

## Article

# Encirclement of Natural Resources, Green Investment, and Economic Complexity for Mitigation of Ecological Footprints in BRI Countries

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**Abstract:** Environmental deterioration has been increasing constantly for many years and has become the major reason for climatic changes. Consequently, policy makers and researchers are enquiring into the factors affecting environmental quality. The earlier literature describes little about the impact of economic complexity, natural resources, and green investment on ecological footprint for countries participating in the Belt and Road Initiative (BRI), so this research is an effort to close this gap for the 45 BRI countries covering the time period 1995–2020. We applied a number of methods to address the issue of cross-sectional dependence, then cointegration is determined through the Lagrange multiplier bootstrap method. The Driscoll–Kraay standard error method is employed to find the long-run estimates while the robustness of the estimated findings is checked through panel-corrected standard errors (PCSE) and feasible generalized least squares (FGLS). The estimated outcomes suggest a significant negative effect of green investment on ecological footprint while natural resources, economic complexity, economic growth, and globalization have significant and positive effects on ecological footprint. These conclusions provide profound insight into natural resources, green investments, and economic complexity for sustainable development of the environment in BRI participating economies and provide a meaningful reference for ecological safety for other economies in the world. This study also highlights some necessary insights for policy makers and practitioners engaged in obtaining the target of sustainable development policies.

**Keywords:** ecological footprint; natural resources; economic complexity; green investment



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## 1. Introduction

Harsh weather, food shortages, and ecological destruction are some of the challenges that climatic changes have brought to the survival and progress of humankind [1]. In December 2015, the members of the Paris Agreement agreed upon the significance of rising global carbon emissions and temperatures [2]. Balancing environmental and economic goals was declared a great challenge for both developing and developed economies. On the one hand, the recent tremendous expansion of economies globally has made it possible to build the necessary infrastructure, reduce poverty, and improve the living standards of their populations. Conversely, land degradation, biodiversity loss, exploitation of energy resources, water and air pollution are just a few examples of how natural capital is compromised globally in the name of swift economic progress [3–5]. These issues are coupled with the fragility of society, the diminution of the planet's ecological resources, and the growth in the usage of energy. According to some estimates, 25% of the world's pollution emissions are caused by energy consumption and product creation [6]. Because of this, failing to meet the Sustainable Development Goals (SDGs) will cause a massive ecological deficit and we will not be able to meet the targets of sustainable societies and pollution reduction. Therefore, the main objective is to attain the highest level of development

without compromising the quality of the environment by achieving a balance between people's demands and the planet's biological capacity for regeneration and looking for more sustainable means to prevent socio-ecological disasters. Consequently, in order to lower the overall environmental degradation and deal with environmental problems, governments are designing and implementing economic and environmental policies [7,8]. Nevertheless, a number of countries are vulnerable to decreasing their ecological footprints despite their efforts to reduce carbon pollution and energy consumption [9].

The rising greenhouse gas emissions are the main obstacle to sustainable development globally. A large proportion of the global population is facing various diseases, starvation, shortage of water, and flooding as a result of climatic changes and global warming [10–15]. In 2018, the World Health Organization (WHO) assessed that air pollution is causing almost 7 million premature deaths of humans [16]. Environmental issues including pollution, loss of forest reserves, depletion of natural resources, and poor sanitation have emerged as major problems for nations in recent years. Physical, natural and health capital, as well as safe access to land, food, and water, are all at risk due to climatic changes [16]. Poor environmental conditions put the health of people and the economy at risk. Growing global warming trends have compelled policymakers to utilize the techniques mitigating climatic changes to save the natural environment, and there is broad consensus on this point.

Because carbon dioxide makes up the biggest portion of greenhouse gases, many researchers frequently utilize it as a proxy in studies of environmental risks [17]. Many scholars, however, disagree with this measure since carbon emissions only account for a minor percentage of the entire ecosystem and do not adequately account for environmental contamination. According to Nathaniel and Khan [18], CO<sub>2</sub> emissions do not predict the stock of available resources such as petroleum, gas, forest, soil, oil etc. We need a proxy that may incorporate the sustainability of the environment comprehensively, providing a broader view of the environment to policymakers and other authorities with appropriate information. Ecological footprint is a generally accepted indicator of quality of environment that may be used to manage and evaluate natural resources [19]. Ecological footprint is a measure of how fast humans are consuming resources and generating waste, and how quickly nature is able to absorb these activities. It encapsulates “the impact of human activities measured in terms of the biologically productive land and water to produce the goods consumed and to assimilate the wastes generated” [9]. It is a way to determine the human demand for natural capital. Ecological footprints can be compared at individual, regional and global levels. The main focus of ecological footprints is renewable resources.

Natural resources are a crucial component of the world economy, especially in the BRI participating economies. These economies depend on extraction of natural resources to boost and sustain their economic growth [20,21]. Coal, minerals, oil, gas, and forests are examples of natural resources. However, there is a conflicting and complex relation between environmental deterioration and natural resources. The studies [22–25] demonstrated that the rent of natural resources contributes to the degradation of the environment, in contrast to [19,26–28], who found a negative relationship between natural resources and environment. Since natural resources are necessary for the GDP of an economy, but studies exploring the relation between natural resources and environmental quality are inconclusive, more inquiry into this relationship is important for a sustainable environment. It is argued that countries use more resources at their earlier stage of growth and development while ignoring their impact on the environment. However, as standards of living rise, then they protect their natural resources, implement strategies for a cleaner environment, and place a greater emphasis on energy-efficient products. So, natural resources are crucial for both environmental quality and development [29] and should be further investigated in the case of BRI countries.

The earlier studies on the Environment Kuznets Curve (EKC) acknowledge the favorable impact of renewable energy on ecosystems [30]. In their adaptation and mitigation measures for climate change, countries prioritize environmental conservation with renewable energy. Green investments are more successful than investments in nonrenewable

energy because they enhance the production capacity and reliance of industry on cleaner energy that decreases industrial emissions and energy consumption [18]. Energy consumption in transition and emerging countries will climb by 50% over the next 25 years, rising from 1.8 to 3.1 in the industrial sector as mentioned in the 2020 annual report by United Nations Industrial Development. Additionally, the industrial sector may reduce the intensity of energy by 26%, which would lead to a decrease in global energy consumption of 8% as well as a 12.4% decrease in carbon emissions as highlighted in the 2020 annual report by the International Energy Agency. Green manufacturing investments support economic development and assist in cutting carbon emissions, which is consistent with the industrial sector's reliance on energy usage. Although the industrial sector is a major economic engine and is highly dependent on energy consumption, earlier research has ignored the impact of green investments on carbon emissions.

Economic complexity is one of the primary variables of this research, which includes all production-related factors including knowledge, competency, and development [31]. Economic complexity index (ECI) has received considerable attention in the current economic situation from environmental and social scientists since it is also a very reliable and accurate measure of growth [32]. ECI expands the variety and range of production while speeding up future investment and production, increasing the consumption of energy and pollution. Economic complexity, on the other hand, is better equipped to sustain the environment because it focuses on research and development, machinery and equipment, uses cleaner, greener, and renewable technology, and products which are more friendly to the environment [33]. The manufacturing of complex products requires higher energy consumption. This energy demand is met through several sources, such as fossil fuels, nuclear and renewable energy. It is clear that the production structure of a country has an impact on the environment. In other words, the level of complexity of products can harm the environment through generation of pollution and consumption of natural resources. The most economically complex nations have recently seen impressive economic development due to industrialization and urbanization. Energy consumption in these countries has also multiplied as a result of shifting from agriculture to complex industrial countries. These countries are therefore seen as making a significant contribution to GHG emissions, and the future of the global environment will depend on their ecological footprint [34,35]. The ECI expresses the capability of a country to produce and export complex products and estimates the amount of productive knowledge. A higher ECI value represents the higher capabilities of a country for production and exporting higher value-added or more complex products. So, this study is an important and significant addition in the literature on ecological footprint.

Globalization is characterized by a reduction in the obstacles regarding the flow of products and services, human capital, and physical capital. According to the studies, the process of globalization can result in growth [36–38] because it connects economies through trade, FDI, increased resource efficiency, transfer of technology, and the exchange of physical and human capital. The earlier literature undertook a thorough analysis of how globalization affects environmental sustainability, but scholars were unable to agree on the exact role that these factors play for the environment. For instance, studies [25,39] examined the role of globalization for environmental performance and found that it has a positive impact. In contrast, other studies [9,40] highlighted the negative effects of globalization on the environment; this topic is still open for debate. Since globalization has an important role to enhance growth, and growth requires the consumption of energy, it is crucial to separate environmental deterioration from the track of rising consumption of energy. It is important to understand how globalization and ecological footprint are interlinked. Therefore, the current study also examines how economies participating in BRI are affected by ecological footprint, globalization, and growth.

This study for BRI countries is for a number of good reasons. The Chinese report states that 65 nations, including 24 from Europe, 15 from North Africa and the Middle East, and 26 from Asia, will actively participate in the BRI [29]. This project involves 30% of

global GDP and 4.4 billion individuals. In addition to these 65 nations, 48 more have shown a desire to participate in the BRI project. However, in 2017, the State Information Center hosted 71 cooperating nations and made an investment of USD 6 trillion, which is equivalent to 34% of global GDP [36]. However, in recent years, BRI economies have struggled to modernize their industrial activities, resulting in a substantial rise in consumption of energy gained from fossil fuels in the industrial sector, which tend to increase global warming [41]. China invested USD 760 billion from the BRI's launch in 2013 to the end of 2019, of which 39% went to the energy sector, around 26% to transportation, and 7% to metal. With respect to natural resources, the BRI countries are responsible for 74.69% of global coal production, 53.82% of natural gas, and 55.17% of the known reserves of crude oil [22]. Similarly, this project involves 62% of the global population. These nations provide 31 percent of global GDP, and 35% of global trade [42]. Additionally, 28% of carbon emissions and a 2 °C rise in global temperature are attributable to this project (excluding China). Carbon emissions will therefore increase by 66% prior to 2050 if development goes as planned [43]. Due to economic and worldwide connections, the BRI economies have great economic prominence [44]. Additionally, investment activities are required to support economic development and prosperity among BRI members [45], and cooperation between member nations will help to foster technical improvement. Such economic activities, however, may have a deteriorating impact on the environment. So, BRI economies are now understanding the environmental implications of these economic activities and prioritizing research on the topic. The efficient utilization of natural resources is required to promote growth [44]. In order to attain the path of sustainable development, green investment may improve the efficiency and distribution of natural resources; it enhances the capacity and lifespan of natural resources [46]. In addition, there is a need to pay attention to economic complexity and globalization, which also contribute to environmental sustainability. Investigating whether natural resources, green investments, and economic complexity affect environmental quality is the goal of this research. It is hypothesized that the utilization of natural resources will increase ecological footprint, while green investments counteract the issue of environmental deterioration. Moreover, economically complex societies are polluting the environment due to production activities using natural resources.

In a few ways, this work and the objectives of this study vary from earlier studies. This is the first effort to look at the impacts of natural resources, green investments, and economic complexity on ecological footprint in the 45 BRI member nations from 1995 to 2020. The findings of the study will be helpful for governments, policy makers and the general public to understand the environmental effects of these factors to devise better policies. They will also be able to predict the importance of natural resources, green investment, and economic complexity in the reduction of environmental footprint. Second, this is the first research to explore the effects of green investments, natural resources, and economic complexity on ecological footprint, all of which have been ignored in other studies in the context of BRI participating economies. Third, to address problems such as endogeneity, heteroscedasticity, autocorrelation, integration of variables with different levels, and cross-sectional dependence, this research uses different methods of estimation and robustness checks such as Driscoll–Kraay standard errors, panel-corrected standard errors (PCSE), and feasible generalized least squares (FGLS), enabling us to assess precise findings.

## 2. Methodology

### 2.1. Data and Model

This research explores the impacts of natural resources, green investment, economic complexity, economic growth, and globalization on ecological footprints of the 45 Belt and Road Initiative economies covering the time period 1995–2020. The sample of countries is purely selected on the basis of the availability of data. The ecological footprint of a country is enlarged by increased production and consumption of commodities, which increase the usage of natural resources and energy. The ecological footprint is considered an indicator which represents the quality of the environment comprehensively, and this

proxy has gained popularity in recent years for assessment of environmental pollution because it captures all indirect and direct environmental impacts of production activities and energy consumption more accurately [47]. For estimation of the intended long-run model in this study, the functional form is used as follows:

$$ECFT = f(NARE, GRIN, ECCM, ECGR, GLOB) \quad (1)$$

In the above Equation (1), ECFT, NARE, GRIN, ECCM, ECGR, GLOB represent the ecological footprint, natural resources, economic complexity, economic growth and globalization respectively. Environmental preservation is the aim of green investing. By promoting green investment, green growth may be attained through innovative methods for lessening pollution, sustainable consumption and preventing the depletion of natural resources. Additionally, they can assist the clean energy industry in the energy transition, lowering pollution levels and reaching sustainable development goals. Natural resources include petroleum, soil, forests, and gas resources, which have a contrasting impact on the environment as highlighted in earlier literature on the topic. Because of financial and technological flows that have the overall effect of expanding ecological footprints, ecological process is entangled with economic activities and globalization. Globalization can worsen the environment through loss of biodiversity as a result of increased business activities, while it can improve environmental quality through the transfer of environmentally friendly technologies and encouraging the development of renewable energy sources.

All variables are transformed to natural logarithms before the model is estimated in order to normalize the data and produce accurate estimates by providing the interpretation of the regression coefficient elasticity. As a result, Equation (1) may now be written as:

$$\ln ECFT_{it} = \alpha_0 + \alpha_1 \ln NARE_{it} + \alpha_2 \ln GRIN_{it} + \alpha_3 \ln ECCM_{it} + \alpha_4 \ln ECGR_{it} + \alpha_5 \ln GLOB_{it} + \epsilon_{it} \quad (2)$$

where intercept is denoted by  $\alpha_0$  and  $\alpha_1$  to  $\alpha_5$  show the long run coefficient of NARE, GRIN, ECCM, ECGR, and GLOB, while  $t$  subscript represents the time period (1995–2020),  $i$  subscript shows the number of economies (45 BRI economies) and  $\epsilon$  is error term. Table 1 presents the summary of variables.

**Table 1.** Information about Variables.

| Variables            | Symbols | Measurements                           | Sources                               | Source Link                                                                                                                                                                         |
|----------------------|---------|----------------------------------------|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ecological Footprint | ECFT    | Global hectares Per Person             | Global Footprint Network              | <a href="https://www.footprintnetwork.org/">https://www.footprintnetwork.org/</a><br>accessed on 14 February 2022                                                                   |
| Green Investment     | GRIN    | Public Investment in Renewable Energy  | International Renewable Energy Agency | <a href="https://www.irena.org/">https://www.irena.org/</a><br>accessed on 14 February 2022                                                                                         |
| Economic Complexity  | ECCM    | Economic Complexity Index              | Atlas of Economic Complexity          | <a href="https://atlas.cid.harvard.edu/">https://atlas.cid.harvard.edu/</a><br>accessed on 14 February 2022                                                                         |
| Natural Resources    | NARE    | Natural Resources Rent (% of GDP)      | World Development Indicators          | <a href="https://databank.worldbank.org/source/world-development-indicators">https://databank.worldbank.org/source/world-development-indicators</a><br>accessed on 14 February 2022 |
| Economic Growth      | ECGR    | Per Capita GDP                         | World Bank                            | <a href="https://databank.worldbank.org/home.aspx">https://databank.worldbank.org/home.aspx</a><br>accessed on 14 February 2022                                                     |
| Globalization        | GLOB    | KOF (Konjunkturforschungsstelle) Index | KOF Swiss Economic Institute          | <a href="https://kof.ethz.ch/en/">https://kof.ethz.ch/en/</a><br>accessed on 14 February 2022                                                                                       |

## 2.2. Econometric Strategy

This research utilized panel data analysis while considering cross sectional dependence (CSD). Since most econometric panel techniques overlook the impact of CSD and the results may be misleading in the test statistics in the analysis of the panel data, the necessity of econometric methods dealing with the issue of CSD has been increased. Variables and residual CSD may exist; therefore, it is important to monitor non-observable common elements including national policies, global shocks, political systems, and the integration of socioeconomic structures that produce inter-dependence impacts among nations. The earlier studies used many CSD methods depending on the size of cross sections and time periods. This study used the bias corrected scaled Lagrange Multiplier (CDSL<sub>MBC</sub>) by Baltagi et al. [48], Lagrange Multiplier (CDL<sub>MBP</sub>) tests by Breusch and Pagan [49] to find cross sectional dependence. If time periods are greater than cross sections, then these tests are more appropriate for the panel data. According to the null hypothesis of cross-sectional independence, the test statistics for these approaches are computed as follows:

$$\text{CDL}_{\text{MBP}} = \sum_{i=1}^{N-1} \sum_{j=i+1}^N p_{ij}^2 \quad (3)$$

$$\text{CDSL}_{\text{MBC}} = \sqrt{\frac{1}{N(N-1)}} \left[ \sum_{i=1}^{N-1} \sum_{j=i+1}^N (T p_{ij}^2 - 1) \right] - \frac{N}{2(T-1)} \quad (4)$$

where  $p_{ij}^2$  shows the cross-sectional correlation of residuals for  $i$  and  $j$  countries gained from the OLS regression of the panel. In addition, the Friedman [50], Frees [51], and Pesaran [52] tests for cross-sectional dependence are also applied to determine the existence of cross-sectional dependence of residuals in the models. Then, the cross-sectional augmented Dickey–Fuller (CADF) test is employed, and cross-sectional augmented Im, Pesaran, and Shin (CIPS) stationarity tests developed by Pesaran [53] are used to find the level of integration. The CADF produces more reliable results compared with traditional unit root test because it integrates the lagged values of the average of cross sections and the values of first difference in ADF regressions. The test statistics of CIPS and CADF regression under the null assumption of non-stationarity are computed as:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \delta_i \bar{y}_{it-1} + \lambda_i \Delta \bar{y}_{it} + \epsilon_{it} \quad (5)$$

$$\text{CIPS} = \frac{1}{N} \sum_{i=1}^N t_i(N, T) \quad (6)$$

where  $\bar{y}_{it-1}$  is the mean approximate of cross sections of lagged value, while  $\Delta \bar{y}_{it}$  represents the mean approximate of cross sections at first difference. The test statistics of OLS regression is denoted by  $t_i(N, T) = \text{CADF}$  for  $i$ th cross-section. First of all, the unit root tests are applied then cointegration is determined through the Lagrange Multiplier bootstrap panel cointegration test by Westerlund and Edgerton [54]. LM boot strap panel co-integration tackles the problems of heterogeneity and dependence of cross sections. It also allows heteroscedasticity and autocorrelation in the equation, providing efficient estimates even if the sample is smaller. The test statistics of null hypothesis of cointegration under LM boot strap panel cointegration test can be estimated as:

$$\text{LM}_N^+ = \frac{1}{NT^2} \sum_{i=1}^N \sum_{t=1}^T \omega_{ij}^{-2} S_{it}^2 \quad (7)$$

where  $S_{it}^2$  is the partial sum process while  $\omega_{ij}^{-2}$  denotes the estimated long run variance of the error term. The long run coefficients are estimated by the Driscoll–Kraay [55] robust standard error estimators. The Driscoll Kraay estimators adjust the standard error of the pooled OLS model to account for temporal or cross-sectional dependence by estimating the Newey–West correction to the series of the cross-sectional average of the moment condition. The linear relation among the panel data is estimated by dynamic non-parametric technique if the panel data have no constraints on the number of cross-sections, and it provides more

efficient results with an increase in the time period. The Driscoll–Kraay technique has equal applicability for unbalanced and balanced panel data series and has the ability to process the missed values efficiently. The linear model of Driscoll–Kraay standard error for pooled OLS is:

$$Z_{it} = Z_{lit}\beta + \epsilon_{it} \quad i=1, \dots, N, t=1, \dots, T \quad (8)$$

where  $Z_{it}$  shows the ECFT and  $Z_{lit}$  shows the set of independent variables (NARE, GRIN, ECCM, ECGR, GLOB). The robustness of the results is tested by panel corrected standard error (PCSE) by Beck and Katz [56] and feasible generalized least squares (FGLS) by Parks [57]. The panel corrected standard error offers estimates of OLS with panel corrected standard error, while FGLS produces the OLS heteroskedasticity structure. Both PCSE and FGLS control the cross-sectional dependence, serial correlation, and heteroskedasticity, so we may be able to obtain the robust long run estimators.

Lastly, we employed the Dumitrescu and Hurlin [58] panel causality technique to find the causal relation among regressors, providing extended information to policy makers for the designing of an appropriate policy. When cross-sections are less than the time period while the panel data are heterogeneous and balanced, then the Dumitrescu and Hurlin panel causality technique is more suitable. The linear model of the Dumitrescu and Hurlin panel causality test is expressed as:

$$y_{i,t} = \alpha_i + \sum_{k=1}^k \lambda_i^{(k)} y_{i,t-k} + \sum_{k=1}^k \beta_i^{(k)} x_{i,t-k} + \epsilon_{it} \quad (9)$$

where  $\beta_i^{(k)}$  and  $\lambda_i^{(k)}$  are the estimated coefficients of lagged dependent and independent variables and  $k$  denotes the anticipated lag length, which remains unaffected for units of panel.

### 3. Empirical Findings

The econometric techniques utilized in this study are in line with the behavior of the data used in this study. An incorrect technique results in biased and unreliable estimators. This study used the CSD test to avoid such biased findings. If CSD is not considered, then outcomes might be misleading. It is widely acknowledged that the world has become a small, interconnected community of nations. CSD has become widespread as a result of trade agreements, financial crises, international treaties, and other factors.

The outcomes of the CDLM<sub>BP</sub> test, CDSLM<sub>BC</sub> test, Frees, Pesaran, and Friedman techniques of cross-sectional dependence are reported in Table 2. The findings of the tests reveal the presence of cross-sectional dependence for regressors and residuals of the model by the significant results of all tests. The occurrence of regional and spillover effects throughout the panel of chosen economies is supported by these findings.

**Table 2.** Cross-Sectional Dependence Tests.

|               | CDLM <sub>BP</sub> | CDSLM <sub>BC</sub> |
|---------------|--------------------|---------------------|
| LnECFT        | 412.622 *          | 42.268 *            |
| LnNARE        | 518.338 *          | 53.491 *            |
| LnGRIN        | 584.391 *          | 59.372 *            |
| LnECCM        | 834.924 *          | 83.282 *            |
| LnECGR        | 1257.618 *         | 126.382 *           |
| LnGLOB        | 964.88 *           | 96.375 *            |
| Pesaran Test  |                    | 3.645 **            |
| Frees Test    |                    | 3.039 *             |
| Friedman Test |                    | 54.628 *            |

Note: \* and \*\* show the significance at 1% and 5% respectively.

The integration features of the data are also important in addition to the CSD test. Selection of the unit root test depends on whether CSD is present. In the vicinity of CSD, second-generation testing is preferred. As a result, Pesaran's [53] CADF and CIPS tests are applied. Both tests deal with the issues of cross-sectional dependence and heterogeneity. Moreover, the CADF test also deals with problems of structural breaks and heterogeneity. The CADF and CIPS each have particular characteristics. They outperform all first-generation tests and can handle serial correlation.

The results of the CIPS and CADF tests are reported in Table 3. These findings of the tests demonstrate that all variables are integrated at first difference, so the estimated results allow for cointegration analysis.

**Table 3.** Unit Root Tests.

| Variable | CIPS  |            | CADF  |            |
|----------|-------|------------|-------|------------|
|          | Level | Difference | Level | Difference |
| LnECFT   | −3.51 | −6.82 *    | −3.65 | −4.72 *    |
| LnNARE   | −3.81 | −5.38 *    | −3.83 | −4.22 *    |
| LnGRIN   | −2.99 | −4.37 *    | −3.24 | −4.28 *    |
| LnECCM   | −3.69 | −5.69 *    | −3.28 | −4.88 *    |
| LnECGR   | −2.89 | −3.92 *    | −2.99 | −4.29 *    |
| LnGLOB   | −1.37 | −2.64      | −2.14 | −4.53 *    |

Note: \* indicates the significance at 1%.

Table 4 represents the empirical findings of the LM bootstrap panel cointegration test and highlight the higher  $p$  values compared with the significance level. It shows the presence of cointegration among variables. So, the dependent and independent variables have a long-run relationship.

**Table 4.** LM Bootstrap Panel Cointegration Test.

| Constant      |                      | Constant & Trend |                      |
|---------------|----------------------|------------------|----------------------|
| LM-Statistics | Bootstrap $p$ -Value | LM-Statistics    | Bootstrap $p$ -Value |
| 3.927         | 1.000                | 5.927            | 1.000                |

The long-run relationship is determined through the Driscoll–Kraay standard errors method following the fundamental panel data analysis. Table 5 depicts the findings of the Driscoll–Kraay estimates for ecological footprint, which shows the significant values of variables in the long run.

**Table 5.** Regression with Driscoll–Kraay Standard Errors.

| Variable | Coefficient | Std. Error | $p$ -Value |
|----------|-------------|------------|------------|
| LnNARE   | 0.537       | 0.172      | 0.000      |
| LnGRIN   | −0.491      | 0.021      | 0.000      |
| LnECCM   | 0.272       | 0.164      | 0.005      |
| LnECGR   | 0.338       | 0.211      | 0.000      |
| LnGLOB   | 0.517       | 0.187      | 0.001      |

In addition, FGLS and PCSE estimation are reported in Table 6. These tests are used to examine the robustness of the Driscoll–Kraay results. The conclusion drawn by the Driscoll–Kraay regression is supported by the long-run estimated coefficients through PCSE and FGLS. The empirical results support the consistency and robustness of the Driscoll–Kraay

estimates by showing the consistent directional connections of all exogenous regressors with the endogenous variable.

**Table 6.** FGLS and PCSE Estimation.

| Variable                                            | Coefficient | Std. Error | <i>p</i> -Value |
|-----------------------------------------------------|-------------|------------|-----------------|
| Cross-sectional Time Series FGLS Regression         |             |            |                 |
| LnNARE                                              | 0.214       | 0.124      | 0.005           |
| LnGRIN                                              | −0.135      | 0.027      | 0.061           |
| LnECCM                                              | 0.092       | 0.138      | 0.000           |
| LnECGR                                              | 0.341       | 0.267      | 0.001           |
| LnGLOB                                              | 0.387       | 0.139      | 0.005           |
| Correlated Panels Corrected Standard Errors (PCSEs) |             |            |                 |
| LnNARE                                              | 0.386       | 0.281      | 0.003           |
| LnGRIN                                              | 0.261       | 0.143      | 0.000           |
| LnECCM                                              | 0.197       | 0.249      | 0.005           |
| LnECGR                                              | 0.299       | 0.197      | 0.006           |
| LnGLOB                                              | 0.286       | 0.099      | 0.001           |

The empirical findings of the additional robustness tests, such as the augmented mean group (AMG) estimation and common correlated effect mean group (CCEMG), are also consistent as reported in Table 7.

**Table 7.** Results of CCEMG and AMG Estimation.

| Variable | Coefficient | Std. Error | <i>p</i> -Value |
|----------|-------------|------------|-----------------|
| CCEMG    |             |            |                 |
| LnNARE   | 0.038       | 0.028      | 0.015           |
| LnGRIN   | −0.168      | 0.052      | 0.032           |
| LnECCM   | −0.481      | 0.270      | 0.000           |
| LnECGR   | 0.557       | 0.335      | 0.005           |
| LnGLOB   | 0.379       | 0.195      | 0.009           |
| AMG      |             |            |                 |
| LnNARE   | 0.025       | 0.019      | 0.042           |
| LnGRIN   | −0.127      | 0.095      | 0.033           |
| LnECCM   | −0.368      | 0.273      | 0.001           |
| LnECGR   | 0.042       | 0.022      | 0.008           |
| LnGLOB   | 0.195       | 0.099      | 0.024           |

The findings of pairwise Dumitrescu–Hurlin panel causality analysis are shown in Table 8 to highlight the causal relationship among variables. The findings elucidate the existence of bidirectional feedback causality among the variables under consideration. A casual connection between independent variables demonstrates two-way causality for the majority of the variables.

**Table 8.** Pairwise Dumitrescu–Hurlin (DH) Panel Causality.

|        | LnECFT   | LnNARE   | LnGRIN    | LnECCM    | LnECGR   | LnGLOB    |
|--------|----------|----------|-----------|-----------|----------|-----------|
| LnECFT |          | 4.152 ** | −3.614 *  | −4.627 ** | 5.007 ** | 2.911 *** |
| LnNARE | 3.971 ** |          | 4.182 **  | 5.814 **  | 4.819 *  | 3.671 **  |
| LnGRIN | 4.287 *  | 3.618 ** |           | 6.811 *** | 4.682 ** | 4.371 **  |
| LnECCM | 3.947 *  | 4.681 *  | 4.823 **  |           | 6.182 *  | 4.812 **  |
| LnECGR | 5.173 ** | 5.972 ** | 5.817 *** | 4.952 *   |          | 6.728 *   |
| LnGLOB | 3.782 *  | 5.998    | 3.718 *   | 6.971     | 5.716 ** |           |

Note: \*, \*\* and \*\*\* show the significance at 1%, 5% and 10% respectively.

#### 4. Discussion of Empirical Findings

The results presented in Table 5 indicate that natural resources have a positive and significant relation with ecological footprint, showing that a 1% incremental change in NARE will raise ECFT by about 0.21 percent in the economies of the BRI. These findings are in line with [18,22–25]. These studies are of the view that the utilization of natural resources has a detrimental impact on the environment. The NARE and the income level of a country are directly interrelated. In the earlier stages of development, the economy uses more natural resources for development purposes, which boosts economic growth while disregarding its consequences for the environment [33]. However, as society advances and standards of living rise, the economy considers cleaner environmental policies, preserving natural resources and placing a greater emphasis on energy-efficient products. The NARE and ECFT are positively and significantly associated in selected BRI economies. “Based on the rents for oil, natural gas, coal (hard and soft), mineral rentals, and forest rents, the average proportion of natural resources in BRI economies has been increased by 1.968% from 1990 to 2018” (World Bank, 2020). As a result, BRI countries are creating a burden on reserves of natural resources to meet energy demand, so the environment is under more risk [42]. These facts lead us to the conclusion that a key component of lowering the ecological footprint should be investment in clean energy (eco-friendly technologies).

According to the findings of this research, a one percent increase in green investment will result in a 0.13% reduction in environmental footprint. Growth in green investment will enhance the quality of environment in the partner BRI countries because it has a significant long-term impact reducing ecological footprint. The fact that green investment plays a supportive role in these nations demonstrates that environmental innovations through green investment encourage cleaner production, effectively addressing environmental challenges and fostering green growth [18]. Additionally, “it is anticipated that rising environmental deterioration due to high economic growth would further push these economies to adopt technical innovation and pursue alternative renewable energy sources. The region will be able to achieve its goal of environmental sustainability by increasing green investment, which is the most viable direction for green economies” [22]. Studies [59,60] have backed our findings.

Economic complexity in BRI countries contributes to a 0.092% rise in ecological footprint. The findings of this study on economic complexity are consistent with those of Khan et al. [61] for the G-7 economies, [4] for the USA, and Neagu and Teodoru [33] for EU economies. They argue that economic complexity has a positive impact on greenhouse gas emissions, signifying a rising risk to emissions that the complexity of export products adds to an expanding ecological footprint. Therefore, these countries strive hard to generate heavy and premium goods while misusing environmental resources in order to build complex product exports. Consequently, environmental quality is being negatively impacted by the current technology and high demand for nonrenewable energy in the BRI countries.

This study highlights the long-term relation between ecological footprint and globalization (GLOB). It showed that GLOB harms the ecosystem, increasing the ecological footprints of the sampled nations. Globalization unites the world’s markets, raises con-

sumer demand, and promotes industrialization, all of which lead to excessive exploitation of resources, severe biodiversity loss, and ecological deficits. Similarly, globalization causes contamination of the land, water, and air due to increasing transportation, production, and energy usage. Environmental and economic reforms are also hampered by the negative effects of globalization brought on by open trade and FDI in the industrial sector. Because of this, it is alleged that globalization will encourage polluting companies and raise ecological demands in nations with strict land and environmental rules [13]. According to some earlier studies such as that of Pata and Yilanci [62], “globalization can increase economic activity with local changes while having a minimal ecological impact, given that the industrial sector is dedicated to environmental reforms. In order to create long-term environmental policies and achieve sustainable growth, it is crucial to take globalization into account while calculating the ecological footprint function.” Our evidence is consistent with the findings of [5,63].

Economic growth has a positive correlation with ecological footprint, as the empirical findings of this study report. These results suggest that the chosen countries of the panel are primarily concerned with boosting their productivity at the price of environmental quality through massive brown production and polluting sectors. When economic activities increase, then there is also an increase in demand for natural resources, which explains this pattern. As a result, the rapid growth of countries deteriorates ecological reserves by conversion of agricultural land to industrial usage, destroying and depleting wildlife habitats, encouraging deforestation, and overusing natural resources. These findings are in line with the findings of [5,9,64]. These conclusions show that policies aimed at these variables may interact with one another. The conclusions and recommendations of the long-run estimation of the Driscoll–Kraay standard errors, FGLS, and PCSC are supported by these causality findings.

## 5. Conclusions

The notion of a clean and healthy environment is still maturing and has great importance for present agendas and policies. A sustainable environment has been a desired goal on a global scale for the last few decades. Different economic activities might lead to environmental degradation. The environment is impacted by a variety of socioeconomic factors. Many earlier studies highlighted the significance of efficient allocation of resources for a sustainable environment. The Driscoll–Kraay standard error, FGLS, and PCSE regression technique are used to examine the effects of natural resources, green investments, and economic complexity on ecological footprint from 1990 to 2018 in a group of 45 BRI countries. The empirical results of the study confirm the established hypothesis. The findings suggest that green investments help the environment by decreasing the ECFT, whereas the use of natural resources, economic complexity, economic growth, and globalization all cause ecological footprints to increase. Green investments are acknowledged as a means of minimizing the environmental impact of economic activities. Moreover, there is a bi-directional causal relationship among economic complexity, green investment, and ecological footprints.

The following policy implications are recommended to governments, policymakers, and stake holders devising strategies for a sustainable and healthier environment. First, as developed economies are at the forefront of technical innovation, the governments of BRI nations may continue to deepen their ties with them while also expanding their reliance on green technology. According to this study, implementing policies that encourage green investment in these countries may make it easier to reduce their ecological footprint. In order to help the clean energy industry and further energy transition, policymakers should encourage investment in green technology. Governments are recommended to establish an international technological collaboration and provide incentives to private investors for green inventions in order to reduce national and international environmental issues.

Secondly, the results demonstrate that natural resources have a positive relationship with ecological footprints in the BRI countries. This conclusion shows that extensive

utilization of reserves of natural resources is endangering the environment. The availability of natural resources continues to be a crucial feature of global economies, particularly in emerging nations where a sizable portion of their GDP is derived from their extraction. Natural resources and economic expansion are degrading the environment, negatively affecting the atmosphere, reducing the ability of the land to produce food, and diminishing water quality. The ecological footprint is a useful tool for thinking about resource depletion because it is considered a key indicator of environmental deterioration in biologically productive regions. In order to encourage investments to use modern sources for promoting and employing ecofriendly technology, the government should create a favorable political environment and should behave in a helpful manner.

Thirdly, economic complexity is another factor contributing to the environment's decline. Because the industrial sector is responsible for higher levels of energy consumption and high rates of production of complex products, the levels of economic complexity and environmental deterioration are rising. Our findings suggest that economic complexity, which has a close relationship with the environment, should be addressed in developing strategies for growth and energy laws. According to this viewpoint, the study makes a suggestion for adopting clean energy regulations and increasing the use of renewable energy sources. However, a suitable energy mix would lessen the negative effects of economic complexity on the environment. By maximizing productivity and reducing pollution emissions through the use of renewable energy, SDG-7 (Affordable and clean energy) can be attained. Additionally, high-end technologies such as, ICTs, AI, and block chain, can be used for this purpose. The industrial sector in these economies may be regulated by policies to assure sustainable production, distribution, and consumption. Consequently, it will be useful for achieving the objectives of SDG's 2030, "Take urgent action to combat climate change and its impacts globally".

Fourth, environmental sustainability in these economies is found to be causally related to the globalization process. This is why the BRI economies should think about trading clean energy from industrialized nations, such as solar, wind, and hydropower, in order to further alleviate the substantial environmental effects of globalization. Governments should also support foreign direct investments in green technology. In addition, industries that spread pollutants above the legal limit should be subject to heavy taxes. These nations should adopt tight environmental regulations related to the export of energy-intensive products and technologies. These nations might apply dumping tariffs on international business partners and firms that use antiquated technology, particularly those engaged in the resource extraction industry.

This work offers some innovative discoveries, but it also has some limitations that may open up new areas for further study. Economic complexity's effects on the environment are a controversial issue that is influenced by various social, cultural, and institutional aspects. In order to provide more precise information, future research for other emerging countries should use both panel data and country-specific investigation. This study assessed the impact of economic complexity on ecological footprint for a panel of 45 BRI economies. Finally, expanding this research to include additional contributing aspects such as institutional quality and political risk for various case studies may produce fascinating literature.

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