Journal of Cleaner Production 262 (2020) 121344

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Does sustainable growth, energy consumption and environment challenges matter for Belt and Road Initiative feat? A novel empirical investigation

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A R T I C L E I N F O

Article history:
Received 13 June 2018
Received in revised form
23 March 2020
Accepted 24 March 2020
Available online 31 March 2020

Handling Editor: CT Lee

JEL classification:
O13 O44
Q4
Q5
Q42 Q56

Keywords:
Sustainable growth
Energy consumption
Belt and road initiative
Environment challenges
Financial development
Globalization

A B S T R A C T

The concept of modernization and globalization urges a tendency of bilateral cooperation and strategical relationships among the nations. Recently, China has taken the Belt and Road Initiative (BRI) in 2013 to articulate the slogan of "Going global strategy." The primary objective of the current study is to explore the nexus between energy consumption, economic growth, population growth, financial development and carbon emission (CO_2) for the panel of 65 BRI countries over the period of 1981–2016. Empirical results show that energy consumption, high-tech industry, and economic growth deteriorate environmental quality but financial development and renewable energy consumption have a favorable effect for the environment. The energy consumption is positively and significantly affecting the environmental quality for all regions except the South Asian region. The overall outcomes postulate a weak association of economic indicators with carbon emissions in the long run except for Europe, MENA, and Southeast Asian regions. This present study serves as a blueprint to experts, policymakers and BRI listed government officials suggesting that they should advise the masses and industries to shift towards renewable energy sources. Furthermore, the need to install the water treatment plants near to industrial zones is pertinent. Moreover, the environment monitoring organizations and portfolio investors should arrange awareness campaigns for green investments and renewable energy dependency to accomplish visionary BRI feat.

1. Introduction

The concept of modernization and globalization urges a tendency of bilateral cooperation and strategic relationships among all nations of the world. Accordingly, the Chinese Government has taken a heroic stride, called as “Belt and Road Initiative” (BRI). The president of China, Xi Jinping instigated this initiative while he officially visited Kazakhstan in 2013 (Chen, 2016). It is a striving package to tie up territories of Asia, Africa, and Europe through land

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https://doi.org/10.1016/j.jclepro.2020.121344

and oceanic outline adjacent to six economic corridors, with an objective to refine the regional assimilation, fostering the trade magnitude and encouraging to the sustainable economic development. The BRI's global scope is continually increasing it enfolds more than 71 countries, represents around 65 percent global population and bringing about one-third Gross Domestic Product (GDP) of the entire world as asserted by the European Bank for Reconstruction and Development (2018). This position is also affirmed by the recent study of Wang (2016) arguing that despite risks and uncertainties in achieving this feat, the execution will trigger China's affluence, influence and position in regional and international community. The BRI project's major resolutions covers; unimpeded trade, infrastructural connectivity, financial integration, policy coordination and sharing technologies and trained human resources to revolutionize various industries to spread the economic progression magnitude (Fung Business Intelligence, 2017). Besides, it is truly a "unified wide-ranging revitalized and groundbreaking" global structural economic development design to connect the world more densely and to nurture not only the bilateral trading partnership but also sustaining a geopolitical solidity and shared future (Ho, 2017).

The projected budget of this mega project for infrastructural expansion in the Asia Pacific would be around 23 trillion US dollars in 2030 (China Power Team, 2017). However, the International Energy Agency (IEA, 2014) estimated that the investments for interconnected BRI's schemes increase from 4 trillion dollars to 8 trillion dollars. Hence, two-thirds of BRI's investment is deployed for emerging and developing nations to underpin the velocity of their development. As stated by Laurance (2018), BRI will pledge over 7,000 project schemes which comprise the expansion of businesses, industries, power generation plants, the infrastructure of highways and railway, poverty alleviation and strategic collaboration. However, through these projects the concerning nations will have the chance to give a massive boost to their economic progress through the extension of trade, moving into new advanced markets, sharing manpower skills and technologies, and divergence of portfolio funds (Economy, 2017). Therefore, all these projections may reflect as core dynamic forces for sustainable and productive economic progression for BRI economies (Yii et al., 2018).

The BRI schemes in clustered countries will have multi-factor effects on human endeavor explicitly or implicitly. Indeed, every coin has two sides accordingly; on one corner, it will have constructive drifts on enclosed economies through bilateral collaboration and globalization. On the other hand, it might have shocking consequences such as ecological deterioration in the form of massive utilization of energy for power generation, industrial development, mass communication, transportation, urbanization and clearing out of woodlands for road and rail network lines (Laurance, 2018).

In this modern age of technology, energy is not only a base pillar for economic expansion but also an essential strategic reserve for a country. Likewise, the sustainable economic development absolutely depends on energy consumption (Kraft and Kraft, 1978; Li et al., 2018). The classical approach of the Solow growth model underscored the significance of labor force and capital input for economic advancement, later Rauf et al. (2018); Sarwar et al. (2017); Shahbaz et al., (2017) enlarged the Solow growth idea by integrating energy consumption as variables and testified that energy utilization is one of the core components for businesses, industries, and their sustainable development. The parallel findings are conveyed by Rauf et al. (2018) for BRI countries, where a feedback relationship has been confirmed between energy consumption and economic growth. Similarly, Chen et al. (2007) authorized two-way associations between energy consumption and economic growth. Moreover, Omri (2013), also endorsed a bidirectional interconnection between energy consumption and scale of economic development. The findings' of Apergis and Ozturk (2015) informed that strong ties have existed between energy usage and magnitude of economic expansion. Narayan et al. (2010) scrutinized the causal connectedness between economic growth and energy consumption. The findings pronounced that the scale of energy consumption have a definite influence on economic growth in Asia, Latin American and Western European nations; while no link has been stated in Middle East economies.

An ample literature have been pinpointed that financial performance act as a force to reshape the climatic shift in an economy, which is frequently analyzed by Environmental Kuznets curve (EKC) Kuznets (1955), subsequently Grossman and Krueger (1991) testified well-known (EKC) hypothesis, which is a turn upside down "U" structure. It utters that during the preliminary point of economic evolution, policy architects generally focus on growth than ecological deteriorating challenges. Consequently, the second phase of economic evolution condenses the stride of pollutant (CO_2) emissions. Eventually, in the third phase, policy architects familiarize with environmentally convivial strategies such as renewable energy sources, awareness about green investments, carbon taxes, industrialized handling plants, power-efficient technologies and transportation to curb the level of GHG emissions (CO_2). Similarly, the EKC curve associates a correlational impact of economic growth over environmental stress (Tiwari et al., 2013).

The links between economic performance and environmental deterioration diverge across the economies due to the energy mix, population growth, industrial infrastructure and transportation means. A considerable volume of investigations; Balsalobre-Lorente et al. (2018) for 5-EU countries namely Germany, France, Italy, Spain, and the United Kingdom. The study finding shows and N-shaped pattern nexus between pollutant emission and economic growth for the 5-EU countries investigated. Furthermore, for single country case in Malaysia Begum et al. (2015) explored the economic expansion-environment nexus. The study fail to validate the EKC hypothesis for the investigated period. However, empirical results shows that in the long-rn ecconmic expansion have deteriorating effect on the ecosystem. The aforementioned studies have testified that through the early phases of economic growth, built-up economies entail more significant sources of energy to intersect the demands which consequentially lift the probabilities of environment worsening process (Bekun et al., 2019). Indeed, the heaving tendency of energy consumption around the world is accountable for the boost in CO_2 emission that activated severe ecological complications. This is based on the fact that China is the second most prominent and most rapidly growing economic symbol of the world, alongside information of the Global Carbon Project (GCP) that was informed by World Bank, China is responsible for approximately 30% of worldwide CO_2 emissions which together become more than of 200 nations (U.S. Energy Information Agency, 2014). Since, 2008 engaging an objectionable spot of being the global biggest CO_2 emitter and highest coal consumer in the Asian region; thus China has turned to be a noticeable country around the world and facing pressure to drop its scale of CO_2 emissions (Wang et al., 2016). However, China materializes a gray condition economy with the tag of energy and environment. Thus, condensing to the scale of carbon emissions will be a criterion need if each economy takes off fruitfully to pursue BRI challenges & prospects and drive to its global commitments.

Earlier research studies can be distributed into two strands of knowledge, where the first one is supporting to EKC hypothesis and the second is unable to support for the EKC hypothesis. The literature postulates variant methodologies and economic models to find the correlation between economic prosperity and CO_2

emissions. One school of thoughts follow the environmental Kuznets curve (EKC) to correlate economic development with environmental health fluctuation. For instance, the Environmental Kuznets Curve (EKC) hypothesis have been evaluated by Jaunky (2011), set of 36 high income economies; Apergis and Ozturk (2015) 14 Asian countries; Musolesi et al. (2010) 106 developing and developed countries; and Toman and Jemelkova (2003) examined 25 OECD listed nations to analyzes their correspondence across these regions. All these research studies found a significant long-run correlation between economic growth and carbon emission and finally proved the (EKC) hypothesis. The second school of thought determined EKC in the presence of others predicting regressors. Ayeche et al. (2016) confirmed the linkages between economic growth (GDP), financial development, trade openness, and CO_2 emission over the period of 1985–2014, inclosing 40 European countries. Resultantly, the outcomes displayed bidirectional causation between financial development and economic growth, CO_2 emission and economic growth (GDP), trade openness and economic growth, CO_2 emission and trade openness and lastly trade openness and financial development.

Additionally, Rauf et al. (2018a) also endorsed an EKC hypothesis under Mean Group (MG) analysis in full and continent regional panel for 65 BRI countries, but PMG model only publicized the existence of EKC hypothesis in developed economies. Meanwhile, Chen and Chen (2015) contended that swift urbanization is a tracking component to strengthen the scale of energy consumption. Since the different episode of activities in metropolitan cities are accountable for around 70% of (GHGs) emission, but an epic scale of approximately 67% is due to energy consumption in the world. Additionally, Chen and Chen (2015); Xu and Lin (2016b) propagated that over and above 50% of entire world's population is residing in urban zones (areas). Hence, the surprising proliferate in urban population is a rationale backed by energy resources management and sustainable socioeconomic advancement (Lee and Chang, 2007). Recently, Omri (2013) addressed that developing economies are meticulously linked with the expansion of energy consumption due to explicit bind between energy consumption and economic development. Furthermore, Khan et al. (2017) scrutinized the empirical association of energy consumption, financial development, trade and CO_2 emission on income based dataset (2001–2014) for the world. Concludingly, various dynamic panel models portrayed a strong nexus among the variables and bidirectional connectedness also observed in those income based-regions.

Though, some researcher is not firmly supported the EKC hypothesis, e.g. (Toman and Jemelkova, 2003) investigated links of growth and CO_2 emission, and postulated conflicting environmental states. Arouri et al. (2012) uses Granger causality approach and establish a weak signal to leverage EKC hypothesis, similarly Saboori and Sulaiman (2013) verified EKC hypothesis for Brazil, but Saboori and Sulaiman (2013) fail it for Malaysia, their study applied ARDL approach on annual series of CO_2 emission and GDP as a proxy for economic development. Soytas et al. (2007) explored a nexus between fixed capital formation, energy consumption, income, labor force, and CO_2 emissions, but their study also fails to signify the EKC hypothesis in the USA. However, Halicioglu (2009) uncovered contradictory results for the case of Turkey, and Smyth (2013) classified data for each studying region accurately to avoid heterogeneity shocks for measuring the EKC hypothesis. Thus, the researcher postulates that aggregated dataset distracts the actual relation between economic growth and carbon emission across the regions. Thus, it seems that most researchers are ignoring to control the exogenous shocks as an economic indicator. In this regard, Rauf et al. (2018b); Sarwar et al. (2017) suggested that researcher need to use the individual country dataset in categorical structure with same econometric techniques over the regions to content the robust and reliable outcomes.

Xu and Lin (2016a, 2016b) detailed that factor of industrialization and economic growth is primarily accountable for carbon dioxide emission in China. However, the BRI projected schemes relieve to China, to transfer detrimental and carbon-emitting businesses and industries out of the country (Dombrowski, 2017). Furthermore, in BRI plans around 65 percent of entire energy production investments are capitalized in coal-based power generation plants, and only 1 percent of total funds are expended on renewable energy production. Thus far, China is constructing 240 coal-based energy generation plants in 25 BRI nations, which comprises 251 Gigawatts (GW) installed magnitude. Besides, Chinese companies have been specified their intention for initiating up to 92 add-ons such as coal-based power generation projects in 27 BRI economies (Dombrowski, 2017).

Fig. 1 exhibited a divergence scale of carbon emissions for selected BRI economies and entire world; trend line of carbon emissions in BRI countries is more straight than global trend, as it had been enlarging from past four decades.

The correspondent intensity of global CO_2 emissions in BRI clustered nations is touching near to 61.4% in China (BP, 2017). Additionally, the share of CO_2 emissions based on energy consumption in BRI grouped countries is approximately 80%, representing a dominant involvement in ecological deterioration. Based on these facts, it is tough to escape the inferences which BRI-intensive developmental projects are going to cause the detriment to atmospheric conditions, along with being advantageous for sustainable economic development. Moreover, a few investigators have been proclaimed that the global shifting BRI approach would harvest several sterns and unwanted impacts on hosting county's natural resources, culture and ecology (Rauf et al., 2018a). However, it is developing one of the critical matters that are hindering the fruitful accomplishment of BRI projects in participated nations. Likewise, various socioeconomic variations from BRI projects will have critical implications for a project-holding country about its energy consumption accompanied by its CO_2 emissions.

Based on the above highlights, Chinese economy's energy mix and its relationship with rest of the world specifically in BRI initiative countries, the current study explores the carbon-energy and income function relationship on a broader scale. This present study explores the nexus between energy consumption, economic growth and environmental deterioration in BRI 65 countries by keeping in view their sustainability over the period of 1981–2016 in a panel framework. This study is different from previous documented study in the energy-environmental literature in two main fronts (i) In terms of scope. To the best of the authors knowledge this is probably the first study to explore the subject matter in broad blocs like; East Asia, South East Asia, South Asia, Central Asia, MENA, and European countries for a more robust empirical debate. Furthermore, this study is a complimentary in the existing knowledge by accounting for other covariates like; financial development, gross fixed capital formation, population growth and CO_2 emission in 65 BRI listed countries. Therefore, the current study seeks to bridge this identified gap for BRI nations as a full and regional panel. Besides it addresses the challenges and prospects with regard to energy consumption sources, sustainable development and environmental degradation in selected countries to accomplish BRI aims and goals. (ii) The presents study also contributes on methodological front. It is known fact that in panel econometrics, where panel dataset is plagued with cross-sectional dependency, which previous studies fail to address. This study circumvents for cross-sectional dependence issues in its econometric modelling setting. It adopts most recent panel estimators; those renders more consistent and reliable coefficients which are

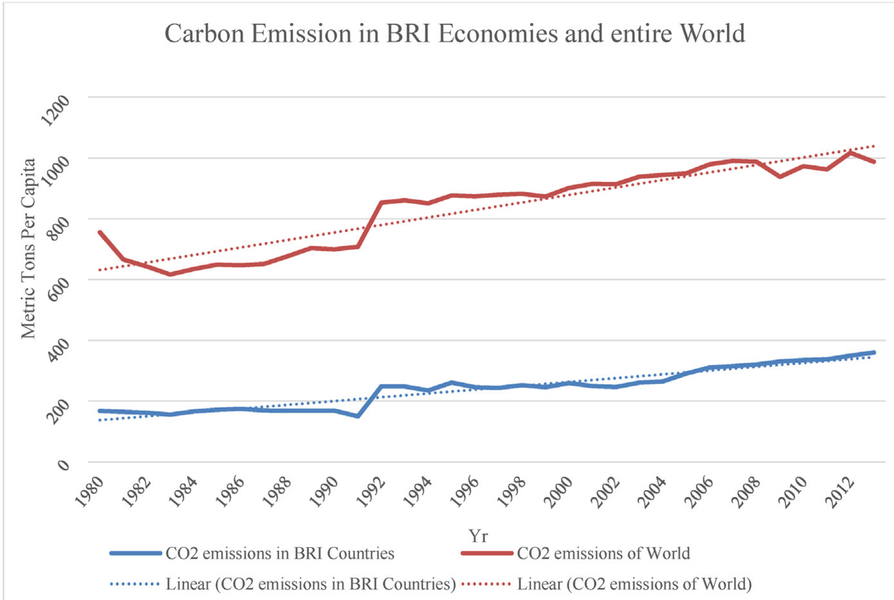

Fig. 1. The Comparison of CO_2 emission in BRI economies World levelSource
: World Development Indicators (2016).

worthwhile for decision road maps. This sort of studies is appropriate and, debatable and pertinent for environmental scientists and governmental officials in concerned countries as policy blueprint.

The rest of this study's sections are structured as follows: Section 2 is about the research methodologies and data description. Subsequently, section 3 focuses on empirical results and discussions. Finally, conclusions, recommendations and policy implications are presented in Section 4.

2. Methodological procedures and data

2.1. Variables and data sources

The present study incorporated 65 BRI listed countries in Table 12 Appendix.A.3, further categorized into six regions according to their continental distribution (The World Bank Group, 2017). Outstretching the importance of economic actions in all segment of an economy is decisive for its progression and sustainability. However, those contributions may consist of capital investment, labor operations and massive energy sources which are obligatory to expedite such economic development.

The "Going Global Strategy" is a bottom line of BRI, where more than 65 nations come and join side by side for this marvelous program. Achieving sustainable development, doing businesses, upgrade energy consumption patterns and environmental sustainability among the participated states is an imperative objective of this stride. Accordingly, the data collection was underpinned for 65 BRI countries ranging from 1981 to 2016 from World Development Indicators (The World Bank Group, 2017) to explores such interrelationships among them. Additionally, the study retains carbon emissions as a dependent, while energy consumption, economic growth, financial development, gross fixed capital formation, renewable energy consumption, medium and high-tech industry, and population growth are considered as independent variables. Furthermore, three indicators are utilized to test to the sensitivity of financial development in different three models. The variables used to proxy financial development includes (i) domestic credit to private sector % of GDP (FD) (ii) domestic credit provided by the financial sector (% of GDP) (DCFS) and (iii) domestic credit provided to the private sector by banks (% of GDP) (DCPB) in order to check for robustness of study objectives. See Table 1 for details on variables, units of measurement and sources.

However, for standardization and conversion purposes all panel data series are transformed into natural logarithm which is vital to ask to stabilize and evading the data information and its estimates from lengthy coefficients, autocorrelation and multicollinearity issues.

2.2. Econometric test process

In order to operationalize the research hypothesis between the underlined variables namely ECON, FD, GDPPC, GFCF, MHTECH, REC, POPG and CO_2 emission as reported in its functional lead form in Equation.1, where superscript "i" denotes a specific country identity, that i.e. cross-sectional dimension of the panel and "t" time dimension for BRI nations ranging from 1981 to 2016. Supplementary a precise methodological diagram has been constructed to elaborate the complete track of this on hand study in Fig. 2.

The empirical path of this study follows four routes namely (a) Investigation of basic statistics of the variables under review like correlation analysis among the series. (b) test for Cross sectional dependence (CD) it is imperative to detect cross-section dependence (CD) for the selected dataset to ensure the reliability and applicability of estimates. Afterward, panel unit root tests would be proposed based on CD test estimations. However, if CD test outcomes establish that, there is cross section dependence in the dataset, then unit root tests under 1st generation would not be fitted due to their low power. To capture the robust inferences, first and second generation unit roots tests (Levin, Lin and Chu (LLC) (Levin et al., 2002), I'm, Pesaran and Shin (Im et al., 2003), ADF Fisher Chi-square (Choi, 2001), CIPS and CADF (Pesaran, 2007) would apply to ascertain order of integration among the studied variables; either stationary at level or first order. Subsequently, results will guide for cointegration checkup to verify long-run

Table 1
Variables description and Data Sources.

Variables	Elaboration	Data Source
Carbon emission (CO_2)	Metric tons of CO_2 equivalent per capita	WDI
Energy consumption (*ECON*)	Energy Consumption (kg of oil equivalent per capita)	WDI
Gross domestic product (*GDPPC*)	GDP per capita (constant 2010 US$)	WDI
Financial development (FD)	Domestic credit to private sector as a share of GDP	WDI
Gross Fixed Capital Formation (GFCF)	Gross Fixed Capital Formation percentage of GDP	WDI
Population (POP) growth	Population growth (annual %)	WDI
Medium and high-tech industry (MH.Tech)	(MH.Tech) (% manufacturing value added)	WDI
Renewable energy consumption REC	Renewable energy consumption % of total energy	WDI
Domestic credit by the financial sector (DCFS)	Domestic credit by the financial sector (% of GDP)	WDI
Domestic credit to private by bank (DCPB)	Domestic credit to private sector by bank (% of GDP)	WDI

Note: Author's tabulation, where WDI represents world development indicators available at https://data.worldbank.org/.

cointegrating combinations amongst the variables as operated (Al-mulali et al., 2013). (c) test for long-run equilibrium relationship among the variables under review over investigated period via dynamic panel fully modified OLS (FMOLS) and Dynamic OLS (DOLS) models would be explicitly the best choice for displaying the cointegrating relationships in four economic models, and seemingly unrelated regression (SUR) is also utilized to support the robustness of panel as mentioned earlier. Finally, (d) the detection of causality flow via the Panel Heterogeneous Granger causality test this is in accordance with see (Rauf et al., 2018a).

The functional form that expressed these relationship between this study variables follows after (Ahmad et al., 2019; Chandio et al., 2019; Jebli et al., 2016; Karanfil, 2008; Rauf et al., 2018c; Rehman et al., 2019; Sadorsky, 2014).The function form is presented below:

$$CO_2 = f(EC, GDP, FD, GFCF, MHTech, \; REC, POPG) \tag{1}$$

The Eq. (1) is a suitable depiction of main model, and hereafter it has renewed into natural logarithm in Eq. (2) as below:

$$CO_{2\;i,t} = \alpha + \beta_1 \mathrm{lnECON}_{i,t} + \beta_2 \mathrm{lnGDPPC}_{i,t} + \beta_3 \mathrm{lnFD}_{i,t} + \beta_4 \mathrm{lnMDtech}_{i,t} + \beta_5 \mathrm{lnGFCF}_{i,t} + \beta_6 \mathrm{lnREC}_{i,t} + \beta_7 \mathrm{lnPOPG}_{i,t} + \varepsilon_{i,t} \tag{2}$$

Since, financial development has been measured through three different proxies in three models Eqs. (4)–(6) to certify the robustness of outcomes. Hence, four econometric models are developed as following:

Model.1

$$CO_{2\;i,t} = \alpha + \beta_1 \mathrm{lnECON}_{i,t} + \beta_2 \mathrm{lnGDPPC}_{i,t} + \beta_4 \mathrm{lnMDtech}_{i,t} + \beta_5 \mathrm{lnGFCF}_{i,t} + \beta_6 \mathrm{lnREC}_{i,t} + \beta_3 \mathrm{lnPOPG}_{i,t} + \varepsilon_{i,t} \tag{3}$$

Model.2

$$CO_{2\;i,t} = \alpha + \beta_1 \mathrm{lnECON}_{i,t} + \beta_2 \mathrm{lnGDPPC}_{i,t} + \beta_3 \mathrm{lnFD}_{i,t} + \beta_4 \mathrm{lnMDtech}_{i,t} + \beta_5 \mathrm{lnGFCF}_{i,t} + \beta_6 \mathrm{lnREC}_{i,t} + \varepsilon_{i,t} \tag{4}$$

Model.3

$$CO_{2\;i,t} = \alpha + \beta_1 \mathrm{lnECON}_{i,t} + \beta_2 \mathrm{lnGDPPC}_{i,t} + \beta_3 \mathrm{lnDCSF}_{i,t} + \beta_4 \mathrm{lnMDtech}_{i,t} + \beta_5 \mathrm{lnGFCF}_{i,t} + \beta_6 \mathrm{lnREC}_{i,t} + \varepsilon_{i,t} \tag{5}$$

Model.4

$$CO_{2\;i,t} = \alpha + \beta_1 \mathrm{lnECON}_{i,t} + \beta_2 \mathrm{lnGDPPC}_{i,t} + \beta_3 \mathrm{lnDCPB}_{i,t} + \beta_4 \mathrm{lnMDtech}_{i,t} + \beta_5 \mathrm{lnGFCF}_{i,t} + \beta_6 \mathrm{lnREC}_{i,t} + \varepsilon_{i,t} \tag{6}$$

The description of Eqs. (2)–(6) reflects both dependent and independent variables, where "*ln*" outlining the symbol for natural logarithm, "*i*" and "*t*" described the country-specific information and time respectively. ″α″ is the intercept, ″β″ illustrate the respective country-specific parameters and ″$\varepsilon_{i,t}$″ is the error term.

2.2.1. Cross-sectional dependence (CD) test

As above-mentioned, cross-sectional dependence (CD) is one of the most imperative tests in panel econometrics modelling. Researchers inspect before assessing any panel-based investigation. The presence or absence of this delinquent fixes the auxiliary footpath which is demanding to be trailed later. If dataset information is bearing cross-sectional dependence, then other stages of the investigation should reserve those tests which are agreeing with cross-section dependence. Therefore, LM test of Breusch and Pagan (1980), bias-corrected scaled LM test Baltagi et al. (2012) and CD test Pesaran H., (2004), to check the residual based cross dependence in structured variables. The common null hypothesis for such analytical tests is "no cross-sectional dependence to be presented in the residuals dataset". Hence, the LM Breusch and Pagan (1980) and CD test Pesaran H., (2004) are designed as follow:

$$LM = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\widehat{\rho}_{ij}\right)\frac{(T-k)\widehat{\rho}_{ij}^{2} - E(T-k)\widehat{\rho}_{ij}^{2}}{Var(T-k)\widehat{\rho}_{ij}^{2}} \tag{7}$$

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\widehat{\rho}_{ij}\right) \sim \; N(0,1)i, \; j = 1,2,3\ldots65\ldots N \tag{8}$$

In Eq. (7) and Eq. (8), ″$\widehat{\rho}_{ij}^{2}$″ implies the residual-based two-way correlational sample in variables and its evaluation has been grabbed through simple OLS regression equation. The inferences from the above-mentioned two equations have been stated in Table 2, where above cited null hypothesis (H0) cannot be rejected at 1% level.

We also utilized residuals-based CD tests to grip the cross-dependence in dynamic panels. However, for this essence, one parametric and two semi-parametric tests advised by Frees (2004, 1995); Friedman (1937); Pesaran (2004), are operated with short time and larger cross-sections to evaluate residual cross-section dependence in panels. As per period "*t*" 36 years and 65 economies with "*i*" are symbolized in our investigation, to evaluate errors-based cross dependence. Hence, the outcomes of three tests are demonstrated in Table 3, specifies that the null hypothesis of cross-section independence is significantly overruled by Pesaran, Friedman and Frees' tests disjointedly.

2.2.2. Panel unit root tests

In the context of panel modelling, the unit root tests have

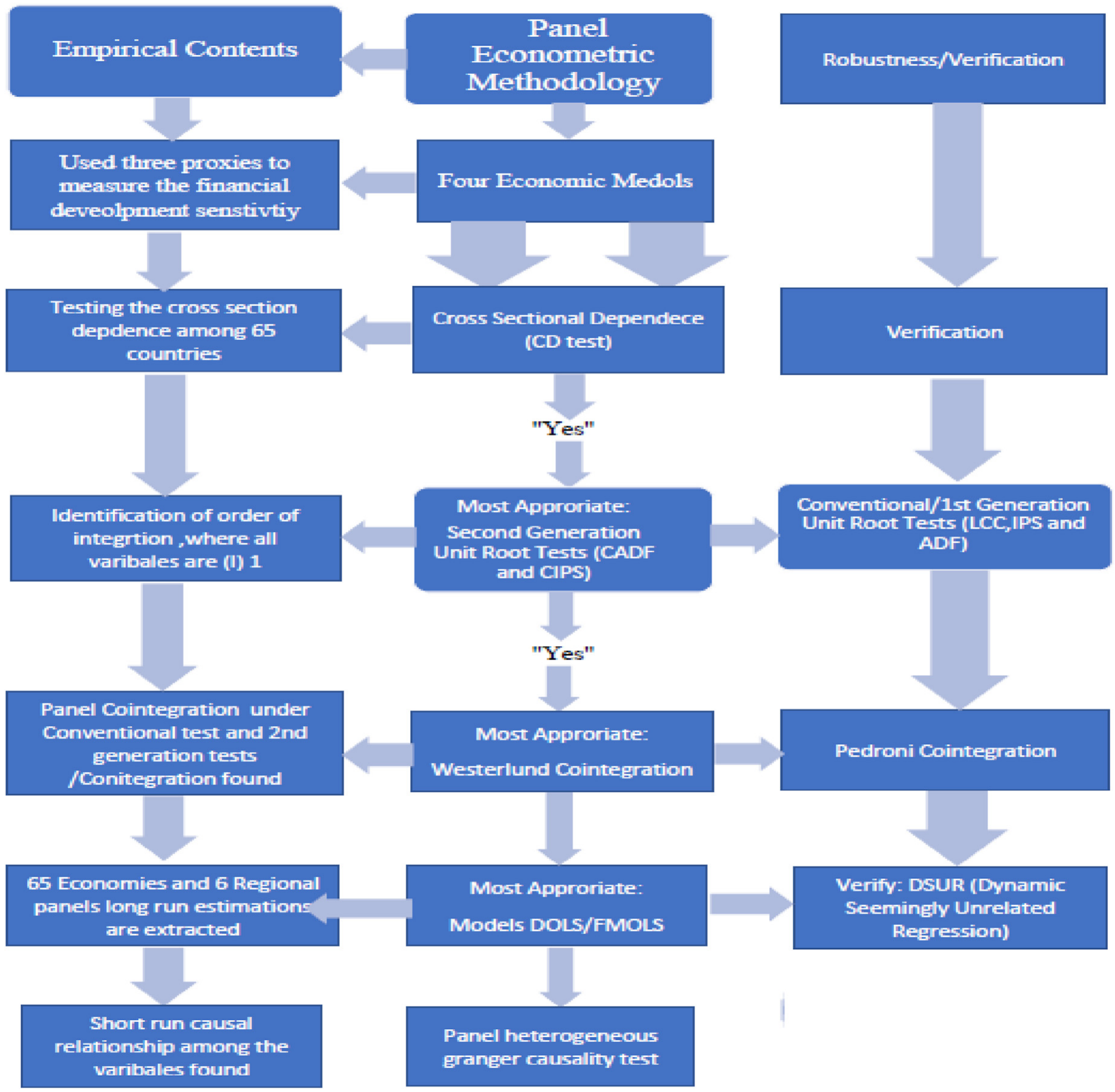

Fig. 2. Methodological roadmap of econometric framework.

twofold according to their generations (1st generation unit root and 2nd generation unit root). The 1st generation of unit root tests supposes that countries in our investigation are cross-sectionally self-determining; while the 2nd generation unit root tests ease this supposition and permits for cross-sectional dependence in those countries.

However, in our study, we have been utilized both first and second-generation unit root tests to claim strong preliminary evidence about the stationarity. The current panel data postulate a higher number of time instances, those may foster degrees of freedom (d.f) and emits the crises of multicollinearity for estimating a simple OLS equation. Consequently, panel data tolerate for added convincing scientific techniques and asymptotically statistics, those tracks a normal distribution instead of a noisy dispersion. The pioneering studies on panel unit root tests have been advised by (Choi (2001) Panel stationarity test with reverse hypothesis like Hadri (2000) also the heterogenous penel unit root of Im et al. (2003) and the more restrictive Levin et al. (2002) panel unit root for finite sample properties. Thus, the current study employed three-panel unit root tests (LLC), (IPS) and ADF Fisher presented in

Table 2
Cross-sectional dependence tests.

Test	Statistic	p-value
Pesaran scaled LM	5458***	0.0000
Bias-adjusted LM	111.9***	0.0000
Pesaran CD	32.56***	0.0000

Note: “***” represent 1% level of significance.

Table 10 Appendix A.1 to grasp order of integration among the variables. So, the panel unit root test of IPS was grounded on the following model equation:

$$\Delta y_{i,t} = \alpha_i + \beta_i y_{i,t-1} \sum_{j=1}^{pi} \rho_{ij} \Delta y_{i,t-j} + \varepsilon_{i,t} \qquad i = 1, \dots \ t = 1, \dots T \tag{9}$$

Eq. (9) grasps $y_{i,t}$ as a data series for i nation in t time, however, lags operator implies with pi in the regression equation. $\varepsilon_{i,t}$

Table 3
Residuals CD tests.

Test	Statistic	p-value
Pesaran CD test	21.247***	0.0000
Friedman test	148.399***	0.0000
Frees test	13.964***	0.0000

Note: "***" represent 1% level of significance.

itemizes the errors term for entire BRI nations with a random normal distribution. The development of null and alternative hypothesis is instituted, to inspect the features of each variable in term of stationarity; so H_0 = Null hypothesis and divergently H_1 = Alternative hypothesis is either accepted or rejected by comparing asymptotically predefined tabulation values.

As per cross dependence results in Tables 2 and 3, enticing that there is cross section dependence in the dataset. Thus, to defeat this problem, the on-hand study favored for exercising the cross-sectional Im, Pesaran, and Shin (CIPS) and cross-sectional augmented Dickey-Fuller (CADF) methods determined by (Pesaran, 2007). The CIPS and CADF tests will justify the obstruction of cross-sectional dependence from nation to nation in our investigation and would yield reliable and steadfast outcomes in the attendance of cross depended and heterogeneity. Thus, the 2nd generation unit root tests (CIPS and CADF) reported in Table 6 to capture the cross-section dependency. However, these Pesaran's tests are fitter in their structures due to asymptotic postulation and do not force for N→∞. Accordingly, the test may build as follows:

$$\Delta y_{i,t} = c_i + \alpha_i y_{i,t-1} + \beta_i \bar{y}_{t-1} + \sum_{j=0}^{p} \gamma_{ij} \Delta \bar{y}_{i,t-j} + \sum_{j=1}^{p} \delta_{ij} \Delta \bar{y}_{i,t-j} + \eta_{i,t} \quad i = 1, \dots n \tag{10}$$

In Eq. (10) detailed that $''c_i''$ is the constant tag in equation, $''\bar{y}''$ illustrate the cross-sectional mean values for $''t''$ time span, and lags operator exhibited as $''p''$. Assume t_i (N, TM) represents the identical t-ratio of α_i. At this juncture, average statistic values of t-ratios will stand in this mode:

$$CIPS\,(N,\ T_m) = \frac{\sum_{i=1}^{N} t_{i,}\ (N,\ T_{m,}\ )}{N} \tag{11}$$

Wherever, $t_{i,}\ (N,\ T_{m,})$ is cross-sectionally augmented Dickey–Fuller pointer values for the i^{th} cross-section item.

2.2.3. Panel cointegration tests

Taking into account, the endorsement of stationary from first and 2nd generation unit root tests, the on-hand study favors for utilizing, Pedroni Cointegration tests Pedroni (2004, 1999), for glancing the level of cointegration. Furthermore, the robustness for cointegration has been confirmed by employing Westerlund cointegration test fostered by Westerlund (2007), to obtain cross-sectional dependency in materialized variables. The cointegration test of Pedroni (2004, 1999) is grounded on Engle-Granger typical unit root test which further enlarged by Westerlund et al. (2015) to determine the long-run connection among the candidate variables see (Al-mulali et al., 2012; Ciarreta and Zarraga, 2010; Khan et al., 2017; Rauf et al., 2018). Therefore, it is evidently verified that all variables cohesively integrated into order I (1). Alike, Pedroni cointegration test supplemented an equation as following:

$$CO2_{i,t} = \alpha + \delta_i t + \beta_1 lnECON_{i,t} + \beta_3 lnGDP_{i,t} + \beta_2 lnFD_{i,t} + \beta_4 lnGFCF_{i,t} + \beta_5 lnPOPG_{i,t} + \beta_5 lnMHTech_{i,t} + \beta_5 lnREC_{i,t} + \varepsilon_{i,t} \tag{12}$$

$i = 1, \dots \ t = 1, \dots T$

The Eq. (12) is an elaboration of cointegration test where α_i is the country-specific constant, and deterministic trend termed as $\delta_i t$ for specific individual countries in full and region-wise panels. Pedroni test has been stated eleven statistics for inspecting the null and alternative hypothesis (H0 and H1respectively), however for "H0" co-integrating association β_1 is homogenous and for 'H1" it is heterogeneous within-dimensional statistics. Moreover, it is reported in Table 11 Appendix A.2, where Pedroni cointegration test approved the existence of cointegration in concerned variables for full and regional-based panels. The homogenous information normally dispersed asymptotically and agreeing to Pedroni cointegration test, that can be shown in an equation as following:

$$\sqrt{\frac{N_{N,T}^{'} - \mu\sqrt{N}}{\sqrt{V}}} \rightarrow N\,(0,1) \tag{13}$$

Eq. (13) reveal μ and V exposed Monte Carlo shaped adjustment terms. Though, the Cointegration incorporates parametric and non-parametric statistics that range up to eleven statistical values. The preliminary four statistics characterizes panel assessment statistics or within-dimension, whereas the latter three characterizes group (cluster) statistics test or between the dimension of variables, reported in Table 11 Appendix A.2. Hence, at least 4 out of 7 statistics is the lowest prerequisite to approving the long run liner co-integration in studied variables.

Accordingly, in the presence of cross dependence the Westerlund (2007) cointegration test will deliver more steady and robust outcomes, to approve the level of cointegration. Later, the retrieved outcomes from Westerlund test are fragmented into two forms: cluster-based (group) statistics those comprise on "Gt" and "Ga", whereas panel statistics reported as "Pt" and "Pa" statistics see (Rauf et al., 2018a; Saud et al., 2019). The results are learned in Table 7, discloses that the null hypothesis of no cointegration is overruled in full and six regional basis panels. Henceforward, it is apparent that cointegration endures amongst CO_2 emissions, gross fixed capital formation, medium and high technology industry, renewable energy consumption, financial development, energy consumption, economic growth and population growth in all four models for 65 BRI economies.

2.2.4. Dynamic panel modelling

The study uses Fully Modified OLS Pedroni (2000, 2001) and Dynamic OLS (Kao and Chiang (2000); Stock and Watson (1993), to gauge the long run cointegrating drifts in studying variables. The prime focus of using these two models (FMOLS and DOLS), is to overcome the dynamic endogeneity issues and take into account the correlational problem between their error terms. Generally, the problems of heterogeneity and cross-sectional dependence surfaces in panel study, holding such matters in observance the current study favors to operate second-generation estimators through "dynamic seemingly unrelated regression" (DSUR) familiarized by Mark et al. (2005) for further robustness. As it happened, the historical time T is larger than countries N, even so this estimator can deliver good forecasting and reliable standard normal distribution. The robust outcomes of the (DSUR) estimator are exhibited in Table 13 Appendix A.4.

Table 4
Descriptive statistics.

Variables→	CO_2	ECON	FD	GDPPC	GFCF	MHTECH	POPG	REC
Mean	5.03924	2015.049	27.1718	7130.34	18.5174	15.4486	1.51203	15.0502
Median	2.17489	936.3354	18.4487	2436.81	20.7647	10.8322	1.38813	2.77863
Maximum	70.1356	21959.44	166.504	110645	68.0227	88.037	16.3316	95.9199
Minimum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	−5.8143	0.0000
Std. Dev.	8.23784	2993.163	30.7773	12243.7	12.5806	16.8385	1.93134	23.3218
Skewness	3.46905	2.912172	1.37159	3.17514	−0.0137	1.09683	1.7035	1.7956
Kurtosis	19.2733	13.48702	4.7832	15.35	2.86734	4.06724	11.2682	5.40034
Observations	2340	2340	2340	2340	2340	2340	2340	2340

Note: Author's tabulation.

Table 5
Correlational statistics.

Correlation	CO_2	ECON	FD	GDPPC	GFCF	MHTECH	POPG	REC
CO_2	1.0000							
	–							
ECON	0.9438***	1.0000						
	0.0000	–						
FD	0.1855***	0.1711***	1.0000					
	0.0000	0.0000	–					
GDPPC	0.6604***	0.6684***	0.2979***	1.0000				
	0.0000	0.0000	0.0000	–				
GFCF	−0.0271	−0.0474**	0.3962***	0.0146	1.0000			
	0.1907	0.0220	0.0000	0.4789	–			
MHTECH	0.1777***	0.2136***	0.4722***	0.2687***	0.2890***	1.0000		
	0.0000	0.0000	0.0000	0.0000	0.0000	–		
POPG	0.3901***	0.3681***	0.1202***	0.3766***	−0.0824***	−0.1448***	1.0000	
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	–	
REC	−0.2667***	−0.2708***	0.0028	−0.2201***	0.1946***	0.0492**	−0.1221***	1.0000
	0.0000	0.0000	0.8919	0.0000	0.0000	0.0174	0.0000	–

Notes: Author's Estimation, where; CO_2 denotes carbon emissions; ECON depicts the Energy consumption; GDPPC shows Gross domestic product per capita; FD represents Financial development; GFCF indicates Gross Fixed Capital Formation; POP identifies Population growth; and REC signifies Renewable energy consumption. *, **, *** indicates that statistics are significant at the 10%, 5% and 1% level of significance, respectively.

Table 6
Results of panel unit root tests CIPS and CADF.

Regions	Methods	CO_2	ECON	GDPPC	GFCF	MHTech	REC	POPG	FD	DCFS	DCPB
At Level											
All	CIPS	−2.153	−1.741	−2.032	−2.232	−1.897	−1.021	−1.991	−2.449	−2.376	−2.439
	CADF	8.336	18.33	−2.663***	−1.924**	7.628	13.129	2.506	−0.136	0.985	−0.32
East	CIPS	−2.186	−1.705	−1.561	−2.828*	−5.198***	−1.442	−1.195	−3.294***	−3.187***	−1.9
Asia	CADF	0.022	−0.392	−1.97***	−4.089***	−0.362	1.388	1.562	−2.792***	−1.833**	0.218
Southeast	CIPS	−1.869	−1.709	−3.063***	−1.822	−1.948	−1.318	−2.404	−2.264	−2.376	−2.205
Asia	CADF	2.315	9.238	−4.104***	1.51	−0.95	3.263	−0.241	−0.749	0.378	−0.561
Central	CIPS	−1.944	−1.426	−3.389***	−2.322	−1.249	−1.525	−2.339	−3.655***	−3.953***	−3.617***
Asia	CADF	1.66	1.147	−3.382***	−1.017	2.515	1.049	−0.829	−5.191***	−4.288***	−5.266***
MENA	CIPS	−2.331	−2.309	−2.011	−2.511	−2.064	−1.51	−2.206	−1.813	−2.129	−1.955
	CADF	1.47	5.196	0.414	−1.023	2.839	3.439	0.569	2.9	0.872	2.23
South Asia	CIPS	−1.233	−2.034	−1.257	−2.336	−1.995	−1.567	−1.136	−2.415	−2.781	−2.211
	CADF	4.018	8.022	3.322	−0.712	0.978	1.094	3.869	−0.643	−0.362	−0.849
Europe	CADF	−2.038	−1.327	−2.152	−1.95	−2.408	−1.74	−1.804	−2.434	−2.052	−2.448
	CADF	7.503	7.422	−0.738	0.676	1.947	1.644	2.986	0.253	2.506	0.295
1st Difference											
All	CIPS	−5.663***	−4.725***	−4.91***	−5.031***	−4.817***	−3.616***	−3.101***	−5.002***	−5.14***	−4.999***
	CADF	−6.74***	−21.946***	−13.20***	−11.751***	−12.008***	−11.781***	−24.444***	−13.412***	−14.418***	−13.515***
East	CIPS	−6.364***	−6.044***	−2.86***	−3.881***	−6.42***	−5.44***	−4.552***	−4.859***	−4.437***	−4.456***
Asia	CADF	−6.467***	−5.952***	−2.583***	−3.422***	−6.557***	−4.982***	−3.422***	−4.049***	−3.37***	−3.4***
Southeast	CIPS	−5.618***	−3.181***	−5.455***	−4.399***	−3.621***	−4.583***	−2.863***	−5.173***	−5.416***	−5.007***
Asia	CADF	−12.354***	−3.169***	−8.476***	−2.454***	−4.71***	−8.453***	−7.657***	−7.006***	−7.687***	−6.847***
Central	CIPS	−5.597***	−4.315***	−5.288***	−5.035***	−4.662***	−3.333***	−4.314***	−5.327***	−5.564***	−5.242***
Asia	CADF	−3.244***	−2.562***	−7.491***	−5.358***	−3.379***	−2.522***	−5.483***	−6.419***	−5.424***	−6.69***
MENA	CIPS	−5.685***	−5.486***	−5.24***	−5.368***	−5.155***	−4.155***	−3.089***	−4.229***	−4.386***	−4.176***
	CADF	−5.966***	−13.376***	−5.268***	−6.629***	−4.797***	−7.718***	−11.428***	−3.001***	−5.181***	−2.939***
South Asia	CIPS	−5.622***	−5.222***	−4.314***	−4.995***	−4.722***	−2.291***	−3.856***	−5.039***	−5.35***	−4.846***
	CADF	−2.812***	−9.262***	−3.838***	−4.369***	−7.658***	−1.538*	−8.433***	−4.111***	−5.043***	−3.909***
Europe	CADF	−5.745***	−4.766***	−4.924***	−4.977***	−5.227***	−4.216***	−3.402***	−5.192***	−5.204***	−5.225***
	CADF	−18.958***	−13.507***	−7.518***	−6.919***	−10.803***	−4.139***	−13.193***	−8.71***	−7.79***	−8.843***

Author's estimation: *, **, *** indicates that statistics are significant at the 10%, 5% and 1% level of significance, respectively.

However, the FMOLS and DOLS estimation equations are presented below to measure the study hypothesis:

$$\widehat{\beta}_{NT} = \left[\frac{\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it} - \overline{x}_i)(y_{it} - \overline{y}_i) - T\widehat{\gamma}_i}{\sum_{t=1}^{T}(x_{it} - \widehat{x}_i)^2}\right]$$

Where $\widehat{\gamma}_i = \widehat{\Gamma}_{21i} + \widehat{\Omega}^0_{21i} - \frac{\widehat{\Omega}_{21i}}{\widehat{\Omega}_{21i}}(\widehat{\Gamma}_{22i} + \widehat{\Omega}^2_{22i})$

And $\widehat{\Omega}_i = \widehat{\Omega}^0_i + \widehat{\Gamma}_i + \widehat{\Gamma}'_i$

The $\widehat{\Omega}_i$ term shows the matrix of long run stationarities following by $\widehat{\Omega}^0_{21i}$, which contend the covariance between stationary error terms. Furthermore the $\widehat{\Gamma}_i$ shows the adjusted covariance term among independent variables.

2.2.5. Heterogeneous panel causality test

In conclusion, panel Granger causality test is operated to capture the causality connectedness between CO_2 emissions, financial development, energy consumption, gross fixed capital formation, renewable energy, medium and high technology industry and population growth. We observed causative connections among such variables, by managing an economic model that tolerate for heterogeneity in diagonal to the cross-section. Therefore, Dumitrescu and Hurlin (2012) recommend a simple tactical method for examining the homogeneous non-causality hypothesis, in contrast to an alternative of heterogeneous non-causality. However, the null hypothesis infers no causality connectedness in any cross-sections; contrary to the alternative of causality connectedness is prevailing in cross-sections. The Dumitrescu and Hurlin (2012) contended that panel causality statistics converge to a standard distribution below the homogeneous non-causality premise, when T has a tendency to eternity first and then N lean toward to perpetuity.

3. Empirical results and discussions

This study has operated a fitting methodological track to evaluate empirical estimates for harvesting the successful policy implications to achieve BRI goal lines in full and regional panels.

3.1. Descriptive statistics

In Table 4, shows the summary statistics for all variables, comprises of 65 cross sections and 36-time periods, which holds total 2340 observations. The variables primarily are converted into natural log to avoid heteroscedasticity among the variables and linearity of the underlined variables over the sampled period. The variation in GDPPC and ECON is ranging with mean value of (7130.34$) and (2015.049$) respectively. However, CO_2 emissions seems to be small in million tons (Mt) over the periods in BRI countries and directs that consumption of fossil fuels is very much volatile at variant regions. The on-hand study individually investigates, the study hypothesis in every region to cope with such kind of volatility. Hence, the summary statistics also unveiled skewness and kurtosis evolution in 65 BRI countries to explore the nature of dataset and its features.

Table 7
Results of the Westerlund Cointegration test.

	Model 1			Model 2			Model 3			Model 4		
Statistic	Value	Z-value	P-value	Value	Z-value	P-value	Value	Z-value	P-value	Value	Z-value	P-value
All												
Gt	−6.175	−29.851	0.000	−4.969	−19.646	0.000	−4.731	−17.635	0.000	−4.975	−19.697	0.000
Ga	−5.382	9.383	1.000	−5.271	9.491	1.000	−5.457	9.309	1.000	−5.243	9.518	1.000
Pt	−37.080	−16.605	0.000	−30.753	−10.751	0.000	−26.853	−7.143	0.000	−30.419	−10.442	0.000
Pa	−6.560	4.601	1.000	−6.270	4.881	1.000	−6.727	4.439	1.000	−5.859	5.279	1.000
East Asia												
Gt	−3.824	2.259	0.012	−4.342	2.516	0.006	−4.823	3.230	0.001	−4.521	2.782	0.003
Ga	−5.663	1.116	0.868	−5.128	1.689	0.954	−5.620	1.605	0.946	−5.871	1.562	0.941
Pt	−5.420	2.258	0.012	−9.286	5.486	0.000	−9.872	6.028	0.000	−7.502	3.836	0.000
Pa	−5.643	0.425	0.664	−7.744	0.606	0.728	−8.151	0.537	0.704	−7.335	0.676	0.750
Southeast Asia												
Gt	−3.098	1.571	0.058	−2.908	1.566	0.059	−4.356	4.237	0.000	−3.215	2.564	0.005
Ga	−2.637	4.964	1.000	−4.697	3.642	1.000	−5.187	5.494	1.000	−4.465	3.734	1.000
Pt	−8.509	0.591	0.277	−1.343	4.782	1.000	−4.404	5.420	1.000	−1.842	4.364	1.000
Pa	−2.951	3.329	1.000	−0.256	3.693	1.000	−3.656	4.860	1.000	−0.327	3.666	1.000
Central Asia												
Gt	−6.271	7.992	0.000	−8.273	−12.651	0.000	−3.631	1.849	0.032	−6.282	8.018	0.000
Ga	−4.886	3.062	0.999	−3.401	3.436	1.000	−3.488	3.414	1.000	−3.604	3.385	1.000
Pt	−13.086	6.804	0.000	−17.352	−10.767	0.000	−7.487	1.603	0.054	−16.193	9.690	0.000
Pa	−4.901	2.091	0.982	−3.565	2.423	0.992	−2.761	2.622	0.996	−3.758	2.375	0.991
MENA												
Gt	−3.511	2.629	0.004	−3.457	2.419	0.008	−3.286	1.754	0.040	−3.483	2.518	0.006
Ga	−14.009	1.287	0.901	−13.503	1.499	0.933	−12.667	1.851	0.968	−13.287	1.590	0.944
Pt	−11.944	2.140	0.016	−12.662	2.807	0.003	−12.400	2.563	0.005	−12.620	2.768	0.003
Pa	−19.769	2.681	0.004	−21.918	3.574	0.000	−21.727	3.495	0.000	−21.813	3.531	0.000
South Asia												
Gt	−2.679	1.335	0.091	−3.927	4.161	0.000	−2.376	1.962	0.975	−11.978	−26.480	0.000
Ga	−8.287	1.266	0.897	−1.298	4.259	1.000	−5.903	4.100	1.000	−1.286	4.262	1.000
Pt	−5.242	0.065	0.526	−3.021	2.506	0.994	−6.396	1.490	0.932	−2.955	2.562	0.995
Pa	−4.985	1.084	0.861	−0.885	2.947	0.998	−8.766	2.168	0.985	−0.835	2.963	0.999
Europe												
Gt	−9.119	−32.027	0.000	−10.551	−39.014	0.000	−102.07	−522.51	0.000	−10.572	−39.112	0.000
Ga	−2.757	7.882	1.000	−3.270	6.218	1.000	−2.619	9.413	1.000	−3.165	6.279	1.000
Pt	−25.468	−11.933	0.000	−14.824	−3.695	0.000	−12.247	2.234	0.987	−14.804	−3.679	0.000
Pa	−3.560	5.310	1.000	−5.396	2.580	0.995	−4.473	6.759	1.000	−5.361	2.599	0.995

Author's estimation: *, **, *** indicates that statistics are significant at the 10%, 5% and 1% level of significance, respectively.

3.2. Correlational statistics

In Table 5 presents the correlation analysis among the variables. The positive highly significant correlation linkages are stated of energy consumption (0.9438***), economic growth (0.6604***), population growth (0.3901***), financial development (0.1855***) and medium and high technology (0.1777***) with carbon emissions respectively, whereas renewable energy is negatively (−0.2667***) correlated with CO_2 emission in 65 BRI countries. The correlation between energy consumption and CO_2 emission clarified strong enough among all other associations. However, a weak association is displayed for carbon emission with financial development and medium and high technology industry among all other variables. Hence, it infers that energy consumption and economic growth hurt the atmosphere much more harmfully than other regressors. Thus, all the pair-wise correlation among the series are insightful. However, there is need to further investigate the outcomes given that correlation analysis is not sufficient to validate the preposition established. Subsequent estimations are available in next section.

3.2.1. Panel unit root tests

3.2.1.1. Null: Unit root (assumes individual/common unit root process). The stationarity position of the on-hand dataset is analyzed by using three different approaches LLC, IPS and ADF unit root tests under the first generation presented in Table 10 Appendix A.1, and CIPS and CADF under second generation test offered in Table 6, with particular regions. All studying variables individually examined for the stationary purpose, where outcomes exposed that all variables under 1st generation and 2nd generation tests are stationary at first difference in full and regional panels. Though some tests do discard the null hypothesis at the level, most of the tests make a testimony in support of the first-order stationarity in variables. The cross-sectional dependence (CD) estimates, strongly suggested that there is cross section dependence among the panels; however, first generation cointegration tests (Pedroni and Kao based tests) may suffer from problems to evaluate possible cointegration in variables. And so, to make a strong infers under cross dependence, the Westerlund (2007) cointegration test is used to elaborate the level of cointegration in studied panels see (Yasmeen et al., 2018). The Pedroni cointegration test permits large T and N, to examine the cointegrating relationships among the variables which are depicted in Table 12 Appendix A.2. The model enumerated, four out of seven tests with significant "p" value, rejected the null hypothesis which contended that variables are cointegrated in the long run. Moreover, the best choice to explore cointegration under cross dependence situation is Westerlund cointegration test, that presented in Table 7, to confirm I (1) long run cointegration in subjected panels. Thus, the Fully Modified OLS (FMOLS) and (DOLS) models are, used to investigate long run cointegrating interrelationships in full and regional panels.

3.2.2. Dynamic panel modellings

The FMOLS and DOLS are functioned to acknowledge desired connections between predicted and predictors. The empirical estimates in Table 8, divulges that energy consumption and economic growth unfavorably impacted the ecological quality (CO_2 emission) in all four models for a full panel. However, medium and high technology industry in only first model unpleasantly dented to the environment, but renewable energy consumption in model one and financial development proxied by domestic credit by the financial sector (DCFS), have a favorable effect for the environment. Therefore, it is determined that BRI economies should join hands to provide awareness to the general masses about renewable energy sources and their utilization. Furthermore, industries should also adopt new technologies to preserve energy and sponsored them with low-cost renewable energy sources.

In East Asian region, energy consumption, population growth, high-tech industry, and economic growth positively effect to the level of CO_2 emissions (damaging to ecological position); however, gross fixed capital formation and renewable energy consumption are found eco-friendly. Hence, it is suggesting that, as China is a big player in this region where it needs to control population explosion for limiting the ecological deterioration and focus should be on renewable rather than fossil fuels and coal-based energy sources. In Southeast Asian (11 countries), MENA (14 countries) and Europe (24 countries) regions, displayed long run associations among the variables in all four models. Where it is confirmed that energy consumption and economic growth deteriorating to the environmental quality, additionally the high-tech industrial growth is unfriendly in MENA and Southeast Asian regional panel, but population growth, financial development (domestic credit provided by financial sectors) and renewable energy consumption are having a negative relationship with CO_2 emissions in Southeast Asian panel. Thus, renewable energy consumption in all four-models muscularly effectual for environmental quality in MENA economies, but population growth and (FD) domestic credit provided by financial banks are adversely impacting to ecology (Hafeez et al., 2018). Furthermore, in Europe, population growth is also hampering to the environmental quality, but renewable energy consumption, gross fixed capital formation and financial development under three proxies (FD, DCSF, and DCPB) are workably decent for the ecological position. Hence, it is confirmed that only in the European region, financial development retrieved the similar negative impacts towards CO_2, while the other panels offered some mixed results.

In central Asian region (5 countries) estimations are elucidating that energy consumption, high-tech industry growth and financial development under all three proxies harmfully effect to the environmental quality, but renewable energy consumption and population growth are efficient for environment position in this region. On the other hand, for South Asian region (8 countries) estimations depicted that economic growth, renewable energy consumption, and population growth negatively affect to CO_2 emissions in this region, but gross fixed capital formation and financial development under all three proxies are deteriorating to the environmental quality. Thus, Central Asian and South Asian countries should restraint from population growth, and new technologies should be introduced to assimilate the importance of renewable energy and to urge to the financier for green-energy investments in such regions. In addition, it is confirmed that gross fixed capital formation and financial development in developed countries is a negative and significant effect on the intensity of carbon dioxide emission that fosters a good gesture for environment perspective.

The findings divulge that energy consumption is presently a critical element for the magnitude of CO_2 emissions, which is extremely frightening in full panel (65) BRI countries. The elevated level of energy consumption roots for extreme environmental deterioration, and accordingly, the legislator needs to an emphasis on technological improvement which can condense the immensity of carbon dioxide emissions, by boosting dependence on renewable energy consumption and utilizing more and more energy conservable technologies (Choi et al., 2012). The carbon-off renewable energy, e.g. (solar, hydro, nuclear, biomass and wind) and associated cutting-edge equipment will also encourage to get sound ecological quality. Such findings are consistent with verdicts grasped by Javid and Sharif (2016) for Pakistan; Zhang and Gao (2016) investigation for China; Kasman and Duman (2015) studies for EU member countries; and Rauf et al. (2018a) for BRI 65 countries. In other expressions, proxies for financial development (FD) are

Table 8
Fully Modified OLS and DOLS Panel Models for Full and Region wise countries.

Predicted Variable CO_2 Emissions in all four models									
Panels		Model 1		Model 2		Model 3		Model 4	
	Regressors	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS
		Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
All 65 countries	ECON	0.141***	0.137***	0.142***	0.131***	0.160***	0.136***	0.143***	0.125***
	GDPPC	0.033**	0.031**	0.038***	0.040***	0.030*	0.054**	0.035**	0.051***
	GFCF	0.028	0.027	0.025	0.029	0.056	0.028	0.017	0.012
	MHTECH	0.099***	0.114***	0.097	0.108	0.106	0.098	0.096	0.083
	REC	−0.048**	−0.052*	−0.050	−0.031	−0.166	−0.066	−0.054	−0.048
	POPG	0.015	0.021	–	–	–	–	–	–
	FD	–	–	−0.007	−0.036*	–	–	–	–
	DCFS	–	–	–	–	−0.035**	−0.049**	–	–
	DCPB	–	–	–	–	–	–	0.014	−0.005
	R2	0.851	0.973	0.852	0.956	0.904	0.987	0.851	0.956
	Adj. R2	0.845	0.936	0.847	0.920	0.897	0.943	0.845	0.920
East Asia 2 Countries	ECON	0.236***	0.161***	0.179***	0.772***	0.180***	0.759***	0.201***	0.361***
	GDPPC	−0.003	−0.097***	−0.004	0.518***	−0.006	0.592***	−0.008	0.259*
	GFCF	−0.025	0.215***	−0.088	−1.680**	−0.128	−2.125***	−0.096	−1.226**
	MHTECH	0.046***	0.097**	0.168**	0.031	0.177***	0.031	0.151***	0.053
	REC	−0.096***	−0.123**	−0.068	0.011	−0.087	−0.016	−0.137*	−0.192*
	POPG	0.090*	0.867***	–	–	–	–	–	–
	FD	–	–	0.083	−0.955	–	–	–	–
	DCFS	–	–	–	–	0.131	−0.727	–	–
	DCPB	–	–	–	–	–	–	0.126**	0.205*
	R2	0.978	0.998	0.860	0.980	0.863	0.980	0.876	0.963
	Adj. R2	0.974	0.992	0.844	0.941	0.848	0.942	0.862	0.899
South East Asia 11 Countries	ECON	0.141***	0.201***	0.140***	0.150**	0.131***	0.250*	0.140***	0.209**
	GDPPC	0.057**	0.169*	0.054*	0.232***	0.059**	−0.006	0.051*	−0.037
	GFCF	−0.013	−0.366*	0.072	−0.702***	0.089	0.073	0.070	0.132**
	MHTECH	0.116***	0.190	0.129***	0.396*	0.123***	0.243*	0.130***	0.194***
	REC	−0.041	−0.221**	−0.007	−0.241	0.006	0.025	−0.008	0.030
	POPG	−0.379***	−0.713***	–	–	–	–	–	–
	FD	–	–	−0.002	−0.024	–	–	–	–
	DCFS	–	–	–	–	−0.050	−0.123**	–	–
	DCPB	–	–	–	–	–	–	0.003	−0.058
	R2	0.973	0.948	0.903	0.831	0.904	0.985	0.903	0.982
	Adj. R2	0.936	0.879	0.896	0.672	0.897	0.963	0.896	0.965
Central Asia 5 Countries	ECON	0.061***	0.050	0.082***	0.027	0.073***	0.019	0.082***	0.027
	GDPPC	−0.042	0.017	−0.054*	0.046	−0.049	0.046	−0.052	0.046
	GFCF	0.219***	0.128	0.125*	0.044	0.102	0.033	0.118	0.043
	MHTECH	0.469***	0.565***	0.461***	0.486***	0.456***	0.503***	0.462***	0.482***
	REC	−0.337***	−0.352***	−0.342***	−0.323***	−0.335***	−0.343***	−0.342***	−0.320***
	POPG	−0.188***	0.002	–	–	–	–	–	–
	FD	–	–	0.153***	0.106*	–	–	–	–
	DCFS	–	–	–	–	0.172***	0.126*	–	–
	DCPB	–	–	–	–	–	–	0.158***	0.106*
	R2	0.973	0.821	0.837	0.950	0.842	0.964	0.837	0.950
	Adj. R2	0.936	0.810	0.827	0.915	0.833	0.939	0.827	0.914
MENA 14 Countries	ECON	0.168***	0.155***	0.167***	0.113***	0.169***	0.187***	0.169***	0.112***
	GDPPC	0.022**	0.000	0.032***	0.040**	0.028**	0.034*	0.024**	0.033**
	GFCF	0.040	0.022	0.036	0.007	0.031	−0.032	0.014	−0.016
	MHTECH	0.142***	0.190***	0.128***	0.113***	0.130***	0.091*	0.133***	0.118***
	REC	−0.250***	−0.261***	−0.241***	−0.169***	−0.249***	−0.165***	−0.256***	−0.189***
	POPG	0.064***	−0.004	–	–	–	–	–	–
	FD	–	–	−0.025	−0.032	–	–	–	–
	DCFS	–	–	–	–	−0.004	−0.046	–	–
	DCPB	–	–	–	–	–	–	0.050*	0.050*
	R2	0.833	0.968	0.829	0.928	0.829	0.945	0.830	0.929
	Adj. R2	0.825	0.925	0.821	0.881	0.821	0.877	0.822	0.883
South Asia 8 Countries	ECON	−0.085	0.203***	−0.098	0.045	−0.104	0.148***	−0.095	0.139
	GDPPC	−1.402***	−0.418***	−1.196***	−0.096	−1.511***	−0.203*	−1.188***	−0.098
	GFCF	3.123***	0.313**	2.834***	−0.340	2.419**	−0.393	2.768***	−0.501*
	MHTECH	0.732**	−0.169	0.916***	0.241***	0.995***	0.134	0.905***	0.162
	REC	−0.732***	0.197**	−0.742***	−0.169**	−0.844***	−0.034	−0.734***	−0.076
	POPG	−1.227***	−0.621***	–	–	–	–	–	–
	FD	–	–	0.127	0.404***	–	–	–	–
	DCFS	–	–	–	–	1.133**	0.464**	–	–
	DCPB	–	–	–	–	–	–	0.169	0.385***
	R2	0.667	0.996	0.609	0.974	0.522	0.989	0.614	0.989
	Adj. R2	0.632	0.990	0.568	0.954	0.473	0.971	0.575	0.971
	ECON	0.170***	0.134***	0.166***	0.135***	0.164***	0.141***	0.166***	0.140***

(*continued on next page*)

Table 8 (*continued*)

Predicted Variable CO_2 Emissions in all four models									
Panels		Model 1		Model 2		Model 3		Model 4	
	Regressors	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS
		Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
Europe 24 Countries	GDPPC	0.082***	0.103***	0.090***	0.096***	0.095***	0.086***	0.090***	0.095***
	GFCF	−0.074**	−0.044	−0.065**	−0.022	−0.059*	−0.005	−0.066**	−0.014
	MHTECH	0.039**	0.016	0.024	0.018	0.030	0.013	0.024	0.019
	REC	−0.025	−0.007	−0.034**	−0.011	−0.031*	−0.001	−0.034**	−0.038
	POPG	0.089***	0.082*	–	–	–	–	–	–
	FD	–	–	−0.028*	−0.025*	–	–	–	–
	DCFS	–	–	–	–	−0.054***	−0.041**	–	–
	DCPB	–	–	–	–	–	–	−0.028*	−0.020*
	R2	0.838	0.973	0.832	0.970	0.832	0.966	0.832	0.968
	Adj. R2	0.831	0.941	0.826	0.935	0.825	0.934	0.826	0.933

Notes: Author's Estimation, where; CO_2 denotes carbon emissions; *ECON* depicts the Energy consumption; *GDPPC* shows Gross domestic product per capita; *FD* represents Financial development; GFCF indicates Gross Fixed Capital Formation; *POP* identifies Population growth; and *REC* signifies Renewable energy consumption. *, **, *** indicates that statistics are significant at the 10%, 5% and 1% level of significance, respectively.

sensitive in full and regional panels, where it has found a mixed contribution to detriment ecological conditions or environmental tidiness. Our outcome is alike to the conclusion grasped by Khan et al. (2017) for different global territories; and Rauf et al. (2018a) for BRI countries. In divergence, our outcome is not harmonized with Bekhet and Othman (2017) for Malaysia; and Hafeez et al. (2018) for OBORI states. Furthermore, matured financial development (FD) can boost the deployment of financial funds for green environmental sustainably schemes and ease in liability costs for such funds (Tamazian et al., 2009). Our outcome also endorses the assessment of Kumbaroğ;lu et al. (2008), who tender that a well-developed financial and fiscal division in an economy, enables all administrative tiers to acquire finance for hygienic environment-allied projects, and fetch greater technology transformations to support decent ecological quality. Therefore, it is decisive to concentrate on capital investments and financial development, which may have a meaningfully positive influence on environmental condition by dropping carbon dioxide emissions in selected BRI nations.

3.2.3. Panel heterogeneous granger causality test

The granger causality test grounded on panel heterogeneous causality test Dumitrescu and Hurlin (2012), is operated to treasure the short-run granger causality in studied variables for selected BRI economies. The results for panel granger causality test are portrayed in Table 9, that showed some mixed outcomes, where energy consumption and financial development has bidirectional relationship (feedback hypothesis) with environmental deterioration, but economic growth and medium and high-tech industry are unidirectionally influenced to the ecological quality. In conclusion, the path of connectedness will support to the legislators, with the purpose of authorize pertinent economic strategies those ancillary with environmental policies in BRI economies. The way as causality illustrates that economic growth justify for high carbon emissions in BRI nations, infers that economic development not only destructive influences on environmental situation and triggering to the global warming, but also can disturb humanoid health and their well-being. The larger economic growth can bring about long-standing effluence; however, such deteriorating conditions can be structured by means of accessibility of pollution antagonistic devices and use of well-developed technology. Similarly, the outcomes also sponsor a bidirectional causativeness from energy consumption and medium and high-tech industry to economic growth. These outcomes are matched with the findings achieved by (Katircioglu, 2017). The existence of two-way causal connectedness between CO_2 emissions and financial development infers that, both carbon dioxide emissions and financial development are multiparty impacts on each other, aligned with (Al-mulali et al., 2015; Rauf et al., 2018a; Saud et al., 2019).

3.3. Robustness scrutiny under “DSUR”

The Dynamic Seemingly Unrelated Regression (DSUR) model is utilized to check the robustness of results from DOLS and FMOLS, those are line up with evaluating estimates in Table 13 Appendix A.4. C. The observed R-square value in Europe and MENA countries is seems comparatively higher and showing a direct impact of subjected indicators on carbon emissions (CO_2) which implies an antagonistic worsening the environment. The reported results of DSUR are aligned with of DOLS and FMOLS estimations, where financial development and energy consumption are causing a stern troublemaker to enlarge the magnitude of carbon emissions and decaying to the environment in selected BRI economies, which might become a big challenging hazard for accomplishment of BRI projects in impending time.

4. Conclusion, recommendations and policy implications

This present study explores the interaction between energy consumption, economic expansion, population growth, financial development and carbon emissions for 65 BRI countries over the period of 1981–2016 in a panel framework. This current study employed robust panel methodology that accounts for cross-sectional dependence and heterogeneity in the regional panels. The study fitted four functional form to operationalize study's objectives. The energy consumption and economic growth in all four-models unfavorably impacted the ecological quality (CO_2 emission) in BRI full panel. However, medium and high technology industry in the first model unpleasantly dented to the environment quality but renewable energy consumption and financial development proxied by domestic credit by the financial sector (DCFS) in model one has a favorable effect for the environment quality. The mixed outcomes are obtained from all six regional panels, where prominently in Southeast Asian, MENA and European region, in all four models verified that energy consumption and economic growth worsening to the environmental quality. Additionally, the high-tech industrial growth is also unfriendly in MENA and Southeast Asian region, but population growth, financial development (domestic credit provided by financial sectors) and renewable energy consumption are having negative relationships with CO_2 emissions in Southeast

Table 9
Panel Granger Causality test estimation.

DependentVariables	Independent Variables									
	ΔCO_2	ΔECON	ΔGDPPC	ΔGFCF	ΔMHTECH	ΔPOPG	ΔREC	ΔFD	ΔDCPB	ΔDCFS
ΔCO_2	–	9.627***	0.659	0.001	0.072	0.090	0.090	8.732***	9.16671***	9.469***
ΔECON	10.64***	–	2.707*	0.851	9.456***	1.026	0.871	23.50***	22.6171***	16.87***
ΔGDPPC	13.42***	5.866**	–	3.787*	12.38***	2.807*	0.027	0.122	0.014	0.549
ΔGFCF	0.060	5.407**	5.517**	–	5.869**	12.94***	6.725***	0.072	0.30159***	0.427
ΔMHTECH	47.39***	152.8***	2.280	0.345	–	0.207	3.443*	3.604*	2.654	1.554
ΔPOPG	0.089	14.36***	4.069**	0.178	0.751	–	2.735*	5.432**	4.19354**	5.093**
ΔREC	0.089	9.456***	6.937***	0.734	6.493**	3.511**	–	17.40***	17.4303***	7.523***
ΔFD	8.732***	27.57***	54.02***	50.85***	31.03***	1.545	12.65***	–	0.016	1.856
ΔDCPB	9.166***	27.34***	48.29***	47.90***	26.39***	1.099	11.54***	12.09***	–	0.011
ΔDCFS	9.469***	38.95***	37.80***	38.40***	32.05***	0.719***	9.928***	10.07**	14.5745***	–

Author's estimation: *, **, *** indicate that statistics are significant at the 10%, 5% and 1% level of significance, respectively.

Asian panel. However, renewable energy in all four-models muscularly effectual for environment quality in MENA economies (Hafeez et al., 2018; Rauf et al., 2018a). The overall outcomes claim a weak association of economic indicators with carbon emissions in the long run except for Europe, MENA, and Southeast Asian regions.

Conclusively, the BRI projects success is grounded on (EEE), i.e., economy, energy, and environment, such triple (E's) are in balance outline may pose huge consideration for BRI candidature economies. The present study will deliver as a guidance gadget for experts, policymakers, and BRI listed governments that they should implement proposed population restrains, advise to the masses and industries to shift towards renewable energy and to install the water treatment plants near to industry-based projects. The industrial production for economic growth is an essence (exporting and trading) through bilateral trading projects, it will input to gross domestic products (GDP) massively and strengthen mutual trade and cooperation among the BRI selected nations. Additionally, constructing policies for full and region wide panels should be advocated in term of economic indicators, i.e., financial development and gross fixed capital formation should in a way, those may not harmful for the environment and persistently focuses on eco-friendly investments by yielding positive response to an economy and its environment quality.

The study outcomes propose few necessary policy implications for the environment legislators and experts; they need to allocate economic resources based on study outcomes for maximum yields but in a prudent way. Accordingly, the scholars should adopt short and long run anticipatory approaches for attending the environmental issues especially greenhouse gases (GHG, s) and climatic change sensitivity in BRI economies. It suggests that the quest for economic expansion comes with its trade-off for environment quality. Thus, for all regions examined to achieve CO_2 emission reduction, there is need for more pragmatic and stringent policies/strategies from policymakers and stakeholders alike. Furthermore, diversified estimates of on-hand study are also a supporting tool for full and region wide countries to make strategies for supplying renewable energy for risk aversion of (GHG's) emissions, besides it is needful to anticipate energy demand and supply for realizing the sustainable development and BRI projects accomplishment. Moreover, an improvement in GDP per capita (earnings) would facilitate to general peoples (masses) to access more dynamic and eco-friendly conveniences. Hence, it is also recommended to policymakers, experts and governments that they must emphasize and appreciate to portfolio investors for green investments and acquainted its advantages, besides that alert them about the climatic sensitivity through (non-green) investments.

The fresh on hand study tolerating with few limitations, for instance; it does not notice the Environmental Kuznets Curve (EKC) nexus by holding BRI listed economies with other diverse economic variables. It holds only one part of environment degradation, which is GHG's in the form of CO_2 emissions. However, the impending research will interlock associations of nominated variables with aid of several other pointers of ecological degradation, i.e., natural disasters, global warming, carbon mono oxide, PM2.5, industrial pollution and health influences with an intention to catch a comprehensive environment impression among selected BRI countries.

Funding

"The study is supported by the Startup Foundation for Introducing Talent of Nanjing University of Information Science and Technology, (NUIST), PR , China (EMP#003203); National Natural Science Foundation of China (No. 71673043, 71473070); National Social Science Fund; Ministry of Education of China (18VSJ035), Humanity and Social Science Youth foundation of Ministry of Education of China (Grant No. 18YJC790216) and Technology project of Headquarter of China's State Grid Co., Ltd Contract No. SGFJJY00GHWT800059).

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.

CRediT authorship contribution statement

Abdul Rauf: Conceptualization, Methodology, Software, Data curation, Writing - original draft, Software, Validation, Writing - review & editing. **Xiaoxing Liu:** Supervision. **Waqas Amin:** Visualization, Investigation. **Obaid Ur Rehman:** Data curation, Writing - original draft. **Jinkai Li:** Supervision. **Fayyaz Ahmad:** Data curation, Writing - original draft, Writing - review & editing. **Festus Victor Bekun:** Visualization, Investigation.

Acknowledgment

The authors wish to thank to the responsible Editor and four anonymous reviewers for their constructive and valuable comments for enhancing the quality of our manuscript.

Appendix

Table 10 Appendix A.1Unit Root tests (LLC, IPS and ADF)

At Level									
Regions	Method	CO_2	ECON	FD	GDPPC	GFCF	POP	MHTech	REC
All	LLC	4.1146	13.517	−1.599 *	0.355	−2.409 ***	−11.1762 ***	0.2457	−0.3046
	IPS	2.9981	3.483	2.662	2.882	−1.549 **	−15.0537 ***	−1.3521	−1.6741 **
	ADF	94.450	91.339	63.791	121.74	141.962	494.681 ***	89.576	103.17
Central Asia	LLC	−0.6438	0.0886	−0.6855	−2.0281 **	−1.0345	0.326	0.06098	0.00630
	IPS	−1.019	−0.509	0.715	−1.013	−1.666 **	2.354	−0.62148	−0.29281
	ADF	13.467	8.951	2.417	11.886	16.130 *	3.752	9.58929	8.02361
East Asia	LLC	0.434	2.099	−0.654	0.543	1.051	−0.106	0.0656	0.11568
	IPS	−2.122 **	−1.228	0.617	1.933	−0.587	1.046	−0.2251	−0.0578
	ADF	12.724 **	7.093	1.661	0.424	4.622	3.494	3.2827	2.8414
South East Asia	LLC	2.053	9.786	−0.101	−0.894	−2.008 **	−6.138 ***	0.1154	−0.0186
	IPS	2.304	1.037	0.963	0.330	−2.145 **	−2.708 ***	−0.3341	−1.2219
	ADF	8.753	13.802	12.450	32.101 *	33.683 **	60.321 ***	14.080	27.9832
Middle East and North Africa	LLC	10.006	28.108	−0.986	1.196	0.122	−0.037	0.13594	−0.12827
	IPS	2.201	4.053	0.441	2.803	−0.558	3.199	−0.69614	−0.97168
	ADF	22.162	11.258	16.341	17.093	29.436	15.634	22.5515	25.5912
South Asia	LLC	−0.077	10.504	−1.124	1.919	0.162	−1.610 *	−0.11855	−0.02609
	IPS	2.669	−1.405 *	0.843	5.277	0.558	0.896	−0.58965	−0.77876
	ADF	10.735	19.864	7.470	4.731	10.594	18.834	12.7969	14.1842
Europe	LLC	2.252	4.314	−0.985	−2.843 ***	−3.033 ***	0.180	0.1605	0.22211
	IPS	1.327	3.179	2.033	−0.817	−1.494 *	−1.442 *	−0.9965	−0.42235
	ADF	39.130	30.369	23.375	54.560	53.130	88.665 ***	41.265	37.2498
At First Difference									
All	LLC	−11.35 ***	3.518	−22.66 ***	−20.96 ***	−20.06 ***	−11.87 ***	−7.4497 ***	−4.790 ***
	IPS	−10.67 ***	−0.636	−22.66 ***	−20.25 ***	−20.73 ***	−17.28 ***	−21.018 ***	−18.337 ***
	ADF	439.21 ***	262.28 ***	743.66 ***	670.12 ***	691.57 ***	610.28 ***	609.286 ***	548.04 ***
Central Asia	LLC	−4.454 ***	−6.106 ***	−7.006 ***	−8.191 ***	−4.223 ***	−4.567 ***	−9.007 ***	−2.673 ***
	IPS	−5.382 ***	−4.718 ***	−6.986 ***	−6.366 ***	−5.930 ***	−3.321 ***	−5.987 ***	−6.292 ***
	ADF	48.216 ***	40.993 ***	52.381 ***	57.653 ***	53.864 ***	32.590 ***	53.036 ***	57.014 ***
East Asia	LLC	−2.284 **	−0.720	−4.546 ***	−3.501 ***	2.343	−2.951 ***	−5.701 ***	−2.398 ***
	IPS	−1.274	0.148	−4.156 ***	−2.972 ***	−0.610	−1.651 **	−3.87***	−4.44 ***
	ADF	16.368 ***	6.816	23.933 ***	16.290 ***	12.060 **	11.629 **	21.57***	25.3***
South East Asia	LLC	−4.851 ***	1.869	−9.871 ***	−7.149 ***	−8.240 ***	−4.287 ***	−3.510 **	−2.941 ***
	IPS	−5.107 ***	0.496	−9.695 ***	−8.089 ***	−9.025 ***	−4.286 ***	−9.040 ***	−8.836 ***
	ADF	79.589 ***	31.487 **	134.08 ***	107.30 ***	117.09 ***	69.570 ***	109.16 ***	110.652 ***
Middle East and North Africa	LLC	0.983	10.075	−6.504 ***	−5.844 ***	−5.019 ***	−13.13 ***	−4.2411 ***	−7.940 ***
	IPS	−0.287	5.393	−8.269 ***	−7.690 ***	−9.139 ***	−14.23 ***	−10.688 ***	−11.268 ***
	ADF	48.043 **	20.937	125.40 ***	128.76 ***	142.31 ***	229.13 ***	156.57 ***	172.98 ***
South Asia	LLC	−3.871 ***	5.1803	−7.889 ***	−6.025 ***	−5.857 ***	−4.152 ***	12.79 **	−2.548 ***
	IPS	−4.192 ***	0.538	−7.330 ***	−6.772 ***	−6.135 ***	−5.799 ***	−7.219 ***	−7.164 ***
	ADF	55.578 ***	45.060 ***	82.927 ***	76.818 ***	64.416 ***	75.440 ***	75.62 ***	80.824 ***
Europe	LLC	−9.479 ***	1.355	−15.74 ***	−16.78 ***	−17.54 ***	−8.570 ***	−4.957 ***	−17.007 ***
	IPS	−8.017 ***	−3.642 ***	−15.30 ***	−13.73 ***	−16.40 ***	−8.760 ***	−14.284 ***	−9.625 ***
	ADF	178.97 ***	116.98 ***	312.36 ***	271.93 ***	335.92 ***	180.57 ***	275.589 ***	192.003 ***

Author's Estimation: *, **, *** indicate that statistics are significant at the 10%, 5% and 1% level of significance, respectively.

Table 11 Appendix A.2
Pedroni Cointegration test results

Pedroni residual co-integration tests statistics				
	Model1	Model2	Model3	Model4
All				
Panel v-Statistic	1.068	2.518***	2.469***	2.526***
Panel rho-Statistic	1.047	1.413	0.744	1.394
Panel PP-Statistic	−9.465***	−9.415***	−9.999***	−9.426***
Panel ADF-Statistic	−3.166***	−5.089***	−4.288***	−5.119***
Group rho-Statistic	3.564	4.194	3.757	4.164
Group PP-Statistic	−14.086***	−13.232***	−13.051***	−13.203***
Group ADF-Statistic	−2.917***	−5.085***	−3.619***	−5.082***
East Asia				
Panel v-Statistic	−1.022	−1.330	−1.283	−1.216
Panel rho-Statistic	−0.594	0.088	−0.014	0.101
Panel PP-Statistic	−7.079***	−6.555***	−6.675***	−5.640***
Panel ADF-Statistic	−1.404*	−4.933***	−5.049***	−4.516***
Group rho-Statistic	0.104	0.434	0.389	0.404
Group PP-Statistic	−13.002***	−14.419***	−15.302***	−14.352***
Group ADF-Statistic	−2.215**	−4.560	−4.667***	−4.434***
Southeast Asia				
Panel v-Statistic	0.182	1.143	0.912	1.144
Panel rho-Statistic	−0.204	−0.673	−0.425	−0.718
Panel PP-Statistic	−3.683***	−4.831***	−4.637***	−4.841***
Panel ADF-Statistic	−3.860***	−4.381***	−4.758***	−4.373***
Group rho-Statistic	0.980	0.820	1.024	0.774
Group PP-Statistic	−5.259***	−5.799***	−5.631***	−5.878***
Group ADF-Statistic	−4.750***	−4.414***	−4.215***	−4.302***
Central Asia				
Panel v-Statistic	0.350	−0.010	−0.082	0.000
Panel rho-Statistic	3.198	0.729	−0.050	0.722
Panel PP-Statistic	−4.057***	−1.409*	−1.524**	−1.420*
Panel ADF-Statistic	−5.586***	−4.246***	−1.880**	−4.254***
Group rho-Statistic	2.141	1.123	0.957	1.064
Group PP-Statistic	−4.790***	−1.652**	−1.379*	−1.775**
Group ADF-Statistic	−5.204***	−3.034***	−1.594*	−3.132***
MENA				
Panel v-Statistic	−0.356	0.100	0.100	0.054
Panel rho-Statistic	0.556	1.056	1.056	1.089
Panel PP-Statistic	−4.161***	−2.813***	−2.813***	−2.760***
Panel ADF-Statistic	−2.505***	−4.897***	−4.897***	−3.196***
Group rho-Statistic	1.539	2.439	2.439	2.444
Group PP-Statistic	−8.831***	−6.006***	−6.006***	−5.916***
Group ADF-Statistic	−5.715***	−3.089***	−3.089***	−3.712***
South Asia				
Panel v-Statistic	−0.020	−0.035	0.154	0.496
Panel rho-Statistic	0.209	−0.454	0.206	−0.469
Panel PP-Statistic	−1.349*	−3.617***	−1.993**	−3.779***
Panel ADF-Statistic	−1.334*	−3.615***	−1.924**	−3.800***
Group rho-Statistic	1.997	1.501	2.058	1.891
Group PP-Statistic	0.290	−1.563**	−3.741***	−4.090***
Group ADF-Statistic	−0.179	−2.452***	−1.664**	−2.496***
Europe				
Panel v-Statistic	0.953	2.459***	2.355***	2.468***
Panel rho-Statistic	0.321	0.669	0.561	0.668
Panel PP-Statistic	−6.835***	−7.449***	−7.674***	−7.442***
Panel ADF-Statistic	−7.189***	−8.042***	−8.140***	−8.048***
Group rho-Statistic	1.958	2.464	2.163	2.457
Group PP-Statistic	−7.339***	−7.011***	−7.575***	−6.967***
Group ADF-Statistic	−6.468***	−6.294***	−6.796***	−6.240***

Author's Estimation: *, **, *** indicate that statistics are significant at the 10%, 5% and 1% level of significance, respectively.

Table 12 Appendix A.3
65 Countries list by their Regional wise line up with BRI

No	Central Asia	No	East Asia	No	South East Asia	No	South Asia	No	Middle East and North Africa (MENA)	No	Europe
1	Kazakhstan	1	China	1	Brunei Darussalam	1	Afghanistan	1	Bahrain	1	Albania
2	Kyrgyz Republic	2	Mongolia	2	Cambodia	2	Bangladesh	2	Egypt, Arab Rep.	2	Armenia
3	Tajikistan	3		3	Indonesia	3	Bhutan	3	Iran, Islamic Rep.	3	Azerbaijan
4	Turkmenistan	4		4	Lao PDR	4	India	4	Iraq	4	Belarus
5	Uzbekistan	5		5	Malaysia	5	Maldives	5	Iraq	5	Bosnia and Herzegovina
				6	Myanmar	6	Nepal	6	Jordan	6	Bulgaria
				7	Philippines	7	Pakistan	7	Kuwait	7	Croatia
				8	Singapore	8	Sri Lanka	8	Lebanon	8	Czech Republic
				9	Thailand			9	Oman	9	Estonia
				10	Timor-Leste			10	Qatar	10	Georgia
				11	Vietnam			11	Saudi Arabia	11	Hungary
								12	Syrian Arab Republic	12	Latvia
								13	United Arab Emirates	13	Lithuania
								14	Yemen, Rep.	14	Macedonia, FYR
										15	Moldova
										16	Montenegro
										17	Poland
										18	Romania
										19	Russian Federation
										20	Serbia
										21	Slovak Republic
										22	Slovenia
										23	Turkey
										24	Ukraine

Source: World Bank Classification (http://data.worldbank.org/about/country-classifications/country-and-lending-groups).

Table 13 Appendix A.4
Dynamic Seemingly Unrelated Regression (DSUR) Results

Panels		Model 1			Model 2			Model 3			Model 4		
	Regressors	Coefficient	*t-value*	*P-value*	Coefficient	*t-value*	*P-value*	Coefficient	*t-value*	*P-value*	Coefficient	*t-value*	*P-value*
All 65 countries	ECON	0.211	46.351	0.000	0.212	47.875	0.000	0.210	45.518	0.000	0.212	48.228	0.000
	GDPPC	0.047	18.146	0.000	0.041	16.547	0.000	0.044	16.935	0.000	0.040	16.336	0.000
	GFCF	−0.062	−13.374	0.000	−0.062	−13.298	0.000	−0.052	−10.714	0.000	−0.062	−13.499	0.000
	MHTECH	0.137	16.927	0.000	0.139	17.244	0.000	0.142	17.052	0.000	0.139	17.183	0.000
	REC	−0.286	−37.005	0.000	−0.279	−36.493	0.000	−0.281	−36.622	0.000	−0.278	−36.289	0.000
	POPG	−0.015	−4.576	0.000	–	–	–	–	–	–	–	–	–
	FD	–	–	–	0.019	5.552	0.000	–	–	–	–	–	–
	DCFS	–	–	–	–	–	–	−0.007	−2.400	0.017	–	–	–
	DCPB	–	–	–	–	–	–	–	–	–	0.025	7.100	0.000
	Constant	−0.412	−15.049	0.000	−0.452	−16.395	0.000	−0.442	−14.889	0.000	−0.453	−16.730	0.000
	R2	0.6426			0.6466			0.6360			0.6499		
	F statistic (Prob.)	699.182***			711.673***			679.418***					
East Asia	ECON	0.175	12.581	0.000	0.159	13.354	0.000	0.158	13.082	0.000	0.158	13.188	0.000
2	GDPPC	−0.020	−1.697	0.095	−0.002	−0.268	0.790	−0.001	−0.204	0.839	0.000	−0.030	0.977
Countries	GFCF	0.037	1.085	0.282	−0.014	−0.589	0.558	−0.023	−0.929	0.356	−0.067	−2.355	0.022
	MHTECH	0.050	2.498	0.015	0.039	2.529	0.014	0.042	2.641	0.010	0.046	2.874	0.006
	REC	0.000	−0.013	0.990	0.031	1.288	0.202	0.030	1.196	0.236	0.002	0.073	0.942
	POPG	−0.217	−3.382	0.001	–	–	–	–	–	–	–	–	–
	FD	–	–	–	−0.003	−0.114	0.909	–	–	–	–	–	–
	DCFS	–	–	–	–	–	–	0.006	0.264	0.793	–	–	–
	DCPB	–	–	–	–	–	–	–	–	–	0.061	2.297	0.025
	Constant	−0.412	0.001	0.984	−0.049	−1.799	0.077	−0.054	−1.945	0.056	−0.058	−1.985	0.051
	R2	0.908			0.934			0.931			0.933		

	F statistic (Prob.)	106.604***			152.546***			146.713***			150.504***		
South East Asia 11 Countries			ECON	0.131	25.904	0.000	0.159	28.155	0.000	0.163	27.905	0.000	0.158
			28.325	0.000									
			GDPPC	0.155	20.707	0.000	0.169	21.763	0.000	0.168	20.196	0.000	0.168
			21.872	0.000									
			GFCF	−0.224	−12.501	0.000	−0.234	−13.387	0.000	−0.244	−13.755	0.000	−0.232
			−13.234	0.000									
			MHTECH	0.284	19.531	0.000	0.366	23.434	0.000	0.390	25.282	0.000	0.367
			23.405	0.000									
			REC	−0.329	−24.305	0.000	−0.343	−24.092	0.000	−0.339	−24.958	0.000	−0.343
			−23.873	0.000									
			POPG	−0.253	−13.881	0.000	–	–	–	–	–	–	–
			–	–									
FD	–	–	–	0.019	−9.543	0.000	–	–	–	–	–	–	
DCFS	–	–	–	–	–	–	−0.137	−16.292	0.000	–	–	–	
DCPB	–	–	–	–	–	–	–	–	–	−0.097	−9.229	0.000	
Constant	−0.412	−15.049	0.000	−0.849	−19.025	0.000	−0.804	−19.263	0.000	−0.855	−19.244	0.000	
R2	0.842			0.865			0.882			0.866			
F statistic (Prob.)	345.3013***			414.645***			484.723***			418.556			
Central Asia 5 Countries	ECON	0.047	2.431	0.016	0.069	3.770	0.000	0.065	3.551	0.001	0.070	3.789	0.000
	GDPPC	−0.002	−0.101	0.920	−0.025	−1.673	0.096	−0.021	−1.368	0.173	−0.024	−1.590	0.114
	GFCF	0.192	6.696	0.000	0.122	4.894	0.000	0.126	5.082	0.000	0.120	4.721	0.000
	MHTECH	0.415	12.314	0.000	0.386	12.104	0.000	0.382	11.701	0.000	0.387	12.107	0.000
	REC	−0.364	−14.960	0.000	−0.415	−18.773	0.000	−0.409	−18.327	0.000	−0.414	−18.692	0.000
	POPG	−0.164	−4.356	0.000	–	–	–	–	–	–	–	–	–
	FD	–	–	–	0.148	6.898	0.000	–	–	–	–	–	–
	DCFS	–	–	–	–	–	–	0.134	6.609	0.000	–	–	–
	DCPB	–	–	–	–	–	–	–	–	–	0.148	6.754	0.000
	Constant	−0.271	−1.894	0.060	−0.433	−4.598	0.000	−0.448	−4.626	0.000	−0.441	−4.706	0.000
	R2	0.782			0.867			0.868			0.867		
	F statistic (Prob.)	103.447***			187.851***			190.024***			188.323***		
Middle East and North Africa 14 Countries	ECON	0.242	76.335	0.000	0.241	82.753	0.000	0.241	75.311	0.000	0.241	91.568	0.000
	GDPPC	0.039	10.715	0.000	0.033	9.183	0.000	0.035	10.098	0.000	0.034	9.251	0.000
	GFCF	0.001	0.194	0.847	−0.011	−1.598	0.111	0.004	0.497	0.619	−0.023	−3.137	0.002
	MHTECH	0.140	27.989	0.000	0.133	28.266	0.000	0.143	28.720	0.000	0.124	28.106	0.000
	REC	−0.409	−66.715	0.000	−0.398	−67.085	0.000	−0.403	−66.712	0.000	−0.392	−66.786	0.000
	POPG	−0.018	−6.334	0.000	–	–	–	–	–	–	–	–	–
	FD	–	–	–	0.026	4.741	0.000	–	–	–	–	–	–
	DCFS	–	–	–	–	–	–	−0.003	−0.843	0.400	–	–	–
	DCPB	–	–	–	–	–	–	–	–	–	0.051	10.769	0.000
	Constant	−0.438	−13.990	0.000	−0.468	−15.314	0.000	−0.453	−14.064	0.000	−0.491	−15.868	0.000
	R2	0.965			0.967			0.963			0.973		
	F statistic (Prob.)	2262.895***			2455.091***			2177.45***			2987.938***		
South Asia8 Countries	ECON	0.184	19.220	0.000	0.161	19.233	0.000	0.169	20.903	0.000	0.159	18.961	0.000
	GDPPC	0.064	16.860	0.000	0.003	0.530	0.597	0.050	13.858	0.000	0.000	0.086	0.931
	GFCF	0.032	2.116	0.035	−0.046	−2.496	0.013	−0.010	−0.589	0.556	−0.050	−2.658	0.008
	MHTECH	0.113	6.409	0.000	0.096	5.931	0.000	0.106	6.685	0.000	0.097	5.992	0.000
	REC	−0.273	−12.613	0.000	−0.276	−12.133	0.000	−0.262	−13.620	0.000	−0.278	−12.258	0.000
	POPG	−0.031	−3.493	0.001	–	–	–	–	–	–	–	–	–
	FD	–	–	–	0.254	11.371	0.000	–	–	–	–	–	–
	DCFS	–	–	–	–	–	–	0.083	5.587	0.000	–	–	–
	DCPB	–	–	–	–	–	–	–	–	–	0.266	11.653	0.000
	Constant	−0.930	−14.003	0.000	0.254	−14.472	0.000	−0.967	−15.314	0.000	−0.943	−14.392	0.000
	R2	0.841			0.827			0.800			0.834		
	F statistic (Prob.)	247.315***			224.286***			187.061***			235.006***		
Europe 24 Countries	ECON	0.217	226.431	0.000	0.231	158.087	0.000	0.234	367.887	0.000	0.231	158.157	0.000
	GDPPC	0.005	4.422	0.000	0.022	15.686	0.000	0.037	31.895	0.000	0.021	15.588	0.000
	GFCF	0.015	5.986	0.000	−0.058	−18.951	0.000	−0.054	−16.863	0.000	−0.058	−19.002	0.000
	MHTECH	0.173	67.566	0.000	0.134	55.589	0.000	0.145	52.367	0.000	0.134	55.885	0.000

(*continued on next page*)

Table 13 Appendix A.4 (*continued*)

Panels	Model 1			Model 2			Model 3			Model 4		
Regressors	Coefficient	*t-value*	*P-value*	Coefficient	*t-value*	*P-value*	Coefficient	*t-value*	*P-value*	Coefficient	*t-value*	*P-value*
REC	−0.242	−170.222	0.000	−0.278	−131.412	0.000	−0.274	−380.413	0.000	−0.278	−130.682	0.000
POPG	0.089	52.460	0.000	–	–	–	–	–	–	–	–	–
FD	–	–	–	0.059	39.671	0.000	–	–	–	–	–	–
DCFS	–	–	–	–	–	–	−0.014	−17.314	0.000	–	–	–
DCPB	–	–	–	–	–	–	–	–	–	0.059	40.024	0.000
Constant	−0.389	−31.986	0.000	−0.341	−27.234	0.000	−0.341	−30.896	0.000	−0.341	−27.240	0.000
R2	0.994			0.985			0.998			0.985		
F statistic (Prob.)	23650.67***			9303.53***			76335.12***			9239.964***		

Author's Estimation: *, **, *** indicate that statistics are significant at the 10%, 5% and 1% level of significance, respectively.

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