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Logistics performance and environmental sustainability: Do green innovation, renewable energy, and economic globalization matter?

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The logistics sector plays an imperative role in the economic development of a country. However, it can also affect environmental quality as it the viewed as a major energy-consuming sector. The current literature on the relationship between logistics performance and environmental quality is scant and most studies neglect its environmental impact in the context of emerging countries. In this context, this study investigates the impact of logistics performance index (LPI), green innovation, renewable energy, and economic globalization on the environmental quality in the 22 emerging countries. Using the panel data from 2007 to 2018, we employed the Method of Moments Quantile Regression (MM-QR) for empirical analysis. The empirical results show that LPI deteriorates the environmental quality by increasing CO_2 emissions across all quantiles (10th–90th). Moreover, green innovation is significantly and negatively related to CO_2 emission in all the quantiles except at the 10th quantiles, while renewable energy use significantly improves the environmental quality across all quantiles (10th–90th). Economic globalization shows a significant and negative impact on CO_2 emission across quantiles (10th–90th) in emerging countries. Based on these findings, this study proposes that emerging countries need to align their logistics sector policies with sustainable development goals. At the same time, more resources should be allocated for green innovation and the renewable energy sector and promote economic globalization to foster sustainable development.

KEYWORDS

logistics performance, green innovation, renewable energy, economic globalization, environmental sustainability

Introduction

The seventeen sustainable development goals (SDGs) and their objectives offer a coherent and fresh perspective on contemporary issues of the world, such as hunger, gender inequality, and climate change. These goals are believed to be indivisible, integrated, and designed to counterbalance the three factors of sustainable development., i.e., “social, economic, and ecological” (UN, 2015). SDGs were created to spur action over the subsequent 15 years in areas that are extremely important for humankind and the environment (UN, 2015). Development toward SDGs relies on governments and a wide range of bodies consisting of public society organizations, private sector organizations, and millions of people (Scharlemann et al., 2020). Contrarily, the environmental sciences have recorded significant and serious changes in earth systems, including changes in the nutrient cycles, biodiversity loss, diminution of natural resources, and climate variation (Vitousek et al., 1997). A significant cause of global warming is greenhouse gas emissions (Ahmed et al., 2021d). Over the years, CO_2 emissions have received a lot of attention in the literature as a measure of pollution (Zhang et al., 2021). The focus of the international society is now on the pursuit of green development (He et al., 2017). According to World Bank statistics, the concentration of CO_2 emissions has been rapidly increasing, for instance, CO_2 emissions rose by an average of 2.08 percent per year between 1970 and 2013, reaching 35.84 billion tonnes in 2013, or 2.42 times more than in 1970 (WDI, 2016). The International Energy Agency recognized greenhouse gases as the primary contributor to CO_2 emissions, which have been the primary factor in determining the health of the world’s socioeconomic sustainable system and ecosystem (IEA, 2012). The year 2021 observed a turning point regarding climate change that provoked concerns for future sustainability. In the year 2021, confronted with intensifying influence of severe flooding, heat, drought, forest fires, and storms during the pandemic (WDI, 2021). More resilience is needed to reduce CO_2 emissions which is impossible without major social, technological, and economic changes.

The environmental impact largely arises from the production and logistics activities (Khan and Qianli, 2017; Ahmed et al., 2020). Logistics can be defined as managing an organization’s inventory, transportation of goods, procurement, and information flow through its marketing channels for increasing revenues (Christopher, 2016). Logistics has grown to be the backbone and resilience of the global economy, propelled by consumption and production. Logistics takes a substantial position in a nation’s economic growth and development and raises air pollution, including greenhouse gases like CO_2 emissions (Wang et al., 2022). Transportation, one of the most well-recognized and highly regarded logistical systems and operations, accounts for 23% of global CO_2 emissions in 2018 (Solaymani, 2019). Moreover, CO_2 emissions from transportation pursuits are expected to substantially increase (almost 60 percent) by 2050, and the majority of these emissions will generate from freight in case no further environmental safety measures are carried out (OECD, 2017).

At present, emerging countries’ logistics industry undergoes the serious problem of low efficacy in the form of large differences (Tan et al., 2019). Moreover, given the growing push for sustainable development, the logistics sector’s high levels of energy consumption and carbon emissions do not support the sustainable progress of logistics (Giannetti et al., 2020). In both emerging and developed economies, firms are driven to enlarge their productivity while employing efficient and sustainable resources to eradicate environmental destruction, which is close to green innovation, supply chain loop, economic globalization, and use of renewable energy (Simão et al., 2016; Geng et al., 2017; Ahmed et al., 2022). Therefore, in a situation where emerging countries are surfacing a shortfall in the efficiency of logistics, can focus on other factors to counterbalance the impact of such a factor through cultivating and converging the use of green innovation, economic globalization, and renewable energy to attain the objectives of sustainable development.

The literature has demonstrated that renewable energy can aid in restoring energy security and focus on climate change challenges (Xue et al., 2022). Using and supporting renewable energy sources can help reduce pollution and minimize reliance on fossil fuels (Ahmad et al., 2021a). Experts on climate change believe that renewable energy sources have long been known for their ability to reduce CO_2 emissions and foster a more environmentally friendly environment. For instance, Pata and Caglar (2021) argued that renewable energy shows an important role in combating CO_2 emissions. There is a harmony that energy-consumption approaches should be revised to increase the percentage of renewable energy resources and supplies to minimize pollution (Hongqiao et al., 2022; Peng et al., 2022).

The green innovation that engenders green technology could lower CO_2 discharges by cutting the consumption of fossil fuels would be the best option to attain a clean environment free of CO_2 emissions, which would ultimately result in a reduction in the social cost of pollution. Green innovation (also known as “environment-related innovation, ecological innovation, and eco-innovation”) indicates several types of innovation pursuits that lead to or aim to enhance environmental safety and protection significantly (Ahmad et al., 2021b; Yang et al., 2022). It includes new production techniques, business practices, and products and services. Given that it is acknowledged as a key factor in the global reduction of CO_2 emissions, green innovation has been added as a new determinant to the growing ecosystem framework. Therefore, conducting research and development in green technologies is expedient for better ecological sustainability and economic growth (Shao et al., 2021; Zhang et al., 2022).

To create the ideal atmosphere for effectively transmitting global environmental standards and norms, local governments are given the opportunity and pressure to improve environmental institutions by using economic openness and globalization (Kulin and Sevä, 2019). Economic openness and globalization offer local governments favorable conditions for well-informed awareness of global ecological guidelines and norms, consequently offering them pressures and opportunities to reinforce the environmental institutions (Jahanger et al., 2022). Economic globalization refers to the process by which production and markets in various nations become more interconnected as a result of dynamics in international trade in services and goods as well as flows of capital and technology (Gygli et al., 2019). From an optimistic standpoint, it is argued that any type of global economic integration, including increased export levels, will result in a relative decrease in environmental destruction by improving asset utilization efficiency in exploitative and productive processes (Cole, 2006). These improved efficiencies are partially fueled by economic growth brought on by trade and investment on a global scale, which encourages technological investments and related infrastructure to cut back on material inputs and waste outputs (Pirages, 2003). Globalization directs countries to adopt new technologies and methods in production procedures through stimulating knowledge transfer and capital spillovers, and also introduces better organizational structures and diverse management practices (Hansen and Rand, 2006).

Why emerging countries? This study focuses on these economies due to several reasons. Firstly, emerging economies significantly contribute to a staggering 40% of the world's GDP, make up 59% of the world's population, and consume 47.75% of world energy (Ahmad et al., 2020). Secondly, these economies are liable for deteriorating environmental quality, and their CO_2 emission increased from 649.62 to 849.57 (million tonnes of carbon dioxide) from 2007 to 2018. Thirdly, emerging countries are leading the logistics performance index with an average value of 3.267, which is higher than the world average of 2.87. Fourthly, how the logistics performance index impact environmental quality remains a literature gap.

Based on the arguments mentioned above, the authors contributed to the environmental literature in this study through the following perspectives. Firstly, this study empirically inspects the linkage between logistics performance and environmental quality. Although emerging economies are among the top logistics performance countries, previous literature does not present any study that examines the association between LPI and CO_2 emission in these countries. Secondly, we examined the influence of green innovation, economic globalization, and renewable energy on CO_2 emissions. Thirdly, unlike the previous studies, we employed the Method of Moments Quantile Regression (MM-QR) for empirical analysis, which provides robust measurements on various quantiles.

Literature review

Global logistics play a vital role in global supply chain management and contribute significantly toward economic development (Lean et al., 2014). Logistic activities can also impact environmental quality. Thus, logistics performance and environmental quality have been a subject of intense discussion in recent years. Liu et al. (2018) utilized the data from 42 Asian economies to gauge the linkage between LPI and carbon emissions from 2007 to 2016. The findings from the GMM regression model revealed that LPI and environmental quality are negatively related in the selected countries. Moreover, the logistics timeliness significantly exaggerates pollution in Asian countries. While the improvement in sub-categories of LPI such as the efficiency of customs, infrastructure quality, service quality, and competence, tracking and tracing curb the environmental pollution in Asia. Zaman and Shamsuddin (2017) utilized the data of 27 EU economies from 2007 to 2014 to analyze the impact of LPI on national-scale economic indicators (i.e., economic, energy, and environmental health). They disclosed that international shipments raise fossil fuel energy consumption in a region while the sub-categories of LPI have a varying impact on environmental quality.

Suki et al. (2021) studied the impact of LPI on economic growth and CO_2 emissions using the data of top Asian nations from 2010 to 2018. Their outcomes exposed that LPI significantly boosts economic growth and helps to curb pollution. Wang et al. (2022) explored the logistics efficiency of total factor carbon productivity from different scales and investment levels using the data of China from 2008 to 2017. Their empirical outcome depicts that logistics efficiency is beneficial for the total factor carbon productivity under the low carbon economy. Logistics efficiency can reduce carbon emissions and help countries achieve economic efficiency. Likewise, Magazzino et al. (2021) analyze the relationship between LPI and environmental quality in the context of 25 top logistics economies. They applied quantile regression methods and disclosed that logistics performance worsens the environmental quality. They suggested that further worldwide efforts must be pitched toward attaining sustainable logistics.

While the preceding studies demonstrate that green innovations play a substantial part in attaining ecological sustainability. Most of the prevailing literature focused on the environmental impact of overall technological innovation, while few studies are available that used patents in green innovations. For instance, Ding et al. (2021) used the data of G7 nations to study the impact of green innovation on consumption-based carbon emissions from 1990 to 2018. They concluded that innovation in environmental technologies significantly lessens environmental pollution in G7 economies. Similarly, Hashmi and Alam (2019) showed that green innovations could play a critical role in lowering pollution in OECD countries. Another study by Ahmad et al. (2021d) unveiled that green technologies are helpful in reducing the ecological footprint in G7 countries. On the contrary, Adebayo et al. (2021) findings evident that recent technologies stimulate environmental pollution in Chile. In the case of China, Guo et al. (2021) unveiled that innovation in technologies natively impacts environmental quality. While Chen and Lee (2020) claim that there is no global association between greenhouse gas emissions and technological innovation. However, Sinha et al. (2020) suggested that technological innovation can help countries to accomplish sustainable development goals (SDGs).

A strand of the literature discusses the empirical linkages among renewable energy (RE) consumption and degradation using the panel and time series data. For instance, Boluk and Mert (2015) showed that RE could curtail environmental degradation. Likewise, Bilgili et al. (2016) suggested that RE use can limit ecological degradation in OECD nations. Tiba and Omri (2017) unfolded that clean energy can play a central role in curbing ecological deterioration and achieving climate-related goals. Bekhet and Othman (2018) suggested that renewable energy and GDP decrease CO_2 in Malaysia. A study by Xue et al. (2021) exposed that RE is natively related to the ecological footprint in South Asia, while economic growth expands the footprints. The negative relationship between RE and environmental degradation was also reported by a number of studies, such as Ahmad et al. (2021a) for emerging countries, Destek and Aslan (2020) and Cai et al. (2018) in the G7 economies, and Dong et al. (2017) in BRICS. On the contrary, Pata and Caglar (2021) fail to find a significant association between RE and environmental degradation in China.

The studies on the relationship between economic globalization and environmental pollution are limited and show mixed empirical conclusions. For example, Lv and Xu (2018) used emerging countries' data to inspect the connection between economic globalization and environmental pollution from 1970 to 2012. Their results demonstrated that a 1% increase in economic globalization reduces CO_2 emissions by −0.11% in the long run. Likewise, Yang et al. (2021) analyzed the correlation between economic globalization and emission in the context of OECD countries. Using the FMOLS and AMG methods, they conclude that economic globalization improves ecological excellence. On the contrary, Ahmad et al. (2021c) advocated that economic globalization leads to environmental deterioration in emerging countries. A recent study by Ahmad and Wu (2022) also disclosed that economic globalization deteriorates environmental quality in OECD countries.

In summary, the literature review exposed that there are limited studies on the nexus between logistics performance index on CO_2 emissions with contradictory results. In addition, scholars have not gauged the impact of logistics performance on CO_2 emissions in the context of emerging countries. Thus, this study adds to the environmental economics literature and studies the impact of logistics performance, green energy, renewable energy, and economic globalization on CO_2 emissions in emerging countries.

Data and estimation methods

The current article used the yearly data, spanning the period of 2007–2018 for 22 emerging countries, including Brazil, Chile, China, Colombia, Czech Republic, Egypt, Greece, Hungary, India, Indonesia, South Korea, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Russian Federation, South Africa, Thailand, Turkey, United Arab Emirates. The environmental quality is the dependent variable measured using CO_2 emissions million tonnes of carbon dioxide, and the data is retrieved from BP (2021). The main explanatory variable is the logistics performance index based on logistics quality, timeline, ease of international shipments, tracing and tracking, infrastructure, and customs. The data on the logistics performance index is retried from the WDI (2021). The time duration mainly depends on this variable's data availability from 2007 to 2018. Moreover, green innovation (green patents as a % of overall technological innovation), renewable energy (per capita energy use from renewables), and economic globalization indices (trade and financial globalization) are utilized as independent variables to explain the CO_2 emissions. The data on GI is derived from the (OECD, 2022), while the data on RE is derived from the (OWD, 2021). The data on the economic globalization index is retrieved from Gygli et al. (2019). The variables utilized in the study are defined in Table 1.

To investigate the impact of logistics performance, green innovation, renewable energy consumption, and economic globalization, we constructed the model following the studies of Liu et al. (2018) and Magazzino et al. (2021), which is given as follows.

$$CO2_{i,t} = \alpha_0 + \beta_1 LPI_{i,t} + \beta_2 GI_{i,t} + \beta_3 RE_{i,t} + \beta_4 EG_{i,t} + \epsilon_{it} \quad (1)$$

In Eq. 1, CO_2 stands for environmental quality. LPI, GI, RE, and EG represent the logistics performance index, green innovation, renewable energy, and economic globalization. The symbol i and t represent the cross-sections (22 emerging countries) and time dimension (2007–2018). While $\beta_1, \beta_2, \beta_3$, β_4, denotes the coefficient of explanatory variables, while α_0 and ϵ_{it} represent the constant and error term.

In terms of empirical analysis, the study employed the Variance Inflation Factor (VIF) to detect multicollinearity in the model. In the next step, we diagnose the most common issue in the panel data (i.e., cross-sectional dependence and slope heterogeneity), which may affect the consistency of the estimator and leads to biased results. For this purpose, the study uses the second-generation estimation method of Pesaran (2004) for CD and Pesaran and Yamagata (2008) for slope heterogeneity analysis. The next specified method is to check the stationary characteristics of the variables. The CIPS test is used to pursue this objective, which is quite famous for handling the panel data problems such as CD

TABLE 1 Variables description.

Variable	Abbreviation	Measurement	Data source
Carbon dioxide emissions	CO_2	Million tonnes of carbon dioxide	BP (2021)
Logistics performance index	LPI	It is an index based on logistics quality, timeline, ease of international shipments, tracing and tracking, infrastructure, and customs	WDI (2021)
Green innovation	GI	Green patents as a % of overall technological innovation	OECD (2022)
Renewable energy	RE	Per capita energy use from renewables	OWD (2021)
Economic globalization	EG	Economic globalization index	Gygli et al. (2019)

TABLE 2 Descriptive statistics and correlation matrix.

	CO_2	LPI	GI	RE	EG
Descriptive statistics					
Mean	762.782	3.178	12.222	1.782	59.468
Median	252.493	3.175	11.770	1.005	57.046
Maximum	9507.110	3.942	34.000	7.046	86.609
Minimum	31.015	2.368	1.740	0.002	33.755
Std. Dev	1794.035	0.345	4.1458	1.791	13.699
Observations	264	264	264	264	264
Correlation matrix					
CO_2	1.000				
LPI	0.278	1.000			
GI	−0.219	−0.217	1.000		
RE	0.012	0.135	0.071	1.000	
EG	−0.309	0.035	0.027	0.022	1.000

TABLE 3 VIF test results.

Variable	VIF	1/VIF
LPI	1.13	0.886
GI	1.10	0.908
RE	1.05	0.956
EG	1.02	0.977
Mean VIF	1.07	—

(Pesaran, 2007). Since our dataset has large cross-sections and fewer periods (N > T). This study used the MM-QR method of Machado and Santos (2019), also known as fixed effect quantile regression. The method is famous for controlling the endogeneity and individual effects in the panel data analysis. In particular, MM-QR estimate quantiles from estimates of the conditional mean and the conditional scale function. Additionally, MM-QR is an appropriate econometric method to examine the effect of heterogeneity and different quantiles.

The following model is utilized under the quantile framework.

$$Q_Y(\tau/X_{it}) = (\gamma_i + \beta_i q(\tau)) + X_i^{'}\alpha + Z_i^{'}\delta_q(\tau) \tag{2}$$

In Eq. 2, the vector of explanatory variables is shown by X_{it} (i.e., logistics performance, green innovation, renewable energy and economic globalization). $Q_Y(\tau/X_{it})$ depicts the conditional quantile distribution of the dependent variable.

Afterward, this study employed Feasible Generalized Least Squares (FGLS), and Panel Corrected Standard Errors (PCSE) methods to check the reliability of MM-QR results.

Results and discussion

Table 2 represents the descriptive statistics and panel correlation matrix of selected emerging countries. The findings indicate that CO_2 emissions and economic globalization show more variation. On average, the CO_2 emission of million tonnes per capita increased from 649.49 in 2007 to 845.45 in 2018. While the LPI also depicts a little increasing trend from 3.045 to 3.266 during 2007–2008. The panel correlation matrix shows that LPI is positively correlated with CO_2 with a value of 0.278, while green innovation and economic globalization are negatively related to CO_2 with values of −0.219 and −0.319.

After the descriptive statistics and correlation matrix, we computed the variance inflation factor (VIF) to check the possible state of multicollinearity. The VIF test results are shown in Table 3, indicating that VIF values for all the explanatory variables are below 5. Thus, our model is free from the multicollinearity problem.

Table 4 depicts the Pesaran (2004) CD and Pesaran and Yamagata (2008) slope heterogeneity test results. The CD test is used to diagnose the dependency between the independent and explanatory variables across the panel of emerging countries. The results reject the null hypothesis of cross-sectional independence,

TABLE 4 CD and slope homogeneity test.

	Test stat.	Prob.	Abs (corr)
Pesaran (2004) CD test			
CO_2	5.602*	0.000	0.683
LPI	17.043*	0.000	0.483
GI	4.615*	0.000	0.261
RE	16.644*	0.000	0.544
EG	2.249**	0.025	0.517
Pesaran and Yamagata (2008) slope heterogeneity test			
$\tilde{\Delta}$	7.421*	0.000	
$\tilde{\Delta}_{adjusted}$	10.495*	0.000	

Note: *<1%, and **<5% significance.

which implies the presence of CD in panel countries. The results from the slope heterogeneity test reject the null hypothesis of slope homogeneity, which means that emerging countries have heterogeneity in their slope parameters.

Table 5 shows the unit root test results, which is a precautionary measure to analyze the stationarity properties of the study variables. This study used the CIPS unit root test, which indicates that the variables dependent variable (CO_2) is stationary at the level, while LPI and EG s rejected the unit root hypothesis at the first difference.

Table 6 demonstrates the findings of the MM-QR test. The outcome shows that the logistics performance index (LPI) positively and significantly impacts the CO_2 emissions in all the quantiles. However, the magnitude of this effect is greater in the lower quantiles. These findings imply that the logistics sector in emerging countries is not sustainable. The findings can be vindicated on the ground that the logistics sector increases transportation activities by consuming fossil fuel energy which ultimately increases CO_2 emissions. Another reason is that the logistics industry in emerging countries suffers from the severe problem of low efficiency. The logistic sector, with high energy use and higher pollution in logistics operations, is not environmentally friendly despite the increasing pressure for green development. Our findings are similar to Magazzino et al. (2021) for 25 top logistics countries and Liu et al. (2018) for Asian economies. While contrary to Liu et al. (2018) and Suki et al. (2021) who concluded that logistic performance is negatively related to environmental degradation.

Moreover, the outcome of green innovation (GI) is significantly and negatively related to CO_2 emission in all the quantiles except at $Q_{0.10}$. The magnitude of this effect is larger for higher quantities. These findings imply that emerging countries are on the right track to curb emissions through innovation in environmentally related technologies. The GI can also help to lower the damages caused by logistic activities and economic growth. These results are comparable with Ahmad et al. (2021b) and Ding et al. (2021) for G7 countries and Hongqiao et al. (2022) for the United States. However, contrary to the results of Adebayo et al. (2021) for Chile and Guo et al. (2021) for China, who disclosed that technological innovation negatively impacts environmental quality.

Furthermore, the favorable impact of renewable energy consumption (RE) on environmental quality is found in all the quantiles. However, the coefficient does not show the variations from 10th to 90th quantiles. These findings are similar to the theoretical expectations that renewable energy use improves environmental quality. This outcome can be justified on the ground that renewable energy is environmentally friendly and can be used as a crucial tool to alleviate CO_2 emissions. Thus, emerging countries should continue their investment in the renewable energy section until their infrastructure matures in the pursuit of a low-carbon economy. Our results are consistent with the studies of Bilgili et al. (2016) for OECD nations, Bekhet and Othman (2018) for Malaysia, and Xue et al. (2021) for South Asia. However, our results are inconsistent with Pata and Caglar (2021), who claimed that there is no significant relationship between renewable energy and environmental quality.

Empirical findings provide evidence that economic globalization (EG) contributes to the environmental quality in emerging countries in all the quantiles. However, the coefficient of GE shows an increasing trend from the 10th to 90th quartiles. As a result of economic globalization, the environmental quality improves in emerging countries. These results can be justified on

TABLE 5 CIPS unit root test results.

Variable	I (0)		I (1)	
	Level	Constant and trend	Constant	Constant and trend
CO_2	−2.910*	−3.949*	−2.917*	−3.451*
LPI	−1.223	−1.316	−3.090*	−3.119*
GI	−3.237*	−3.239*	−3.849*	−4.129*
RE	−2.267**	−2.723**	−3.441*	−3.622*
EG	−1.421	−2.352	−3.125*	−2.978*

Note: * < 1%, and ** < 5% significance.

TABLE 6 MM-QR regression results.

	Low			Medium			High		
	$Q_{0.10}$	$Q_{0.20}$	$Q_{0.30}$	$Q_{0.40}$	$Q_{0.50}$	$Q_{0.60}$	$Q_{0.70}$	$Q_{0.80}$	Q0.90
LPI	1.327* [0.323]	1.301* [0.272]	1.267* [0.219]	1.237* [0.195]	1.222* [0.193]	1.201* [0.205]	1.179* [0.231]	1.142* [0.296]	1.071** [0.454]
GI	−0.034 [0.023]	−0.044** [0.020]	−0.056* [0.016]	−0.067* [0.014]	−0.072* [0.014]	−0.079* [0.015]	−0.088* [0.017]	−0.101* [0.022]	−0.127* [0.033]
RE	−0.194* [0.069]	−0.194* [0.058]	−0.193* [0.046]	−0.192* [0.041]	−0.192* [0.041]	−0.192* [0.043]	−0.192* [0.048]	−0.191* [0.063]	−0.190** [0.096]
EG	−0.026* [0.007]	−0.030* [0.006]	−0.035* [0.005]	−0.039* [0.004]	−0.042* [0.004]	−0.045* [0.005]	−0.048* [0.005]	−0.053* [0.007]	−0.064* [0.010]

Note: * < 1%, ** < 5%, and [] contains the standard error.

the ground that economic globalization enables emerging countries to allocate more funds toward green projects. Emerging countries benefit from economic globalization through technological improvements and production and consumption efficiency. These results in consistent with Lv and Xu (2018) for emerging countries and Yang et al. (2021) for OECD countries. While the contrary to Ahmad and Wu (2022), who also disclosed that economic globalization deteriorates environmental quality in OECD countries. Figure 1 visually demonstrates the coefficient of explanatory variables across quantiles.

This study employed Feasible Generalized Least Squares (FGLS) and Panel Corrected Standard Errors (PCSE) methods for the robustness check. The results are shown in Table 7; the coefficient of the LGI has a positive and significant value, while GI, RE, and EG are found to have a negative impact on environmental quality. Thus, the results of FGLS and PCSE are strongly aligned with the MM-QR estimates.

Conclusion and policy implications

This article is devoted to examining the impact of logistics performance, green innovation, renewable energy, and economic globalization on environmental quality. We utilized the Method of Moments Quantile Regression (MM-QR) for empirical analysis using the data from 2007 to 2018 in the 22 emerging countries. The empirical outcome depicts that LPI degrades the environmental quality by escalating emissions across all quantiles (10th–90th) with a decreasing trend. Furthermore, the findings show that green innovation has an insignificant impact on the CO_2 in the 10th quantile; however, it significantly reduces CO_2 emissions across 20th to 90th quantiles. The results further revealed that renewable energy and economic globalization significantly and positively contribute to environmental quality across quantiles (10th–90th) in emerging countries.

Our study demonstrated the positive impacts of the logistics performance index on CO_2 emissions. Thus, governments and policymakers in emerging countries should align logistics policies with SDGs. In addition, better regulation for the logistics sector can also help to reduce the environmental pollution caused by logistics activities. The emerging countries should improve logistics service quality, such as using clean energy for transportation. These countries should develop logistics policies that discourage fossil fuel consumption, which helps reduce environmental degradation and achieve carbon neutrality targets. In this context, the focus should be on using more electric vehicles for reducing the consumption of oil. Using more efficient vehicles with hybrid engines can reduce the consumption of fossil energy sources. In addition, rail and bus-based transportation can be extended to different parts of countries because generally, such kinds of transportation pose less environmental threats compared to other forms of transportation. Green innovation

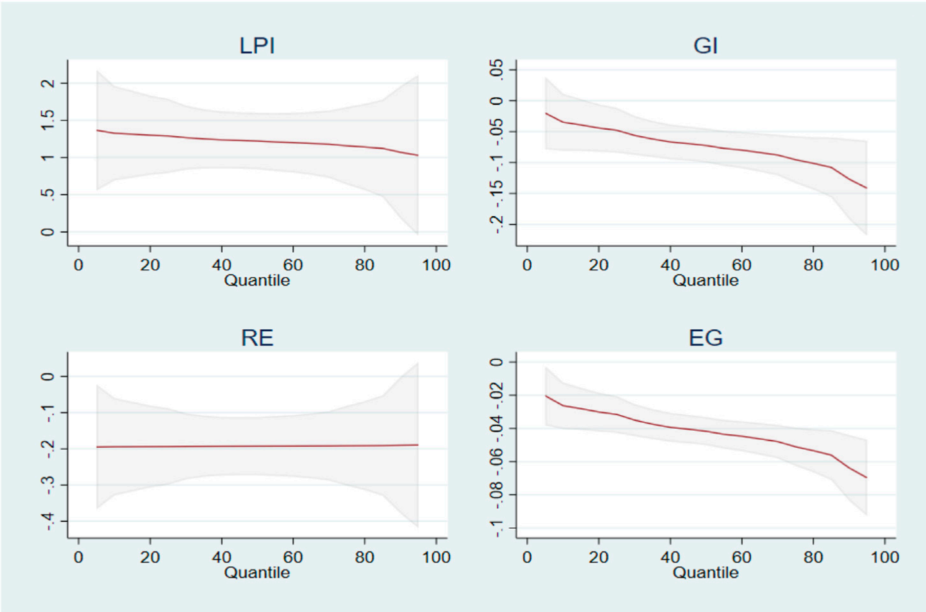

FIGURE 1
Quantile regression plot.

TABLE 7 Robustness test.

Variable	FGLS		PCSE	
	Coefficient	Std. Error	Coefficient	Std. Error
LPI	1.238*	0.181	1.014*	0.161
GI	−0.070*	0.015	−0.009***	0.005
RE	−0.193*	0.045	−0.143*	0.035
EG	−0.043*	0.004	−0.038*	0.005
Constant	5.049*	0.674	4.739*	0.518

Note: * < 1%, and ***10% significance.

mitigates environmental pollution; emerging countries should distribute more funds for the R&D of green technologies. Government should make policies that encourage green and low-carbon technological innovation. These countries should provide tax incentives and lower financial costs to promote the development of green innovation. Government should vigorously support the development of the renewable energy sector and boost economic globalization.

This study focuses only on the 22 emerging countries to explore the relationship between logistics performance and environmental quality. This study used a limited time dimension (2007–2008) for empirical analysis. Future research works can explore the impacts of logistics performance on environmental quality for different countries by expanding the time frame of the analysis. In addition, future studies can also check the moderating role of technological innovation and human capital in the relationship between logistics performance index and environmental quality.

Data availability statement

The raw data supporting the conclusions of this article available on the public sources mentioned in the Table 1.

Author contributions

BW: Conceptualization, methodology, data curation, formal analysis, writing original draft. WW: Conceptualization, formal analysis, writing original draft. NH: Writing original draft, writing review and editing. ZA: Supervision, writing—review, and editing. All authors read and approved the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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