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RESEARCH ARTICLE

Globalization, financial development, and environmental sustainability: evidence from heterogenous income groups of Asia

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Abstract

This study examines the effects of energy use, financial development, and globalization on carbon dioxide emissions for Asian countries comprising the panel data over the period 1990–2017. To account for cross-sectional dependence, Pesaran cross-sectional dependence test is used. The second-generation tests are used to determine the stationarity level of the variables. Furthermore, the Westerlund panel cointegration test confirms cointegration among the variables. For long-run association, fully modified ordinary least squares approach is used. The study also used Dumitrescu and Hurlin's (Econ Model 29:1450-1460, 2012) panel causality test to explore the causal relationship among the variables. The results suggest that financial development contributes to carbon emissions, whereas globalization helps to mitigate emissions. As financial development deteriorates environmental quality, therefore, the government should monitor the disbursement of loans for research and development, green financing, and efficient products that reduce resource consumption and improves environmental quality. Financial development should not compromise environmental quality and endanger sustainability. Such findings show that both renewable energy industries and financial development in the Asian economies are not meeting the maturity level in terms of leading to changes in environmental quality. Furthermore, Asian countries should promote globalization to support the inflow of green technologies to enhance environmental quality.

Keywords Asian countries · CO_2 emissions · Energy use · Financial development · FMOLS globalization

Introduction

Over the past few decades, an increasing consensus has arisen among science, energy, and environmental researchers about the detrimental impact of climate change on individual life, human wellbeing, and the nature of the atmosphere for future generations (Sohail et al. 2021). To avert a major environmental catastrophe, researchers and politicians have stressed to decrease the rising greenhouse gas (GHG) emissions, which are known to be the primary cause of temperature change (Bhattacharya et al. 2017; Pérez et al. 2017). Forest burning, droughts, storms, and flooding in multiple countries are significant factors in the deterioration of the environment (Majeed and Mazhar 2019a). These factors threaten the citizen's lives, infrastructures, natural resources, and agricultural lands.

Globalization is playing a vital role in influencing climate change and global warming. It connects economies all over the world by enhancing trade, foreign direct investment (FDI), capital mobility, and information stream (Grossman and Krueger 1991). Environmental effects of globalization are quite complex. The literature suggests both positive and negative impacts of globalization on environmental quality. On the one hand, it supports technological transfer and diffusion to uplift labor and capital productivity and supports efficient production techniques which help to abate emissions (Sbia et al. 2014). On the other hand, globalization escalates ecological degradation by enhancing production (scale effect) and facilitating transfer of pollution-intensive plants in developing countries (Majeed and Mazhar 2020). Besides, globalization depletes natural resources for industrialization, harming the environment (Wijen and Van Tulder 2011).

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Doytch and Uctum (2016) investigated the effects of globalization on environmental degradation for a global sample of 132 countries over the period 1984–2011. According to their findings, globalization of financial development increases the inflow of investment, which harms the environment and causes environmental degradation. Shahbaz et al. (2019) investigated the relationship between globalization and CO_2 emissions in 87 economies. According to their findings, globalization in high- and middle-income economies reduces CO_2 emissions, whereas globalization has a positive impact on environmental degradation in low-income economies. On the other side, globalization opponents claim that the advantages of globalization are overwhelmingly at the cost of the middle class in developed economies with major political, social, and prosperous consequences, which will remain apparent in periods to come. Le et al. (2016) investigated the effects of trade openness on CO_2 emissions change according to the income level of countries. According to their findings, trade openness has a lower environmental impact in high-income economies than in low- and middle-income economies.

Zhang et al. (2017) reported that trade openness has substantial negative effects on CO_2 emissions in ten recently developed economies. Shahbaz et al. (2018) investigated the globalization-emissions nexus for twenty-five developed countries from 1970 to 2014, using the augmented mean group (AMG) and the common correlated effects means group (CCEMG) approaches to monitor heterogeneity in cross-section panel results. Their results revealed that globalization has a positive impact on environmental degradation. Destek (2019) investigated the effect of political, economic, and social globalization on carbon emissions in the Central and Eastern European countries (CEECs) over the period 1995–2015. They used the AMG technique for long-run estimation and discovered that economic globalization and total globalization increase CO_2 emissions, while policy globalization decreases CO_2 emissions.

The Asia Pacific Economic Cooperation (APEC) member states aim to increase economic growth through transparency, projects for production, digital technologies, and the transition of skills. Several relevant policy alternatives have been built from a realistic point of view to help plan an environmental strategy to minimize the growing emissions of CO_2. In particular, three ideas are of special importance from energy, environmental, and economic point of view: (i) promoting renewable energies, (ii) developing the financial sector, and exploring interactions between GDP growth and (iii) carbon emissions between renewable energy and financial development. The first solution includes the development and extension of efficient, affordable, and economically sustainable alternative energy sources. This will help significantly limit CO_2 emissions and other pollutant forms through clean energy sources (Kahia et al. 2017; Özbuğday and Erbas 2015; Tiwari 2011). Concerning the second proposition, multiple observational studies found that a major role in lowering CO_2 emissions can be played by the financial sector in promoting development advancement in the energy sector (Abbasi and Riaz 2016; Nasreen et al. 2017).

The literature shows that a significant function in the mitigation of CO_2 pollution is played by the relationship between renewable use and financial development (Kim and Park 2016; Brunnschweiler 2010; Sadorsky 2010). Sadorsky (2010) asserts that efficient financial intermediation enables customers to purchase expensive goods such as cars that increase carbon emissions. Brunnschweiler (2010) states that in promoting and enhancing the clean energy industry, corporate banking and credit markets play a competitive role. Kim and Park (2016) have recorded the extremely fast rise in emerging capital markets due to reliance on debt and equity funding in the sustainable sectors.

He et al. (2012) reported that Asian countries are struggling with environmental pollution due to industrial waste streams into rivers which pollute the water which harms the health of Asian people. Acquaye et al. (2017) have pointed out that since the 1990s, industrialized economies and especially ASEAN economies have been faced with environmental degradation because of their factories that produce lots of emissions to the growing economies. According to Ghosh (2018), globalization is causing environmental degradation in low-income Asian countries over the period 1974–2014. Zakaria and Bibi (2019) investigated the relationships between financial growth, institutional quality, and environmental quality and discovered that financial development reduces environmental quality, while institutional quality improves it. Various studies support financial development as it strengthens investments in current, carbon-reducing technology (Shahbaz et al. 2016b; Zafar et al. 2019). This research also involves the state of globalization and CO_2 pollution in the discussion of financial development. With the absence of this crucial element, the reliability of scientific findings may be doubtful.

With this background, the study discusses the influence of energy use, financial development, and globalization on the environmental quality of Asian countries. This study tries to cover two gaps. (I) The analysis aims to fill the methodological literature gap regarding the effect on CO_2 emissions in the Asia region. The analysis of the Asia region is extremely important because most Asian countries are highly energy-intensive, have tremendous renewable (as solar and wind) energy potential, and most of them have enormous funding ability. In this study, the index of financial development and globalization is used to cover the gap instead of using one variable as a proxy for financial development and globalization (trade). Secondly, unlike earlier work that utilizes conventional econometric methods, this analysis uses new second-generation econometric techniques that cover the data complexities such as heterogeneity.

The remainder of the paper is arranged in the order below. The second section includes a literature review, the third and fourth sections discuss the methodology and data description. The fifth section discusses results and discussion. The sixth section describes the conclusion.

Literature review

Renewable energy and Co_2 emissions

A vigorous discussion about the rapid growth of renewable energy and its effect on the environmental condition has been sparked over the last two decades (Al-Mulali et al. 2015; Moutinho and Robaina 2016; Kahia et al. 2016). Through a view of environmental change, the use of renewable energy sources has extensively been recognized for having a beneficial impact on environmental conditions by decreasing the amount of atmospheric GHG emissions (Bölük and Mert 2014; Bhattacharya et al. 2017). Furthermore, according to the 2013 OECD report[1], investments in renewable energy sources are also considered to be less carbon-intensive compared with conventional energy. Countries will thus boost the quality of the environment by boosting the use of renewable energy and create a global green and clean environment system. The creation of renewable energy sources, however, provides many economic and energy benefits from an environmental perspective (Dai et al. 2016; Spiegel-Feld et al. 2016). Such economic assistances include, but are not limited to, addressing many problems, for example, energy stability, diversification of the energy mix portfolio, foreign currency outflow, and unemployment, as the renewable energy sector is more labor-intensive compared to the non-renewable energy sector (Blazejczak et al. 2014; Mu et al. 2018). Investing in renewable energy would allow oil-importing economies to lessen their reliance on outside oil (Kahia et al. 2017). It would, however, boost technology transfers and economic diversification for oil-exporting countries, as well as sustain hydrocarbon export revenues (Kahia et al. 2016).

Pao and Tsai (2010) investigated the relationship between energy usage, economic growth, and environmental degradation. According to the findings, the use of energy and economic growth promotes environmental degradation in the BRICS economies. Using GMM, Jaunky (2011) investigated the impact of income on environmental degradations in thirty-six high-income economies from 1980 to 2005. According to their findings, income has a positive impact on CO_2 emissions. Saboori and Sulaiman (2013) investigated the effect of energy usage and economic growth on environmental degradations between 1980 and 2009. Malaysia's economic growth and energy consumption harm environmental degradation. Majeed et al. (2021) examined the asymmetric effects of energy usage and economic growth on ecological footprint for Pakistan over the period 1971–2014. Their findings suggested mixed effects depending upon the form of energy use. Energy usage in the form of oil disrupts the environment, while its usage in the form of gas improves environmental quality. Generally, empirical results are mixed and tend to rely on the time series or panel data econometric techniques applied, the country/country economic attributes studied, and the period of study. For example, various research studies have shown the indication of a two-way correlation between renewable energy and carbon emissions and between renewable energy and output growth (Apergis and Payne 2014) for seven Central American countries (Moutinho and Robaina 2016) and study for Caribbean and Latin America countries. Some empirical studies have also established the unidirectional causality between CO_2 emissions, renewable energy, and output growth (Adewuyi and Awodumi 2017). Additionally, several other studies have proved that renewable energy use is an effective approach for sustainable growth and improvements in ecological quality (Bölük and Mert 2014) for sixteen European Union countries; Bhattacharya et al. (2017) studied this for eighty-five advanced and emerging economies, and Ito (2017) considered this for forty-two underdeveloped economies.

Financial development and CO_2 emissions

In particular, the central position that financial progress plays in promoting economic growth is widely accepted by scholars. There is no question now that financial development is an important part of economic growth as it enables capital to accumulate by combining and mobilizing investments, refining the requisite knowledge on investment activities, and allocating capital optimally. While development in the financial sector is important for economic growth in a region, its negative impacts on the economy, energy use, GDP, and environmental quality cannot be overlooked (Charfeddine and Khediri 2016). Mallick and Mahalik (2014) investigated the impact of financial development on CO_2 emissions. They noted that financial development helps to reduce CO_2 emissions because financial development contributes to the use of less-energy-consuming technology, which reduces energy consumption as well as CO_2 emissions. Katircioğlu and Taşpinar (2017) investigated the effects of financial development in combination with other factors on environmental degradation in Turkey. Financial growth drives economic development, while economic growth and energy use are the primary contributors to CO_2 emissions. Sadorsky (2010) demonstrates that financial innovations, which represent the real accessibility for productive activities of financial capital and financing mechanisms for banks and stock market ventures,

[1] https://www.oecd.org/daf/inv/investment-policy/CleanEnergyInfrastructure.pdf

will play a positive and crucial role to counter environmental degradation, especially through reductions in carbon dioxide emissions. The environmental loss falls from this angle, with financial changes. However, financial development will typically begin with research and development (R&D), draw FDI, and stimulate economic activities, to impact environmental efficiency through investments in green-related projects (Tamazian and Rao 2010; Charfeddine et al. 2018). Nasreen et al. (2017) investigated the impact of financial progress, economic growth, energy use, and population on environmental quality. According to the findings, financial growth reduces environmental degradation, while energy usage, economic development, and population density all have a positive impact on environmental degradation. Haseeb et al. (2018) studied the effects of energy use, financial growth, globalization, economic development, and urbanization on environmental degradation in the BRICS countries. Energy use and financial development have a positive impact on environmental deterioration, while globalization and urbanization have a negligible and insignificant impact. Majeed and Mazhar (2019b) explore the environmental effects of financial development for a panel of 131 countries over the period 1971–2017. Their findings show that financial development supports environmental quality by reducing the ecological footprint. However, energy use, FDI, and GDP per capita deteriorate environmental quality.

A well-developed financial sector lowers the cost of financing, boosts innovation, and curbs the proliferation of carbon pollutants by improving energy efficiency (Majeed and Mazhar 2019b; Charfeddine 2017). Empirically, the effect of financing production on CO_2 emissions and economic growth is not accepted by the researchers. The most significant elements of previous studies are different causal directions between financial production, CO_2 emissions, and growth. In different studies, financial development has been unidirectional correlated to economic growth by Sadorsky (2011) for 9 countries in Central and Eastern Europe and by Al-Mulali and Sab (2012) for sub-Saharan Africa. A significant number of scholars, including Salahuddin et al. (2015) and Bekhet et al. (2017), find support for one-way causality from financial development to carbon emissions.

For instance, Boutabba (2014) and Al-Mulali et al. (2015) recorded a significant contribution to financial development in environmental deterioration in India and for the panels of twenty-three European countries from 1990 to 2013. The contributions of financial development to CO_2 emissions have also been tracked for Malaysia by Bekhet and Othman (2017) by using the ARDL technique and claim that financial development tends to increase CO_2 emissions. Pata (2018) followed an identical strategy for Turkey and developed that the EKC theory validated financial development in terms of carbon emissions.

Zakaria and Bibi (2019), using their panel data technique, analyzed the linkages between political, institutional, and environmental efficiency, demonstrating that financial development substantially lowers the quality of the environment and institutional quality is the reverse of it. More recently, the panel vector autoregressive (PVAR) approach was used by Charfeddine and Kahia (2019) in twenty-four MENA countries and found that financial development plays a positive contribution towards accelerating carbon emission level. Majeed et al. (2020) explore linear and nonlinear effects of financial development on CO_2 emissions in Pakistan using time series data over the period 1972–2018. The ARDL estimates show that financial development escalates CO_2 emissions, while nonlinear ARDL estimates show that it does not confirm a positive and significant association between financial development and CO_2 emissions. Samreen and Majeed (2020) investigated the effect of financial development on carbon emissions including economic growth, industrial growth, and renewable energy consumption as control variables for 89 developed and developing countries over the period 1992–2014. The results of their study reveal heterogenous effects of financial development emissions according to income group of countries. In particular, financial development mitigates emissions in developed economies while escalate emissions in developing countries.

Globalization and carbon emissions nexus

The literature on the correlation between globalization and CO_2 emissions is scarce. Lee and Min (2014) investigated this relationship with panels from 1980 to 2011 and stated that globalization tends to decrease environmental degradation. In a panel study of 166 economies for the timeframe 1990–2009, Bu et al. (2016) find that globalization plays an active part in environmental degradation, but the impact on both OECD and non-OECD economies is significantly different.

By using ARDL and pooled mean group (PMG), Shahbaz et al. (2016a, b) suggest that globalization is decreasing the level of CO_2 pollution in African countries, but the findings for each nation are different. The relation for India was explored in another analysis that found a negative impact on environmental quality by globalization. Solarin et al. (2017) also measured globalization through the Trans-Pacific Partnership Agreement (TPP) and examined its environmental quality impact by using data from Malaysia from the 1970–2014 period. Their findings from ARDL and FMOLS methods have shown that globalization is significantly playing its role in increasing CO_2 emission increase. During the 1985–2013 era, You and Lv (2018) checked connections with data from 83 countries. They claim that the pollution of carbon had spillover impacts on neighboring countries. Its spatial regression findings indicate that economic globalization has had a detrimental effect on CO_2 emissions.

The methodology for dynamic seemingly unrelated regression (DSUR) is used by Haseeb et al. (2018) and has been analyzing relations between 1995 and 2014 with BRICS economies, including globalization, financial development, and the usage of energy, urbanization, and CO_2 emissions. They have reported a null association in globalization with CO_2 emissions for the BRICS countries. Time series data have demonstrated that globalization, on the one side, is significantly improving the environmental quality of the countries Brazil, China, and South Africa while on the other side is significantly accelerating CO_2 emissions in Russia and India.

The globalization-emissions link for twenty-five developing countries was also tracked by Shahbaz et al. (2018) for the timeframe 1970–2014. Their results show that globalization has a significant effect on the deterioration of the climate, while the same result is observed by Xu et al. (2018) for Saudi Arabia from 1971 to 2016.

Salahuddin et al. (2019) have examined the links between globalization, planning, and quality of the environment in sub-Saharan African economies. However, the conclusions of their panel analysis did not indicate any major impact of globalization on environmental sustainability. Destek (2019), by covering the yearly periods of the Central and Eastern European countries (CEECs), has identified an effect of social-political and economic globalization on carbon emissions. They noticed that economic and social globalization tends to increase, while political globalization tends to decrease CO_2 emissions. Majeed and Mazhar (2020) investigated the effects of trade ecological footprint from 1961 to 2018 for a sample of 20 high-income countries, 36 middle-income countries, and 20 low-income countries. The FMOLS results show that trade supports environmental quality in the high- and low-income countries while degrades the environment in middle-income countries.

Empirical model

The globalization debate is not new, and scholars have been studying the impact of globalization for years, including Grossman and Krueger (1991), who researched the North American Free Trade Agreement (NAFTA) and addressed the scale effect, the effect of technique, and the compositional effect of globalization. The consequence of scale is as demand rises, foreign trade and investment also increase.

When manufacturing and trade activities are increasing, so many systemic changes take place as the impact of globalization entails increased emissions, ceteris paribus (Dreher 2006). With the impact on composition, higher production contributes to higher investments that lead to environmental harm, as pollute-causing production is a source of income for investors. As economic stability stabilizes with production size, the technological impact of globalization is observed.

When new manufacturing techniques and innovations will be adopted/accepted, the frameworks and economies of scale, foreign trade, and investment will minimize per-unit carbon emissions (Shahbaz et al. 2016a, b, c). Financial development is another determinant of our CO_2 emissions in this report. The development and expansion of finance play a significant role in any country's carbon emissions. Sadorsky (2011), for example, argued that financial development involves buyers' scope to sustainability and goods' durability that intensify energy use and environmental degradation. A strengthened financial structure raises funds and helps the corporate community to grow its activities and production potential with increased demand for goods and services (Charfeddine and Khediri 2016).

Several authors used various proxy variables to measure financial development but use the proxy measure proposed by Shahbaz et al. (2018) to measure the effects of CO_2 emissions on France. We also use economic energy use (kg of oil equivalent per capita) and growth since, without these factors, the consequences of globalization and financial development cannot necessarily be properly considered.

For example, Ahmad et al. (2016) for the Indian economy, Begum et al. (2015) for Malaysia, Pao and Tsai (2010) in respect of BRICS, Ozturk and Acaravci (2010) in Turkey, and Sinha and Shahbaz (2018) in respect of India have addressed extensively the relationship between economic growth and carbon emission. Different studies like Sekantsi et al. (2016) and Khan et al. (2019) examined the relationship between economic growth on CO_2 emissions; Shahbaz et al. (2016a, b, c) investigated the effects of financial development on environmental degradations; Shahbaz et al. (2016a, b, c) analyzed the association of globalization and environmental degradations; Majeed and Mazhar (2019b), Abbasi and Riaz (2016), Charfeddine and Khediri (2016), and Sadorsky (2011) examined the impact of financial development along with energy use on environmental degradations. Following Sadorsky (2010), Topcu and Payne (2017), Destek (2018), and Shahbaz et al. (2018) following functions are performed to estimate carbon emission:

$$CO_2 = F(GDP, FD, EU, Glob) \quad (1)$$

We take the natural log of all variables to reduce the sharpness of the data. The log-linear model provides empirically accurate, effective outcomes in comparison to a linear transformation. The main problem in data is multicollinearity and heteroscedasticity. To control these issues, data is converted into a log form. After the log transformation, the model can be rewritten as,

$$lCO_{2it} = \propto_0 + \propto_1 lGDP_{it} + \propto_2 lFD_{it} + \propto_3 lEU_{it} + \propto_4 lGlob_{it} + \varepsilon_{it} \quad (2)$$

Table 1 List of selected Panel of Asian countries

Afghanistan	China	Japan	Malaysia	Qatar	Turkmenistan
Armenia	Cyprus	Jordan	Maldives	Saudi Arabia	UAE
Azerbaijan	Georgia	Kazakhstan	Mongolia	Singapore	Uzbekistan
Bahrain	India	Republic of Korea	Myanmar	Sri Lanka	Vietnam
Bangladesh	Indonesia	Kuwait	Nepal	Tajikistan	Yemen”
Bhutan	Iran, Islamic Republic	Kyrgyz Republic	Oman	Thailand	
Brunei Darussalam	Iraq	Lao People’s Democratic Republic	Pakistan	Timor-Leste	
Cambodia	Israel	Lebanon	Philippines	Turkey	

where i refers to the countries involved for estimation (1, 2 ..., N), t shows the analysis period (1990–2017), and α refers to coefficients $\alpha1$, $\alpha2$, $\alpha3$, and $\alpha4$ which are the coefficients of GDP, EU, Glob, and FD, and ε_{it} is the error term.

Panel data techniques neglect to consider the cross-sectional dependency of cross-section results. Consequently, second-generation panel data methodologies are more appropriate following the validity of cross-sectional dependency.

Pesaran (2007) proposed the cross-sectionally augmented ADF (CADF) for the regression of cross-sectional units by cross-sectional means with lagging values and time series variations. That is written as follows:

$$\Delta y_{it} = \alpha_i + \rho_i y_{it-1} + \beta_i y_{t-1} + \sum_{j=0}^{k} \Upsilon_{ij} \Delta y_{it-1} + \sum_{j=0}^{k} \delta_{ij} y_{it-1} + \varepsilon_{it} \quad (3)$$

where αi is the deterministic term, k is the order of lag, and yt is the cross-sectional meantime. According to Pesaran (2007), this method allows cross-sectional dependence across the countries observed, and findings are also consistent, even if the sample size is limited. Compared with the cross-sectionally augmented IPS (CIPS) statistics determined using CADF statistics, the critical values of CIPS statistics (given in Pesaran (2007)) are

$$CIPS = \left(\frac{1}{N}\right) \sum_{i=1}^{N} t_i(N, T) \quad (4)$$

Pedroni and Kao’s tests are not preferred in the existence of dependency. The Westerlund cointegration method (Westerlund 2007) aims to find cointegration between the variables. Group statistics examine the cointegration within a cross-sectional segment, while panel statistics examine the cointegration presence within the whole sample. A fully modified ordinary least square test is applied to successfully address and minimize the endogeneity problem of the series and to find out the long-run relationship.

To identify probable causal linkages between the variables used in the study, Dumitrescu and Hurlin (2012) used the heterogeneous panel causality method. This test is simply described as the modified non-causality test by Granger (1981). This approach is valuable as it provides consistent results. The null hypothesis shows that there is no homogeneous causality in the panel.

Data

This research aims at finding links between globalization, financial development, and carbon emissions, taking the additional determinant of energy consumption and economic

Table 2 Variable definition and sources

Variable	Symbol	Measure	Source	
CO_2 emission	CO_2	CO_2 emissions released by gas, coal, oil, biomass, and fuel wood	Metric tons per capita	World Bank (2019)
GDP per capita	GDP	GDP divided by one-half year of the population	Constant 2010 US $	World Bank (2019)
Energy Consumption	EU	Energy consumption from oil, gas, coal, hydropower, nuclear, and renewable energy sources	Kilograms of oil equivalent per capita	World Bank (2019)
Financial Development	FD	The financial development is measured with the total sum of domestic credit provided by the financial sector (% of GDP), domestic credit to the private sector (% of GDP), and domestic credit to the private sector by banks (% of GDP)	Index	World Bank (2019)
Globalization	Glob	Globalization is measured with economic, social, and political indices as defined by Dreher (2006)”	Index	KOF index (Dreher 2006)”

Table 3 Descriptive statistics and correlation

Asia	LCO_2	LGDP	LEU	LFD	LGlob
Descriptive statistics					
Mean	0.9066	8.2607	4.9960	−0.0284	3.9136
Std. Dev.	1.6168	1.5004	0.7390	1.0084	0.3326
Correlation matrix					
LCO_2	1				
LGDP	0.8758	1			
LEU	−0.0557	−0.2536	1		
LFD	0.5356	0.5293	−0.0411	1	
LGlob	0.6011	0.6505	−0.4706	0.5826	1

growth. This study includes 45 countries' panels in the Asia region from 1990 to 2017. The list of selected panels of Asian countries is given in Table 1. The Asia region is classified according to the classification of the World Development Indicator (WDI). This study has analyzed the Asia region according to the region-wise and income-wise classification. According to region-wise classification, there are 5 Central Asian, 8 South Asian, 11 Southeast Asian, 17 West Asian, and 4 East Asian countries included, while 13 high-income, 12 high-middle-income, 17 low-middle-income, and 3 low-income countries are included on income-wise classification. The data of financial development, CO_2 emissions, GDP, and energy use are taken from the World Development Indicator (World Bank 2019), and globalization is taken from Dreher (2006). To examine the internal consistency of the variables used for index construction, Cronbach alpha is calculated, and the value of alpha is 0.77, suggesting higher internal consistency. The details of the variables used in this study are outlined in Table 2.

Descriptive statistics

Table 3 shows the descriptive and correlation statistics for all variables used in the analysis. The table shows that the mean value of CO_2 emission is 0.9066 and the standard deviation is 1.6168. The mean and standard deviation of GDP per capita standard deviation is 8.2607 and 1.5004, respectively. Energy use and financial development mean values are 4.9960 and −0.0284, and the standard deviation is 0.7390 and 1.0084, respectively. The mean value of globalization is 3.9136, and the standard deviation is 0.3326. Table 3 also indicates the correlation between the variables used in the model. The frequency and direction of a linear relationship between the two or more variables are calculated. The correlation value ranges from −1 to +1. This table indicates a GDP ratio per capita of 0.8758, which suggests a strong association between the two. The remaining all variables also reflect a strong relationship between CO_2 emissions.

Table 4 CD test results

		LCO_2	LGDP	LEU	LFD	LGlob
Asia	Pesaran's test of cross-sectional independence	−0.9910	8.996***	34.250***	4.124***	51.066***
	Average absolute value of the off-diagonal elements	0.385	0.465	0.371	0.320	0.455
Western Asia	Pesaran's test of cross-sectional independence	−0.153	1.300	0.689	8.781***	27.902***
	Average absolute value of the off-diagonal elements	0.267	0.259	0.302	0.299	0.523
Southeast Asia	Pesaran's test of cross-sectional independence	−0.525	8.070***	6.318***	−1.235	5.611***
	Average absolute value of the off-diagonal elements	0.392	0.511	0.481	0.407	0.360
South Asia	Pesaran's test of cross-sectional independence	4.221***	0.092	1.461	0.858	6.818***
	Average absolute value of the off-diagonal elements	0.277	0.461	0.249	0.228	0.425
East Asia	Pesaran's test of cross-sectional independence	−1.114	−2.625***	−2.475***	−1.839**	1.995**
	Average absolute value of the off-diagonal elements	0.232	0.339	0.409	0.625	0.474
Central Asia	Pesaran's test of cross-sectional independence	−0.724	0.191	−2.833***	0.749	10.188***
	Average absolute value of the off-diagonal elements	0.275	0.409	0.530	0.221	0.609
Upper income	Pesaran's test of cross-sectional independence	−2.781***	0.754	1.872**	0.378	21.260***
	Average absolute value of the off-diagonal elements	0.296	0.353	0.301	0.363	0.507
Upper middle-income	Pesaran's test of cross-sectional independence	−0.702	2.268***	−0.530	1.721**	12.122***
	Average absolute value of the off-diagonal elements	0.307	0.331	0.357	0.352	0.431
Lower middle-income	Pesaran's test of cross-sectional independence	−0.146	16.663***	8.751***	0.022	8.769***
	Average absolute value of the off-diagonal elements	0.389	0.406	0.400	0.329	0.390
Low-income	Pesaran's test of cross-sectional independence	−1.815**	0.091	−1.477	−0.611	6.869***
	Average absolute value of the off-diagonal elements"	0.298	0.326	0.453	0.083	0.530

Note: Null hypothesis; no cross-sectional dependence, level of significance is *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 5 CIPS and CADF test results

	IPS			ADF		
	Level	Diff	Decision	Level	Diff	Decision
Asia						
LCO_2	1.5038	−17.0932***	I (1)	−1.8738***	−20.1455***	I (0)
LGDP	7.7630	−14.1937***	I (1)	1.6001	−24.1910***	I (1)
LEU	4.0725	−18.3529***	I (1)	3.7501	−25.7528***	I (1)
LFD	−0.1704	−18.1614***	I (1)	−1.4456**	−25.8222***	I (0)
LGlob	−1.9839***	−21.5658***	I (0)	−2.9226***	−29.3858***	I (0)
Western Asia						
LCO_2	−1.6225**	−11.4305***	I (0)	−6.5891***	−13.2813***	I (0)
LGDP	−0.6391	−9.7877***	I (1)	−4.9573***	−23.0979***	I (0)
LEU	0.6281	−11.8778***	I (1)	0.4496	−19.2137***	I (1)
LFD	0.7793	−10.6458***	I (1)	−0.4530	−17.8060***	I (1)
LGlob	−0.4706	−13.2134***	I (1)	0.0088	−20.1054***	I (1)
Southeast Asia						
LCO_2	3.1837	−8.1354***	I (1)	2.7357	−9.6614***	I (1)
LGDP	6.4932	−7.0802***	I (1)	4.3690	−8.0497***	I (1)
LEU	1.3843	−8.6850***	I (1)	1.8866***	−10.8548***	I (0)
LFD	−0.8744	−8.7539***	I (1)	−2.2209***	−14.0727***	I (0)
LGlob	−1.4720**	−9.5199***	I (0)	−2.1583***	−11.8454***	I (0)
South Asia						
LCO_2	3.4269	−7.5796***	I (1)	3.2371	−8.2513***	I (1)
LGDP	7.3365	−6.8276***	I (1)	4.8684	−6.3247***	I (1)
LEU	2.4482	−8.6245***	I (1)	2.6168	−11.3657***	I (1)
LFD	1.0136	−8.0775***	I (1)	1.2167	−9.0614***	I (1)
LGlob	1.2194	−8.8968***	I (1)	1.0355	−10.8475***	I (1)
East Asia						
LCO_2	−0.5180	−4.0843***	I (1)	−1.5079**	−4.7963***	I (0)
LGDP	1.0246	−3.8236***	I (1)	0.5530	−6.0768***	I (1)
LEU	2.5810	−4.2842***	I (1)	2.4838	−4.6836***	I (1)
LFD	1.3050	−5.0925***	I (1)	1.5455	−4.8268***	I (1)
LGlob	−0.8998	−6.5128***	I (1)	−1.8811***	−8.8402***	I (0)
Central Asia						
LCO_2	−1.0903	−4.8956***	I (1)	−0.2841	−7.3699***	I (1)
LGDP	4.6399	−1.9754***	I (1)	1.2554	−5.0991***	I (1)
LEU	3.6010	−5.5338***	I (1)	2.2232	−7.7352***	I (1)
LFD	−3.1004***	−7.0978***	I (0)	−3.1610***	−8.5627***	I (0)
LGlob	−3.6380***	−9.1339***	I (0)	−5.3362***	−12.6187***	I (0)
Upper income						
LCO_2	−1.7580***	−9.7884***	I (0)	−6.6794***	−12.9665***	I (0)
LGDP	−2.4217***	−9.0862***	I (0)	−6.7043***	−17.9951***	I (0)
LEU	1.6237	−10.6346***	I (1)	2.3701	−16.0330***	I (1)
LFD	0.3445	−9.1839***	I (1)	−0.0587	−16.6123***	I (1)
LGlob	−0.0936	−10.6647***	I (1)	0.2737	−16.0506***	I (1)
Upper middle-income						
LCO_2	−0.7280	−9.8050 ***	I (1)	−1.5228**	−12.2207***	I (0)
LGDP	3.0010	−7.9037 ***	I (1)	1.7950	−16.3283***	I (1)
LEU	1.0332	−9.7854 ***	I (1)	0.5540	−15.0487***	I (1)
LFD	−0.1496	−9.3737 ***	I (1)	−2.3941***	−10.8286***	I (0)

Table 5 (continued)

	IPS			ADF		
	Level	Diff	Decision	Level	Diff	Decision
LGlob	−1.5257	−12.9034 ***	I (1)	−2.4391***	−17.0174***	I (0)
Lower middle-income						
LCO_2	4.7698	−9.2031***	I (1)	3.7822	−10.0235***	I (1)
LGDP	12.0139	−6.4992***	I (1)	6.0777	−7.4525***	I (1)
LEU	4.0290	−9.9419***	I (1)	3.2049	−11.4016***	I (1)
LFD	0.4422	−10.8034***	I (1)	−0.0987	−15.2639***	I (1)
LGlob	−1.9195***	−11.9435***	I (0)	−2.6222***	−15.7623***	I (0)
Low-income						
LCO_2	0.5751	−4.1736***	I (1)	1.1332	−3.0731***	I (1)
LGDP	1.9448	−4.4050***	I (1)	2.5410	−4.8855***	I (1)
LEU	1.3090	−5.5886***	I (1)	1.4905	−8.6922***	I (1)
LFD	−1.7059**	−6.6448***	I (0)	0.0538	−8.8767***	I (1)
LGlob	0.0537	−6.5306***	I (1)	−0.7018	−8.9360***	I (1)

The first step is to determine the existence of cross-sectional dependency in the countries selected. The cross-sectional dependence test results are shown in Table 4 based on their region and income level. The Asian region consists of five groups and four levels of income. The findings indicate that Asian countries are vulnerable to cross-sectional dependency. In other countries, this means that a shock can also easily affect other countries.

Following the investigation of cross-sectional dependence, the variables' stationarity is examined. Since cross-sectional dependency exists, the first-generation non-stationarity tests are unreliable, so we used the second-generation IM Pesaran and Shin tests recommended by Pesaran (2007). This approach has the advantage of controlling cross-sectional dependency while testing the order of integration. Using the appropriate stationarity tests increases the reliability of reports. For measuring stationarity, the analysis used two methods: (1) cross-sectionally augmented IPS (CIPS) and (2) cross-sectionally augmented ADF (CADF). CIPS and ADF tests are used based on cross-sectional dependency in Table 5 for evaluating the unit root test. All variables have unit roots, besides globalization at a level form. The tests are also beneficial when the CIPS and ADF root testing are carried out for the first difference. The null hypothesis shows a strong rejection of the unit root.

The third step is to verify the cointegration based on its classification according to the income level and regional location. With one lag and lead, the Westerlund cointegration test was used. The lead and lag are chosen using Akaike's information criteria (AIC). The Westerlund test's H0 (Null) of no cointegration has been rejected. The null hypothesis of no cointegration is tested by the Westerlund test, which involves

Table 6 Results of Westerlund cointegration test

	Gt	Ga	Pt	Pa
Asia	−3.039*	−4.470	−16.689***	−7.917**
Western Asia	−3.110	−6.153	−11.457***	−9.894**
Southeast Asia	−2.918	−2.549	−8.319	−9.069
South Asia	−3.271**	−5.492**	−8.393**	−9.350*
East Asia	−2.366	−3.218	−2.719	−3.263
Central Asia	−3.226**	−2.341**	−5.583**	−4.686 *
Upper income	−2.611	−5.207	−10.180	−10.206
Upper middle-income	−3.226***	−4.645	−10.926***	−10.962**
Lower middle-income	−3.028	−3.326	−6.597	−5.057
Lower income	−3.655	−5.604	−5.225*	−11.855*

Note: Null hypothesis; no cointegration, level of significance is *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7 FMOLS estimates

	Asia	Western Asia	Southeast Asia	South Asia	East Asia	Central Asia	Upper income	Upper middle-income	Lower middle-income	Lower income
LGDP	0.86***	0.98***	0.52***	1.36***	0.59***	0.60***	0.62***	0.85***	0.85***	1.64***
	185.14	93.86	116.47	83.64	77.76	34.24	49.07	175.61	78.48	49.10
LEU	0.72***	0.78***	0.64***	0.60***	1.44***	0.35***	0.76***	0.69***	0.87***	0.25***
	118.19	98.92	59.62	18.11	39.11	25.84	75.74	94.56	40.94	5.53
LFD	0.10***	0.07***	0.14***	0.15***	0.01***	0.05***	0.19***	0.02***	0.07***	0.18
	22.61	5.66	30.06	9.36	−5.34	5.74	8.87	20.03	11.39	0.36
LGlob	0.02***	−0.06***	0.01***	0.24***	0.56***	−0.51**	−0.57***	0.25***	0.49***	−0.76*
	8.09	−5.71	16.84	12.09	−3.46	−2.35	−18.99	18.04	12.53	1.67

Note: Level of significance is *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

"inferring if the error correction term in a conditional panel error correction model is equal to zero" (Persyn and Westerlund 2008). The other hypothesis is based on the individual test. The alternative hypothesis for the group mean tests (Gt and Ga), which are that at least one unit has been cointegrated, is also examined in the panel testing (Pt and Pa), which also suggests that the panel has been cointegrated. In Table 6, panel cointegration test results report the rejection of the null hypothesis. That gives evidence of the existence of cointegration. Overall, we concluded that carbon emission GDP per capita, energy use, financial development, and globalization indicators are cointegrated.

In the fourth stage of our analytical study, FMOLS is applied to examine the effects on carbon emission. Table 7 shows the results of FMOLS. The results show a positive significant impact of all the indicators used in the study according to the region- and income-wise except financial development and globalization in the case of lower-income countries.

The main share of energy usage is in the production sector. The relationship of energy usage with the production process is positive. The developing countries focus is on the development side, and they cannot afford the economic-friendly technologies due to a lack of information and resources. The industrial sector often ignores the level of emissions for their higher production, and the consumption of energy also increases with their increase in production. On one side, this leads to higher economic growth, which helps to raise the GDP per capita, but along with this, emission level also increases. When the proportion of conventional energy consumed exceeds the proportion of renewable energy, environmental pollution occurs. Traditional energy generates more emissions because it is derived from fossil fuels, which when burned release higher concentrations of carbon dioxide into the atmosphere, endangering environmental quality. Our findings agree with those of Ozturk and Acaravci (2010), Majeed and Mazhar (2019b), and Phong (2019).

The GDP per capita coefficient is positive and important, indicating that rising per capita GDP is correlated with environmental degradation. When the manufacturing process is inefficient, an increase in income contributes to a deterioration in environmental quality. Our findings are consistent with those of Majeed and Tauqir (2020), Zafar et al. (2019), and Solarin et al. (2017).

On the other side, globalization has increased all those activities by investing in these regions that have increased environmental degradation. For lower-income economies that has a detrimental effect on carbon emission, the results are consistent with Doytch and Uctum (2016) and Zhang et al. (2017) empirics.

The positive, significant nexus of CO_2 emissions with financial development shows that financial sectors have not attained a maturity level in the allocation of financial resources

Table 8 Panel heterogeneous causality results

	LCO_2	LGDP	LEU	LFD	LGlob
Asia					
LCO_2		12.0162***	21.4779***	11.7416***	27.3798***
LGDP	6.3852***		9.0547***	7.1575***	28.1353***
LEU	19.9648***	23.8985***		10.0197***	14.5844***
LFD	17.4448***	30.4077***	14.3554***		35.4089***
LGlob	8.5528***	10.0943***	8.8027***	14.2513***	
Western Asia					
LCO_2		6.5237***	12.7890***	7.8464***	7.5978***
LGDP	11.9714***		15.5737***	7.5030***	17.6914***
LEU	13.0508***	15.6250***		2.3694***	6.2954***
LFD	11.3622***	7.8824***	15.6592***		8.6072***
LGlob	8.7794***	3.1752***	6.6221***	15.3635***	
Southeast Asia					
LCO_2		7.1293***	14.2599***	11.3973***	20.9154***
LGDP	2.8860***		3.4443***	3.4598***	8.8096***
LEU	4.6542***	10.1783***		8.2368***	13.6936***
LFD	6.0001***	34.2237***	17.7657***		4.2032***
LGlob	4.5679***	6.9173***	3.8586***	3.7667***	
South Asia					
LCO_2		3.5215***	4.6347***	3.8687***	24.1181***
LGDP	6.4824***		5.5186***	5.7556***	5.4264***
LEU	5.5780***	16.0247***		6.0376***	5.0412***
LFD	5.4907***	6.0628***	4.5191***		16.4437***
LGlob	3.5942***	3.6641***	3.6267***	6.0467***	
East Asia					
LCO_2		9.3718***	7.5802***	0.1094	4.3449***
LGDP	5.3551***		4.8669***	0.3653	3.2814***
LEU	18.9057***	8.7514***		0.7088	2.2993***
LFD	10.8923***	14.1340***	6.0481***		92.8831***
LGlob	3.2730***	3.1038***	2.0779***	1.2870	
Central Asia					
LCO_2		2.9650***	7.6414***	0.4864	5.1677***
LGDP	5.4918***		3.1160***	7.5042***	30.3188***
LEU	5.4164***	7.6764***		6.6428***	3.4009***
LFD	5.7963***	9.7086***	2.0809***		4.6293***
LGlob	18.5338***	9.4025***	3.6001***	0.6796	
Upper income					
LCO_2		6.6197***	15.6445***	6.2737***	11.6031***
LGDP	6.5004***		5.8991***	1.3471	10.7053***
LEU	11.1966***	7.2137***		3.7607***	9.3931***
LFD	7.9222***	3.6229***	7.9449***		53.5087***
LGlob	6.8530***	4.2810***	5.9382***	2.1062***	
Upper middle-income					
LCO_2		5.7820***	4.7215***	2.0755***	0.9326
LGDP	5.1086***		4.2519***	5.0852***	29.0276***
LEU	11.0557***	13.5069***		6.6834***	4.1782***
LFD	13.8821***	8.0189***	4.1408***		5.2668***
LGlob	6.5205***	4.3124***	3.6790***	4.9876***	

Table 8 (continued)

	LCO_2	LGDP	LEU	LFD	LGlob
Lower middle-income					
LCO_2		8.2521***	18.1352***	11.0558***	27.8905***
LGDP	3.5205***		4.1251***	2.7482***	8.7141***
LEU	12.2874***	18.5346***		3.8493***	11.2414***
LFD	5.1726***	35.0769***	11.6138***		7.2449***
LGlob	1.9119***	7.1797***	5.9077***	5.8979***	
Lower income					
LCO_2		10.4487***	9.5825***	3.8135***	17.7533***
LGDP	3.4962***		4.2020***	6.2316***	3.3122***
LEU	3.1739***	6.8324***		5.3815***	3.5265***
LFD	8.2303***	14.9653***	4.6424***		9.7149***
LGlob	7.8972***	6.8169***	3.7674***	5.4074***	

Null hypothesis; no causality, level of significance is *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, respectively

for environmental projects. They are using conventional, inefficient technologies for the production of goods and services. Financial development in countries in which this sector is in an early stage is not proved helpful to environmental quality. These findings are compatible with the different studies. For example, Haseeb et al. (2018) for BRICS, Abbasi and Riaz (2016) in Pakistan, and Xiong et al. (2017) in the emerging regions of China studies also find the same results. Sufficient growth, commercialization, and investment incentives for the private sector will mitigate unemployment and promote advancement in developmental projects.

Causal relationships should also be explicit to better understand the connection between the dependent and separate variables. Thus, the Dumitrescu and Hurlin (2012) heterogeneous panel causality test has been used to detect the direction of the relationship of the variables. Table 8 reveals the two-way causality of all variables to carbon emissions.

In Table 9, we used the fully modified OLS for a full sample to check the country-wise impacts of explanatory variables on carbon emissions. In Table 9, GDP per capita positively affects the CO_2 emissions in 38 countries (Afghanistan, Azerbaijan, Armenia, Bahrain, Bhutan, Bangladesh, Cambodia, Cyprus, China, Georgia, Indonesia, India, Iran, Iraq (Islamic Republic), Israel, Jordan, Japan, Republic of Korea, Kazakhstan, Kuwait, Kyrgyz Republic, Lao People's Democratic Republic, Lebanon, Malaysia, Myanmar, Maldives, Nepal, Oman, Philippines, Pakistan, Saudi Arabia, Sri Lanka, Turkey, Thailand, Turkmenistan, United Arab Emirates, Vietnam, Yemen) and shows negative effect in 6 countries (Brunei Darussalam, Mongolia, Qatar, Singapore, Timor-Leste, Uzbekistan) and shows insignificant impact in 1 country (Tajikistan). Energy use has positive impact in 36 countries (Armenia, Azerbaijan, Bahrain, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Cyprus, Georgia, India, Indonesia, Iran (Islamic Republic), Iraq, Israel, Japan, Jordan, Kazakhstan, Republic of Korea, Kuwait, Kyrgyz Republic, Lebanon, Mongolia, Myanmar, Oman, Pakistan, Philippines, Qatar, Sri Lanka, Thailand, Timor-Leste, Turkey, Turkmenistan, Uzbekistan, Vietnam, Yemen) and negative effect in four countries (Afghanistan, Lao People's Democratic Republic, Maldives, Singapore) and insignificant impact in five countries (Malaysia, Nepal, Saudi Arabia, Tajikistan, United Arab Emirates), and financial development shows positive effect in 21 countries (Afghanistan, Armenia, Bahrain, Bangladesh, Cambodia, Cyprus, Iran (Islamic Republic), Kazakhstan, Kuwait, Lebanon, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Turkey, United Arab Emirates, Uzbekistan, Vietnam) and negative effect in 10 countries (Bhutan, China, Georgia, India, Lao People's Democratic Republic, Oman, Qatar, Timor-Leste, Turkmenistan, Yemen) and insignificant impact in 14 countries (Azerbaijan, Brunei Darussalam, Indonesia, Iraq, Israel, Japan, Jordan, Republic of Korea, Kyrgyz Republic, Malaysia, Maldives, Mongolia, Saudi Arabia, Tajikistan). Empirical results indicate that due to the development and income differences in Asian countries, globalization has a mixed influence on carbon emissions.

Empirical results for the regional analysis of Asia suggest that globalization has a positive impact on carbon emissions in 16 countries (Afghanistan, Armenia, Bangladesh, China, India, Iran (Islamic Republic), Jordan, Lao People's Democratic Republic, Maldives, Mongolia, Myanmar, Oman, Pakistan, Philippines, Thailand, Timor-Leste). While in 13 countries (Azerbaijan, Bahrain, Brunei Darussalam, Cyprus, Georgia, Japan, Republic of Korea, Kuwait, Lebanon, Nepal, Singapore, Tajikistan, and Uzbekistan), it

Table 9 Country-wise FMOLS results

	LGDP		LEU		LFD		LGlob	
	Coef	S. E	Coef	S. E	Coef	S. E	Coefficient	S. E
Afghanistan	1.85***	0.09	−0.41***	0.04	0.11***	0.02	1.28***	0.1
Armenia	0.73***	0.03	0.67***	0.03	0.07***	0.01	0.27***	0.07
Azerbaijan	1.09***	0.06	1.03***	0.07	0.01	0.01	−0.14**	0.06
Bahrain	1.31***	0.08	1.09***	0.09	0.44***	0.02	−1.11***	0.05
Bangladesh	0.99***	0.04	0.98***	0.07	0.41***	0.02	0.06**	0.02
Bhutan	1.3***	0.19	0.35***	0.07	−0.19**	0.07	−0.43	0.44
Brunei	−2.37***	0.42	1.31***	0.14	−0.06	0.04	−0.43**	0.16
Cambodia	0.47***	0.09	0.18*	0.1	0.32***	0.04	−0.06	0.1
China	1.15***	0.01	1.18***	0.03	−0.22***	0.02	0.05*	0.03
Cyprus	1.18***	0.01	0.91***	0.01	0.01***	0	−0.4***	0.02
Georgia	2.02***	0.15	1.07***	0.07	−0.09**	0.04	−0.6***	0.15
India	1.4***	0.01	1.32***	0.03	−0.09***	0.01	0.1***	0.02
Indonesia	1.38***	0.27	1.24***	0.42	0.01	0.06	0.06	0.25
Iran	0.3***	0.03	0.75***	0.02	0.06***	0.01	0.46***	0.03
Iraq	0.57***	0.1	0.38***	0.06	−0.03	0.02	0.8	0.52
Israel	1.13***	0.15	1.79***	0.14	0.06	0.08	−0.08	0.13
Japan	1.23***	0.07	0.44***	0.02	−0.01	0.01	−0.33***	0.04
Jordan	0.49***	0.05	0.72***	0.05	0.05	0.05	0.37***	0.07
Kazakhstan	0.65***	0.03	0.89***	0.05	0.12***	0.01	0.05	0.06
Republic of Korea	1.03***	0.12	1.35***	0.16	−0.01	0.04	−0.31*	0.17
Kuwait	0.84***	0.04	1.11***	0.17	0.19***	0.04	−1***	0.18
Kyrgyz Republic	0.95***	0.23	0.64***	0.19	0.06	0.06	−0.23	0.24
Lao People’s Democratic Republic	0.64***	0.09	−0.1***	0.03	−0.1**	0.05	2.11***	0.24
Lebanon	0.75***	0.04	0.63***	0.03	0.05**	0.02	−0.31***	0.07
Malaysia	0.85***	0.07	−0.01	0.14	0.01	0.04	0.13	0.16
Maldives	0.29***	0.03	−0.07**	0.03	−0.03	0.04	2.29***	0.15
Mongolia	−1.05*	0.56	2.82***	0.89	0.28	0.25	2.82**	1.07
Myanmar	2.41***	0.07	2.35***	0.07	0.07***	0.01	0.48***	0.07
Nepal	2.72***	0.28	1.05	0.74	0.72***	0.1	−2.05***	0.27
Oman	1.77***	0.11	0.66***	0.03	−0.18***	0.02	1.02***	0.12
Pakistan	1.02***	0.23	0.98***	0.27	0.08*	0.04	0.58***	0.12
Philippines	1.28***	0.03	0.87***	0.03	0.15***	0.01	0.07***	0.02
Qatar	−0.66***	0.05	1.2***	0.01	−0.03***	0.01	−0.01	0.01
Saudi Arabia	1.89***	0.26	0.16	0.29	0.02	0.06	0.54	0.38
Singapore	−0.92***	0.11	−0.3***	0.09	1.13***	0.1	−3.89***	0.36
Sri Lanka	1.27***	0.12	0.61***	0.15	0.19***	0.02	0.11	0.12
Tajikistan	0.66	0.5	−0.6	0.72	0.07	0.13	−2.28**	1.02
Thailand	0.8***	0	1.07***	0.01	0.09***	0	0.28***	0.01
Timor-Leste	−0.21***	0.06	0.16***	0.01	−0.09*	0.05	1.24***	0.09
Turkey	0.95***	0.02	0.66***	0.03	0.01*	0	−0.01	0.02
Turkmenistan	0.85***	0.02	0.72***	0.02	−0.01***	0	−0.02	0.02
United Arab Emirates	1.01*	0.55	−0.56	0.79	0.77**	0.31	−0.84	0.83
Uzbekistan	−0.13*	0.05	0.12***	0.02	0.02***	0.01	−0.07*	0.04
Vietnam	1.43***	0.09	0.22***	0.04	0.07***	0.02	0.09	0.11
Yemen	1.34***	0.02	0.98***	0.04	−0.18***	0.01	0.02	0.02

Note: Level of significance is *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

has a negative significant effect on carbon emissions while an insignificant impact in 16 countries (Bhutan, Cambodia, Indonesia, Iraq, Israel, Kazakhstan, Kyrgyz Republic, Malaysia, Qatar, Saudi Arabia, Sri Lanka, Turkey, Turkmenistan, United Arab Emirates, Vietnam, Yemen). This may be that the laws and legislation on the atmosphere are stringent, so they do not release pollution. Another explanation is that companies are less economically active, suggesting the detrimental effect of de-industrialization on CO_2 emissions. This finding also indicates that these countries depend primarily on the non-polluting soft industry, so there is a need to motivate the investors towards these non-polluting soft sectors that will help in lessening the emission.

Conclusions and policy implications

This study examines the relations of GDP per capita, energy usage, and financial development with carbon emissions for 45 Asian countries over the timeframe of 1990 and 2017. To account for cross-sectional dependence, Pesaran cross-sectional dependence test is used. The second-generation tests are used to determine the stationarity level of the variables. Furthermore, the Westerlund (2007) panel cointegration test confirms cointegration among the variables. For long-run association, FMOLS approach is used. The study also used Dumitrescu and Hurlin's (2012) panel causality test to explore the causal relationship among the variables.

The results have demonstrated the high cross-sectional dependence of Asian countries. The results of the cointegration tests indicate that GDP per capita, energy use, financial development, globalization, and carbon emissions are cointegrated. The results show that increased financial development, energy usage, and GDP growth all contribute to environmental degradation by rising pollution, while globalization enhances environmental quality. As a result, to boost environmental sustainability, economies should take measures that foster globalization while still implementing environmentally friendly technologies. Furthermore, financial growth can only boost environmental quality if financial institutions are well established, so policymakers should pay attention to this as well. The reliance on traditional energy resources should be reduced in favor of renewable resources, which improve environmental quality. Furthermore, the economic growth of a country also influences carbon emissions. As the per capita income increases, investment in different sectors also increases which in turn rise the emissions. Financial development and energy use also significantly affect carbon emissions. One of the reasons can be an investment in those sectors that emits more emissions by using more energy. In the case of globalization, the results suggest an increase in carbon emissions by globalization. Increasing trade openness and foreign direct investment inflows enhance the emission level in Asian countries. To conclude, it is also evident from regional results that financial development and energy use also increases with the increase in globalization that leads to a rise in carbon emissions.

The aforementioned factors are the primary causes of environmental degradation. It is proposed that policymakers create policies that enable foreign investors to invest in green energy projects for long-term economic growth and environmental protection. To improve the climate and economic development, policymakers in the government are advised to improve economic, social, and political relationships with those countries, which are expert in renewable energy technologies. Environmental and energy-efficient programs should be prioritized by policymakers. The position of energy intensity in CO2 emissions is both a challenge and an incentive for policymakers to adopt policies involving renewable energy sources such as solar, biodiesel, thermal, and wind, as well as environmentally friendly technologies.

This research could not incorporate all Asian economies, owing to the data availability limitations. Further, this study mainly focused on overall globalization to explain its links with the environment, ignoring its different dimensions. Therefore, future studies can focus on different forms of globalization such as political, social, and economic globalization.

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Data Availability Available on request.

Declarations

Ethical approval This manuscript is solely submitted to the esteemed journal. Further, this article is not under consideration for publication elsewhere.

Consent to participate All the authors have read and approved the final version of the manuscript.

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Conflicts of interest The authors declare no competing interests.

References

Abbasi F, Riaz K (2016) CO_2 Emissions and financial development in an emerging economy: an augmented VAR approach. Energy Policy 90:102–114

Acquaye A, Feng K, Oppon E, Salhi S, Ibn-Mohammed T, Genovese A, Hubacek K (2017) Measuring the environmental sustainability performance of global supply chains: a multi-regional input-output analysis for carbon, sulphur oxide, and water footprints. J Environ Manag 187:571–585

Adewuyi AO, Awodumi OB (2017) Renewable and non-renewable energy-growth-emissions linkages: review of emerging trends with policy implications. Renew Sust Energ Rev 69:275–291

Ahmad A, Zhao Y, Shahbaz M, Bano S, Zhang Z, Wang S, Liu Y (2016) Carbon emissions, energy consumption, and economic growth: an aggregate and disaggregate analysis of the Indian economy. Energy Policy 96:131–143. https://doi.org/10.1016/J.Enpol.2016.05.032

Al-Mulali U, Sab CNBC (2012) The impact of energy consumption and CO_2 emission on economic growth and financial development in the sub-Saharan African countries. Energy 39(1):180–186

Al-Mulali U, Ozturk I, Lean HH (2015) The influence of economic growth, urbanization, trade openness, financial development, and renewable energy on pollution in Europe. Nat Hazards 79: 621e644. https://doi.org/10.1007/S11069-015-1865-9

Apergis N, Payne JE (2014) Renewable energy, output, CO_2 emissions, and fossil fuel prices in Central America: evidence from a nonlinear panel smooth transition vector error correction model. Energy Econ 42:226–232

Begum RA, Sohag K, Abdullah SMS, Jaafar M (2015) CO_2 emissions, energy consumption, economic and population growth in Malaysia. Renew Sust Energ Rev 41:594–601. https://doi.org/10.1016/J.Rser.2014.07.205

Bekhet HA, Othman NS (2017) Impact of urbanization growth on Malaysia CO_2 emissions: evidence from the dynamic relationship. J Clean Prod 154:374–388. https://doi.org/10.1016/J.Jclepro.2017.03.174

Bekhet HA, Matar A, Yasmin T (2017) CO_2 Emissions, energy consumption, economic growth, and Financial Development in GCC Countries: Dynamic Simultaneous Equation Models. Renew Sust Energ Rev 70:117–132

Bhattacharya M, Churchill SA, Paramati SR (2017) The dynamic impact of renewable energy and institutions on economic output and CO_2 emissions across regions. Renew Energy 111:157–167

Blazejczak J, Braun FG, Edler D, Schill WP (2014) Economic effects of renewable energy expansion: a model-based analysis for Germany. Renew Sust Energ Rev 40:1070–1080

Bölük G, Mert M (2014) Fossil & renewable energy consumption, GHGs (greenhouse gases), and economic growth: evidence from a panel of EU (European Union) countries. Energy 74:439–446

Boutabba MA (2014) The impact of financial development, income, energy, and trade on carbon emissions: evidence from the Indian economy. Econ Model 40:33–41

Brunnschweiler CN (2010) Finance for renewable energy: an empirical analysis of developing and transition economies. Environ Dev Econ 15(3):241–274

Bu M, Lin CT, Zhang B (2016) Globalization and climate change: new empirical panel data evidence. J Econ Surv 30(3):577–595

Charfeddine L (2017) The impact of energy consumption and economic development on ecological footprint and CO_2 emissions: evidence from a Markov switching equilibrium correction model. Energy Econ 65:355–374

Charfeddine L, Kahia M (2019) Impact of renewable energy consumption and financial development on CO_2 emissions and economic growth in the MENA region: a panel vector autoregressive (PVAR) analysis. Renew Energy 139:198–213

Charfeddine L, Khediri KB (2016) Financial development and environmental quality in UAE: cointegration with structural breaks. Renew Sust Energ Rev 55:1322–1335

Charfeddine L, Al-Malk AY, Al Korbi K (2018) Is it possible to improve environmental quality without reducing economic growth: evidence from the Qatar economy? Renew Sust Energ Rev 82:25–39

Dai H, Xie X, Xie Y, Liu J, Masui T (2016) Green growth: the economic impacts of large-scale renewable energy development in China. Appl Energy 162:435–449

Destek MA (2018) Financial development and energy consumption nexus in emerging economies. Energy Sour B Econ Plann Policy 13(1): 76–81

Destek MA (2019) Investigation on the role of economic, social, and political globalization on the environment: evidence from CEECS. Environ Sci Pollut Res:1–14

Doytch N, Uctum M (2016) Globalization and the environmental impact of sectorial FDI. Econ Syst 40(4):582–594

Dreher A (2006) Does globalization affect growth? Evidence from a new index of globalization. Appl Econ 38(10):1091–1110

Dumitrescu EI, Hurlin C (2012) Testing for Granger non-causality in heterogeneous panels. Econ Model 29:1450–1460

Ghosh S (2018) Globalization and environment: an Asian experience. J Int Commer Econ Policy 09:1850010

Granger CW (1981) Some properties of time series data and their use in econometric model specification. J Econ 16(1):121–130

Grossman GM, Krueger AB (1991) Environmental Impacts of a North American Free-Trade Agreement (No. W3914). National Bureau of Economic Research

Haseeb A, Xia E, Baloch MA, Abbas K (2018) Financial development, globalization, and CO 2 emission in the presence of EKC: evidence from BRICS countries. Environ Sci Pollut Res 25(31):31283–31296

He G, Lu Y, Mol AP, Beckers T (2012) Changes and challenges: China's environmental management in transition. Environ Dev 3:25–38

Ito K (2017) CO_2 emissions, renewable, and non-renewable energy consumption, and economic growth: evidence from panel data for developing countries. Int Econ 151:1–6

Jaunky VC (2011) The CO2 emissions-income nexus: evidence from rich countries. Energy Policy 39(3):1228–1240

Kahia M, Aïssa MSB, Charfeddine L (2016) Impact of renewable and non-renewable energy consumption on economic growth: new evidence from the MENA Net Oil Exporting Countries (NOECS). Energy 116:102–115

Kahia M, Kadria M, Aissa MSB, Lanouar C (2017) Modeling the treatment effect of renewable energy policies on economic growth: evaluation from MENA countries. J Clean Prod 149:845–855

Katircioğlu ST, Taşpinar N (2017) Testing the moderating role of financial development in an environmental Kuznets curve: empirical evidence from Turkey. Renew Sust Energ Rev 68:572–586

Khan MK, Teng JZ, Khan MI (2019) Effect of energy consumption and economic growth on carbon dioxide emissions in Pakistan with a dynamic ARDL simulations approach. Environ Sci Pollut Res 26(23):23480–23490

Kim J, Park K (2016) Financial development and deployment of renewable energy technologies. Energy Econ 59:238–250

Le TH, Chang Y, Park D (2016) Trade openness and environmental quality: international evidence. Energy Policy 92:45–55

Lee KH, Min B (2014) Globalization and the carbon-constrained global economy: a fad or a trend. J Asia Pac Bus 15(2):105–121

Majeed MT, Mazhar M (2019a) Environmental degradation and output volatility: a global perspective. Pak J Commer Soc Sci 13(1):180–208

Majeed MT, Mazhar M (2019b) Financial development and ecological footprint: a global panel data analysis. Pak J Commer Soc Sci 13(2): 487–514

Majeed MT, Mazhar M (2020) Reexamination of environmental Kuznets curve for ecological footprint: the role of biocapacity, human capital, and trade. Pak J Commer Soc Sci 14(1):202–254

Majeed MT, Tauqir A (2020) Effects of urbanization, industrialization, economic growth, energy consumption, financial development on carbon emissions: an extended STIRPAT model for heterogeneous income groups. Pak J Commer Soc Sci 14(3):652–681

Majeed MT, Samreen I, Tauqir A, Mazhar M (2020) The asymmetric relationship between financial development and CO 2 emissions: the case of Pakistan. SN Appl Sci 2(5):1–11

Majeed MT, Tauqir A, Mazhar M, Samreen I (2021) Asymmetric effects of energy consumption and economic growth on ecological footprint: new evidence from Pakistan. Environ Sci Pollut Res:1–17

Mallick H, Mahalik MK (2014) Energy consumption, economic growth, and financial development: a comparative perspective on India and China. Bull Energy Econ 2(3):72–84

Moutinho V, Robaina M (2016) Is the share of renewable energy sources determining the CO_2 Kwh and income relation in electricity generation? Renew Sust Energ Rev 65:902–914

Mu Y, Wang C, Cai W (2018) The economic impact of China's INDC: distinguishing the roles of renewable energy quota and the carbon market. Renew Sust Energ Rev 81:2955–2966

Nasreen S, Anwar S, Ozturk I (2017) Financial stability, energy consumption, and environmental quality: evidence from South Asian economies. Renew Sust Energ Rev 67:1105–1122

Özbuğday FC, Erbas BC (2015) How effective are energy efficiency and renewable energy in curbing CO_2 emissions in the long run? A heterogeneous panel data analysis. Energy 82:734–745

Ozturk I, Acaravci A (2010) CO_2 emissions, energy consumption, and economic growth in Turkey. Renew Sust Energ Rev 14(9):3220–3225

Pao HT, Tsai CM (2010) CO_2 Emissions, energy consumption, and economic growth in BRIC countries. Energy Policy 38(12):7850–7860. https://doi.org/10.1016/J.Enpol.2010.08.045

Pata UK (2018) Renewable energy consumption, urbanization, financial development, income, and CO_2 emissions in Turkey: testing EKC hypothesis with structural breaks. J Clean Prod 187:770–779

Pérez K, González-Araya MC, Iriarte A (2017) Energy and GHG emission efficiency in the Chilean manufacturing industry: sectorial and regional analysis by DEA and Malmquist indexes. Energy Econ 66: 290–302

Persyn D, Westerlund J (2008). Error-correction–based cointegration tests for panel data. The STATA Journal 8(2)232–241

Pesaran MH (2007) A simple panel unit root test in the presence of cross-section dependence. J Appl Econ 22(2):265–312

Phong LH (2019) Globalization, financial development, and environmental degradation in the presence of environmental Kuznets curve: evidence from ASEAN-5 countries. Int J Energy Econ Policy 9(2): 40–50

Saboori B, Sulaiman J (2013) Environmental degradation, economic growth, and energy consumption: evidence of the environmental Kuznets curve in Malaysia. Energy Policy 60:892–905

Sadorsky P (2010) The impact of financial development on energy consumption in emerging economies. Energy Policy 38(5):2528–2535

Sadorsky P (2011) Financial development and energy consumption in Central and Eastern European frontier economies. Energy Policy 39(2):999–1006

Salahuddin M, Gow J, Ozturk I (2015) Is the long-run relationship between economic growth, electricity consumption, carbon dioxide emissions, and financial development in Gulf Cooperation Council countries robust? Renew Sust Energ Rev 51:317–326

Salahuddin M, Ali MI, Vink N, Gow J (2019) The effects of urbanization and globalization on CO 2 emissions: evidence from Sub-Saharan Africa (SSA) countries. Environ Sci Pollut Res 26(3):2699–2709

Samreen I, Majeed MT (2020) Spatial econometric model of the spillover effects of financial development on carbon emissions: a global analysis. Pak J Commer Soc Sci 14(2):569–202

Sbia R, Shahbaz M, Hamdi H (2014) A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. Economic Modelling 36:191–197

Sekantsi LP, Thamae RI, Mohatonyane LE (2016) Electricity consumption in Lesotho: the role of financial development, industrialization, and urbanization. J Int Bus Econ 4(1):1–12

Shahbaz M, Jawad S, Shahzad H, Ahmad N, Alam S (2016a) Financial development and environmental quality. Way Forw 98:353–364

Shahbaz M, Shahzad SJH, Ahmad N, Alam S (2016b) Financial development and environmental quality: the way forward. Energy Policy 98:353–364

Shahbaz M, Mallick H, Mahalik MK, Sadorsky P (2016c) The role of globalization on the recent evolution of energy demand in India: implications for sustainable development. Energy Econ 55:52e68. https://doi.org/10.1016/J.Eneco.2016.01.013

Shahbaz M, Mallick H, Mahalik MK, Hammoudeh S (2018) Is globalization detrimental to financial development? Further evidence from a very large emerging economy with a significant orientation towards policies. Appl Econ 50(6):574–595

Shahbaz M, Mahalik MK, Shahzad SJH, Hammoudeh S (2019) Testing the globalization-driven carbon emissions hypothesis: international evidence. Int Econ 158:25–38

Sinha A, Shahbaz M (2018) Estimation of environmental Kuznets curve for CO_2 emission: the role of renewable energy generation in India. Renew Energy 119:703–711

Sohail MT, Ullah S, Majeed MT, Usman A (2021) Pakistan management of green transportation and environmental pollution: a nonlinear ARDL analysis. Environ Sci Pollut Res:1–10

Solarin SA, Al-Mulali U, Sahu PK (2017) Globalization and its effect on pollution in Malaysia: the role of the Trans-Pacific Partnership (TPP) Agreement. Environ Sci Pollut Res 24:23096e23113

Spiegel-Feld D, Rudyk B, Philippidis G (2016) Allocating the economic benefits of renewable energy between stakeholders on Small Island Developing States (SIDS): arguments for a balanced approach. Energy Policy 98:744–748

Tamazian A, Rao BB (2010) Do economic, financial, and institutional developments matter for environmental degradation? Evidence from transitional economies. Energy Econ 32(1):137–145

Tiwari AK (2011) A structural VAR analysis of renewable energy consumption, real GDP, and CO_2 emissions: evidence from India. Econ Bull 31(2):1793–1806

Topcu M, Payne JE (2017) The financial development–energy consumption nexus revisited. Energy Sour B Econ Plann Policy 12(9):822–830

Westerlund J (2007) Testing for error correction in panel data. Oxf Bull Econ Stat 69(6):709–748

Wijen F, Van Tulder R (2011) Integrating environmental and international strategies in a world of regulatory turbulence. Calif Manag Rev 53(4):23–46

World Bank (2019) Retrieved From. https://www.databank.worldbank.org/source/world-development-indicators

Xiong L, Tu Z, Ju L (2017) Reconciling regional differences in financial development and carbon emissions: a dynamic panel data approach. Energy Procedia 105:2989–2995

Xu Z, Baloch MA, Meng F, Zhang J, Mahmood Z (2018) Nexus between financial development and CO 2 emissions in Saudi Arabia: analyzing the role of globalization. Environ Sci Pollut Res 25(28):28378–28390

You W, Lv Z (2018) Spillover effects of economic globalization on CO_2 emissions: a spatial panel approach. Energy Econ 73:248–257. https://doi.org/10.1016/J.Eneco.2018.05.016

Zafar MW, Saud S, Hou F (2019) The impact of globalization and financial development on environmental quality: evidence from selected countries in the Organization for Economic Co-Operation and Development (OECD). Environ Sci Pollut Res 26(13):13246–13262. https://doi.org/10.1007/S11356-019-04761-7

Zakaria M, Bibi S (2019) Financial development and environment in South Asia: the role of institutional quality. Environ Sci Pollut Res 26(8):7926–7937

Zhang S, Liu X, Bae J (2017) Does trade openness affect CO 2 emissions: evidence from ten newly industrialized countries? Environ Sci Pollut Res 24(21):17616–17625

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