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Original Research

Greening Global Competitiveness: Analyzing the Environmental Kuznets Curve in Developing Economies in the Light of Economic Fitness and Global Integration

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Abstract

Human life is greatly affected by increasing globalization, which has strong environmental implications in developing nations. Moreover, nations have experienced major transformations in their production structures to maintain their competitive positions in the global market. Therefore, this study aims to analyze the individual and synergistic impacts of globalization (GLOB) and economic fitness (ECF) on CO_2 emissions in light of the environmental Kuznets curve (EKC) hypothesis in developing nations. The panel corrected standard error and system generalized moments methods have provided robust evidence for the existence of the EKC hypothesis based on a panel of 79 developing nations from 1995 to 2019. Moreover, GLOB (=0.60, p<0.01) and ECF (= 0.003, p<0.01) had a significant and positive impact on CO_2 emissions. They concluded that diversified exports, trade openness, and economic expansion in developing nations cause high emissions. In contrast, the model revealed a significant and positive (= 0.082, p<0.01) impact of the interaction term (ECF*GLOB). It was observed that ECF moderates the impact of GLOB on CO_2 emissions, as high ECF in economies increases their GLOB by increasing production scale to enhance their trade, which leads to environmental degradation. However, the findings also show that developing nations have experienced earlier turning points as compared to the baseline model and their individual impact on ECK trajectories because ECF and GLOB simultaneously expand production scale and trade volume. Thus, developing nations must develop strong institutional frameworks with strict implementation and enforcement of environmental regulations, environmentally oriented trade policies, sustainable infrastructure, and environment-oriented international cooperation to obtain a favorable impact of ECF and GLOB on domestic environmental quality.

Keywords: diversified production, CO_2 emission, environmental degradation, EKC trajectories, developing economies

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Introduction

Without preserving the environment, achieving sustainable development seems very difficult because both are strongly interlinked. The major issue of the continuous rise in CO_2 emissions around the globe made the Paris Agreement on climate change harder to implement. For example, almost 30 gigatons of CO_2 are emitted around the globe in the atmosphere, which is the major cause of climate change [1]. Thus, climate change threatens the existence of humankind and sustainable development [2]. Where CO_2 emissions have been the major cause of climate change in the last decades, globalization (GLOB) has also increased through the political, social, and economic integration of economies and their international trade [3]. The economies are greatly integrated with each other than ever before, and in developing economies, GLOB has a more beneficial impact on their growth in terms of poverty reduction and income equality among nations, but GLOB's environmental implications are still debated [4].

Farooq et al. [5] highlight that closed economies have experienced lower development than open economies, and open economies are facing more environmental challenges. Additionally, human life is greatly affected by GLOB on a global scale through the political, social, and economic integration of economies. Therefore, GLOB is increasing continuously, and developing economies may be negatively influenced by GLOB because of their unbalanced and poor environmental regulations. This may lead to pollution-intensive industries in developing economies [6]. For example, industries demand high energy, which causes high CO_2 emissions as a byproduct of GLOB, thereby leading to global warming and air pollution [7].

There are two opinions regarding the impact of GLOB and CO_2 emissions. Lee et al. [8], Shahbaz et al. [9], and Haseeb et al. [10] argued that GLOB had a decreasing impact on CO_2 emissions. On the other hand, opponents have shown that GLOB will strongly damage the environment if current industrial technologies remain unchanged [11, 12]. Similarly, GLOB increases economic growth by expanding industrial activities, which consume more natural resources, leading to a scarcity problem. Shahbaz et al. [13] also highlighted that pollution and environmental degradation are currently more intense in developing economies than 45 years ago.

The developed economies now have strong concerns with the contaminated production and manufacturing in the developing economies because economic growth through the expansion of industrialization is directly associated with environmental degradation. Therefore, open economic policies, weak environmental regulations, and poor policy stringency are the factors greatly responsible for environmental degradation and significant climate variability in developing economies [14]. Moreover, through the GLOB, the developed nations transferred their pollution-intensive industries to the developing economies due to the aforementioned reasons [5].

With the rapidly growing GLOB, international trade and climate change are also emerging as burning research topics among the research community. National and international institutions have a strong desire to produce eco-friendly goods and services in order to lower CO_2 emissions. In this context, economies start to adopt eco-friendly policies that foster the sustainable and climate-neutral production of goods and services. To produce sustainable and eco-friendly products, diversified production is one of the sustainable options, which is known as "diversified products" [15]. These diversified products are characterized as energy-efficient and considered more environmentally friendly [16]. In order to analyze the influence of trade on CO_2 emissions, trade volume is used as a proxy variable for trade, which describes the scale effect only of trade [17]. Similarly, few studies have used export product diversification as a proxy variable for trade. Currently, product diversification is widely acknowledged as a

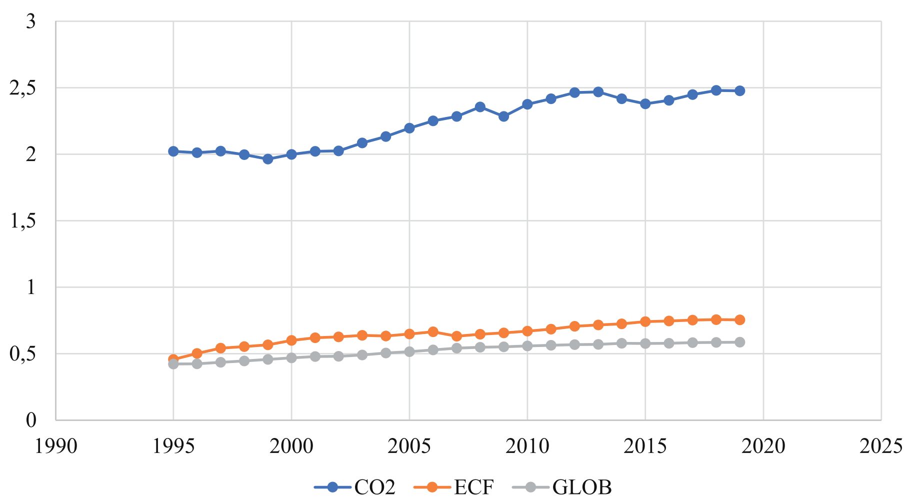


Fig. 1. GLOB, ECF, and CO_2 emission in developing nations.

proxy variable for trade compared to export product diversification [18]. Additionally, economic fitness (ECF) is a superior method for product diversification [15].

ECF describes the ability of an economy to produce diversified and globally competitive complex goods, which fosters the long-run economic growth of an economy. As developing nations majorly emit emissions, they must transform their production structure in order to produce eco-friendly products [19]. In this context, ECF is the most important element of economic growth as well as lowering CO_2 emissions.

GLOB in developing economies significantly complicates the process of achieving sustainable development because it may cause environmental degradation. On the other hand, the ECF has a strong reduction effect on CO_2 emissions. Fig. 1 presents the average CO_2 emissions, GLOB, and ECF of developing nations. It is observed that the CO_2 emissions in the panel of 80 developing nations are continuously increasing. Moreover, their GLOB has also increased over the years at a rapid pace. Their increasing trend in the ECF indicates that developing countries are improving their capabilities to produce diversified and complex globally competitive products.

Therefore, based on the aforementioned debate, the current study is planned to investigate the individual and synergistic impact of GLOB and ECF along with gross fixed capital formation (GFCF), renewable energy consumption (REC), and urbanization (URB) in developing nations in the light of the Environmental Kuznets Curve (EKC) hypothesis. This study significantly contributes to the literature in many ways. First, it enhances the understanding of insights regarding environmental function with the inclusion of GLOB and ECF in the lens of the EKC hypothesis in developing nations. Second, it is the first study that considers the GLOB and ECF in a single frame, which has not been explored before. Third, we have also included the interaction effect between GLOB and ECF (GLOB*ECF) on CO_2 emissions. Fourth, we also analyzed the EKC trajectories or fluctuations in turning points while including both GLOB and ECF individually and together with the other aforementioned variables.

Considering the specific contribution of this study, it provides advanced insights into environmental dynamics by considering the GLOB and ECF within the framework of the EKC hypothesis. However, this study pioneered the integration of GLOB and ECF in a single analytical framework. Incorporating the interaction effects of GLOB and ECF also provides a nuanced view of their impact on CO_2 emissions. Additionally, examining the EKC trajectories and fluctuations in the turning points with individual and combined effects of ECF and GLOB provides important insights for policy-makers and institutions in developing nations. The findings of the study are expected to provide important insights for policymakers and institutions in developing nations in order to conserve their environment under increasing globalization and changing production structures.

Literature Review

There is extensive literature available that explores the GLOB as an important determinant of CO_2 emissions based on different types of panel and time series data. All of them acknowledged the impact of GLOB on emissions, as GLOB enhances interaction among nations through social, political, and economic integration [20]. In the context of the GLOB impact on CO_2 emissions, the findings are contradictory. It implies that the literature reveals both a positive and negative impact of GLOB on CO_2 emissions. Considering the favorable impact of GLOB's negative impact on CO_2 emissions, we can find various studies. For example, Chen et al. [21] used a panel of 16 Central and Eastern European (CEE) nations from 1980–2016 and analyzed the impact of GLOB and financial development on CO_2 emissions along with renewable and non-renewable energy consumption. The findings of dynamic, seemingly unrelated regression revealed the negative impact of GLOB on CO_2 emissions, which implies that GLOB improves the environmental quality in CEE economies. Similarly, You and Lv [22] highlight the impact of economic GLOB on CO_2 emissions using a panel of 83 countries from 1985–2013. They found a spatial impact of GLOB on CO_2 emissions and signified that being surrounded by highly globalized economies has a strong effect on GLOB in reducing CO_2 emissions. Moreover, they also found this negative impact of GLOB in light of the EKC hypothesis. Zaidi et al. [23] used the panel of Asia Pacific Economic Cooperation (APEC) economies from 1990–2016 and applied a family of econometric models. They also confirmed the favorable impact of GLOB on environmental quality by reducing CO_2 emissions in the presence of the EKC hypothesis. Liu et al. [20] have confirmed the inverted U-shaped relationship between GLOB and CO_2 emissions based on the panel of G7 nations from 1970–2015. They described that an increase in GLOB increases the CO_2 emission; after reaching a certain level of GLOB, the CO_2 emission declines as GLOB among G7 nations increases. Lv and Xu [24] used a panel of 15 emerging nations and found a negative impact of GLOB on CO_2 emissions in the time period of 1970–2012. Haseeb et al. [10] explored the impact of GLOB on CO_2 emissions in the case of BRICS nations. They found a negative impact of GLOB on emissions, but this impact was insignificant. After applying the panel ARDL econometric model, Koengkan et al. [25] found the beneficial impact of GLOB on environmental quality by lowering CO_2 emissions in 18 Latin American nations. On the other side, many studies have found a positive impact of GLOB on CO_2 emissions, which implies that a rise in GLOB increases CO_2 emissions. For example, Bilal et al. [26] found a positive impact of

GLOB on CO_2 emissions in the region of the Belt and Road Initiative economies and South Asia. Kalayci and Hayaloğlu [27] used only one dimension of GLOB, like economic GLOB, and described that the economic GLOB increases the CO_2 emission in the case of North American Free Trade Agreement (NAFTA) nations. Moreover, Khan and Ullah [28] also found that GLOB pollutes the environment by increasing CO_2 emissions in Pakistan. Phong [29] used the panel of ASEAN nations from 1971–2014 and applied fixed and random effect regression. They explored the impact of GLB, along with energy consumption, urbanization, and financial development, on CO_2 emissions in light of the EKC hypothesis. They have signified that the GLOB increases the emission of CO_2.

The GLOB and vertical specialization have strongly affected international trade [30], majorly transforming the nature of cross-border trade. It has also modified the production systems and marketing strategies. Most of the studies concentrated on the scale effect of trade on the environment. This effect describes the direct impact of trade on emissions by using imports and exports as a proxy variable for trade, which only shows the volume of trade [31, 32]. There are many other indicators that are widely used as proxy variables for trade to analyze the impact of trade on CO_2 emissions or environmental degradation, including export product diversification (EPD), import product diversification, export product concentration, and export product quality [15]. Moreover, trade has scale, composition, technology, and spillover effects on the environment. Considering the EPD, Mania [33] has used a panel of 98 developing and developed nations from 1995–2013. They explored the EPD impact on CO_2 emissions in the context of the EKC hypothesis and found a positive impact of EPD on emissions by applying the system-GMM and long-run PMG methods. On the other hand, Zafar et al. [34] have found the negative impact of EPD on CO_2 emissions in the case of 22 top remittance-receiving nations.

With growing globalization and weak and polluted production systems in developing nations, developed countries started to focus on complex and sophisticated products that consume low energy and contribute to environmental preservation [35]. Therefore, the production of sophisticated and diversified products majorly contributes to economic growth, maintains revenue, improves human skills, and fosters the adoption of advanced technologies [36, 37]. Instead of EPD, there are many studies that have focused on the economic complexity index (ECI) proposed by Hidalgo and Hausmann [38] in order to explore the environmental implications of economic activities [39, 40]. ECI shows the level of capability of a nation to produce sophisticated manufacturing products [41]. Can and Gozgor [42] have described that economic complexity lowers air pollutants in developed nations. Yilanci and Pata [43] have found a positive impact of economic complexity on emissions in China. However, due to the ECI's linear computational approach, it is greatly criticized in terms of proxy variables as economic activities for producing diversified products [44, 45]. Therefore, Tacchella et al. [46] proposed the ECF index, which is measured based on a non-linear fixed-point iteration approach. This index considers both nations' economic complexity and production capabilities.

Based on the aforementioned discussion, it is confirmed that the developing nations are involved in continuously growing economies, which also have serious problems with environmental degradation. Moreover, with their increasing GLOB, the current study aims to understand the dynamic relationship between GLOB, ECF, and CO_2 emissions in developing nations by analyzing the impact of GLOB and ECF within a single framework. Considering all these points, the current study extends the existing literature by analyzing the individual and synergistic impact of GLOB and ECF on CO_2 emissions in developing nations.

Materials and Methods

Model Specification

Based on the aforementioned studies, it has been observed that there are many factors affecting CO_2 emissions, including energy consumption, GLOB, and economic growth. Our theoretical model is specified as follows: GDP per capita (GDP) as a proxy variable for economic growth, globalization (GLOB), economic fitness (ECF), gross fixed capital formation (GFCF), renewable energy consumption (REC), and urbanization (URB).

$$\mathrm{CO_2 emission} = f\,(\mathrm{GDP, GLOB, ECF, GFCF, REC, URB}) \tag{1}$$

We have decomposed eq. 1 to analyze the existence of the EKC hypothesis, incorporated the square form of GDP into our model, and developed our basic model for exploring the EKC hypothesis in developing economies.

$$CO_2 = f(GDP_{it}, GDP_{it}^2, GFCF_{it}, REC_{it}, URB_{it},) \qquad \text{Model-1}$$

In Model 1, we have included two of our main variables, including GLOB and ECF. GLOB indicates the level to which economies interconnect with other nations around the world, which is expected to have a strong impact on CO_2 emissions in developing nations. ECF depicts the capabilities of developing nations to produce diversified and globally competitive products, which is also expected to have a strong negative impact on CO_2 emissions in developing nations. Moreover, the inclusion of GLOB and ECF, along with GFCF, REC, and URB, is also expected to provide comprehensive insights for understanding the EKC hypothesis and fluctuations in its trajectories.

$$CO_{2,it} = f(GDP_{it}, GDP^2_{it}, GLOB_{it}, ECF_{it}, GFCF_{it}, REC_{it}, URB_{it},)$$

Model-2

Before executing the model analysis, we transformed all variables using natural logarithms to remove the fluctuation of data and the presence of heteroscedasticity [47]. Sinha and Shahbaz [48] indicated that the logarithm transformation provides robust and accurate estimates as compared to the simple linear specification.

$$lnCO2_{it} = \alpha_{it} + \delta_1 lnGDP_{it} + \delta_2 lnGDP^2_{it} + \delta_3 lnGLOB_{it} + \delta_4 lnECF_{it} + \delta_5 lnGFCF_{it} + \delta_6 lnRE_{it} + \delta_7 lnURB_{it} + e_{it}$$

Model-3

In Model-3, the a_{it} and δ_1, δ_2….δ_7 are the coefficients to be estimated and e_{it} is the error term. In the model, i describes the cross-sectional identifier (countries), and t depicts the time period from 1995-2019. Model-3 further decomposed into various models. Model-4 was developed to analyze the individual impact of GLOB on CO_2 emission through the presence of the EKC hypothesis. ECF is included in the model, which is presented by Model-5 in the light of the EKC hypothesis. Model-6 signifies the synergistic impact of GLOB and ECF (GLOB*ECF) on CO_2 emission through the lens of the EKC hypothesis.

$$lnCO2_{it} = \alpha_{it} + \delta_1 lnGDP_{it} + \delta_2 lnGDP^2_{it} + \delta_3 lnGLOB_{it} + \delta_5 lnGFCF_{it} + \delta_6 lnRE_{it} + \delta_7 lnURB_{it} + e_{it}$$

Model-4

$$lnCO2_{it} = \alpha_{it} + \delta_1 lnGDP_{it} + \delta_2 lnGDP^2_{it} + \delta_4 lnECF_{it} + \delta_5 lnGFCF_{it} + \delta_6 lnRE_{it} + \delta_7 lnURB_{it} + e_{it}$$

Model-5

$$lnCO2_{it} = \alpha_{it} + \delta_1 lnGDP_{it} + \delta_2 lnGDP^2_{it} + \delta_3 lnGLOB_{it} + \delta_4 lnECF_{it} + \delta_5 lnGLOB * lnEF_{it} + \delta_6 lnGFCF_{it} + \delta_7 lnRE_{it} + e_{it}$$

Model-6

to analyze the existence of the EKC hypothesis and the sign and value of coefficients regarding GDP and GDP^2 (δ_1 and δ_2, which highlights the nature of the relationship between economic growth and the environment. When both coefficients (δ_1 and δ_2 possess the zero value, there is no relationship between variables. It indicates a flat relationship between economic growth and the environment. If δ_1 is greater than 0 and significant, while δ_2 is equal to 0, it means there is a positive relationship between GDP and CO_2 emissions, which implies that an increase in economic growth causes environmental degradation with a rise in CO_2 emissions. Similarly, negative δ_1 and δ_2 zero imply a negative impact of GDP per capita on CO_2 emissions, whereas GDP^2 does not have any impact on CO_2 emissions. This depicts the consistent decline in CO_2 emissions as economic growth increases. The inverted U-shaped relationship exists when δ_1 is significant and positive, while δ_2 is significant and negative. This relationship signifies the existence of the EKC hypothesis. On the other hand, the negative values and positive values describe the U-shaped relationship between economic growth and the environment.

Variables and Data Sources

A panel of 79 different developing nations was used in the study from 1995-2019. The data regarding the variables is obtained from world-famous reliable organizations. Data regarding GLOB is obtained from KOF, which is openly available at https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html. The CO_2 emission per capita, GDP per capita, economic fitness index (ECF), gross fixed capital formation (GFCF), renewable energy consumption (REC), and urbanization (URB) have been downloaded from "World Development Indicators" (WDI), which are available at https://databank.worldbank.org/source/

Table 1. Description of variables and data sources.

Variables	Description	Source
GLOB	Globalization	KOF-Globalization index
ECF	Economic fitness	WDI
GDP per Capita	Gross domestic product	WDI
CO_2 Emission	Carbon dioxide emission	WDI
GFCF	Foreign direct investment	WDI
REC	Renewable energy consumption	WDI
URB	Urbanization	WDI

world-development-indicators. Table 1 provides the description and source of the data.

Descriptive Analysis

The empirical analysis of the data was started by conducting a descriptive analysis of the variables. We applied the standard deviation to analyze the volatility for each variable. The distribution quality of variables was assessed with skewness and kurtosis. The normalcy of the variables was analyzed by Jarque and Bera [49].

Analyzing Slope Heterogeneity of Coefficients

The slope heterogeneity test proposed by Pesaran and Yamagata [50] was applied, and slope coefficient heterogeneity was tested by delta (eq.2) and adjusted-delta (eq.3).

$$\widehat{\Delta} = \sqrt{N(2k)^{-1}(N^{-1}S' - K)} \tag{2}$$

$$\text{Adj.}\widehat{\Delta} = \sqrt{N}\sqrt{\frac{T+1}{2K(T-K-1)}}((N^{-1}S' - 2K) \tag{3}$$

Cross-section Dependency

The cross-section dependency (CSD) was executed in order to select the suitable econometric panel data analysis. For this purpose, we applied the test of CSD, which is suggested by Pesaran [51].

$$CD = \sqrt{\frac{2T}{N(N-1)}}\sum_{i=0}^{N-1}\sum_{j=i+1}^{N-1}\hat{\rho}_{ij}^2 \tag{4}$$

where CD depicts the cross-section dependency, N depicts the number of developing nations (=79), T shows the time period (24 years), and ρ_{ij} is the cross-sectional correlation between the residual of countries i and j.

Panel Unit-root Test

To assess the stationarity of the variable, we have applied 2nd generation unit root tests because the 1st generation unit root test is not efficient in the presence of CSD. For this purpose, we used 2nd generation unit root tests, including CADF and CIP tests [52]. Eq.5 describes the CADF statistics to test the stationarity.

$$\Delta Y_{it} = a_i + b_i Y_{i,t-1} + c_i \bar{Y}_{t-1} + c_i \Delta \bar{Y}_t + \omega_{it} \tag{5}$$

where Δ shows the difference operator, and ω_{it} is the error term. The CIPS based on the CADF is presented in eq.6.

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF_i \tag{6}$$

Cointegration Test

We have applied the Padroni panel cointegration test to analyze whether the panels are cointegrated with each other or not. The rejection of the null hypothesis serves as evidence for the existence of cointegration.

Panel Econometric Method

In the presence of heteroskedasticity and contemporaneous correlation, the panel corrected standard error (PCSE) method provides reliable outcomes [53]. PCSE effectively deals with complex panel structures and allows heteroskedasticity in multiple cross-sections. For robustness checks, we used long-run estimator techniques such as the system generalized moments method (system-GMM). This method provides robust estimators in the presence of heteroscedasticity, correlation at panels, and autocorrelation. This method minimizes the data loss by averaging across all possible future values of the variables. Moreover, when N is greater than T, the system-GMM provides reliable estimates. Moreover, system-GMM is also a reliable estimation technique in the presence of mitigating bias

Table 2. Descriptive analysis of variables.

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
$LnCO_2$	-0.048	0.25	2.73	-3.83	1.55	-0.43	-0.85	119.60*
LnGDP	7.43	7.42	10.42	4.60	1.21	0.023	-0.93	71.13*
LnGLOB	3.93	3.95	4.44	3.11	0.255	-0.47	-0.06	73.81*
LnECF	-3.52	-2.21	3.50	-623.12	16.33	-29.14	10.58	9200.01*
LnGFCF	22.46	22.33	29.44	-0.072	2.18	-0.46	5.41	2462.00*
LnREC	3.14	3.65	4.58	-2.81	1.45	-1.15	0.55	458.70*
LnURB	15.82	15.69	20.56	11.45	1.54	0.24	0.38	30.26*

Note: *, **, *** depict significance levels at 1%, 5%, and 10%.

Table 3. Correlation matrix.

Variables	$LnCO_2$	LnGDP	LnGLOB	LnECF	LnGFCF	LnREC	LnURB
$LnCO_2$	1.00						
LnGDP	0.83	1.00					
LnGLOB	0.69	0.78	1.00				
LnECF	0.05	0.78	0.14	1.00			
LnGFCF	0.61	0.65	0.65	0.14	1.00		
LnREC	-0.75	-0.54	-0.39	0.06	-0.42	1.00	
LnURB	0.35	0.28	0.41	0.08	0.84	-0.31	1.00

Table 4. Slope heterogeneity test.

Statistics	Test value	p-value
$\widehat{\Delta}$	6.501 *	0.00
Adj.$\widehat{\Delta}$	8.333 *	0.00

Note: *, **, *** shows significant at 1%, 5% and 10%.

arising from measurement errors, variable omissions, and endogeneity that affect the dependent variables [54, 55].

Results

Table 2 presents the descriptive analysis of the variables. The skewness and kurtosis show the deviation of the variables from the normal distribution. The p-value of each variable regarding the Jarque and Bera tests indicates that the null hypothesis is rejected, which implies that variables are not normally distributed.

Table 3 presents the correlation matrix, which describes whether the variables are positively and negatively correlated with each other. For example, LnREC (=-0.75) implies that as the REC increases, the CO_2 emission tends to decrease. Similarly, LnURB (=0.35) means that with an increase in URB, CO_2 emissions tend to increase. Considering GLOB (=0.69) and ECF (=0.05), both of them are also positively related to CO_2 emissions.

The findings of the slope heterogeneity test are presented in Table 4. We found significant test values of both Δ (delta) > and Adj. Δ (delta) >, which implies that the null hypothesis is rejected. It concludes that slope coefficients are heterogeneous and depict slope heterogeneity.

Table 5 presents the stationarity and CSD of each variable. The CSD is explored by using the CD-test, and its findings provide a p-value of less than 1%, which implies that the null hypothesis of no cross-section dependency is rejected. It depicts those variables as showing cross-sectional dependency, which emphasizes that any change in one country has a strong effect on the other nations within the panel.

The stationarity of each variable was assessed with CIPS and CADF; these two panel unit root tests provide the findings at both level and first difference. The outcomes of tests signify that at the first difference, each variable shows stationarity.

Table 5. Cross-section dependency and Panel unit root test.

Variables	CIPS		CADF		CD
	At level	1st difference	At level	1st difference	
$LnCO^2$	-2.060	-4.451*	-2.295	-4.575*	68.33*
LnGDP	-2.562*	-4.235*	-2.733*	-4.340*	234.19*
LnGLOB	-1.987	-4.796*	-1.906	-4.895*	249.64*
LnECF	-1.732	-4.906*	-1.576	-4.826*	103.69*
LnGFCF	-2.558*	-4.353*	-2.775*	-4.405*	223.18*
LnREC	-1.372	-4.231*	-1.725	-4.391*	39.48*
LnURB	-1.849	-2.159**	-2.080	-3.704*	190.19*

Note: *, **, *** shows significant at 1%, 5% and 10%.

Table 6. Padroni panel cointegration test.

Tests	Statistics	p-value
Modified Phillips-Peron t	7.944	0.00
Phillips-Peron t	-5.668	0.00
Augmented Dickey-fuller t	-5.765	0.00

Panel Cointegration Test

Table 6 presents the Padroni cointegration test. The p-value of the findings is less than 1%, which strongly rejects the null hypothesis. It implies that all panels are cointegrated.

Analyzing the Existence of the EKC Hypothesis

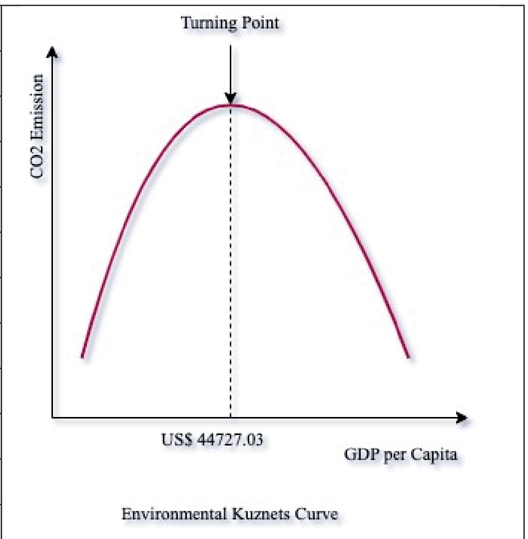
Table 7 presents the findings of the PCSE, which confirms the existence of the EKC hypothesis in developing countries. The coefficient of GDP per capita δ_1 (=2.57) is significant and positive, which implies that a rise in economic growth in developing nations increases CO_2 emissions. The significant and negative coefficient of GDP squared δ_2 (=-0.12) highlights the diminishing CO_2 emissions as economic growth increases in developing nations. Therefore, the sign and significance of both coefficients have demonstrated the existence of the EKC hypothesis in the panel of developing nations. When GDP per capita reaches US$ 44727.03, the EKC takes its turn downward.

Analyzing the Impact of GLOB and ECF on Emissions through the EKC Hypothesis

Table 8 shows the three different models, including the individual and interaction impacts of GLOB and ECF on emissions. After integrating the GLOB in the model alone, the PCSE outcomes again confirm the existence of the EKC hypothesis in developing economies, with a positive sign of δ_1 (-=2.31) and a negative sign of δ_2 (=-0.11). Considering the impact of GLOB on emissions in developing nations (= 0.60) is positive and significant in the light of EKC. It implies that a rise in GLOB increases emissions in developing nations. It may be emphasized through various interconnected mechanisms. With the rise in GLOB in developing nations, economies expand their industrialization rapidly due to the demand for export-oriented production, which increases energy consumption, leading to high CO_2 emissions. GLOB may also change consumption patterns, which may also encourage developing nations to use outdated technologies leading to high CO_2 emissions. Model-5 presents the individual impact of ECF on emissions through the EKC hypothesis in developing nations. This implies that the increase in ECF of developing nations causes the rise in CO_2 emissions, while this impact is much weaker (ECF = 0.003) than those GLOB (= 0.60) have on CO_2 emissions. ECF in developing nations leads to the growth of energy-intensive sectors like manufacturing and construction and the consumption of more fossil fuels. Moreover, the ECF describes the ability of developing nations to maintain their globally competitive positions, and to maintain this position, developing economies start to use cheaper sources of energy to lower their cost of production, which increases CO_2 emissions. The interaction impact of GLOB and ECF (GLOB*ECF) is presented by Model 6. The

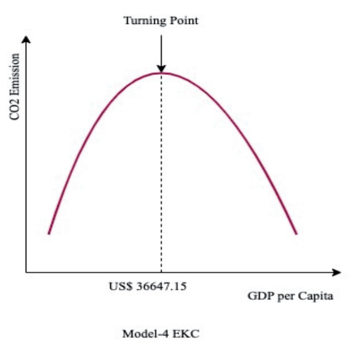
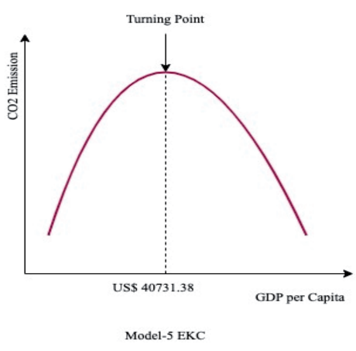
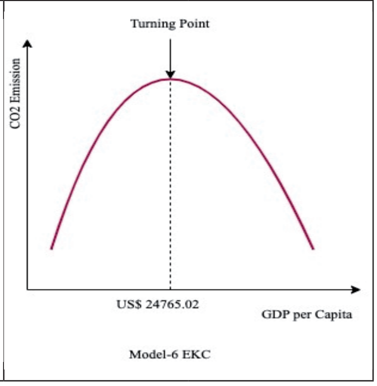
Table 7. Existence of the EKC hypothesis in developing countries.

	PCSE	
Model-3	Coefficient	p-values
Constant	-11.53*	0.00
GDP	2.57*	0.00
GDP^2	-0.12*	0.00
GFCF	-0.021	0.33
REC	-0.44*	0.00
URB	0.069*	0.002
Wald chi^2/F-statistics	27746.75*	0.00
R^2	0.83	
No. of group	79	
No. of obs.	1975	



Note: *, **, *** depict significance levels at 1%, 5%, and 10%.

Table 8. Analyzing the impact of GLOB and ECF on emission through the EKC hypothesis.

Variables	Model-4		Model-5		Model-6	
	Coefficients	p-values	Coefficients	p-values	Coefficients	p-values
Constant	-12.20	0.00	-11.49*	0.00	-13.34	0.00
GDP	2.31*	0.00	2.591*	0.00	2.598*	0.00
GDP^2	-0.11*	0.00	-0.122*	0.00	-0.128*	0.00
GLOB	0.60*	0.00			0.722*	0.00
ECF			0.003*	0.00	0.29*	0.00
GLOB*ECF					0.082*	0.00
GFCF	-0.022	0.30	-0.028	0.15	-0.038	0.165
REC	-0.45*	0.00	-0.44*	0.00	-0.046*	0.00
URB	0.05**	0.03	0.07*	0.00	0.047**	0.023
Wald chi^2	31609.04*	0.00	29781.32*	0.00	30181.30*	0.00
R^2	0.834		0.836		0.84	
No. of group	79		79		79	
No. of obs.	1975		1975		1975	
EKC trajectories						

Note: *, **, *** depict significance levels at 1%, 5%, and 10%.

findings of Model-6 depict a significant positive impact of GLOB and a significant negative impact of ECF on CO_2 emissions. Their interaction impact (GLOB*ECF) is positive and significant on CO_2 emissions. This interaction term confirms the moderating role of ECF between GLOB and CO_2 emissions in developing nations. It can be explained by various interacting factors. The positive impact of GLOB in developing nations often attracts more foreign direct investment and enhances their trade level, which expands their industrial activities rapidly, leading to high CO_2 emissions in developing economies due to high energy consumption and increased production. On the other hand, ECF varies significantly among developing nations. ECF demonstrates its ability to produce diversified and globally competitive complex products that sustain economic growth through the development of infrastructure, institutional quality, and technical capabilities. This may initially reduce CO_2 emissions by making the industry more efficient, but rapid industrial growth, high production levels, high energy consumption through the GLOB, and an increasing level of ECF in developing nations lead to high emissions.

Considering the EKC trajectories, the baseline model describes that developing economies require a relatively high level of economic growth in terms of GDP per capita (US $ 44727.03) to reach the turning point at which CO_2 emissions start to decline. Considering Model-4, the GLOB facilitates the developing economies to reach the immediate level of GDP per capita as compared to the baseline model. It implies that the turning points due to the integration of GLOB were reduced to US $ 36647.15. It confirms that GLOB accelerates the process of economic growth by expanding industrial activities and production levels in developing nations. Similarly, when ECF was integrated only in Model-5, the turning point was also reduced to US $ 40731.38 from the point of the baseline survey. It also demonstrates that when developing economies start to diversify their production levels to maintain their competitive position in the global market, they also expand their manufacturing and industrial activities, which increase their economic

Table 9. System-GMM for robustness.

Variables	Model-3		Model-4		Model-5		Model-6	
	Coefficients	p-values	Coefficients	p-values	Coefficients	p-values	Coefficients	p-values
Constant	-5.10*	0.00	-0.86*	0.01	-4.50*	0.00	-0.68*	0.00
CO_2	0.57*	0.00	0.78*	0.00	0.64*	0.00	0.94*	0.00
GDP	0.878*	0.00	0.32*	0.00	0.80*	0.00	0.11*	0.003
GDP^2	-0.035*	0.00	-0.015*	0.00	-0.033*	0.00	-0.007*	0.001
GLOB			0.235*	0.00			0.072*	0.00
ECF					0.0006*	0.00	-0.025*	0.00
GLOB*ECF							0.007*	0.00
Control variables	Yes		Yes		Yes		Yes	
F-statistics	2153.56*	0.00	20175*	0.00	38607.77*	0.00	89130.74*	0.00
Significance test (p-value)								
Sargan Test	51.67	0.199	45.28	0.173	74.42	0.306	43.09	0.144
Hansen Test	45.81	0.397	59.96	0.773	50.28	0.956	61.51	0.99
2^{nd} order Correlation	-1.03	0.155	-1.23	0.201	-1.41	0.187	-1.41	0.176

growth. Therefore, the developing economies can reach the earlier turning point at EKC, but this is not as strong as GLOB alone. The interaction impact of ECF and GLOB significantly reduced the turning point to US $ 24765.02. It implies the strong synergistic impact of ECF and GLOB, where both of them together greatly increase the economic activities of the developing economies and enable the economies to experience the turning point at a much earlier stage of economic growth in terms of GDP per capita.

Robustness Check

We have applied the System-GMM model for robust checking (Table 9). The findings of system-GMM provide robust evidence for PCSE estimators.

Discussion

Rapidly growing integration among nations around the world has generated serious concerns about the environmental implications of globalization (GLOB) and economic fitness (ECF) in developing economies. These economies are characterized by unbalanced and weak environmental regulations and pollution-intensive industrial activities [6]. Therefore, this study is the first to examine the individual impacts of GLOB and ECF on CO_2 emissions through the EKC hypothesis in developing nations. The robust estimators of PCSE provide important and comprehensive insights regarding the impacts of variables in light of the EKC and its trajectories in developing nations.

Our empirical analysis shows a significant and positive impact of GLOB on CO_2 emissions, along with the EKC hypothesis in developing nations. This implies that GLOB in developing nations strongly affects environmental quality and is the primary cause of pollution by increasing the impact of GLOB on CO_2 emissions. This may be explained by the weakly inefficient technologies and environmental regulations for polluting sectors that lead to a further rise in CO_2 emissions in developing nations. Our findings are in line with the outcomes of Pata [12], Kalayci and Hayaloğlu [27], Khan and Ullah [28], and Phong [29]. All these studies found a positive impact of GLOB on CO_2 emissions in different panels of nations. Jahanger [56] described a positive and significant relationship between GLOB and CO_2 emissions in developing nations. They demonstrated that trade openness, a basic element of GLOB, is the main cause because developed nations generally shift polluting industries to developing nations. Moreover, developing economies mainly focus on economic growth rather than environmental quality. Increasing GLOB increases economic activity, which substantially depends on conventional energy sources to produce goods and services, leading to high CO_2 emissions [57].

The empirical findings reveal that the ECF also had a significant positive impact on CO_2 emissions in light of the EKC hypothesis. This implies that ECF, in the case of a panel of developing nations, causes a serious environmental quality issue because developing economies do not have strong and reliable production capabilities [58] to produce low-cost and globally attractive products. This may pressure developing nations to expand their manufacturing and industrial activities without considering the environmental quality. Moreover, to remain globally competitive, developing nations consume conventional energy sources and traditional technologies [59] to produce diversified and complex goods, which may cause high CO_2 emissions. Moreover, due to cheaper economic sources in developing nations, multinational corporations shift their production to developing nations, which spurs their industrial activities along with high CO_2 emissions. The economic complexity before ECF, which is extensively considered a proxy variable for country production structure to measure the capability of a nation to produce complex exporting products [60], developing economies characterized by a high population while adopting modern technologies to enhance their economic complexity by increasing exports of complex goods are at greater risk of environmental degradation due to the deficiency of green technologies [61]. Therefore, when developing nations start to enhance their ECF, they focus only on innovations that may produce low-cost, diversified, and complex products with no concern for environmental quality.

The findings of the model also revealed a significant positive interaction impact of GLOB and ECF (ECF*GLOB) on CO_2 emissions in developing nations. It is likely that a complex and diversified production structure is a driving force behind the reduction of CO_2 emissions by fostering the adoption of environmentally friendly methods that are easily accessible through GLOB. However, it may become more complex for nations to transform their production and consumption patterns from low environmentally friendly to highly environmentally friendly products that may demand high energy consumption, leading to a high risk of CO_2 emissions [61]. Moreover, the emission level may increase owing to diversified exports, economic expansion, and trade openness because of the high consumption of economic resources and energy [62, 63], which evaporates the combined impact of ECF and GLOB. In the context of interaction impact, the ECF moderates the impact of GLOB on CO_2 emissions because, after integrating the combined effect of ECF and GLOB in the model in light of the EKC, it is observed that their combined effect is stronger than their individual impact. Additionally, ECF enhanced the impact of GLOB on CO_2 emissions. Therefore, developing nations with high ECF may experience high GLOB through production expansion and improved capabilities to scale up production and trade, leading to high CO_2 emissions. Therefore, ECF enhances the positive impact of GLOB on CO_2 emissions due to scaled-up production and industrial activities enabled by GLOB in developing nations.

Concerning the impact of GLOB on the turning point of the EKC, it was observed that GLOB significantly reduced the turning point compared to the baseline model. This may be due to the impact of GLOB on the scale of production in developing nations because developing nations expand their production levels due to GLOB and increase the demand for energy and transportation [27]. Therefore, developing nations focus on economic growth rather than environmental quality, which enables them to reach a turning point immediately. Considering the ECF and EKC trajectories, the turning points are lower than those of the baseline model, but not as strong as those of GLOB alone. The strong combined effect has significantly reduced the turning point at a much earlier stage of economic growth due to its combined large effect on the country's economic activities through diversified production expansion and trade openness. This implies that developing nations have great potential for expanding their economic activities through ECF and GLOB, but they require strong and careful international policies with no compromise on the domestic environment while integrating with other nations.

Conclusion

Globalization greatly affects human lives through the political, economic, and social integration of developing nations. Moreover, increasing globalization has caused serious environmental issues around the world, especially in developing nations, which are characterized by high population growth, high poverty, uneven distribution of natural resources, and different production scales. Simultaneously, the global demand for green products around the world requires the production of sophisticated and complex goods with low emissions and low energy consumption. This changes the production structure of developing economies to maintain their competitive positions in the global market. Thus, the current study analyzes the individual and synergistic impacts of globalization (GLOB) and economic fitness (ECF) on CO_2 emissions through the EKC hypothesis in developing economies.

The econometric method findings based on a panel of 79 developing economies from 1995 to 2019 confirm the existence of the EKC hypothesis in developing economies. This describes how increasing economic growth causes high CO_2 emissions, and after reaching a certain level of GDP per capita, the rise in economic growth diminishes CO_2 emissions. In light of the EKC hypothesis, both GLOB and ECF had a significant positive individual impact on CO_2 emissions. Therefore, GLOB and ECF in developing economies deteriorate environmental quality. With increasing GLOB, developing economies expand their industrial activities, which consume more energy, leading to high CO_2 emissions in developing economies. As many developing economies shift their low environment-friendly production to green products without modern and energy-efficient technologies, this may cause more emissions. The findings regarding the interaction impact of ECF and GLOB on CO_2 emissions based on the EKC hypothesis indicate a significant positive impact of ECF*GLOB on CO_2 emissions in developing economies. It was concluded that diversified exports, trade openness, and economic expansion in developing nations cause high emissions due to their high demand for resources and energy, which eliminates the combined favorable impact of ECF and GLOB on CO_2 emissions in developing economies. Moreover, the ECF moderates the impact of GLOB on CO_2 emissions, as economies with high ECF increase their GLOB through increased production scale to enhance their trade, which leads to environmental degradation. Concerning the ECK trajectories, ECF and GLOB reduced the turning point significantly compared to their individual impacts and baseline models.

This study has strong policy implications because the findings refute the current policies in developing nations. First, to achieve a favorable impact of GLOB and ECF in reducing CO_2 emissions, developing nations must develop a strong institutional framework. This institutional framework must strictly implement and enforce environmental standards to capture the environment-oriented benefits of GLOB and ECF. For this, developing nations must strengthen their regulatory frameworks, which must be compatible with international standards. Moreover, they must develop effective trade policies that encourage only the import of green technologies, which turns the positive impact of globalization into a negative one on CO_2 emissions. Similar to the favorable impact of ECF, developing nations must invest in sustainable infrastructure, especially environmentally friendly energy sources, which still have great potential for improvement. Moreover, they provide incentives for R&D in environment-friendly technologies and practices. Moreover, they must increase their international cooperation through climate agreements, foreign aid, and grants, and the mutual collaboration of neighboring countries to increase access to knowledge, resources, and financial support to enhance the diminishing impact of economic fitness on CO_2 emissions. At the domestic level, the development of effective economic policies, including carbon pricing, subsidies, and incentives, may encourage green investment to improve the economic fitness level. Thus, economies that increase their economic fitness may have a favorable impact on CO_2 emissions to align economic growth with environmental preservation.

Conflict of Interest

The authors declare no conflict of interest.

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