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Does Globalization Affect the Environment? The relationship between Energy Consumption, Carbon Dioxide Emission, and Economic Growth

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ABSTRACT

Global warming and environmental degradation have recently been a most important confront for the countries. Ever-increasing CO2 emissions and more greenhouse gas emissions have formed wide-ranging ecological influences. Such influences have caused for unpredicted transforms in climate settings, improved earth temperatures. Taking into consideration the importance of these variables, we have investigated how globalization, education, economic growth, energy consumption, and urban population affect environmental degradation in developing economies. We used data from 1996 to 2023. We used the panel ARDL technique here. The results highlighted the positive association between globalization and ecological degradation in the long-run. Results show that economic growth and energy consumption have enhanced CO2 emissions in the long-run. However, education reduced environmental degradation in developing economies. The short-run result showed that education increased environmental degradation. However, economic growth leads to an increase in CO2 emissions in developing countries. The study suggests that reducing CO2 emissions through decreased globalization often involves "re-globalization" policies, including targeted trade restrictions, strengthening local labor markets, and promoting domestic production. Government generation, transportation, and industrial heating with renewable sources like solar, wind, and hydropower. More educational facilities and more employment opportunities should be provided to the people. Clean energy would reduce emissions by replacing fossil fuels (coal, oil, and gas) in electricity.

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INTRODUCTION

The most important greenhouse gas responsible for ecological pollution and climate change caused by humans is carbon dioxide (Gaies et al., 2022). Thus, cutting CO2 emissions has become a major part of the worldwide strategy plan for countries. Additionally, ecologically sustainable economic growth is considered a serious technique for gaining long-term progress (Zhao et al., 2023; Hao et al., 2021). Internationally, governments consider protecting ecological sustainability even as getting economic growth as a major purpose of their strategy. The improvement of green technology is necessary to lower CO2 emissions and nurture green growth (Ojha et al., 2020). CO2 emissions are a huge fear not only for developing economies but for the whole globe, through introducing a lot of technical novelty and increasing economic growth with increasing fresh energy. Consequently, sustainable economic growth has been a main concern in developing economies (Tawiah et al., 2021).

Climate change is a famous subject in the worldwide economy (Ali & Rahman, 2022). Burning fossil fuels is the most important issue following comprehensive warming, which is the major driver of climate change (Isfat & Raihan, 2022). Fossil fuels produce CO2 into the air, subsequent safeguarding of heat and following universal warm. This global warming incidence will have catastrophic effects on the earth, causing an increase in extreme weather occurrences, an increase in sea levels, and the extinction of many species (Raihan & Tuspekova, 2022). Therefore, businesses and policymakers have to put into practice measures aimed at reducing CO2 emissions to ward off these catastrophic consequences. This can be achieved by transitioning to a cleaner energy infrastructure and increasing the efficiency of energy (Tian et al., 2022). Gaining insight into the factors that contribute to CO2 emissions is vital for inventing well-organized policies to alleviate them. On the other hand, the factors driving CO2 emissions are different from one state to another because of the distinctiveness of every country that affects its quantity of CO2 emissions. The drivers include factors, for instance, the economy, energy use, ecological restrictions, globalization, growth of population, and technology (Shahbaz et al., 2019).

Policymakers can optimize the efficiency of the guiding principle for reducing CO2 emissions and mitigating climate change by comprehending these rudiments. The ecological Kuznets Curve (EKC) hypothesis explains that there is a substantial effect of financial performance on emissions of CO2 (Saboori et al., 2012). The excellence of the environments can be built up by better utilization of energy and sustainable growth strategies of growth. Additional efficient strategies are necessary, particularly in developing economies, where emissions stay far above the ground. Correspondingly, nitrogen and sulfur dioxide have been analyzed (Wang et al. 2016; Hanif & Gago-de-Santos, 2016); the majority have in addition experienced sulfur dioxide (Selden & Song 1994).

In view of the significance of globalization, education, energy usage, economic growth, and urban population, our work aims to analyze such factors affecting CO2 emissions in developing countries.

Objective of the study

1. To estimate the effect of globalization on environmental degradation.
2. To examine how education reduces CO2 emissions.
3. To investigate how economic growth affects CO2 emissions.
4. To explain the effect of energy consumption on CO2 emissions.
5. To point out the influence of the urban population on CO2 emissions.

Research Questions

1. How does globalization affect CO2 emissions?
2. Does education influence environmental degradation?
3. What is the effect of growth on ecological degradation?
4. How does energy consumption affect CO2 emissions?
5. What is the impact of the urban population on CO22 emission?

Significance of the Study

Numerous studies show that factors like inflation, foreign direct investments, industrialization, and gross fixed capital formation affect CO2 emissions. However, we explain the effect of education, globalization, urban population, energy consumption, and economic growth on CO2 emissions.

Research Hypotheses

H1: Globalization enhances CO2 emissions.

H2: Education tends to decrease CO2 emissions.

H3: A positive association exists between economic growth and CO2 emissions.

H4: The energy consumption and CO2 emissions are positively related.

H5: A positive link may exist between urban population and CO2 emissions.

LITERATURE REVIEW

Lantz and Feng (2006) examined the effect of population on CO2 emissions in Canada. The study result showed that population expansion and income levels enhanced CO2 emissions. However, technological improvement decreased CO2 emissions. The study suggested improved technological advancements in the economic system. Sun et al. (2008) analyzed the influence of patent technology on ecological degradation in China. The findings highlighted that technological advancement reduced carbon emissions. Shahbaz et al. (2013c) examined the influence of globalization on CO2 emission by using data from 1970 to 2010 in Turkey. They confirmed the EKC hypothesis. The findings showed that an increased globalization rate reduced CO2 emissions. Shahbaz et al. (2016) used data from 1971 to 2012 and showed an association between the intensity of energy, globalization, and the carbon emissions nexus in 19 African economies. The study supported the continuation of the EKC hypothesis. By using data from 1970 to 2014, Shahbaz et al. (2017) worked on globalization and CO2 emission in 25 developed nations. The results revealed that globalization increased CO2 emissions. The study found a long-run relationship between carbon emissions, growth, energy, and globalization.

Zafar et al. (2019) analyzed the effect of factors affecting economic growth by using data from 1991 to 2018. It was found that foreign direct investment and trade openness increased CO2 emissions and affected green growth negatively in the countries. The study suggested more research and development on green growth. By using data from 1985 to 2019, Anser et al. (2021) analyzed the relationship between energy usage, globalization, and growth and confirmed the EKC in Bangladesh. The result showed that globalization has increased CO2 emissions. Bilal et al. (2021) used data from 1991 to 2019 to show the effect of technological innovation and globalization on CO2

emissions by controlling for ICT and growth in all regions. Findings showed that technological innovation reduced globalization. ICT increased globalization for OBOR, Europe, and Central Asia. Raihan et al. (2022) analyzed the influences of green energy usage, growth, globalization, and urbanization on CO2 emissions in the United States by using data from 1970 to 2022. The ARDL result indicated that increased green energy reduced CO2 emissions. The results also showed that growth and urbanization increased CO2 emissions.

Chen et al. (2023) showed that patents and environmental innovations were positively related. Financial globalization tended to increase green growth in the BRICS countries. More focus should be placed on R&D activities. Van (2024) concluded that green growth, globalization, and renewable energy consumption affected environmental quality negatively. But economic growth affected CO2 emissions positively. Khan et al. (2026) used data from 1990 to 2022 to check the association between globalization and economic performance in BRICS. The results highlighted that globalization, green growth, financial expansion, urbanization, and trade affected positively the financial progression of BRICS countries.

METHODOLOGY

On the basis of data from 1996 to 2023, we have checked the contribution of economic globalization, education, economic growth, energy consumption, and urban population on CO2 emissions. We have used CO2 emissions as the dependent variable. Data were drawn from nine Asian countries, including Bangladesh, India, Indonesia, Iran, Jordan, Malaysia, Pakistan, Thailand, and the Philippines are selected for the analysis. These countries are chosen based on data availability. Data is taken from WDI.

We have used the unit root test to check the stationarity of the data. On the basis of the test, we have used Panel ARDL analysis to check the relationship between dependent and independent variables.

Model Specifications

The equation is:

$$CO2EM = \beta 0 + \beta 1GLOBZECit + \beta 2EDUCATit + \beta 3\ LGDPPC\ it + \beta 4LENRGC\ it + \beta 5\ URPOPP\ it + uit \quad (1)$$

CO2EM = CO2 emission kt per capita

GLOBZN= KOF Index

EDUCA = Secondary school enrolment

LGDPPC= Log GDP per capita

LENRGC = Log energy consumption per capita

URPOPP= Urban population % total population

ui = (error term)

it= it = (time trend)

The details of the variables are explained in Table 1.

Table 1: Details of the variables.

Variable	Symbol	Description	Source	Time
Environmental Degradation	CO2EM	Environmental degradation	WDI	1996 to 2023
Globalization	GLOBZN	KOF Index (economic)	KOF Swiss Economic Institute	1996 to 2023
Education	EDUCA	Secondary school enrollment	WDI	1995 to 2023
Economic Growth	LGDPPC	Economic growth (gdp per capita)	WDI	1996 to 2023
Urban population	URPOPP	Urban population % total population	WDI	1996 to 2023

RESULTS AND DISCUSSION

The results of the unit root test are explained in Table 3. CO2 EM and GLOBZEC are stationary at a level, while education, GDP per capita, energy consumption, and urban population are non-stationary at a level and become stationary after taking the first difference.

Table 3: Results of Panel unit technique

Variables	Probability	Levin, Lin &Chu t*	IP & Shin W-stat	ADF - Fisher Chi-square	ADF - Fisher Chi-square
CO2 2EM	At level	0.0000	0.0678	0.0292	0.0000
GLOBZEC	At level	0.0003	0.0028	0.0085	0.0084
EDUCAT	At level	0.3594	0.8341	0.4477	0.7331
	At First Difference	0.0000	0.0000	0.0000	0.0000
LGDPPC	At level	0.9828	1.0000	0.9973	1.0000
		0.0000	0.0000	0.0000	0.0000
LENRGC	At level	0.0031	0.3446	0.5683	0.1367
	At First Difference	0.0000	0.0000	0.0000	0.0000
URPOPP	At level	0.3776	0.9226	0.6588	0.0000
	At First Difference	0.0061	0.0003	0.0007	0.0305

In Table 3, descriptive statistics are given.

Table 3: Descriptive Statistics

Variables	Observations	Mean	St. deviation	Minimum	Maximum	Skewness	Kurtosis	Jarque-Bera	Probability
CO2 2EN	252	502127.2	379301.9	14187.62	2238377.0	2.4116	8.3271	542.2401	0.0000
EDUCAT	252	70.7580	18.1940	19.8385	124.3306	-0.6025	3.4484	18.3585	0.0000
GLOBZEC	252	50.1139	17.6919	15.6890	77.3314	-0.0781	1.5606	22.0119	0.0000
GDPPC	252	3432.929	2383.658	552.0771	11445.39	1.1320	4.1049	66.6363	0.0000
ENRGC	252	1125.786	881.0614	135.9485	881.0614	0.9212	2.4737	38.5512	0.0000
URPOPP	252	50.4179	19.4062	19.4062	92.6822	0.4531	1.9652	19.8652	0.0000

On average, CO2EM is 502127.2 percent. The mean value of EDUCA is 70.7580 percent in such countries. Although on average, GLOBLZEC is 50.1139 percent. On average, GDPPC is 3432.929 percent in these countries. However, the mean value of the urban population is 50.4179 percent. Financial Results show that GLOBZEC and EDUCAT are negatively skewed, whereas GDPPC, ENRGC, and URPOP are positively skewed. Jarque-Bera explains that each and every variable of the econometric model is normally distributed with zero mean and constant variance; as a result, it is pointed out that data sets are normally distributed. Panel ARDL Results are given in Table 4.

Table 4: Panel ARDL Long-Run Results

Variables	Coefficients	Standard Errors	t-values
GLOBZEC	0.0049*	0.0015	3.19
EDUCAT	-0.00224*	0.0004	-5.89
LGDPPC	0.6084*	0.0884	6.88
LENRGC	0.5482*	0.1094	5.01
URPOPP	0.00002	0.0015	0.0150

** p<0.05, * p<0.1.

Table 5: Panel ARDL Shot-run Results

Variables	Coefficients	Standard Errors	t-values
COINTEQ01	-0.4778*	0.1005	-4.75
D (GLOBZEC)	-0.0077	0.0056	-1.38
D (EDUCAT)	0.0042 *	0.0018	2.34
D (LGDPPC)	0.0038* * *	0.0020	1.85
D (LENRGC)	-1.4848	1.4397	-1.03
URPOPP	0.1402	0.1686	0.83
C	0.0784	0.0196	4.01

The study result indicates that globalization increases environmental degradation (CO2) in developing economies in the long run, as shown in Table 4. Findings indicate that a one-unit increase in economic globalization results in an increase in environmental degradation by 0.0049 percent in the long run. The reason may be that economic globalization increases CO2 emissions first and foremost by driving rapid industrialization, increasing international transportation, and encouraging the relocation of polluting industries to countries with weaker environmental regulations. The result is favored by Shahbaz et al. (2017).

Education also affects CO2 emissions in developing countries. Finding highlights that education contributes to increasing income inequality in developing countries. Education makes a reduction in CO2 emissions by nurturing environmental awareness, promoting sustainable consumption habits, and driving technological innovation for green energy. The result indicates that a one-unit increase in secondary school enrolment decreases environmental degradation by 0.0022 percent in the long-run in developing economies.

The results show that economic growth also contributes to environmental degradation in developing countries. One percent increase in economic growth results in an increase in CO2 emissions by 0.6084 percent in the long-run in developing economies. The reason may be that GDP enhances CO2 emissions primarily because economic growth historically relies on burning fossil fuels (coal, oil, and gas) for energy to power industrial production, transportation, and electricity generation. As economies expand, higher production levels increase energy consumption and emissions. The result is favored by Raihan et al. (2022).

The role of energy consumption cannot be ignored. It also increases CO2 emissions in these economies. One percent increase in energy consumption leads to an increase in environmental degradation in developing economies by 0.5482 percent in the long-run. The reason may be that energy consumption increases CO2 emissions, as the huge bulk of the world's energy, roughly 80 percent, is generated by burning fossil fuels, which results in carbon emissions. The result is consistent with the study by Van (2024).

Urban population seems to affect the CO2 emission, but the result is insignificant.

Short-run results are given in Table 5. The value of the ECM coefficient is significantly negative, showing long-run co-integration exists between variables, ensuring they return to equilibrium after short-term shocks. It is found that globalization results in a reduction in environmental degradation, but the result is insignificant.

The result also shows that in the short run, education increases environmental degradation by 0.0042 percent in developing countries. The reason may be that education can increase CO2 emissions primarily through the "consumption effect," where higher education levels increase income, higher material demands, and more energy-intensive lifestyles, such as increased travel and larger housing. While education fosters environmental

awareness, it also acts as a driver for economic growth, which can raise emissions if not accompanied by green technology adoption.

Short-run result shows that CO2 emission is increased by increase in GDPPC. The positive coefficient is 0.0038 percent. The reason may be that GDP enhances CO2 emissions primarily because economic growth historically relies on burning fossil fuels for energy to power industrial production, transportation, and electricity generation. As economies expand, higher production levels increase energy consumption and emissions. The result is supported by Raihan et al. (2022). The result of energy consumption and urban population is insignificant in the short run.

CONCLUSIONS

Our research work analyses the factors affecting environmental degradation (CO2) in developing countries. The data covers the period from 1996 to 2023 for this analysis. Explanatory factors were globalization, education, economic growth, energy consumption, and urban population in eight developing countries. We used the panel ARDL method for the analysis. The results highlighted the positive relationship between globalization and environmental degradation in the long run, as supported by Shahbaz et al. (2017). The study results show that education decreases CO2 emissions in developing countries. Moreover, economic growth and energy consumption also increase ecological degradation in the long-run in developing countries. The short-run results also show that education and economic growth enhance environmental degradation in developing countries. The study suggests that reducing CO2 emissions through decreased globalization often involves "re-globalization "policies, including targeted trade restrictions, strengthening local labour markets, and promoting domestic production. The government should provide more educational facilities to the people. More employment chances should be given. As education and female labour force participation reduce income inequality, more education and employment opportunities should be increased in developing countries. Clean energy would reduce emissions by replacing fossil fuels in electricity generation, transportation, and industrial heating with renewable sources like solar, wind, and hydropower.

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