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The dynamic nexus among financial development, renewable energy and carbon emissions: Moderating roles of globalization and institutional quality across BRI countries

Muhammad Sheraz [a], Xu Deyi [a,*], Avik Sinha [b], Muhammad Zubair Mumtaz [c], Nudrat Fatima [d]

[a] School of Economics and Management, China University of Geosciences, Wuhan, China
[b] Centre for Excellence in Sustainable Development, Goa Institute of Management, India
[c] College of Business Administration, University of Bahrain, Bahrain
[d] Bahria University Islamabad, Pakistan

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ABSTRACT

Belt and Road (BRI) countries are trying to realize the potential of financial resources and renewable energy in order to mitigate the effects of carbon dioxide (CO2) emissions and to attain the Sustainable Development Goals (SDGs). However, prevailing structural issues have been found to stymie the environmental outcome. This issue calls for a policy reorientation in the BRI countries, and therein lies the role of the present study. This study examines how the environmental impacts of financial development and renewable energy respond to exogenous moderation. Using a second-generation methodological approach on the data of the 64 BRI countries over 2003–2019, findings reveal that globalization enhances the negative environmental externality exerted by financial development, while institutional quality suppresses it. Both globalization and institutional quality augment the positive environmental externalities exerted by renewable energy and human capital. Using dynamic elasticity measures, the evolutionary impacts of the moderators are also captured. An SDG-oriented policy framework is recommended based on the study outcomes.

1. Introduction

In recent times, global warming and climate change have been influential topics for policymakers, researchers, and scholars around the world. The fast growth of developing economies creates more investment opportunities and stimulates the demand for energy, which also causes environmental degradation. However, countries are investing in green projects for shifting energy sources toward green or renewable energy sources to meet the demand for energy. This transition can create the base for sustainable development by demanding financial support for green technology. This transition, however, is a daunting task for developing countries, where the risk level is high to invest in green projects (in terms of restrictions, low level of government support, high cost of investment, energy poverty, etc.) to minimize the usage of fossil fuel. The progress report of Sustainable Development Goals (SDG) also emphasizes the importance of green investment and shifting toward the latest technology for green energy to meet the SDG objectives (United Nations, 2020).

This role could be vital for developing countries, as the growth objectives for emerging economies compel policymakers to strive toward the attainment of these goals even at the cost of environmental degradation. Therefore, it is crucial for developing countries to make financial investments in green projects and switch toward renewable energy and attain the SDG. In this context, Belt and Road Initiative countries (BRI) led by China need significant mention. The second BRI conference was held in 2019 to focus on climatic vulnerability, infrastructure connectivity, and sustainable development of BRI countries. The key recommendation of these conferences is to construct the green BRI through facilitating green investment, the shift toward renewable energy and infrastructure connectivity, and better governance to attain the 2030 SDG (BRIGC, 2020). The discourse of policies underscores the concerns expressed by policymakers about the deteriorating climatic conditions in the BRI countries. Therefore, it is crucial to intervene regarding financing and renewable energy and it is the main concern of this study

* Corresponding author.
E-mail addresses: sheraz_sadiq96@cug.edu.cn (M. Sheraz), xdy@cug.edu.cn (X. Deyi), f11aviks@iimidr.ac.in (A. Sinha), zubairmumtaz76@gmail.com (M.Z. Mumtaz), nufatima.buic@bahria.edu.pk (N. Fatima).

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too.

As explicated above, it is imperative to maintain the pace of economic growth but also find alternative solutions of energy (investing in green energy projects) to meet the demand and also improve the environmental quality. The economic growth of BRI countries heavily relies on financial development (FD), as strong financial systems offer loans at a low cost of borrowing for industries and household sectors. This, in turn, stimulates the demand for energy and causes environmental issues. BRI countries facing climate issues due to the stage of traditional industrialization and high consumption of fossil fuel, but the only solution is to find a substitute source of energy (green or renewable energy). Despite not appearing to be complicated, this transition needs several policy implications. As a continuous change in technological capabilities, distribution of resources, poor financial systems, the first-time investment in such kind of projects (new entrance), and less governmental support, can sometimes compromise the mutual interests of nations, one of the major concerns is the level of risk associated with financial investment for green or renewable energy projects. The Green Development Guidance for Belt and Road Project Baseline Study report 2020 (BRIGC, 2020) also endorse the possible risk related to financial investment in green or renewable projects to achieve the SDG goals.

However, 2015, 2016 annual reports of BRI (Chin et al., 2015; Liu, 2019) have suggested ways of accomplishing the financial goals for sustainable green energy projects through strengthening the financial cooperation, improving financing systems, establishing Brazil, Russia, India, China, and South Africa (BRICS) New Development Banks (NDB), Shanghai Cooperation Organization (SCO), and financing institutions as well as creating green bounds markets to address the climates issues. The facts of assessment reports (BRIGC, 2020; HKTDC, 2017; IEA& OECD, 2018) suggest geopolitical events circumvent the funding of green energy projects and raise the level of risks. In such circumstances, adopting new strategies for a better financial mechanism that could achieve sustainable goals is crucial. Likewise, BRI countries can adopt the *Organization for Economic Cooperation and Development* (OECD) and the *International Partnership for Energy Efficiency Collaboration* (IPEEC) in G20 countries sorts of financial innovative strategies for green or renewable projects (IPEEC, 2016). These findings suggest that financial innovation can play a vital role in a sustainable environment by investing in alternative sources of energy projects (renewable energy).

Moreover, BRI countries face challenges in achieving the objects of SDG 13 (climate action) and SDG (clean and affordable energy), as cross border traversing of resources, financial investment, trades fossil fuel trajectory boosts the economic activities (globalization) but also poses risks for environmental quality. Although it is crucial to have sustainable financial investment and import of efficient technology for green energy projects from the policymaking perspective, it is equally important not to lose sight of environmental degradation issues (Sinha et al., 2020a,b,c). This part is a very crucial aspect of achieving the objectives of SDG 7 and SDG 13. International relations are influenced by geopolitical shocks of regions; in this context, some inconsistency may be found when it comes to investing in green projects and harnessing the innovative capabilities of developing countries. This impact may be evident in green or renewable energy projects, thus improving the environmental quality by mitigating carbon emission (CO2) levels. Further, economic activities are also influenced by these shocks and ultimately affect environmental quality. The intervention of policy plays a crucial role in minimizing the unpredictability of environmental change caused by these shocks. The key objective of this empirical study is to recommend these policy interventions for BRI countries, and the research question can be as follow:

Research Question: *Do the shocks of financial investment and renewable energy stimulate the environmental quality in BRI nations?*

As per research objectives, this study aims to formulate a sustainable development growth-oriented policy framework for shocks of financial development and renewable energy and its influence on environmental quality in BRI countries. The core objective of this formulated policy framework is to bring innovation into BRI countries so as to address issues of SDG 7, and 13. However, this policy framework specified for BRI countries can also be generalized toward other developing countries, which are also facing environmental issues. Through gauging innovative shocks for the BRI countries, the incorporated SDG-oriented framework of policies can address the policy level impact of the study.

While incorporating the policy framework, it is vital to capture the evolutionary effect of the policy instruments of study on the directed policy indicators (Sheraz et al., 2021a,b). To cover this dimension, the study adopted an analytical framework as it complements the research objectives of the study. Besides that, due to socio-economic collaboration or association among BRI countries can cause ambiguity in the estimated results (Sheraz et al., 2021a,b). Therefore, this study adopted a second-generation methodological approach to address this problem.

Further, this empirical study is organized as follows: section 2 based on a critical review of the literature, theoretical background, and discussion of the study is presented in section 3. Moreover, section 4 comprises data sources and econometric techniques, while sections 5 and 6 present findings discussions, conclusions, policy recommendations, and limitations respectively.

2. Literature review

2.1. Relationship between financial development and carbon emissions

A growing body of empirical literature has been examining the influence of financial development on CO2 emission. Due to differences in methodology, sample period, country selection (single or panel), FD measurement indicators, and environmental indicators (CO2 emissions in environmental footprint), empirical evidence is frequently found to yield contradictory results. Over the past few years, the relationship between FD, economic growth, and CO2 has elicited plenty of attention in the literature on energy economics. Many scholars have examined the nexus between FD and CO2 emissions. The first study on the environment was conducted by Grossman and Krueger (1995) using the Environmental Kurtz Curve (EKC) concept. Concordantly, Khan (2001) stated FD is critical because it provides financial resources associated with economic growth and environmental quality. Economic activity occurs as a result of financial lending which stimulates the demand for energy, which influences environmental quality (Khan et al., 2017a,b).

According to previous research, there is no consensus on the relationship between FD and CO2. As a case in point, Zioło et al. (2020) found in their study that conventional financing is being replaced by sustainable financing, which includes imposing taxes on anti-environmental sectors, giving funds for research and development (R&D), and switching toward low carbon technologies, all of which support pro-environmental solutions. Moreover, it was found that there is a substantial association between financial tools (FD of the R&D sector, environmental taxes) and GHGs. Similarly, Ozturk and Acaravci (2013) explored the relationship between energy consumption (EC), FD, commerce, and CO2 emissions in Turkey. The findings indicate that FD exerts a positive influence on environmental quality. In the context of Malaysia. On the other hand, Islam et al. (2013) claimed that investing in green projects helps to switch toward renewable energy, which also mitigates CO2 emissions. Correspondingly, Shahbaz et al. (2013) used the ARDL test to demonstrate that FD and trade openness improve environmental quality in Indonesia. Similarly, FD was found to reduce CO2 emissions in other recent studies (Khan et al., 2021; Omoke et al. 2020).

Meanwhile, the second school of thought opined that FD causes environmental corrosion. According to Charfeddine et al. (2018), FD facilitates inexpensive borrowing and low-interest rates for development projects. Due to the low cost of borrowing, industries and households may readily invest in acquiring fossil fuel consumption machinery, equipment, and durable commodities, thus creating a surge in energy consumption and CO2 emissions (Zhang, 2011). Khan et al. (2017a,b) examined the relationship between FD, EC, and CO2 emissions in 34 upper-middle-income economies. As per the findings, FD and EC cause CO2 emissions. Likewise, the relationship between FD and CO2 emissions was explored by Saud et al. (2020) and Sheraz et al. (2021a,b) in countries within one belt. Using the pool mean group test, the results revealed that FD has a negative influence on environmental quality.

By adopting the Autoregressive Distributed Lag (ARDL), approach, the study showed that FD and trade openness contributed 2.475% and 1.65% of carbon emissions respectively. Meanwhile, Salahuddin et al. (2015) found that FD does not affect carbon emissions. Summing up, it can be inferred that the development of the financial sector is critical to a country's economic growth. In that context, there is a direct correlation between the growth of energy consumption and that of the financial sector. Inevitably, the availability of finances improves individuals' living standards and stimulates human activities that boost energy consumption.

2.2. Renewable energy consumption and carbon emission

Switching to renewable energy is one of the most important revolutionary steps in achieving a green and clean environment. According to the International Energy Agency (IEA) and Organization for Economic Co-operation and Development (OECD) (2018), renewable energy consumption (REC) will see a growth of 60% by 2040. Sadorsky (2011) stated that for a clean and green environment to become a reality, renewable energy contributes 50–80% to the total energy mix. Several prior research studies have examined the correlation between renewable energy and its influence on environmental quality. To support their argument, Bhattacharya et al. (2017) examined the relationship between REC and institutional quality for CO2 emissions in 84 countries. Generalized Methods of Moment (GMM) and Fully Modified Ordinary Least Squares (FMOLS) estimation techniques findings suggest that renewable energy improves the quality of the environment by reducing CO2 emissions.

Similarly, Balsalobre-Lorente et al. (2018) studied the impacts of renewable energy, trade openness, Gross Domestic Product (GDP), and natural resources on CO2 emissions in five European countries. The findings of this study show that renewable natural resources improve environmental quality whereas GDP and trade openness stimulate carbon emissions. On the other hand, Hao et al. (2021) and Khan et al. (2020) examined the relationship between REC and environmental quality in G7 countries and found that green energy improves environmental quality. Furthermore, other studies (Bao and Xu, 2019; Charfeddine and Kahia, 2019; Rahman and Velayutham, 2020; Uzar, 2020; Khan and Hou, 2021) showed that the global industrial structure is shifting toward sustainable and green economics which, in turn, is enhancing the quality of the environment. Thus, that the literature review shows that the use of fossils has a positive influence on CO2 emissions, whereas using renewable energy significantly decreases the level of CO2 emissions.

2.3. Globalization as a moderator

In recent literature, globalization (GB) is one of the factors to have been neglected in terms of influencing Financial Development (FD), Energy Consumption (EC) Human Capital (HC), Gross Domestic Product (GDP), and CO2 emissions. One of the pioneer studies conducted by Mishkin (2009) examined the influence of GB on FD and GDP. Findings show that the GB is a crucial component that promulgates the financial sector by lowering the cost of borrowing, resulting in greater investments in various projects and the accompanying growth in GDP. Similarly, Kandil et al. (2015) found that GB has a direct relationship with FD and GDP. However, energy remains a major impediment for the production of goods and services, while also acting as a source of CO2 emissions. GB raises energy demand and CO2 emissions (Shahbaz et al., 2018a; Shahbaz et al., 2018b). To lend credence to this argument, Shahbaz et al. (2017a,b) found in their study that economic growth causes environmental degradation through GB and EC in Japan. Likewise, Kamran et al. (2019) conducted a study in Pakistan to investigate the relationship between GB, GDP, EC and CO2. Using the ARDL method, it was shown that GB, FD, and EC were positively linked with CO2 emissions in both the short and long term.

By contrast, another school of thought indicates that FD and GB improve environmental quality. This is because GB facilitates financial investments (Green Investment) and financial operations through trade. Haseeb et al. (2018) and Shahbaz et al. (2019) revealed that importing new technologies from developed economies into developing economies via GB increases energy efficiency and reduces CO2 emissions. Similarly, other studies (Zafar et al., 2019) found that GB and FD improve environmental quality, whereas Zafar et al. (2019) examined the influence of FD and GB on CO2 emissions using the EC of OECD countries. According to the study's findings, FD and GB improve environmental quality by reducing CO2 emissions. Zaidi et al. (2019a,b) carried out a study on Asia-Pacific Economic Cooperation (APEC) countries, using GDP, foreign direct investment (FDI), and CO2 emissions as determinants. According to the findings, FD and GB reduce the effect of CO2 emissions. Finally, Shahbaz et al. (2015) revealed through a study that EC is responsible for CO2 emissions, although FD and GB reduced the effects of CO2 emissions in the long run.

The above literature indicates that there is a direct relationship between EC, FD, GB, and CO2 emissions. However, except for one study (Sheraz et al., 2021a,b), none of the past studies have examined the moderating or joint effect of GB with FD, EC, and HC on CO2 emission in the case of G20 countries. Against this backdrop, the present study aims to fill the aforementioned research gap.

2.4. Institutional quality as a moderator

A growing body of literature has highlighted the significance of institutional quality (IQ) in ensuring a country's long-term sustainability (Sinha et al., 2019). The empirical findings on the institutional-environmental quality nexus, on the other hand, do not show a consensus. Some researchers revealed that poor IQ exacerbates environmental deterioration. Others contend that various factors of IQ, such as corruption control and democracy, have a positive influence on environmental quality.

For instance, Bhattacharya et al. (2017) found that institutional quality is negatively related to environmental deterioration in Sub-Saharan African countries. Meanwhile, according to Ibrahim and Law (2016) and Wang et al. (2018), better institutional quality significantly reduces CO2 emissions. By contrast, Godil et al. (2020) pointed out that institutions and governance are responsible for environmental degradation. Similarly, Hunjra et al. (2020) studied the association between FD and CO2 emissions in five South Asian countries, using IQ as a moderator. According to the findings, institutional quality has a negative influence on financial development and carbon emissions.

In the light of the aforementioned literature, this study also estimates the joint effect of IQ with FD, REC, GB, and HC on carbon emission.

2.5. Human capital and carbon emission

HC is an important factor that may accelerate GDP and bring about improvements in environmental quality. A skilled and well-trained workforce is generally more competent at using natural resources and financial services (Hatemi & Shamsuddin, 2016). Human capital creates environmental awareness, leading to pro-environmental acts and behaviors such as energy conservation and recycling (Ahmad et al., 2021). According to Zafar et al. (2019), countries with educated and trained human capital may adopt sustainable natural resource exploration methods and minimize energy insecurity. Equally, HC also helps communities to adopt technologies that are both environmentally friendly and energy-efficient (Ahmad et al., 2021; Zafar et al., 2019). The primary evidence claims that a greater understanding of environmental sustainability might be achieved by investing in HC (Sinha and Sen, 2016). On the contrary, a large portion of HC is a lot more likely to engage in energy-intensive activities including trade, manufacturing, and the use of polluting technologies (Sharma et al., 2021a,b).

2.6. Research gap

The review of literature has shown a divergence in the impacts of the chosen parameters on the CO_2 emissions. Because of this persisting divergence in the academic literature, it has not been possible to develop a harmonized policy framework for any of the study contexts, and the debate regarding the directionalities of the impact is still growing. In order to develop a policy framework, it is necessary to converge the impacts of the policy instruments on the target policy variable, and the convergence should be in line with the long-run policy objective of the chosen context. Hence, there lies a policy void in the academic literature on the streamlining policy orientation in the empirical framework, and there lies the policy level contribution of the study. In this study, the empirical outcomes are utilized to develop an SDG-oriented policy framework, which can be used as a benchmark policy framework for addressing the objectives of SDG 13 and 7. This SDG-oriented policy design approach has not been attempted in the academic literature so far, and hence, in coherence with the global policy dialogue, this study contributes to the literature by addressing this policy void.

3. Modeling and methods

3.1. Theoretical model

The empirical framework of the study is based on financial development (FD), renewable energy (REC), globalization (GB), institutional quality (IQ), and human capital (HC) as explanatory variables and carbon emission (CO2) as dependent variables. According to prior studies, financial institutions provide funding for economic activities (financing at low cost to households and businesses) which stimulates the demand for energy but also causes environmental degradation. (Khan et al., 2017a,b; Sheraz et al., 2021, Wang et al., 2018; Zhang, 2011). This study expects a positive relationship of FD with CO2 emissions. Renewable or green energy improves the quality of the environment by mitigating CO2 emissions. Therefore, like past studies (Armeanu et al., 2019; Bao and Xu, 2019; Hao et al., 2021; Rahman and Velayutham, 2020), we assume that REC has a negative relationship with CO2 emissions. Globalization opens the trade avenue and boosts economic activities (increases the demand for goods and services) and stimulates the energy demand which causes CO2 emissions. As was observed in an influx of previous studies (Nasir et al., 2018; Shahbaz et al., 2015, 2016; Sheraz et al., 2021a,b), this study also assumes a negative impact of globalization on the environment.

An improved situation of institutions and proper implementation of environmental laws and good governance helps to improve the quality of the environment, so as was observed in prior studies (Bano et al., 2018; Bhattacharya et al., 2017; Hunjra et al., 2020; Ibrahim and Law, 2016), we expect a positive impact of IQ on CO2 emissions. Also, in line with previous studies (Bano et al., 2018; Lan et al., 2012; Khan, 2020), having better educations, skills, R&D, and awareness helps to improve the environment, so we can infer a positive impact of HC on CO2 emissions. The functional form of our empirical model is as follows:

$$CO2 = f(FD, REC, GB, IQ, HC) \quad (1)$$

Here CO2 refers to carbon emission, FD financial devilment, REC renewable energy, GB globalization, IQ institutional quality, and HC human capital respectively. The empirical form of the model is as follows:

$$CO2_{it} = \alpha_0 + \alpha_1 FD_{it} + \alpha_2 REC_{it} + \alpha_3 GB_{it} + \alpha_4 IQ_{it} + \alpha_5 HC_{it} + \varepsilon_{it} \quad (2)$$

Here, t denotes the study period, i represents the sample countries, and ε is the error term. It is also hypothesized that in presence of GB and IQ, the impact of FD, REC, and HC might exert differential impacts on CO2 emissions. Allowing cross-border movement of the resources might influence the financialization channel toward higher growth prospects, thereby paving the way toward higher emissions. On the other hand, the exchange of superior technologies might enhance the environmental benefits of REC and HC. Now, these augmented impacts are also subject to the institutional environment of the nation. Better institutional quality might lead to an internalization of the negative environmental externalities caused by GB and FD, while enhancing the positive environmental externalities exerted by the REC and HC, in presence of globalization. Accordingly, the baseline empirical model outlined in Eq. (2) [hereafter Model 1] can be described as follows:

$$CO2_{it} = \beta_0 + \beta_1 FD_{it} + \beta_2 REC_{it} + \beta_3 GB_{it} + \beta_4 IQ_{it} + \beta_5 HC_{it} + \beta_6 FD_{it}GB_{it} + \beta_7 REC_{it}GB_{it} + \beta_8 HC_{it}GB_{it} + \varepsilon_{it} \quad (3)$$

$$CO2_{it} = \gamma_0 + \gamma_1 FD_{it} + \gamma_2 REC_{it} + \gamma_3 GB_{it} + \gamma_4 IQ_{it} + \gamma_5 HC_{it} + \gamma_6 FD_{it}GB_{it} + \gamma_7 REC_{it}GB_{it} + \gamma_8 HC_{it}GB_{it} + \gamma_9 FD_{it}IQ_{it} + \gamma_{10} REC_{it}IQ_{it} + \gamma_{11} HC_{it}IQ_{it} + \varepsilon_{it} \quad (4)$$

In Eq. (3) [hereafter Model 2], environmental impacts of FD, REC, and HC are moderated by GB, while in Eq. (4) [hereafter Model 3], the moderation effects are exerted by GB and IQ. These moderating impacts can be represented in terms of the elasticity of CO2 emissions, as shown below:

$$\frac{\partial CO2_{i,t}}{\partial FD_{i,t}} = \begin{cases} Model\ 1: \ \alpha_1 \\ Model\ 2: \ \beta_1 + \beta_6 * GB_{i,t} \\ Model\ 3: \ \gamma_1 + \gamma_6 GB_{it} + \gamma_9 IQ_{it} \end{cases}$$

$$\frac{\partial CO2_{i,t}}{\partial REC_{i,t}} = \begin{cases} Model\ 1: \ \alpha_2 \\ Model\ 2: \ \beta_2 + \beta_7 * GB_{i,t} \\ Model\ 3: \ \gamma_2 + \gamma_7 GB_{it} + \gamma_{10} IQ_{it} \end{cases}$$

$$\frac{\partial CO2_{i,t}}{\partial HC_{i,t}} = \begin{cases} Model\ 1: \ \alpha_3 \\ Model\ 2: \ \beta_3 + \beta_8 * GB_{i,t} \\ Model\ 3: \ \gamma_3 + \gamma_8 GB_{it} + \gamma_{11} IQ_{it} \end{cases}$$

The movement of these elasticities will indicate the possible moderation impacts of GB and IQ. For all three cases, the comparison between the three conditions will indicate whether the moderation impacts are dampening or augmenting in nature.

3.2. Data

The sample of this study is based on the lower, middle, and upper-middle-income countries of (East, South, and Central) Asia, (North-South) Africa, Europe, and Middle East (list of countries provided in Appendix 1). The data is collected from world development indicators (WDI), international monetary funds, and Penn world table (PWT) (mentioned in Appendix 1). The data for CO2 (per capita metric tons) REC (cumulative of solar, hydro, wind, geothermal marine, waste, and gaseous biofuel derived energy), and IQ have been collected from World Bank Indicators (2019). The data for financial development (comprising sub-indices of the financial institutional index and financial market index) were sourced from Syirydzenk (2016) and International Monetary Fund (2019). The data source for GB (comprising sub-indices of economic, social, and political global indices) is the Swiss institute of technology in Zurich, Global Economy Website KOF (2019), and data for HC (average years of education) has been collected from Penn World Table (PWT) 9.0. The variable descriptions are provided in Table 1. The multicollinearity statistics of the variables using variance inflation factor (VIF) has been provided in Appendix 1, and the results show that the variables are free from the issue of multicollinearity.

Table 1
Variable descriptions.

Variable name	Data source	Description of variables
Dependent		
Carbon emission	World Bank Indicator (2019) (WDI)	CO2 emission per metric ton
Independent		
Financial development	FD index by Syirydzenk (2016) and international monetary fund (2019)	Comprises of sub-indices of a financial institution and financial market indices
Renewable energy	World Bank Indicator (2019) (WDI)	REC per capita
Globalization	The Swiss Institute of Technology in Zurich, Global Economy Website KOF (2019)	Comprises of sub-indices of social, economic, political globalization
Institutional quality	World Bank Indicator (2019) (WDI)	Comprises of sub-indices of control of corruption, voice and accountability, government effectiveness, rule of law, regulatory quality, absence of terrorism, and political stability
Human capital	Penn World Table (PWT) 9.0	Average year of education

3.3. Empirical estimation

3.3.1. Cross-Sectional Dependency Test (CD test)

To address the cross-sectional dependence issues between the variables, this study used one of the advanced econometric techniques known as the Cross-Sectional Dependency Test (CD Test) proposed by Pesaran (2004). This test helps to address issues of unobserved shocks before estimating the unit root test and co-integration analysis to avoid biased or misleading results. This study adopts the following equations for CD and Lagrange multiplier (LM)

$$CD = \left(\frac{TN(N-1)}{2}\right)^{1/2}\overline{\hat{P}} \tag{6}$$

$$\overline{\hat{P}} = \left(\frac{2}{N(N-1)}\right)\sum_{i-1}^{N-1}\sum_{j=i+1}^{N}\hat{P}_{i,j} \tag{7}$$

3.3.2. Second generation unit root test

After confirmation of cross-sectional dependency, the next step is to confirm the stationarity of the variables (weather variables are stationary at level I (0) or first difference I (1). The study used a second-generation unit root test proposed by (Pesaran (2007) called Cross-Sectional Augmented Dickey-Fuller (CADF) and Cross-Sectional Im-Pesaran-Shin (CIPS) test. The following econometric equations for CADF and CIPS (CIPS test can be computed from the mean value of CADF):

$$\Delta z_{i,t} = \Phi_i + \gamma_i y_{i,\ t-1} + \beta_i \overline{y_{t-1}} + \sum_{i=0}^{q}\rho_{i,t}\Delta\overline{y_{it-1}} + \sum_{i=0}^{q}\zeta_{i,t}y_{i,\ t-1} + \mu_{i,t} \tag{8}$$

$$CIPS = \frac{1}{N}\sum_{i=1}^{N}t_i(N,T) \tag{9}$$

3.3.3. Westerlund Co-Integration test

After ascertaining the cross-sectional dependence and stationarity of the variables, the next step is to investigate the long-run relationship by employing the panel co-integration techniques. After the confirmation of CD between variables, this study employs a robust panel co-integration technique developed by Westerlund (2007). This technique aids in estimating the statistical values that determine the long-run relationship of the data. The following equation is used for this purpose:

$$\Delta W_{i,t} = \alpha_i T_t + \gamma_i W_{i,t-1} + \rho_i V_{i,t-1} + \sum_{l=1}^{p_i}\gamma_{i,l}\Delta W_{i,t-1} + \sum_{l=-q_i}^{p_i}\beta_i V_{i,t-1} + \mu_{i,t} \tag{10}$$

The results will be a constant trend if T_t= (1) and if there is no constant trend, then it will be T_t=(0). However, if it is equal to (1,t), then it can be constant and trend.

$$\varepsilon_{i,t} = \gamma_i F_t + \mu_{i,t} \tag{11}$$

Further, to estimate the average, CD provides the proxies for Ft, which is factor matric in Eq. (11). Proxies are expected to be consistent for the efficient management of the CD results. The null hypothesis indicates no existence of co-integration and alternative vice versa.

3.3.4. Estimation for the long run

In seminal studies, several econometric techniques are used to analyze the panel data; however, the first-generation co-integration techniques, such as Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) may have biased or inaccurate estimation if the data has heterogeneity or cross-sectional dependence. The study employs the Cross-Sectional Autoregressive Distributed Lags (CS-ARDL) technique proposed by Chudik and Pesaran (2015). Unlike the first-generation techniques, CS-ARDL also addresses non-stationarity and endogeneity issues. The following test equation of CS-ARDL is used for estimation:

$$\Delta CO2_{it} = \mu_i + \varphi_i\left(CO2_{it-1} - \beta_i X_{it} - \varphi_{1i}\overline{CO2}_{t-1} - \varphi_{2i}\overline{X}_{t-1}\right) + \sum_{j=1}^{p-1}\lambda_{ij}\Delta CO2_{it-j} + \sum_{j=0}^{q-1}\zeta_{ij}\Delta X_{it-j} + \eta_{1i}\Delta\overline{CO2}_t + \eta_{2i}\Delta\overline{X}_t + \varepsilon_{it} \tag{12}$$

here, t and j represent the time and cross-sections, whereas ΔGHG_{it} and X_{it} are dependent variable and independent variables for the long-run estimations. Similarly, $\overline{GHG}_{t-1}$ and $\overline{X}_{t-1}$ indicate the lagged of dependent and independent variables. For the short-run, dependent and independent lagged are represented by $\Delta\overline{GHG}_t$ and $\Delta\overline{X}_t$, and ε_{it} denote the error term.

4. Empirical results and discussion

The study first performs the CD test to check the cross-sectional dependence of variables. Results suggest that the null hypothesis of no cross-sectional dependence is rejected at a 1% level of significance and the alternative hypothesis is accepted (Table 2). Further, to confirm the stationarity of variables, this study employs second-generation unit root tests, namely, Cross-Sectional Augmented Dickey-Fuller (CADF) and Cross-Sectional Im-Pesaran-Shin (CIPS). All the variables are found to be stationary at the first difference, indicating that variables are integrated to first order I(1) (Table 3).

In addition, to confirm the long-run relationship, this study employs co-integration techniques proposed by Westerlund (2007). The results shown in Table 4 indicate that the null hypothesis of no co-integration is rejected and an alternative is accepted, thus implying the existence of the long-run relationship between the variables.

Finally, after the confirmation of the cross-sectional dependence of the variables, this study performs the CS-ARDL test. Table 5 presents the results of our three models estimated through the CS-ARDL test. The study used Eq. (2) to capture the individual impact of the model parameters as reported in Model 1. Similarly, models 2 and 3 that present moderation effects of the model parameters on the environmental impact of globalization (GB) and institutional quality (IQ) are captured through Eqs. (3) and (4). In the following subsections, these above three models and likewise, the impact of the model parameters will be examined.

Table 2
Cross-sectional dependence test outcomes.

	CO2	FD	REC	HC	GB	IQ
CD statistics	68.206[a]	35.676[a]	78.743[a]	5.673[a]	34.567[a]	51.356[a]
Slope heterogeneity	42.561[a]	26.510[a]	21.531[a]	27.351[a]	19.234[a]	30.102[a]

Note.
CD statistics are calculated by Chudik and Pesaran (2015).
Slope heterogeneity is calculated by Pesaran (2007).
a is p-value<0.01.

Table 3
Second-generation Unit Root test outcomes.

Variables	CIPS		CADF	
	Level	First Difference	Level	First Difference
CO2	−1.224	−2.456[a]	−1.386	−4.538[a]
FD	−1.476	−3.256[a]	−1.531	−3.560[a]
REC	−1.755	−2.345[a]	−1.357	−4.657[a]
GB	−1.143	−2.502[a]	−1.245	−4.903[a]
IQ	−1.864	−2.113[a]	−1.456	−4.131[a]
HC	−1.122	−2.313[a]	−1.257	−3.610[a]

a is p-value<0.01.

4.1. Individual impacts and discussion

The reported results of model one shown in Table 7 show that financial development (FD) has a positive and statistically significant correlation with carbon emission (CO2), suggesting that a 1% increase in FD leads to an increase of 1.0577% and 0.4272% in the long and short run. The positive coefficient of FD refers to the financial markets and institutions that impede the quality of the environment by increasing CO2 emissions in Belt and Road initiative (BRI) countries. Financial institutions provide cheap loans to the private and household sector for projects and durable products (increase the economic activates), consequently stimulating the energy demand and also causing environmental degradation. Moreover, most of the BRI countries are developing and underdeveloped countries, therefore they boost economic activities while compromising the environmental laws and policies (by using obsolete technologies, investing in polluting projects). Likewise, the other reason could be fewer restrictions and weak financial systems, which affect the ability of these financial institutions to fund green projects. These results are in line with the past studies (Khan and Hou, 2021; Sheraz et al., 2021; Wang et al., 2018; Zhang, 2011).

Table 4
Westerlund (2007) cointegration test outcomes.

Statistics	Value	Z-value	P-value	Robust P-value
Gt	−1.108	4.062	1.000	0.001
Ga	−3.635	5.090	1.000	0.004
Pt	−4.790	3.520	1.000	0.000
Pa	−1.579	3.317	0.889	0.012

Table 5
Outcomes of CS-ARDL estimation.

Nature of coefficients	Model parameters	Model 1	Model 2	Model 3
Long run	FD	1.0577[b]	0.3507[a]	0.2167[a]
	REC	−0.0332[a]	−0.1168	−0.7041[a]
	GB	0.2421[a]	0.2410[b]	0.3464[c]
	IQ	0.0624[c]	0.0613[c]	0.0413[b]
	HC	−0.2115[c]	−0.2532	−0.2731
	FD * GB	–	1.1903[b]	1.0122[c]
	REC* GB	–	−0.0415[a]	−0.1182
	HC * GB	–	−0.0125[c]	−0.1270
	FD *IQ	–	–	0.4210[a]
	REC * IQ	–	–	−0.2621[a]
	HC * IQ	–	–	−0.2831
Short run	Δ FD	0.4272[a]	0.3619[b]	0.2310[a]
	Δ REC	−0.2510[a]	−0.1036[c]	−0.1416
	Δ GB	0.2165[b]	0.0252[c]	0.1040[c]
	Δ IQ	0.1022[c]	0.4031[b]	0.0410[c]
	Δ HC	−0.1242	−0.2620[b]	−0.2571
	Δ (FD * GB)	–	0.8103	0.7019[a]
	Δ (REC* GB)	–	−0.0281[a]	−0.0121
	Δ (HC * GB)	–	−0.1703[b]	−0.1162
	Δ (FD *IQ)	–	–	0.2021[c]
	Δ (REC * IQ)	–	–	−0.0250[a]
	Δ (HC * IQ)	–	–	−0.1035

a is p-value<0.01; b is 0.01<p-value<0.05; c is 0.05<p-value<0.10.

Table 6
Changes in the elasticity of CO_2 emissions with respect to model parameters.

	FD	REC	HC
Model 1: No Interaction	1.0577	−0.0332	−0.2115
Model 2: Interacting with GB	5.2686	−0.2883	−0.3048
Model 3: Interacting with GB and IQ	4.3291	−1.1491	−0.7510

Further, renewable energy consumption (REC), which is an important source of green energy, is negatively correlated with CO2 emissions. A 1% increase in renewable energy is associated with a 0.0332% and 0.2510% reduction in CO2 emissions for the long and short run. These findings indicate that countries shifting from fossil energy to renewable energy can mitigate CO2 emissions. The BRI countries need to deploy green technologies and provide funds for advanced technology to increase the usage of green energy for a sustainable environment. BRI countries are already focusing on achieving the green energy goals by reducing the cost of financing, lowering taxes, and increasing subsidies for green energy projects. Our findings are similar to those of past studies (Armeanu et al., 2019; Bao and Xu, 2019; Hao et al., 2021; Rahman and Velayutham, 2020).

Meanwhile, GB is significantly and positively related to CO2 emissions, as a 1% change in GB can increase the CO2 emissions by 0.2421% and 0.2165%, respectively in the run and the short run. These findings reveal that GB helps to lower the cost of borrowing from international financial institutions which facilitates investments in different projects, as results stimulate economic growth and also cause CO2 emissions via the utilization of fossil energy. Moreover, due to energy deficiency, obsolete and traditional machinery, countries under the BRI platform are highly reliant on fossil fuel-based solutions. At the same time due to high dependence on fossil energy BRI countries also facing regional conflicts and energy insecurity problems, which also have a significant impact on the quality of the environment. Another reason could be the trade agreement between developed and BRI countries that results in moving polluting production units toward developing countries and compromising environmental laws. Our findings are similar to prior studies (Nasir et al., 2018; Shahbaz et al., 2015, 2016; Sheraz et al., 2021a,b).

In addition to that, institutional quality has interesting findings for BRI countries. Results suggest that IQ exerts a positive and significant impact on CO2 emission levels, as a 1% increase in IQ increases CO2 emission levels by 0.0624% and 0.1022% for the long and short run. These findings imply that weak bureaucracy, corruption, and bad governance compromise environmental laws and lead to a rise in CO2 emission levels in BRI countries. Our finding is consistent with those of

Table 7
Robustness check outcomes for long-run estimates.

Model parameters	CS-DL			CCE		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
FD	1.1234[a]	0.3221[a]	0.5440[b]	1.0280[a]	0.4214[b]	0.4211[b]
REC	−0.0153[c]	−0.0643	−0.0210[b]	−0.0622	−0.0213[a]	−0.0762
GB	0.0204 [a]	0.0303	0.1042[a]	0.1420 [C]	0.1004	0.1173[b]
IQ	0.2031[b]	0.10477 [c]	0.1035	0.0321 [c]	0.0420[c]	0.1042
HC	−0.2410	−1.0320[c]	−0.3506	−0.8021[c]	−1.1024	−1.0351[a]
FD * GB	–	0.1347[c]	1.0305	–	1.1401[a]	1.2043
REC* GB	–	−0.0241[a]	−0.0031	–	−0.0150[a]	−0.0214[a]
HC * GB	–	−0.1300[c]	−0.3480	–	−0.0372	−0.0146[a]
FD *IQ	–	–	0.7790[a]	–	–	0.6042
REC * IQ	–	–	−0.0047[c]	–	–	−0.0035[b]
HC* IQ	–	–	−0.0406	–	–	−0.0633

a is p-value<0.01; b is 0.01<p-value<0.05; c is 0.05<p-value<0.10.

past studies (Bhattacharya et al., 2017; Hunjra et al., 2020; Ibrahim and Law, 2016).

Similarly, the coefficient of human capital exerts a negative but statistically significant effect on carbon emission, suggesting that a 1% rise in HC reduces CO2 emission levels by 0.2115% in the long run. The findings imply that countries with high levels of HC can mitigate CO2 emission levels by stimulating R&D, intensifying Fridley activities, ensuring effective utilization of resources, and energy conservation. It is in line with the past studies as well (Bano et al., 2018; Khan, 2020; Lan et al., 2012). Lastly, the model diagnostics reported in Appendix 2 show that the model is free from heteroskedasticity, normality, serial correlation, and omitted variable bias.

4.2. Interactive impacts and discussion

The model parameters of the study have individual effects on CO2 emissions. In a unified policy framework, all the variables interact with each other; likewise, the impact of GB and IQ on CO2 emissions will encounter a moderating effect of the other policy instruments. The moderating effects are captured through Models 2 and 3.

The joint effect of FD and GB in Model 2 is evaluated by using the interaction term. The positive coefficient of interaction term depicts that the moderating effect of GB negatively contributes to environmental quality with a magnitude of 1.1903% for the long run. GB helps integrate the countries with each other, which raises the demand for goods and series while also stimulating financial activities (Gökmenoğlu and Taspinar, 2016). These economic activities also increase the energy demand, leading to environmental degradation (Ozatac et al., 2017). Apart from that, GB also helps lower the cost of borrowing from international financial institutions to attain the economic growth that hurts the environment too. These findings are congruent with those of Sheraz et al. (2021a,b), who demonstrated that the moderating effect of g GB and FD enhances the quality of the environment in G20 countries.

Similarly, in Model 3, the interaction between FD and IQ has a positive correlation with CO2 emissions, as a 1% joint effect damages environmental quality by 0.4210% and 0.2021% in the long and short run. These findings reveal that bad governance and a weak financial institutional system exacerbates climate-related challenges by compromising environmental laws and are in line with the study conducted by Hunjra et al. (2020), which demonstrated that the moderating effect of IQ and FD mitigates environment quality in Asian countries.

Further, the joint effect of REC and GB in Model 2 reveals that the moderating effect of GB between REC and CO2 emissions improves the quality of the environment. Findings indicate a 1% change due to a joint effect decline in CO2 emissions by 0.0415% and 0.0281% for the long and short run. These results indicate that GB facilitates investments in green energy projects and helps import the latest technology from developed countries, which ends up mitigating CO2 emissions. At the same time, it helps international firms collaborate in R&D and learn efficient ways to produce green or renewable energy. Likewise, in Model 3, the interaction between REC and IQ exerts a positive impact, as the 1% change due to the joint effect improves the quality of the environment by −0.2621% and −0.0250% in the long and short run. Results suggest that IQ aids in the implementation of environmental laws and efficient use of energy, which mitigate CO2 emissions. Our findings are in line with past studies (Ahmad et al., 2021; Bhattacharya et al., 2017).

The joint effects of HC and GB on CO2 emissions for Model 2 reveal a positive impact on environmental quality, implying that a 1% increase in joint effects reduces CO2 emissions by 0.0125% and 0.1703% for the long and short run. These findings suggest that due to global connectivity, there are more opportunities for collaboration in terms of R&D, training, workshops, and launching awareness companies about global climate change has a significant impact on the mitigation of carbon emission in BRI countries. Moreover, the interaction between HC and IQ is gauged in Model 3. As the coefficient is negative, it can be inferred that there is a positive impact on environmental quality; however, it is insignificant for both the long and short run.

To the end, the model diagnostics reported in Appendix 2 show that the models are free from heteroskedasticity, normality, serial correlation, and omitted variable bias, and thereby, showing the strength of the estimation process.

4.3. Elasticity analysis of model parameters

Following the development and estimation of the empirical models, elasticities of CO_2 emissions concerning the model parameters are estimated, and the results are reported in Table 6. The elasticity analysis provides insights into the impact of interaction parameters. Upon comparing Models 1 and 2, it is evident that GB causes an increase in the negative environmental externality of financial development. At the same time, the positive environmental externalities of REC and HC also increase. This indicates that the pattern of GB in these countries facilitates the financialization toward industrialization while aiding in the development of the capacity of REC and the quality of HC for sustainable development. Hence, globalization might appear as a double-edged sword for these economies.

While undertaking a comparison of Models 2 and 3, it can be seen that in presence of strong institutions, the negative environmental externality of FD is decreased, while the positive environmental externalities of REC and HC have increased further. It indicates that in presence of strong institutions, the negative environmental externality exerted by GB can be internalized, and its positive environmental externality can be enhanced.

To demonstrate this aspect, the elasticities of CO_2 emissions concerning the model parameters over the entire timeframe are presented in Figs. 1–3. Although the presence of strong institutions has diluted the negative environmental externality of FD, it is increasing over time. This indicates that it is necessary to internalize this negative environmental

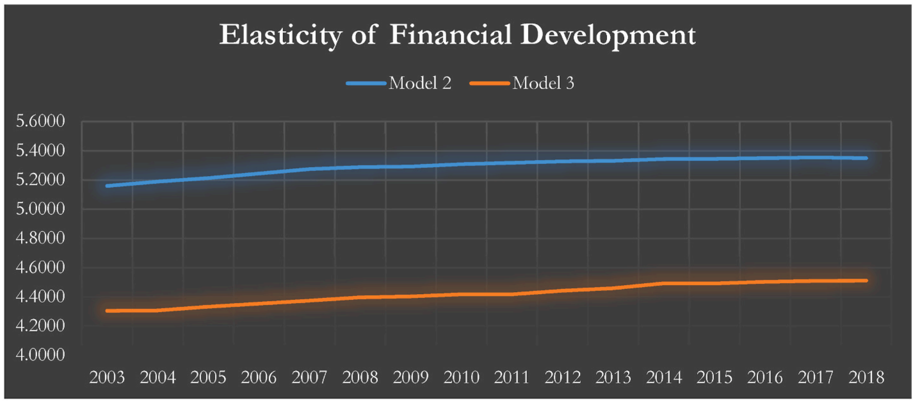

Fig. 1. Elasticity of Financial Development w.r.t. CO_2 emissions for Model 2 and 3.

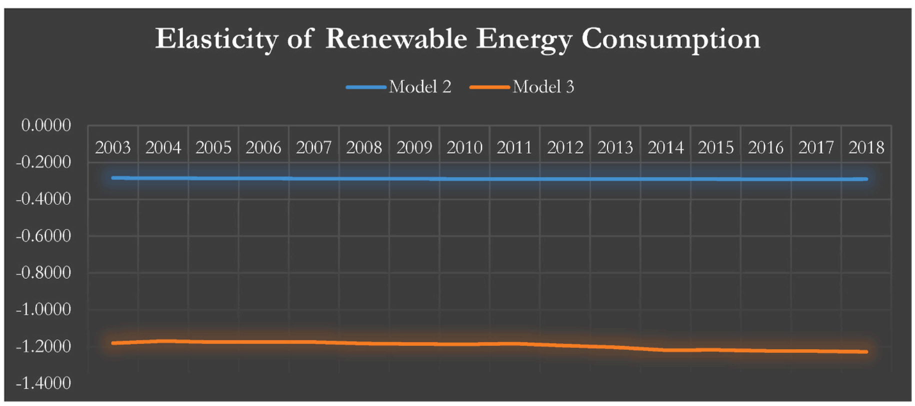

Fig. 2. Elasticity of Renewable Energy Consumption w.r.t. CO_2 emissions for Model 2 and 3.

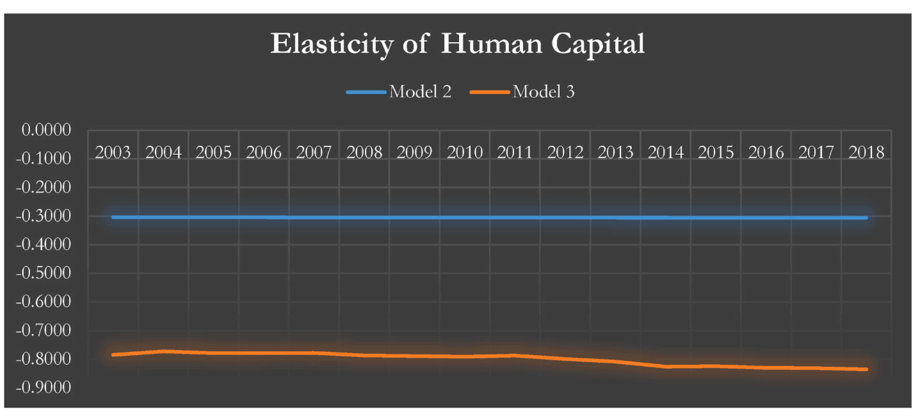

Fig. 3. Elasticity of Human Capital w.r.t. CO_2 emissions for Model 2 and 3.

impact by bringing suitable policy interventions into existing financialization channels, which are responsive to globalization. On the other hand, the positive environmental externalities of REC and HC are found to be increasing during the study period. Hence, it can be assumed that these two policy instruments can play a significant role in restoring the ecological balance in the BRI countries.

4.4. Robustness check estimates

Once the long-run coefficients are estimated, it is necessary to check the robustness of the model outcomes. As the modeling approach is the second generation in nature, cross-sectionally augmented distributed lag (CS-DL) and cross-correlation estimates (CCE) techniques are used to assess the robustness of the CS-ARDL estimation. The test outcomes presented in Table 7 show that the coefficient values are stable in terms of sign and magnitude, which is reflected across the models. The outcome of this portion is the warranted robustness of our model estimation.

5. Conclusions and policy implications

By far, the moderating effects of globalization (GB) and institutional quality (IQ) on the environmental impacts of the financial development (FD), renewable energy consumption (REC), and human capital (HC) are analyzed for the 64 BRI countries over 2003–2019. Using the second-generation methodological approach, the study outcomes revealed that GB augments the negative environmental externality exerted by FD, while IQ suppresses it. The positive environmental externalities exerted by REC and HC are augmented by both GB and IQ. According to the study outcomes, an SDG-oriented policy framework is recommended.

5.1. Core policy framework

Given that FD is exerting a negative environmental externality, while REC and HC are exerting a positive environmental externality, the policy framework should be developed in a way so that the negative environmental externalities can be internalized. However, this might require a phase-wise policy development approach (Zafar et al., 2022).

During the first phase, the policymakers need to look into reorienting the channel of FD. One possible way to actualize this reorientation is to utilize the financial mobilization channel to reduce the usage of dirtier technologies and fossil fuel-based solutions. In doing so, the financial institutions might be viewed as intermediaries to use the credit disbursing channel for promulgating green growth. To begin with, through the globalization channel, the policymakers need to import cleaner technologies, as the development of these solutions domestically might require some time. These solutions will be made available to the industrial houses, and they will be given a certain timeframe to replace their existing technologies. While procuring these solutions, the firms might need to take credits from the financial institutions. It is at this stage that these financial institutions need to introduce the differential interest rate process based on the carbon footprint of the firms, i.e., a higher rate of interest is to be borne by the firms with a higher carbon footprint. This will allow cleaner firms to gain an important competitive edge over their dirtier counterparts in the economy. This financing mechanism will gradually impose pressure on the dirtier firms, and the demand for fossil fuel and less-expensive dirtier technologies will start diminishing. The reduced demand for fossil fuel solutions and the rising demand for renewable energy and cleaner technologies will gradually start internalizing the negative environmental externalities exerted by financial development channels.

Once this phase is operational, the policymakers need to initiate the second phase of the policy framework. In this phase, the policymakers require to accentuate the generation process of renewable energy within the nation. As this process requires a high development and implementation cost, the policymakers need to intervene. Given that the demand for renewable energy solutions has started to increase during the phase, it will create an opportunity for new firms to enter this segment. To commensurate the rising demand, these firms will inexorably require financial assistance. The policymakers might channelize the interest income received in the first phase to boost the operations of these firms. The objective of this phase should be to achieve economies of scale in renewable energy generation so that renewable energy solutions are available at a cheaper cost. When these two policy phases become operational, the BRI countries might start making a progress toward the attainment of SDG 7.

As the first two phases of the policy framework turn operational, the policymakers need to initiate the third phase, and skill development should be the main objective of this phase. As the new firms have commenced their operations, the need for skilled laborers will inevitably arise. This is when the policymakers need to focus on human capital development. This process might entail bringing amendments to the educational curriculums so that the knowledge base about the latest technological development in the field of renewable energy and cleaner production can be passed on to the students. Moreover, the development of HC will also help augment environmental awareness among the citizens, which, in turn, might lead to environmentally-responsible behaviors. Once these three phases are operational, the BRI nations will start experiencing a gradual improvement in environmental quality. This improvement will allow these countries to attain the objectives of SDG 13.

5.2. Tangential policy framework

Once the core policy framework is in place, a support mechanism should then be developed for its sustenance (Sinha et al., 2022a,b,c). To accomplish this objective, the tangential policy framework is developed by logically extending the study outcomes. As the core policy framework is operational, the policymakers need to undertake a deep exploration of the import substitution policies for restricting the import of dirtier technologies. However, the regulations need to be made stringent to enforce this and safeguard environmental sustainability. Gradually restricting the dependence on imported technologies will increase the demand for locally-developed cleaner technologies. This will encourage these nations to develop their capabilities to innovate and create new job opportunities, which, in turn, will be accompanied by an increase in the number of startup ventures. This policy initiative will not only allow policymakers to curtail the outflow of foreign currency reserves but also go a long way in raising the standard of living and increasing income levels for citizens. The accumulated benefits of these concerted steps will allow countries to move toward attaining the objectives of SDG 8.

5.3. Assumption and policy caveats

While elucidating the policy framework, the policy caveats and assumptions need to be explicitly mentioned, without which the policy framework might not be able to yield the desired results. First, the policymakers need to ensure that the bureaucratic structure is bereft of the rent-seeking mechanism, as it can discourage the emergence of startups within the economy. Second, existing legislation must be made more stringent to protect public goods. Third, the laborers employed in the traditional fossil fuel-based energy generation sector should be rehabilitated, as a transient rise in the unemployment rate might disturb the social balance in the economy. Policymakers need to adhere to these caveats to maintain the basis of sustainable development in these economies.

5.4. Limitations and future projections

Although an SDG-oriented phased policy framework has been suggested in the study, it is pertinent to remember that this study has only encompassed financial development, renewable energy consumption, and human capital, while considering the moderating effects of globalization and institutional quality. Hence, it would be worthwhile to investigate the comprehensiveness of the policy framework to explore the possibility of betterment. However, the issues discussed in the study are nearly present in the majority of the emerging economies, which is why this policy framework has an acceptable scale of generalizability. It makes this policy framework a standard policy framework for other emerging economies around the globe. Furthermore, taking the spatial dimension of the GB and CO2 emissions into account could have procreated additional intuitions. Yet, the recommended framework is flexible to consider context-driven policy instruments, which is suggestive of the future direction of research in this pursuit.

Consent to participate section

All authors participated in the process of draft completion. All authors have read and agreed to the published version of the manuscript.

Ethical approval

The study did not use any data which need approval.

Consent to publish

All authors agree to publish.

Authors contributions

All Authors contributed conceptually, formally and in original drafting. All Authors contributed. Responsibilities are as follows; **Muhammad Sheraz**: conceptualization; formal analysis; methodology; writing—original draft preparation, revision. Xu **Deyi**: supervision; funding acquisition; validation; writing—review and editing. **Avik Sinha:** conceptualization; methodology; results validation; writing—review and editing. **Muhammad Zubair Mumtaz:** conceptualization; methodology, software, draft preparation; writing—review and editing. **Nudrat Fatima:** conceptualization; writing—original methodology; validation; writing—review and editing.

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Availability of data and materials

Data available upon request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1. Multicollinearity statistics

	VIF	VIF-sqrt	Tolerance	R^2
CO_2	1.05	1.02	0.9524	0.0476
FD	1.24	1.11	0.8065	0.1935
REC	1.01	1.00	0.9901	0.0099
GB	2.47	1.57	0.4049	0.5951
IQ	1.04	1.02	0.9615	0.0385
HC	1.06	1.03	0.9434	0.0566

Appendix 2
Outcomes of model diagnostics

Diagnostic tests	Model 1	Model 2	Model 3
Heteroskedasticity (Breusch and Pagan, 1979)	0.88	1.79	2.15
	(0.5582)	(0.3578)	(0.1869)
Normality (Jarque and Bera, 1987)	1.099	1.035	1.236
	(0.5665)	(0.4728)	(0.2579)
Serial Correlation (Wooldridge, 2002)	0.97	1.17	1.41
	(0.1549)	(0.2688)	(0.1685)
Omitted Variable Bias (Ramsey, 1969)	0.33	0.51	0.86
	(0.9147)	(0.7153)	(0.4689)

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