

*Majors: Finance*

*Major/No. F20*

**Exploring the impact of Green Finance, Green Technology Innovation, Green Growth and Natural Resource Rent on CO<sub>2</sub> Emission: Evidence from BRICS + Economies.**



**By:**

*Sitwat Qureshi*

*01-321242-029*

**Supervisor:**

**Dr. Lubna Maroof**

**HR and Management Department**

**Bahria University Islamabad**

**Fall 2025**

## **ACKNOWLEDGEMENT**

I would like to express my gratitude to my supervisor, Ms. Lubna Maroof, for her role in supervising this thesis and for providing academic guidance where required.

A special thanks to my family for their constant support in every phase of life, to my classmates for making this MBA journey memorable.

## ABSTRACT

The global economic supremacy battle has rapidly increased environmental deterioration. BRICS + nations have prioritized environmental sustainability in their policies. This study examines the effect of Green Technology Innovation, Green Finance, Green Growth, and Natural Resource Rent on CO<sub>2</sub> emission in BRICS + economies for the period of 2000 – 2024. Quantile regression and FGLS were employed. The results revealed that Green Growth, Green Finance, and Natural Resource Rent have a statistically significant negative relation with environmental deterioration. The empirical findings suggest that promoting Green Finance, Green Growth, and Natural Resource Rent, can be powerful levers for promoting environmental sustainability in BRICS + economies. Whereas, Green Technological Innovation can lead to climate degradation. The study also applied robustness test which further confirmed the mainstream results. These research directions can provide valuable insights for policymakers, businesses and scholars, helping in promoting environmental sustainability.

**Keywords:** *Natural Resource Rent; Green Technology Innovation; Green Finance; Green Growth; CO<sub>2</sub> emission; BRICS +*

# Table of Contents

<b>ACKNOWLEDGEMENT</b>	2
<b>ABSTRACT</b>	3
<b>CHAPTER 1</b>	7
<b>INTRODUCTION</b>	7
<b>1.1 Overview</b>	7
<b>Green Finance (GF)</b>	8
<b>Green Growth (GG)</b>	8
<b>Natural Resource Rent (NRR)</b>	9
<b>Green Technology Innovation (GTI)</b>	10
<b>1.2 Problem Statement</b>	11
<b>1.3 Research Questions</b>	11
<b>1.4 Research Objectives</b>	11
<b>1.5 Research Gap</b>	12
<b>1.6 Significance of Study</b>	12
<b>CHAPTER 2</b>	13
<b>LITERATURE REVIEW</b>	13
<b>2.1 Green Finance and CO<sub>2</sub> Emission</b>	13
<b>2.2 Natural Resource Rent and CO<sub>2</sub> Emission</b>	16
<b>2.3 Green Technology Innovation and CO<sub>2</sub> Emission</b>	19
<b>2.4 Green Growth and CO<sub>2</sub> Emission</b>	21
<b>2.5 Conceptual Framework</b>	24
<b>CHAPTER 3</b>	25
<b>DATA &amp; METHADODOLOGY</b>	25
<b>3.1 Research Design</b>	25
<b>3.2 Research Type</b>	25
<b>3.3 Research Philosophy</b>	25
<b>3.4 Research Approach</b>	25
<b>3.5 Data</b>	25
<b>3.6 Methodology</b>	25
<b>3.7 Econometric model</b>	27
<b>CHAPTER 4</b>	29
<b>RESULTS &amp; DISCUSSIONS</b>	29

<b>CHAPTER 5</b>	40
<b>CONCLUSION</b>	40
<b>5.1 Theoretical Implication</b>	41
<b>5.2 Practical Implication</b>	41
<b>5.3 Limitations and Recommendations</b>	42
<b>REFERENCES</b>	43

## List of Tables

TABLE 3.1 VARIABLES DESCRIPTION .....	28
TABLE 4.1 DESCRIPTIVE STATISTICS .....	29
TABLE 4.2 MATRIX OF CORRELATION .....	30
TABLE 4.3 VARIANCE INFLATION FACTOR .....	30
TABLE 4.4 TEST FOR CROSS-SECTION DEPENDENCE IN PANEL DATA .....	33
TABLE 4.5 SLOPE HOMOGENEITY TEST .....	34
TABLE 4.6 PANEL COINTEGRATION TESTS .....	35
TABLE 4.7 PANEL QUANTILE REGRESSION .....	37
TABLE 4.8 FEASIBLE GENERALIZED LEAST SQUARES .....	38

## List of Figures

FIGURE. 2.1 CONCEPTUAL FRAMEWORK.....	24
FIGURE 3.1 ESTIMATION METHODS ROADMAP.....	27

# CHAPTER 1

## INTRODUCTION

---

### 1.1 Overview

In recent times environmental degradation and climate uncertainties are the biggest threat faced by the mankind. Not addressing this issue can seriously impact human lives in various facets. These global environmental challenges have resulted due to a delayed response to fast climate change in past few decades (Gorji & Gorji, 2021). These harsh weather condition have shifted factors of production which caused disturbance in worldwide production of goods and services (Dellink et al., 2017). United Nation has developed 17 Sustainable development interconnected goals as part of the 2030 Sustainable Development Plan to deal with worldwide economic, political and ecological challenges. Sustainable Development Goal 13 has been specifically developed to deal with climate change. In 2016, a global climate change agreement known as the Paris Agreement was signed by 196 countries. One of the primary objectives of the agreement was to keep the rise in the average global temperature well below 2°C over pre-industrial levels and to work toward a 1.5°C limit for ensuring a significant decrease in greenhouse gas emissions worldwide. Various countries across the globe are implementing techniques for reducing greenhouse gas emission for complying with the legal requirements.

Prioritizing growth at the expense of environmental quality is mostly to blame for environmental issues. The developing world, which includes emerging economies, in particular strives for rapid economic expansion by relying heavily on local and imported fossil fuels. The economies of the BRICS have performed admirably in terms of growth in recent decades. However, greenhouse gas emissions particularly carbon emission is inseparable from this economic progress. CO<sub>2</sub> concentration in the atmosphere has raised by 45 % in the last 130 years

Numerous specialists in energy, environmental studies, and decision-makers find it concerning that BRICS growth is an alarming sign for overall worldwide environmental health (Su et al., 2021). In order to address the growing environmental concern BRICS nation have included it in their policy framework and started working on creating a harmony between environmental protection and economic advancement. Researchers are focusing on various factors like Green Growth (GG), Green Finance (GF) and Natural Resource Rent (NRR) for creating a sustainable environment

(Udeagha & Ngepah, 2023). Moreover, Green Technology Innovation (GTI) is a pivotal factor in dealing with the environmental concerns (Sun et al., 2022). This paper provides an overview of various linkages between GF, GTI, GG, NRR and their impact on CO<sub>2</sub> emission in BRICS nations.

### **Green Finance (GF)**

GF describes an environmentally conscious investment strategy. GF makes it possible for private businesses to fund environmentally beneficial projects, which are crucial for promoting sustainable growth (Yang et al., 2021). This strategy promotes the growth of eco-friendly businesses, enhances ecological integrity, and aids in the creation of loan finance in businesses. Green credit, CO<sub>2</sub> emission trading are the two primary categories of environmentally friendly investing products. Green bonds are another major category for GF which give green enterprises more financing choices and facilitate their ability to obtain funds immediately (L. Zhang et al., 2022). GF mandates financial institutes to consider pollution supervision and environmental preservation when making loans. This technique uses financial leverage to protect environment. Financial institutes are stimulated to halt lending to high-polluting projects, as well as recoup any loans already issued (X. Zhao et al., 2022). A major chunk of world-wide production comes from BRICS economies. However, this rapid economic prosperity has resulted in serious environmental damage. Hence in order to achieve goals designed by Paris Agreement for environmental protection BRICS economies specifically those having stable political and credit risk have taken vigorous green finance initiatives (Udeagha & Muchapondwa, 2023). Such initiatives have already started showing results in the form of reduced CO<sub>2</sub> emission in BRICS economies (Lisha et al., 2023).

### **Green Growth (GG)**

Green growth, as defined by OECD is the fostering of economic prosperity while preserving natural resources for the mankind. GG comes under the umbrella of sustainable economic development which prioritizes combined socioeconomic development, enhances social welfare, boosts employment, and successfully addresses environmental problems by shifting manufacturing and utilization methods (Zhao et al., 2023). GG is an essential tool for attaining sustainable development (Wiebe and Yamano, 2016). This will protect natural resources and mitigate CO<sub>2</sub> emission. In recent times as battle for economic supremacy has intensified this has caused environmental problems to rise which has shifted the attention of policy makers towards green growth. GG balances economic and environmental gains to provide benefit to todays and

future generation. GG involves switching towards renewable energy sources and promoting recycling of waste material. However favorable trade and fiscal policies are extremely important for promoting renewable energy which will further enhance GG (Huang, 2023). The development of green technologies, green production methods, and the expansion of green products are all necessary to bring forward green growth (Tokpunar & Dalgıç, 2024). Adapting towards green technologies along with cleaner production procedures and advance processes of supply chain can help in attaining demand-based emissions which is essential for GG (Lin & Ullah, 2023) .

### **Natural Resource Rent (NRR)**

The financial benefits that a country receives from the ownership, exploitation, and use of its natural resources are collectively referred to as natural resources rents. One of the main causes of CO<sub>2</sub> emissions is the process of mining and using these resources. Hence, compared to countries with fewer natural resources, those with abundant natural resources, such as coal, oil, and natural gas tend to have greater levels of CO<sub>2</sub> emissions per GDP unit. The term "carbon curse" is frequently used to describe this state of affairs in relation to natural resources (Chiroleu-Assouline et al., 2020). NRR can promote corruption by keeping a blind eye on misappropriation of natural resource to satisfy greed of earning rent. Economies with abundant natural resources ought to accelerate more quickly and more effectively in contrast to those without such resources ( Huang et al., 2020). Financial development depends on natural resources, yet as economies grow, environmental quality improves due to people's demand for clean air. Therefore, maintaining the ecological balance of the globe depends on both economic growth and the preservation of natural resources. Natural resources meet the requirements of people in a number of ways, including providing food and shelter, cleaning the air, and even serving as structures for tourist destinations. Environmental degradation can result from the overuse of natural resources (Y. Yu, 2023). Usage of these rents towards sustainability policies and initiatives can however, lead to lowering the emissions. (Wang et al., 2024) demonstrate that the impact of natural resource rents on emissions can become negative in the presence of high economic complexity and strong institutional frameworks, indicating that policy and structural conditions materially influence the environmental outcomes of resource dependence. Natural resource rents, when paired with sustainable technology and supportive policies, can contribute to reducing environmental degradation and lowering ecological pressure, implying that resource revenues have the potential to be favorable for sustainable outcomes. (Hacıımamoğlu & Cengiz, 2024).

## **Green Technology Innovation (GTI)**

GTI is considered as one of the most important tools for mitigating environmental damage caused by the growing economic activity (Q. Zhang et al., 2022). Countries can modify their economic models to utilize clean energy and have access to carbon; less technology with the help of GTI which enables them to produce energy efficient goods (R. Ibrahim et al., 2022). GTI offers several immediate operational benefits, including enhanced resource efficiency, cost reductions, and improved logistics. Motive of green technology innovation should not only be monetary in fact it should be pursued as an ethical and moral responsibility of major producers of goods and services for preserving the environment not only for the current but also for the next generation. After effects of environmentally hazardous production and consumption methods are already visible and this is time to switch towards green production methods otherwise situation will get worse. Switching towards green technology innovation could involve efforts as small as reducing water and power wastage to as large as developing sustainable cities. Indirect benefits include stronger relationships with officials and more favorable public image. In order to encourage sustainable economy, GTI has become a crucial concept in recent years. It is thought to be a technique that accomplishes sustainability of resources and environment (Omokanmi et al., 2022). GTI supports smart grid innovations that maximize energy efficiency. In addition to reducing the ecological footprint, this is also economical Moreover, hydroponics and vertical farming are advanced agricultural technologies that allow crops to be grown year-round in urban environments, reducing the need for extensive land use and production logistics (Tang et al., 2023). Modern recycling technology converts waste into valuable resources, reducing the amount of waste going to landfills and promoting a circular economy (Hojnik et al., 2023). Despite facing environmental degradation, the BRICS nations have remained committed to address this problem by adopting technological innovations that aims to promote green environment (Yuerong et al., 2024). However, when more technology leads to energy use and production it can lead to industrialization causing more emissions. Green technology innovation has both carbon reduction and carbon rebound effects, where efficiency improvements can paradoxically increase carbon emissions through broader economic and consumption responses (Xinhui Lu & Zirui Lu, 2024). Green technological innovation and carbon emissions may follow an inverted U-shaped pattern, where emissions initially rise with early innovation before declining at greater innovation intensities.(J. Zhu et al., 2025).

## **1.2 Problem Statement**

Degradation of environment is one of the major issues faced by the modern world (Sohail et al., 2021). Emission of carbon dioxide is one factor that is threatening planet earth. Carbon emission occurs due to rapidly growing economies, and with initiatives to progress, like depletion of natural resources, technological advancements, industrialization, etc., leads to deterioration of the environment.

Research indicates that the rapid economic expansion of BRICS nations has been significantly associated with environmental degradation and increased CO<sub>2</sub> emissions. (Asif et al., 2024) documents that economic growth negatively impacts environmental sustainability in the BRICS countries, emphasizing the challenge of decoupling growth from environmental harm. The BRICS countries are responsible for approximately 42 percent of global carbon emissions (Erkılıç et al., 2025). (Asif et al., 2024) emphasize that rapid economic expansion in BRICS economies has significantly worsened environmental quality, with serious implications for human health and long-term sustainability. Despite these efforts, the literature finds that policy effectiveness varies, and economic growth often continues to offset environmental gains, especially in the short run. Environmental neglect results in serious health and welfare losses, particularly for vulnerable populations in rapidly growing economies.(Nathaniel & Rehman Khan, 2020). Thus, this study aims to check GG, GF, NRR, and GTI and their interplay will help in mitigating this issue in economies progressing quickly, just as the BRICS nations.

## **1.3 Research Questions**

- How does green growth influence CO<sub>2</sub> emissions in BRICS+ economies?
- To what extent does green technological innovation contribute to the reduction of CO<sub>2</sub> emissions in BRICS+ economies?
- What role do natural resource rents play in shaping CO<sub>2</sub> emission levels in BRICS+ economies?
- Does green finance promote environmental sustainability by mitigating CO<sub>2</sub> emissions in BRICS+ economies?

## **1.4 Research Objectives**

- To evaluate the effect of Natural Resource Rent on CO<sub>2</sub> Emission in BRICS + Economies
- To examine the effect of Green Growth on CO<sub>2</sub> Emission in BRICS + Economies

- To scrutinize the effect of Green Technology Innovation on CO<sub>2</sub> Emission in BRICS + Economies
- To analyze the effect of Green Finance on CO<sub>2</sub> Emission in BRICS + Economies

### **1.5 Research Gap**

Previous studies have been conducted on the original BRICS economies consisting of 5 members (Liu et al., n.d.; Peng et al., 2022; Ullah et al., 2024; Wei et al., 2024). This study is amongst the few to have examine the existing set of variables on new BRICS + economies after the induction of 5 additional members from January, 2024 onwards which included Iran, Ethiopia, Saudi Arabia, United Arab Emirates and Egypt.

A large portion of the literature is predicated on the Porter Hypothesis (Porter and van der Linde, 1995), which holds that innovation in green technology naturally lowers carbon emissions. This assumption, however, ignores the existence of scale effects and rebound effects which could lead to short to medium term emission increases from green technology innovation, particularly in economies that rely on fossil fuels. By addressing these limitations, this study provides updated and comprehensive evidence on the determinants of CO<sub>2</sub> emissions within the new BRICS+ framework.

### **1.6 Significance of Study**

In order to raise living standards, combat poverty, and promote human welfare; economic growth is required. Nonetheless, human-caused CO<sub>2</sub> emissions are one of the downsides of economic advancement because it is considered as the main reason of climate change and environmental deterioration (Peng et al., 2022). BRICS economies have been one of the major contributors to global greenhouse gas emission (Adebayo et al., 2023). This contribution to greenhouse gas emissions reflects the group's noteworthy economic advancements, which have contributed to its prominence as global economic leaders (Ibrahim et al., 2021). By extending previous researches in this area, this study aims to reflect how Natural Resource Rent, adaption of Green Finance, Green Technology Innovation and Green Growth can bring outcomes for the environment of BRICS economies which may be adapted by other countries too and allows them to play their role in preserving the environment along with improving their economic prosperity.

## CHAPTER 2

### LITERATURE REVIEW

---

#### 2.1 Green Finance and CO<sub>2</sub> Emission

The study of (Udeagha & Ngepah, 2023) investigated the potential contributions of GF and Fintech towards the BRICS countries' objective of reducing CO<sub>2</sub> emission between 2000 and 2018. Findings show that GF encourages environmental sustainability and the relationship between GF and CO<sub>2</sub> emissions is bidirectional. Results revealed that the BRICS nations give top priority to the creation of environmentally friendly monetary products and increase the ability of financial institutions to provide green loan options in light of these findings.

(Sethi et al., 2023) investigated how innovative green technology, green finance, institutional quality, and agricultural value added contribute to environmental sustainability through reducing CO<sub>2</sub> emissions for 25 chosen developing nations. The data was selected from 1998 to 2019. Recognizing the endogeneity issue in the model, this study employs the Driscoll-Kraay and two-step SGMM estimators to measure the impact of regressors on the response variable. The empirical results show that CO<sub>2</sub> emission and GF have positive relation.

The impact of green finance on environmental performance in developing nations was investigated by (Bakry et al., 2023). As per the results a long-standing association exists between GF and environmental sustainability. CO<sub>2</sub> discharge and green finance are cointegrated. Panel cointegration analysis and VECM are applied to a sample of 76 developing economies from 2010 to 2019. It has been discovered that green finance significantly reduces CO<sub>2</sub> emissions.

ARDL model was used by (Han et al., 2024) to assess the symmetric effect of GF on environmental sustainability for the 1<sup>st</sup> time in China. Quarterly data from 1995 Q1 to 2019 Q4 was utilized. Findings revealed that green finance reduces environmental deterioration in China.

(Iqbal et al., 2021) examined the input of GF to the reduction of environment pollution for a sample of 16 countries. by establishing a green finance index. It was discovered that green financing considerably promotes the reduction of environmental pollutants. By doing a sensitivity analysis on the study data, the results of the investigation are further validated. As a result, the study hypothesis that green financing contributes significantly to the decrease of environmental pollution is accepted.

(Ren et al., 2020) used green credit, green securities, green insurance, and green investment to create green finance development index and data from 2000 to 2018. A vector error correction model is employed to examine correlations amongst the degree of growth of green financing, non-fossil energy use, and carbon concentration. Research indicates that China's green finance sector grew quickly, and that decreases in carbon intensity were attributed to advancements in the green finance development index.

(Al Mamun et al., 2022) studied the influence of GF on decarbonization. They established that GF considerably lowers CO<sub>2</sub> emissions over the short and long terms using a large sample of 46 nations. The issuance of green bonds to promote waste and pollution control as well as increase energy efficiency is causing this effect. Green financing has a greater effect on CO<sub>2</sub> emissions in established credit markets and nations that have had more successful innovations and are more susceptible to climatic changes. In light of the sample's cross-sectional dependence as well as short- and long-term homogeneity results were solid.

In order to guarantee environmentally sustainable growth in Asia and the Pacific, the ADB implemented significant initiatives. Among these is climate change finance, an ADB and Global Environment Facility collaborative project. Climate mitigation finance is one of its constituents. (M. A. Khan et al., 2022) measured green finance as "climate mitigation finance" in light of the growing role of this sector and looks at how it affects the ecological footprint of 26 Asian economies by employing a baseline model based on ordinary least squares and fixed-effects estimation. As per the results green finance looks to be environmentally beneficial and has a smaller ecological imprint. Specifically, from an Asian standpoint, green financing performs as expected. Furthermore, the results hold up well when utilizing different metrics and estimating techniques, which ought to encourage decision-makers to keep funding climate change initiatives.

(D. Zhang et al., 2022) used a quantile regression model to assess the influence of GF and digital finance on environmental protection, based on data from the G-20 economies from 2008 to 2018. The panel quantile regression results demonstrate that GF diminishes CO<sub>2</sub> emissions in the environment.

(Atif Nawaz et al., 2021) assessed the mean causal effects of a treatment on an outcome of the drivers of increasing green financing and mitigating climatic deterioration in the N-11 countries between 2005 and 2019 using the difference in differences (DID) technique. Following a dummy

analysis, it was determined that outcomes covariates are highly important in encouraging green financing and mitigating climatic deterioration in the study countries.

In this study, (S. Khan et al., 2022) gathered data from five regions—South Asia, South-East Asia, China, Middle Eastern nations, and European nations for over a 15-year period to analyze how green finance affects environmental sustainability. GDP, investments in renewable energy sources, R&D expenditures for environmentally friendly enterprises, and public-private ventures funding for renewable energy initiatives are indicators of the green finance development. Hausman test is utilized to validate the model in this study, which is based on heterogeneous panels. It is revealed that green financing has a significant favorable relation with environmental sustainability. Using public-private partnerships to finance investments in renewable energy sources is one of top strategies for promoting environmental sustainability.

(Cao, 2023) examined how green finance affects the green economic performance index in emerging seven (E7) countries between 2005 and 2018, taking into account per capita income, corporate social responsibility, green energy, and technological advancements. Second-generation panel cointegration techniques were used in this investigation. The panels' correlation and the presence of slope heterogeneity are confirmed by the results of the cross-sectional dependency and slope heterogeneity tests. The association between the green economic performance index and GF is confirmed by the short- and long-term results. Long- and short-term reductions in carbon emissions are achieved through green financing. The results are validated by the robustness check findings derived from the D-H panel causality test.

Using a combination of multiple econometric techniques, (Sinha et al., 2021) investigated the impact of green bond financing on environment by taking into account the S&P 500 Global Green Bond Index and S&P 500 Environmental Responsibility Index, from 2010 to 2020. According to the findings, there is a chance that green funding schemes would gradually have a detrimental transformative effect on environmental responsibilities.

H<sub>1</sub>: Green Finance has a positive relation with CO<sub>2</sub> Emission.

H<sub>2</sub>: Green Finance has a negative relation with CO<sub>2</sub> Emission.

## 2.2 Natural Resource Rent and CO<sub>2</sub> Emission

The effect of resource rent on CO<sub>2</sub> emissions for the BRICS countries between 1990 and 2020 is examined by (L. Huang & Zhao, 2022). According to this study, which uses a quantile regression approach, resource rents are to blame for the increase in CO<sub>2</sub> emissions in the BRICS nations. The study promotes utilizing resources revenue for sustainable development.

The world is now seriously threatened by the ongoing rise in pollution, and professionals are working hard to address environmental issues in order to meet the Sustainable Development Goals. The world has implemented a number of clean and green remedies to address environmental issues, but the issue still persists. (R. Zhu et al., 2024) used the CS-ARDL method to examine the effect of natural resource rent on CO<sub>2</sub> emissions for BRICS economies from 1998 to 2021 within the context of the STIRPAT model. The empirical result demonstrates that environmental contamination is increased by natural resources. Additionally, this study validates results using Panel Quantile Regression, Common Correlated Effect Mean Group, and AMG which shows a negative relation between natural resource rent and emission in BRICS nations.

(Sicen et al., 2022) examines, for the period of 1995 to 2018 the pollution halo and the blessing of natural resources in the economy of the BRICS countries. Panel methodologies are used in the investigation. Findings supported the idea that total natural resource rents contribute to lessening in CO<sub>2</sub> emissions.

(Fu et al., 2023) investigated impact of natural resource rent on CO<sub>2</sub> emission in BRICS nations from 1990 to 2019. The behavior of estimates is seen at multiple conditional quantiles of the carbon emissions when MMQR is employed. The data imply that natural resource rent, are sources of growing emissions in the BRICS region. At lower quantiles, the impact of this variable increases, whereas at higher quantiles, it decreases. The AMG and common correlated effect mean group estimators also support this finding.

This research builds two models for environmental sustainability, each with an ecological footprint and CO<sub>2</sub> emissions, by establishing a theoretical framework. (X. Zhou et al., 2024) takes into account panel data from the BRICS countries since these five significant growing nations need steady economic growth at the lowest possible environmental cost. The years 1994–2018 comprise the data period. The results show that natural resource rent is bad for the sustainability of the ecosystem. Consequently, it is determined that the heedless utilization of natural resources to attain

economic expansion without increasing productivity and green energy is not sustainable from an ecological standpoint.

Using the STIRPAT model as a theoretical foundation, (F. Zhou et al., 2023) examines the influence of NRR on environmental sustainability as indicated by CO<sub>2</sub> discharge and PM2.5 air pollution in BRICS economies between 1995 and 2019. This study is based on second-generation estimators, which include Panel Quantile Regression, AMG, and Common Correlated Effects Mean Group. FMOLS is used for robustness analyses to measure the country-specific impacts. It is revealed that NRR positively drive CO<sub>2</sub> emissions which hinders the BRICS economies' efforts to achieve environmental sustainability.

From the standpoint of the BRICS economies, (Y. Zhang et al., 2024) investigated the linear and non-linear relationships between environmental quality and NRR. The study uses the CS-ARDL and NARDL models for the years 2016–2023. It was discovered that NRR worsens the state of the ecosystem.

Using STIRPAT model, (Voumik et al., 2023) observed the impact of NRR on CO<sub>2</sub> emission in Bangladesh, Pakistan, India, Nepal, and Sri Lanka. Slope heterogeneity (SH) and the cross-sectional dependence (CSD) problem were examined in this study using the second-generation unit root and cointegration tests for the period of 1972 to 2021. As a robustness check, the study used CS-ARDL AMG, MG and CCEMG. The rent from natural resources has caused a decrease in CO<sub>2</sub> emissions in South Asian countries.

(Alola et al., 2023) investigated the association between CO<sub>2</sub> emission and natural resource rents for a sample of 45 developing and transitional economies between 1995 and 2017. Economic dependence on the rents from natural resources increases CO<sub>2</sub> emissions by 0.022%, which means that it increases CO<sub>2</sub> emission.

Rapid economic growth in emerging nations has intensified climatic issues in recent decades, endangering environment. (Amin et al., 2024) examined how CO<sub>2</sub> discharge in the BRICS nations are affected by the rents from natural resources between 1995 and 2021 using CS-ARDL model. Results show that there is a significant 0.840% rise in CO<sub>2</sub> emissions for every 1% increase in natural resource rents.

Countries all around the world strive for economical sustainability, natural resource abundance, and efficient energy use for mitigating the consequences of CO<sub>2</sub> emission and achieve the SDGs. (Bosah et al., 2023) examined the long-term effects of NRR, economic development, and energy consumption on CO<sub>2</sub> emission and their relation across a worldwide panel of 159 countries divided into six continents from 2000 to 2019. In Asia, it has been discovered that the rent from natural resources encourages environmental contamination. The findings of the causality test by continent and by country were mixed.

One of the regions that has been struggling with high emissions and energy consumption, particularly in the past ten years, is Asia. Additionally, one of the influencing factors that degrades the quality of the ecology is NRR. (Sadiq et al., 2023) investigated at how CO<sub>2</sub> discharge was influenced by the NRR in ten Asian economies between 2006 and 2020. Results confirmed that CO<sub>2</sub> discharge and NRR are positively correlated.

(Bekun et al., 2021) studied the influence of NRR on the environmental protection of the G7 economies within the framework of STIRPAT model. It does this by combining QR, AMG, FMOLS and DOLS. It was revealed that, with the exception of Q 0.05, there is a positive and significant correlation between pollution and the whole NRR. This study backs up the claims that the majority of the money generated by natural resources is used to fund increased production, which in turn causes environmental deterioration.

The impact of NRR on CO<sub>2</sub> discharge in the BRICS economies between 1995 and 2022 is examined by (Amin et al., 2025). CS-ARDL model was used to investigate correlations using data from the OECD and WDI. Second-generation advanced panel methods are employed to take into consideration possible cross-sectional dependencies and heterogeneity. It was concluded that CO<sub>2</sub> discharge are made worse by NRR.

H<sub>3</sub>: Natural Resource Rent has a positive relation with CO<sub>2</sub> Emission.

H<sub>4</sub>: Natural Resource Rent has a negative relation with CO<sub>2</sub> Emission.

### **2.3 Green Technology Innovation and CO<sub>2</sub> Emission**

(Ahakwa et al., 2024) checked contribution of sustainable energy consumption, green human capital and green innovation capital to the mitigation of CO<sub>2</sub> emissions and attaining carbon neutrality using data from Ghana from 1980 to 2018. For accurate tests, up-to-date econometric tests are used, and the results variables are stationary and co-integrated over the long term. Using the novel quantile regression, findings show that green innovation reduces CO<sub>2</sub> emissions.

(Habiba et al., 2022) investigated the impact of financial development and GI on CO<sub>2</sub> emission for twelve major emitters covering the data from 1991 to 2018, with the goal of determining how these variables contribute to environmental protection. The authors used the D-H causality test along with second generation econometric tools to achieve this goal. Empirical findings show that green technology innovation lower CO<sub>2</sub> emission. Furthermore, the projections indicate that one of the main causes of the decline in CO<sub>2</sub> emission in the future will be the introduction of green technology innovations.

(Raihan, 2023) looked at how South Korea's greenhouse gas (GHG) emissions are affected by energy use, urbanization, industrialization, economic growth, and technological innovations. The results of empirical research using data from 1990 to 2021 and the ARDL method show that technology innovations enhance environmental sustainability by lowering GHG discharge. Furthermore, results were confirmed through the application of Canonical Cointegration Regression (CCR), DOLS, and FMOLS.

Through the use of carbon dioxide emissions, (Ahakwa et al., 2023) examined how natural resources and innovative green technologies affect environmental degradation. For accuracy and dependability, modern econometric techniques are applied. The study panel is found to be cross-sectionally based and heterogeneous, containing annual data from Asian nations between 1990 and 2019. The relationship between the variables is investigated using the AMG and DCCEMG estimators. Results confirm that advancing green technology innovation slows down environmental deterioration. In order to mitigate environmental degradation, it is advised that Asian countries give priority to guidelines that encourage the expansion and employment of green technology, such as smart grids, energy-efficient building systems, and hybrid cars.

(Qin et al., 2021) examined and assesses how environmental policy, green innovation, the CRI, and R&D in renewable energy contributed to the G7 economies' attainment of carbon neutrality

targets between 1990 and 2019. The outcomes validated the EKC hypothesis's applicability to the economies of the G7. The outcome also demonstrates that green innovation contributes to the reduction of carbon emissions. Moreover, bidirectional causality exists between Co2 emission and green innovation.

In the context of macroeconomic indicators, (Hao & Chen, 2022) investigated how GI affect CO<sub>2</sub> discharge in the E7 countries and whether they may help the countries reach their carbon neutrality goals. Multiple econometric models are applied in the study including FMOLS and DOLS. Empirical data supports existence of a longstanding cointegration amongst variables. However, ARDL results reveal that green innovation does not effect on environmental sustainability.

Using the ARDL model, (Li et al., 2022) attempted to inspect the effect of GI, clean energy investment, and education on environmental sustainability in severely polluted Asian economies during the years 1991–2019. The results suggest that, over time, China, India, and Japan's CO<sub>2</sub> emissions decrease by increasing green innovation. Short-term projections vary. Therefore, in order to reduce CO<sub>2</sub> emissions, governments in polluted economies should spend more in technology.

For BRICS countries, (Udeagha & Muchapondwa, 2023) studied the impact of the CRI, GI and EPS on CO<sub>2</sub> discharge for the time span of 1960 to 2020. Renewable energy research and development (RERD) and Gross Domestic Product (GDP) are being used as control variables. Using the 2<sup>nd</sup> generational CSA- ARDL framework to assess long- and short-run models, the study tackles the issues of cross-sectional dependency and slope heterogeneity. Cointegrating correlations between the research variables are demonstrated by the matching findings. Furthermore, the regression's findings show that GI helps to lower CO<sub>2</sub> discharge over the long run.

The contribution of green technology to environmental sustainability was evaluated in recent research. It highlights that environmentally friendly technologies are the most effective way to carry out resource management in an efficient manner, therefore preventing environmental damage. (Aneja et al., 2023) examined how the G-20 countries' environmental deterioration has been impacted by technical innovation, renewable energy, economic growth and green and sustainable technologies between 1992 and 2018. According to CS-ARDL model estimation results, there is a long-term correlation between the quantity of completed patent applications and

environmental deterioration. Green technology from the G-20 countries is crucial to maintaining the environmental circumstances of the countries that have been chosen.

For Selected European Union nations, (Aydin & Degirmenci, 2023) investigated about how clean energy use, green innovation, and technology diffusion affected environmental sustainability between 1990 and 2018. The LCC model's cointegration was ascertained by applying Westerlund's (2008) panel cointegration test. In conclusion, green innovation is critical to leaving a more habitable world for upcoming generations and to promote the adoption of ecologically friendly activities.

(Behera et al., 2024) investigated the roles played by the usage of renewable energy, green innovation, political stability, and fiscal decentralization in achieving sustainable environment. For reliable empirical analysis, this study used the CSA-ARDL and AMG estimator. The findings show that innovations in green technology have an insignificant effect on CO<sub>2</sub> emissions.

(Kılıçaslan et al., 2024) considered a number of factors that have an impact on environmental quality, including resource depletion, resource taxes, institutional quality, and green innovation. Sustainable Development Goals (SDGs) 7, 12, and 18 deal with these matters. Data from 1994 and 2020 in a sample of 18 nations that are members of the OECD is used. Four steps make up the econometric process: unit root analysis, cointegration analysis, two-method estimation of long-run coefficients, and panel causality analysis. The empirical results imply that green energy innovation has a long-term beneficial effect on the panel's environmental quality.

H<sub>5</sub>: Green Technology Innovation has a positive relation with CO<sub>2</sub> Emission.

H<sub>6</sub>: Green Technology Innovation has a negative relation with CO<sub>2</sub> Emission.

## **2.4 Green Growth and CO<sub>2</sub> Emission**

By Using the CS-ARDL, (Hao et al., 2021) investigated the impact of green growth on CO<sub>2</sub> emissions for G7 nations between 1991 and 2017. According to the results green growth lower CO<sub>2</sub> emissions and policy makers must focus on green growth. These results were also verified by the panel causality test.

The possible impact of China's green growth on CO<sub>2</sub> emissions was investigated by (J. Zhao et al., 2023) Provincial panel data from 2004 to 2018 was used. Conclusions revealed that China's green growth has a promising aspect and has a major detrimental effect on CO<sub>2</sub> emissions.

In order to address environmental issues and accomplish sustainable development objectives, green growth is crucial. By building three distinct models, (Dam et al., 2024) analyzes how institutional quality and green growth affect CO<sub>2</sub> emissions, ecological footprint, and inverse load capacity factor in OECD nations. The study's findings show that green growth has a long-term, considerable mitigating and distinguishing impact on CO<sub>2</sub>. This is demonstrated by the fact that a 1% increase in green growth lowers CO<sub>2</sub> by 0.563%.

(Lin & Ullah, 2024) examined how Pakistan's CO<sub>2</sub> emissions from 1990 to 2020 are affected by energy depletion, green growth, technical cooperation grants, and labor force participation. The STIRPAT framework and innovative dynamic ARDL approaches were employed in this study. KRLS was used to perform a robustness check. Over time, green growth is lowering environmental contamination. The results indicate that the shift to green growth should be a priority for policymakers for reducing CO<sub>2</sub> emission.

(Chien et al., 2021) investigated, within the framework of the United States, the relationship between carbon neutrality goals and green growth. Data were gathered for this purpose between 1970 and 2015. The QARDL technique was used in this study. Green growth, significant and negative impact on both the long-run and short- term estimation of CO<sub>2</sub> emission for the US economy.

(Lin & Ullah, 2023) examined the influence of green innovation, green growth and ICT on CO<sub>2</sub> emission in Pakistan from 1990 to 2020. The findings of the augmented ARDL analysis support green growth which enhances Pakistan's ecological sustainability. Thus, to cut CO<sub>2</sub> emissions and accomplish sustainable development goals, policymakers and officials should concentrate on advancing green growth plan.

For policies improvement and climate change mitigation in Bangladesh, (Akther et al., 2024) investigated the effects of green growth, nonrenewable energy, renewable energy, and innovations in technology on CO<sub>2</sub> in Bangladesh from 1990 to 2020. Green growth has a negative prolonged

influence on carbon emissions in Bangladesh, but a favorable short-term impact, according to the results revealed by ARDL, FMOLS, and canonical cointegration regression.

The G7 nations' strong performance on green growth metrics is a key characteristic. As a result, the question of whether green development can help the G7 achieve their carbon neutrality targets becomes a crucial area of study. (Cetin & Sarigul, 2024) examines the relationship between CO<sub>2</sub> emissions and green growth for the G7 nations between 1990 and 2019. Advanced panel procedures like the Dumitrescu-Hurlin panel causality test, the AMG and Driscoll-Kraay estimators, and the Westerlund test of cointegration are used to conduct the empirical investigations. The results show an extended connection between the variables. CO<sub>2</sub> emissions and green growth have a negative relation. According to the findings, in order to combat environmental pollution, policymakers in the G7 nations should act to boost green growth.

In the framework of 12 Asian economies, (Saleem et al., 2022) examined the effects of green growth on CO<sub>2</sub> emission between 1990 and 2018. This work employed AMG approach for robustness and the CS-ARDL method to determine the effect of green growth on environmental quality. According to the CS-ARDL data, green growth has adverse impact on CO<sub>2</sub> in context of Asian economies. Policymakers should concentrate on changing the nation's energy system in ways that will lower energy-related CO<sub>2</sub> emissions,

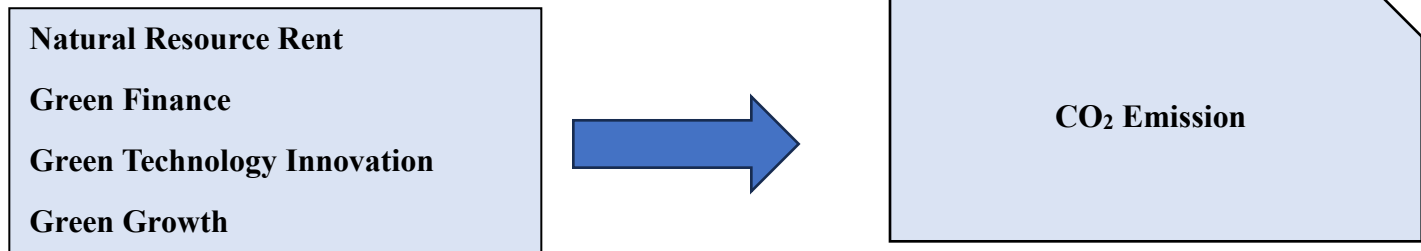
Using sophisticated panel data analysis methods, (Dogan et al., 2022) explored the effects of green growth on CO<sub>2</sub> emissions by incorporating sustainable pointers for a group of 25 eco-friendly nations between 1994 and 2018. Results show that green growth is essential for lowering CO<sub>2</sub> emissions because its coefficients are adverse at lower, medium, and higher quantiles.

China has been under more economic and international pressure to manage its resources responsibly and to focus on resolving significant environmental problems. (L. Huang & Zhao, 2022) examined the affiliation between green trade and green growth in China with regard to the use of energy-related natural resources (oil, gas, and coal) throughout the 1980s–2020s. The influence of the variables on one another was examined using paired Granger causality tests and the ARDL bound test for co-integration. The findings showed that improved green growth of the Chinese economy and green trade policies can lead to a large rise in efficient resource utilization which mitigates environmental damage.

H7: Green Finance has a positive relation with CO<sub>2</sub> Emission

H8: Green Finance has a negative relation with CO<sub>2</sub> Emission

## 2.5 Conceptual Framework



*Figure 2.1 Conceptual Framework*

## CHAPTER 3

### DATA & METHADODOLOGY

---

#### **3.1 Research Design**

The proposed research design selected for this study is quantitative research design, which will be based on secondary data. Quantitative research design allows for collection and analysis of numerical data.

#### **3.2 Research Type**

The research type will be correlational research, as this study will focus on exploring the relationship between green finance, green growth, natural resource rent, green technology innovation and carbon emission in BRICS + economies.

#### **3.3 Research Philosophy**

The positivist research philosophy has been chosen for this investigation. The foundation of positivism is the idea that knowledge may be acquired via scientific observation and empirical evidence.

#### **3.4 Research Approach**

The linkages between green finance, green growth, natural resource rent, green technology innovation and carbon emission will be examined in this study using a deductive approach. Deductive research involves testing a hypothesis through the collection of data.

#### **3.5 Data**

The research aims to examine the impact of green finance, green growth, natural resource rent, and green technology innovation on CO<sub>2</sub> emission. The time period of research is from 2000 to 2024 as per the availability of data. This study has been carried on a panel of BRICS + Economies (Brazil, Russia, Saudi Arabia, Egypt, India, China, South Africa, UAE, Ethiopia, and Iran). It is based on secondary data. All data has been sourced from the World Development Indicator (WDI) and Organization of Economic Cooperation and Development (OECD).

#### **3.6 Methodology**

This research empirically analyses the dynamic effects of Green Technology Innovation, Green Financing, Green Growth and Natural Resource Rent on the CO<sub>2</sub> emission in the BRICS+

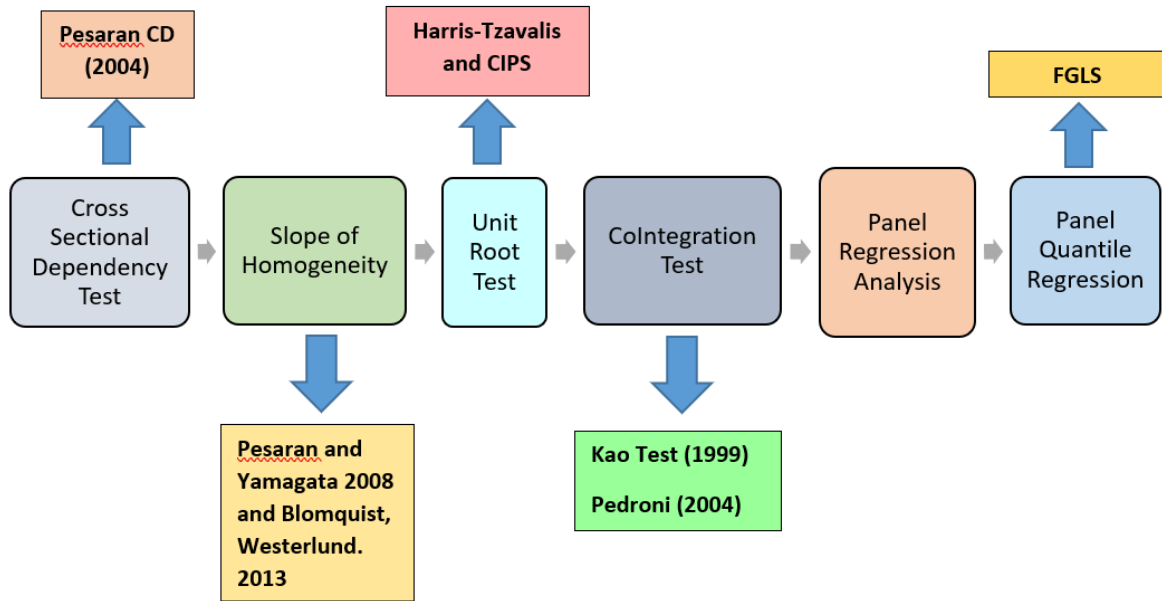
countries. One of the main reasons to select the BRICS+ is that these nations, jointly emit around 38% of the global CO<sub>2</sub> emissions, also represent the primary contributors to the overall global CO<sub>2</sub> emission levels. This does not imply the absence of substitute energy sources to swap for fossil fuels.

In order to accomplish this, we used various techniques including descriptive statistics, Pearson correlation matrix, CIPS unit root test, Harris-Tzavalis unit-root test, Quantile panel regression, and Feasible generalized least squares (FGLS), regression models are employed to incorporate several variables and estimate their relationship with environment sustainability (CO<sub>2</sub>). Quantile regression is employed to estimate the effects of the independent variables on the quantiles of the dependent variable in order to show how the effects of independent variables vary with a different quantile of the dependent variable.

Thus, this study used a multifaceted research design to answer the research question. The first step in the path analysis is to analyze the raw data to provide a summary of the variables using descriptive statistics of the data. Correlation matrix is utilized in order to perform Pearson correlation in order to check for correlations between at least two independent variables and thus determine if there are correlations that could lead to multicollinearity of the variables. Tests of slope heterogeneity is used to detect whether the mean association between variables differed between multiple groups or quantiles, while Pesaran CD test was used to determine the presence of cross section dependence. Unit root tests performed to test for stationarity of variables while cointegration tests are used to inspect long term association between variables.

**Figure 3.1 Estimation methods roadmap.**

*Source: Author*



### 3.7 Econometric model

$$CO2_{it} = \alpha_0 + \beta_1 GG_{it} + \beta_2 NRR_{it} + \beta_3 GTI_{it} + \beta_4 GF_{it} + \mathcal{E}$$

In the above equation, CO<sub>2</sub> denotes Carbon Dioxide Emission, GG is the Green Growth, NRR is the Natural Resource Rent, GTI is Green Technology Innovation, GF is Green Finance,  $\mathcal{E}$  is error term,  $\hat{i}$  and t represent country and time.

**Table 3.1 Variables Description**

<b>Variables</b>	<b>Proxy</b>	<b>Acronym</b>	<b>Source</b>
CO <sub>2</sub> Emission		CO <sub>2</sub>	WDI
Green Technology Innovation	Number of Patents in Environment Related Technology	GTI	OECD
Green Finance	Renewable Energy Consumption (% of total final energy consumption)	GF	WDI
Green Growth	Environment Opportunities and Responses	GG	OECD
Natural Resource Rent		NRR	WDI

## CHAPTER 4

### RESULTS & DISCUSSIONS

---

This section explains the results of the analysis. Table 4.1 shows the summary statistic of the data. Mean, show average value of the data. The deviation of the data from its mean is shown by standard deviation. Scattering of the data is shown by the minimum and maximum.

**Table 4.1 Descriptive statistics**

<b>Variable</b>	<b>Obs</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>
<b>CO<sub>2</sub></b>	250	7.295	6.745	0.053	28.139
<b>GTI</b>	250	18.518	1.532	15.002	21.068
<b>GF</b>	250	21.165	28.323	0.079	95.5
<b>GG</b>	250	1.517	1.021	1.398	3.792
<b>NRR</b>	250	14.800	12.885	0.864	55.024

The analysis of the results reveals that the overall average value of the CO<sub>2</sub> is 7.29 and the smallest values based on which it has been determined can be taken as 0.05 and the largest value as 28.14, thus the dispersion is 6.75. Innovation in green technology has a mean of 18.52 with the corresponding maximum and minimum figure of 21.07 and 15.00 respectively distributed with a standard deviation of 1.53. It can therefore be noted that the descriptive statistic for average green finance is 21.17, minimum value is 0.08, maximum value is 95.5, and standard deviation is 28.32. Green growth value has the minimum of 1.39 to the maximum of 3.792 with mean of 1.52 and dispersion of 1.02. Average natural resource rent is 14.8, its maximum and minimum values are 55.02 and 0.86 respectively. It is distributed with a standard deviation of 12.89.

**Table 4.2 Matrix of Correlation**

	<b>CO<sub>2</sub></b>	<b>GI</b>	<b>GF</b>	<b>GG</b>	<b>NRR</b>
<b>CO<sub>2</sub></b>	1.0000				
<b>GTI</b>	0.0018	1.0000			
<b>GF</b>	-0.6184	-0.0421	1.0000		
<b>GG</b>	-0.2901	0.0902	0.259	1.0000	
<b>NRR</b>	-0.4818	-0.2078	-0.308	-0.1983	1.0000

To express the relationship between two continuous variables we have employed the term “correlation”. The degree of variation in one variable is correlated to change in other variable either in same direction (positive) or inverse direction (negative). The correlation is assessed on the scale that ranges from -1 and +1, where 0 implies the absence of a linear link. Where +1 points to perfect positive association as one variable increases the other variable increases in same direction by the same degree. Whereas for -1, which indicates perfect negative correlation where one variable increases other variable increase in same manner but in inverse direction. When perfect correlation exists, all point exists on straight line. Table 4.2 displays the findings that were obtained by the correlation matrix. As indicated by the findings in the correlation study, CO<sub>2</sub> has a positive relation with green technology innovation but a negative link to with green growth, green finance and natural resource rent among the BRICS+ nations. The correlation matrix demonstrates that GF, GG, and NRR all contribute to a reduction the carbon dioxide emissions while GTI lead to an increase in environmental degradation, due to increased CO<sub>2</sub> emissions.

**Table 4.3 Variance Inflation Factor**

<b>Variable</b>	<b>VIF</b>	<b>1/VIF</b>
<b>NRR</b>	1.18	0.846293
<b>GF</b>	1.18	0.850241
<b>GG</b>	1.1	0.911895
<b>GTI</b>	1.07	0.938695
<b>Mean VIF</b>	1.13	

Occurrence of multicollinearity problem in the variables is analyzed by applying the VIF. The results show that there is no multicollinearity among the variables of interest. All variables, CO<sub>2</sub>, NRR, GF, GTI, and GG have values of VIF below 5 and close to 1, whereas the tolerance values are all greater than 0.20 (ranging from 0.846 to 0.939). The VIF is reported as 1.13, which asserts that no multicollinearity exists and it would not distort the regression estimates.

**Table 4.3 Panel unit root tests**

Variables	Harris-Tzavalis unit-root test		CIPS	
	At Level	At Difference	At Level	At Difference
<b>CO<sub>2</sub></b>	0.9372	0.2991***	-1.191	-3.273***
<b>GTI</b>	1.1956	0.8396***	-3.197***	-5.877***
<b>GF</b>	0.6369	-0.3121***	-1.707	-4.277***
<b>GG</b>	0.8902	0.5176***	-2.699	-5.244***
<b>NRR</b>	0.8846	0.147***	-1.34	-3.827***

To check the stationarity of the variables, panel unit root tests have been conducted. Results from two tests named as **Harris–Tzavalis (HT)** and **CIPS** are shown in the table above. CO<sub>2</sub> emissions, GTI, GF, GG, and NRR are not stationary at level but are stationary at difference at 1% level of significance in the HT test. As reported in the CIPS test, GTI has no unit root problem at level as well as at first difference. Furthermore, CO<sub>2</sub>, GF, GG, and NRR are stationary at difference, but not at level.

**Table 4.4 Test for cross-section dependence in panel data**

<b>Variable</b>	<b>CD-test</b>	<b>p-value</b>	<b>corr</b>	<b>abs(corr)</b>
<b>CO<sub>2</sub></b>	10.13	0.000	0.302	0.559
<b>GF</b>	4.13	0.000	0.123	0.418
<b>NRR</b>	16.9	0.000	0.504	0.556
<b>GTI</b>	9.27	0.000	0.276	0.442
<b>GG</b>	1.81	0.000	-0.054	0.306

Cross sections might demonstrate the same or inverse characteristics; the estimation of cross-sectional dependence (CD) is the beginning for the examination of panel data. This can result in findings that are inaccurate, influenced, and suspicious. Consequently, doing the CD test on the panel data is important before going on to the subsequent analysis.

In table 4.4, the CD test developed by **Pesaran (2004)** is employed to Scrutinize panel dependence. The findings of the CD test disagree with the null hypothesis that there is no cross-sectional dependence, which implies that the variables under scrutiny are interconnected. The results of the CD test demonstrate that the variables of interest have cross-sectional dependency across all the countries of BRICS.

**Table 4.5 Slope homogeneity test**

<b>Pesaran and Yamagata. 2008</b>	<b>Value</b>
$\Delta$	12.15***
$\Delta$ adj.	13.938***

\*p < 0.1, \*\*p < 0.05, \*\*\*p < 0.01

<b>Blomquist, Westerlund. 2013</b>	<b>Value</b>
$\Delta$	10.281***
$\Delta$ adj.	13.938***

\*p < 0.1, \*\*p < 0.05, \*\*\*p < 0.01

The null hypothesis states that slope coefficients are homogenous according to the tests performed in the study; Pesaran, Yamagata (2008) and Blomquist, Westerlund (2013). We can reject the null hypothesis. The results of the test demonstrate that statistical analysis is significantly emphasizing slope coefficients heterogeneities in delta and adjusted delta.

**Table 4.6 Panel Cointegration tests**

	<b>Statistics</b>	<b>P value</b>
Kao test for cointegration		
MDF t	-11.2209	0.000
DF t	-6.8413	0.000
ADF t	-4.2349	0.000
UMDF t	-10.7529	0.000
UDF t	-6.7878	0.000
Pedroni cointegration test		
MPP t	2.025	0.0214
PP t	-2.0083	0.0223
ADF t	-2.1984	0.014

MDF t modified Dicky Fuller t, DF t Dicky Fuller t, ADF t augmented Dicky Fuller t, UMDF t unadjusted modified Dicky Fuller t, UDF t unadjusted Dicky Fuller t, MPP t modified Phillips-Perron t, PP t Phillips Perron t

Cointegration approaches were applied for this study, which portrayed the long-run equilibrium linkage of CO<sub>2</sub> emissions with GTI, GG, GF, and NRR in the BRICS+ nations. Panel co-integration tests generate advanced results in comparison to model estimates based

on individual time series. This is because the model estimation permits for greater liberty in the analysis of time series cross sections, which then creates more reliable results.

As a result, we utilize two different panel cointegration tests, namely the Pedroni test for cointegration (2004) and the cointegration test that Kao et al. (1999) created. These approaches are based upon techniques developed by Engle and Granger (1987). The findings of Kao cointegration tests are shown in the Table. The data gives proof that cointegration does exist between regressors and regressand throughout the BRICS+ nations. In this test, the null hypothesis states, no cointegration.

It was evaluated through an enhanced version of the Dickey-Fuller approach. The alternative hypothesis was also considered. The outcomes of both the Pedroni and the Kao tests suggest that cointegration is significant, pointing towards the existence of integration between the variables of interest. This outcome is coherent with the hypothesis that integration exists. Table outcomes show that cointegration is present, acknowledging the long run association between variables in the research. Significant P-value validates the rejection of  $H_0$ .

**Table 4.7 Panel Quantile Regression**

	PQR		
	Q25	Q50	Q75
<b>GTI</b>	0.2081809*** (0.018192)	0.2554329*** (0.0352)	0.1660236*** (0.0275245)
<b>GF</b>	-0.9714971*** (0.0319821)	-.7232773*** (0.044209)	-1.135642*** (0.0483512)
<b>GG</b>	-0.2469077*** (0.0525975)	-0.2071517*** (0.1046356)	-0.1428973*** (0.0528812)
<b>NRR</b>	-0.2975311*** (0.0562581)	-0.320202*** (0.112405)	-0.5986115*** (0.0871304)
<b>_con</b>	3.053815*** (0.2216926)	2.409791*** (0.3780747)	5.131824*** (0.3484245)
<b>Pseudo R<sup>2</sup></b>	0.7289	0.6069	0.5875
<b>N</b>	250		

\*p < 0.1, \*\*p < 0.05, \*\*\*p < 0.01.

Quantile regression, which is also commonly known as simultaneous regression, is a method that was used to determine the relationship between variables by analyzing the impact on the whole distribution rather than just the central tendency.

According to the table, from quantile 25 through 75 there is a significant inverse correlation between green finance and CO<sub>2</sub> emissions. From the findings of the quantile regression, 1% increase in use of GF is responsible for -0.971%, -0.723%, and -1.136% decrease respectively in the environmental deterioration as measured by the carbon emissions, aligning with the findings of (Udeagha & Ngepah, 2023) who report that GF is a significant contributor to environment sustainability in BRICS+ economies. Moreover, GG and NRR also show a negative correlation to the CO<sub>2</sub> emissions. As documented by (J. Yu et al., 2026) and (Sicen et al., 2022) green growth

and natural resource rent have shown a decrease in CO<sub>2</sub> emissions, and hence aligns with the results of quantile regression.

Furthermore, GTI has a positive impact on CO<sub>2</sub> emission. (J. Yu et al., 2026), states that GTI increases emissions before it starts to reduce it. As per (Cai et al., 2021), GTI can reduce emissions, but may also increase emissions through scale and rebound effects, as efficiency gains stimulate higher production and energy use. The quantile regression results indicate that GTI has a positive and statistically significant impact on CO<sub>2</sub> emissions across all quantiles, with coefficients of 0.208% at Q25, 0.255% at Q50, and 0.166% at Q75. The relatively high effect at the lower quantile reflects the transition phase of BRICS+ economies, where green technologies are introduced alongside existing carbon-intensive systems, leading to increased production and energy use. The effect peaks at the median quantile, suggesting that rapid economic expansion and industrialization intensify scale and rebound effects as efficiency gains encourage output growth. Toward the upper quantile, the declining coefficient indicates that although emissions continue to rise, regulatory pressure, and technological maturity effects begin to moderate the raising impact of green technology innovation. Moreover, the quantile regression results are all significant at 1% level of significance.

**Table 4.8 Feasible Generalized Least Squares**

<b>FGLS</b>		
<b>CO<sub>2</sub></b>	<b>Coefficient</b>	<b>std. errs.</b>
<b>GTI</b>	0.177219***	0.0172735
<b>GF</b>	-1.028523***	0.0303674
<b>GG</b>	-0.1766037***	0.0499421
<b>NRR</b>	-0.4324854***	0.0534178

\*p < 0.1, \*\*p < 0.05, \*\*\*p < 0.01.

FGLS has been applied to confirm the robustness of the expected outcomes. The variables of interest; GF, GG, and NRR all have a negative impact on the carbon emissions, so if there is a 1% increase in them, there will be a -1.028%, -0.176%, -0.432%, decrease in the emissions whereas GTI would increase emissions by 0.172% at 1% level of significance, in the BRICS+ economies respectively. Thus, we can confirm the validation of the results reported by this study.

## CHAPTER 5

### CONCLUSION

---

In this research, relationships between CO<sub>2</sub> emissions, Green Technology Innovation (GTI), Green Growth (GG), Green Finance (GF) and Natural Resource Rent (NRR) in a panel of 10 BRICS countries (Brazil, UAE, Egypt, Russia, India, China, Iran, Saudi Arabia, Ethiopia, and South Africa) with a dataset spanning from 2000-2024 is examined.

Quantile regression from quantile 25 to quantile 75 is used to scrutinize the relationship between variables. Existence of cointegration among variables is showcased using Pedroni, Kao test. Moreover, robustness of the quantile regression estimators has been confirmed by FGLS. In addition, the CIPS test and Harris-Tzavalis test is utilized in the panel unit root test to find out whether variables of interest are stationary. The results of quantile regression show that, there is a significant connection between the variables of the research, that remains consistent over the quantiles. Increase in GG, GF, and NRR, promote environmental sustainability whereas GTI degrades the environment. Results of FGLS are statistically significant at 1% and confirm robustness of variables and results of the quantile regression.

The rapidly developing BRICS economies are experiencing progressive economic growth and rise in technological innovation due to which the increasing level of CO<sub>2</sub> emissions are destroying the environment. To strive against the current economic hurdles, economic growth in the BRICS countries should be achieved with essential policies and regulations that will protect the environment. The outcomes of this research suggest implementation of appropriate policies to stimulate green investments and initiatives to conserve the environment.

Policy makers should implement policies that align with the UN Sustainable Development Goals (SDGs). BRICS nations should encourage SDGs of Affordable and Clean Energy (SDG 7), Industry, Innovation, and Infrastructure (SDG 9), Climate action (SDG 13).

Responsible development of policies implemented, that will foster green economic growth, environment related technologies, green energy sources and encourage to use the rents from utilizing the natural resources to fund green projects to protect the environment and fulfil SDGs by the year 2030.

## **5.1 Theoretical Implication**

Resource theory of sustainable finance, stating that countries having advance Fintech systems, awareness about sustainability and investors willing to invest in green financial products can easily achieve sustainable finance goals (Morelli, 2011). This study has conducted analysis on green finance which supports the argument made by the resource theory of sustainable finance, that eagerness to invest in sustainable financial products lead towards sustainable financing preventing environmental deterioration.

## **5.2 Practical Implication**

The study carries significant practical implications for policymakers, providing valuable insights that can guide actions to foster environmental sustainability through, Green Growth, Natural Resource Rent, Green Finance, and right use of Green Technological Innovation. Policymakers are urged to prioritize green growth through government grants, academic partnerships and enhance regulatory framework for the nurturing of environment.

The empirical findings of the study have important applications that align with the Sustainable Development Goals of the United Nations, particularly SDG 7 (Affordable and Clean energy), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 13 (Climate Action). The results demonstrate that green growth and green financing play a critical role in promoting sustainable industrialization and resilient infrastructure by facilitating the adoption of clean, energy-efficient technologies and encouraging environmentally responsible investment in BRICS+ economies. Green technology innovation's increasing effects on CO<sub>2</sub> emissions point to the existence of scale and rebound effects in the BRICS<sup>+</sup> economies. In order to guarantee that green technology result in actual emission reductions rather than increased energy consumption, innovation strategies should be supplemented by regulatory compliance, and targeted incentives.

In line with SDG 9, this directly supports the modernization of industrial systems. Additionally, the positive effects of green growth suggest that economic development in underdeveloped countries can be achieved without worsening environmental degradation, which supports the integration of sustainability into development plans. Simultaneously, the management of natural resource rents becomes a crucial instrument for policy since it may successfully reinvest resource

earnings into green infrastructure and innovation, so reducing the carbon-intensive effects normally associated with resource-dependent growth.

These findings collectively emphasize the significance of coordinated green finance, innovation-driven growth policies, and practical resource governance for reducing CO<sub>2</sub> emissions and boosting climate mitigation efforts, thereby supporting the implementation of SDG 13 strategies, by incorporating climate action into national economic and industrial strategies across BRICS+ economies.

### **5.3 Limitations and Recommendations**

This study utilized secondary data from various sources like the WDI, and OECD which may have inherent limitations in accuracy and completeness. Potential discrepancies could arise due to variations in data collection methods, reporting standards, and availability across different countries. Careful interpretation and acknowledgment of potential biases within these sources are crucial.

This study was conducted on BRICS + economies consisting of 10 nations. For future researches the panel of countries can be extended for capturing greater impact on environmental sustainability.

This study measured green finance through renewable energy consumption (% of total final energy consumption), in future researches green finance index can be constructed as an alternate proxy.

Moreover, this study applied panel quantile regression and FGLS for data analysis, for future researches more advanced econometric techniques like DOLS or FMOLS could provide more detailed insights regarding the results.

## REFERENCES

---

- Adebayo, T. S., Kartal, M. T., Ağa, M., & Al-Faryan, M. A. S. (2023). Role of country risks and renewable energy consumption on environmental quality: Evidence from MINT countries. *Journal of Environmental Management*, 327, 116884. <https://doi.org/10.1016/J.JENVMAN.2022.116884>
- Ahakwa, I., Tackie, E. A., Tackie, F. K., Mangudhla, T., Baig, J., Islam, S. ul, & Sarpong, F. A. (2024). Greening the path to carbon neutrality in the post-COP26 era: Embracing green energy, green innovation, and green human capital. *Innovation and Green Development*, 3(3), 100134. <https://doi.org/10.1016/J.IGD.2024.100134>
- Ahakwa, I., Xu, Y., Tackie, E. A., Odai, L. A., Sarpong, F. A., Korankye, B., & Ofori, E. K. (2023). Do natural resources and green technological innovation matter in addressing environmental degradation? Evidence from panel models robust to cross-sectional dependence and slope heterogeneity. *Resources Policy*, 85, 103943. <https://doi.org/10.1016/J.RESOURPOL.2023.103943>
- Akther, S., Sultanuzzaman, M. R., Zhang, Y., Almutlaq, F., & Huq, M. E. (2024). Exploring the influence of green growth and energy sources on “carbon-dioxide emissions”: implications for climate change mitigation. *Frontiers in Environmental Science*, 12. <https://doi.org/10.3389/fenvs.2024.1443915>
- Al Mamun, M., Boubaker, S., & Nguyen, D. K. (2022). Green finance and decarbonization: Evidence from around the world. *Finance Research Letters*, 46, 102807. <https://doi.org/10.1016/J.FRL.2022.102807>
- Alola, A., L. E., Gyamfi, B., & Bekun, F. (2023). Toward sustainable use of natural resources: Nexus between resource rents, affluence, energy intensity and carbon emissions in developing and transition economies. *A United Nations Sustainable Development Journal*.

- Amin, N., Sharif, A., Shabbir, M. S., & Pan, Y. (2025). Evaluating the impact of natural resource rents, R&D expenditures, green finance and energy efficiency on carbon emissions in BRICS economies: Greening the path to carbon neutrality in the post-COP 27 era. *Technology in Society*, 81, 102826. <https://doi.org/10.1016/J.TECHSOC.2025.102826>
- Amin, N., Sharif, A., & Tayyab, M. (2024). Green Technological Advances and Resource Rents as Levers for Carbon Reduction in BRICS: Implications for SDGs 7, 8, 9, 12, and 13. *Sustainable Development*.
- Aneja, R., Yadav, M., & Gupta, S. (2023). The dynamic impact assessment of clean energy and green innovation in realizing environmental sustainability of G-20. *Sustainable Development*.
- Asif, M., Li, J. Q., Zia, M. A., Hashim, M., Bhatti, U. A., Bhatti, M. A., & Hasnain, A. (2024). Environmental Sustainability in BRICS Economies: The Nexus of Technology Innovation, Economic Growth, Financial Development, and Renewable Energy Consumption. *Sustainability (Switzerland)*, 16(16). <https://doi.org/10.3390/su16166934>
- Atif Nawaz, M., Seshadri, U., Kumar, P., Aqdas, R., Ataul, &, Patwary, K., & Riaz, M. (n.d.). *Nexus between green finance and climate change mitigation in N-11 and BRICS countries: empirical estimation through difference in differences (DID) approach*. <https://doi.org/10.1007/s11356-020-10920-y>/Published
- Aydin, M., & Degirmenci, T. (2023). The impact of clean energy consumption, green innovation, and technological diffusion on environmental sustainability: New evidence from load capacity curve hypothesis for 10 European Union countries. *Sustainable Development*.
- Bakry, W., Mallik, G., Nghiem, X. H., Sinha, A., & Vo, X. V. (2023). Is green finance really “green”? Examining the long-run relationship between green finance, renewable energy and environmental performance in developing countries. *Renewable Energy*, 208, 341–355. <https://doi.org/10.1016/J.RENENE.2023.03.020>
- Behera, P., Behera, B., Sethi, N., & Handoyo, R. (2024). What drives environmental sustainability? The role of renewable energy, green innovation, and political stability in OECD economies. *International Journal of Sustainable Development & World Ecology* .

- Bekun, F., Onifade, S., & Gyamfi, B. (2021). Environmental Science and Pollution Research . *Environmental Science and Pollution Research* .
- Bosah, C. P., Li, S., Ampofo, G. K. M., & Sangare, I. (2023). A continental and global assessment of the role of energy consumption, total natural resource rent, and economic growth as determinants of carbon emissions. *Science of The Total Environment*, 892, 164592. <https://doi.org/10.1016/J.SCITOTENV.2023.164592>
- Cai, A., Zheng, S., Cai, L. H., Yang, H., & Comite, U. (2021). How Does Green Technology Innovation Affect Carbon Emissions? A Spatial Econometric Analysis of China's Provincial Panel Data. *Frontiers in Environmental Science*, 9. <https://doi.org/10.3389/fenvs.2021.813811>
- Cao, L. (2023). How green finance reduces CO2 emissions for green economic recovery: empirical evidence from E7 economies. *Environmental Science and Pollution Research*, 30(2), 3307–3320. <https://doi.org/10.1007/s11356-022-22365-6>
- Cetin, M., & Sarigul, S. (2024). The green growth-CO2 emissions link in G7 countries: the role of energy productivity. *International Journal of Environmental Science and Technology* .
- Chien, F., Ananzeh, M., Mirza, F., Bakar, A., Vu, H. M., & Ngo, T. Q. (2021). The effects of green growth, environmental-related tax, and eco-innovation towards carbon neutrality target in the US economy. *Journal of Environmental Management*, 299, 113633. <https://doi.org/10.1016/J.JENVMAN.2021.113633>
- Chiroleu-Assouline, M., Fodha, M., & Kirat, Y. (2020). Carbon curse in developed countries. *Energy Economics*, 90, 104829. <https://doi.org/10.1016/J.ENERCO.2020.104829>
- Dam, M. M., Durmaz, A., Bekun, F. V., & Tiwari, A. K. (2024). The role of green growth and institutional quality on environmental sustainability: A comparison of CO2 emissions, ecological footprint and inverted load capacity factor for OECD countries. *Journal of Environmental Management*, 365, 121551. <https://doi.org/10.1016/J.JENVMAN.2024.121551>

- Dogan, E., Hodžić, S., & Šikić, T. F. (2022). A way forward in reducing carbon emissions in environmentally friendly countries: the role of green growth and environmental taxes. *Economic Research-Ekonomska Istraživanja*, 35(1), 5879–5894. <https://doi.org/10.1080/1331677X.2022.2039261>
- Erkiliç, E., Gazeloğlu, C., & Özgören Ünlü, E. (2025). Renewable Energy Solution to Carbon Emissions: BRICS Countries in the Grip of Globalization and Economic Growth. *Sustainability (Switzerland)*, 17(9). <https://doi.org/10.3390/su17094117>
- Estimating CO2 Emissions Embodied in Final Demand and Trade Using the OECD ICIO 2015: Vol. 2016/05* (OECD Science, Technology and Industry Working Papers). (2016). <https://doi.org/10.1787/5jlrcm216xkl-en>
- Fu, H., Guo, W., Sun, Z., & Xia, T. (2023). Asymmetric impact of natural resources rent, monetary and fiscal policies on environmental sustainability in BRICS countries. *Resources Policy*, 82, 103444. <https://doi.org/10.1016/J.RESOURPOL.2023.103444>
- Gorji, S., & Gorji, A. (n.d.). *COVID-19 pandemic: the possible influence of the long-term ignorance about climate change*. <https://doi.org/10.1007/s11356-020-12167-z/Published>
- Habiba, U., Xinbang, C., & Anwar, A. (2022). Do green technology innovations, financial development, and renewable energy use help to curb carbon emissions? *Renewable Energy*, 193, 1082–1093. <https://doi.org/10.1016/J.RENENE.2022.05.084>
- Haciimamoğlu, T., & Cengiz, V. (2024). Are Natural Resource Rents and Renewable Energy Consumption Solutions for Environmental Degradation? Fresh Insights from a Modified Ecological Footprint Model. *Sustainability (Switzerland)*, 16(7). <https://doi.org/10.3390/su16072736>
- Han, F., Ibrahim, R. L., Al-Mulali, U., & Al-Faryan, M. A. S. (2024). Tracking the roadmaps to sustainability: what do the symmetric effects of eco-digitalization, green technology, green finance, and renewable energy portend for China? *Environment, Development and Sustainability*, 26(6), 13895–13919. <https://doi.org/10.1007/s10668-023-04289-4>

- Hao, L. N., Umar, M., Khan, Z., & Ali, W. (2021). Green growth and low carbon emission in G7 countries: How critical the network of environmental taxes, renewable energy and human capital is? *Science of The Total Environment*, 752, 141853. <https://doi.org/10.1016/J.SCITOTENV.2020.141853>
- 'Hao, Y., & 'Chen, P. (2022). Do renewable energy consumption and green innovation help to curb CO2 emissions? Evidence from E7 countries. *Springer Nature*. <https://doi.org/10.1007/s11356-022-23723-0>
- Hojnik, J., Ruzzier, M., Konečnik Ruzzier, M., Sučić, B., & Soltwisch, B. (2023). Challenges of demographic changes and digitalization on eco-innovation and the circular economy: Qualitative insights from companies. *Journal of Cleaner Production*, 396. <https://doi.org/10.1016/j.jclepro.2023.136439>
- Huang, F. (2023). How does trade and fiscal decentralization leads to green growth; role of renewable energy development. *Renewable Energy*, 214, 334–341. <https://doi.org/10.1016/J.RENENE.2023.05.116>
- Huang, L., & Zhao, W. (2022). The impact of green trade and green growth on natural resources. *Resources Policy*, 77, 102749. <https://doi.org/10.1016/J.RESOURPOL.2022.102749>
- Huang, S. Z., Chau, K. Y., Chien, F., & Shen, H. (2020). The impact of startups' dual learning on their green innovation capability: The effects of business executives' environmental awareness and environmental regulations. *Sustainability (Switzerland)*, 12(16). <https://doi.org/10.3390/su12166526>
- Ibrahim, R., Huang, Y., Mohammed, A., & Adebayo, T. (2022). Natural resources-sustainable environment conflicts amidst COP26 resolutions: investigating the role of renewable energy, technology innovations, green finance, and structural change. *International Journal of Sustainable Development & World Ecology*, 30.
- Ibrahim, R. L., & Ajide, K. B. (2021). The dynamic heterogeneous impacts of nonrenewable energy, trade openness, total natural resource rents, financial development and regulatory quality

- on environmental quality: Evidence from BRICS economies. *Resources Policy*, 74, 102251. <https://doi.org/10.1016/J.RESOURPOL.2021.102251>
- Iqbal, S., Taghizadeh-Hesary, F., Mohsin, M., & Iqbal, W. (2021). Assessing the Role of the green finance index in environmental pollution reduction. *Estudios de Economia Aplicada*, 39(3). <https://doi.org/10.25115/eea.v39i3.4140>
- Khan, M. A., Riaz, H., Ahmed, M., & Saeed, A. (2022). Does green finance really deliver what is expected? An empirical perspective. *Borsa Istanbul Review*, 22(3), 586–593. <https://doi.org/10.1016/J.BIR.2021.07.006>
- Khan, S., Akbar, A., Nasim, I., Hedvičáková, M., & Bashir, F. (2022). Green finance development and environmental sustainability: A panel data analysis. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.1039705>
- Kılıçaslan, H., Aydın, M., Inal, V., Teksan, E., & Torusdag, M. (2024). A step towards sustainable environment in OECD countries: Do natural resource depletion, resource tax, institutional quality, and green innovation matter? *Natural Resources Forum*. <https://doi.org/10.1111/1477-8947.12515>
- Li, L., Li, G., Ozturk, I., & Ullah, S. (2022). Green innovation and environmental sustainability: Do clean energy investment and education matter? *Sage Journals*.
- Lin, B., & Ullah, S. (2023). Towards the goal of going green: Do green growth and innovation matter for environmental sustainability in Pakistan. *Energy*, 285, 129263. <https://doi.org/10.1016/J.ENERGY.2023.129263>
- Lin, B., & Ullah, S. (2024). Effectiveness of energy depletion, green growth, and technological cooperation grants on CO2 emissions in Pakistan's perspective. *Science of The Total Environment*, 906, 167536. <https://doi.org/10.1016/J.SCITOTENV.2023.167536>
- Lisha, L., Mousa, S., Arnone, G., Muda, I., Huerta-Soto, R., & Shiming, Z. (2023). Natural resources, green innovation, fintech, and sustainability: A fresh insight from BRICS. *Resources Policy*, 80, 103119. <https://doi.org/10.1016/J.RESOURPOL.2022.103119>

- Liu, Y., Sohail, M. T., Khan, A., Muhammad, &, & Majeed, T. (n.d.). *Environmental benefit of clean energy consumption: can BRICS economies achieve environmental sustainability through human capital?* <https://doi.org/10.1007/s11356-021-16167-5>/Published
- Nathaniel, S., & Rehman Khan, S. A. (2020). The nexus between urbanization, renewable energy, trade, and ecological footprint in ASEAN countries. *Journal of Cleaner Production*, 272.
- Omokanmi, O. J., Ibrahim, R. L., Ajide, K. B., & Al-Faryan, M. A. S. (2022). Exploring the dynamic impacts of natural resources and environmental pollution on longevity in resource-dependent African countries: Does income level matter? *Resources Policy*, 79, 102959. <https://doi.org/10.1016/J.RESOURPOL.2022.102959>
- Peng, G., Meng, F., Ahmed, Z., Ahmad, M., & Kurbonov, K. (2022). Economic growth, technology, and CO2 emissions in BRICS: Investigating the non-linear impacts of economic complexity. *Environmental Science and Pollution Research*, 29(45), 68051–68062. <https://doi.org/10.1007/s11356-022-20647-7>
- Qin, L., Kirikkaleli, D., Hou, Y., Miao, X., & Tufail, M. (2021). Carbon neutrality target for G7 economies: Examining the role of environmental policy, green innovation and composite risk index. *Journal of Environmental Management*, 295, 113119. <https://doi.org/10.1016/J.JENVMAN.2021.113119>
- Raihan, A. (2023). Nexus between greenhouse gas emissions and its determinants: The role of renewable energy and technological innovations towards green development in South Korea. *Innovation and Green Development*, 2(3), 100066. <https://doi.org/10.1016/J.IGD.2023.100066>
- Ren, X., Shao, Q., & Zhong, R. (2020). Nexus between green finance, non-fossil energy use, and carbon intensity: Empirical evidence from China based on a vector error correction model. *Journal of Cleaner Production*, 277, 122844. <https://doi.org/10.1016/J.JCLEPRO.2020.122844>
- Sadiq, M., Chavali, K., Kumar, V. V. A., Wang, K. T., Nguyen, P. T., & Ngo, T. Q. (2023). Unveiling the relationship between environmental quality, non-renewable energy usage and natural

- resource rent: Fresh insights from ten asian economies. *Resources Policy*, 85, 103992. <https://doi.org/10.1016/J.RESOURPOL.2023.103992>
- Saleem, H., Khan, B., & Mahdavian, M. (2022). The role of green growth, green financing, and eco-friendly technology in achieving environmental quality: evidence from selected Asian economies. *Environmental Science and Pollution Research* .
- Sethi, L., Behara, B., & Sethi, N. (2023). Do green finance, green technology innovation, and institutional quality help achieve environmental sustainability? Evidence from the developing economies. *Sustainable Development*.
- Sicen, L., Khan, A., & Kakar, A. (2022). The Role of Disaggregated Level Natural Resources Rents in Economic Growth and Environmental Degradation of BRICS Economies. *Biophysical Economics and Sustainability* .
- Sinha, A., Mishra, S., Sharif, A., & Yarovaya, L. (2021). Does green financing help to improve environmental & social responsibility? Designing SDG framework through advanced quantile modelling. *Journal of Environmental Management*, 292, 112751. <https://doi.org/10.1016/J.JENVMAN.2021.112751>
- Sohail, M. T., Ullah, S., Majeed, M. T., & Usman, A. (n.d.). *Pakistan management of green transportation and environmental pollution: a nonlinear ARDL analysis*. <https://doi.org/10.1007/s11356-021-12654-x/Published>
- Su, C. W., Xie, Y., Shahab, S., Faisal, C. M. N., Hafeez, M., & Qamri, G. M. (2021). Towards achieving sustainable development: Role of technology innovation, technology adoption and co2 emission for brics. *International Journal of Environmental Research and Public Health*, 18(1), 1–14. <https://doi.org/10.3390/ijerph18010277>
- Sun, Y., Anwar, A., Razzaq, A., Liang, X., & Siddique, M. (2022). Asymmetric role of renewable energy, green innovation, and globalization in deriving environmental sustainability: Evidence from top-10 polluted countries. *Renewable Energy*, 185, 280–290. <https://doi.org/10.1016/J.RENENE.2021.12.038>

- Tang, M., Cao, A., Guo, L., & Li, H. (2023). Improving agricultural green total factor productivity in China: do environmental governance and green low-carbon policies matter? *Environmental Science and Pollution Research*, 30(18), 52906–52922. <https://doi.org/10.1007/s11356-023-26090-6>
- Tokpunar, S., & Dalgıç, B. (2024). Relationship Between Green Complexity and Carbon Dioxide Emissions: Evidence from Global Panel Data. *Polish Journal of Environmental Studies*, 33(6), 6373–6387. <https://doi.org/10.15244/pjoes/183854>
- Trade, O., & Working, E. (2017). *International trade consequences of climate change*. <https://doi.org/10.1787/9f446180-en>
- Udeagha, M. C., & Muchapondwa, E. (2023a). Achieving green environment in Brazil, Russia, India, China, and South Africa economies: Do composite risk index, green innovation, and environmental policy stringency matter? *Sustainable Development*, 31(5), 3468–3489. <https://doi.org/10.1002/sd.2597>
- Udeagha, M. C., & Muchapondwa, E. (2023b). Environmental sustainability in South Africa: Understanding the criticality of economic policy uncertainty, fiscal decentralization, and green innovation. *Sustainable Development*, 31(3), 1638–1651. <https://doi.org/10.1002/sd.2473>
- Udeagha, M. C., & Ngepah, N. (2023). The drivers of environmental sustainability in BRICS economies: Do green finance and fintech matter? *World Development Sustainability*, 3, 100096. <https://doi.org/10.1016/J.WDS.2023.100096>
- Ullah, S., Luo, R., Adebayo, T. S., & Kartal, M. T. (2024). Paving the ways toward sustainable development: the asymmetric effect of economic complexity, renewable electricity, and foreign direct investment on the environmental sustainability in BRICS-T. *Environment, Development and Sustainability*, 26(4), 9115–9139. <https://doi.org/10.1007/s10668-023-03085-4>

- Voumik, L., Memi, M., & Raihan, A. (2023). Nexus Between Urbanization, Industrialization, Natural Resources Rent, and Anthropogenic Carbon Emissions in South Asia: CS-ARDL Approach. *Anthropocene Science*.
- Wei, H., Yue, G., & Khan, N. U. (2024). Uncovering the impact of Fintech, Natural Resources, Green Finance and Green Growth on Environment sustainability in BRICS: An MMQR analysis. *Resources Policy*, *89*, 104515. <https://doi.org/10.1016/J.RESOURPOL.2023.104515>
- Xinhui Lu, & Zirui Lu. (2024). How does green technology innovation affect urban carbon emissions? Evidence from Chinese cities, *Energy and Buildings*. *Science Direct*, *325*.
- Yang, Y., Su, X., & Yao, S. (2021). Nexus between green finance, fintech, and high-quality economic development: Empirical evidence from China. *Resources Policy*, *74*, 102445. <https://doi.org/10.1016/J.RESOURPOL.2021.102445>
- Yu, J., Long, H., Shahzad, I., & wang, J. (2026). Driving sustainable development in BRICS through green finance and economic growth: A quantile regression perspective. *Journal of Innovation and Knowledge*, *11*. <https://doi.org/10.1016/j.jik.2025.100879>
- Yu, Y. (2023). Role of Natural resources rent on economic growth: Fresh empirical insight from selected developing economies. *Resources Policy*, *81*, 103326. <https://doi.org/10.1016/J.RESOURPOL.2023.103326>
- Yuerong, H., Javaid, M. Q., Ali, M. S. e., & Zada, M. (2024). Revisiting the nexus between digital trade, green technological innovation, and environmental sustainability in BRICS economies. *Environmental Science and Pollution Research*, *31*(6), 8585–8607. <https://doi.org/10.1007/s11356-023-31661-8>
- Zhang, D., Mohsin, M., & Taghizadeh-Hesary, F. (2022). Does green finance counteract the climate change mitigation: Asymmetric effect of renewable energy investment and R&D. *Energy Economics*, *113*, 106183. <https://doi.org/10.1016/J.ENERCO.2022.106183>

- Zhang, L., Berk Saydaliev, H., & Ma, X. (2022). Does green finance investment and technological innovation improve renewable energy efficiency and sustainable development goals. *Renewable Energy*, *193*, 991–1000. <https://doi.org/10.1016/J.RENENE.2022.04.161>
- Zhang, Q., Adebayo, T., Ibrahim, R., & Al-Faryan, M. (2022). Do the asymmetric effects of technological innovation amidst renewable and nonrenewable energy make or mar carbon neutrality targets? *International Journal of Sustainable Development & World Ecology*, *30*.
- Zhang, Y., Zheng, K., Xia, F., & Cheng, Z. (2024). Fintech, natural resource rents, renewable energy consumption and environmental quality: A perspective of green economic recovery from BRICS economies. *Resources Policy*, *89*, 104604. <https://doi.org/10.1016/J.RESOURPOL.2023.104604>
- Zhao, J., Taghizadeh-Hesary, F., Dong, K., & Dong, X. (2023). How green growth affects carbon emissions in China: the role of green finance. *Economic Research-Ekonomika Istrazivanja*, *36*(1), 2090–2111. <https://doi.org/10.1080/1331677X.2022.2095522>
- Zhao, X., Adebayo, T. S., Kong, X., & Al-Faryan, M. A. S. (2022). Relating energy innovations and natural resources as determinants of environmental sustainability: The role of globalization in G7 countries. *Resources Policy*, *79*, 103073. <https://doi.org/10.1016/J.RESOURPOL.2022.103073>
- Zhou, F., Ibrahim, R., & Samsurijan, M. (2023). An assessment of the aggregated and disaggregated effects of natural resources rents on environmental sustainability in BRICS economies. *International Journal of Sustainable Development & World Ecology*.
- Zhou, X., Patel, G., Mahalik, M. K., & Gozgor, G. (2024). Effects of green energy and productivity on environmental sustainability in BRICS economies: The role of natural resources rents. *Resources Policy*, *92*, 105026. <https://doi.org/10.1016/J.RESOURPOL.2024.105026>
- Zhu, J., Yao, W., Liu, F., & Qi, Y. (2025). Has Green Technological Innovation Become an Accelerator of Carbon Emission Reductions? *Sustainability (Switzerland)*, *17*(16). <https://doi.org/10.3390/su17167499>

Zhu, R., Xu, Q., Xiqiang, X., Sibt-e-Ali, M., Waqas, M., Ullah, I., & Anwar, A. (2024). Role of resources rent, research and development, and information and communication technologies on CO2 emissions in BRICS economies. *Resources Policy*, 93, 105072. <https://doi.org/10.1016/J.RESOURPOL.2024.105072>