Financial Development, Renewable Energy and Carbon Emissions: The Role of Institutional Quality

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SCHOOL OF ECONOMICS,

QUAID-I-AZAM UNIVERSITY, ISLAMABAD

2023

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A thesis submitted to the Quaid-i-Azam University, Islamabad, in partial fulfillment of the requirements for the award of the degree of Master of Philosophy in Economics.

SCHOOL OF ECONOMICS,

QUAID-I-AZAM UNIVERSITY, ISLAMABAD

2023


بسم الله الرحمن الرحيم
In The Name of ALLAH,
The Most Gracious and The Most Merciful

Certificate

This is to certify that the thesis titled **"Financial Development, Renewable Energy and Carbon Emissions: The Role of Institutional Quality"** submitted by Ayesha Rehman, Registration number 02092113021 is accepted in its present form by the School of Economics, Quaid-i-Azam University, Islamabad, as satisfying all the requirements for the partial fulfillment of the degree of Master of Philosophy in Economics.

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Declaration

I, Ayesha Rehman, daughter of Aziz-ur-Rehman, Registration # 02092113021, student of MPhil Economics at the School of Economics, Quaid-i-Azam University, Islamabad, do hereby declare that the thesis ***"Financial Development, Renewable Energy and Carbon Emissions: The Role of Institutional Quality"*** submitted for the partial fulfillment of Master of Philosophy (MPhil) degree in Economics, is my own work. All the errors and omissions are purely on my part, and I also somberly pronounce that it will not be submitted for attaining any other degree in the future from any institution.

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DEVOTION

This thesis is dedicated to my family whose unconditional support and encouragement have been the cornerstones of my path. Their belief in my capabilities strengthened my desire to pursue this academic journey. Devotion to my kids, whose twinkling eyes gave me the courage to light a candle of my own. I hope that this effort of mine serves as a testament to their perseverance and trust in my capacity to succeed.

ACKNOWLEDGMENT

All praises of worthiness belong to **ALLAH** Almighty my creator and guide, and to the noble messenger, **Prophet Muhammad** (peace be upon him), who lights up our path with the wisdom of life's meaning. I extend my heartfelt gratitude to my advisor, Dr. Tariq Majeed, whose guidance and expertise have been instrumental in shaping the trajectory of this research. His insightful feedback and thought-provoking discussions have illuminated my path and refined the focus of this thesis.

I express my heartfelt gratitude to my parents for their contributions to the completion of this thesis. I am thankful for the sincere guidance of my seniors and my friends who have been there through thick and thin to help me in every possible manner. Indeed, I am blessed to have all of them in my life.

Thank you for all the support and encouragement.

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Abbreviations	**Words**
GHG	Green House Gases
CO_2	Carbon-Dioxide
SDGs	Sustainable Development Goals
FD	Financial Development
REC	Renewable Energy Consumption
IQ	Institutional Quality
IMF	International Monetary Fund
IFS	International Financial Statistics
WDI	World Development Indicators
OLS	Ordinary Least Square
SGMM	System Generalized Method of Moments

ABSTRACT

Amidst the pressing global concern of climate change, efforts are being made worldwide to mitigate the risks associated with climate change by switching to alternative cleaner energy sources under the supervision of strict regulatory authorities paving the path to sustainability. This study explores the intricate relationships of financial development, renewable energy, institutional quality, and their joint effect on carbon emissions by using panel data from diverse geographical locations i.e. across the globe and for the continents of Asia, Africa, and Europe from 1990 to 2020. The robust theoretical framework followed by an empirical analysis employing econometric techniques of pooled OLS, fixed and random effects, and then a two-step System GMM uncover the dynamic interaction among variables and their influence on environmental quality. The results reveal that financial development exacerbates environmental quality in the form of increased carbon emissions in all regions except Europe while renewable energy consumption and institutional quality result in the upgradation of the environment. The moderation effect of institutional quality sheds light on how institutional reforms can aid in shaping financial institutions by redirecting their investments to green growth projects curbing carbon emissions and leading to sustainable development across the globe and continents. The findings in this study can be used as a road map by policymakers, businesses, and researchers to design and implement effective policies that align with global sustainability development goals.

Keywords: Financial development, Renewable energy consumption, Institutional Quality, Carbon emissions. System GMM

Chapter 1

Introduction

"Energy is the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive."

Dr. Fatih Birol, International Energy Agency (IEA)

1.1. Background

The economic and demographic developments across the globe all need energy as the basic input. The macroeconomic assessment of any nation depends on the performance of key indicators like GDP, employment, price stability, the balance of trade, etc., all of them being dependent on the provision of energy services. Thus, a continuous flow of energy is of vital importance for all economic activities to prosper and aid in the process of development. The rapid economic growth characterized by industrialization and technological advancement in the past was mainly driven by the energy produced by fossil fuels like coal and oil which led to the deterioration of the quality of life by increasing the emission of greenhouse gases (Hunjra et al., 2020; Yamaka et al., 2021; Khan et al., 2021; Ahmed et al., 2020). One of the primary contributors to pollution among other greenhouse gases is carbon dioxide (CO_2) which accounts for at least 75% of the worldwide emissions (Our World in Data, 2022). These rising temperatures and adverse climatic conditions led the 'think tank' to propose substituting fossil fuels with renewable energy sources, which are now inevitable for attaining Sustainable development goals (Chen et al., 2022). This signifies the importance of renewable energy in meeting the rising energy demands in the case of the fastest-growing economies and the estimated price elasticity of these variables helps in designing an effective energy policy for economic development.

The inevitable role of energy in each sector of our life and its ever-increasing demand forced scientists, researchers, and policymakers to look for other alternatives that led to the generation of energy from renewable, energy sources like sunlight, wind, the flow of water, etc.

1.2. Sustainable Development and Renewable Energy

In recent years, the concept of sustainable development geared by renewable energy emphasizing green growth has garnered significant attention (Usman et al., 2020; Khan et al., 2023). Renewable energy sources are inexhaustible, cheaper, and environment-friendly hence providing a better and much more reliable solution to combating all the problems associated with non-renewable energy sources. The use of renewable energy not only helps in the achievement of a clean environment but also helps nations attain energy security by diversifying power supply options and reducing a nation's dependency on imported fuels. With an average annual capacity addition of around 340 GW, the year 2022 set a new record for the growth of renewable electricity capacity (IEA, 2023). This leads to numerous economic benefits like an increase in production due to decreased costs, environmental safety in the form of reduced carbon emissions, and increased employment opportunities all paving the development path.

The reduction of pollution and climate impacts alone can save the world up to $4.2 trillion per year by 2030. Thus, switching to renewables and providing clean energy has become the need of time, and the concept of sustainability demanding stable sources of energy is well aligned with it. This issue has been addressed on national and international forums and countries are working on individual as well as global levels to raise awareness about the increased environmental risks directing them to invest in energy efficiency projects. Several studies have been published to explore the interrelationship of variables that can play a positive role in the upgradation of quality of life. Sadorsky (2009) conducted a study between real per capita income and per capita renewable energy consumption and found a significant positive relationship between the two in the case of emerging economies. A one percent increase in real per capita income increases renewable energy consumption by 3.5% in the long run which necessitates the role of financial institutes making investments in the direction of renewable energy projects.

In developing nations, the need for a well-founded and cost-effective energy system is indispensable. It will boost economic growth by incrementing productive activities, lowering prices, and mitigating climate risks. Thus, this energy transition from 'vulnerable' to 'sustainable' is being followed everywhere in the world. However, there are a few financial barriers that hinder the process of sustainable development. They include credit availability, ease of access to financial services, infrastructure investment, and high running costs.

1.3. **Sustainability and Financial Development**

The financial sector is the main driving force of economic activity in society and encourages investments that are beneficiary for the biome. A strong financial system indicates the prevalence of an effective monetary policy in which financial institutions manage to increase profits, reduce the odds of future crises, and decline costs to society. Thus, financial market development leads to stability which helps in the innovation of techniques that could trigger growth by prioritizing environmental safety. This goal is achieved by investing in renewable energy sources through capital funding or by buying equities or funds (Shobande & Ogbeifun, 2022). However, the material risks associated with the deployment of renewable energy projects like lack of proper awareness, political instability, inadequate infrastructure, absence of regulatory policies, the high initial cost of installation, and low revenue refrain investors from doing so.

A safe financial institution is a guarantor of the economic progress of the nation but the questionable thing is its impact on the environmental quality affecting the health of the residents. An increase in per capita GDP or overall GDP growth does not necessitate the nation's overall well-being. On the contrary, economic growth can be a reason for increased carbon emissions and employment of renewable energy sources can help in lowering it (Usman et al., 2020). The rise in global warming and the resulting adverse effects on the environment including deforestation, loss of the habitat of flora and fauna, and natural disasters in the form of floods and volcanic eruptions have displaced many from their native places. Moreover, an increase in the population puts upward pressure on the prices thus raising the cost of living, deteriorating health conditions, and eventually low productivity of the individuals. All these factors have contributed to shifting the conventional paradigm of production utilizing fossil fuels and have led researchers to think about alternative ways of energy generation by exploiting natural resources that are abundant, infinite, and economical. A significant number of empirical studies (Sadorsky, 2009; Apergis & Payne, 2010; Bhattacharya et al., 2016) have confirmed the positive linkage between financial development and renewable energy highlighting their significance for economic growth and development.

Finance plays a significant role in the allocation of investments to the organization working on projects that aim for a nation's sustainable development, escalating the energy transition process to a low-carbon environment which is mandatory to meet the target of a clean environment. (Dogan & Seker, 2016).

Environmental degradation in the form of greenhouse gases specifically carbon emissions leading to a rise in temperature poses a significant challenge to the quality of life. (Intergovernmental Panel on Climate Change (IPCC), 2007). The attainment of sustainable development goals (SDGs) requires a careful analysis of the underlying factors exacerbating these emissions and then making conscious efforts to minimize the adverse effects of carbonization. This can be done by restructuring the financial institutions with a strong emphasis on eco-friendly policies and providing them incentives to invest in clean energy projects thus bringing energy efficiency and green innovations.

1.4. Sustainability and Institutional Quality

One of the key driving factors in achieving sustainable growth is institutional quality which is usually taken as a proxy of effective governance that plays a pivotal role in the implementation of every policy suggested. The success of these sustainable energy initiatives can be accelerated further by bringing a positive shift in institutional factors (Abid, 2017). A transparent governance with almost no corruption prioritizing the rule of law and political stability ensures the effective enforcement of rules and regulations and thus helps in attracting foreign investment, and technological diffusion fostering renewable energy development which will eventually curb carbon emissions leading to economic prosperity.

1.5. Research Gap

A considerable amount of literature has tried to explore the nexus between financial development, renewable energy consumption, and carbon emission (Arestis & Demetriades, 1997; Frankel & Rose, 2002; Tamazian & Rao, 2010; Gokmenoglu, 2015; Jiang & Ma 2019; Habiba & Xinbang, 2022; Udeagha & Breitenbach, 2023) yet certain areas of the study still need a more comprehensive analysis by incorporating a wide variety of relevant factors. A review of the existing literature has shown the following shortcomings in theoretical as well as empirical frameworks.

Based on econometric analysis, the literature is underlined with few weaknesses. Firstly, a limited number of studies have used institutional quality as a core variable to determine its impact on carbon emissions. Most of the studies have used a single variable as a proxy measure rather than constructing an index of all the potential variables that can influence the quality of institutions. Secondly, the research conducted earlier is clustered around different regions, and even though there is plenty of literature available on regional analysis (Hunjra et al., 2020; Sheraz et al., 2022; Musa et al., 2021; Chandio et al., 2022; Adedoyin et al., 2022; Vatamanu & Zugravo, 2023), no efforts have been made for inter-continental analysis which could highlight their differences and help policymakers in implementing targeted interventions to transition towards a low carbon economy.

Thirdly, there are very few global-level studies (Ahmed et al., 2020; Kassi, 2020; Khan et al., 2022), and to the best of our knowledge, there is no such study that has used renewable energy consumption, financial development, and institutional quality together to determine its impact on carbon emissions at the global level and inter-continental level by using a moderator term to examine the combined effect of financial development and institutional quality on carbon emissions. The moderator term provides a nuanced understanding of how the interplay between financial development and institutional quality can either amplify or mitigate the effects of financial development on carbon emissions and renewable energy adoption.

1.6. Objectives of the Research

The objectives of the research include

- To examine the influence of financial development, renewable energy, and institutional quality on CO_2 emissions
- To assess the moderating effect of institutional quality on CO_2 emission

The whole analysis will be carried out globally as well as in the selected continents.

1.7. Research Questions

In light of the aforementioned background and the present situation, this study tries to fill the void in research by addressing the following questions:

- Does there exist a linear relationship between financial development, renewable energy, institutional quality, and carbon emissions in global panel data?
- Does the combined effect of financial development and the quality of institutions have a different impact on carbon emissions than each component acting alone?
- How does the relationship between carbon emission, renewable energy adoption, financial development, and institutional quality vary across different continents (Asia, Africa, Europe)?

1.8. Research Hypothesis

The following hypotheses have been formulated to answer the above-mentioned questions at the global level:

Hypothesis 1:

H_0: There is no significant impact of financial development on carbon emissions.

H_1: Financial development is associated with changes in carbon emissions.

Hypothesis 3:

H_o: There is no significant relationship between renewable energy consumption and carbon emissions.

H_1: Adoption of renewable energy helps in lowering the level of carbon emissions.

Hypothesis 4:

H_0: Institutional quality does not significantly influence carbon emissions.

H_1: Improved institutional quality leads to changes in emissions of carbon dioxide.

Hypothesis 5:

H_0: The interaction of financial development with institutional quality does not moderate the relationship between carbon emissions and the independent variable.

H_1: The interaction of financial development with institutional quality moderates the relationship between carbon emissions and the independent variable.

The same hypotheses will be tested for the continents of Asia, Africa, and Europe to quantify the effect of financial development, renewable energy, and institutional quality on environmental degradation (CO_2). This will help in the deduction of meaningful conclusions which will provide a better perspective of the reasons for the difference in development across continents.

1.9. Significance of the Study

This thesis aims to contribute to the existing knowledge by examining the interrelationships between carbon emissions, renewable energy, financial development, institutional quality, trade, GDP, urbanization, and industrialization at the global and continental levels. By delving into the intricate dynamics of these factors, we aim to provide valuable insights that inform policy decisions, bridge research gaps, and pave the way towards a greener and more sustainable worl"

1.10. Thesis Framework

The analysis of the complex dynamics of the determinants of carbon emission levels globally and continentally is structured as follows. Section 2 provides a comprehensive survey of the existing literature in this domain proceeding to Section 3 which introduces the methodological framework constituting theoretical and econometric modeling of the intricate interconnections we are trying to explore. Section 4 provides an insight into the data chosen and a brief explanation of the variables selected. The statistical analysis of the variables is done in Section 5. The outcomes achieved after an in-depth analysis of the chosen variables guided by the econometric methodology outlined in discussed in Section 6 of this thesis. Section 7 provides a conclusive logical summary of the results obtained and also points out the limitations of the present study. Some policy recommendations based on the predicted results are also put forward in this section.

Chapter 2

Literature Review

2.1. Introduction

This chapter of the study highlights the existing literature about the interconnection of financial development, renewable energy, institutional quality, and carbon emission. The first section of the study outlines all the relevant theories given in perspective of these variables and signifies their relationship with their environment while the second section provides empirical evidence in the context of all these theories.

2.2. Theoretical Literature

The financial sector plays a critical role in the smooth functioning of an economy by disseminating funding information, monitoring investments, enhancing profits, minimizing risks, accelerating trade, and creating employment opportunities, all contributing to the economic growth of a nation (Pagano,1993; Calderon & Liu, 2003; Arestis et al., 2001). The past history of each developed nation depicts the presence of strong financial institutions which helped them in the mobilization of capital and allocated resources according to the need that aided in balancing the growth in every sector of the economy.

Over the past few decades, the process of industrialization powered by the utilization of fossil fuels fostered breakthrough economic growth. However, these developments have brought radical changes in the living standard of the people they have downturned the quality of life by polluting the atmosphere due to the emission of greenhouse gases (Jackson,2013; Darcin,2014). To fight these worsening climatic conditions, there are global platforms and agreements that work together and guide progress. The following section highlights the theoretical evidence regarding the quality of the environment, energy consumption, financial institutions, and effective governance that work in a harmonious manner to bring sustainability.

Environmental Kuznets Curve Hypothesis (EKC)

The concept of the EKC model emerged in the early 1990's first proposed by Grossman and Krueger, (1991), and is derived from the original Kuznets "Inverted U-shaped hypothesis" developed by S. Kuznets (1995). In accordance with the EKC theory, a country's environmental deterioration will likely accelerate as its GDP rises as a result of increased industrialization and energy use. However, after a certain income level continuing economic development is linked to better environmental quality because newer technologies and policy changes result in less pollution and carbon emissions.

Financial Development Theory

This theory highlights how markets and financial institutions work together to foster economic growth. This theory is a product of all the researchers and scholars around the globe. However, one of the prominent economists is "Raghuram Rajan" who has contributed to understanding how financial development affects economic growth and stability. (Rajan and Zinghales,1996). Rajan's research highlights the critical role that effectively operating financial institutions and markets play in facilitating investments, stimulating entrepreneurship, and allocating resources.

Institutional Theory

Institutional economics theory explains the influential role of a nation's institutes on the economic and social behavior of the people. The term was first coined by an American economist Walton H. Hamilton in December 1918 in his paper "The Institutional Approach to Economic

Theory". It consists of a wide set of rules, norms, and values and guides developing countries to learn from developed nations and make appropriate policies that could pave the way to prosperity.

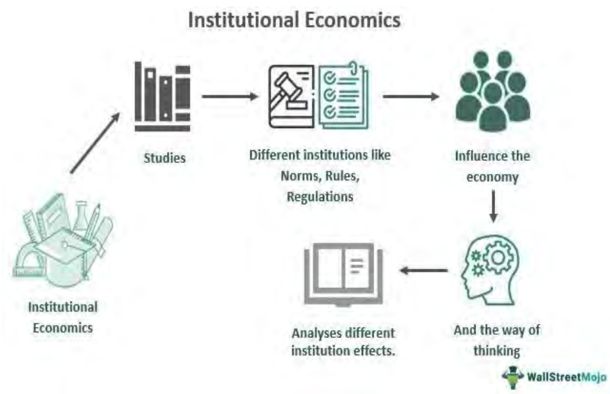


Figure 2.2. Institutional Approach to Economic Theory

Sustainable Development Theory

The Brundtland Report from 1987 introduced the first "official" definition of sustainable development. It is defined as "the development that meets the needs of the present without compromising the ability of future generations to meet their needs. It explains the inseparable crisis of environment, energy, and development and the insufficiency of existing resources. "The 2030 Agenda of Sustainable Development" emphasizes the achievement of goals that promote inclusive growth and harmonized economic, social, and environmental progress. (Nations, U. 2015)

Ecological Modernization Theory

It is a school of thought that emerged in the early 1980s which integrates economy and ecology. The theory proposes that both market forces and governmental rules and policies can play their part in protecting the environment. It emphasizes efficiently using natural resources to enhance environmental productivity. It promotes the idea of technological innovations and adopting cleaner production processes which could foster green growth and sustainable development.

2.3. Empirical Literature

Empirical evidence regarding the nexus between carbon emissions, financial development, renewable energy, and institutional quality can be best provided by the previous studies.

2.3.1. Relationship between Financial Development and Carbon Emissions

Financial development has conflicting effects on the ecological footprint of a nation. A vast amount of reported analysis has shown variation in the results. On one hand, it is assumed to stimulate the economy by increasing access to funds that could be invested in clean energy projects while on the other hand, increased consumption and production based on the consumption of fossil fuels as an energy source leads to increased carbon emissions.

A recent study explored the direct and indirect impact of financial development (F.D) on climate change mitigation utilizing the Environment Kuznets Curve (EKC) analytical framework in South Africa indicated that a temporary or permanent change in F.D will always help in decreasing CO_2 emissions and suggested some useful national interventions to achieve sustainability targets of net zero carbon emissions. (Udeagha and Breitenbach, 2023)

A panel study of 155 countries conducted by Jiang and Ma (2019) indicated that financial growth exacerbates carbon emissions in developing and emerging economies while being proven insignificant for developed nations. Achieving energy independence and security without polluting the environment becomes a challenging task for large populous economies like China. It requires a careful evaluation of all the possible influential factors that could affect renewable energy consumption. A study conducted by Chang et al. (2022) examined the impact of financial development, economic expansion, and energy pricing on energy use for 30 provinces of China by using the NARDL approach for 2000-2020. The findings suggested a 0.24% increase in renewable energy use for each 1% increase in financial development.

2.3.2. Relationship between Renewable Energy and Carbon Emissions

Renewable energy consumption boosts economic growth by protecting the environment from the hazardous poisonous chemicals released during the burning of fossil fuels directing us to opt for clean technology. To prove this point, a study conducted by Habiba et al. (2022) for the top twelve emitter countries confirmed the presence of a negative association between green technology innovation, renewable energy use, and carbon emissions. Thus, constructive efforts for the implementation of green growth policies need to be made.

Dogan and Seker (2016) analyzed the influence of real income, trade openness, and renewable and non-renewable energy consumption on carbon emissions in the top 38 renewable-consuming countries. They found the result worthwhile in the case of renewables. Investment in this sector will not only help in achieving self-sufficiency in the power sector but also help in reducing the carbon footprint.

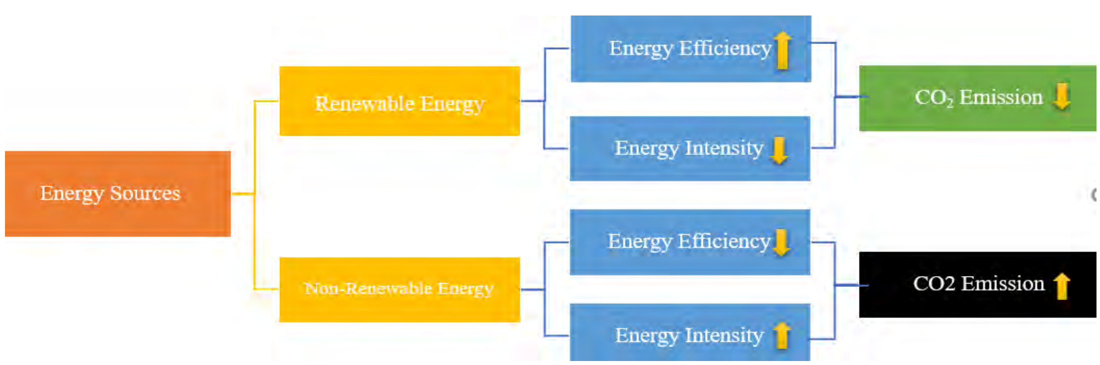


Figure 2.3.1. Linkage between Energy Sources and Carbon Emissions

2.3.3. Relationship between Institutional Quality and Carbon Emissions

The struggle of developing nations on the path of sustainable development is marked by challenges like political instability, poverty and inequality, high population growth rate, lack of resources, and specifically their dependence on fossil fuels which contributes to environmental degradation in the form of greenhouse gas emissions. (Anwar et al., 2021). The weak financial institutions and poor governance also aggravate the persisting issues.

Halder and Sethi (2020) investigated the moderating impact of IQ on energy consumption and CO_2 emissions of 39 developing countries from 1995-2017 and found IQ helpful in the abatement of emissions. The finding also supported the role of renewable energy in improving the quality of the environment. Financial Investment in the form of renewable energy projects and opting for green growth can help in ending the long-prevailing economic, social, and environmental problems.

Khan and Rana (2021) used a panel data study for 41 Asian countries to measure the direct and indirect impact of institutional quality on pollution emissions **(CO_2)** by using cointegration and VECM over the period 1996-2015. They found that better political institutions play a significant part in the reduction of carbon emissions in Asia. A moderating impact of IQ on the adverse effects of income was also observed. This signifies the effective role of governance in upgrading environmental quality. Economic Growth is a main indicator of a country's overall performance in different sectors of the economy. A growth emission nexus conducted for Indonesia, Thailand, and South Korea also supported the existence of efficient domestic institutions to augment growth and curb emissions (Salman et al. 2019).

Ibrahim and Law (2016) examined the role of trade and institutional quality in a sample of 40 Sub-Saharan African countries and found institutional reforms to be extremely helpful in actualizing the benefits of trade and in the reduction of carbon emissions. The study advocated for the development of sound financial institutions to enhance economic growth, trade, and environmental quality.

However, the literature also consists of studies that have shown contradictory results of IQ on carbon emissions. Dinca et al. (2022) conducted a comparative study of the European Union (EU) and G-20 members for 1995-2020 and investigated the impact of education and institutional quality on carbon emissions. The study found IQ to have a direct positive impact on increased emissions in these regions. The authors suggested policymakers make and implement strict rules and regulations to build the public's confidence in the government and make more use of the primary sources of energy (renewables) to enhance environmental performance.

2.3.4. Impact of F.D, R.E & IQ on CO_2 Emissions (Aggregate)

Several studies in the literature have explored the relationship between countries on the individual level as well as on the global level. A panel data study of 192 countries conducted on the global level examined the heterogeneity of renewable energy consumption, financial development, and carbon emissions utilizing panel quantile regression has shown the positive influence of financial development on carbon emissions while a shift towards renewables can cause a reduction in the pollution level i.e. CO_2 emission (Khan et al., 2020)

Another panel data study of 103 economies (global level) used a dynamic panel data approach and examined national heterogeneity by dividing the sample into developed and developing economies indicating that overall financial development had a positive impact on renewable energy consumption on the macro level in developed economies while in developing economies a definite positive effect was seen only in financial institutions. (Sun et al., 2023)

A similar global-level study invigorating the effect of renewables and financial development on environmental sustainability presented a contrasting result of a significant positive effect of both variables on sustainability while economic growth was found to have an increasing impact on global carbon emissions. The study recommended more energy policy reforms in both developing and developed nations (Kirikkaleli & Adebayo, 2020).

Financial development has both direct and indirect effects on ecological footprint of a country. It can affect carbon emissions directly by providing grants which if used by industries based on fossil fuels result in increased emissions. On the other hand, it augments the economic progress of the nation by providing easy access to loans that can further be used to enhance human capital by raising the literacy rate and polishing their skills which eventually raises better and sensible individuals who are more concerned about protecting the environment thus decreasing poisonous emissions.

2.3.5. Impact of F.D, R.E & IQ on CO_2 Emissions (Disaggregate level)

To explore the nexus between financial development, the use of renewable energy, and its impact on carbon emissions, Sheraz et al. (2021) conducted a study for 64 BRI countries. The results indicated an increase in CO_2 emissions with financial development while renewable energy usage and globalization aid in mitigating these emissions and improve the quality of life. Institutional quality was found to be positive in correlation with CO2 emission and suggested restructuring of the financial system and energy consumption patterns to combat the evils of bad governance and corruption raising institutional quality which could help achieve a sustainable environment.

To date, there is a vast amount of literature that has explored the relationship between financial development and the consumption of renewable energy (Sadorsky, 2011; Kakar et al., 2011; Shahbaz & Lean, 2012; Rafindadi & Ozturk, 2016) by using different factors like economic growth, international trade, urbanization, etc. All these studies have highlighted the significance of a sound financial system that could boost renewable energy consumption, contributing to the nation's power security and economic prosperity.

Qayyum et al. (2021) conducted a study for India which showed similar results of a positive impact of financial development on CO_2 emission while renewable energy and technological innovation show a significant reduction in the amount of CO_2 gas emitted and enhance environmental quality. An analysis of the study conducted by Wang et al. (2020) for N-11 countries demonstrated that financial development does increase carbon emissions but incrementing renewable energy usage and bringing technological innovation will help in the reduction of these emissions.

Similarly, many regional studies constituting developing nations of East and South Asia have deduced the same conclusive benefiting results of investment in renewable energy on economic growth, environmental upgradation, and quality of life in the long run. At the same time, financial development and ICT contributed positively to the emission of carbon dioxide gas in the long run. (Batool et al., 2020). However, a few studies have also shown contrasting results. A study by Saygin & Iskenderoglu (2022) indicated no effect of financial development on renewable energy consumption when financial development was measured using banking and stock market variables for 20 emerging economies from 1990-2015.

A recent study conducted by Vatamanu & Zugravo (2023) shed light on the dynamic relationship between financial development and renewable energy consumption in the presence of institutional variables. The results of this panel data study for 27 European Union (EU) member states for 2000-2020 confirmed the existence of a robust positive relationship between all the variables emphasizing the role of governance in enhancing the quality of institutions and ensuring transparency which could boost the confidence of investors to invest in renewable energy projects and achieve SDGs.

Amin et al. (2022) utilized a time series econometric approach namely the dynamic ARDL simulations and found a negative correlation between carbon emissions and the indicators of governance, trade, financial development, and renewable energy consumption in China. These findings suggested the need for comprehensive policies i.e. the establishment of stable financial institutions with environmental protection policies that could boost the use of renewable energy fostering green growth to combat global warming and ensure sustainability.

The government can play a pivotal role in the efficient use of energy resources by providing financial assistance in the form of loans, and grants and by establishing agencies of renewable energy. A panel data study conducted by Khan et al. (2019) for high-income countries from the continents of Asia, Europe, and America revealed the same fact characterizing a diminishing effect on the emission of greenhouse gases due to financial development, tourism, and renewable energy.

Based on the empirical evidence, we can say that the empirical literature consists of plenty of research studies that have tried to configure the exact nature of the relationship between financial development, renewable energy, and carbon emissions by using time series and panel data. Some recent studies have also incorporated institutional quality as an important explanatory variable that can be used in conjunction with the other variables to deduce meaningful results from it that can help model an effective policy for the growth and development of nation. The influential role of these determinants of carbon emissions is evident from the review of the literature but it also points out a few weaknesses.

Firstly, the literature is dominated by the studies that have based their analysis on the theoretical basis of EKC whose prime focus is economic growth, not sustainable development. The term sustainable development is a broader concept that requires the integration of financial development redirecting investments in the direction of alternative energy sources i.e. renewables coupled with institutional reforms that could promote green growth and eventually a sustainable future. Secondly, most of the studies that have determined the impact of financial development and institutional quality on carbon emissions are by taking their proxy variables instead of constructing a complete index that includes all the potential variables presumed to affect the carbon emission. Thirdly, the literature is full of studies that investigate the relationship among these variables targeted for specific regions (Sadorsky, 2011; Chang et al., 2022; Jiang & Ma, 2019; Qayyum et al., 2021; Amin et al., 2022; Vatamanu & Zugravo, 2023) while there are very few global level studies (Khan et al., 2020; Kirikkaleli & Adebayo, 2020; Sun et al., 2023) which have employed all these variables together for the assessment of carbon emissions. Lastly, panel data analysis at the continental level is missing specifically a comparative global and continental analysis that could highlight the differences that were masked in the global frame. These differences can be due to geographical position, differences in natural resource endowments, population, and cultural or institutional factors, etc.

The current study fills all these gaps by providing a comprehensive analysis of the impact of financial development, renewable energy, and institutional quality on carbon emissions worldwide and in the continents of Asia, Africa, and Europe by employing panel data techniques of Pooled OLS, fixed and random effect, and system GMM from 1990 to 2020. The study also measures the combined impact of financial development and institutional quality on CO_2 emission and explains its significance in the context of differences in results across continents.

2.4. Conclusion

The analysis of the theoretical and empirical literature has outlined the findings of the previous studies that presented mixed results and pointed out a few shortcomings that will be addressed in the upcoming chapters. Financial development can either upgrade the environmental quality by granting easy access to loans that can be used to promote green growth or they can also escalate industrial production powered by fossil fuels thus increasing carbon emissions. The role of institutional quality and its moderating impact across the globe and in different continents is also a question mark for the researchers. This study attempts to address all the ambiguities by conducting a comprehensive analysis exploiting advanced econometric techniques.

Chapter 03

Methodology

3.1. Introduction

This chapter presents the comprehensive methodology employed in this research to explore the intricate nexus between financial development, institutional quality, renewable energy adoption, and carbon emissions. The theoretical modeling and econometric modeling aspects of the chapter are divided into two distinct yet linked parts. The first section formulates a theoretical framework of the model in the context of the existing economic theories influencing the environment while the econometric modeling constitutes the econometric models and the methodologies opted for the analysis of these models. Together, these parts offer a solid foundation for analyzing the complex relationships entailed by our research goals.

3.2. Modelling Framework

3.2.1. Theoretical Modelling

The theoretical modeling section lays the conceptual foundations for our empirical investigation. We build a strong framework for comprehending the interactions between financial development, institutional quality, renewable energy, and carbon emissions by drawing on well-established theories in the fields of sustainable development, energy economics, and financial systems.

The concept of the EKC model is derived from the original Kuznets "Inverted U-shaped hypothesis" developed by Kuznets (1995). According to the EKC theory, a country's environmental deterioration will likely accelerate as its GDP rises as a result of increased industrialization and energy use. However, after a certain income level continuing economic development is linked to better environmental quality because newer technologies and policy changes result in less pollution and CO_2 emissions.

Financial development theory highlights the work of markets and financial institutions to foster economic growth. “Raghuram Rajan”, a prominent economist, emphasized on the development of efficient financial institutions to promote economic growth and stability (Rajan and Zinghales, 1996). Rajan's research highlights the role of financial institutions and markets in facilitating investments, stimulating entrepreneurship, and allocating resources.

The theory of environmental governance (Yoshida, 2012) justifies the relationship between environmental degradation and a country’s institutions. It necessitates the ‘making of a strong regime’ for dealing with environmental problems. It signifies the role of a government to devise a workable structure of environmental regulations and implement them.

We embrace ideas from sustainable development theory, “the development that meets the needs of the present without compromising the ability of future generations to meet their needs”. paying importance to the necessity of balanced advancement in the fields of economic, social, and environmental factors (UN, 2015). The Energy Transition Theory also helps us understand the crucial significance that the adoption of renewable energy sources has on the world's energy landscape. Hence, the theoretical model to explore the interconnection between these variables can be written as:

Carbon emissions= f (Financial development, Renewable energy, Institutional quality, Economic growth, Trade, Industrialization, Urban Population, Interaction term) (1)

3.2.2. Econometric Modeling

Building upon the theoretical framework represented in equation (1), the econometric model can be written as:

Model 1(Global)

$$CO_{2it}=\alpha+\beta_1 FD_{it}+\beta_2 REC_{it}+\beta_3 IQ_{it}+\beta_4 GDP_{it}+\beta_5 TRADE_{it}+\beta_6 IND_{it}+\beta_7 URB_{it}+\beta_8 FD*IQ_{it}+\mu_{it}+\nu_{it}+\varepsilon_{it} \quad (2)$$

Where,

CO_2 is the carbon emissions which is our dependent variable in this model. **FD** shows the financial development index, **REC** stands for Renewable energy consumption and **IQ** is the institutional quality index. All the other variables **GDP** (Economic Growth), **TRADE** (Trade openness), **IND** (industrialization), and **URB** (urban population) are used as control variables in the model. Moreover, to test the moderating role of quality institutions on carbon emissions we have added an interaction term of financial development and institutional quality represented by **INT.** α and ε_{it} shows intercept and the error term while the unobserved country-specific effects and temporal-specific effects are described μ_{it} and ν_{it} respectively. The slope coefficients, parameters 1 to 8, represent the marginal impact of the explanatory variables. The coefficients on the slope, ranging from parameter 1 to 8, indicate the incremental effect of the explanatory variables.

The aforementioned model will assist us in analyzing the quantitative impact of explanatory variables on the worldwide emission of CO_2 and in drawing significant conclusions. To gain more insight into it, the analysis has been split into three independent continents—Asia, Africa, and Europe—to determine which continent would benefit the most from changes to its financial institutions and more effective governance.

Thus, for the inter-continental analysis, the same model will be used but for different continents i.e. Asia, Africa, and Europe respectively

3.3. Econometric Techniques

This study uses panel data to conduct a thorough analysis of how financial development, institutional quality, renewable energy, and other variables interact and change over time. Due to its intrinsic advantages, panel data is a convincing option for this research as it integrates cross-sectional and time-series data. To investigate the causal relationship between the variables under observation, conventional econometric methods such as pooled OLS, fixed effect, and random effect will be used. Lastly, the System Generalized Method of Moments (SGMM) is employed for the estimation of the dynamic panel data set. A brief explanation of the specific tests used for the choice of the best possible technique is also provided in the following section.

3.3.1. Traditional Econometric Techniques

Pooled OLS Regression

The first fundamental technique used to estimate regression equations in panel data analysis is Pooled OLS. It provides a single regression model by integrating data from multiple sources or time zones. To evaluate average impacts throughout the entire dataset, it assumes a constant intercept for all entities overlooking individual variations and generates overall estimates. The regression equation using Pooled OLS will take the following form:

$$\mathbf{CO_{2it}=\alpha+\beta_1FD_{it}+\beta_2REC_{it}+\beta_3IQ_{it}+\beta_4GDP_{it}+\beta_5TRADE_{it}+\beta_6IND_{it}+\beta_7URB_{it}+\beta_8FD*IQ_{t}+\varepsilon_{it}} \quad \mathbf{(3)}$$

Reliable results can be produced only if the estimator fulfills the criteria of a classical regression model but the presence of these strict assumptions is one of the limitations of the study. Due to the individual heterogeneity of countries, endogeneity, and other potential biases, it is better to opt for other panel data estimation techniques like fixed and random effects.

Fixed Effect Model

The limitations of Pooled OLS directed us to use Fixed effect models to incorporate dummy variables for each entity to account for entity-specific traits. Each country has its own specific characteristics like cultural factors, policy framework, and geographical features that do not vary over time. Isolation of the within-entity variation helps in the interpretation of changes in the dependent variable brought about by the independent ones. The regression equation in the fixed effect will take the following form:

$$\mathbf{CO_{2it}=\alpha_i+\beta_1 FD_{it}+\beta_2 REC_{it}+\beta_3 IQ_{it}+\beta_4 GDP_{it}+\beta_5 TRADE_{it}+\beta_6 IND_{it}+\beta_7 URB_{it}+\beta_8 FD{*}IQ_{it}+\varepsilon_{it}} \quad \textbf{(4)}$$

Here, α_i is the intercept term that varies for each cross-sectional entity and captures inherent differences between countries that remain stable over time.

Although the fixed effect enhances the validity of our analysis by tackling potential biases brought on due to variables affecting the dependent variable at the national level, it is unable to capture time-invariant characteristics of the model. Moreover, it also results in the loss of the degree of freedom of the model potentially leading to imprecise estimates. This drawback pushes us to look for a technique that could address time-variant variables.

Random Effect Model

Assuming a zero correlation between individual terms, the random effect model treats unobserved heterogeneity as a random variable. It is useful for estimating average effects while considering entity-specific variation. The regression equation using this technique will be written in the following manner**:**

$$\mathbf{CO_{2it}=\alpha_i+\beta_1 FD_{it}+\beta_2 REC_{it}+\beta_3 IQ_{it}+\beta_4 GDP_{it}+\beta_5 TRADE_{it}+\beta_6 IND_{it}+\beta_7 URB_{it}+\beta_8 FD{*}IQ_{it}+\mu_{it}} + \varepsilon_{it} \quad \textbf{(5)}$$

Where μ_{it} (within entity errors) captures the individual impact of the country while ε_{it} is showing within entity error term.

In a nutshell, both fixed and random effect models will be helpful in the empirical analysis of our chosen variables due to their specific advantages.

Breusch and Pagan and LM Test

Few diagnostic tests are applied for the selection of the best possible model. One of those tests is the Breusch and pagan LM test which determines the significance of random effect in the model. The hypothesis of the test is the following:

H_0 = There are no differences across units

H_1= There are differences across units (Random Effect is better)

If the probability value of chi square is less than 0.05 then the null hypothesis will be rejected and the preferred model will be 'Random Effect Model'.

Hausman Test

The Hausman Test is used to differentiate between fixed effects (FE) and random effects (RE) models. Based on the correlation between individual-specific effects and the regressors, it evaluates the consistency and effectiveness of the parameter estimates between these two models and helps in deciding which one is more suitable. The hypotheses are as follows:

H_0 = Differences in the coefficients are not systematic (Random Effect is preferred)

H_1= Differences in the coefficients are systematic (Fixed Effect is preferred)

A p-value of chi-square lesser than 0.05 will lead to the rejection of the null hypothesis and the preferred model will be the "Fixed Effect Model".

3.3.2. SGMM Technique:

A solid advanced econometric method designed explicitly for dynamic panel data models is the System GMM (Generalized Method of Moments) technique proposed by Blundell and Bond and Arellano and Bond (1998). By leveraging moment conditions between lagged variables, it handles difficult problems including endogeneity, unobserved heterogeneity, and potential simultaneity by utilizing both the first differences and the instruments. The regression equation will then take the following form.

$$\mathbf{CO_{2it}} = \alpha_i + \beta_1 \mathbf{CO_{2i,t-1}} + \beta_2 \mathbf{FD_{it}} + \beta_3 \mathbf{REC_{it}} + \beta_4 \mathbf{IQ_{it}} + \beta_5 \mathbf{GDP_{it}} + \beta_6 \mathbf{TRADE_{it}} + \beta_7 \mathbf{IND_{it}} + \beta_8 \mathbf{URB_{it}} + \beta_9 \mathbf{FD{*}IQ_{it}} + \eta_{it} + \nu_{it} \quad \textbf{(9)}$$

In the above equation, the lagged level of the endogenous variable CO_2 is also included as a regressor. β_1 is the slope coefficient, the magnitude of which will help in predicting the strength of the relationship between the lagged and the dependent variable. η_i represents country-specific effects while the error term is shown by ν_{it}.

This approach is especially well-suited for analyzing big datasets where both individual and temporal differences are significant since it makes use of both cross-sectional and time-series data. It provides better estimates than the conventional econometric techniques and also resolves the issue of reverse causality. The reliability of the instruments and residual correlation analysis are key components of this method's efficacy.

For the implementation of this framework, the two specifications tests Hansen J Test and Arellano Bond Test are suggested.

Hansen J Test

The Hansen J test assesses the validity of overidentifying constraints in instrumental variable models. It evaluates to see if the model's presumptions are true and whether the chosen instruments are exogenous. The following hypotheses are tested:

H_0= Instruments are valid

H_A= Instruments are not valid

The null hypothesis of valid instruments will be rejected if the p-value is less than 5%.

Arellano-Bond Test

Another specification test known as the "Arellano Bond test" is reported along with the regression outcomes in system GMM. It assesses if panel data models with serial correlation are present. It examines to see if errors develop a relationship over time, which is crucial for reliable parameter estimations. The following hypotheses are tested:

H_0= Residuals are serially uncorrelated

H_A= Residuals are serially correlated

A p-value of below 0.05% suggests the rejection of the null hypothesis providing significant evidence of serial correlation in the model residuals.

3.4. Conclusion

This chapter has explained the methodological framework that will be followed in exploring the nexus between carbon emission, financial development, renewable energy consumption, and institutional. This objective will be achieved by utilizing a panel data set of 111 countries (global) and at the continental level. Traditional econometric techniques like pooled

OLS, fixed effect, and random effect will be used to find the impact of these variables on the dependent variable. Moreover, a more advanced econometric technique System GMM will be used to address the issues of endogeneity, heteroscedasticity, and serial correlation which will enable us to gain a deeper understanding of the nonlinear linkage between the variables and a better understanding of the existing differences among the three major continents Asia, Africa and Europe.

Chapter 04

Data and Variables Description

4.1. Introduction

The nature of the data used in the inquiry for this study is explained in detail in the following section. The variables that were used in the data analysis in addition to the relative indices constructed are detailed. Additionally, the necessity of a continent-based disaggregated study is also covered.

4.2. Data and Variables Description

4.2.1. Data Type

The empirical analysis of the theoretical relationships presented in the form of econometric models in Chapter 3 is done by selecting panel data also called "longitudinal data" at aggregate and disaggregated levels. Panel data is a compelling option for this research as it integrates cross-sectional and time-series data methods which helps in capturing both the temporal dynamics and the individual variation. Its capability to adjust unobserved heterogeneity, endogeneity, omitted variable bias, and a higher degree of freedom than fixed effect makes it suitable to conduct a thorough analysis of how financial development, institutional quality, renewable energy, and other variables interact and change over time.

4.2.2. Data Sample

Data collected from 217 countries were chosen for this study, however, the initial data set was cut down to 111 countries because many of the countries had missing data series for various variables. The study period spans from 1990 to 2020 aiding us in exploring the historical context of the variables over time.

The disaggregated analysis consisted of dividing the sample set into diverse countries from Asia (41), Africa (47), and Europe (21). This inter-continental analysis will provide us with a nuanced understanding of the causes of the differences in various regions of the world.

4.2.3. Variables Description.

Here is a brief description of the variables used for the analysis in order to meet the goals of our study:

4.2.3.1. Dependent Variable

To analyze the impact of financial development, renewable energy, and institutional quality on environmental degradation, carbon dioxide is chosen as a dependent variable. The literature consists of a plethora of studies that have used CO_2 as a proxy variable to assess environmental quality (Jiang and Ma, 2019; Ahmed et al., 2020; Khan et al., 2021; Habiba et al., 2022)

Carbon-Dioxide Emission (CO_2)

Emission of carbon dioxide has been selected as a dependent variable to measure environmental sustainability. It is the central variable of interest that represents the amount of carbon dioxide released into the atmosphere by a nation. The data was extracted from the site of World Development Indicators (WDI) and is measured in metric tons per capita. According to Climate Watch (2020), "Both the manufacturing of cement and the burning of fossil fuels produce carbon dioxide emissions. It consists of all the flammable gases and CO_2 produced through the consumption of solid, liquid, and gaseous fuels.".

A review of the existing literature (Dogan and Seker, 2016; Wang et al., 2020; Anwar et al., 2021; Qayyum et al., 2021; Adedoyin et al., 2022; Sheraz et al.,2022) shows the choice of this variable as a dependent variable to investigate the environmental consequences of the factors under study. The econometric analysis uses the transformed log form of the variable. (**lCo_2**)

4.2.3.2. Independent Variables

The analysis compiles the following focus and control variables for the estimation of the derived regression equation.

Financial Development (FD)

One of the main focused variables that also defines the theoretical baseline of our model is "Financial Development". It refers to the financial system intricacy, efficiency, and accessibility of a country's financial system and includes aspects like banking services, capital markets, and financial regulations.

The study utilizes a "Financial Development Index" constructed from its components broad money, domestic credit to private sector, and domestic credit to private sector by banks through principal component analysis (PCA). Each of these components is described below:

Broad Money (BM)

> According to IMF, IFS, and World Bank, "The total currency held outside of banks; demand deposits not held by the government; the time, saving accounts, and foreign currency deposits held by non-resident government agencies; bank and traveler's checks; and other securities such as certificates of deposit and commercial paper."

Domestic Credit to Private Sector (DCP)

> It is a term that is used to describe financial resources given to the private sector by financial institutions, such as through loans, buying and selling of nonequity securities, trading, and other accounts receivable, that create a claim for repayment. (WDI-2022).

Domestic Credit to Private Sector by Banks (DCPB)

According to IMF, IFS, and World Bank, "domestic credit to the private sector by banks denote to the financial resources provided to the private sector by other businesses that take deposit excluding central bank through loans granted, purchases of nonequity securities, and trade credits, and other accounts receivable, that leads to a claim for repayment.

The construction of a financial development index will provide a holistic assessment of a country's financial system, its investment decisions, financial stability, and progress over time. Moreover, it will enable comparisons between nations, regions, or over time, making it easier to identify the most effective practices and set benchmarks.

Renewable Energy Consumption (REC)

Another focused variable of our model is "Renewable Energy" **(RE)**. Energy produced from naturally replenishing resources, such as solar, wind, hydroelectric, and geothermal power, is referred to as renewable energy. To assess the impact of renewable energy on emissions of CO_2, we have taken the overall consumption of renewable energy in a regression model measured as a percentage of total final energy consumption. It can be said more firmly that "Renewable Energy Consumption is the share of renewable energy in total final energy consumption" (WDI-2022).

A higher adoption rate of renewable energy sources in an economy will be an indicator of its commitment to the achievement of (SDGs) leading to a lower carbon footprint.

Institutional Quality (IQ)

It refers to the effectiveness, strength, and overall performance of a nation's institutions, such as its government, legal system, and regulatory framework. To examine its role fully an index of six components named rule of law, government effectiveness, regulatory quality, control of corruption, voice and accountability, political stability and absence of violence is constructed which is named as Institutional quality (**IQ**). A brief explanation of its components is given below:

Rule of law (ROL)

According to WDI, "The Rule of Law demonstrates the level of confidence of individuals in law enforcement authorities, protection of property rights, the possibility of crime and violence, the police, and the courts and how much they follow the social norms".

Government Effectiveness (GE)

In accordance with WDI (2022)," Government Effectiveness measures how well the public perceives the quality of public services, civil service and the degree of its independence from political influences, the caliber of policy formulation and its implementation, and the reliability of the government's commitment to such policies.

Regulatory Quality (RQ)

In line with WDI (2022), "Regulatory Quality measures the degree to which the general population believes in the ability of the government to carry out sound laws and regulations that support and encourage private sector development".

Control of Corruption (COC)

According to WDI (2022), "Control of Corruption reflects views of usage of public authority for private benefit including major as well as minor corruption, as well as the "take over" of the state by elites and personal interests".

Voice and Accountability (VOA)

"Voice and Accountability measure the belief of a nation's resident on his ability to influence the choice of government, as well as freedom of speech, association, and press" (WDI-2022).

Political Stability and Absence of Violence (PS)

According to WDI (2022), "Political Stability and Absence of Violence/Terrorism measures the risk of political instability and/or politically driven violence, including terrorism".

Table 4.1. Data Description & Source

Variable	Abs	Definition/Description	Source
Carbon Emission	CO_2	Metric tons per capita	WDI
Independent Focused Variables			
Financial Development	FD	Index of dcp, dcpb, and bm	WDI
Renewable Energy Consumption	REC	percentage of final total energy consumption	WDI
Institutional Quality	IQ	Index of COC, PS, RQ, ROL, GE and VOA	WDI
Interaction Term	FD*IQ	Product of FD and IQ	Self-constructed
Control Variables			
Economic Growth	GDP	Constant 2015 US$	WDI
Trade	TRADE	% of Gdp	WDI
Urban Population	URB	% of the total population	WDI
Industrialization	IND	Industry (including construction), % of Gdp	WDI

Economic Growth

Economic growth, a crucial independent variable in the data description of this study, is an essential component of contemporary economies. It includes the gradual rise in a country's output of goods and services through time as well as the expansion of its productive capacity which is usually considered as an indicator of prosperity. GDP per capita is taken as a proxy for economic growth.

According to WDI (2022), “GDP per capita is gross domestic product calculated by dividing by midyear population by 100. It is the total economic output produced in any country including all goods and services adding product taxes and subtracting any. It does not take into account depreciation”. The data is measured in constant 2015 U.S. dollars.

The incorporation of “Economic growth” as a regressor in our model will shed light on the important question of whether increased economic activity leads to increased energy consumption and emissions or not.

Trade

Trade serves as a nation’s entry point to the world. It measures the exchange of goods and services across countries. In accordance with WDI (2022), “Trade is the total of goods and services exports and imports measured as a percentage of GDP”. All the countries across the globe are dependent on each other in some manner and are connected to each other through this gateway.

The countries engaged in international trade can have different emission patterns due to transportation or production processes. It can either accelerate or mitigate these emissions therefore it is an important explanatory variable for carbon emissions in the atmosphere.

Industrialization (IND)

The degree of economic transition from an agrarian to an industrial economy is measured by industrialization. According to WDI (2022), “It includes value added in mining, manufacturing, construction, electricity, water, and gas. After combining all outputs and deducting intermediate input, the value added is the net output. It does not consider depreciation of assets or depletion of natural resources”.

Due to the energy-intensive nature of industrial operations, industrialization can have a major impact on carbon emissions. If effective and sustainable production techniques are not used, more industrialization may increase emissions.

Urban Population (URB POP)

Urban population is a quantitative term that gives the actual count or percentage of the people residing in cities in comparison to the people in villages. According to WDI statistics, “Urban population refers to people residing in urban areas”. It reflects the concentration of people in the cities and usually happens when people migrate from rural to urban areas in search of better economic and social opportunities.

Urban expansion may place a growing strain on the energy and transportation sectors, leading to excessive emissions. Including the urban population as an explanatory variable will help explain the effect of urbanization on environmental sustainability.

Interaction term (FD*IQ)

A moderator or an interaction term is an additional explanatory variable in the regression equation that impacts or modifies the relationship between an independent variable and a dependent variable It enhances gaining an understanding of the situations and periods at which the influence of the independent variable on the dependent variable is stronger, weaker, or even reversed.

In this model, an interaction term of financial development (FD) and institutional quality (IQ) is added to analyze whether the combined effect of these variables is different from their individual effects. The inclusion of this interaction term will take into account any possible contradictions or advantages between institutional strength and financial development in terms of affecting carbon emissions and will help in unleashing the potential effects of well-developed financial institutions with excellent governance.

4.3. Conclusion

This chapter contains a comprehensive view of each and every variable that will be used in the upcoming econometric analysis. It includes the definition, symbols, and their derived source. The components of the indices constructed (FD and IQ) are also explained in detail which will be beneficial for the understanding of their relative importance in the analysis.

Chapter 05

Statistical and Graphical Analysis

5.1. Introduction

This chapter is the first critical step in data analysis that will aid in the comprehension and analysis of data. It comprises two sections. The first section will tell us about the statistical characteristics of the data while the second section visualizes it in the form of graphs presenting a clear picture of the data which will refine our analytical skills further.

5.2. Statistical Analysis of Data

The statistical techniques applied to the data reports result in the form of descriptive stats while the next segment consists of correlation matrices representing the pairwise correlations among each variable. The subsequent explanations of the results are also given.

5.2.1. Descriptive Analysis

Descriptive statistics includes a wide range of statistical measures that provide a concise and clear picture of the data by using measures of central tendency and dispersion like mean, median, mode, variance, and standard deviation.

Global Data

The given Table 5.1 (a) shows the summary statistics of 111 countries at the global level. A simple breakdown of these statistics with respect to each variable will provide in-depth information about them.

Table 5.1 (a): Descriptive Statistics (Global Data)

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2	4401	4.48	5.778	0	47.657
FD	2922	0	1	-.773	9.509
REC	4357	36.145	32.981	0	98.34

IQ	3099	0	1	-1.749	2.531
GDP	4165	12859.91	21038.516	189.282	191194.47
TRADE	3865	84.989	51.989	.021	437.327
URB POP	4464	53.65	23.533	5.416	100
IND	3908	28.336	12.426	3.243	86.67
FD*IQ	2197	.49	1.091	-2.148	11.673

- **CO_2:** The data for 4401 carbon dioxide emissions is available; on average, the emissions are 4.48 per unit. The standard deviation of 5.778 represents the degree of variation. The lowest value of emission is 0 while the highest level of carbon dioxide emitted is 47.6 units per capita.
- **FD:** FD represents a composite index of financial development with a total of 2922 observations with a balanced distribution reported by 0 mean value. The minimum and maximum values are -0.773 and 9.509 which represent the diversity of financial development.
- **REC:** The data of 4357 observations show the average consumption of renewable energy is about 36.14 percent while its value can vary from 0 to 98.34.
- **IQ:** IQ is the institutional quality index constructed from six components and has a total observation of about 3099. The average score of this index is also 0 indicating a balanced distribution and the variation in value can be from -1.7 to 2.53.
- **GDP:** The indicator of economic growth has about 4165 observations with a mean value of about 12859.91 with a variation of about 21038.56. The lowest and highest GDP recorded in the global analysis are about1 89.28 and 191194.47.
- **TRADE:** The total 3865 observations of trade show the mean value of 84.98 while the lowest and highest trade activity recorded is 0.021 and 437.32.

- **URB POP:** The total observation of the urban population are 4464 with a mean value of 53.56 while the values range from 5.41 to 100 percent.
- **IND:** The data is collected from 3908 observations and the average level of industrialization is 28.33. The lowest and highest levels of industrialization are 3.24 and 86.67 respectively.
- **FD*IQ:** This is the first interaction term of FD and IQ with total observations of about 2197. The average value of this interaction term comes out to be 0.49 with a variation of about 1.091. The values can range from -2.148 to 11.673.

Continental Data

The descriptive analysis of the same variable for the three continents namely Asia, Africa, and Europe given below:

Table 5.1(b) Descriptive Statistics (Asia)

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2	1394	6.137	8.147	0	47.657
FD	1006	0	1	-1.149	3.892
REC	1389	21.873	27.863	0	95.92
IQ	987	0	1	-1.548	3.082
GDP	1316	10042.765	14587.638	189.282	73493.269
TRADE	1214	89.375	57.606	.021	437.327
IND	1224	34.041	13.947	5.05	84.796
URB POP	1394	53.886	25.33	8.854	100
FD*IQ	763	.55	1.226	-2.093	7.141

Table 5.1 (c) Descriptive Statistics (Africa)

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2	1643	1.053	1.736	0	9.986
REC	1619	61.66	29.967	.06	98.34
FD	1415	0	1	-1.089	5.376
IQ	1151	0	1	-2.638	3.009
GDP	1514	2191.152	2707.651	190.333	16747.343
TRADE	1398	68.005	36.362	9.955	347.997
IND	1445	26.305	13.224	3.243	86.67

URB POP	1644	40.489	17.566	5.416	90.092
FD*IQ	1025	.656	1.743	-.977	15.274

Table 5.1 (d) Descriptive Statistics (Europe)

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
CO_2	1302	7.092	3.591	.47	30.371
FD	477	0	1	-.903	4.823
REC	1287	18.789	16.477	0	82.79
IQ	917	0	1	-2.849	1.609
GDP	1273	28970.755	28482.057	647.481	191194.47
TRADE	1191	100.673	55.901	13.388	377.843
IND	1177	24.893	6.428	9.973	54.625
URB POP	1364	69.67	16.767	14.303	100
FD*IQ	385	.282	.936	-4.399	2.041

The summary statistics reported in the above tables from Asia, Africa, and Europe show the different levels of all the variables with the maximum number of observations from Africa i.e. 1643. The highest mean value of carbon emission is in Europe i.e. 7.092 in comparison to 6.137 in Asia and 1.503 in Africa. The score for the composite indices of FD and IQ have a mean value of 0 in all e continents depicting balanced data while the average value of renewable energy consumption variable is highest in the continent of Africa i.e. 61.66 as compared to the continent of Asia (21.87) and Europe (18.78). The mean, standard deviation, and the range of all the control variables and interaction terms are also reported in Table 5.1(b) 5.1(c) and 5.1(d).

5.2.2. Correlation Analysis

Correlation analysis shows the correlation coefficients of different variables in the form of a correlation matrix and is indicative of the strength and direction of the relationship between these variables. The value of these coefficients ranges from -1 to 1 depicting negative, zero and positive correlation.

A global correlation analysis shows the positive and significant correlation of all the variables with carbon emissions except renewable energy consumption, which shares a negative relationship with **Co_2**. Urban population shares the highest positive correlation of 0.064 with carbon emissions.

Table 5.2 (a) Matrix of Correlation (Global)

Variables	CO2	FD	REC	IQ	GDP	TRADE	URB	IND	FD*IQ
CO_2	1.000								
FD	0.282*	1.000							
	(0.000)								
REC	-0.579*	-0.359*	1.000						
	(0.000)	(0.000)							
IQ	0.475*	0.522*	-0.349*	1.000					
	(0.000)	(0.000)	(0.000)						
GDP	0.659*	0.517*	-0.375*	0.798*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)					
TRADE	0.308*	0.205*	-0.360*	0.386*	0.388*	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
URB POP	0.664*	0.418*	-0.669*	0.563*	0.632*	0.397*	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
IND	0.373*	0.027	-0.308*	-0.100*	0.007	0.099*	0.222*	1.000	
	(0.000)	(0.166)	(0.000)	(0.000)	(0.662)	(0.000)	(0.000)		
FD*IQ	0.102*	0.482*	-0.012	0.531*	0.689*	0.113*	0.319*	-0.084*	1.000
	(0.000)	(0.000)	(0.567)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

Continental Level

The tables given below represent the correlation matrices for the individual continents under the current study.

Table 5.2 (b) Matrix of Correlation (Asia)

Variables	CO_2	FD	REC	IQ	GDP	TRADE	IND	URB POP	FD*IQ
CO_2	1.000								
FD	0.222*	1.000							
	(0.000)								
REC	-0.495*	-0.349*	1.000						
	(0.000)	(0.000)							
IQ	0.510*	0.547*	-0.229*	1.000					
	(0.000)	(0.000)	(0.000)						

GDP	0.839*	0.440*	-0.443*	0.748*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)					
TRADE	0.194*	0.216*	-0.225*	0.451*	0.355*	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
IND	0.570*	0.129*	-0.382*	0.179*	0.358*	0.092*	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)			
URB POP	0.704*	0.473*	-0.713*	0.615*	0.727*	0.320*	0.372*	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
FD*IQ	0.021	0.478*	-0.191*	0.391*	0.397*	0.245*	0.116*	0.294*	1.000
	(0.562)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	

Table 5.2 (c) Matrix of Correlation (Africa)

Variables	CO_2	REC	FD	IQ	GDP	TRADE	IND	URB POP	FD*IQ
CO_2	1.000								
REC	-0.680*	1.000							
	(0.000)								
FD	0.380*	-0.575*	1.000						
	(0.000)	(0.000)							
IQ	0.351*	-0.541*	0.650*	1.000					
	(0.000)	(0.000)	(0.000)						
GDP	0.842*	-0.668*	0.354*	0.427*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)					
TRADE	0.273*	-0.390*	0.228*	0.278*	0.484*	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
IND	0.477*	-0.319*	-0.035	-0.040	0.462*	0.338*	1.000		
	(0.000)	(0.000)	(0.210)	(0.190)	(0.000)	(0.000)			
URB	0.585*	-0.603*	0.317*	0.192*	0.578*	0.370*	0.439*	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
FD*IQ	0.324*	-0.400*	0.747*	0.467*	0.374*	0.152*	-0.042	0.140*	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.189)	(0.000)	

Table 5.2 (d) Matrix of correlations (Europe)

Variables	CO_2	FD	REC	IQ	GDP	TRADE	IND	URB POP	FD*IQ
CO_2	1.000								
FD	-0.122*	1.000							
	(0.008)								
REC	-0.329*	0.238*	1.000						
	(0.000)	(0.000)							
IQ	0.409*	0.262*	0.131*	1.000					
	(0.000)	(0.000)	(0.000)						
GDP	0.486*	0.334*	0.186*	0.735*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)					
TRADE	0.313*	-0.025	-0.193*	0.277*	0.321*	1.000			
	(0.000)	(0.593)	(0.000)	(0.000)	(0.000)				
IND	0.062*	-0.271*	-0.027	-0.086*	-0.245*	-0.220*	1.000		
	(0.035)	(0.000)	(0.359)	(0.010)	(0.000)	(0.000)			
URB POP	0.380*	0.094*	-0.167*	0.437*	0.598*	0.256*	0.305*	1.000	

	(0.000)	(0.040)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
FD*IQ	0.130*	-0.669*	-0.085	0.019	0.141*	-0.121*	0.049	0.174*	1.000
	(0.011)	(0.000)	(0.097)	(0.705)	(0.006)	(0.018)	(0.334)	(0.001)	

The above correlation matrices explain the correlation between variables of the continents of Asia, Africa, and Europe respectively. All the variables show a positive correlation with carbon emission while renewable energy consumption shares a significant negative correlation with carbon emissions in every region. However, in Europe FD is also negatively correlated to carbon emissions.

5.3. Graphical Analysis of Data

One of the best and quickest ways to get meaningful information about data is to view in the form of graphs and charts. This section deals with the visual representation of the data in the form of scatter plots depicting the nature of relationship between the dependent and independent variables of the study. This section is divided in to two parts. The first part represents the overall data of all variables for each country while the second part shows the relationship on the basis average values for each cross-section.

5.3.1 Whole Data Analysis (Scatter Plot)

The whole data analysis considers all the values of the chosen variables for all countries. A scatter plot is an illustration of individual data points in the form of dots on a two-dimensional space that helps us to observe the trend, pattern, strength, and direction of the relationship between the two variables. It also helps us to identify the outliers in the data. The scatter plots between the core variables and the dependent variable for the global data are given below.

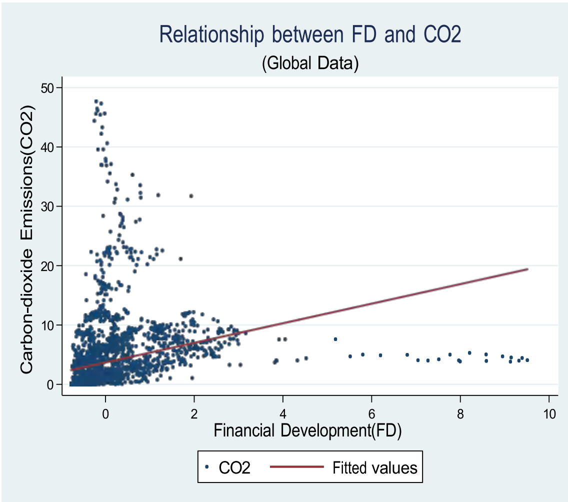


Figure 5.1: FD and CO_2 (Global Data)

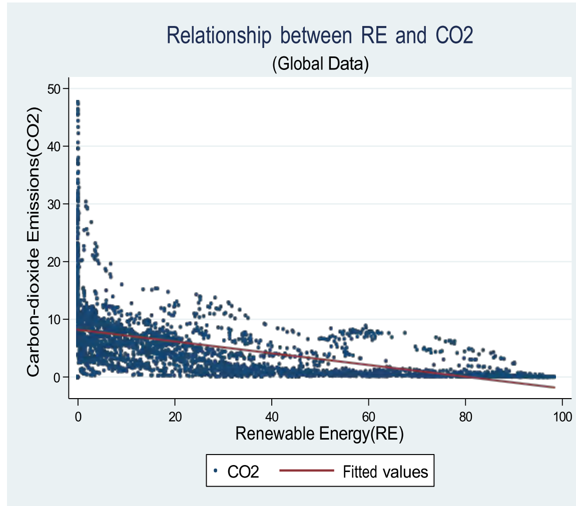


Figure 5.2: RE and CO_2 (Global Data)

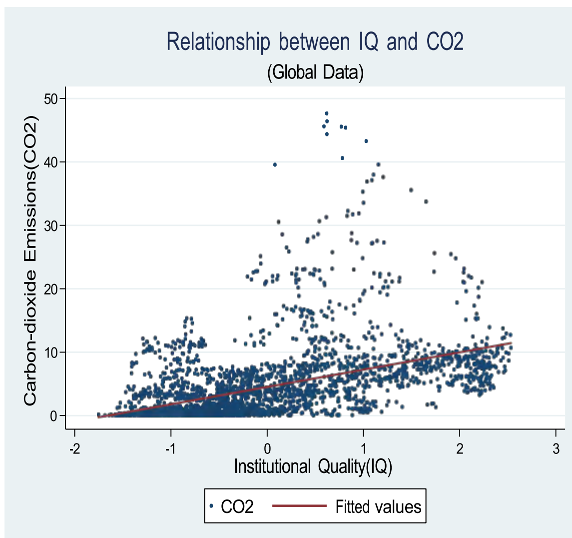


Figure 5.3: IQ and CO_2 (Global Data)

The above graphs show a positive relationship between financial development and institutional quality while the graph between renewable energy and CO_2 shows a negative relationship depicting that the increase in the consumption of renewable energy will help in the reduction of emission of carbon-dioxide gas.

Graphs of the Continents

ASIA

The relationship between financial development, renewable energy, institutional quality, and carbon emissions in the case of Asia is shown in the following graphs.

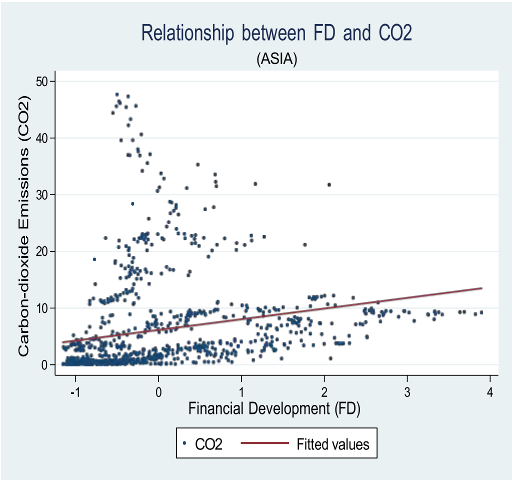


Figure 5.4: FD and CO_2 (Asia)

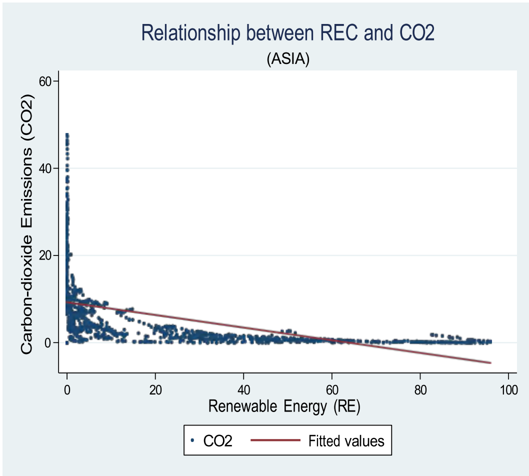


Figure 5.5: RE and CO_2 (Global Data)

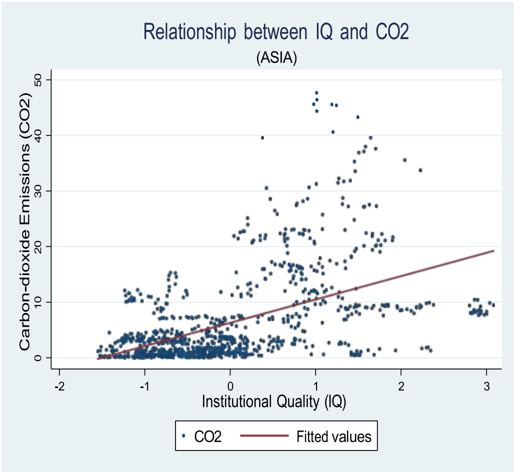


Figure 5.6: IQ and CO_2 (Global Data)

The downward sloping data line shows that RE plays a significant role in the reduction of CO_2 emissions while IQ and FD both share a positive relationship with carbon emissions.

AFRICA

The relationship between FD, RE, IQ and CO_2 in the case of Africa is shown in the following graphs.

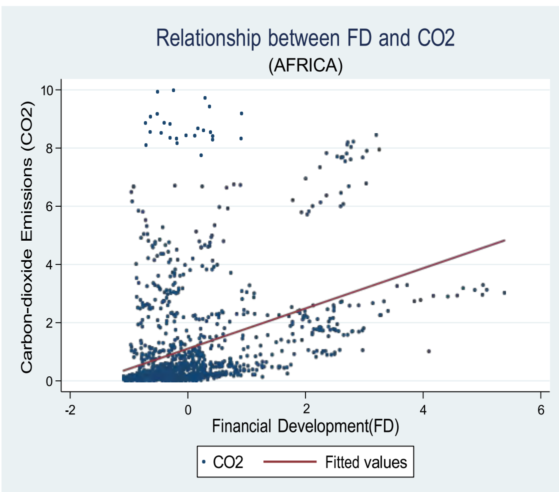


Figure 5.7: FD and CO_2 (Africa)

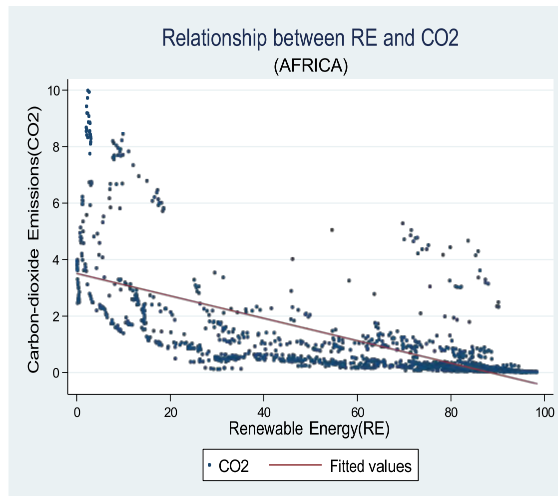


Figure 5.8: RE and CO_2 (Africa)

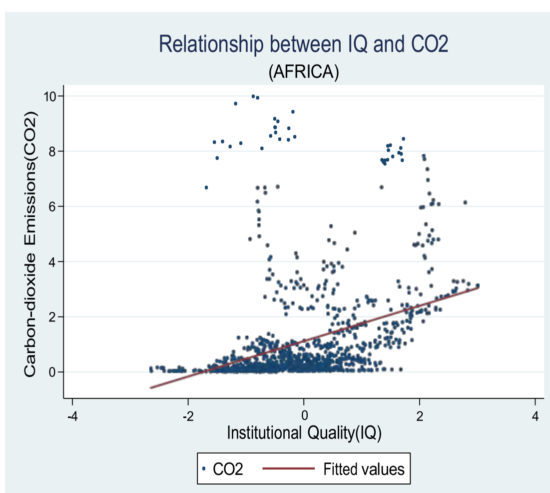
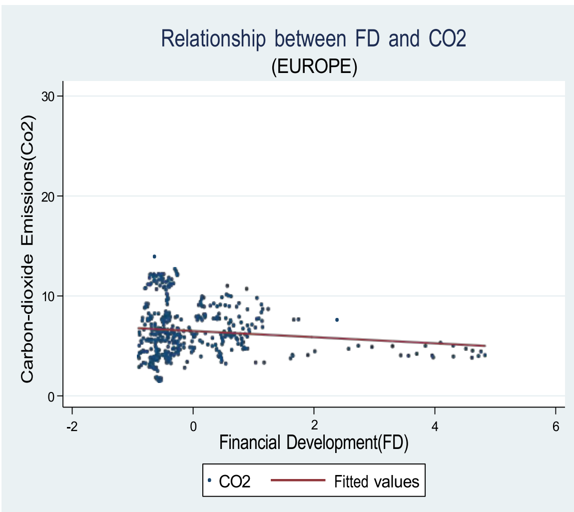


Figure 5.9: IQ and CO_2 (Africa)

A positive relationship between FD, IQ and carbon emission can be seen while the consumption of RE lowers CO_2 emission.

Europe

The relationship between FD,RE, IQ and carbon emissions in the case of Europe is shown.



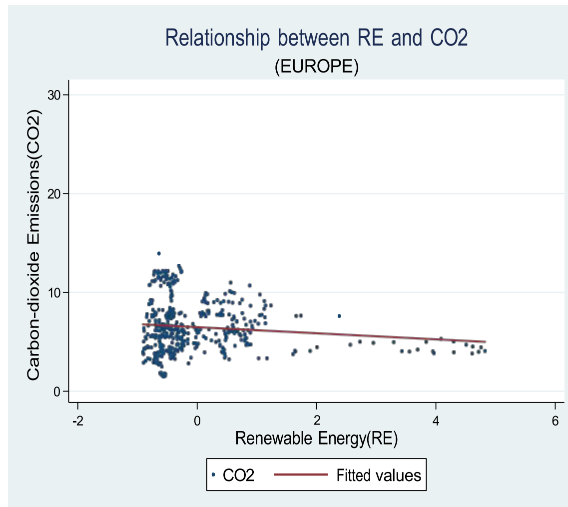


Figure 5.10: FD and CO_2 (Europe)

Figure 5.11:RE and CO_2 (Europe)

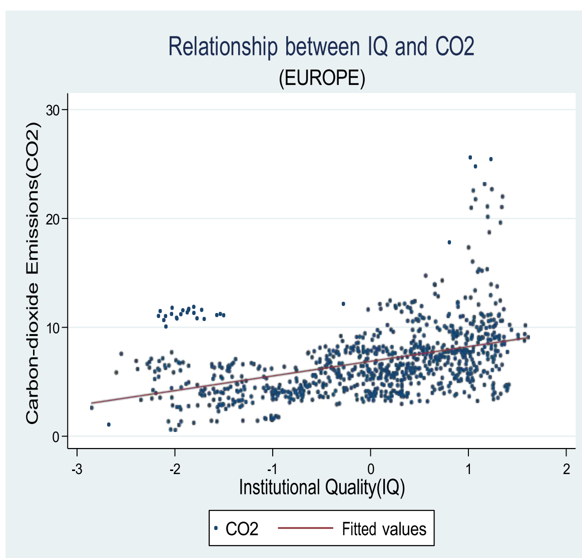


Figure 5.12: IQ and CO_2 (Europe)

The negative slope of the fitted line, which differs from the positive link between institutional quality, financial development, and carbon emissions, is an indicator that the consumption of renewable energy will aid in mitigating carbon emissions.

5.4. Diagnostic Tests

A few diagnostic tests including multicollinearity, heteroscedasticity, and serial correlation were conducted to check the correlation of independent variables, variance of residuals, and independence of errors across the panel data. A brief explanation of each test is given below.

5.4.1. Pre-Estimation Test:

- **Multicollinearity**

The assessment of a high correlation's existence between two or more independent variables in a regression model is checked through a test called "Variance Inflation factor". A VIF value of 5 or above 10 indicates high multicollinearity that needs remedial measures to obtain reliable and unbiased estimates.

5.4.2. Post-Estimation Tests

- **Heteroscedasticity**

It refers to the unequal variance of the residuals across different levels of the independent variables. It tests whether the assumption variance of constant variance of errors holds in a model or not. A p-value of less than 0.05 indicates the variance of error component is not constant and it needs to be corrected.

- **Serial Correlation**

The interconnection of error terms in a time series regression model violates the assumption of independently distributed errors which is termed serial correlation or autocorrelation. A p-value of less than 0.05 indicates the errors are not independently distributed and need amendment.

The results of all these diagnostic tests for all four models are arranged in Table 5.3

Table 5.3. Results of Multicollinearity, Heteroscedasticity and Serial correlation

Model	Multicollinearity	Heteroscedasticity	Serial Correlation
1	2.58	0.0000	0.0000
2	3.64	0.0000	0.0000
3	3.34	0.0000	0.0000
4	4.38	0.0000	0.0000

The first column of the model refers to the models constructed in Chapter 1. Model 1 is for all the countries across the globe (as per data availability) and models 2, 3, and 4 represent the models for Asia, Africa, and Europe respectively.

The VIF score for multicollinearity ranges from 2.5 to 4.38 indicating low to moderate multicollinearity which is not a problem. The p-values of heteroscedasticity and autocorrelation are all less than 0.05 i.e. 0.0000 which indicates the severity of the problem that needs to be addressed.

5.5. Conclusion

The detailed descriptive and graphical analysis presented in this chapter has provided us valuable insight into the relationship and trend of the variables over time. The summary statistics served as a foundation stone and the correlation matrix affirmed the relationship between variables. Scatter plots in the graphical analysis aided in the visualization of the patterns within the data indicating the possible outliers and nonlinearity in the model. To ensure the validity of our analysis, both pre-estimation and post-estimation diagnostic tests are performed, the results of which will be useful in our upcoming stages of analysis.

Chapter 06

Econometric Analysis and Findings

6.1. Introduction

Regression analysis is a key tool that is employed in econometric research to figure out correlations among variables. This chapter provides a detailed explanation of the quantitative relationships among variables based on economic theory that will help us to draw meaningful conclusions from it. It is divided into two sections on the basis of the nature of the relationship among the variables. The first section addresses the research questions and hypothesis of whether the linear relationship exists among the variables or not. This is explained through the results of pooled OLS, fixed and random effect while the second section describes the nonlinear linkage by employing SGMM and the interpretation of its empirical results will help us in giving a conclusive statement.

6.2. Linear Relationship between CO_2 and FD, REC and IQ

The assessment of whether a linear association exists between carbon emission, financial development, renewable energy consumption, and institutional quality is explored through pooled OLS, fixed, and random effects. The result of each of these methods is discussed below.

6.2.1. Outcomes of Pooled OLS

The foundational technique employed for the estimation of panel data is pooled OLS which assumes that entities across all regions are homogenous and considers a single regression equation to be sufficient for the representative of the whole data.

Table 6.1: FD, REC, IQ and CO_2 (Pooled OLS)

	Dependent Variable: Carbon Dioxide Emissions			
Variables	**(A)**	**(B)**	**(C)**	**(D)**
FD	0.118***	0.236***	0.253***	0.00586
	(0.0132)	(0.0229)	(0.0259)	(0.0256)
LREC	-0.129***	-0.124***	-0.132***	-0.237***
	(0.00880)	(0.0136)	(0.0155)	(0.0183)
IQ	-0.405***	-0.176***	-0.103***	-0.172***
	(0.0271)	(0.0347)	(0.0375)	(0.0349)
LGDP	0.847***	0.385***	0.976***	0.271***
	(0.0209)	(0.0361)	(0.0271)	(0.0428)
LTRADE	0.113***	0.0119	0.00970	0.146***
	(0.0253)	(0.0288)	(0.0351)	(0.0512)
LIND	0.219***	0.402***	0.248***	0.696***
	(0.0325)	(0.0449)	(0.0383)	(0.0960)
LURB POP	0.532***	0.978***	0.438***	0.504***
	(0.0396)	(0.0598)	(0.0420)	(0.142)
FD*IQ	-0.249***	-0.0848***	-0.0686***	0.00534
	(0.0136)	(0.0164)	(0.0143)	(0.0245)
Constant	-9.285***	-7.293***	-9.794***	-5.231***
	(0.193)	(0.375)	(0.217)	(0.738)
Observations	1,922	638	875	385
R-squared	0.908	0.922	0.920	0.597
Number of Ids	111	41	47	21

Standard errors in parenthesis
***p<0.01, **p<0.05, *p<0.1

The above-estimated model clearly states the dependent variable to be carbon dioxide emissions while the columns labeled as A, B, C, and D represent models 1(Global), 2(Asia), 3(Africa), and 4(Europe) respectively.

According to the estimates of pooled OLS, financial development affects carbon emissions positively at the global level and in the continents of Asia and Africa while it has no or insignificant impact on Europe. The impact of renewable energy and institutional quality on carbon emissions is negative in all the regions represented by the negative sign of their coefficients. Moreover, increments in economic growth (GDP), industrialization, and urban population all will have a significant positive impact on the emission of carbon dioxide at the global and continental levels. The estimated coefficients are at 1% significance level.

The sign and magnitude of the interaction term of financial development and institutional quality **(FD*IQ)** show the existence of a strong dependence between the two variables which implies that effective governance paired up with strong financial institutes will lead to a major decline in carbon emissions. This effect is particularly stronger in the continents of Asia and Africa.

6.2.2. Outcomes of Fixed Effect

The inability of pooled OLS to account for individual-specific effects directed us to use a fixed effect model. It allows the introduction of dummy variables to capture individual specific effects with each entity having its own intercept. The regression output from the fixed results is displayed in Table 2.

Table 6.2: FD, REC, IQ, and CO_2 (Fixed Effect)

	Dependent Variable: Carbon Dioxide Emissions			
Variables	**(A)**	**(B)**	**(C)**	**(D)**
FD	0.0959***	0.206***	0.0468**	0.0320**
	(0.0142)	(0.0206)	(0.0236)	(0.0143)
LREC	-0.316***	-0.139***	-0.345***	-0.300***
	(0.0149)	(0.0219)	(0.0396)	(0.0174)
IQ	0.0182	0.0116	-0.100**	0.110***
	(0.0297)	(0.0379)	(0.0468)	(0.0251)
LGDP	0.389***	0.399***	0.498***	0.107**
	(0.0278)	(0.0433)	(0.0484)	(0.0507)
LTRADE	0.0731***	0.0228	0.162***	-0.0377
	(0.0197)	(0.0289)	(0.0293)	(0.0432)
LIND	0.128***	0.195***	0.0216	0.484***
	(0.0233)	(0.0384)	(0.0328)	(0.0763)
LURB POP	0.964***	0.997***	0.615***	1.105***
	(0.0631)	(0.113)	(0.0902)	(0.274)
FD*IQ	-0.0636***	-0.123***	0.00204	0.0305**
	(0.00924)	(0.0150)	(0.0123)	(0.0139)
Constant	-6.368***	-6.804***	-6.133***	-4.453***
	(0.245)	(0.377)	(0.445)	(1.150)
Observations	1,922	638	875	385

R-squared	0.598	0.799	0.517	0.629
Number of Ids	111	41	47	21

Standard errors in parenthesis
***p<0.01, **p<0.05, *p<0.1

The above results show a significant positive impact of financial development on carbon emissions globally as well as continentally. Consumption of renewable energy helps in the abatement of carbon emission which is evident from its negative coefficient in all regions. A contrasting effect is seen in the case of Africa where institutional quality has an insignificant effect on carbon emissions at the global level and in the continent of Asia whereas it is negative in the case of Africa and positive in Europe. An increase in economic growth (GDP) and urban population brought a significant positive impact on the emission of carbon dioxide at the global and continental levels.

The sign and magnitude of the interaction term of financial development and institutional quality **(FD*IQ)** reveal different characteristics in different areas. It is negative across the globe and for Asia which shows the existence of a strong dependence between the two variables that implies that effective governance paired up with strong financial institutes will lead to a major decline in carbon emissions while it is insignificant for Africa and positively significant for Europe.

6.2.3. Outcomes of Random Effect

Another approach used to compensate for individual-specific effects is the random effect. It assumes individual-specific effects to be uncorrelated with the error term and estimates them as random variables. Table 3 presents the results from the random effect model.

Table 6.3: FD, REC, IQ, and CO_2 (Random Effect)

	Dependent Variable: Carbon Dioxide Emissions			
Variables	**(A)**	**(B)**	**(C)**	**(D)**
FD	0.0968***	0.209***	0.0552**	0.0329**
	(0.0140)	(0.0199)	(0.0229)	(0.0140)
LREC	-0.292***	-0.130***	-0.331***	-0.294***
	(0.0132)	(0.0181)	(0.0346)	(0.0166)
IQ	6.38e-05	-0.0147	-0.0746*	0.101***
	(0.0284)	(0.0344)	(0.0451)	(0.0247)
LGDP	0.423***	0.392***	0.593***	0.108**
	(0.0259)	(0.0402)	(0.0458)	(0.0457)
LTRADE	0.0653***	0.0160	0.152***	-0.0339
	(0.0197)	(0.0280)	(0.0294)	(0.0405)
LIND	0.130***	0.201***	0.0275	0.497***
	(0.0235)	(0.0374)	(0.0329)	(0.0740)
LURB POP	0.924***	0.990***	0.576***	0.963***
	(0.0599)	(0.102)	(0.0828)	(0.238)
FD*IQ	-0.0680***	-0.124***	-0.00396	0.0280**
	(0.00916)	(0.0145)	(0.0122)	(0.0137)
Constant	-6.559***	-6.714***	-6.737***	-3.966***
	(0.236)	(0.361)	(0.416)	(0.964)
Observations	1,922	638	875	385
Number of Ids	111	41	47	21

Standard errors in parenthesis
***$p<0.01$, **$p<0.05$, *$p<0.1$

The results from the above table show a positive significant impact of financial development on carbon emissions across the globe and in specified continents. The highest emission is in Asia where a one-unit increase in FD will increase the carbon emission to increase by 20.9% The negative sign of the coefficient of renewable energy shows it to be helpful in minimizing the concentration of CO_2 in the atmosphere and is highest in magnitude for Africa i.e. -0.331. The institutional quality index shows contrasting results for different areas. It shows an insignificant impact on carbon emissions at the global level and in Asia whereas it is significantly positive for Europe and negative for Africa. GDP and urban population play a significant role in increasing carbon emissions.

The interaction term (FD*IQ) gives different results. A one-unit change in it causes a significant drop in emissions i.e. 6.8% worldwide and 12.4% in Asia. It is insignificant for Africa and is positively significant for Europe.

6.2.4. Outcomes of LM and Hausman Test

The application of Breusch and Pagan Lagrangian Multiplier test (LM test) and Hausman test helps us choose between the best possible model from pooled OLS, fixed and random effect (Gujrati, 2009). LM test is used to select the model between pooled OLS and random effect. The null hypothesis states OLS is a better model while the alternative hypothesis prefers the random effect model to be appropriate. The results are given in Table 6.4 which shows the chi-square and p-values. In all four models, the p-value is less than 0.05 % which leads to the rejection of the null hypothesis and declares the random effect to be the better model.

Table 6.4: Outcomes of LM and Hausman Test

Models	Chi (2)	P-value>chi (2)	Selected Model
Breusch & Pagan Lagrangian Multiplier Test (LM Test)			
1	10480.59	0.0000	Random Effect
2	3981.99	0.0000	Random effect
3	3501.24	0.0000	Random effect
4	1951.56	0.0000	Random effect
Hausman Test			
1	-27.95	--------	Random Effect
2	4.51	0.8747	Random Effect
3	245.54	0.0000	Fixed effect is better
4	7.57	0.5781	Random Effect

Hausman test is used to select between the model specification between fixed and random effect. The underlying null hypothesis is that there is not much difference between the two models and using either the fixed or random effect would be appropriate. The results of Hausman statistics are given in Table 6.4. Based on the p-value, either effect could be used in models 2 and 4 and the p.value is greater than 0.05 while the 3rd model prefers fixed effect over random effect.

6.2.5. Scatter Plot Explaining Linear Assumptions:

A scatter plot is a helpful visual instrument to test for linear assumptions as well as to identify non-linear relationships among variables in a regression analysis. After a meticulous econometric analysis of the linear models constructed in Chapter 3, a scatter plot between the residuals and the predicted value is drawn for all four models in the given figures.

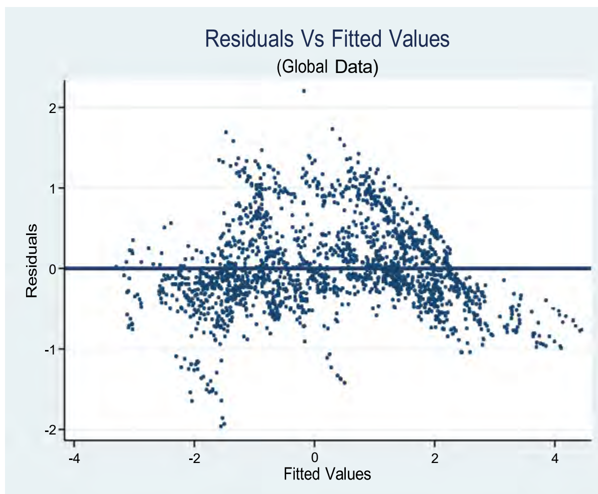


Figure 6.1. Scatter Plot (Non-Linearity Analysis)

The above figure shows the scatter plot of residuals against predicted values for global data. The horizontal line is the reference line that indicates zero residuals. The deviation of the data points from the reference line indicates the existence of a non-linear relationship.

Continental Data

The scatter plot of residuals for the continents of Asia, Africa, and Europe are drawn to test the presence of nonlinearity are given below

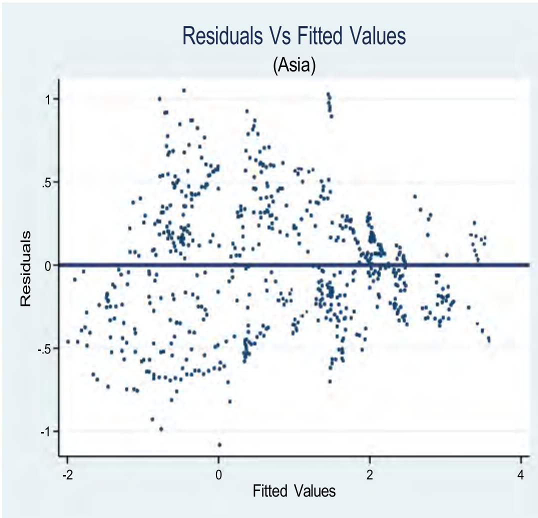


Fig 6.2. Scatter Plot(Non-Linearity Analysis)

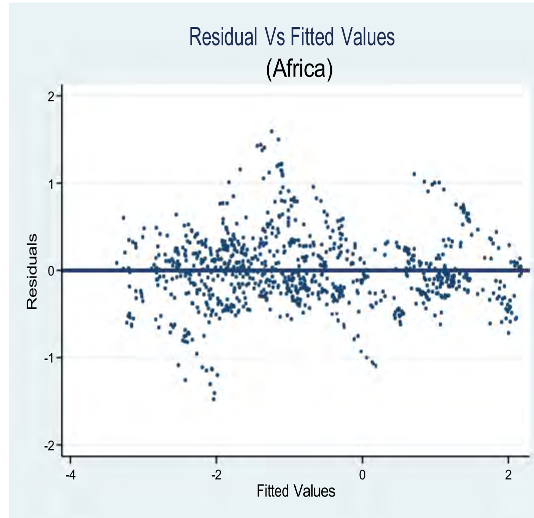


Fig 6.3.Scatter Plot(Non-Linearity Analysis)

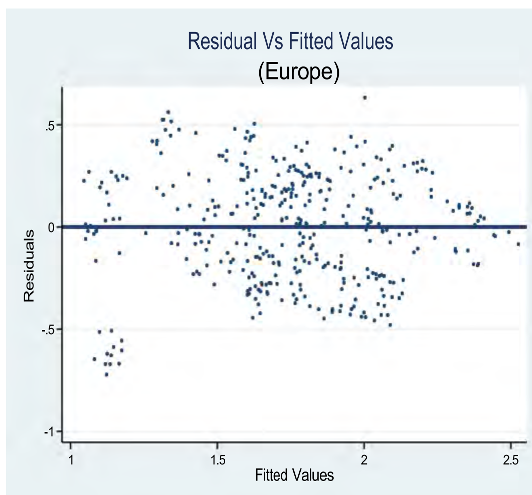


Fig 6.4. Scatter Plot (Non-Linearity Analysis)

Figure 6.2, 6.3, and 6.4 shows the scatter plot of residuals of Asia, Africa, and Europe respectively drawn against the predicted line. The pattern clearly indicates a non-linear linkage among the variables which needs to be investigated. This non-linear association is explained by applying system GMM to the data. The results obtained are explained in detail in the next section.

6.2.6. Outcomes of System GMM

To address the issue of endogeneity and unobserved heterogeneity, a more advanced econometric technique is employed for dynamic panel data models i.e. System GMM is applied in this study that provides much better, consistent, and efficient estimates of the parameters. The dependent variable of carbon emission is taken as an endogenous instrumental variable whereas the lagged values of all regressors are treated as exogenous instrumental variables. The estimated equation for this model is

$$CO_{2it}=\alpha_i+\beta_1 CO_{2i,t-1}+\beta_2 FD_{it}+\beta_3 RE_{it}+\beta_4 IQ_{it}+\beta_5 GDP_{it}+\beta_6 TRADE_{it}+\beta_7 IND_{it}+\beta_8 URB_{it}+\beta_9 INT_{it} +\eta_{it}+\nu_{it}$$

This equation will be estimated for all the models i.e. across the globe and for Asia, Africa, and Europe. The coefficients estimated are reported in Table 6.5

Table 6.5: FD, REC, IQ, and CO_2 (System GMM)

	Dependent Variable: Carbon Dioxide Emissions			
Variables	**(A)**	**(B)**	**(C)**	**(D)**
$CO_{2i,t-1}$	0.796***	0.579***	0.596***	0.685***
	(0.00645)	(0.0912)	(0.0650)	(0.0985)
FD	0.0255***	0.110***	0.0849***	-0.0503***
	(0.00441)	(0.0221)	(0.0159)	(0.0140)
LREC	-0.0288***	-0.0484***	-0.0672***	-0.0934***
	(0.00318)	(0.0130)	(0.00842)	(0.0302)
IQ	-0.0719***	-0.0527***	-0.0445**	-0.0851***
	(0.00532)	(0.0153)	(0.0213)	(0.0220)
LGDP	0.161***	0.148***	0.364***	0.143***
	(0.00669)	(0.0343)	(0.0645)	(0.0362)
LTRADE	0.0303***	0.0114	0.0281	-0.0573
	(0.00658)	(0.00878)	(0.0242)	(0.0353)
LIND	0.0511***	0.187***	0.0953***	0.0132
	(0.00769)	(0.0298)	(0.0271)	(0.108)
LURB POP	0.0552***	0.353***	0.137***	-0.354*
	(0.00589)	(0.124)	(0.0320)	(0.202)
FD*IQ	-0.0595***	-0.0479***	-0.0202***	-0.0361***
	(0.00295)	(0.0109)	(0.00704)	(0.0127)

Constant	-1.608***	-2.778***	-3.586***	-0.874
	(0.0790)	(0.713)	(0.629)	(0.991)
Observations	1,920	635	875	385
Number of Ids	111	41	47	21
AR (1) Pr>z	0.373	0.410	0.057	0.160
AR (2) Pr>z	0.592	0.558	0.146	0.530
Hansen Test	0.734	0.942	0.807	0.877

Standard errors in parenthesis
***p<0.01, **p<0.05, *p<0.1

The reported significant coefficients from the aforementioned table support the notion of a non-linear relationship among variables. The significant values of the lagged variable $\mathbf{CO_{2i,t-1}}$ show that the current level of carbon emissions is dependent on the previous year's emission i.e. a one-unit increase in carbon emission will increase the consumption of CO_2 in the current year by 79.6% universally.

The increase in carbon emissions for Asia, Africa, and Europe are 57.9, 59.6 and 68.5% respectively. Financial Development has a significant positive relationship with CO_2 emission globally and for the continents of Asia and Africa but a one-unit increase in FD decreases carbon emission by 5.3% points for Europe. Consumption of renewable energy aids in mitigating emissions significantly being the highest for Europe i.e. 1% increment in renewable energy decreases the release of CO_2 by 9.34% points. The effect of IQ on CO_2 emission is negative across the globe and in specific continents which shows that there is a dire need for effective governance to help in the abatement of carbon discharge.

The non-linearity of the relationship is also confirmed by the significant coefficients of the interaction term **FD*IQ**. The parameters of the estimated variables show a significant negative relationship with carbon emissions globally as well as continentally. A one-unit increment in financial development moderated by institutional quality is estimated to decrease CO_2 by 5.9% at the global level while a similar one-unit change leads to a decrease in the carbon footprint in Asia, Africa, and Europe by 4.7%, 2.02%, and 3.61%. The coefficients of other control variables along with their magnitude and sign are also reported in Table 6.5.

6.3. Conclusion

The findings of this chapter provided key insights into the complex dynamics of financial development, renewable energy, and institutional quality and their collective impact on carbon emissions. The results reveal the role of institutional quality as a key mediator in influencing the role of financial development in limiting carbon emissions worldwide as well as in all continents. This signifies the crucial role that strong governance can play by restructuring financial institutions, and encouraging investments for renewable energy projects that not only promote economic growth but also promotes environment sustainability.

Chapter 07

Conclusion and Policy Recommendations

7.1. Introduction

The exploration of the convoluted relationship between financial development and renewable energy consumption has become the focal point of inquiry for researchers around the globe and conscious efforts have been made to address climate change and foster green growth to help in the attainment of Sustainable Development Goals (SDGs). This research has examined the intricate relationship between financial development and renewable energy, with prime focus on the role of institutional quality on environmental degradation i.e. emission of CO_2 at global and continental level (Asia, Africa and Europe).

This chapter is segmented into two sections. The first section summarizes the results of the findings providing a conclusive statement and suggests policies on the basis of it while the second section explains the limitations of the study paving the path for future research.

7.2. Conclusion of the Study

The raising environmental concerns and the need of a cleaner and safer environment led to find an answer to the questions pointed in the beginning (Chapter 1) of this thesis. This study has explored the complex inter relationships between carbon emissions, financial development, renewable energy consumption and institutional quality. The study takes an interesting turn when the mediating role of institutional quality comes into play i.e. an interaction term of financial development and institutional quality **(FD*IQ)** that plays a key role in solving the dilemma of whether the financial institutions along with effective governance help in curbing carbon emissions or escalate them. All this analysis is done by establishing a strong theoretical foundation followed by a meticulous empirical analysis that spans the years from 1990-2020 both at the global level and for the three continents Asia, Africa and Europe.

The study at first tried to assess the linear association of the models constructed in Chapter 3 by using traditional econometric techniques i.e. pooled OLS, fixed and random effect models. To check the presence of non-linearity and existing endogeneity, a two-step system generalized method of moments (SGMM) is employed to obtain efficient and consistent estimates. The results obtained from the panel data analysis show that urban population and financial development are positively correlated to carbon emissions worldwide and in the continents of Asia and Africa while well-developed financial institutes and increased population in Europe is helpful in declining carbon emissions. Employment and consumption of renewable energy in different sectors of the economy help in lowering the concentration of carbon dioxide in the atmosphere in all regions. Economic growth (GDP) and industrialization also exacerbate carbon emissions except in Europe where the coefficient of industrialization shows an insignificant impact. The influence of trade on carbon emissions is significant across the board but is insignificant for Asia, Africa and Europe.

The quality of institutions and its moderating effect along financial development **(FD*IQ)** yields a significant negative relationship across the globe and in the specified continents rejecting the null hypothesis of no significant moderating effect of **FD*IQ**. It establishes the fact that strong regulatory frameworks, effective governance structures, and control of corruption in a society along with well-developed and well-managed financial institutes aid in reducing carbon footprint by transitioning from non-renewable to renewable energy sources and stimulating green growth. The institutions capable of risk management, enforcing agreements, and assuring the fair distribution of gains inculcate confidence in the investors to invest in long-term eco-friendly projects that pave the path to resilient and sustainable development.

7.3. Policy Recommendations

Based on the findings of this study, some policy suggestions are put forward that align well with the intricate relationship between financial development, renewable energy, and institutional quality:

- Institutional quality should be strengthened by making strict rules and regulations supporting transparency, equity, and accountability. Policymakers should devise policies that aim at reducing corruption, safeguard the public interest, and are stable over time. A decrease in investment risks bolsters an investor's confidence.
- The concept of 'Sustainable Financing' should be promoted by channeling the financial resources from non-renewable to renewable energy projects with the help of innovative financial instruments like green bonds, green securities, etc.
- Fiscal instruments like tax and government spending should be used to promote renewable energy projects. Policies of tax cuts or subsidies on the projects targeted for green growth should be formulated to encourage private sector participation.

7.4. Study Limitations

The study provides valuable insight into the complex interplay between carbon emissions financial development, renewable energy, and institutional quality yet it has certain limitations.

- The data for most variables was missing for many countries which reduced the sample size of global analysis to 111 countries for the time period 1990-2020. The employed technique for econometric analysis was system GMM.
- . Even though the potential variables that could impact carbon emissions were included as explanatory variables, there could be unobservable factors having an influential impact.

- Moreover, for the continental analysis, only three continents namely Asia, Africa, and Europe were chosen so the results cannot be generalized to other continents because of the geographical and institutional differences.

7.5. Future Research Direction

This research can be used as a base to explore the further dynamics of this inter-twined relationship. Future studies can extrapolate this research in many ways:

- A research study employing advanced causal inference methods can be used to investigate the causal relationships between financial development, renewable energy, and institutional quality.
- Incorporating technological innovations like smart grids, carbon capture and storage (CCS), hydrogen economy, and blockchain technology into the analysis can provide an in-depth understanding of the efficacy of these innovations and their consequent effect on carbon emissions.
- To get a comprehensive view of the impact of these variables on carbon emission, including the externalities associated with renewable energy adoption like employment level can also be considered.
- Advanced econometric techniques like polynomial regression or machine learning algorithms can be used to explore the non-linear relationship between the variables.
- A comparative analysis comprising the countries having differences in economic development, institutional structures, and cultural factors can shed light on how significant these factors are in combating climate change

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