller generalized least square, DF-GLS (Elliot et al., 1996), and Kwiatkowski-Phillips-Schmidt-Shin, KPSS (Kwiatkowski et al., 1992)). Unlike ADF and DF-GLS, Kwiatkowski et al., 1992) proposed a unit root test in which the presence of a unit root is in the alternative hypothesis. Secondly, the long-run relationship between economic growth, globalization and the environment were examined by applying autoregressive distributed lag (ARDL) bound testing and thereafter estimate equation (1) using the ARDL framework developed by Pesaran et al. (1999, 2001). According to Pesaran et al. (2001), the error correction representation of the ARDL model is:

$$\begin{aligned} \Delta co2_t = & \gamma_0 + \gamma_1 co2_{t-1} + \gamma_2 income_{t-1} + \gamma_3 glob_{t-1} + \gamma_4 rolaw_{t-1} + \gamma_5 renergy_{t-1} + \gamma_6 popr_{t-1} \\ & + \gamma_7 oilp_{t-1} + \sum_{i=1}^p \psi_i \Delta co2_{t-1} + \sum_{j=1}^{q1} \tau_{1j} \Delta income_{t-1} + \sum_{j=1}^{q2} \tau_{2j} \Delta glob_{t-1} + \sum_{j=1}^{q3} \tau_{3j} \Delta rolaw_{t-1} + \sum_{j=1}^{q4} \tau_{4j} \\ & \Delta renergy_{t-1} + \sum_{j=1}^{q5} \tau_{5j} \Delta popr_{t-1} + \sum_{j=1}^{q6} \tau_{6j} \Delta oilp_{t-1} + \varepsilon_t \end{aligned} \quad (2)$$

where ε_t is a white noise error term and Δ is a first difference operator. In Eq. (2), the terms with summation represented short-run dynamics, whereas the terms with γ s indicated long-run relationships. The null hypothesis of no cointegration is that $H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = 0$, which indicated that no long-run relationship existed and the alternative hypothesis that cointegration exists is: $H_1: \text{any } \gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6 \neq 0$ (at least one parameter not equal to zero), it's performed by Wald test using F-test. The null hypothesis can be rejected, when the value of F-statistic is greater than the upper bound critical value.

Thereafter, the study applied several diagnostic tests among which are; Harvey test to check for the heteroscedasticity of the residuals of the ARDL model, Breusch-Godfrey Serial Correlation LM test to check

for serial correlation of the residuals, Jarque-Bera normality test to test for the normality of the residuals of the models and Ramsey RESET test as a model specification test.

3. EMPIRICAL RESULTS AND DISCUSSION

Table 1 shows the results of the unit roots of the time-series data on all the variables based on ADF, DF-GLS, and KPSS unit root tests. The results showed that only the globalization series was stationary at level while others become stationary after first difference. Therefore, the unit root results gave a mixture of I(1) and I(0) series. The features of the data series justified the use of the ARDL model proposed by Pesaran et al. (2001), which is appropriate for variables with different order of integration, that is, a combination of I(0) and I(1).

**Table 1: Results of Unit root tests
ADF, DF – GLS AND KPSS Test**

	ADF		DF - GLS		KPSS	
	Level	First Diff.	Level	First Diff.	Level	First Diff.
co2	-1.175	-5.633***	-1.091	-4.640***	0.6692**	0.5000**
income	-0.9883	-2.967**	-0.7815	-2.753***	0.5627**	0.1687
glob	-3.623**	-3.482**	-0.9498	-3.251***	0.6242**	0.4370*
rolaw	-1.187	-5.118***	-1.127	-5.171***	0.5665**	0.064
renergy	-1.841	-5.631***	-1.536	-5.352	0.5435**	0.053
popr	-2.079	-4.403***	-2.054*	-2.071**	0.2872	0.2587
oilpr	-1.193	-4.842***	-1.073	-4.935***	0.5391**	0.092

'***', '**' and '*' denote significance at the 1%, 5%, and 10% level respectively. The 1%, 5% and 10% critical values are - 3.66, -2.96 and - 2.61 respectively for ADF; -2.64, -1.95 and -1.61 respectively for DF-GLS test; and 0.7390, 0.4630 and 0.3470 respectively for KPSS test.

Source: Author's computation

The results of ARDL bounds test revealed that F-test is 4.8644. The value of the estimated F- statistic of the model has exceeded the upper bound at the 1% level of significance. The result suggested that there existed a long-run relationship among the variables. Thus, the series are related and even if there are shocks in the short-run, which may affect the movement in the individual series, they would converge with time.

Table 2: ARDL Bounds Test for Cointegration Results

Test Statistic	Value	k
F-statistic	4.8644	6
Critical Value Bounds		
Significance	I(0) Bound	I(1) Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Source: Author's computation

Lag Order Selection

Since unit root tests have been applied, the next step is selection of the lag order to be used for the ARDL approach as developed by Pesaran *et al.* (2001). The Table 3 below shows the results of 5 lag order selection criteria - LR test statistic (LR), Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn (HQ) information criterion. Table 3 shows the optimal lag length of the selected by all the selection criteria except LR test statistic, is 3.

Table 3: Lag Length Selection for External Debt Sustainability (1981-2018)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-109.2771	NA	5.49e-06	7.751810	8.078756	7.856403
1	72.40398	266.4657	8.67e-10	-1.093599	1.521970	-0.256856

2	141.0338	68.62985	4.26e-10	-2.402255	2.501936	-0.833362
3	377.6685	126.2051*	1.34e-14*	-14.91123*	-7.718418*	-12.61019*

* indicates lag order selected by the criterion

The study found evidence in favor of short-run dynamics as shown by the signs and values of the coefficients of the first-difference lagged CO₂ and per capita GDP as reported in Panel (A) of Table 4. The coefficient of error correction term (ect) was negative and significant, which implied that there was an adjustment toward a long-run equilibrium relationship for this equation if there was a shock in the short run. The long run estimates are presented in Panel (B) of Table 4. The coefficients of the long run estimates for per capita GDP and globalization were negative and statistically significant at 1 percent. On the included other determinants of carbon emission, population growth rate and renewable energy have significant effect on environmental quality at 1 percent level while rule of law and crude oil price have expected signs but they are not statistically significant.

Table 4: ARDL Result

Dependent Variable: co2				
Method: Autoregressive Distributed Lags ARDL(2, 2, 2, 0, 1, 2, 0)				
<i>R²=0.986559; Adjusted R² =0.973118; Prob.(F-statistic)= 0.000000</i>				
(A) Short Run Estimate				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(co2(-1))	0.487657	0.124278	3.923935	0.0014
D(income)	-0.916536	0.208754	-4.390510	0.0005
D(income(-1))	-0.251092	0.186353	-1.347399	0.1979
D(glob)	-0.003842	0.005509	-0.697372	0.4962
D(globI(-1))	0.004240	0.003428	1.237053	0.2351
D(rolaw)	-0.091363	0.058673	-1.557168	0.1403
D(popr)	-0.302672	0.371465	-0.814805	0.4279
D(oilpr)	0.000202	0.000344	0.586142	0.5665
D(oilpr(-1))	-0.000987	0.000334	-2.953258	0.0099
D(renergy)	-0.025560	0.004162	-6.141074	0.0000
ect	-1.410741	0.123767	-11.398373	0.0000
(B) Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
income	-0.347314	0.072515	-4.789522	0.0002
glob	-0.012373	0.004000	-3.093138	0.0074
rolaw	-0.064763	0.041827	-1.548344	0.1424
popr	0.231973	0.073249	3.166911	0.0064
oilpr	0.000339	0.000483	0.701880	0.4935
renergy	-0.018118	0.002961	-6.119463	0.0000
c	6.503442	0.773998	8.402406	0.0000

Source: Author's Computation (2024)

Table 5 shows the results of different diagnostic tests. To check the heteroscedasticity of the residuals of the ARDL model, we used the Harvey test, and for the serial correlation check, we used the Breusch-Godfrey test. The results on these two tests revealed that the residuals obtained from the model were homoscedastic and uncorrelated. For the normality test, the study utilized the Jarque-Bera test, which showed that the residuals of the test employed were normally distributed while the result of Ramsey RESET test suggested that the model is well specified.

Table 5 Results from different diagnostic tests

Harvey		Breusch-Godfrey		Ramsey		Jarque-Bera	
F-Stat.	Sig.	F-Stat.	Sig.	F-Stat.	Sig.	F-Stat.	Sig.

2.0904	0.1147	2.642549	0.1610	0.0017	0.9694	0.0063	0.9968
--------	--------	----------	--------	--------	--------	--------	--------

Based on empirical estimations and findings, the study found in the case of Nigeria that; first, globalization and CO₂ emissions is cointegrated in the long run and in event of short-run shock in globalization there is evidence of over-adjustment of the environment variable i.e CO₂ . The effect of globalization on CO₂ emissions is negative which implies that globalization improves the environment i.e causing reduction in environmental degradation in Nigeria. A 10 point unit increase in globalization causes degradation to drop by 0.12 unit.. Intuitively, it means that means that globalization helps improve environmental quality. With globalization, the comprehensive globalization index suggests that Nigeria has been connected with developed economies interdependently in terms of social, economic, and political aspects. From a policy perspective, in spite of reservation expressed on future of globalization in terms of global supply chain, globalization appears to have come to stay with its attending impact, policy makers should intensify effort on building green economy as being champion recently by Nigeria government. This finding is consistent with Dogan and Deger (2016), Rahman (2020) and Islam et al. (2021) which imply an improvement in the quality of the environment through the transfer of technologies that are friendly to the environment and promotion of environmental laws and regulations that prevent indigenous and multinationals firms from using nonrenewable energy sources in production activities. However, the study's findings are incompatible with Khan et al. (2019), Akadiri et al. (2019), Nguyen and Le (2020), Wang et al. (2020) and Akadiri et al. (2022), that shows that political, social and economic globalization index have positive impact on CO₂ emissions.

The finding also showed that GDP per capita growth, consumption of renewable energy, adherence to rule of law, population growth rate and international price of crude oil are determinants of environmental quality in Nigeria. They all have expected signs except price of crude oil and its not significant even at 10% level.

\$. CONCLUDING REMARKS

This study attempts to examine the effect of globalization on the environment, measure by carbon emissions in Nigeria over the period 1990 – 2023. Unlike, previous studies that employed trade, foreign direct investment, remittances and foreign portfolio as proxies for globalization, this study looked beyond trade and economic components of globalization in order to posit a robust influence on the environment by using KOF globalization index. The study utilizes ARDL estimation after testing for the order of integration of the variables. The study found that globalization negatively affects environmental quality in Nigeria, that is, the more globalized Nigeria becomes, the more improved the environment. The diagnostic tests results indicate the absence of normality, autocorrelation, and heteroskedasticity issues. The study recommends that government should be concerned more about environmental development when promoting globalization through economic and social activities. Policymakers should continue to encourage investment in renewable energy as energy-intensive industries and transport sector are the major source of CO₂ emissions in Nigeria. Moreso, policy that subsidize the use clean energy and tax non-renewable energy will produce desire result of tackling problem of environmental degradation.

Area of further study –

This current study used carbon emissions to proxy environmental degradation. Future research could focus on other environmental metrics such as ecology footprint and other key drivers of environmental degradation. Future study may also investigate blocs' of countries especially oil dependent countries in panel data or time series studies.

References

- Akadiri, S. S., Adebayo, T. S., Nakorji, M., Mwakapwa, W., Inusa, E. M. & Izuchukwu, O. (2022). Impacts of globalization and energy consumption on environmental degradation: what is the way forward to achieving environmental sustainability targets in Nigeria? *Environmental Science and Pollution Research*, 29: 60426–60439
- Akadiri, S. S., Alola, A. A. & Akadiri, A. C. (2019). The role of globalization, real income, tourism in environmental sustainability target. Evidence from Turkey. *Science of The Total Environment*, 687:423–432
- Akbulut, D. & Çoban, M. N. (2023). The impact of globalization on environmental degradation: evidence from NIC countries, *Van Yüzüncü Yıl Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 8 (16). 186-201. DOI: 10.54831/vanyuiibfd.1290055

- Al-Malkia, A, Abidb, M., Sekrafc, H. & Alnor, N. H. A. (2024). Does globalization matter for environmental sustainability? New evidence from the QARDL approach. *Cogent Economics & Finance*, 12(1), 2306767. <https://doi.org/10.1080/23322039.2024.2306767>
- Çetin, M., Sarıgül, S. S., Topcu, B. A., Alvarado, R. & Karataser, B. (2023). Does globalization mitigate environmental degradation in selected emerging economies? Assessment of the role of financial development, economic growth, renewable energy consumption and urbanization. *Environmental Science and Pollution Research*, 30: 100340–100359.
- Dickey, D.A. and Fuller, W.A. (1981) Likelihood Ratio Statistics for Autoregressive Time Series with Unit Root. *Econometrica*, 49, 1057-1072. <http://dx.doi.org/10.2307/1912517>
- Dogan B, Deger O (2016) How globalization and economic growth affect energy consumption: panel data analysis in the sample of Brazil, Russia, India, China countries. *Int J Energy Econ Policy* 6(4):806–813
- Dreher, Axel (2006): Does Globalization Affect Growth? Evidence from a new Index of Globalization, *Applied Economics* 38, 10: 1091-1110.
- Ejovi, A., Sunday, E. & Akpokighe, O.R. (2014). Globalization and environmental degradation of the Niger Delta region of Nigeria. *Research on Humanities and Social Sciences*, 4(13), 142-152.
- Elliott, Graham, Rothenberg, Thomas J., and James H. Stock (1996). Efficient Tests for an Autoregressive Unit Root. *Econometrica*, 64(4), 813-836.
- Enyinna, U. K. , Emmanuel , O. & Ejike, D. E. (2020). Globalization and economic environment: Nigerian experience from 1990-2018. *Transatlantic Journal of Multidisciplinary Research*, 2(1&2)
- Grossman GM, Krueger AB (1991) Environmental impacts of a North American free trade agreement. In Papers (No. 158; Papers). Princeton, Woodrow Wilson School - Public and International Affairs. <https://ideas.repec.org/p/fth/priwpu/158.html>.
- Gygli, Savina, Florian Haelg, Niklas Potrafke and Jan-Egbert Sturm (2019): The KOF Globalisation Index – Revisited, *Review of International Organizations*, 14(3), 543-574. <https://doi.org/10.1007/s11558-019-09344-2>
- Islam, M. M., Khan, M. K., Tareque, M., Jehan, N. & Dagar, V. (2021). Impact of globalization, foreign direct investment and energy consumption on CO2 emission in Bangladesh: Does institutional quality matter? *Environmental Science and Pollution Research*, 28(35): 48851–48871
- Kwiatkowski, D.; Phillips, P. C. B.; Schmidt, P.; Shin, Y. (1992). "Testing the null hypothesis of stationarity against the alternative of a unit root". *Journal of Econometrics*. 54 (1–3): 159–178. Doi:10.1016/0304-4076(92)90104-Y
- Lee, K.H. & Min, B. (2014) Globalization and carbon constrained global economy: a fad or a trend? *J Asia Pac Bus* 15(2):105–121
- Panayotou T (1997) Demystifying the environmental Kuznets curve: turning a black box into a policy tool. *Environ Dev Econ* 2(4):465–484. <https://doi.org/10.1017/S1355770X97000259>
- Pesaran M.H., Shin Y, Smith R.J. (2001). Bounds testing approaches to the analysis of level relationships. *J Appl Econ* 16(3):289–326 <https://doi.org/10.1002/jae.616>
- Pesaran M.H., Shin, Y. (1999). An autoregressive distributed lag approach to Cointegration analysis. In: Strom S (ed) *Econometrics and Economic Theory in the Twentieth Century*. Cambridge University Press, Cambridge
- Samour, A., Tawfik, O.I., Radulescu, M. and Baldan, C.F. (2023). Do Oil Price, Renewable Energy, and Financial Development Matter for Environmental Quality in Oman? Novel Insights from Augmented ARDL Approach. *Energies*, 16, 4574. <https://doi.org/10.3390/en16124574>
- Shahbaz , M., Bhattacharya, M. & Ahmed, K. (2016). CO₂ emissions in Australia: economic and non-economic drivers in the long-run. *Appl Econ* 1–14
- Shahzadi, A., Yaseen, M. R., & Anwar, S. (2019). Relationship Between Globalization and Environmental Degradation in Low Income Countries: An Application of Kuznet Curve. *Indian Journal of Science and Technology*, 12(19): 1-13.
- Wang, L, Vo X. V., Shahbaz, M & Ak, A. (2020) Globalization and carbon emissions: Is there any role of agriculture value-added, financial development, and natural resource rent in the aftermath of COP21? *Journal of Environmental Management*, 268:110712
- Wen, J., Mughal, N., Zhao, J., Shabbir , M. S., Niedbała, G., Jain, V. & Anwar , A. (2021). Does globalization matter for environmental degradation? Nexus among energy consumption, economic growth, and carbon dioxide emission. *Energy Policy*, 153, 112230
- Yameogo, C. E. W. Omojolaibi, J. A. Dauda, R. O. S. (2021). Economic globalisation, institutions and environmental quality in Sub-Saharan Africa, *Research in Globalization* 3, 100035

Appendix I

Components of KOF Index of Globalization

A	Data on Economic Integration	[36%]
i	Actual Flows	(50%)
	Trade (in percent of GDP)	(23%)
	Foreign Direct Investment (in percent of GDP)	(29%)
	Portfolio Investment (in percent of GDP)	(27%)
	Income payments to foreign nationals (in percent of GDP)	(22%)
ii	Restrictions	(50%)

		Hidden Import Barriers	(20%)
		Mean Tariff Rate	(30%)
		Taxes on International Trade (in percent of current revenue)	(24%)
		Capital Account Restrictions	(26%)
B		Data on Political Engagement	[27%]
		Embassies in Country	(34%)
		Membership in International Organizations	(34%)
		Participation in UN Security Council Missions	(32%)
C		Data on Social Globalization	[37%]
	i	Data on Personal Contact	(24%)
		Outgoing telephone traffic	(31%)
		Transfers (in percent of GDP)	(9%)
		International Tourism	(1%)
		Telephone Average Costs of Call to USA	(33%)
		Foreign Population (in percent of total population)	(26%)
	ii	Data on Information Flows	(39%)
		Telephone Mainlines (per 1000 people)	(18%)
		Internet Hosts (per capita)	(15%)
		Internet Users (as a share of population)	(18%)
		Cable Television (per 1000 people)	(16%)
		Daily Newspapers (per 1000 people)	(16%)
		Radios (per 1000 people)	(17%)
	iii	Data on Cultural Proximity	(37%)
		Number of McDonald's Restaurants (per capita)	(100%)

Sources: Dreher (2006) and Gygli, Haelg, Potrafke, Sturm (2019).

Notes: The number in parenthesis indicates the weight used to derive the indexes. Weights may not sum to 100 because of rounding errors. All indexes range between 0 (not globalized) and 10 (globalized).