Contemporary Issues in Social Sciences and Management Practices (CISSMP)
ISSN: 2959-1023
Volume 4, Issue 4, December 2025, Pages 57-77
Journal DOI: 10.61503
Journal Homepage: https://www.cissmp.com

Globalization and Environmental Quality in Emerging Economies: A Panel Quantile Approach across ASEAN, BRICS, and Next-11

[1]Sidra Liaqat, [2]A. R Chaudhary & [3]Nawaz Ahmad
[1]Ph.D Scholar, Department of Economics, NCBA& E, Pakistan
[2]Professor, Department of Economics, NCBA& E, Pakistan
[3]Professor Department of Economics, University of Lahore, Pakistan

ABSTRACT

Article History:
Received: Sep 11, 2025
Revised: Sep 22, 2025
Accepted: Oct 29, 2025
Available Online: Dec 30, 2025

Keywords:
Globalization,
Environmental Quality,
Renewable Energy,
Emerging Economies

Funding:
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

This study investigates the link between globalization and environmental quality in emerging economies, using panel data from 2011 to 2024. Theoretically, globalization can shape environmental outcomes through multiple channels. On one hand, increased trade, technology transfer, and cross-border cooperation can promote cleaner production and environmental standards. On the other hand, economic expansion and industrial integration may heighten environmental pressure through resource depletion and emissions. To explore these dynamics, the study employs Panel Quantile Regression (PQR) under a fixed effects framework for three groups of emerging economies: ASEAN, BRICS, and Next-11. Environmental quality, measured by indicators such as lead exposure, outdoor air pollution, particulate matter, and waste recovery, is regressed on overall globalization, as captured by the KOF index. The results reveal a U-shaped relationship across all groups, suggesting that globalization initially improves environmental quality but later deteriorates it after reaching a certain level. However, when interacting globalization with renewable energy consumption, the moderating effect differs across groups. Institutions and technological innovations are included as control variables to account for governance and innovation dynamics. These findings highlight that the environmental outcomes of globalization depend on the stage of integration and the capacity to manage energy transitions effectively.

Corresponding Author's Email: sidraliaqatali1122@gmail.com
DOI: https://doi.org/10.61503/cissmp.v4i4.360
Citation: Liaqat, S., Chaudhary, A. R., & Ahmad, N. (2025). Globalization and Environmental Quality in Emerging Economies: A Panel Quantile Approach across ASEAN, BRICS, and Next-11. *Contemporary Issues in Social Sciences and Management Practices*, 4(4), 57-77.

1.0 Introduction

Globalization has come out as a central element that is connecting economies, businesses, and societies across the world in terms of trade, investment and cultural exchange. It supports economic growth through expansion of market penetration, improvement of production and spreading innovation. Globalization offers opportunities to many developing economies in order to curb poverty and unemployment. However, it, at the same time, poses serious environmental issues. Many countries are seeking the path of industrialization and urbanization towards attaining sustainable growth and thus there has been increased energy consumption, which is often reliant on fossil fuels. This increased energy consumption leads to greater amounts of CO 2, poor environmental quality, and climate change, which endangers the stability of the society and economy and places it as a challenge that necessitates policies that make globalization sustainable (Shahbaz, Mallick, Mahalik, and Loganathan, 2015).

According to Panayotou (1997), globalization has increased the level of environmental pollution in the newly industrialized and developing countries compared to other decades. Although globalization has led to increased production and exports, which have favored economic development, it has also caused the concentration of industries that have a high fuel consumption in a jurisdiction that has reduced environmental policies. This has enabled the developed countries to outsource the dirty industries to the developing countries, thus minimizing the pollution levels in their own countries at the expense of their economies moving towards environmental degradation. The theoretical nexus between globalization and environmental quality is thus ambiguous wherein globalization might bring growth and destruction of the ecosystem simultaneously due to industrial development and resource misuse. The same is further shown by the evidence provided by the World Resources Institute in its Climate Data Explorer which shows that emerging economies are recording high emissions based on open market policies and high rates of industrialization. The same results were also stated by Baek, Cho and Koo (2009) who noted that export-led growth in the open economies often reduces the level of environmental quality. All in all, even though globalization has the chances of economic growth, it also has environmental issues that have a disproportionate impact on the developing countries with only a limited ability to control pollution and develop sustainable management.

It is critical to analyze the relationship between globalization and CO 2 emissions since the information will provide policy makers with the knowledge of the impact of global integration on environmental quality. Since sustainable development is one of the policy goals, the insights of globalization on the environment provide useful information on how to reconcile the growth and sustainability. The literature currently available shows that there are two research strands that are dominant in this relationship. The former uses time-series analysis of individual countries (Baek et al., 2009; Dean, 2002; Shahbaz et al., 2015, 2016, 2017) and the latter the cross-sectional and panel data to evaluate the impact of globalization on the emissions of various economies (Leamer, 1988; Lucas, Wheeler, and Hettige, 1992; Copeland and Taylor, 1994, 2004; Copeland, 2 Most of such studies examine nonlinear links between globalization and emissions, and frequently they model these nonlinear links as U-shaped or inverted-U shaped curves. The so called Environmental

Kuznets Curve (EKC) is an inverted-U shaped pattern according to which the CO 2 emissions will rise at the beginning of the process of globalization and then the quality of the environment will increase once the economies will become more mature and use the cleaner technologies. The U-shaped pattern, on the other hand, indicates that globalization could initially improve the environmental quality but eventually produce an ultimate outcome of degrading the environment beyond some point of integration.

The reason to choose the Next-11 (N-11) countries is in their huge potential to contribute to the global economy, energy consumption, and CO 2 emission. These are the economies of Turkey, Mexico, Nigeria, Pakistan, etc that are becoming powerful players in the direction of global growth and sustainability. The increased participation in trade, production and investment shows that they have a significant say in global environmental policies and decisions that are related to climate. Here, the N-11 bears lots of attributes of the BRIC countries (Brazil, Russia, India and China) which have also portrayed strong economic performance, financial openness, and the growing shares in world trade. Although there are many developmental and institutional challenges facing the N-11 countries, they continue to engage in broad economic reforms that would see them grow sustainably in the long run. As an illustration Nigeria has strengthened anti-corruption efforts; Turkey has been trying to be more integrated into the European Union and Pakistan has been undertaking corporate, taxation, and financial reforms to strengthen their economic foundation. These reformist efforts emphasize the objectives of the N-11 to realize both inclusive and sustainable growth, which makes them very relevant to the study to the complex environment-related globalization, energy consumption, and climate.

The high rate of economic growth in the emerging economies in the last three decades has seen the rate of carbon emission in Asia increase sharply. It has been empirically shown that economic growth has compromised the sustainability of the environment in the BRICS countries (Brazil, Russia, India, China, and South Africa). The rapid growth of emissions that has been witnessed in China, South Asia, and other emerging economies has been synonymous with increasing energy consumption as indicated by Adebayo et al. Besides economic growth, there are other issues like population pressure, fast industrialization and poor governance systems, which also lead to increased environmental degradation. Although recent debate in Asian economies is given more attention to the use of renewable energy, technological innovation, and good governance, the interrelation of their effects concerning the environmental sustainability has not been properly explored. The dynamics are of particular concern to fast developing countries like China, South Korea, India, Pakistan, Indonesia, Malaysia and Thailand that can influence the sustainable development trend of the region significantly. These nations are endowed with a lot of natural resources and as reported by Danish et al. [13], the resources would be exploited without proper management of these resources, thus increasing the ecological problems in future.

The aim of the proposed research is to examine the quadric influence that general globalization has on the quality of the environment. It also looks at how the renewable energy is a direct cause of the level of environmental quality and how it acts as a moderating factor to determine a relationship between globalization and environmental outcomes. The analysis also

includes technological innovation and institutional quality as some of the control variables to attract environmental performance. Lastly, the research aims at making evidence-based policy suggestions on the basis of research findings in order to help nations to balance globalization, renewable energy, and environmental sustainability. The paper will be divided into five major sections: the first will introduce the background of the research, motivation, and objectives; the second one will offer the review of existing literature, analysis of previous results, and the identification of the research gap which will be addressed in the given paper; the third section will describe the methodological framework, in particular, data collection, theoretical modelling, and the estimation strategy; the fourth part will present the empirical results and its interpretation and discussion; and the final part will conclude the study and provide the policy recommendations based on the key findings.

2.0 Literature Review

The last several decades have seen globalization become one of the characteristic aspects of the modern world economy that has significantly transformed the interaction of governments, production processes, and developmental patterns. Its impact is not restricted to the field of trade and finance, as it has penetrated into technological innovation, social exchange and environmental outcomes. In case of emerging economies, globalization has triggered economic growth, inflow of foreign investment and increased industrialization. Nonetheless, such increases have often been achieved at the expense of environmental sustainability because, due to the accelerated industrialization, urbanization, and overreliance on fossil energy, carbon emissions have increased and endangered the ecological balance. Therefore, the intersection between globalization and environmental quality has acquired preeminence in the contemporary sphere of economic studies. There is controversy among scholars on the role of globalization in causing environmental degradation in terms of increased production and energy use, or in the globalization acting as a channel to cleaner technologies and sustainable development through knowledge transfer and international collaboration. The debate forms the basis of exploring the effects of globalization on environmental performance in the emerging economies such as those found in ASEAN, BRICS, and the Next-11 regions, which are currently central in altering the global economy.

In a study, Karaduman (2022) estimated 11 countries that had become newly industrialised between 1975 and 2017 with the Augmented Mean Group (AMG) estimator and bootstrap causality tests to study the effect of globalization, human capital, and productivity on ecological footprints. The research established that globalization and human capital reduce environmental pressure, as compared to GDP per capita and total factor productivity, which enhance them. These findings support the pollution halo hypothesis and indicate the need to have stronger regulation systems and sustainable integration policies to reconcile growth with environmental conservation.

Shahbaz et al. (2018) examined 25 developed economies in the 1970-2014 period in Asia, the North America, Western Europe, and Oceania using advanced panel methods, such as CIPS unit root tests, Westerlund cointegration, CCEMG, and AMG estimators. Their analysis demonstrates a long-run correlation where globalization has a great effect on CO 2 emission, thus validates the hypothesis on globalization origin of emission. The paper highlights that

globalization may accelerate the degradation of the environment unless proper control mechanisms are in place, and policymakers are strongly encouraged to incorporate the environmental protection mechanisms into the global economic policies.

Tahir et al. (2021) studied South Asian economies between 1990 and 2014 to determine the impact of financial development, globalization, and energy utilization on the environmental quality. With the help of extensive panel methods, such as cross-sectional dependence tests, Westerlund cointegration, FMOLS, DOLS, and PMG estimators, the authors have found out that financial development increases CO 2 emissions, but globalization decreases the emissions. One-way directional causality tests show that there are causal relationships between growth, globalization, and finance and emissions. The paper supports the idea of green financing and technology-led globalization in the promotion of sustainable development.

Islam et al. (2021) examined the Bangladesh environmental dynamic between the period of 1972 and 2016 by applying the dynamic ARDL simulations model developed by Jordan and Philips (2018). Through their analysis, they have shown that the three factors that decrease CO 2 emissions, which are globalization, foreign direct investment and innovation increase the quality of the environment and the factors that increase it include economic growth, trade, the consumption of energy and urbanisation. The political terror scale as an indicator of institutional quality also positively correlates with emissions. The results suggest the encouragement of innovative ideas and sustainable globalization and responsible energy and urban policies to ensure the preservation of the environment in Bangladesh.

Sabir and Gorus (2019) discussed the South Asian region between 1975 and 2017, using Westerlund cointegration test, a panel ARDL specification, to determine the impacts of globalization and technological change on environmental degradation. Findings are in line with the Environmental Kuznets Curve (EKC) hypothesis, whereby globalization (through FDI, openness to trade, and the KOF index) amplifies ecological footprints, and technological change does not have significant effects. The research recommends the need to implement renewable energy to achieve sustainable development.

Baloch et al. (2021) examined the relationships between financial development, economic growth, energy innovation, and environmental pollution by means of the Pooled Mean Group (PMG) ARDL estimator that was applied to OECD countries between 1990 and 2017. Their results show that financial development as well as globalization promote the innovation in energy, hence minimizing the emission of gases that cause global warming. The findings also support the Environmental Kuznets Curve, where finance and innovation play a significant role in improving the quality of the environment. The review of the literature of the previous decade by Zhang et al. (2022) aimed to find out the connection between globalization, the green economy, and climate issues. Their research reveals that, developing a green economy not only contributes to efficiency in production and creation of sustainable infrastructure but also helps to reduce poverty, promote human security and equitable access to environmental resources.

The gap in the literature is evident after a thorough examination of the literature. In the first place, the paper is aimed at exploring emerging economies, which makes them particularly

important in the context of environmental sustainability as they are more exposed to globalization. In addition, this study breaks down the concept of globalization to undertake a deep examination of its impact on the environmental sustainability. Even though much literature has been written on renewable energy and environmental sustainability, the present study is the only one that places it as a factor of environmental quality and moderator of globalization. Unlike the use of the traditional environmental proxies, which include CO 2 emissions, greenhouse gas emissions and ecological footprints, the study uses the Social Progress Index, which is a socially oriented sustainability indicator, which encompasses lead exposure, outdoor air pollution, particulate matter pollution, and waste recovery. The reasons are that these aspects make the work new compared to the existing research.

3.0 Methodology

As shown in table 1, we have listed a full list of the variables that we are using in this study, and all the variables are carefully chosen in order to capture the complex interrelationships between renewable energy, globalization, and environmental quality in the developing economies. The database used to support the current research is entirely based on secondary sources, namely legitimate international databases and therefore, the reliability and comparability are ensured to the sampled states. The empirical analysis is for the time range of 2011-2024, and this range was selected mainly due to the accessibility and the uniformity of the data to all the variables taken into consideration.

Environmental Quality (ENQ) is a dependent construct that measures the ability of a country to reduce pollution and control waste in an economical way, thus, being an aggregate measure of a country environmental performance. This indicator is derived out of Social Progress Index (SPI) which provides a solid measure of social and environmental performance. Overall Globalization (GLO) is the main explanatory measure that represents the extent to which a given country is represented in the global economic, social, and political environment; it is based on the KOF Globalization Index.

4.0 Findings and Results

To empirically test the theoretical relationships, the following functional form is developed:

$$ENQ_{it}=f(GLO_{it},REN_{it},TEC_{it},INS_{it},\epsilon_{it})$$

ENQ it represents the environmental quality of country i at time t. The covariates include globalization, renewable energy consumption, technological innovation, and institutional quality, which are defined as, globalization, (GLO)it), renewable energy consumption, (REN)it), technological innovation, (TEC)it) and institutional quality, (INS)it). It uses a system of panel quantile regression to explore the relation among variables in a different manner in different quantiles of the distribution. In contrast to standard regression methods, which only focus on the average effects, quantile regression breaks the effects of the explanatory variables, on several points (e.g., median, upper or lower tails) of the distribution of the dependent variable. This approach to methodology is especially beneficial when the data are not in the same form or the amount of change across countries and across time is extensively diverse and variable. To expand

on the work of Koenker and Bassett, the methodology calculates conditional features of distribution, thus producing a more detailed understanding of how globalization, renewable energy use, and institutional quality interact to determine the environment in emerging economies. The quantile regression model may be specified as a canonical manner as below: $yi=x'\beta q+ei$,

In the quantile regression model, β_represents the vector of parameters estimated for the specific percentile (quantile) q^th Dash et al., (2022) Unlike the conventional Ordinary Least Squares (OLS) method, which estimates the conditional mean of the dependent variable by minimizing the sum of squared residuals (∑e_i^2), quantile regression focuses on estimating the conditional median or other quantiles of the response variable. It achieves this by minimizing an asymmetric loss function, allowing the model to capture variations across the entire distribution of the data rather than just the average trend.

Table 1 - Description of the variables

Variable (symbol)	Short definition	Source
Environmental Quality (ENQ)	Country's ability to minimize pollution and manage waste for healthier living conditions.	SPI
Overall Globalization (GLO)	Reflects a country's combined integration into global economic, social, and political networks and activities.	KOF
Technological Innovations (TEC)	Country's capacity to create and apply new knowledge, measured through total patent applications.	WDI
Institutional Quality (INS)	Represent the quality of governance and public service delivery, captured through the government effectiveness indicator.	WDI
Renewable Energy (REN)	Share of clean energy sources in total energy consumption, indicating sustainable energy use.	WDI

Table 2-4 give the descriptive statistics of the main variables, environmental quality (ENQ), globalization (GLO), technological innovation (TEC), institutional quality (INS), and renewable energy consumption (REN) of the Next-11 economies, BRICS and ASEAN economies. As shown in Table 2, the Next-11 economies have a mean environmental quality index (ENQ) of 48.49 with a very high standard deviation of 13.29 thus representing a high level of variability in environmental performance across the member states. Its globalization index having a mean of 60.78 shows a moderate level of integration into the global markets; the range of 48.9 to 79 takes care of the variability in openness. The technological innovation indicator (mean 24591) has a remarkably high dispersion (SD=59907) indicating that in terms of technological advancement N-11 countries are vastly different with some being highly invested in technological advancement whilst the rest lag behind. The mean value reported in institutional quality is negative and stands at -0.202, indicating the issue of governance in a number of member nations. Lastly, consumption

of renewable energy (mean=24.65) shows a high degree of scattering with some economies highly dependent on non-renewable ones.

Table 2 – Descriptive statistics for Next-11 Economies

Variables	Obs	Mean	Std. dev.	Min	Max
ENQ	154	48.489	13.295	17.36	72.33
GLO	154	60.777	9.036	48.947	79
TEC	154	24591.01	59907.32	235	237998
INS	154	-0.202	0.615	-1.213	1.404
REN	154	24.646	22.473	0.900	84.1

Table 3 of the BRICS economies implies that the average environmental quality (ENQ 57.57) is better than the N-11, which implies relatively better environmental management yet with a significant amount of heterogeneity (standard deviation 15.83). The average stage of globalization (67.59) also exceeds the N-11, which is a more profound integration in trade and finance. Mean technological innovation (25,172) is widely variable, which is also in line with the varying levels of development among members of BRICs. With the average of 0.076, institutional quality suggests rather more desirable governance circumstances as compared to the N-11, but the average of renewable-energy consumption is 23.60, which demonstrates a middle-grade accomplishment of cleaner energy sources.

Table 3 – Descriptive statistics for BRICS Economies

Variables	Obs	Mean	Std. dev.	Min	Max
ENQ	70	57.572	15.833	26.87	70.89
GLO	70	67.593	5.227	59	76
TEC	70	25172.02	18273.92	2792	61573
INS	70	0.076	0.483	-.712	1.178
REN	70	23.601	15.970	3.2	50

According to Table 4, the ASEAN economies report the highest mean of the environmental

quality (61.00) compared with the other two groups, but the standard deviation is relatively low (=6.88), which implies that environmental performance of ASEAN economies is somehow stable. Globalization index (mean= 62.09) shows moderate global involvement though some significant disparities are observed among member states. The technological innovation (mean=4549) is significantly less than the BRICS and N-11 levels, and it shows the differences in technological potentials and level of investment. The level of institutional quality (mean = 0.212) is more stable and stronger in ASEAN countries, but the level of renewable energy consumption (mean = 28.80) is significantly higher, which would mean a more successful transition to clean energy.

Table 4 – Descriptive statistics for ASEAN Economies

Variables	Obs	Mean	Std. dev.	Min	Max
ENQ	140	61.001	6.875	46.74	72.99
GLO	140	62.085	11.600	32	82
TEC	140	4549.042	4246.323	0	14590
INS	140	.212	0.990	-1.752	2.317
REN	140	28.799	23.073	0	83.8

Table 5, Table 6 and Table 7 are the correlation matrices of the Next -11, BRICS and ASEAN economies that reveal the strength and direction of the relationship between globalization (GLO), technological innovation (TEC), institutional quality (INS) and renewable energy consumption (REN). In the Next-11 economies, the positive relationship between globalization and technological innovation (r=0.608) and institutional quality (r=0.707) is strong, which means that the higher the globalization the higher the technological innovation and institutional quality. Moreover, the fact that the correlation between technological innovation and quality of the institution is highly significant (r = 0.740) shows that the technological development is strictly connected with the effectiveness of the institution. Conversely, the use of renewable energy is positively related to globalization (r -0.548), technology (r -0.352), and institutions (r -0.535), which implies that as these economies continue to pursue higher globalization and industrialization, the use of renewable energy could lag behind because people continue to depend on traditional sources of power.

Table 5 – Correlation coefficient for Next-11 Economies

	GLO	TEC	INS	REN
GLO	1.000			
TEC	0.608	1.000		
INS	0.707	0.740	1.000	
REN	-0.548	-0.352	-0.535	1.000

Table 6 presents globalization having a negative correlation with technological innovation

(r -0.699) and a positive correlation with institutional quality (r 0.520) in the BRICS economies. These results suggest that in as much as globalization can lead to the increased governance and institutional cooperation, it can also be associated with lower technological development in some of the member states, which can be explained by the structural dependency on traditional industries. The use of renewable energy has a moderate negative relationship with globalization ($r = -0.522$), indicating that the further integration into the global markets can still be associated with carbon-intensive production.

Table 6 – Correlation coefficient for BRICS Economies

	GLO	TEC	INS	REN
GLO	1.000			
TEC	-0.699	1.000		
INS	0.520	-0.483	1.000	
REN	-0.522	0.160	0.056	1.000

Table 7 shows that the structure of correlation between the ASEAN economies is not similar to other parts in any way. Globalization is also positively correlated with technological innovation (r=0.720) and institutional quality (r=0.742) as well, which means that greater openness will enable technology to be transferred and institutions to evolve. On the other hand, the consumption of renewable energy has a negative correlation with globalization (r= -0.821), technology (r= -0.620) and institutional quality (r= -0.917); the reverse trend can be discussed as the continuation of dependence on fossil fuels inhibits the transition to renewable energy sources.

Table 7 – Correlation coefficient for ASEAN Economies

	GLO	**TEC**	**INS**	**REN**
GLO	1.000			
TEC	0.720	1.000		
INS	0.742	0.641	1.000	
REN	-0.821	-0.620	-0.917	1.000

The panel quantile regression estimates of the N-11 economies exploring the effect of globalization and the variables on the environmental quality (ENQ) in terms of 25 th, 50 th, and 75 th quantile are reported in Table 8. The quantile system of analysis allows investigating the way these relationships differ among countries with diverse rates of environmental performance as low emitting countries to high ones.

The globalization coefficient (GLO) value is negative and statistically significant at all levels of quantiles (-14.540, -13.193, and -9.179, p-value less than 0.01). This conclusion means that, firstly, globalization weakens the quality of the environment by increasing carbon emissions

and consumption of resources especially in the economies that are located in the lower quantiles (poor environmental performance). However, the value of such effect diminishes with increasing quantile meaning that the negative effects of globalization are diminishing as the environmental performance increases. These are observations that are in line with the scale effect as described by Copeland and Taylor (2004) and Shahbaz et al. (2015) whereby expansion of trade and industrial growth increases the level of emissions during the early stages of globalization.

These statistically significant positive coefficients of the squared globalization term (GLO 2) in all quantiles (0.112, 0.096, and 0.062; $p<0.01$) support the fact that there is an inverted-U shaped Environmental Kuznets Curve (EKC) pattern. It means that although globalization does worsen the quality of the environment, this process in the end leads to environmental improvement as soon as some level of integration is reached. These findings are consistent with the theoretical framework, offered by Grossman and Krueger (1995), and empirical data cited by Suki et al. (2020) and Pata and Yilanci (2020) who found that the process of globalization could be used to promote sustainability by using cleaner technologies and by applying more stringent environmental norms in developed phases.

The technological innovation (TEC) coefficient has a mixed trend. This is statistically insignificant at the 25th quantile; however, it is positive and extremely significant at the 50th and 75th quantiles. This trend indicates that technology can play a significant role in improving the quality of the environment of nations having moderate to high environmental performance. The influence of technology in the lower quantiles (at the initial stages) is less, which may be explained by the underdeveloped systems of innovation or low absorptive capacity. These results confirm the findings of Zaidi et al. (2019) and Destek (2019) that assert that the positive environmental impact of technology is being enhanced when strong institutional structures and sufficient research and development investments are established.

The quality of the institution (INS) exerts a great and significant impact on all quantiles (17.965, 14.989, and 16.041; $p < 0.01$). This implies that governance, political stability, and regulatory efficiency will improve consistently better the quality of the environment in the distribution. The uniform influence of institutions is a testament to the fact that good governance reduces corruption, and better environmental law enforcement and the sustainable delivery of policies (Farooq et al., 2022). Strong institutions are especially important to the emerging economies where the environment frequently suffers due to loose regulatory controls.

The coefficient of the use of renewable energy (REN) is negative and significant at all quantiles (-3.792, -4.798, and -4.634; $p<0.01$) proving that the higher the use of renewable energy, the less the emissions and the better the environment. The discovery adds weight to the critical importance of clean energy transitions in the sustainable development and supports the results by Apergis and Payne (2015) and Khan et al. (2020) (who concluded that adopting renewable energy sources leads to significant CO 2 emissions in developing and emerging economies).

Lastly, the GLO x REN interaction is significant and has a positive value in all quantiles (0.073, 0.091 and 0.089; $p < 0.01$) indicating that globalization benefits are enhanced on the positive effects of renewable energy adoption at higher levels of openness. That is, through

countries adopting renewable energy policies coupled with globalization policies, negative effects of globalization are reduced, and it becomes a means of improving the environment. This synergistic influence supports the points of view of Shahbaz et al. (2018) and Suki et al. (2020), who state that globalization with a coherent approach toward sustainable energy systems can hasten the process of changing it into a low-carbon economy.

Table 8 – Overall Globalization Results for Next-11 Economies

	25th Quantile		50th Quantile		75th Quantile	
Variables	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
GLO	- 14.5	0.000	-13.193	0.000	-9.179	0.000
GLO^2	0.112	0.000	0.096	0.000	0.062	0.000
TEC	-6.60e	0.827	0.000077	0.000	0.000098	0.000
INS	17.965	0.000	14.989	0.000	16.041	0.000
REN	-3.792	0.000	-4.798	0.000	-4.634	0.000
GLO*REN	0.073	0.000	0.091	0.000	0.089	0.000

Table 9 shows the quantile regression estimates of the BRICS economies (Brazil, Russia, India, China and South Africa) in terms of how globalization and the associated variables affect the environmental quality on the 25th, 50th, and the 75th quantile. The findings are extremely heterogeneous, thus, pointing to the variety of economic and environmental settings present in these emerging powers.

The coefficient of globalization (GLO) is significantly different in its quantile values (positive at the 25th and 75th quantile with negative value at the median). This is a non-linear trend indicating that globalization has both positive and negative impacts depending on the level of environmental development of a country. In particular, the positive coefficients at the left (56.79, $p = 0.007$) and right (39.95, $p < 0.01$) quantiles suggest that globalization can raise the level of environmental quality in the least developed and most eco-advanced members of the BRICS, which may be the result of the access to cleaner technologies, the spillovers of innovations, and the global collaboration (Grossman and Krueger, 1995; Zaidi et al., 2019). On the other hand, the negative value of the coefficient at the median quantile (= -19.46, p=0.049) suggests that in intermediate emitters, globalization can move to encourage industrial activity and emissions, as it is reflected by the scale effect of Shahbaz et al. (2015).

The squared term of globalization (GLO 2) also testifies to a non-linear type of EKC relationship assuming negative and positive alternating signs by the quantile. The mixed sign

pattern indicates the change of the influence of globalization on the environmental state at the various stages of its development, thus corroborating the conclusions by Pata and Yilanci (2020) and Suki et al. (2020) who found out that globalization first makes the environmental state worse and then makes it better.

The impact of technological innovation (TEC) is weak and sporadic. Only at the median quantile, it turns negative and statistically significant, which means that the technology helps reduce emissions in the case of the mid-level BRICS economies with equal capacities in innovation and industrial maturity (Zaidi et al., 2019). Conversely, its influences are statistically non-significant in the lower and upper quantiles implying low or imbalanced technology spread within the bloc.

The same can be said of institutional quality (INS): non-significant at the first quantile, but negative and significant at the median (-18.25, $p < 0.01$) and last (-8.98, $p < 0.05$) quantiles. This trend shows that the better the governance and regulatory mechanisms the lower are the emissions especially of the more developed members of the BRICS. This is in line with Farooq et al. (2022), who emphasized that institutional effectiveness improves environmental sustainability by improving its enforcement and decreasing corruption.

The coefficient of renewable energy consumption (REN) changes drastically to a negligible fact at the 25th quantile to a positive and significant value at the 50th (10.60, $p < 0.01$) and 75th (8.48, $p < 0.05$) quantiles. It demonstrates that with the rise in the consumption of renewable energy, the environmental quality increases, and in higher quantiles, where renewable infrastructure and policies are more developed, it is higher (Apergis and Payne, 2015; Khan and Ullah, 2020).

Table 9 – Overall Globalization Results for BRICS Economies

	25th Quantile		**50th Quantile**		**75th Quantile**	
Variables	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
GLO	56.790	0.007	-19.463	0.049	39.954	0.000
GLO^2	-0.404	0.019	0.203	0.005	-0.241	0.000
TEC	0.00044	0.227	-0.00026	0.000	7.15e-06	0.877
INS	16.034	0.424	-18.247	0.000	-8.982	0.010
REN	-1.010	0.902	10.601	0.000	8.481	0.030
GLO*REN	0.024	0.843	-0.150	0.000	-0.116	0.044

Table 10 – Overall Globalization Results for ASEAN Economies

	25th Quantile		50th Quantile		75th Quantile	
Variables	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
GLO	-2.218	0.012	-1.094	0.000	-0.247	0.001
GLO^2	0.014	0.013	0.0075	0.000	0.0017	0.001
TEC	-0.00089	0.000	-0.00077	0.000	-0.00077	0.000
INS	7.789	0.000	6.474	0.000	8.505	0.000
REN	-0.890	0.001	-0.519	0.000	-0.203	0.000
GLO*REN	0.016	0.000	0.0090	0.000	0.0050	0.000

The results of the quantile regression of the ASEAN economies are shown in Table 10 which seems to show a more stable trend as compared to the BRICS economies. The coefficient of globalization (GLO) is negative and significant in all quantiles ([-]2.218, [-]1.094, [-]0.247; 0.05>p), which implies that globalization is more prone to lower the environmental quality with the smallest quantiles because industrialization and reliance on fossil fuels are more combative. This decreasing trend of this coefficient at lower and higher quantiles indicates the watering down of the negative effect of globalization at the onset of improvement of environmental performance, a pattern that is consistent with the Environmental Kuznets Curve (EKC) hypothesis, which argues that globalization increases pollution in the initial stages but eventually leads to sustainability by transferring technology and strengthening institutions (Copeland and Taylor, 2004; Shahbaz et al., 2016).

The squared value of globalization (GLO 2) acquires a positive value, which is noteworthy within all quantiles, and this supports the inverted-U shaped EKC pattern. The implication of this observation is that there will be a point of such a high level of globalization integration that additional interaction will positively impact the quality of the environment by increasing efficiency, facilitating cleaner processes, and environmental awareness, as Pata and Yilanci (2020) and Suki et al. (2020) have suggested.

The correlation between technological innovation (TEC) and all quantiles is constantly negative and statistically significant; it shows that technological improvement is an essential factor in the reduction of emissions and enhancement of the environmental situation in ASEAN countries. This tendency indicates the success of the regional policy that contributes to digital transformation and green technologies use, which is stressed in the works of Destek (2019) and Zaidi et al. (2019).

This means that strong governance mechanisms have the potential to enhance environmental outcomes as the positive effect of institutional quality (INS) is meaningful

throughout the quantiles. The coefficients (7.789, 6.474, 8.505; p(s) =-0.01) indicate the stabilizing effect of institutions in enforcing environmental policies and creating sustainable investment (Farooq et al., 2022). The fact that these coefficients are similar in all of the quantiles suggests that the influence of governance in ASEAN is more homogenous than in BRICS, which might be explained by more effective regional cooperation frameworks, including the ASEAN Sustainable Development Agenda.

The coefficient of renewable energy use (REN) is negative and significant at the statistical level in all quantiles and proves that the higher the renewable energy usage, the less the emissions are. The coefficients decrease continuously between -0.890 and -0.203 which means that the role of renewable energy in improving the environment increases as the nations reach higher levels of environmental standards (Apergis and Payne, 2015; Kahn and Ullah, 2020). GLO and REN interaction are positive and significant at all quantiles, which means that the use of renewable energy can enhance the positive influence of the globalization process on the environmental quality. Such an outcome highlights how globalization and renewable energy in ASEAN countries have a positive association, which promotes green trade and sustainable innovations (Suki et al., 2020; Shahbaz et al., 2018).

Figure 1 represents the moderating role played by renewable energy use on the association amid globalization and environmental quality in the Next-11 economies. The downward trend of the globalization curve of the world shows that the global environmental degradation is increased with low levels of renewable energy adoption with the growth of industries and dependence on fossil fuels. The slope becomes flatter as the consumption of renewable energy goes up, and then it becomes upward, which shows that the negative effects of globalization are countered with the use of renewable energy. These dynamics confirm that in case global economic integration is coupled with renewable energy policies, the end-result will not be worse but instead, it will be improved. The figure is a model of a conditional EKC, where the negative scale impacts of globalization are counterbalanced by the positive technique impacts of globalization based on cleaner energy and transfer of technology. The trend is consistent with the empirical evidence of Shahbaz et al. (2018) and Pata and Yilanci (2020) who found that in the emergent markets renewable energy positively influences the environmental value of globalization, especially after the development of the institutions and energy reforms.

Figure 1 – Overall Globalization Model Moderation for Next-11 Economies

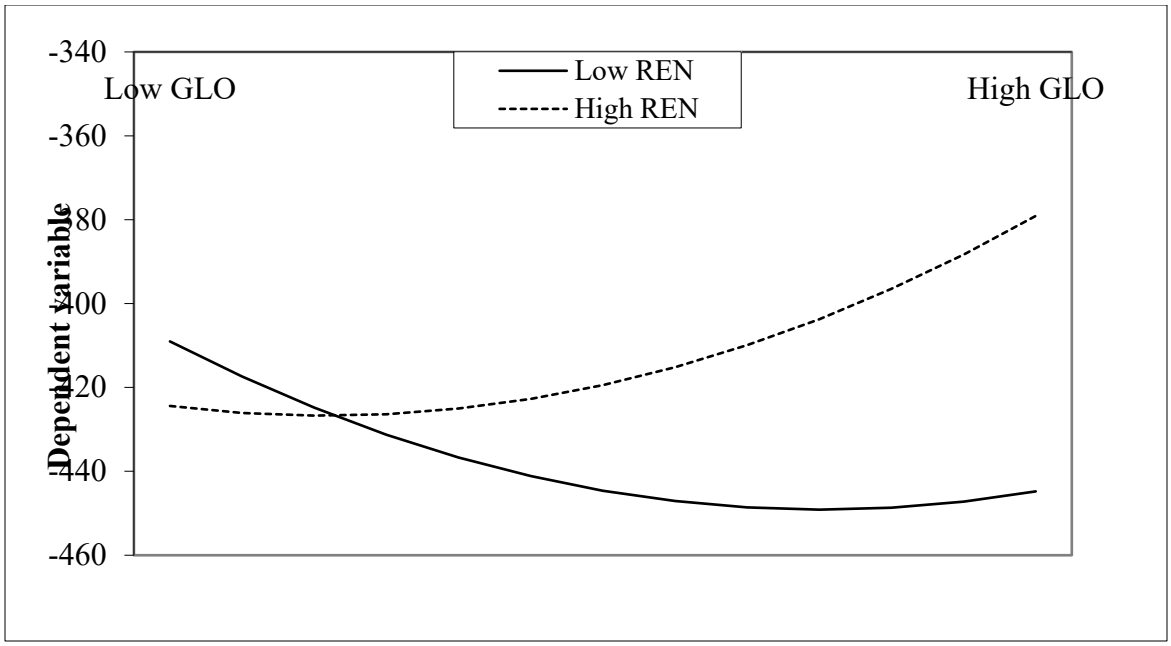
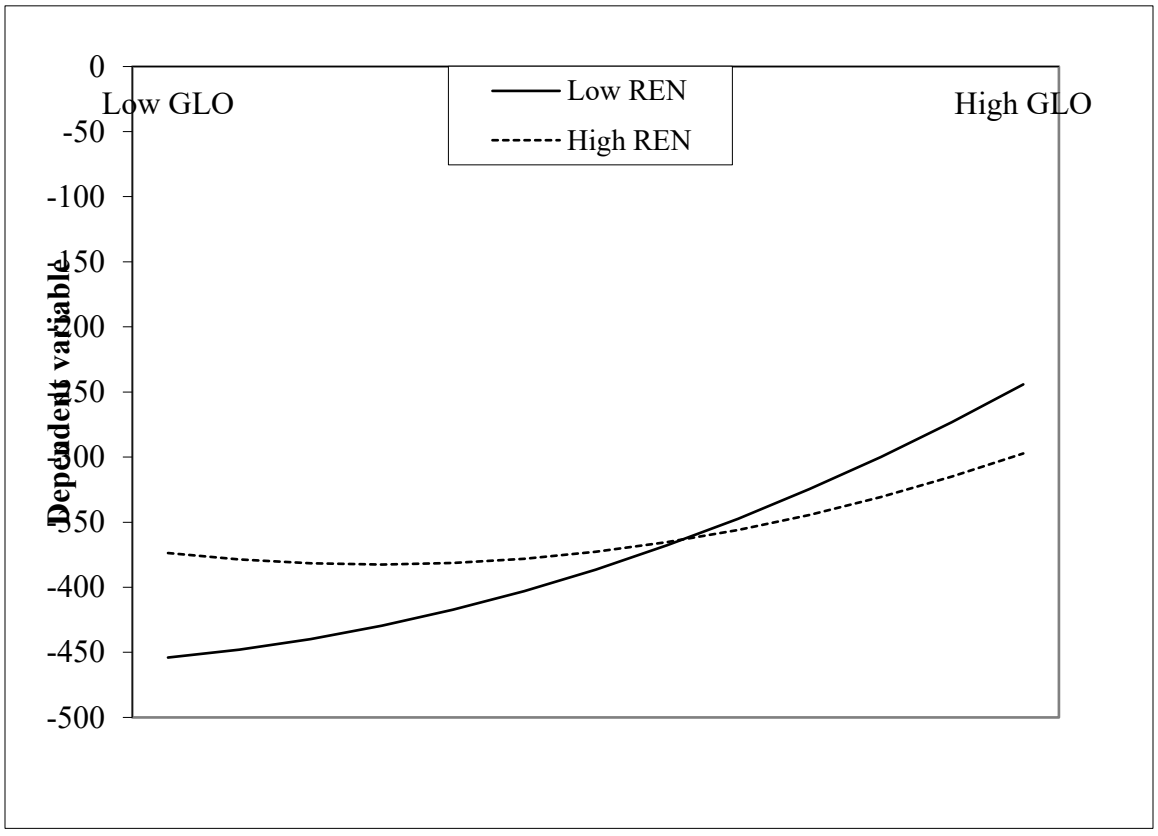


Figure 2 – Overall Globalization Model Moderation for BRICS Economies



The figure 2 shows the moderating role of the renewable energy on the nexus between globalization and the quality of the environment in the BRICS countries. The curve suggests a less stable relation as compared to Next-11 cohort, which is a characteristic of structural heterogeneity of BRICS members. During the early years of the globalization process, the quality of the

environment improves negatively due to the rapid rates of industrialization and excessive use of fossil fuels, especially in China and India. But with the increased adoption of renewable energy, the curve will shift upwards which means that renewable energy acts as a stabilizing element that will reduce the environmental damages caused by globalization. The fact that BRICS economies are transitioning slower would indicate that they are still in the phase of transition of the Environmental Kuznets Curve (EKC) where benefits of globalization are offset by ongoing reliance on energy-intensive sectors. This explanation can be compared to the conclusions by Zaidi et al. (2019) and Farooq et al. (2022) that recognize that, despite the potential to contribute to the cleaner growth, the positive aspects of globalization concerning the environment related to BRICS is strongly dependent on the institutional capacity and polymerization of the policies aimed at promoting renewable energy development.

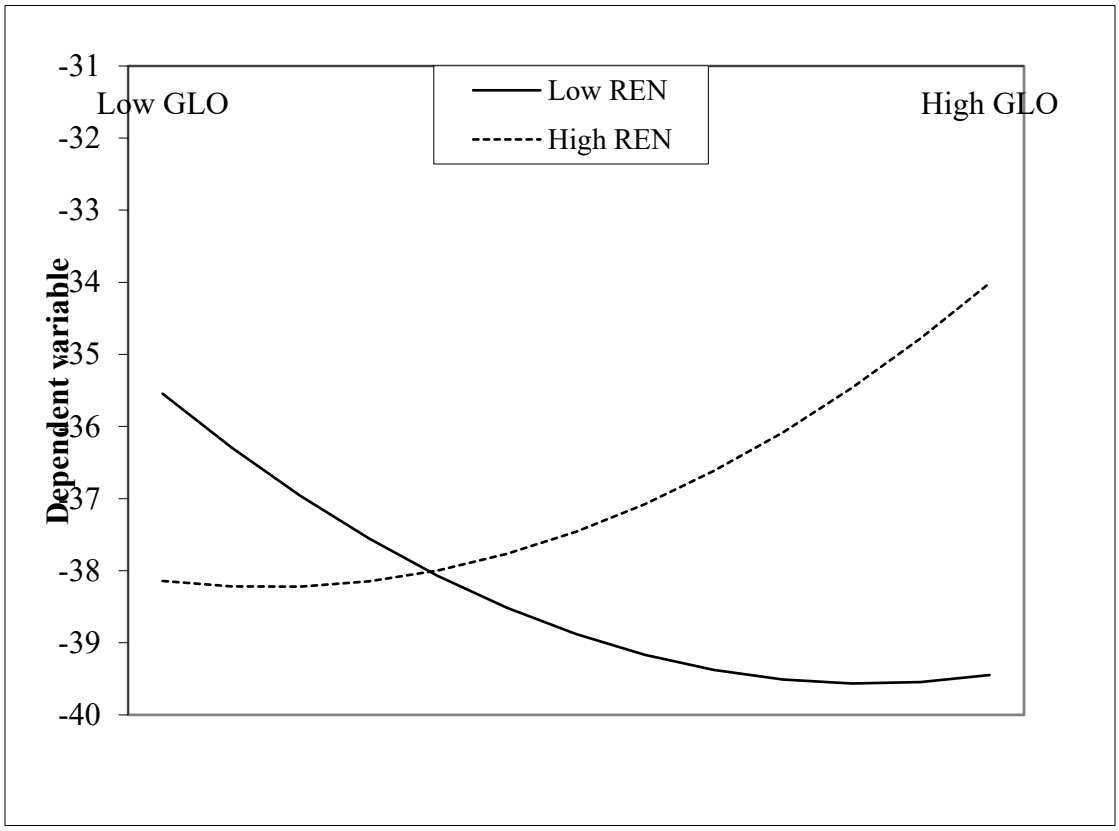


Figure 3 – Overall Globalization Model Moderation for ASEAN Economies

The moderating role of renewable energy in the globalization-environmental quality model, which is applied to the ASEAN economies, is shown in Figure 3. Unlike BRICS and Next-11, the ASEAN trend shows more gradual and steady shift between environmental degradation to better, which suggests a stronger synergy between globalization and renewable energy. Globalization at lower penetration rates of renewable energy is linked with the degradation of the environment hence replicating the early industrialization stage that is characteristic of the developing economies. With the increased use of renewable energy, the trend is on the rise meaning that globalization will be turned into a sustainability driver due to the integration of cleaner energy sources. This trend indicates that ASEAN economies have successfully been able

to utilize the benefits of globalization to access green technologies, international environmental standards and cleaner streams of investments. The results are per the discussions of Suki et al. (2020) and Destek (2019), who emphasized that in countries with stronger governance and energy transformations, globalization complements with renewable energy to improve the environmental performance and sustainable development. Comprehensively, the figure supports the relatively high level of harmonization of the goals of both globalization and sustainability in the context of other emerging regions of which ASEAN belongs.

5.0 Discussion and Conclusion

This paper examined the dynamic nexus between globalization and environmental quality of three key sets of developing economies of ASEAN, BRICS, and Next-11, using panel quantile regression (PQR) methodology. Analysis was created in a way that would reflect the heterogeneity of effects at varying levels of quantiles and groupings of economies. Empirical evidence indicates that the effect of globalization on the environmental quality is heterogeneous and nonlinear and differs among quantiles and economic cohorts. In the case of the Next-11 economies, globalization in the early part of its development worsens the quality of environmental conditions because of the development of industries and the production of energy-consuming development. These negative consequences of globalization decrease as these economies become more mature which confirms the hypothesis of the Environmental Kuznets Curve (EKC). The aspects of technological innovation and institutional quality prove to be of great importance and can turn globalization into an environmentally positive factor.

In the BRICS nations, globalization and its effects on the environment are not as stable as the relationship. Globalization is a positive factor in environmental performance in countries that have strong institutional structures and substantial investment in renewable energy sources, but it increases pollution in the economies that majorly depend on fossil energy sources and have low environmental regulations. This imbalance is indicative of the different economic bases of the members of BRICS and highlights the transitional character of the sustainability paths. Conversely, the ASEAN economies have a more homogenous and healthier trend. When strengthened with the use of renewable energy and proper institutions, globalization has a significant positive impact on the quality of the environment. This implies that regional integration processes, strict environmental standards and focus on green development has made ASEAN regional processes to be more sustainable as compared to other up and coming blocs.

The aggregate of the study establishes the fact that the environmental implications of the globalization process is conditional upon the supportive domestic conditions - the energy structure, the quality of the institutional infrastructure and the technological capacity. The findings emphasize that globalization is not necessarily bad, and the environmental consequences of globalization are predetermined by the ways in which the countries coordinate the policy of openness, trade, and innovation along with the policy of using sustainable sources of energy. The emerging economies are supposed to match their trade and investment policies with renewable energy promotion. They can promote the use of green trade agreements, renewable energy subsidies, technology-sharing alliances, and make sure that globalization contributes to sustainable energy changes instead of contributing to the perpetuation of dependence on carbon.

The institutional quality of the positive impact on the entire range of quantiles supports the assumption that the good governance is a precondition of environmental sustainability. The governments should implement environmental policies, minimize corruption and increase transparency in the industrial licensing and energy investment. The strategy of focusing on investing in environmental technology and innovation systems will give an optimum of the positive globalization technique effect. The innovation centres and regional partnerships between the government and businesses can accelerate the uptake of cleaner production technologies and energy efficient infrastructure.

Sidra Liaqat: Problem Identification and Theoretical Framework
Nawaz Ahmad: Data Analysis, Supervision and Drafting
A. R Chaudhary: Methodology and Revision

Conflict of Interests/Disclosures

The authors declared no potential conflicts of interest in this article's research, authorship,and publication.

References

Adebayo, T. S., Adedoyin, F. F., & Kirikkaleli, D. (2021). Toward a sustainable environment: Nexus between consumption-based carbon emissions, economic growth, renewable energy and technological innovation in Brazil. *Environmental Science and Pollution Research, 28*, 52272–52282.

Baek, J., Cho, Y., & Koo, W. W. (2009). The environmental consequences of globalization: A country-specific time-series analysis. *Ecological Economics, 68*(8), 2255–2264.

Baloch, M. A., Ozturk, I., Bekun, F. V., & Khan, D. (2021). Modeling the dynamic linkage between financial development, energy innovation, and environmental quality: Does globalization matter? *Business Strategy and the Environment, 30*(1), 176–184.

Chintrakarn, P., & Millimet, D. (2006). The environmental consequences of trade: Evidence from sub-national trade flows. *Journal of Environmental Economics and Management, 52*(1), 430–453.

Copeland, B. R., & Taylor, M. S. (1994). North–South trade and the environment. *Quarterly Journal of Economics, 109*(3), 755–787.

Copeland, B. R., & Taylor, M. S. (2004). Trade, growth, and the environment. *Journal of Economic Literature, 42*(1), 7–71.

Copeland, B. R., & Taylor, M. S. (2005). Free trade and global warming: A trade theory view of the Kyoto Protocol. *Journal of Environmental Economics and Management, 49*(2), 205–234.

Danish, Baloch, M. A., & Wang, B. (2019). Analyzing the role of governance in CO_2 emissions mitigation: The BRICS experience. *Structural Change and Economic Dynamics, 51*, 119–125.

Dean, J. (2002). Does trade liberalization harm the environment? A new test. *Canadian Journal of Economics, 35*(4), 819–842.

Destek, M. A. (2019). Investigation on the role of globalization on the environment: Evidence from CEECs. *Environmental Science and Pollution Research, 26*, 1–11.

Farooq, A., Shahzad, U., Sarwar, S., & Zai, S. A. Y. (2022). Globalization and environmental degradation in Asian economies: The role of institutional quality. *Environmental Science and Pollution Research, 29*(2), 2300–2314.

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *Quarterly Journal of Economics, 110*(2), 353–377.

Islam, M. M., Khan, M. K., Tareque, M., Jehan, N., & Dagar, V. (2021). Impact of globalization, foreign direct investment, and energy consumption on CO_2 emissions in Bangladesh: Does institutional quality matter? *Environmental Science and Pollution Research, 28*(35), 48851–48871.

Karaduman, C. (2022). The effects of economic globalization and productivity on environmental quality: Evidence from newly industrialized countries. *Environmental Science and Pollution Research, 29*(1), 639–652.

Khan, D., & Ullah, A. (2020). Testing the relationship between globalization and carbon emissions in Pakistan: Does the Environmental Kuznets Curve exist? *Environmental Science and Pollution Research, 27*(8), 15194–15208.

Leamer, E. (1988). Measures of openness. In *Trade Policy Issues and Empirical Analysis* (pp. 145–204). National Bureau of Economic Research.

Löschel, A., Rexhäuser, S., & Schymura, M. (2013). Trade and the environment: An application of the WIOD database. *Chinese Journal of Population Resources and Environment, 11*(1), 51–61.

Lucas, R. E. B., Wheeler, D., & Hettige, H. (1992). *Economic development, environmental regulation, and the international migration of toxic industrial pollution: 1960–88*. World Bank Working Paper WPS 1062.

Managi, S., Hibiki, A., & Tetsuya, T. (2008). Does trade liberalization reduce pollution emissions? *RIETI Discussion Paper No. 08013*.

Naughton, B. (2014). China's economy: Complacency, crisis & the challenge of reform. *Daedalus, 143*(2), 14–25.

Panayotou, T. (1997). Demystifying the environmental Kuznets curve: Turning a black box into a policy tool. *Environment and Development Economics, 2*, 383–399.

Paramati, S. R., Apergis, N., & Ummalla, M. (2017). Financing clean energy projects through domestic and foreign capital: The role of political cooperation among the EU, the G20 and OECD countries. *Energy Economics, 61*, 62–71.

Pata, U. K., & Yilanci, V. (2020). Investigating the EKC hypothesis for China: The role of renewable energy consumption and globalization. *Energy & Environment, 31*(5), 807–821.

Pergis, N., & Payne, J. E. (2015). Renewable energy, output, CO_2 emissions, and fossil fuel prices in Central America. *Energy Economics, 49*, 227–236.

Sabir, S., & Gorus, M. S. (2019). The impact of globalization on ecological footprint: Empirical evidence from South Asian countries. *Environmental Science and Pollution Research, 26*(32), 33387–33398.

Shahbaz, M., Khan, S., & Tahir, M. I. (2018). The dynamic links between energy consumption, economic growth, and globalization: Evidence from developing countries. *Energy Economics, 68*, 26–37.

Shahbaz, M., Mallick, H., Mahalik, M. K., & Loganathan, N. (2015). Does globalization impede environmental quality in India? *Ecological Indicators, 52*, 379–393.

Shahbaz, M., Mallick, H., Mahalik, M. K., & Loganathan, N. (2015). Does globalization impede environmental quality in India? *Economic Modelling, 33*, 563–575.

Shahbaz, M., Mallick, H., Mahalik, M. K., & Sadorsky, P. (2016). The role of globalization on the recent evolution of energy demand in India: Implications for sustainable development. *Energy Economics, 55*, 52–68.

Shahbaz, M., Nasreen, N., Ahmed, K., & Hammoudeh, S. (2017). Trade openness–carbon emissions nexus: The importance of turning points of trade openness for country panels. *Energy Economics, 61*, 221–232.

Shahbaz, M., Shahzad, S. J. H., Mahalik, M. K., & Hammoudeh, S. (2018). Does globalisation worsen environmental quality in developed economies? *Environmental Modeling & Assessment, 23*(2), 141–156.

Suki, N. M., Sharif, A., Afshan, S., & Suki, N. M. (2020). Revisiting the Environmental Kuznets Curve hypothesis in the context of globalization: The role of ecological footprint. *Environmental Science and Pollution Research, 27*, 1–14.

Tahir, T., Luni, T., Majeed, M. T., & Zafar, A. (2021). The impact of financial development and globalization on environmental quality: Evidence from South Asian economies. *Environmental Science and Pollution Research, 28*(7), 8088–8101.

Zaidi, S. A. H., Zafar, M. W., Shahbaz, M., & Hou, F. (2019). Dynamic linkages between globalization, financial development, and carbon emissions: Evidence from APEC countries. *Journal of Cleaner Production, 228*, 533–543.