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Promoting Sustainable Growth: The Role of Natural Resource Utilization, Green Investment, Digital Finance, Industrial Usage, Energy Efficiency, and Renewable Energy Consumption

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ABSTRACT

The current study investigates how sustainable development can be enhanced by the use of natural resources, green investment, digital finance, industrial usage, energy efficiency, and consumption of renewable energy. To the best of the authors' knowledge, no prior study has analyzed the role of these factors in sustainable economic growth in Belt and Road Initiative countries. Therefore, to fill this literature gap, the present study analyzes the effect of the above mentioned factors on sustainable economic growth in 20 Belt and Road Initiative countries. Taking the data for the period 2010 to 2020, the study employed the Driscoll-Kraay Standard Error model to carry out the empirical estimation. The findings suggest that digital finance and renewable energy consumption are positively, whereas energy intensity, industrial usage and natural resources are negatively associated with sustainable economic growth in BRI countries. Green investment, however, is not found to be significantly associated with sustainable economic growth. On the basis of the findings, the study suggest the selected countries to gain benefits from the opportunities of digital financial inclusion and renewable energy use. Moreover, the results establish the foundation for policymakers to better craft policies to achieve the goals of the Sustainable Development Goals (SDGs).

Keywords: Sustainable Economic Growth, Belt and Road Initiative Countries, Driscoll-Kraay Standard Error Approach
JEL Classifications: O13, P28, P48, Q20, Q42, P18, P45, Z23

1. INTRODUCTION

In current era of rapid global warming and climate change, the sustainable economic growth gained immense importance as the countries worldwide are attempting to strike a balance between environmental sustainability and economic development (Hanif et al., 2022). Finding a balance between environmental sustainability, social well-being, and economic growth is emphasized by the concept of sustainable economic growth. Achieving sustainable economic development has become a key goal for many countries due to the increasing rate of economic expansion and the growing environmental challenges (Huang and He, 2023). Among several factors, energy consumption an important determinant for attaining sustainable economic growth (Sebri, 2015), but the current economic growth is threatened by the increased use of energy mainly driven by the increase in industrialization[1] and population which has necessitated the increased consumption of the conventional energy resources including coal, natural gas and oil, which are responsible for discharging the pollution causing gases which harm

1 The onset of the industrial revolution in the 18th century, which began in Great Britain and expanded to other nations in Europe, Asia and America, completely changed the direction of economic activity worldwide (Nwanakwere, 2016).

the atmospheric quality (Armeanu et al., 2017). Industrialization or industrial use has been considered to be a sure way to get economic development and growth of the countries all over the globe. Particularly many emerging countries have embraced the industrial policy for achieving their objectives of economic development and growth. But industrialization has always come at an expense to the environment and society because it involves massive fossil fuel based energy consumption (Li and Lin, 2015). Wastes, pollutants, and discharges from industrial operations are thought to be the main source of the environmental problems, which have an adverse effect on the environment and endanger human existence (Huang and He, 2023).

Moreover, the over dependence on fossil fuels to fulfill the increased energy demand is responsible for speeding up the environmental degradation. According to the U.S. Energy Information Administration (EIA) approximately a 48% increase in global energy consumption is expected by 2040 which makes the need of low carbon obvious. Therefore, the feasible alternate of fossil fuels are the renewable resources that not only fulfill the energy demands of the economies with regular renewal, but are also less pollution causing and decrease the dependence of the countries on imported sources with enhanced employment and no safety or security concerns (Armeanu et al., 2017). As a result, renewable energy has become more crucial globally to promoting economic growth and mitigating adverse environmental effects (Vo and Vo, 2021). Similarly, the energy intensity which is usually measured by the required energy for producing one unit of growth or GDP is also an important element of the sustainable economic growth. While high energy intensity can worsen the environment and contribute to climate change, low energy intensity may promote economic growth and environmental sustainability. Thus, it is essential to look into the relationship between energy intensity and sustainable economic growth (Huang and He, 2023). This situation has therefore attracted the attention of the international organizations as well as the developed and developing countries of the world regarding the negative effects of the increasing industrial usage on the environment and sustainable economic growth which necessitated the promotion of green transformation in industrial structures (Nwanakwere, 2016).

In this regard, green investment is the main mechanism to finance green structure and projects as well as the green financial system because financial constraints are always considered to be the main obstacle for stimulating the green economy transformations. Eyraud et al. (2013) from macroeconomic perspective defined green investment as that type of investment which is necessary to reduce GHG and CO_2 emissions, and therefore green investment is also known as environment security or ecological investment. However, according to the microeconomic perspective, green investment refers to green management or corporate environmentalism and it increases the company's financial expenditures on environmental governance which is considered as a special practice in the corporate social responsibility (Li et al., 2021). Green investment, in its narrowest definition, refers to financial investments that are necessary to protect the environment. However, broadly speaking, green investment takes into account a number of societal, economic, and environmental factors (Chen et al., 2023). Therefore to achieve green economy and sustainable economic growth, one of the basic financial policies is the green investment which affect the development of industrial structure positively (Wang and Wang, 2021). Additionally, by promoting green technology innovations, green investment has the potential to control environmental pollution (Zhang et al., 2022). Financial institutions understand the importance of modernizing and optimizing industrial structure with green investment in this context (Sun, 2022). Thus, the countries are required to guide the allocation and circulation of the capital and proficiency of allocation of the resources in industrial sector by promoting the green investment which aid in adjustment and upgrading of industrial structures (Ji and Zhang, 2019).

Another important revolution in financial sector is the digitalization. In this regard, digital finance which is the type of digital technology innovation, is capable of overcoming the inefficient operations and low service quality of the traditional finance sector as well as fulfill the needs of economic growth (Yu et al., 2022). Therefore, the various fields of the economy is integrating digital finance and its role in stimulating innovation and driving consumption (Li et al., 2020) is becoming new economic growth engine. However, some scholars argue that digital finance has environmental impacts too. On the one hand, it expands the scale of business but on the other hand it is associated with huge consumption of energy (Nguyen et al., 2020). In contrast, by altering patterns of production as well as consumption and encouraging industry production efficiency, digital finance can effectively reduce CO_2 emissions (Zhang et al., 2022). Therefore, a deep understanding about the role of digital finance in sustainable economic growth can influence the promotion of the sustainable economic growth (Liu et al., 2023). In this regard, the aim of the present study is to explore the effect of digital finance, industrialization, energy intensity and renewable energy use and green investment on sustainable economic growth. In addition to exploring these factors, the study also analyzes the role of the natural resources in sustainable economic growth. Natural resources hold their importance in socio-political and economic framework and their sustainable consumption is related to the prosperity of an economy. On the one hand, according to Resource Bless Hypothesis, natural resources are considered to be the main driver of economic growth (Zheng et al.), but on the other hand, the expansion of urbanization and industrialization processes and economy results in increase in the demand for natural resources and the over exploitation of natural resources has degrading effects on the environment (Ulucak and Khan, 2020). In the initial stages of economic development, countries destroy natural resources more quickly and ignore environmentally beneficial features. The use of coal and oil increases during the process of growth which is the main factor in environmental deterioration and biodiversity loss (Arslan et al., 2022).

Therefore, the present study aims at the estimation of the role of the natural resources, digital finance, green investment, industrial usage, energy intensity and renewable energy use in sustainable economic growth in 20 BRI countries over 2010 to 2020 period. It is necessary to study the role of these factors in the context of BRI countries because being a major infrastructure project, the BRI has significant impact on the global environment both indirectly and directly. The president of China initiated Belt and Road Initiative, (previously known as One Belt One Road), in 2013 (Chen et al., 2017). It is one of the mega infrastructure projects aimed at connecting the Twenty first Century Maritime Silk Road with Silk Road Economic Belt. In other words, it connects Africa, South and Southeast Asia, the Middle East, and Europe with China (Thürer et al., 2020). This major project contributes to more than 30% of the GDP and 60% of the global population (Islam, 2021). 32 international institutions and 141 nations have committed to working together on the initiatives associated with the BRI as of October 2021. The expected annual investment for the BRI is between $2.9 trillion and $6.3 trillion (Business and Outlook, 2018). Although the project has provided lucrative opportunities to African and Asian countries which caused economic growth to increase rapidly in countries, the heavy dependence on non-renewable energy resources worsens the environmental quality as evident in Figure 1 (Montalbano and Nenci, 2019). Moreover, the increase in economic growth and the living standards also cause higher energy consumption indirectly which causes environmental quality to worsen which questions the achievement of the sustainable economic growth in these countries (Chin et al., 2024).

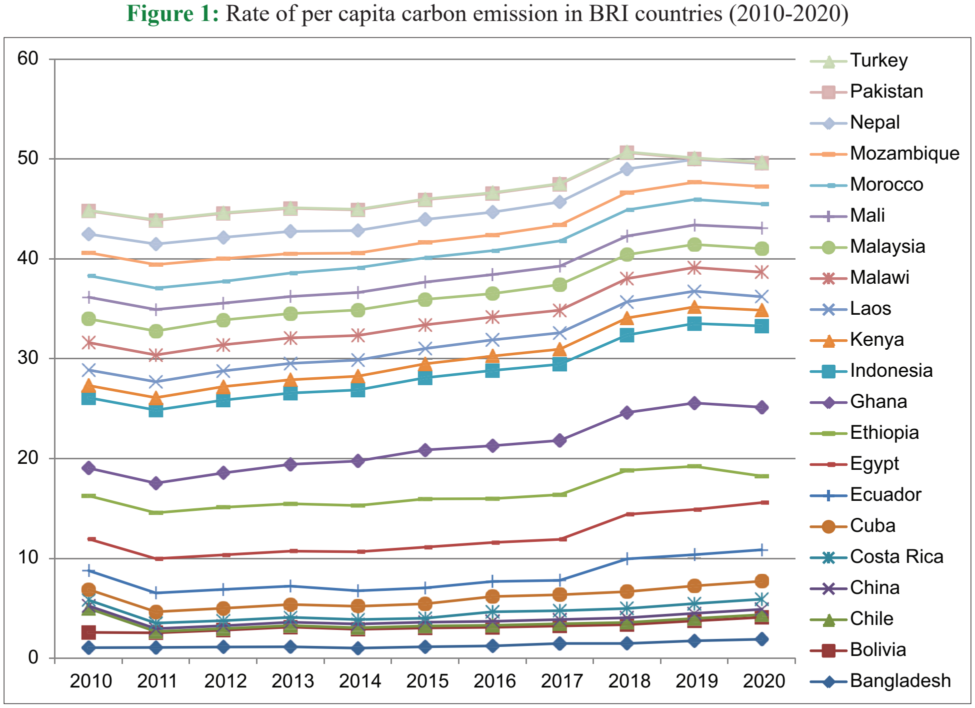
On the basis of the above debate, the present study has significant contribution to the existing literature in the following ways: First, the present study is the first one for the selected BRI countries to analyze the role of digital finance, industrialization, natural resources, green investment, energy intensity and renewable energy on sustainable economic growth. Second, the study implies the advanced panel data estimation technique capable of dealing with cross sectional dependence, autocorrelation and heteroskedasticity which provides robust and reliable estimates in the presence of these issues. The rest of the paper is structured as, the literature review is outlined in Section 2, and the study's methodology is explained in Section 3. The results and comments are presented in Section 4, and the study is concluded in Section 5.

2. REVIEW OF LITERATURE

2.1. Theoretical Foundation

Natural resources play critical role in economic growth and its development. The apparent benefits expected from natural resources are effective capital generation, trade benefits, current appreciation, better infrastructure etc. (Mashokhida et al., 2018). Meanwhile, theoretical foundation based on Dutch disease claims that natural resource abundance causes detrimental effect on economic growth (Corden, 1984). The theory explains that with increased natural resource development, other economic sectors experience decline that may lead to less economic growth specifically in resource-rich countries. The unfavourable impact of Dutch disease generally explains the negative impact of current appreciation that emerges from trade benefits rooted with the growth of resource-based sectors that eventually come up with grievous effect on other sectors' competitiveness (Kutan and Wyzan, 2005). Nevertheless, empirical evidences suggest inconclusive findings when it comes to resource-growth nexus. For example, study of Adams et al. (2019) assessed Dutch disease in the context of oil rich dependent economies and found out that globalization is one of the reasons due to which multinational firms think of factors such as capitalism and fragile governance. Another study concluded that ineffective organization of sectors regulated by government is the reason of Dutch diseases (Venables, 2016). Hasanov (2013) also claimed that there is a need to have balance growth among sectors. On contrary, study of Magud and Sosa (2013) dismissed the evidences that Dutch disease worsens economic growth. The whole argument indicates that Dutch diseases indeed has a greater significance in literature, therefore, it is used as a theoretical lens for present study.

Figure 1: Rate of per capita carbon emission in BRI countries (2010-2020)



Moreover, literature is abundant with the studies that reveal how financial development and innovation lead to effective growth in economy. Following the literature trail, work of Schumpeter (1912) is worth mentioning as it is used as a foundation in many studies such as Bencivenga and Smith (1991), Greenwood and Jovanovic (1990) and Rajan and Zingales (1998). By discussing the key feature contribution of past literature, it is revealed that sectors with more growth opportunities tend to grow faster in those economies where financial development is higher. Besides, it is also revealed that financial innovation increases economic development when opportunities are being utilized effectively (Laeven et al., 2015; Love, 2009). However, it should be cleared that not all kind of financial development and innovation are beneficial for economic growth. For example, excessive growth of credit and new financial products in markets may bring financial instability specifically when banking institutions ignore tail risks (Appiah-Kubi et al., 2023; Beck et al., 2016). Another pile of literature also claim that more finance means less growth (Zhu et al., 2020). Thus, the question arises is financial development really an engine of economic growth as predicted by Schumpeter? Although financial escalation and innovation has a potential to offer fund to inject growth opportunities in real economy, however, it can not be neglected that such development might also bring financial instability which may cause adverse effect on economic growth.

2.2. Hypothesis Development

Different studies have been conducted in order to show the relationship between resources and sustainable economic growth. As (Umar et al., 2020) in his study explained the term "curse of resources" in context to China. This concept says that natural resources are not evenly distributed along the country rather some areas are richer in resources than other but areas which are scarce in resources are more developed than the areas which are rich in resources. (Li et al., 2019) undergone a research in which panel data methods was used and data as result proved the concept of curse of resources in China at provincial level. Khan et al. (2020) in his study discussed the concept of "Dutch Disease" which says that the countries which are rich in natural resources are likely to export those resources in order to gain revenue and these countries do not plan to use these resources for industrial development in any way and hence they get lock in stagnant economic growth. Countries that are rich in natural resources can raise their funds by selling the in foreign market and this leads to higher liquidity in economic market hence boosting the banking sector of the country. Cash in hand can provide stability to the economy and later they can use that for any kind of trade (Ahmad et al., 2020). Likewise, the study of Haseeb et al. (2021) in case of Asian countries studied the impact of natural resources on economic growth for the period 1970-2018. The findings of Quantile on Quantile regression revealed that natural resources promoted the growth in the selected countries except India. A similar attempt was made by Zhang et al. (2021) to explore the nexus between natural resources and economic growth in Pakistan over 1985 to 2018 period using DARDL approach. The authors claimed that resource curse hypothesis was present in Pakistan.

Protecting environment in accordance with economic growth is essential for the sustainable growth. Green investment refers to the investment in those sectors that work for industrial pollution control to control environmental pollution. This strategy has also been discussed in SDG (Sustainable Development Goals) of United Nations (Sachs et al., 2019). Green investment can be done in many ways for instance renewable energy resources in the country, investing in clear energy and in those infrastructures that facilitate clean energy projects, investing in the projects which manage the disposal of waste products and chemicals (Sachs et al., 2019). Several studies have explored the role of green investment in sustainable growth such as Van Hoa et al. (2022) studied the nexus between green investment and sustainable economic development in Vietnam over 1986 to 2020 period and according to the findings of ARDL estimation approach, green investment had positive impact on sustainable economic development. Similarly, Lyeonov et al. (2019) estimated the role of green investment in sustainable development in European Union countries over 2008-2016 period. FMOLS and DOLS estimation techniques were applied in the study which revealed that green investment enhances sustainable development in selected countries. In case of China, Xiong and Dai (2023) studied the impact of green finance investment on sustainable development over 1990-2020 period. According to the findings, the green investment has positive impact on sustainable development. Fang (2023) analyzed the effect of green investment on CO_2 emission in 30 provinces of China over 2005-2019 period using GMM estimation approach. The findings indicated that green investment reduced CO_2 emission in China.

Growth in economy goes hand in hand with financial support. Digital finance helps in boosting economy in a way that all the data is moved to the internet and the country uses Internet for their financial services like payments, mobile banking, credit lines, e-commerce etc. (Jiang et al., 2021). Arjunwadkar (2018) discussed that digital finance has helped in cutting financial cost due to use of innovative technologies like cloud computing and helped in accessibility of financial services. Similarly banks are also getting benefits through this technology in a way that they are cutting cost of paperwork, managing long queues digitally and helping users in mobile banking for day to day usage. Jiang et al. (2021) research study showed that digital finance has directly contributed towards the growth of the economy in China from the perspective of entrepreneurship. Likewise the study of Xue et al. (2022) for China revealed that digital finance reduced regional CO_2 emission. In another study for China, Liu et al. (2023) found that digital finance promoted sustainable economic growth using different econometric methods.

Likewise the relationship between industrialization and sustainable economic growth occupied the attention of the researchers considerably in recent years. For instance, Mbaegbu (2016) analyzed the relationship between industrialization and sustainable development in Nigeria and found that industrialization promoted economic growth and economic diversification. Likewise, taking the data of African countries over 1980-2014 period, Opoku and Yan (2019) analyzed the relationship between industrialization and economic growth and using GMM estimation technique, the authors concluded that industrialization promoted economic growth. Considering the data for Senegalese firms over 1960-2017 period, Ndiaya and Lv (2018) studied the role of industrial output in economic growth. Using OLS estimation technique, the authors found that industrial output promoted economic growth in Senegal. Likewise, Udemba and Keleş (2022) in case of Turkey studied the nexus between industrialization and sustainable development over the period from 1970 to 2018. According to the findings of ARDL approach, industrialization had negative effect on sustainable development as it was found to increase CO_2 emission.

Energy efficiency refers to the amount of services provided in comparison to the input. Qu et al. (2020) in his study provided different policies and mechanism in order to make efficient use of energy by adopting different technologies that help in lowering the energy consumption on the whole, providing the same kind of outputs. Hosan et al. (2022) estimated the role of energy intensity on sustainable growth in emerging countries over 1995 to 2018 period. Applying CS-ARDL and CCEMG estimation approaches, the researchers found that energy intensity had negative impact on sustainable growth. Likewise in case of European countries over the period 1995-2016, Pehlivanoglu et al. (2021) studied the effect of energy intensity on economic growth. According to the findings of the Mean Group estimation approach, energy intensity was found to positively related with economic growth. Olusegun et al. (2023) analyzed the relationship between energy intensity and economic growth in Sub Saharan African countries over 1970 to 2019 period. Using System GMM approach, the authors found that energy intensity had negative correlation with economic growth. Likewise for South Asian countries, Hosan (2021) tried to explore the nexus between energy intensity and economic growth over 1995-2018 period. Using CCEMG approach, energy intensity was found to reduce economic growth.

Renewable energy sources refer to those resources which are beneficial for the environment and help in recycling resources in the nature. The relationship between renewable energy resources and sustainable economic growth has occupied the attention of the researchers in the current era of rapid climate change and global warming issues. The study of Kamoun et al. (2019) is an attempt in this regard in case of OECD countries. The authors analyzed the role of renewable energy on sustainable growth over 1990-2013 period. Using FMOLS regression approach, the authors found that renewable energy use promotes sustainable economic growth. Likewise, in case of developed and developing countries, Güney (2019) estimated the role of renewable energy in sustainable development and found that renewable energy use promoted sustainable development both in developed and developing countries. Similarly, Armeanu et al. (2017) explored the role of renewable energy in sustainable growth in 28 European countries over 2003-2014 period. Using the fixed effects model, it was concluded that renewable energy had positive impact on economic growth. Likewise for SAARC countries, Yikun et al. (2021) analyzed the role of renewable energy resources on sustainable economic growth over the period from 1995 to 2018. According to the findings of Fixed Effects Model, the renewable energy resources contributed to sustainable growth in countries.

Based on the literature, the following hypotheses are formulated in the current study.

H1: Digital finance plays significant role in sustainable economic growth in BRI Countries.

H2: Energy efficiency is in association with economic sustainability in BRI countries.

H3: Renewable energy resources plays significant role in sustainable economic growth in BRI Countries.

H4: Green Investment plays significant role in sustainable economic growth in BRI Countries.

H5: Industrialization plays significant role in sustainable economic growth in BRI Countries.

H6: Natural resource utilization plays significant role in sustainable economic growth in BRI Countries.

2.3. Research Gap

The review of the above literature reveals that the role of the selected regressors in economic growth or sustainable economic growth in the context of different countries or group of countries, but no definite conclusion about their contribution to sustainable growth have been reached. Therefore a further analysis of the matter is required. Moreover, to the author's best understanding, no previous study selected BRI group for the estimation of this objective. Therefore the current study tries to fill this gap in literature by examining the role of these factors in sustainable growth in the selected BRI countries.

3. METHOD OF ANALYSIS

The present study aims to explore the dynamic association among natural resource utilization, green investment, digital finance, industrialization, energy efficiency, renewable energy consumption and sustainable economic growth in 20 BRI countries (Bangladesh, China, Chile, Cuba, Costa Rica, Malawi, Malaysia, Morocco, Nepal, Mozambique, Ethiopia, Ghana, Indonesia, Kenya, Turkey, Laos, Mali, Pakistan, Egypt, Bolivia) over 2010 to 2020 period. For this purpose, the model of the study is specified using Cobb and Douglas Production function (Douglas, 1928). This model assumes economic growth as a function of labour and capital. Following this framework, the basic model of the study is formulated as:

$$SEG = f\,(LF, CAP) \tag{1}$$

However, extending this basic model by taking the support of Van Hoa et al. (2022), Hosan et al. (2022), Liu et al. (2023), Güney (2019) and Haseeb et al. (2021), the basic model is extended by adding digital finance, green investment, industrial use, energy intensity, renewable energy and natural resources as follows:

$$SEG = f\,(LF, CAP, GI, DF, EI, RE, IND, NR) \tag{2}$$

And the model in its econometric form is written as follows:

$$SEG_{it} = \beta_0+\beta_1 GI_{it}+\beta_2 DF_{it}+\beta_3 EI_{it}+\beta_4 RE_{it}+\beta_5 IND_{it}+\beta_6 NR_{it}+\beta_7 LF_{it}+\beta_8 CAP_{it}+\varepsilon_{it} \tag{3}$$

Where, SEG = Sustainable economic growth, DF = digital finance, EI = energy intensity, RE = renewable energy. IND = industrialization, NR = natural resources, LF = labour force, CAP = capital and is the error term.

Based on the research aims and objectives, the researcher has implemented a secondary quantitative design. The dependent variable of the study is sustainable economic growth measured by GDP constant (constant US$). To assess the effect of the independent variables, total natural resource rents as percentage of GDP is used to measure natural resource utilization which is the independent variable of this study. Other variables include green investment GI measured as financial flows for renewable energy generation, EI or energy intensity which has been measured as the energy intensity level of primary energy, renewable energy consumption as percentage of total consumption, industrialization as industry value added as percentage of GDP and digital finance measured as Automated teller machines (per 1000 people). Moreover, labour and capital are added into the model as control variables. The labour is measured by total labour force and capital is measured by gross fixed capital formation (% of GDP). The researcher has attained data within the time frame of 2010-2020. The rationale behind the selection of this time frame is limitation of the data availability. The data of all variables except green investment is collected from the World Development Indicators (WDI), whereas the data for green investment is taken from Our World in Data database.

3.1. Statistical techniques and model estimations

To analyze the data, the researcher has implemented different statistical techniques. The detail of each technique is described as follows:

3.1.1. Cross-sectional dependence (CSD) test

The panel data is most likely to suffer from the issue of CSD resulting from different factors such as the hidden unobserved or observed common shock and the interdependence of residuals. Ignoring the spillover effects between the cross sectional units may result in biased results for stationarity and cointegration analysis, conflicting estimators, and incorrect inference (Nawaz et al., 2021). As a result, the first stage of the analysis should promptly verify whether CSD is present in the panel data. Therefore, the empirical estimation in this study starts with applying CSD test proposed by Pesaran (2004). The test statistics is given as follows:

$$CD=\sqrt{\frac{2T}{N\left(N-1\right)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right)\sim N\left(0,1\right)i,j \tag{4}$$

Where, $\hat{\rho}_{ij}$ reveals the coefficients of pairwise correlation. The null hypothesis of test implies that CSD does not exist among cross sectional units while the alternative hypothesis assumes the reverse.

3.1.2. Slope homogeneity testing

After the CSD issue, the next important issue pertaining to panel data analysis is the presence of slope heterogeneity. To check its prevalence, the slope heterogeneity test proposed by Pesaran and Yamagata (2008) is applied in the present study. The null hypothesis of the test assumes slope homogeneity, whereas the alternative hypothesis assumes the presence of slope heterogeneity in panel data. The basis equations of delta and adjusted delta tilde in slope homogeneity test are provided as follows:

$$\tilde{\Delta}=\sqrt{N}\left(\frac{N^{-1}\tilde{S}-k}{\sqrt{2k}}\right) \tag{5}$$

$$\tilde{\Delta}_{adj}=\frac{\sqrt{N}\left[N^{-1}\tilde{S}-E(\tilde{Z}_{it})\right]}{\sqrt{Var(\tilde{Z}_{it})}} \tag{6}$$

In above equations, $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ denote delta tilde and adjusted delta tilde respectively.

3.1.3. Unit root testing

Following the CSD and slope heterogeneity issues testing, the stationarity of the model variables is assessed using second generation the cross-section augmented Dickey-Fuller (CADF) and cross-section Im Pesaran and Shin (CIPS) unit root tests proposed by (Pesaran, 2007). In the presence of CSD issue, the first generation unit root tests produce biased outcomes. Therefore, the CADF and CIPS tests are the most appropriate tests for unit root analysis. The CADF statistics is formulated as:

$$\Delta y_{it}=\alpha_i+\rho_i^{*}y_{it-1}+d_0\overline{y}_{t-1}+\sum_{j=0}^{p}d_{j+1}\overline{\Delta y}_{t-j}+\sum_{k=1}^{p}c_k\Delta y_{it-k}+\varepsilon_{it} \tag{7}$$

where, Δy_{it} represents the cross-sectional averages. We can obtain CIPS test statistics by using this basic CADF statistics as follows:

$$\text{CIPS}=\frac{1}{N}\sum_{i=1}^{N}CADF_{i_i} \tag{8}$$

3.1.4. Driscoll-Kraay standard error estimation approach

The two commonly used panel data approaches are the fixed effects and the random effects model to get parameter estimation. The selection between these two approaches is made on the basis of the Hausman test. The Fixed Effects model was selected to be the applied in the present study on the basis of the Hausman test. But due to the presence of CSD issue in the data, the Driscoll-Kraay Standard Error (DK-SE) approach with Fixed Effect is found to be appropriate to apply in the study which effectively deals with the issues of CSD, autocorrelation and heteroskedasticity (Shah et al., 2021). Furthermore, the DK-SE approach is applicable to both balanced and un-balanced panel datasets as it handles the missing values properly (Liu et al., 2024).

4. FINDINGS AND DISCUSSION

First of all, the summary statistics, which provide the basic characteristics of data including mean, standard deviation and maximum and minimum values of the variables under observation are given in Table 1. From the output, it can be inferred that industrialization has the highest, while GF has the lowest mean values. Likewise, industrialization has the highest value for standard deviation and energy intensity possesses the lowest one.

The data range of the concerned variables is also provided by the summary statistics analysis.

Subsequently, the correlation matrix which shows the association among different possible pairs of the variables is given in Table 2. From the outcomes, it can be seen that positive association of sustainable development with green investment, industrialization, digital finance, labour force and capital whereas negative association with natural resources and renewable energy consumption is present.

The panel data most commonly face the challenges of CSD and slope heterogeneity. There is a possibility of attaining spurious outcomes if these issues are not dealt with. Therefore, the CSD test proposed by Pesaran (2004) and slope heterogeneity test proposed by Pesaran and Yamagata (2008) are used in the present study to check the presence or absence of CSD and slope heterogeneity issues. Table 4 gives us the results of CSD test and it can be seen that all of the variables except GI and CAP are cross sectionally dependent as the null hypothesis of no CSD can be rejected with high significance.

Besides this, the results of slope heterogeneity test given in Table 4 provides the highly significant values for the delta and adjusted delta which clearly reject the null hypothesis of slope homogeneity.

After confirming the presence of the issues of CSD and slope heterogeneity in our panel data, the study applies the second generation unit root tests namely CIPS and CADF tests to assess the order of integration of the concerned series. The results of both tests are provided in Table 5. According to the results, mixed order of integration is found to be present in concerned data series as some of them are stationary at level whereas other are stationary at the first difference. These results provide the basis for the application of the next empirical strategy.

After fulfilling all the necessary prerequisites, the next step in empirical analysis involves the estimation of the long run relationship between dependent and independent variables. Correspondingly, Table 6 reports the results of DK-STD approach. According to the results, first of all, the coefficient of industrialization is statistically significant and positive. A 1 unit rise in industrialization leads to 1.040 units increase in SEG. This finding can be justified because industrialization process is related with the use of more energy efficient technologies which not only reduces environmental degradation but also promote economic growth (Nasrollahi et al., 2020). The finding is in line with the study of (Opoku and Yan, 2019) who claimed that industrialization is an important determinant of the growth in Africa. The findings of Mbaegbu (2016) also support our results as the authors argued that industrialization can promote the economic growth and diversification of Nigerian economy. However, the finding does not match with the study of (Hussain and Zhou, 2022) for BRI countries as the researchers claimed that industrialization is responsible for lowering sustainable economic growth by promoting CO_2 emission and energy use.

Second, the statistically significant and negative coefficient for natural resources is observed in Table 6. A unit increase in natural resources in selected countries is evident to be related with 1.62 units decline in sustainable economic growth. This finding justifies that natural resource utilization, no doubt is a source of promoting economic growth in the selected countries but the over dependence on these resources harms the environmental sustainability significantly because of the unsafe extraction of natural resources. The unsafe extraction of the resources does not enable them to renew which consequently adds to environmental degradation. Previously, the results of Hassan et al. (2019) support our estimation as the researchers claimed that natural resources were responsible for promoting ecological footprints in Pakistan. Similarly, the finding of Kongbuamai et al. (2020) matches with the present study by arguing the role of natural resources in promoting environmental degradation in ASEAN countries. Likewise, the estimation of DK-SD for the nexus between energy intensity and sustainable economic growth inflict the negative association between them. Specifically, a unit increase in energy intensity reduces sustainable economic growth by 3.05 units. The finding is

Table 1: Descriptive or summary statistics

Variables	Mean	SD	Minimum value	Maximum value
SEG	6.4811	2.3112	7.530	1.4613
GI	2.580	4.550	−9.770	3.3909
IND	126.00	73.172	1.000	252
NR	5.1911	4.555	0.221	18.051
EI	4.418	2.558	1.27	14.72
RE	38.979	28.510	1.96	94.11
DF	106.296	71.137	1.00	230
LF	9.420	2.320	13,555	782,008
CAP	102.45	66.099	1.000	217

SD: Standard deviation, SEG: Sustainable economic growth, IND: industrialization, EI: Energy intensity, RE: Renewable energy, NR: Natural resources, CAP: Capital and $\mathcal{E}$ is the error term, LF: Labour force, DF: Digital finance

Table 2: Correlation matrix

Variables	SEG	GI	IND	NR	EI	RE	DF	LF	CAP
SEG	1.000								
GI	0.040**	1.000							
IND	0.997	0.029	1.000						
NR	−0.183	−0.125	−0.171**	1.000					
EI	0.195	−0.080*	0.2030	0.453	1.000				
RE	−0.255	−0.126	−0.251*	0.2618	0.0543*	1.000			
DF	0.2311	0.0684	0.220	−0.269	−0.054**	−0.080*	1.000		
LF	0.004**	−0.003**	0.013**	0.119	−0.1336	−0.0137	0.007	1.000	
CAP	0.1984	−0.1352	0.2090	0.1748	0.000***	−0.1809	0.066*	0.4072	1.000

SEG: Sustainable economic growth, IND: industrialization, EI: Energy intensity, RE: Renewable energy, NR: Natural resources, CAP: Capital and $\mathcal{E}$ is the error term, LF: Labour force, DF: Digital finance

Table 3: Cross-sectional dependence test

Variables	CD-test	P
SEG	49.486***	0.000
GI	1.188	0.235
IND	4.498***	0.000
NR	27.72***	0.000
EI	19.457***	0.000
RE	5.221***	0.000
DF	2.449**	0.014
LF	9.579***	0.000
CAP	0.473	0.636

* , ** and *** represent significance at a 1, 5 and 10% respectively. SEG: Sustainable economic growth, IND: industrialization, EI: Energy intensity, RE: Renewable energy, NR: Natural resources, CAP: Capital and $\mathcal{E}$ is the error term, LF: Labour force, DF: Digital finance

Table 4: Slope heterogeneity test

Statistic	Test statistics	P
Delta	−4.163	0.000
Adjusted delta	−13.805	0.000

Table 5: Unit root tests

Variables	CIPS		CADF	
	Level	First difference	Level	First difference
SEG	−1.305	−2.217*	−0.896	−1.710**
GI	−3.260***	-	0.932	−2.251**
IND	−1.819	−3.120***	−2.528***	-
NR	−1.775	−2.567***	−2.943***	-
EI	−2.071*	-	0.555	−3.772***
RE	−2.529***	-	−4.328***	-
DF	−2.019	−2.613***	0.286	−3.303***
LF	−0.922	−2.516***	4.752	−2.825**
CAP	−1.381	−2.871***	3.228	−4.038

*, ** and *** represent significance at a 1, 5 and 10% respectively. SEG: Sustainable economic growth, IND: industrialization, EI: Energy intensity, RE: Renewable energy, NR: Natural resources, CAP: Capital and $\mathcal{E}$ is the error term, LF: Labour force, DF: Digital finance, CADF: Cross-section augmented Dickey-Fuller, CIPS: Cross-section I'm Pesaran and Shin

Table 6: Findings of Driscoll-Kraay standard error estimation

Variables	Coefficients	DK-SE	t- statistic	P
GI	28.376	19.762	1.44	0.182
IND	2.616***	0.223	11.73	0.000
NR	−2.790*	1.340	−2.08	0.065
EI	−4.321**	9.910	−2.27	0.047
RE	2.670**	6.680	4.00	0.002
DF	2.560**	1.210	2.12	0.060
LF	−66.202	44.141	−1.50	0.165
CAP	8.720	8.270	1.05	0.317

*, ** and ***Represent significance at a 1, 5 and 10% respectively. DK-SE: Driscoll-Kraay Standard errors, IND: industrialization, EI: Energy intensity, RE: Renewable energy, NR: Natural resources, CAP: Capital and $\mathcal{E}$ is the error term, LF: Labour force, DF: Digital finance

consistent with the earlier estimation of Hosan et al. (2022) as the researchers claimed that energy intensity is negatively associated with sustainable growth in developing countries. Similarly, the finding is in line with Khan et al. (2022) as the authors claimed that higher energy intensity is related with increased carbon emission in Canada. The finding implies that higher energy intensity is associated with rise in more consumption of fossil fuel based resources which lead to environmental degradation and climate change (Huang and He, 2023). Thus the findings highlight the importance of managing the energy consumption and natural resource utilization in order to sustain the economic growth as well as environmental consideration.

In contrast, the long run estimates of DK-SE approach reveal the significant and positive impact of renewable energy on sustainable growth. Specifically, for a unit increase in the use of renewable energy, sustainable economic growth increases by 1.20 units in BRI countries. This finding matches with a number of empirical studies such as Güney (2019) in case of developed and developing countries as the researchers argued that renewable energy is the major source of promoting sustainable development. Likewise, the study of Güney (2021) established that renewable energy is more effective than fossil fuel based energy to drive sustainable economic growth in OECD countries. The finding implies that actions that follow a rise in renewable energy consumption have a favourable impact on economic growth, and many relevant initiatives and future decisions can be implemented (Chang and Fang, 2022).

Likewise, the relationship between digital finance and sustainable growth is evident to be statistically significant and positive in DK-SE approach. In terms of the coefficient, for a unit increase in digital finance, sustainable growth increases by 2.59 units in BRI countries. This finding is justified because digital financial inclusion enables the financial system of a country to serve the whole community and increase the accessibility rate, particularly the financially excluded or poor people. Strong financial institutions promote the expansion of both new and current enterprises which stimulate the level of growth (Tay et al., 2022). This finding is consistent with Li et al. (2022) as the authors argued that digital finance promotes environmental sustainability in more and less polluted regions of China. Likewise, Dell'Erba (2024) also support our results by arguing that digital finance has the potential for promoting sustainable growth by promoting environmental sustainability.

In contrast to other regressors, the findings indicate that green investment has positive but statistically insignificant impact on sustainable economic growth. Thus the finding implies that government in concerned counties must regulate the green investment. Although the finding is contrary to hypothesis and expectation, it aligns with the finding of Zhang et al. (2022) as the researchers found that green investment has positive but insignificant impact on clean energy consumption. Likewise, the finding is also partially in line with Shen et al. (2024) as the researchers argued that green investment promoted environmental pollution in the short run in G-7 countries. Likewise, both of the control variables i.e., labour and capital also do not exhibit any significant impact on sustainable economic growth consistent with the studies of Onyinye et al. (2017) and (Khan and Chaudhry, 2019).

5. CONCLUSION AND IMPLICATIONS

The main objective of the study is to explore the dynamic interaction between natural resource utilization, digital finance, green investment, energy efficiency, industrialization, renewable energy consumption on sustainable economic growth in 20 BRI countries. The research has been executed from 2010 to 2022, using scientific data from World Development Indicator (WDI) and Our World in Data as a reliable data source. After identifying the presence of the issues of CSD and slope heterogeneity in panel data series, the DK-SE approach has been used in the study to assess the relationship between dependent and independent variables. The results of DK-SE model indicated that the relationship between independent variables and sustainable economic growth are both positive and negative and therefore offer differential information to the researcher. The findings confirmed the positive impact of digital finance and renewable energy consumption and the negative impact of energy intensity and natural resource utilization. In contrast, the effect of green investment is evident to be insignificant in model estimation. Overall, this study has contributed towards increased knowledge on variables that regulate sustainable economic growth. This will influence policy formulation and informed decision making as economics adjusts to global economic challenges. The research results will be significantly helpful in understanding the complicated pathways of environmental sustainability, business, technological innovation and the economy via building new communities and infrastructures in BRI countries and other regions of the world.

5.1. Implications

This study has number of theoretical contributions and implications, which would help in understanding the complex relations of the selected regressors and sustainable economic growth in a more apposite theoretical way. Firstly, this study explains the short- and long-run relationship between various economic variables and GDP growth by applying the ARDL model. Furthermore, from the negative coefficients of financial system, energy intensity, and total natural resource rent, while explaining the relationship between the three with GDP growth, this study supports the theoretical justification that for sustainable economic growth, there should be balance between intensive use of natural resources, which suggests that when the countries has unchecked use of resources to exploit GDP growth, the effects on the GDP growth of the countries in long-run would be negative. The positive coefficients of environmental factors (green investment and renewable energy consumption) will help in providing other economic theories, which states that the integration of the environmental factors in the economic model can have positive effects on growth even in short run. Because, in this study the green investment has positive effect on short-run GDP growth.

Policymakers, financial institutions, and corporations should take note of the practical implications of this study to achieve sustainable economic growth in BRI countries. The study demonstrates that caution must be exercised when expanding green investment, as its effects on sustainable economic growth have been found to be insignificant. There is a need by financial sectors to evaluate risk control measures and develop strong regulatory mechanisms regarding green investments. On the other hand, energy intensity and total natural resource rents have been associated with negative effects; therefore, it is important for sustainable resource management practices. Policymakers must develop and introduce environmental and energy policies to enforce more responsible resource use to support sustainable growth and achieve long-term sustainability. The practical implications derived from this study will not only inform decision making in financial matters, but the environment as well. Therefore, it is possible to strike a balance between sustainable growth and addressing the challenges brought about by different factors.

5.2. Limitations and future directions

There are a few limitations of this study as well. The scope of this study makes generalizability of the results limited. By nature of the study, it only holds for one particular geography and in a different location, the results might not have been the same. Whilst the study analyzed a comprehensive time period, this is a relatively short time period – it would take a more extensive study of data to provide concrete figures. The study primarily uses quantitate data and it would thus be interesting to use qualitative methods to find out how the market environment influences.

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