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To cite this article: Shu Lin & Rengmei Wu (2022) On the nexus between energy efficiency, financial inclusion and environment: Evidence from emerging seven economies using novel research methods, Economic Research-Ekonomiska Istraživanja, 35:1, 6756-6779, DOI: [10.1080/1331677X.2022.2053362](https://doi.org/10.1080/1331677X.2022.2053362)

To link to this article: <https://doi.org/10.1080/1331677X.2022.2053362>



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Published online: 07 Apr 2022.



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On the nexus between energy efficiency, financial inclusion and environment: Evidence from emerging seven economies using novel research methods

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ABSTRACT

Emerging seven (E7) are some of the rising economies in the world and are expected to be economically strengthened in the coming few decades due to rapid economic growth. Besides, financial inclusion and globalization are also rising in these economies, which compel them to adopt energy saving techniques to lower carbon (CO₂) emissions in the region. This study aims to explore the influence of these variables on CO₂ emissions in E7 economies over the period from 2004 to 2019. Various panel econometric approaches reveal that all the variables are stationary at first difference. Also, the long-run cointegration association exists between them. The non-normal distribution of data leads to the adoption of the panel quantile estimator for the long run estimations across three quantiles (i.e., $q_{0.25}$, $q_{0.50}$, and $q_{0.75}$). The empirical findings illustrate that energy efficiency is negatively associated to CO₂ emissions in all the quantiles. However, financial inclusion, economic growth, globalization, and composite risk index are the prominent factors of CO₂ emissions. Such factors are the primary reasons for environmental degradation in the region. The estimated panel causality test results confirm the feedback effect for the variables except for globalization, which runs toward CO₂ emissions. Based on findings, this study suggests policies regarding the encouragement of energy efficiency and alteration of economic growth from non-renewable energy sources to renewables. Devotion of financial inclusion towards green finance and green bonds promotion and reducing composite risk to promote environmental sustainability.

ARTICLE HISTORY

Received 24 November 2021
Accepted 9 March 2022

KEYWORDS

Carbon emission; energy efficiency; financial inclusion; globalization; panel quantile regression

JEL CODES

P18; P48; Q5

1. Introduction

Countries have been firmly concerned about environmental degradation issues over the last few decades and consistently making policies to improve energy efficiency without interrupting economic growth. The rising carbon dioxide (CO₂) emission across the globe is considered the main reason for environmental degradation, climate

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change, and global warming (Farooq et al., 2019; Sarwar et al., 2019; Shahzad et al., 2021). Still, the global energy demand is rapidly increasing due to economic growth and population demand for consumption (Javid & Khan, 2020). However, the energy mix's energy efficiency and environmental distress substantially transfer towards lesser carbon fuel (Magazzino et al. 2022). Although, various international organizations have taken steps about the global concern regarding climate change, global warming, and extensive CO₂ emissions to limit the global temperature below 1.5 °C as per the IPCC report (Allen et al., 2019). Thus, the energy demand dominated by traditional fossil fuels will replace the renewable energy system having low or no environmental concerns (Bashir et al., 2020). Hence, building a low carbon economy becomes the primary approach for sustained development in the climate risk management context.

In the modern era, the role of energy efficiency and financial inclusion attracts scholars and policymakers' attention due to their potential in mitigating environmental hazards and energy cost saving. Besides environmental benefits, energy efficiency also offers diverse benefits to the general public. Such benefits include the improvement of energy system reliability, reducing domestic and industrial sector energy cost, shrinking market price of energy, improving productivity, reducing atmospheric emissions, promoting energy security, and encouraging economic growth (Prindle, 2009). An increase in energy efficiency reduces environmental degradation and global warming in two approaches, as mentioned by (Prindle, 2009). Firstly, the energy-saving behavior leads to consuming less energy and less CO₂ would be transmitted to the atmosphere. Thus, the role of energy efficiency is significant in the policies concerning energy and climate change. Secondly, energy saving, or cost-effective energy efficiency, further leads to a sustainable environment at a lower cost. So, the climate policy goals could be achieved via lower economic costs.

At first, Hawksworth and Cookson (2006) developed the name E7 to characterize a group of emerging economies with the rapidly growing globally linked populations and want to achieve economic strength comparable to the group of seven (G7) economies. In terms of purchasing power parity (PPP), the E7 economies had already surpassed the G7 countries by 2014 (Park, 2016). PWC anticipated that by 2050, the E7 economies would be 75 percent greater than the G7 countries in terms of PPP. The E7 nations are performing a growing role in the global energy market, either evaluated by emissions of CO₂ or energy usage (see Figure 1). They accounted for 47 percent of the worldwide population in 2018, 26 percent of world GDP, and more than 40 percent of global energy usage in the same year. The People's Republic of China, for instance, accounted for 27 percent of world energy demand in 2005, a figure that would be anticipated to climb to over 40 percent by 2050. Furthermore, each E7 nation is among the top 20 CO₂ emitters in 2016 across the world, regardless of measured by per-capita or total CO₂ emissions.

In the field of energy-environment-economics, variables such as economic growth, financial inclusion, globalization, and composite risk (including economic, financial, and political risks), among others, are considered the crucial determinants for CO₂ emissions. Furthermore, in some recent studies, these variables are considered as factors of environmental degradation (Khan et al., 2021; Le et al., 2020; Malik et al.,

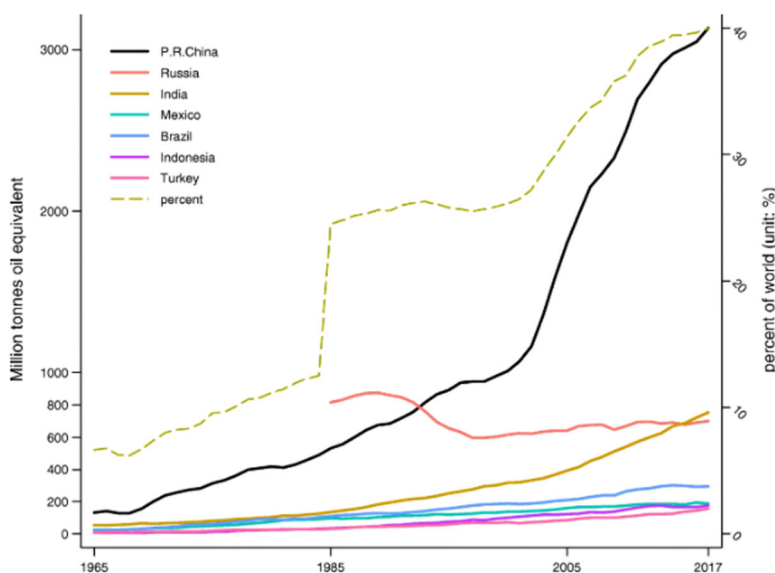


Figure 1. Energy use in E7 economies between 1965 and 2017.
Source: B.P. Statistical Review (2018).

2020; Rafique et al., 2021; Wang & Zhang, 2020). In other words, the existing empirical evidence is observed as two way influential: Firstly, it is observed that economic growth, financial inclusion, globalization, and country's risk have the potential to enhance fossil fuel energy use, due to industrial expansion and increased production, which considerably leads to higher emissions level in the country, thus causes environmental degradation (Dogan & Seker, 2016; Nathaniel & Khan, 2020; Qin et al., 2021). On the other hand, some of the empirical evidence contradicts the statement above, i.e., increased economic growth, globalization, financial inclusion and composite risk are the variables that tend to reduce emissions in the country (Shahzad et al., 2022; Xia et al., 2022). To be more specific, increased economic growth and a higher level of financial inclusion lead towards investment and promotion of green technologies, renewable energy technologies, and technological innovation that reduces the high demand for conventional fossil fuel energy and promotes renewable energy and energy efficiency enhancing environmental sustainability. Similarly, globalization increases business and investments across the border in environmentally friendly resources and technologies, which could help reduce CO₂ emissions in the region (Ghazouani et al., 2020; Xia et al., 2022). Hence, the prior statements asserted contradictory outcomes, forcing the authors to reinvestigate the nexus of environmental quality with prominent economic, financial, and political indicators.

Besides the prior discussion, this study investigates the influence of energy efficiency on the carbon emission level of the emerging seven (E7) economies, which has been neglected for various countries in the economic recovery plan (Wang & Wang, 2020). Also, this study objectivised to empirically analyze the influence of financial inclusion in the E7 economies as these countries are rapidly developing in terms of economic and financial institutions. As discussed, these countries are rapidly increasing their economic activities; thus, the economic growth factor could not be ignored.

Also, globalization is an important factor for economic growth and substantially important for the E7 economies as they will be more globalized soon because of greater participation in international trade and foreign direct investment (Qin et al., 2021). Thus, both of these variables are also taken into consideration for empirically investigating their influence on the environmental quality of the E7 economies. Additionally, the E7 countries' composite risk is also an important factor determining domestic and international investors' economic, financial, and political stability or risk. Therefore, the current study aimed to investigate the impact of the composite risk index on the environmental quality of the E7 economies.

The contribution of this study to the scholarly research literature is three-fold. Firstly, this study provides empirical evidence regarding the influence of energy efficiency on CO₂ emissions across different quantiles in the case of emerging economies. Although the earlier studies explore the said nexus via demonstrating the mean changes, this study focused on the quantile that discovers the relationship beyond mean values. Secondly, this study contributes to the existing literature by providing empirical proof of the impact of financial inclusion, economic growth, and globalization on CO₂ emissions. Nonetheless, the existing literature explored the said nexus. Still, the contradictory results provide a blurred image of the nexus in developing economies. However, this study provides a clear picture of the said nexus in emerging economies. Lastly, this study offers empirical evidence regarding the role of the composite risk index in the quality of the environment. Although this indicator is narrowly used in the literature and very few empirical findings regarding the influence of composite risk and CO₂ emissions are provided. Yet the composite risk index in the E7 is an important contribution for the policy-makers and future researchers. Moreover, this study suggests innovative policy measures that could be used as a remedial measure for environmental sustainability as well as maintaining economic growth.

The rest of the study is organized as Section-2 provides the relevant literature review; Section-3 presents the methodology model specification; Section-4 provides the empirical results and discussion; Section-5 presents conclusion and policy implication based on the empirical findings.

2. Literature review

Carbon dioxide (CO₂) emission is considered the leading environmental and health issue across the globe. The researchers and the policy-makers have made different attempts to restrict the CO₂ emission level to reduce the global temperature under 1.5 °C as per the IPCC report (Allen et al., 2019). Numerous factors and indicators have been studied that empirically illustrate the influence of these factors and indicators on the CO₂ emissions for different regions and countries. Thus, in this section, the relevant and recent literature has been discussed and provided.

Concerning energy efficiency, Wang and Wang (2020) analyzed the short-term and long-term carbon emission drivers by discussing the recent two shocks of Covid-19 and the 2008-09 financial crises while covering the 1990-2014 period for G7 and BRICS economies. The estimated results via VAR techniques reveal that the

deterioration of energy efficiency after global financial crises is the main reason for CO₂ emission in developed economies. For the case of the Chinese 28 industries, Wang et al. (2020) examined 28 industries throughout 1990-2015 and revealed that the development of 21 industries out of the total industries would decrease carbon intensity due to an increase in the efficiencies of coal, metal, and diesel processing. Similarly, Wang and Wei (2014) examined 30 major Chinese cities over the period from 2006 to 2010 and employed Data Envelopment Analysis. The results asserted that economically developed cities have higher energy efficiency than less developed cities. However, the CO₂ emission efficiency and energy utilization gaps have declined across the cities since 2006. Javid and Khan (2020) investigated the top five greenhouse gas emitters covering the period from 1971 to 2016. The study employed a structural time series model and revealed that the countries vary in CO₂ emission concerns. China, India, Germany, and the U.S. consume fewer emissions than their CO₂ emissions. The study argued that this is because of either the less or no use of energy-efficient appliances or the offsetting of technological progress.

Chen et al. (2020) investigated efficiency for energy and CO₂ emission and technological gap for 38 sub-industries of Anhui province China covering the period from 2012 to 2016 via employing data envelopment analysis. The study found that the energy and carbon efficiencies are higher in heavy industries relative to light industries. However, the technological gap ratio of the light industry is significantly higher than the heavy industry. The earlier study of Worrell et al. (2001) examined 47 energy efficiency technologies. It revealed that energy efficiency is an effective tool with the potential of emission reduction with a payback period of three years in the U.S. In continuation, the most recent study of Mahapatra and Irfan (2021) investigated 34 developing and 28 developed economies over the period from 1990-2017 and employed a panel autoregressive (ARDL) approach. The results illustrate that energy efficiency significantly reduces CO₂ emissions, while a reduction in energy efficiency increases CO₂ emissions in both developed and developing economies. The study of Ren et al. (2020) reports that the regional transportation system in China has a low energy and carbon emission efficiency. Further, the study demonstrates that the lower kerosene and gasoline utilization efficiency is the main reason for the inefficiency in the regional transportation system in China. In contrast, these efficiencies vary across the regions, and this also corresponds to regional economic development. Hence, these studies demonstrated that energy efficiency could be used as a tool for environmental recovery and environmental sustainability.

Concerning the influence of economic growth on CO₂ emissions, the literature is extensive. These studies comprehensively investigated the significant impact of economic growth on CO₂ emission in different countries and regions. In this regard, Malik et al. (2020) examined the symmetric and asymmetric influence of economic growth, FDI, and oil prices on CO₂ emissions for Pakistan over the period from 1971 to 2014. The study employed linear and nonlinear ARDL and reported the existence of the country's environmental Kuznets curve (EKC). However, the causality results reveal the feedback effect between carbon emission and economic growth. For the case of China, Ahmad et al. (2018) investigated the asymmetric impact of financial development and economic growth on CO₂ emissions over the period from 1980 to

2014. Employing the nonlinear ARDL approach, the results asserted that financial development, economic growth, energy use positively influence CO₂ emission in both the short and long run. In contrast, the study of Wang and Zhang (2020) reveals that investment in research and development may efficiently promote the decoupling of economic growth from CO₂ emissions. The authors investigated BRICS countries over the period from 1996-2014 via employing the FMOLS approach. The study further argued that only research and development investment could not completely decimate economic growth and CO₂ emissions. Still, economic activities, urbanization, industrialization, and renewable energy also influence decoupling between them. Similarly, other studies include Dong et al. (2020); Wang and Jiang (2020). These studies also reveal the existence of the EKC hypothesis and the positive influence of economic growth on carbon emission for different countries and regions. However, the findings of these studies further illustrate that renewable energy consumption decrease CO₂ emission while non-renewable energy consumption increases CO₂ emission.

In addition, the nexus of energy consumption, economic growth, CO₂ emissions, and other controlled variables is extensively analyzed in the literature. For instance, the recent study of Ahmed and Bhattacharya (2020) examined eight ASEAN economies throughout 1984-2014. Employing panel ARDL specifications, the results unveil that economic growth and energy consumption are the regions' major causes of CO₂ emissions. At the same time, the institutional quality demonstrates mixed effects on emissions. Concerning other factors and indicators of environmental degradation, Ahmed (2016) found that urbanization does not play any significant role in CO₂ emissions reduction in China. While trade openness and economic growth significantly promote emissions in the country. Since urbanization and trade openness are among the policies that contribute to economic growth. Yet, Kirikkaleli and Ozbaser (2020) observed that the country's economic growth enhances government expenditures in the long-run, while government expenditures contribute to economic growth only in the short-run. On the other hand, Kirikkaleli and Doğan (2021) asserted that the total refugees' number and people in a situation like refugees negatively influence the Turkey's per capital energy consumption. Additionally, Ahmed (2017) reveals that economic growth, financial development, and trade openness encourage the intensity of energy, which is a prominent factor of emissions in the BRICS economies. Besides, the study also unveils that financial development and trade openness could be used as a remedial measure for energy intensity reduction – validating EKC paradox. On the other hand, Tufail et al. (2021), although economic growth and total natural resources rents enhance emissions level in the OECD economies. However, natural resources rents, fiscal decentralization, improved institutional quality, renewable energy consumption, and technological innovation could help curbing the CO₂ emissions in the region (Ahmed, 2017; Ahmed et al., 2020). Besides, the recent study of Kirikkaleli et al. (2021), Ahmed and Jahanzeb (2021), Ahmed (2020) asserted that globalization enhances CO₂ emissions in the long run. However, trade openness, stringent environmental policies, strict environmental regulations, market capitalization, financial development, and technological advancement reduce fossil fuel energy use and contribute to environmental sustainability. As an energy, economic, and

environmental policies, the priorly mentioned studies mostly show the negative role of economic growth in enhancing energy consumption, which further contributes to environmental degradation. Yet many other variables could stimulate the positive impact of economic growth on the environment, which are mixed and yet to analyze.

Besides economic growth and energy efficiency, financial inclusion also attracts the policy-makers and researchers' attention as an environmental policy tool. For instance, the most recent study of Qin et al. (2021) investigated the influence of financial inclusion and globalization on CO₂ emission for emerging seven (E7) economies covering the period from 2004 to 2016 and utilized the quantile regression technique. The estimated results found the long-run relationship between the study variables and revealed that financial inclusion reduced CO₂ emission in the 25th and 50th quantiles. Also, globalization and renewable energy consumption are found to affect CO₂ emissions negatively. Furthermore, the study confirmed the existence of the EKC hypothesis in E7 economies. Similarly, Renzhi and Baek (2020) examined 103 economies as a global sample throughout 2004-2014 and employed a GMM estimator. The study's empirical findings reveal that financial inclusion helps reduce CO₂ emissions in the selected group of countries. In contrast, Le et al. (2020) investigated 31 Asian countries over the period from 2004 to 2014 and revealed the positive influence of financial inclusion, economic growth, and globalization on CO₂ emissions. Li et al. (2021) examined the determinants of CO₂ emissions in China throughout 1995-2017. The estimated results are obtained by employing CS-ARDL reveal that the development of the financial sector and energy investment boost CO₂ emissions, while the investments in green projects decrease the atmospheric CO₂ emission level. The results via Westerlund cointegration also confirmed the long-run association between the study variables. Nonetheless, the empirical evidence regarding the association of CO₂ emissions and financial inclusion is broadly available, yet the outcomes are contradictory since some studies demonstrate the negative impact of financial inclusion on CO₂ emissions (Qin et al., 2021; Renzhi & Baek, 2020). Other studies documented its positive role in environmental degradation by enhancing the emissions level (Le et al., 2020; Li et al., 2021).

In every economic and environmental policy, the country's risk is an essential factor that indicates the growth and environmental quality of the country. Regarding the influence of composite risk index (CRI) on CO₂ emission, Khan et al. (2021) studied the role of export diversification and CRI in CO₂ emission reduction for the case of regional comprehensive economic partnership (RCEP) agreement signatories. The study investigated the 1987-2017 period and indicates that lowering the composite risk index leads to adopting renewable energy sources, enhancing environmental sustainability. In the same line, Benítez et al. (2007) works on the global potential for carbon sequestration and illustrates that country's risk, including economic, financial, and political risks, the sequestration of carbon declines by approximately 60 percent. Zhang and Chiu (2020) investigated the nonlinear impact of country risk, energy use, and real income on the CO₂ emission for 111 countries as a global sample throughout 1985-2014. The results asserted an inverted U-shaped association between economic risk and CO₂ emission. However, the political and financial stability increases CO₂ emission across the panel. On the contrary, the recent study of Hassan et al.

(2021) demonstrated the association between country risk and consumption-based CO₂ emissions in the RCEP economies during 1990-2020 period. The CS-ARDL estimates asserted that political risk help reduces consumption-based CO₂ emissions while the CRI, lower economic growth and under-developed financial system significantly enhance it.

Since the existing literature covers the recent scholarly studies regarding each under-study variable in relation to environmental degradation. Most of the authors demonstrate the positive influence of economic growth on CO₂ emissions. In other words, these studies summarized that enhancement in economic growth tends to increase demand for goods and services, which leads to an increase in production and expansion of the industrial sectors. However, expansion of the industrial sector and enhanced production encourages the use of energy, which most of the developing economies are dependent on fossil fuel energy. However, such non-renewable energy is the primary sources of pollution emissions and promotes environmental degradation (Paramati et al., 2022; Shahzad et al., 2020). On the other hand, the influence of financial inclusion, energy efficiency, globalization, and composite risk index on CO₂ emissions are found mixed and contradictory. That is, some studies found positive, while other evidence supports the negative impact of under-discussion variables on CO₂ emissions. These contradictory findings tend the current study to reinvestigate the influence of these variables on CO₂ emissions in the emerging economies.

3. Methodology and model specification

3.1. Theoretical framework

The theoretical framework through which energy efficiency, financial inclusion, economic growth, and globalization affect carbon emission is discussed in this section. Concerning the former, energy efficiency could influence carbon emission. Energy efficiency has been a critical component of global energy security since the last few decades and emissions reduction (Le & Nguyen, 2019; Sovacool & Brown, 2010). According to the research, deviation from energy efficiency objectives greatly impacts carbon emissions in both emerging and industrialized economies (Akram et al., 2020; Javid & Khan, 2020). Currently, energy efficiency is generally recognized as an effective, low-cost approach for addressing the rising issue of CO₂ emissions (López-Peña et al., 2012; NAPEE., 2009). Almost all the studies argued that energy efficiency negatively affects CO₂ emission and promotes environmental quality. However, the energy efficiency could positively influence the environmental quality in two methods: 1) energy efficiency enhances energy saving at both domestic and industrial levels, which limits the CO₂ emission to the atmosphere and 2) the energy cost-saving, and the energy market prices could be retained at lower due to the efficient use of energy (Prindle, 2009). Thus, energy efficiency leads to environmental stability due to lower cost emissions. Thus, it could be assumed that energy efficiency negatively influences the CO₂ emission: $\theta_1 = \frac{\partial CO_{2,it}}{\partial EP_{it}} < 0$. Concerning financial inclusion, there are two types of theories. One group of scholars argued that financial inclusion provides access to financial services, which boosts the consumers' demand for energy and enhances CO₂ emission levels (Renzhi & Baek, 2020). However, the other group of

scholars argued that financial inclusion could provide the opportunity to transit to environmentally friendly energy sources consumption and lowers fossil fuel consumption via enhancing access to financial services (Qin et al., 2021). This ultimately leads to the reduction of CO₂ emissions in the atmosphere. Thus, both the positive and negative influence of the financial inclusion on the CO₂ emission could be expected. However, the emerging economies are more fossil fuel energy intensive that fulfills the energy demand for both the industrial sector; therefore, more investment and focus is paid towards the fossil fuel energy sector, which could boost CO₂ emissions in the region. Hence, the financial inclusion could positively influence CO₂ emissions in the region, which could be represented as: $\theta_2 = \frac{\partial CO_{2,it}}{\partial FIN_{it}} > 0$.

Generally, for CO₂ emission abatement, the EKC hypothesis has been preferred while investigating economic growth or income level. Beyond the EKC hypothesis, research has shown that an increase in income level significantly increases demand for goods and services. Thus, an increase in demand enhances energy demand and consumption, promoting environmental degradation (Dong et al., 2020; Malik et al., 2020; Wang & Zhang, 2020). However, if the threshold level of income is obtained, this tends to consume environmentally friendly energy sources, reducing environmental degradation by lowering the CO₂ emission level. Generally, two types of outcomes could be assumed as: firstly, the economic growth could promote emissions in the region, which is shown as: $\theta_3 = \frac{\partial CO_{2,it}}{\partial GDP_{it}} > 0$. However, after achieving higher economic growth, the economic growth could negatively influence emissions in the region, which could be expressed as follows: $\theta_3 = \frac{\partial CO_{2,it}}{\partial GDP_{it}} < 0$. Similarly, in the case of globalization, two types of outcomes are expected as the pro globalist argued that globalization enhances the innovative and environmentally friendly technologies that reduce CO₂ emissions and promote environmental sustainability. While the anti-globalist claimed that globalization increases energy demand via production for trade and expansion of the industrial sector. However, emerging economies are highly dependent on fossil fuel energy consumption, which inherently contributes to CO₂ emission enhancement and causes environmental degradation. However, globalization in emerging economies is more growth oriented, where most of the trade and other policies are concerned with economic growth, rather than environmental sustainability. Therefore, globalization could promote emissions in the E7 economies, and is expressed as: $\theta_4 = \frac{\partial CO_{2,it}}{\partial Glob_{it}} > 0$.

3.2. Model specification

Based on the theoretical notion and literature provided in Section-2, it is noticed that the recent trend of controlling environmental degradation attracts the attention of scholars and policy-makers. Various economic, environmental, and political indicators have been used to estimate their influence on environmental degradation. However, some of these indicators and are noted as unexplored and for other indicators, studies have provided diverse findings for different countries and regions. Therefore, this study adopted five exogenous variables, including financial inclusion, economic growth, energy productivity, energy efficiency's proxy, globalization, and the composite risk

Table 1. Variables' description and sources.

Variable	Description	Source
Carbon dioxide (CO ₂) emission	Measured in kiloton (kt).	https://databank.worldbank.org/source/world-development-indicators#advancedDownloadOptions
Financial Inclusion (FINC)	Index computed by using variables such as commercial bank's institutions, branches, outstanding deposits (% of GDP), Numbers of ATMs per 100,000 adults, and outstanding loans from commercial banks (% GDP).	https://data.imf.org/
GDP	Measured at constant US 2010 prices.	https://databank.worldbank.org/source/world-development-indicators#advancedDownloadOptions
Energy productivity (E.P.)	GDP per unit of Total primary energy supply.	https://stats.oecd.org/#
Globalization	Index.	https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html
Composite Risk Index (CRI)	cover all three political, economic, and financial risk indices.	https://www.prsgroup.com/explore-our-products/international-country-risk-guide/

index, estimated as a combined index for countries' economic, financial, and political risk. Besides, this study used carbon dioxide (CO₂) emission as the endogenous variable. Data over the period from 2004 to 2019 are taken into consideration for empirical estimation. The data for mentioned period is taken in the log form for the selected panel of emerging seven (E7) economies (Brazil, China, India, Indonesia, Mexico, Russia, and Turkey). The study variables, their description, and sources are provided in Table 1.

Following Qin et al. (2021) studies, the current study constructed two general models. The Model-1 demonstrates that financial inclusion, energy productivity, globalization, and composite risk index function carbon emission in E7 economies. However, the Model-2 displays that economic growth, financial inclusion, energy productivity, globalization, and composite risk index are the determinants of the region's carbon emissions. The reason for constructing two models is the investigation of what-if analysis. Further, it is objectivised to analyze the influence of these two variables, i.e., financial inclusion and economic growth, separately. The Model-1 and Model-2 are presented in the general form given as below:

Model-1

$$CO_2 = f(FIN_{it}, EP_{it}, Glob_{it}, CRI_{it})$$

Model-2

$$CO_2 = f(GDP_{it}, EP_{it}, Glob_{it}, CRI_{it})$$

These two models are modified to the regression form and are presented as Eq. (1) and Eq. (2) below:

$$CO_2 = \gamma_0 + \gamma_1 FIN_{it} + \gamma_2 EP_{it} + \gamma_3 Glob_{it} + \gamma_4 CRI_{it} + \varepsilon_{it} \quad (1)$$

Here, Eq. (1) represents four exogenous variables: financial inclusion, energy productivity, globalization, and composite risk index.

$$CO_2 = \gamma_0 + \gamma_1 GDP_{it} + \gamma_2 EP_{it} + \gamma_3 Glob_{it} + \gamma_4 CRI_{it} + \varepsilon_{it} \quad (2)$$

In Eq. (2), three exogenous variables are included from Model-1 and the GDP as new determinant, that is, three variables of Eq. (1) and economic growth. In both Model-1 and Model-2, the CO_2 represents the carbon emission of the E7 economies and is the main dependent variable across the two models. While FIN represents financial inclusion, GDP indicates gross domestic product (economic growth), E.P. replicates energy productivity, Glob designates globalization, and the CRI is the composite risk index for the E7 economies in both models. Further, γ_0 is the intercept of each equation, and $\gamma_{1,2...5}$ are the slopes of each exogenous variable in the two models. Moreover, "i" and "t" in the subscript denotes the cross-section and the time series across the panel, respectively.

3.3. Estimation strategy

After constructing study models and regression equations, this study employed econometric approaches required in the empirical estimation process. Such empirical approaches include normality test, slope heterogeneity, panel cross-section dependence, stationarity test, cointegration, long-run estimation regression, and the panel causality test.

3.3.1. Normality test

Before moving to empirical estimations, this study checked for the normality of the data of each variable by utilizing the Jarque and Bera (1987) normality test. The said test considers both the skewness and kurtosis combinedly to indicate the normality behavior of each variable under consideration. The null hypothesis of Jarque and Bera (1987) assumed the normal distribution of the variable where skewness and excess kurtosis are zero.

3.3.2. Slope heterogeneity and panel cross-section dependence

Empirical analysis of the current study begins with examining slope heterogeneity and panel cross-section dependence of the concerned group of countries. There are multiple factors where one country depends on other countries. Such factors include globalization, foreign direct investment, trade, inter alia. Therefore, dependency on other countries replicates similarities or differences across these countries. Conversely, in panel econometric analysis, the homogenous characteristics of economies across the selected panel of countries may provide biased results. In this regard, this study aimed to investigate whether these E7 countries vary or holding similar characteristics regarding the selected variables. Thus, we employed the Pesaran and Yamagata (2008) slope coefficient homogeneity (SCH) test for investigating the slope heterogeneity across the panel of E7 economies. The Pesaran and Yamagata (2008) SCH test assumed homogeneity of the panel as the null hypothesis, whereas heterogeneous if the panel countries do not follow the same characteristics. The final form of the said test is provided as Eq. (3) and Eq. (4) below, respectively.

$$\hat{\Delta}_{SCH} = \sqrt{\frac{N}{2k}} \left(\frac{1}{N} \hat{S} - K \right) \quad (3)$$

$$\hat{\Delta}_{ASCH} = \sqrt{\frac{N}{\frac{2K(T-K-1)}{T+1}}} \left(\frac{1}{N} \hat{S} - 2K \right) \quad (4)$$

Where Eq. (3) and Eq. (4) are the slope coefficient homogeneity ($\hat{\Delta}_{SCH}$) and the adjusted slope coefficient ($\hat{\Delta}_{ASCH}$), respectively. It is already discussed that those factors such as globalization, foreign direct investment, and trade, among others significantly influence the market structure, economy, and environmental structure. Hence, the cross-section dependence across the panel leads to unreliable results as mentioned by Campello et al. (2019). Therefore, the current study employed Pesaran (2021) cross-section dependence (CD) test to empirically investigate the cross-section dependency of the E7 economies. The mentioned test assumed cross-section independence across the panel as the null hypothesis, while cross-section dependence remained as an alternative hypothesis. The final form of the Pesaran (2021) CD test is provided in Eq. (5) given below:

$$CD_{Test} = (2T)^{1/2} \frac{1}{\sqrt{N(N-1)}} \sum_{i=1}^{N-1} \sum_{k=1+i}^N T_{ik} \quad (5)$$

3.3.3. Stationarity test

After examining the normality, panel slope heterogeneity, and cross-section dependence, we checked for the presence of a unit root in the variables' data under consideration. It is crucial for an empirical estimation that the panel data consisting of time series and the cross-sections should not have a unit root as this issue exclusively provide biased or inconsistent estimates. In this regard, the current study employed the Pesaran (2007) cross-sectionally augmented IPS (CIPS) test for unit root. The said test is an efficient second-generation unit root test as it considers both the cross-section dependency and heterogeneity issues. The Pesaran (2007) CIPS unit root test claims that the unit root is present in the panel data as its null hypothesis, and stationarity as the alternative one. Thus, before the empirical investigation of the model(s), we checked for the stationarity at level $\{I(0)\}$ and first difference $\{I(1)\}$ of the data. This further reveals the strategies to adopt for long-run estimations.

3.3.4. Cointegration test

Prior to moving to empirically analyze the long-term estimates, we investigated the long-run cointegration relationship between the heterogeneous variables. Investigating the long-run relationship further provides support to the long-run estimates via regression approaches. In this concern, we utilized the Westerlund (2007) error correction model (ECM), which tackles the slope heterogeneity and cross-section dependency issues in the panel. The said test provides estimates for both the group mean statistics and the panel statistics. The final form of the group mean statistics

are $G_t = N^{-1} \sum_{i=1}^N \frac{\hat{\alpha}_t}{S.E\hat{\alpha}_i}$ and $G_t = N^{-1} \sum_{i=1}^N \frac{T\hat{\alpha}_t}{\hat{\alpha}_i(1)}$. However, the final form of the panel statistics is presented as $P_t = \frac{\hat{\alpha}}{S.E(\alpha)}$ and $P_t = T\hat{\alpha}$.

3.4. Long run estimation and panel causality tests

Once the pre-requisites including normality, slope heterogeneity, panel cross-section dependence, stationarity, and cointegration tests, for the long run estimations, are analyzed, it is crucial to regress the variables under consideration with an efficient estimator. In this regard, we utilize the panel quantile regression provided by Koenker and Bassett (1978). This study neglect utilization of the conventional regression techniques for analysis due to over and under-estimates biasedness of the coefficients estimates. These conventional approaches only provide the average impacts of the exogenous variables (Qin et al., 2021). Hence, we adopted the panel quantile regression approach in this study. The panel quantile regression is an efficient estimator because of the normality specifications and also provides results estimated at each selected quantile. Further, this technique is beneficial because it tackles the cross-section dependency and the slope heterogeneity issues (Amin et al., 2020). Generally, the final form of the panel quantile regression for Model-1 and Model-2 is presented as Eq. (6) and Eq. (7) below:

$$Q_{CO_2,it}(\theta \mid \alpha_i, \gamma_t, X_{it}) = \alpha_i + \gamma_t + \gamma_{1,\theta}FIN_{it} + \gamma_{2,\theta}EP_{it} + \gamma_{3,\theta}Glob_{it} + \gamma_{4,\theta}CRI_{it} + \varepsilon_{it} \quad (7)$$

$$Q_{CO_2,it}(\theta \mid \alpha_i, \gamma_t, X_{it}) = \alpha_i + \gamma_t + \gamma_{1,\theta}GDP_{it} + \gamma_{2,\theta}EP_{it} + \gamma_{3,\theta}Glob_{it} + \gamma_{4,\theta}CRI_{it} + \varepsilon_{it} \quad (8)$$

Where θ in the subscript represents quantile for each variable in both eq. (6) and Eq. (7), respectively. This study investigates the influence of each variable on the CO₂ emission across the three quantiles, i.e., Q₂₅, Q₅₀, and Q₇₅ for both models, respectively. Besides, the "i" and "t" in the subscript signifies the cross-section and the time period across the panel, respectively.

Once the long-run estimates are analyzed, the current study also investigated the causal association between the variables under consideration. Therefore, we adopted the Dumitrescu and Hurlin (2012) Granger panel causality heterogeneous test. This test provides efficient estimates where the time series is not equal to the cross-section ($T \neq N$) across the panel. Besides, the Dumitrescu and Hurlin (2012) Granger panel causality approach provides efficient estimates by considering the cross-section dependency and heterogeneity across the panel data. The estimated results via employing these econometric approaches are provided in the next section.

4. Results and discussion

The estimated results for the normality test along with the descriptive statistics for each variable under consideration are presented in Table 2. The mean and the

Table 2. Normality check and descriptive statistics.

	CO ₂	EP	FININCL	GLOB	CRI	GDP
Mean	5.9805	3.9363	-8.04E-09	1.8108	1.8456	12.217
Median	5.7024	4.0043	-0.6135	1.8058	1.8492	12.160
Std. Dev.	0.4862	0.1775	1.5975	0.0290	0.0310	0.3040
Jarque-Bera	14.685	8.8614	29.253	0.8822	2.0457	22.007
Probability	0.0006	0.0119	0.0000	0.6433	0.3595	0.0000

Source: Authors own estimations.

median value of CO₂ emission is approximately the same, reported as 5.9805 and 5.7024, respectively. This reveals the lower standard deviation value, which accounted for 0.4862 distance on average from the mean value. Here, the Jarque and Bera (1987) normality test estimates hold the null hypothesis normal distribution of the data having skewness and excess kurtosis being zero. The estimates for Jarque and Bera (1987) of CO₂ emission carry the p-value 0.0006, reported less than 0.05. Thus, the null hypothesis for the CO₂ being normally distributed is rejected and it is assumed that the said variable is not normally distributed. Similarly, the mean and median values for energy production are presented as 3.9363 and 4.0043, respectively, and the standard deviation value is reported as less than the CO₂ emissions' standard deviation value. The Jarque-Bera probability value is recorded as 0.0119, less than the conventionally recognized P-value of 0.05. Hence, this also rejects the null hypothesis, confirming that the variable's data is not normally distributed.

In contrast, the mean and median values for financial inclusion are reported negative, i.e., $-8.04E^{-09}$ and -0.6135 , respectively. However, the standard deviation is the highest among all the variables. This demonstrates the fluctuations in financial inclusion data of the E7 economies. The probability value for the normality test is highly significant, which rejects the null and concludes that the financial inclusion data is not normally distributed. In the case of globalization and composite risk index (CRI), their mean, median, and standard deviation values are approximately the same. The mean values are reported as 1.8108 and 1.8456, median values are 1.8058 and 1.8492, and the standard deviation values are reported as 0.0290 and 0.0310, respectively, for globalization and CRI. These standard deviation values are the lowest across all variables. Similarly, the Jarque-Bera estimates provide the P-values for globalization and CRI as 0.6433 and 0.3595, respectively. These values are found insignificant at all levels; thus, it is concluded that the globalization and the CRI data are normally distributed. Additionally, the GDP signifies the mean value of 12.217, the median value of 12.160, and the standard deviation value of 0.3040, slightly above the CRI. The Jarque-Bera normality test provides the highly significant P-value at 1%, 5%, and 10% levels. Thus, the GDP could reject the null hypothesis and confirm the data's non-normal distribution. This mixed behavior of the variables' data regarding normality further strengthens our adopted estimating approach, as the traditional regression approach does not consider the non-normal distribution of data.

After the normality test of the data, this study checked for the panel's slope heterogeneity and cross-section dependence, and their empirical estimates are provided in Table 3. The slope coefficient homogeneity of the variables is analyzed via employing Pesaran and Yamagata (2008) SCH test. The results reveal that both the SCH and adjusted SCH are highly significant at the 1% level. Hence, the null hypothesis of the

Table 3. Slope heterogeneity and cross-section dependence.

Slope Heterogeneity Test	Model-1	Model-2
$\frac{\Delta}{\Delta}$ Adjusted	3.853***	4.874***
	3.268***	4.133***
Cross-Section Dependence		
CO ₂	EP	FINC
14.07***	7.469***	15.023***
GDP	CRI	Glob
17.103***	4.163***	6.583***

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.

Source: Authors own estimations.

Pesaran and Yamagata (2008) SCH test is rejected, and it is concluded that the slope coefficients are heterogeneous.

Countries worldwide depend on other countries for different economic, financial, social, and political interests in modern times. Globalization opens the doors for these countries to trade and relocate different sources of production. Therefore, the cross-section dependence may occur; however, the cross-section dependence issue in an econometric investigation may provide misleading results. In this regard, the Pesaran (2021) CD test estimates are provided in Table 3. The estimated result for each variable is reported as highly significant at a 1% level. Thus, the null hypothesis of the Pesaran (2021) CD test could be rejected, and it is concluded that the E7 economies depend on each other for different motives.

After analyzing the slope heterogeneity and cross-section dependence in the panel, their results illustrate that the slope is heterogeneous and cross-section dependency is present. Thus, the current study employed Pesaran's (2007) CIPS test that considers slope heterogeneity and cross-section dependency. The estimated results are provided in Table 4. Firstly, the Pesaran (2007) CIPS test provides insignificant results for the data at level, which means that the unit root is present in all the variables' data. However, the test offers significant results at 1% and 10% levels on the first difference data. Hence, the null hypothesis of the presence of the unit root could be rejected, and it is concluded that the data is stationary.

After estimating the Pesaran (2007) test, which confirms the stationarity of data at the first difference, we further analyze the long-run relationship between the variables under consideration. In this concern, the estimated results via the Westerlund (2007) cointegration test are provided in Table 5. The said test consider that the error correction term is zero (i.e., ECT = 0) in a conditional in the panel conditional error correction model. The examined results revealed both the group mean statistics and the panel statistics highly significant values at 1% level for Model-and Model-2. The negative error correction term suggests that both the group mean and panel statistics significantly converge toward the equilibrium position. Thus, the null hypothesis of the ECT = 0 could be rejected and assumed that the variables such as CO₂ emission, energy productivity, financial inclusion, globalization, composite risk index, and economic growth are associated in the long run. Such findings are also confirmed by the earlier study of Li et al. (2021) by finding the long-run association between the concern variables.

Table 6 presents the empirical findings of the panel quantile regression proposed by Koenker and Bassett (1978). As mentioned earlier, the panel quantile regression

Table 4. Unit root testing (Pesaran, 2007).

Variables	Intercept and Trend	
	I(0)	I(1)
CO ₂	-2.295	-3.651***
EP	-2.034	-2.852*
FINC	-1.713	-2.904*
Glob	-2.052	-3.921***
CRI	-2.300	-3.426***
GDP	-1.557	-2.922*

Note: Significance level is denoted by ***, **and *for 1%, 5% and 10%. I(0) is for level, and I(1) is for the first difference.

Source: Authors own estimations.

does not consider the mean value for estimation. Instead, this estimator considers the estimated value for each selected quantile regarding the influence of exogenous variables on the CO₂ emission level. This study provides the panel quantile results for three quantiles, i.e., $q_{0.25}$, $q_{0.50}$, and $q_{0.75}$. In Model-1, the variables such as financial inclusion, energy productivity, globalization, and the composite risk index reveal highly significant influence at a 1% level across the three quantiles. However, financial inclusion, globalization, and CRI positively influence the CO₂ emission, while the energy productivity or energy efficiency negatively affect the CO₂ emission across the three quantiles. Specifically, in the $q_{0.25}$, a one percent increase in financial inclusion, globalization, and CRI leads to a significant increase in CO₂ emissions by 0.197, 0.946, and 0.703%, respectively. That is, an increase in financial inclusion means an enhancement in commercial banks, their branches, their outstanding deposits, an increase in the number of ATMs per 100,000 adults, and an increase in the commercial bank's outstanding loan, which further provides opportunities to investors and industrial sector to invest in production and expand the industrial sector. However, an increase in the production sector requires more energy to consume and is obtained from traditional fossil fuels, which causes environmental degradation in the economy. Current findings are in line with the findings of Le et al. (2020) in the case of 31 Asian economies and Li et al. (2021) in China. Similarly, globalization enhances economic activities such as free trade, including imports and exports of energy-intensive goods, which enhances the CO₂ emission level in the atmosphere and causes environmental degradation. Additionally, the increased globalization indicates an enhancement in the businesses and organizations across borders, which increase demand for goods and services – boost industrial production. However, in the emerging economies, most of the industrial sector is fossil fuel dependent, which fuels the CO₂ emissions in the region. Current findings are in line with the existing literature such as Kirikkaleli et al. (2021) and Le et al. (2020), which provide empirical evidence of globalization's increasing effect on CO₂ emissions. However, contradictory findings are provided by Qin et al. (2021), demonstrating that globalization could be a remedial measure of environmental degradation that promotes renewable energy and technological innovation. In the same way, if the country is facing political, economic, and financial instability, the law enforcement institution could not bear the cost of preventing environmental degradation. The findings of this study are consistent with the earlier studies of Hassan et al. (2021) in case of the RCEP economies. Specifically, the positive association of CRI and CO₂ emissions is mainly because enhancement in

Table 5. Cointegration results (Westerlund-2007).

Statistics	Model-1	Model-2
G_t	-5.371***	-4.431***
G_a	-8.201***	-8.341***
P_t	-10.731***	-9.345***
P_a	-13.312***	-12.341***

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.

Source: Authors own estimations.

the country's risk promotes uncertainty for investors and industrialists, limiting investment in environmentally friendly energy and technologies. Therefore, the dependency on fossil fuel energy is increased, leading to CO₂ emissions and environmental degradation. In contrast, energy productivity exerts a negative influence on CO₂ emissions. That is, a one percent increase in energy productivity declines the CO₂ emissions by 0.173 percent. The current findings are consistent with the earlier findings of Mahapatra and Irfan (2021), Wang and Wang (2020), and Chen et al. (2020). Energy efficiency promotes energy-saving behavior and encourages renewable energy sources, significantly reducing the CO₂ emission level in the atmosphere and promoting environmental sustainability. Hence, energy efficiency could be a prominent policy tool to achieve a low carbon economy and promote environmental sustainability.

The influence of these variables remained the same across the rest of the two quantiles (i.e., $q_{0.50}$ and $q_{0.75}$). However, a slight change has been observed in the magnitude of the coefficient of each variable. Specifically, the financial inclusion follows the increasing trend in terms of coefficient's magnitude, while the globalization and the CRI decrease in the $q_{0.50}$ and increases in the $q_{0.75}$. In contrast, the energy productivity magnitude increases in the second quantile while it decreases in the third quantile.

Concerning Model-2, economic growth exerts a positive and significant influence on CO₂ emissions across the three quantiles. Specifically, a one percent increase in the GDP causes an increase of 0.858, 1.077, and 1.075% in $q_{0.25}$, $q_{0.50}$, and $q_{0.75}$, respectively. The current findings are found consistent with the earlier studies of Malik et al. (2020), Dong et al. (2020), Wang and Jiang (2020), Bandy and Aneja (2020), Wang and Zhang (2020), and Ahmad et al. (2018). It is well known that GDP is the measure of the economy's health. However, industrial development and economic activities speed up the GDP growth but at the cost of environmental degradation due to high energy demand and consumption on the domestic and industrial levels. In other words, increased GDP enhances the per capita income and savings, where demand for goods and services boosts. In order to fulfill demand for goods, the industrial sector increase production, which also causes expansion of the industrial sector. At the same time, the energy demand for the expanded industrial sector and increased production is fulfilled via traditional fossil fuel consumption. Besides contributing to economic growth, fossil fuel consumption leads to higher emissions in the region that causes environmental degradation and promotes global warming. The rest of the variables, including energy productivity, globalization, and the CRI exert the same impact on the CO₂ emission level as discussed in Model-1. However, a difference in the magnitude of these variables has been observed across quantiles.

Table 6. Panel quantile regression results.

Variables	$q_{0.25}$	
	Model – 1 Coefficients[Std.Error]	Model – 2 Coefficients[Std.Error]
<i>FINC</i>	0.197*** [0.093]	–
<i>GDP</i>	–	0.858** [0.373]
<i>EP</i>	–0.173*** [0.0199]	–0.147*** [0.0211]
<i>Glob</i>	0.946*** [0.122]	0.367*** [0.0672]
<i>CRI</i>	0.703*** [0.1023]	0.521*** [0.0791]
<i>Constant</i>	1.421*** [0.299]	1.722*** [0.201]
	$q_{0.50}$	
<i>FINC</i>	0.211*** [0.0148]	–
<i>GDP</i>	–	1.077*** [0.0217]
<i>EP</i>	–0.170*** [0.0230]	–0.189*** [0.034]
<i>Glob</i>	0.208*** [0.0188]	0.374*** [0.0761]
<i>CRI</i>	0.426*** [0.0811]	0.572*** [0.0991]
<i>Constant</i>	1.0272*** [0.1724]	1.724*** [0.321]
	$q_{0.75}$	
<i>FINC</i>	0.2112*** [0.0062]	–
<i>GDP</i>	–	1.075*** [0.0451]
<i>EP</i>	–0.182*** [0.0253]	–0.137*** [0.0023]
<i>Glob</i>	0.392*** [0.076]	0.788*** [0.1043]
<i>CRI</i>	0.622*** [0.1082]	0.564*** [0.0881]
<i>Constant</i>	1.8422*** [0.2641]	1.821*** [0.231]

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.

Source: Authors own estimations.

The magnitude of these variables in $q_{0.50}$ of Model-2 is reported relatively higher than the magnitude of these exogeneous variables in $q_{0.50}$ of the Model-1. However, the net influence remained the same across the models and quantiles.

After empirically examining the influence of each variable on the CO₂ emissions across the three selected quantiles, it is important to uncover the causal relationship between these variables under consideration. In this regard, the estimated results via Dumitrescu and Hurlin's (2012) Granger panel causality approach are provided in Table 7. The empirical findings illustrate the one-way causal relationship between globalization and CO₂ emission, reported as running from the former to the latter. This further validates the earlier outcomes that globalization is a substantial factor of emissions in the E7 economies. However, the rest of the variables, i.e., energy productivity, financial inclusion, GDP, and the CRI are found in a bidirectional causal

relationship with the CO₂ emission. That is, these variables showed the feedback effect concerning the CO₂ emissions. Regarding the causal relationship, the findings of this study are consistent with the earlier study of Malik et al. (2020), which provides evidence of the feedback effect of CO₂ emission and economic growth. The feedback analysis reveals that energy efficiency, financial inclusion, economic growth and CRI could be necessary policy measures for promoting environmentally friendly energy resources, lowering fossil fuel energy, and achieving carbon neutrality targets.

5. Conclusion and policy implications

5.1. Conclusion

Since the emerging seven (E7) economies are among those rapidly developing economies where economic development is expected to grow at a steady pace in the coming years, such rapid economic growth may also affect the environmental attributes of these economies. In addition, globalization and financial inclusion are reported increasing over time, which further strengthens the industrial sector and manufacturing of goods via fossil energy consumption, leading to environmental degradation. Besides the future environmental attributes, some of these countries are already among the top CO₂ emitting economies globally. Therefore, mitigation or combatting CO₂ emissions would be challenging for these economies. In this sense, the current study aims to explore the influence of energy efficiency, financial inclusion, economic growth, globalization, and composite risk index on the CO₂ emission of the said region over the period 2004-2019. The study used panel data tools such as slope heterogeneity, cross-section dependency, and unit root test. The panel cointegration test validates the existence of long-run association between the variables. However, the irregular distribution of the data leads to the adoption of a panel quantile regression estimator. The empirical estimates reveal that financial inclusion, economic growth, globalization, and the composite risk index significantly increase the CO₂ emission level in the E7 countries. Enhancement in these factors significantly encourages the use of fossil fuel energy via investment provided due to financial accessibility, enhanced per capita income, and expansion of businesses, industries, and organizations across the borders due to globalization. Hence, these factors boost the consumption of non-renewable energy sources, which contributes to CO₂ emissions in the region. Besides, the CRI is also a factor of CO₂ emissions in these regions, which allows industrialists to use more fossil fuel energy due to lower investment due to uncertainty. Therefore, the higher risk leads to higher CO₂ emissions in the region. On the other hand, energy efficiency is found to have a negative and significant effect on the atmospheric CO₂ emission level. An increase in the energy saving approaches reduces dependency on traditional non-renewable energy resources, which lowers CO₂ emissions in emerging economies. Moreover, the panel causality test reports both the unidirectional and bidirectional causality between the variable, where globalization significantly causes CO₂ emissions, while the rest are evident of the feedback effect. This indicates that these variables could be used as a policy tool for environmental recovery.

Table 7. Causality check.

Dumitrescu Hurlin Panel Causality			
H_0	Wald – Stats	\bar{Z} – Stats	p-value(s)
EP-CO ₂	6.62***	4.80	0.000
CO ₂ -EP	5.82**	2.49	0.012
FINC-CO ₂	6.17***	2.76	0.005
CO ₂ -FINC	5.33***	3.58	0.004
GDP-CO ₂	4.79*	1.70	0.088
CO ₂ -GDP	5.44***	2.82	0.006
GLOB-CO ₂	7.79***	4.93	0.000
CO ₂ -GLOB	3.41	0.64	0.517
CRI- CO2	6.09***	3.16	0.008
CO2-CRI	5.84**	2.50	0.012

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.

Source: Authors own estimations.

5.2. Policy implications

This study provides practical policy implications that could benefit both the environment and the economy based on the empirical findings. Firstly, economic growth in these emerging economies is based on the industrial sector, which is heavily energy intensive. Therefore, economic growth must be diverted to the adoption of renewables and structural transformation of the industrial sector, contributing to economic growth and lower emissions in the E7 economies. Secondly, policies should be adopted that promote energy efficiency and energy saving behavior, particularly in the industrial sector. This will reduce fossil fuel energy dependency and promote environmental sustainability. In addition, policies regarding financial inclusion and globalization need to consider renewable energy promotion and consumption via promoting green financing and green bonds in the region. Lastly, the economic, political and financial sectors must be stabilized to reduce the composite risk index, allowing domestic and international investors to invest in the renewable energy sector and green technologies, consequently leading to reduced emissions in the emerging economies.

5.3. Limitations and future research guidelines

This study is limited only to the empirical investigation of the E7 economies due to the unavailability of the data. However, it is recommended that this study be further extended by analyzing the developed or developing economies concerning the role of energy efficiency and financial inclusion in CO₂ emission reduction. Besides, these studies are also recommended to compare these groups while empirically analyzing the role of these variables of interest. In addition, future researchers are directed to explore the association of emissions with more economical and energy related variable such as trade (imports and exports), urbanization, consumption-based carbon emissions, production based carbon emissions, etc.

Acknowledgements

The authors would like to acknowledge the support from the Scientific and Technological Innovation Think-tank Program of Fujian Association for Science and Technology (No. FJKX-B2004).

Disclosure statement

No potential conflict of interest was reported by the authors.

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