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Assessing the Impact of Green Finance on Environmental Sustainability

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Abstract
The research is conducted on five regions and will have a significant contribution by proving the evidence that green finance has a considerable impact on environmental sustainability. Green finance is evaluated by variables including; GDP, investment in renewable energy sources, research and development for environment friendly projects, renewable electricity output share in total electricity mix and public-private-partnership investment in renewable energy projects. The research revealed that increase in production of energy from renewable sources, increase in research and development and the evolution of public-privatepartnership investment in renewable energy causes decrease in CO2 emission. It is evidenced that green finance in renewable energy sources is necessary to achieve environmental sustainability. There is strong need to increase the green finance in renewable sources to target the vindication of global CO2 emissions. There should be cross-border trade of renewable energy in the regions/countries to mitigate CO2 emissions in the whole world. The research paper ranked regions on the basis of environmental sustainability that may help out the researchers and decision makers to entice foreign direct and private investment in such regions.
Keywords: green finance; environmental sustainability; public-private-partnership; renewable electricity output

1. Introduction

The planet has witnessed an intense reinforcement of natural events, such as winds, floods and heat waves, due to the rapid dissolution of glaciers and polar ice caps, resulting from environmental deterioration. Environmental issues such as ecological imbalances, biodiversity loss, soil degradation and ecological destruction are becoming the concerns of global economy and international politics, as they have been closely associated with sustainable growth and human survival (Yan et al, 2021).

In an attempt to control the environmental devastation, all countries in the world committed in Paris collectively to control the increase in CO2 emissions and to trail further efforts to limit the temperature increase to 1.5 °C above pre-industrial levels (UNFCCC, 2015, p.3), indicating the world dedication towards mitigation of CO2 emissions for the achievement of environmental sustainability (Lee & Min, 2015). Nonetheless world is facing the challenge of environmental degradation due to rendezvous of human activities to maximize wealth (Chen, et al,2022). This challenge is more critical for developing countries due to their transition period for economic and social development. Vulnerability of the economy and dependence on global finance to support economy and climate protection are twin evils towards sustainable environment accomplishment.

Environmental sustainability is defined as a condition of interconnectedness, resilience and balance that enables human society to satisfy all its needs while protecting the ecosystems and biological diversity (Morelli, 2011; Rafiq et al., 2022). GF is a broader term for principles and regulations that make banks economically, environmentally and socially sustainable, it is a holistic concept whose key component is green banking. Green Banking refers to banking activities that protect the climate & natural resources and the best alternative to financing eco-friendly projects and agencies that protect the ecosystem (Chen et al, 2022).

In the worlds of academia and business concepts of green finance, an evolving idea with no formal and global definition, also used synonymously with green investments are widespread and have various connotations. The implementation of an efficient green economy through green finance represents an important alternative and an avenue for economic growth, as well as a channel to ensure sustainability via low energy use, consumption and emissions (Yan et al, 2021).

Recently, numerous studies have been conducted on the recent trends, problems and opportunities for the development of green finance to achieve sustainable development goals (SDGs). Besides this, a few studies have attempted to identify the relationship between green finance and green economy (Chen et al,2022); green finance and climate change mitigation in N-11 (next 11 emerging countries) and (Brazil, Russia, India, China, and South Africa) BRICS countries [Nawaz et al,2021]; and green finance, carbon intensity and non-fossil energy consumption (Zheng et al,2021). Yet there exist limited studies that are based on the ranking of the regions based on their emphasis on sustainable environment concerns. The current research has been conducted to assess the relationship of green finance and environmental sustainability and to rank the selected regions based on the response of variables. Green Finance has been categorized into 05 Benefit type variables (BTV) and 01 Cost type variables (CTV). The decrease in CO2 emissions is taken as a proxy for sustainability and it is CTV. Environmental Sustainability- ability to maintain the things which are valued in the natural environment, denoted by low CO2 emissions could be achieved through green finance (Morelli, 2011), via BTV. The research selected five BTV variables: Gross domestic product (GDP), research

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and development (R&D), renewable energy production & output, public private partnership (PPP) investments in renewable energy and electricity production in energy mix.

This research attempted to fill the research gap in the following ways: first, this research presented the rank of green finance activities in selected 5 regions and glimpses of their comparison depicted the situation and concerns of each country for GF. Second, this research contributed to the existing literature, especially on, green finance and environmental performance by analyzing the GF Index constructed. Third, the research evaluated the GF selected variables short run and long run behavior to find significant relationship by applying Panel EGLS Random Effect model.

Green Finance is the protection of environment and has expected positive relationship with environmental sustainability Environmental Sustainability and green transition are strongly associated with each other so the green transition without energy and environmental sustainability is partial and inadequate (Hall et al., 2018; Ji et al., 2021). There is a need for the cross-border renewable energy trade for long-term environmental sustainability and to mitigate climate change (Sun et al., 2020; Ferratet al., 2022). Replacing the traditional fossil fuels with relatively modern and cleaner renewable alternatives is believed to be an effective means of restoring environmental harmony in the globe (Murshed, 2021).From the market perspective and policy point of view, the research explored and revealed how green finance helps to achieve environmental sustainability. The research results revealed that policymakers should dynamically encourage the research and development of low-carbon technologies and renewable energy investments. Nonrenewable energy sources level should be targeted to be reduced and especially those sectors which are more energy-intensive and causing to increase in consumption-based CO_2 emissions.

This study highlights the development of green finance and its relationship with environmental sustainability. From the market perspective and policy point of view, the study explored and revealed how green finance helps to achieve environmental sustainability. The study results revealed that policymakers should dynamically encourage the research and development of low-carbon technologies and renewable energy investments. Nonrenewable energy sources level should be targeted to be reduced and especially those sectors which are more energy-intensive and causing to increase in consumption-based CO2 emissions.

The conceptual framework of research is elaborated below to assess the impact of green finance on environmental sustainability.

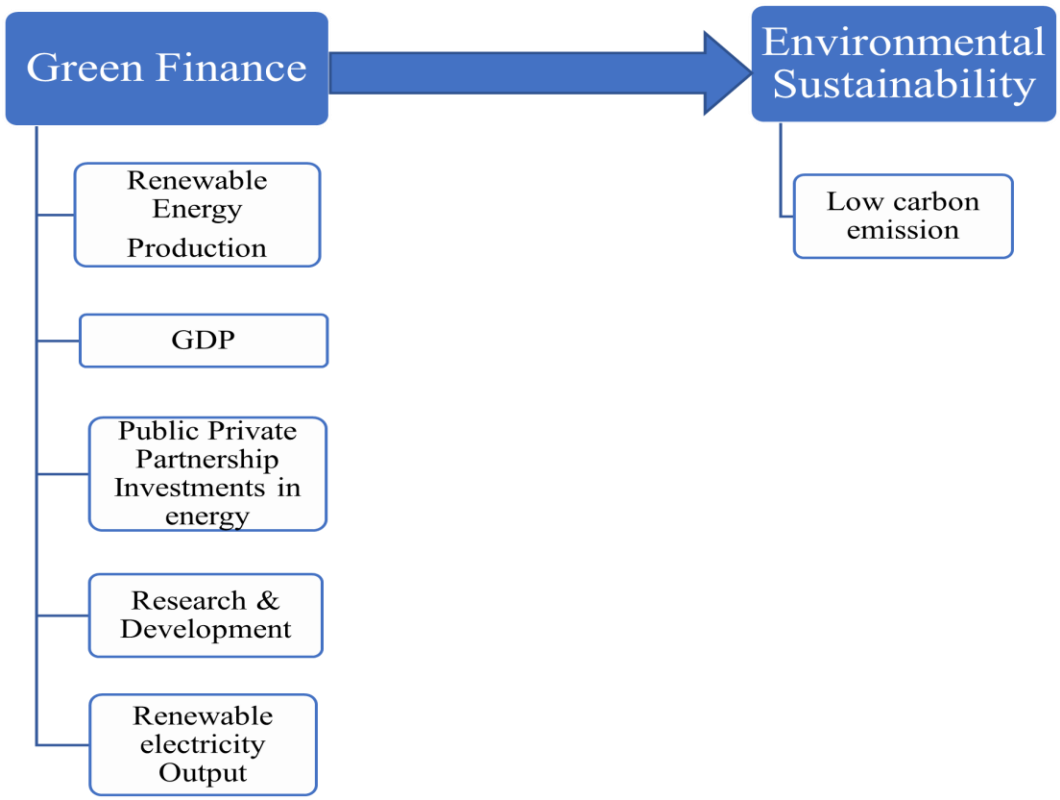

Figure 1.1 Research Framework

The rest of the research is structured accordingly: Section 2 discusses the relevant literature. Section 3 introduces the research methods, which include data collection and methods of analysis. Section 4 presents the results, followed by discussions thereof in Section 5. Lastly, the major policy implications for GF growth and mitigation of environmental effects through green financing are discussed.

Table 1: Abbreviation Used in the Research

BTV	Benefit-type variables
CDM	Clean Development Mechanism
CEM	CO2 emission in Kiloton
CI	Composite Indicators
CSR	Corporate social responsibility
CTV	Cost-type variables
EGLS	Estimated Generalized Least Squares
EPR	Electricity production from renewable sources (kWh)
ESG	Environmental, Social and Governance
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product (current US$)
GHGs	Greenhouse Gases
IES	International Energy Agency
IMF	International Monetary Fund
IRENA	International renewable energy Agency
OECD	Organization for Economic cooperation & development
PPE	Public-Private-Partnership's investment in renewable energy (current US$)
RD	Research and development expenditure (% of GDP)
REO	Renewable electricity output (% of total electricity output)
SSPs	Shared socioeconomic pathways
UNFCCC	United Nations Framework Convention on Climate Change

2. Literature Review

Since the prominence of CO2 emissions and related issues, the financial sector's role towards an environmentally sustainable global economy has increased. The transition of renewable energy requires a substantial amount of global green finance investment. A huge amount up to $61 trillion is needed in the sector to decarbonize speedily in order to control global warming (Murshed et al., 2021; Yu et al., 2022). The relationship between economic growth and environmental degradation has been a theoretical as well as an empirical area of research since the early 1990s in the field of environmental economics. Indeed, the hypothesis of the environmental Kuznets curve (EKC) suggests that there is an Inverted-U relationship between environmental degradation and per-capita income (Grossman and Krueger, 1991). In the early stage of economic growth, environmental degradation would grow; then, beyond a certain level of per capita income, economic growth would result in an improvement of the environment.

The relationship between environmental degradation and economic growth is examined by many studies including Shafik (1994), Grossman and Krueger(1995), Holtz-Eakin and Selden, 1995, List and Gallet (1999), McPherson and Nieswiadomy (2000), Harbaugh et al., 2002, Pallab et al., 2006, Sebri (2009), Nasir and Rehman (2011), Sharma (2011), Itkonen (2012), Adom et al. (2012), Saboori et al., 2012, Shahbaz et al. (2013), Song et al. (2013), Saad and Belloumi (2015) and Sebri (2016). These studies used different indicators for environmental quality, including suspended particulate materials (SPM), nitrogen oxide (NOx), carbon monoxide (CO), sulfur dioxide (SO2), smoke (for air quality), CO_2 (for atmospheric changes), dissolved oxygen, fecal waste, heavy metals, the number of threatened bird species, threatened species of mammals, national risk indicators (for threats to biodiversity), biodiversity and annual deforestation (for deforestation), and water quality metrics. These empirical studies provided three different results with regard to the EKC: positive, negative, and non-significant results. Generally, however, these studies suggested that the relevance of EKC can be country specific with variation, across countries and across different measures of environmental standards.

In recent years, environmental degradation and natural resources have gained more attention from researchers, scholars and policymakers. Ahmed et al. (2020), Hassan et al. (2019), Zafar et al. (2019), found the expansion of human capital helps to curb environmental degradation. Moreover, the unidirectional causality found running from natural resources to Ecological Footprint (EF).

The dilemma of EKC and EF was under discussion that in recent times, examining the impact of economic complexity and environmental worsening has gained extensive research interest. In this respect, Can and Gozgor (2017), Doˇgan

et al. (2020b), Romero and Gramkow (2021), Boleti et al. (2021), originated a debate on the linkage between and economic complexity and environmental decline. Their empirical findings highlighted that a higher degree of economic complexity (structural transformation) helps to curb environmental degradation. Economic complexity contributes to reducing greenhouse gas emissions and helps to improve environmental quality. Conversely; Doˇgan et al. (2019) reported that economic complexity deteriorates the environment quality. Similarly, Neagu and Teodoru (2019) unveiled that economic complexity deteriorates the environmental quality. Pata (2021) and Chu (2021) documented that there exists an inverted U-shaped relationship between economic complexity and CO2 emissions. Nevertheless, there is no evidence of a significant association between economic complexity and environmental degradation in some of the region of EU countries (Adedoyin et al., 2021). In short, we can attribute several reasons to environmental degradation, each links to human activities and CO2 emission. Though mitigation of CO2 emission is inevitable yet has high opportunity cost. It can be attained at the cost of economic growth or ecological footprint. Hence there is need of transformation that requires finance known as Green Finance defined as green credit (Wang et al., 2021). It considers positive and effective environmental results, in the financing of tasks in various eco-friendly activities, such as renewable electricity, green industry establishment, green brick manufacturing, clean energy, pollution management, water management, climate change mitigation and adoption strategies, biodiversity safety, etc. Therefore, the development of green finance, which improves the progress and transition of green economy, allows people to address the issues of climate change, environmental crises and energy conservation. Besides this, a scale-up of funding is needed for investment that provides economic and environmental advantages through new financial tools and new policy initiatives, such as green banks, central banks, green bonds, fintech and energy market tools, to attain the SDGs. Green finance combines financial decisions with environmental commitments in order to produce optimum results (Yan et al., 2021).

Moreover, at the time after Covid-19 Pandemic and Ukraine War with Russia Countries are at a decisive moment, as on one side they are sensitive to climate change and on other side highly dependent on global finance to support their economies and climate protection. Furthermore, for mitigation programs via formal and coordinated green investment in line with the global norm (Chen et al, 2022). It is now generally accepted that green finance is not only beneficial to the ecosystem, but also to the investors. Nonetheless, other than these advantages and its relevance to environment issues, green finance also has disadvantages, such as low yields, complicated processes and a lack of expertise (Yan et al, 2021). Green projects despite having strong externalities and environmental advantages compared to the conventional ones lack professional experience, and are costly at the early developmental stages (Zhang et al, 2021). The method of developing Sustainability in green finance needs creative talents. Zhang et al. (2021) and Haque and Murtaz (2022) stressed on green finance as a vital financial instrument in any country's sustainable economic growth and development. There are issues with green finance in almost all of the countries around the world. More recently, Fedorova (2022) studied the problems related to the development of green finance in Russia. The research identified a number of issues specific to green finance, which included disagreements on the understanding of the principles of green finance and economy; difficulties in evaluating and assessing the external effect of green finance; structural factors hindering the growth of green finance; knowledge imbalance; and issues related to the estimation of credit.

Green Finance refers to the financial sector investment in green projects, includes renewable energy projects with the focus on economic production and green goods production provides loans to support enterprises and institutions involved in green projects (Naqvi et al., 2021). Financial institutions offer concessionary loans for green projects and restrict investment on projects causing CO2 emissions and pollution in addition to some punishable markup rates (Xu, 2013). It may provide financial incentives to green projects and has a desire to preserve the environment of the planet, emphasizes more on the environmental promotion and pays more consideration to environmental protection projects (Wang & Zhi, 2016).

Increase in green financing is a major tool which ensures environmental sustainability through mitigation of CO2 emissions (Gouldson et al., 2015; Umar et al., 2021). The goal of a green economy is on the creation of superior design of products, materials, systems, and business models with the help of green finance (Wackernagel et al., 2017). The research on electricity industry and its effects on energy efficiency (EE) in developed and emerging economies are vital in developing a futuristic pathway, leading to self-sustainable renewable energy use. Simultaneously, natural resources and technological innovations can increase the pace of energy efficiency and ecological sustainability (Yu et al., 2022).

According to Li et al., (2021), elasticity estimates from the cross section augmented autoregressive distributed lag approach indicated the investments in green projects reduce the short and long-term CO2 emission levels. On the other hand, the development of the financial sector, the extraction of natural resources, and energy investments increase CO2 emissions. Decentralization of energy production with the engagement of private sectors can work as a triggering factor for achieving the target of renewable energy which is necessary for sustainability (Newcomb et al. 2013). The Public-private-partnership (PPP) is often defined as a long-term contract between a government agency and a private

party for providing a public asset or service is best alternative to provide support in green finance projects. There is a link between private investment and CO2 emissions (Waqih et al. 2019); an inverted U-shaped association between private carbon investment and CO2 emissions is found. Lorente et al. (2019) found the environmental quality in OECD is significantly related to public investment in the energy sector.

A study has been conducted by Shahbaz et al. (2020) to explore the linkage between PPP investment in energy sector and CO2 emissions considering the important role of technological innovations in CO2 emissions . The empirical results revealed that PPP investment in energy impede environmental quality with the increase of CO2 emissions. On the other hand, technological innovations have significant negative effects on CO2 emissions. The relationship between CO2 emissions and economic growth is Inverted-U shaped. The private investment is accompanied with CO2 emissions and after the threshold level of investment, CO2 emissions start to decline (Ganda, 2019).

The importance of PPP investment for transition in energy production undoubtedly is essential, especially for developing economies having unmet investment needs. The relationship between foreign direct investment, financial development, energy innovations, energy consumption, and CO2 emissions is also estimated in a study of Shehbaz (2020). The research concluded that increase in energy innovations has a negative impact on CO2 emissions and likewise financial development also leads to decline in CO2 emissions. The empirical results also indicated that heavy investments in energy innovations projects can improve environmental quality by reducing CO2 emissions.

Research and development (R&D) comprise activities that are undertaken to innovate and introduce new products and services. It is often the first stage in the development process, to innovate new products and services to bring in market (Karim et al., 2022). Energy innovation improves environmental quality and suggests the policymakers to boost the public budget, particularly in the energy sector for promoting innovation to mitigate CO2 emissions (Herránz et al., 2017). A study was conducted by Fernández et al. (2018) to examine the impact of R&D expenditures on CO2 emissions for the USA, European Union (EU) and China, spanning the period of 1994–2013. The results concluded that R&D expenditures have a positive impact on reduction of CO2 emissions in the US and EU. It is suggested in different studies that the government should focus on renewable energy sources, energy saving policies, and new green technologies for greater reductions in CO2 emissions and focusing more on research and development in the country (Apergis et al., 2013, Koçak et al., 2019). The public budget for R&D in the renewable energy sector could mitigate the CO2 emissions and can also improve environmental quality (Goelet al., 2008, Herranz et al., 2017).

Renewable electricity output (REO) is the percentage share of renewable electricity in total electricity consumption. The empirical findings of various studies indicated that REO has a significant negative impact on CO2 emissions. It has a positive relationship with environmental sustainability. Integrating renewable electricity into the national electricity mix is a difficult task especially for the developing economies which are unable to rapidly undergo the Renewable electricity transition due to financial limitations (Nathaniel et al., 2021). The United Nations' 2030 agenda of Sustainable Development Goals calls for uplifting the REO share in the global electricity-mix, particularly through the mobilization of external financial resources such as FDI. High start-up costs associated with the setup of renewable electricity generation power plants and low availability of green finance opportunity are major reasons behind the fossil fuel dependency among developing countries of the world (Kibriaet al., 2019; Kabel et al., 2020). Electricity is the highly utilized source of energy engaged to produce the national outputs in developing countries. However, countries and in particular the developing, are traditionally relied on the indigenous primary fossil fuel supplies for electricity-generation purposes. Besides, these nations are vastly dependent on imported fossil fuels for generating electricity (Hanifet al., 2019; Murshed et al., 2020). Financial constraints restrict the developing countries most of the time from undergoing the renewable energy transition. It is found that FDI inflows enhanced the share of renewable electricity output in the total electricity output levels of the country (Murshed, 2021).

In recent decades investment in green finance has spurred that is attributed to positive socio-economic externalities and financial brook. Nonetheless, contradictory to the thought most of the studies considered the promotion of carbon-neutral investments among the primary constituents to develop a carbon-neutral economy. In a study of (Ji et al., 2021) comparative performance showed that green funds outperform their counterparts for the entire sample and within-country assessment. It was documented that volatility is less for green funds and mainly absent in high emission funds. In another study the development of a green financial intermediation channel is deemed imperative to achieve zero-carbon economies. Using two specific credit risk measures, Umer et al., (2021) depicted that the exposure to carbon-neutral lending is negatively related to the default risk. The results remained consistent for the various size sorts, depicting that regardless of the bank size, the impact of green financing on the credit risk was the same. Due to lower credit risk, financial institutions can benefit from lower loan loss provisions and economic capital requirements. This incentive is vital to increase the carbon neutral credit and contribute towards pro-environmental goals.

Analyzing the literature, the present research found the gap in reference to the consensus regarding green finance and traditional finance contribution towards economic development and Environmental Sustainability. Hence, the current research has analyzed the impact of green finance on environmental sustainability incorporating several variables not

studied earlier for a broader sample of countries. Utilizing renewable energy sources as an alternative energy has been assumed to improve the condition of the environmental attributes. So, it is important to unearth the possible means by which fossil fuel dependency across the world can be mitigated to ensure relationship between economic and environmental development (Murshed et al., 2021)

Sun et al., (2020) highlighted the research gap and recommended that the study of relationship between green finance and environmental sustainability can be extended for large regions such as South Asia, the European Union and OECD can be valuable in future. The gap indicated by the Sun et al. (2020), is addressed in our research.

3. Methodology

To rationalize the objective of the research, data has been collected for 05 regions **China:** Mainland China, Hong Kong, Macau, **South Asian Countries**: Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka and Maldives, **North American Countries**: Canada, United States, Mexico, Nicaragua, Honduras, Cuba, Guatemala, Panama, Costa Rica, Dominican Republic, Haiti, Belize, El Salvador, The Bahamas, Jamaica, Trinidad and Tobago, Dominica, Saint Lucia, Antigua and Barbuda, Barbados, Saint Vincent and the Grenadines, Grenada, Saint Kitts and Nevis **OECD Countries**: Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxemburg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States **European Union Countries**: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden. Sample size is 05 regions as cross sections and 10 periods from 2010 to 2020 in time series. Data is analyzed in the shape of panel. It is a dataset by which the trend of cross section entities is observed over the time. The entities could be individuals, institutions, companies, cities, states, provinces, countries, and regions etc. Panel data allows researchers to control the variables which one cannot measure e.g., cultural factors or difference in business practices across businesses; or variables that change over time. Panel data also takes into account the individual heterogeneity. The data and information have been collected from the following sources: International Energy Agency (IEA), World Bank, OECD, IMF and US Energy Information Administration.

To analyze the relationship between variables across groups; Panel EGLS Random effect Model is applied. The model aptness was established by Hausman test results. Granger Causality results were also attained to determine the bi-directional causality between variables. This model was used by Bogdan et al., (2022) in the analysis of composition and various characteristics of the board and the executive directors for corporate governance in countries with an emerging capital market. The study analyzed data by applying the EGLS panel models involving five financial indicators and two proxies for gender diversity. It used the random-effects model to perform the panel data analysis.

To better prop-up the results research used graphical information to gauge region's performance in reference to Cost Type Variable (CTV) and Benefit Type Variables (BTV) for ranking of regions in terms of environmental sustainability based on these variables results. The Region's rank improved with the reduction in Cost-type variables (i.e., CO2 emissions) and increase in Benefit-type variables (i.e., EPR, GDP, R&D, REO, and PPE).

The research determined the relationship of 05 independent variables of (BTV) (i.e., Renewable energy, Research & development, Public-Private-Partnership investment in renewable energy, GDP, and Renewable Electricity Output) with 01 dependent variable of (CTV) i.e., CO2 emissions. All variables are summarized in Table 1 along with their abbreviations.

The expected relationship between independent and dependent variables based on empirical literature is given here under:

- The relationship between CEM & GDP is positive and significant
- The relationship between CEM & PPE is negative and significant
- The relationship between CEM & REO is negative and significant
- The relationship between CEM & RD is negative and significant
- The relationship between CEM & EPR is negative and significant

4. Findings of the Research

According to Hair et al. (2010) and Bryne (2010) distribution is normal when Skewness is between -2 to +2 and Kurtosis is between -7 to and7.Statistics in Table 2 showed that Skewness and Kurtosis are within range for all variables. It is evident that variables for which Skewness and Kurtosis are within range show that data is normally distributed and there is no excess Skewness and excess.

Table 2: Descriptive Statistics

Descriptive Statistics	LNCEM	EPR	LNGDP	LNPPE	RD	REO
Mean	15.48116	25.7894	30.00607	22.30112	1.884365	19.19336
Median	15.57246	26.05	30.31953	22.0501	2.047615	18.16407
Maximum	16.40901	27.7416	31.54508	25.1505	2.734596	29.71535
Minimum	14.22808	23.12985	27.81008	19.85926	0.624638	14.73231
Std. Dev.	0.677583	1.193787	1.097689	1.107346	0.671229	3.489294
Skewness	-0.17806	-0.51218	-0.40317	0.240504	-0.71268	1.394246
Kurtosis	1.721063	2.359278	2.125553	2.704932	2.221109	4.746461
Jarque-Bera	3.67186	3.041338	2.947556	0.663403	5.496539	22.55377
Probability	0.159465	0.218566	0.229058	0.717702	0.064039	0.000013
Sum	774.058	1289.47	1500.303	1115.056	94.21824	959.668
Sum Sq. Dev.	22.4968	69.83126	59.04109	60.0845	22.07686	596.5835
Observations	50	50	50	50	50	50

Table 3, contains result of correlations between variables.

Table 3: Correlations

Constructs	LNCEM	LNGDP	LNPPE	REO	RD	LNEPR
LNCEM	1					
LNGDP	-0.35592	1				
LNPPE	-0.32096	0.224257	1			
REO	0.414001	0.238024	0.062317	1		
RD	-0.45794	0.784772	-0.02672	0.196527	1	
LNEPR	-0.19537	0.791659	0.302197	0.50174	0.762465	1

Correlation between dependent variable CEM and independent variables is given below

- EPR is slightly negatively correlated with CEM
- GDP is negatively correlated with CEM
- PPE is negatively correlated with CEM
- RD is negatively correlated with CEM
- REO is positively correlated with CEM

4.1. Graphical Findings

Graphs in Figure 1 showed CO2 emissions for China and North America increased from 2010 to 2020 while same slightly decreased for South Asia, OECD and EU in the selected period. China is the 2nd largest producer of Carbon after EU in this period with having increasing trend.

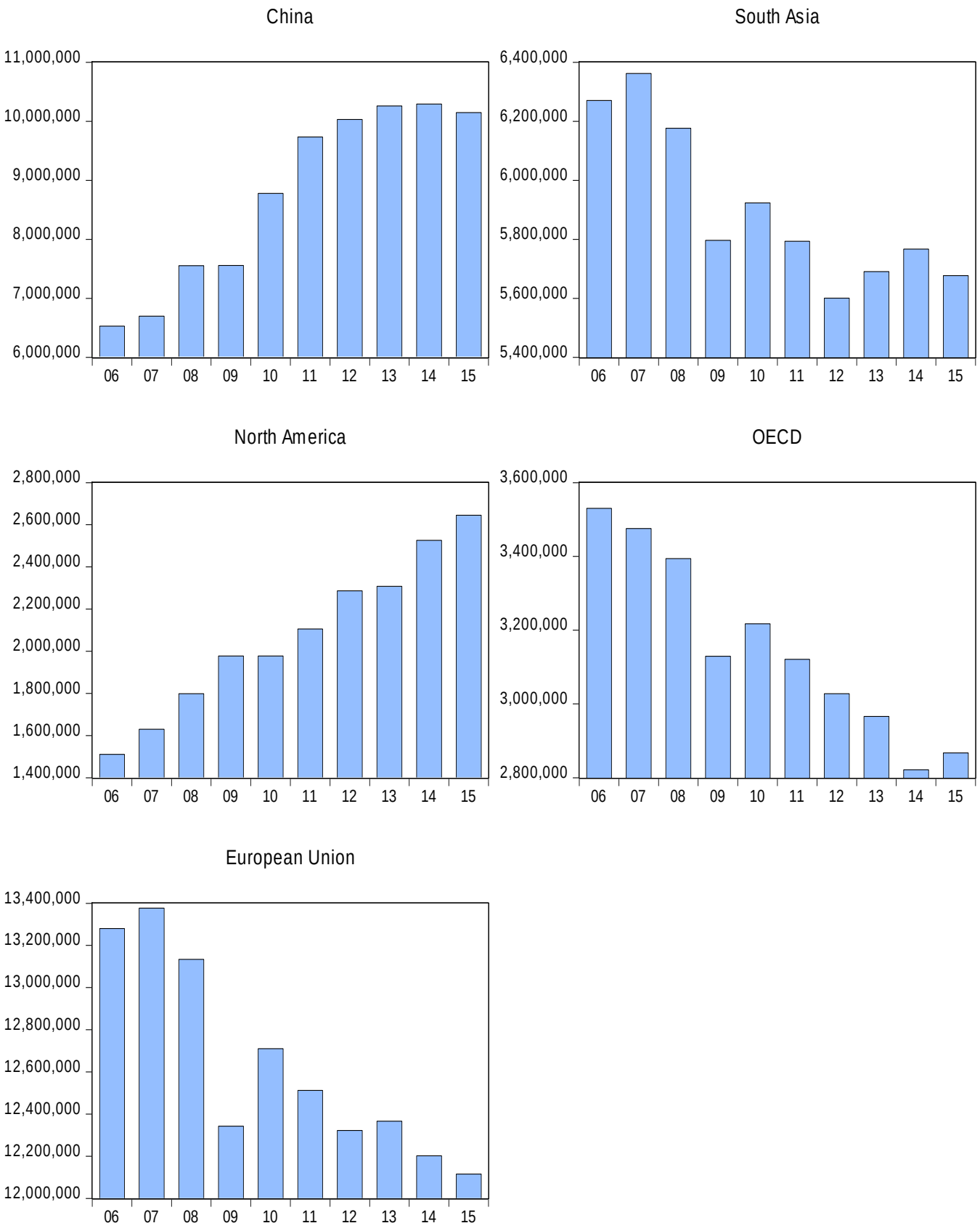

Figure 1: Graphs of CO2 Emission

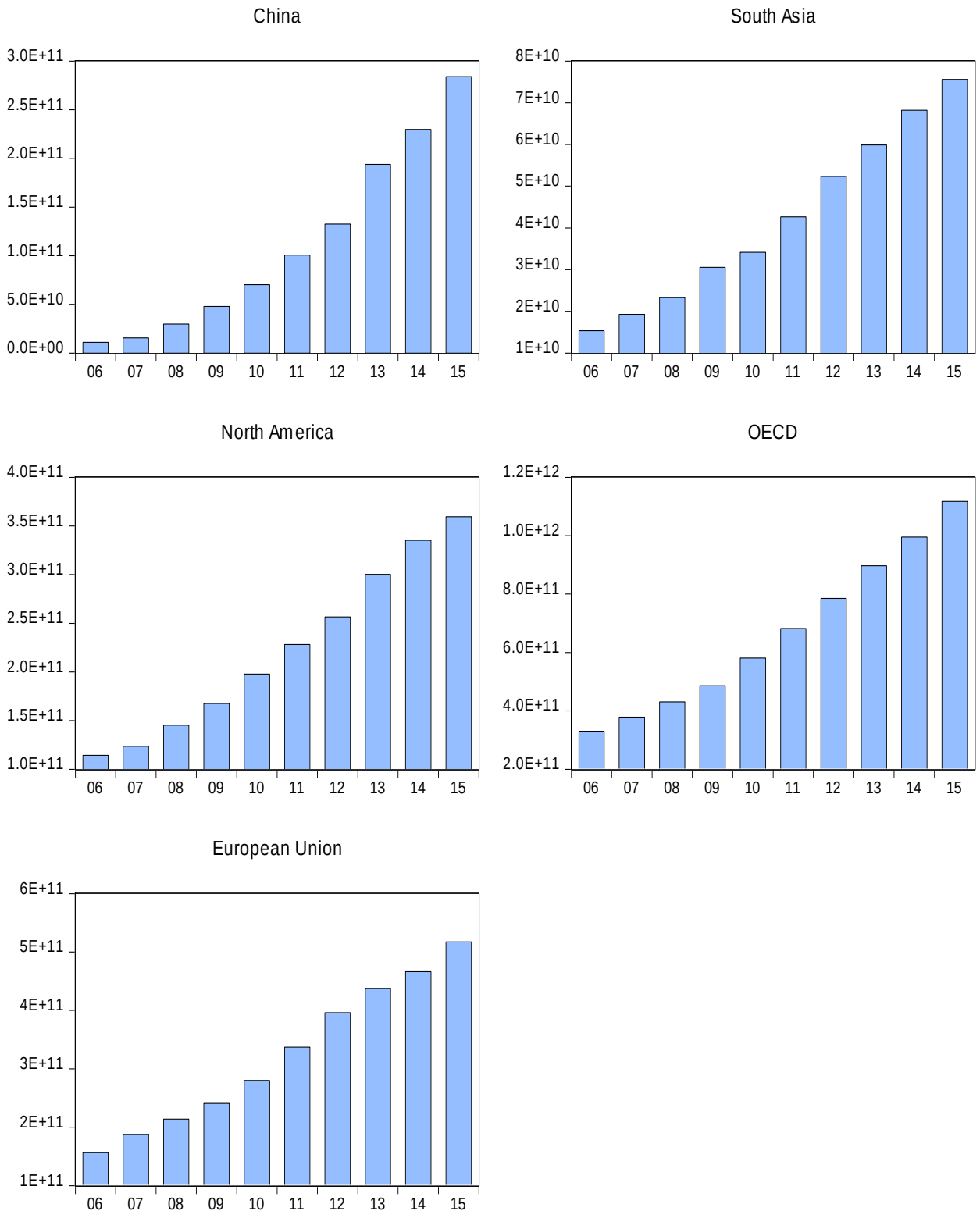

Figure 2: Graphs of Renewable Energy Production (EPR)

Graphs in Figure 2 depicted electricity production from renewable sources. There is increasing trend for all regions. While it is higher for OECD countries and EU is 2nd largest producer. China has negligible production of electricity from renewable sources at the early time period however share in production significantly increased at the later phase. South Asia production from renewable sources is also having increasing trend over the time period.

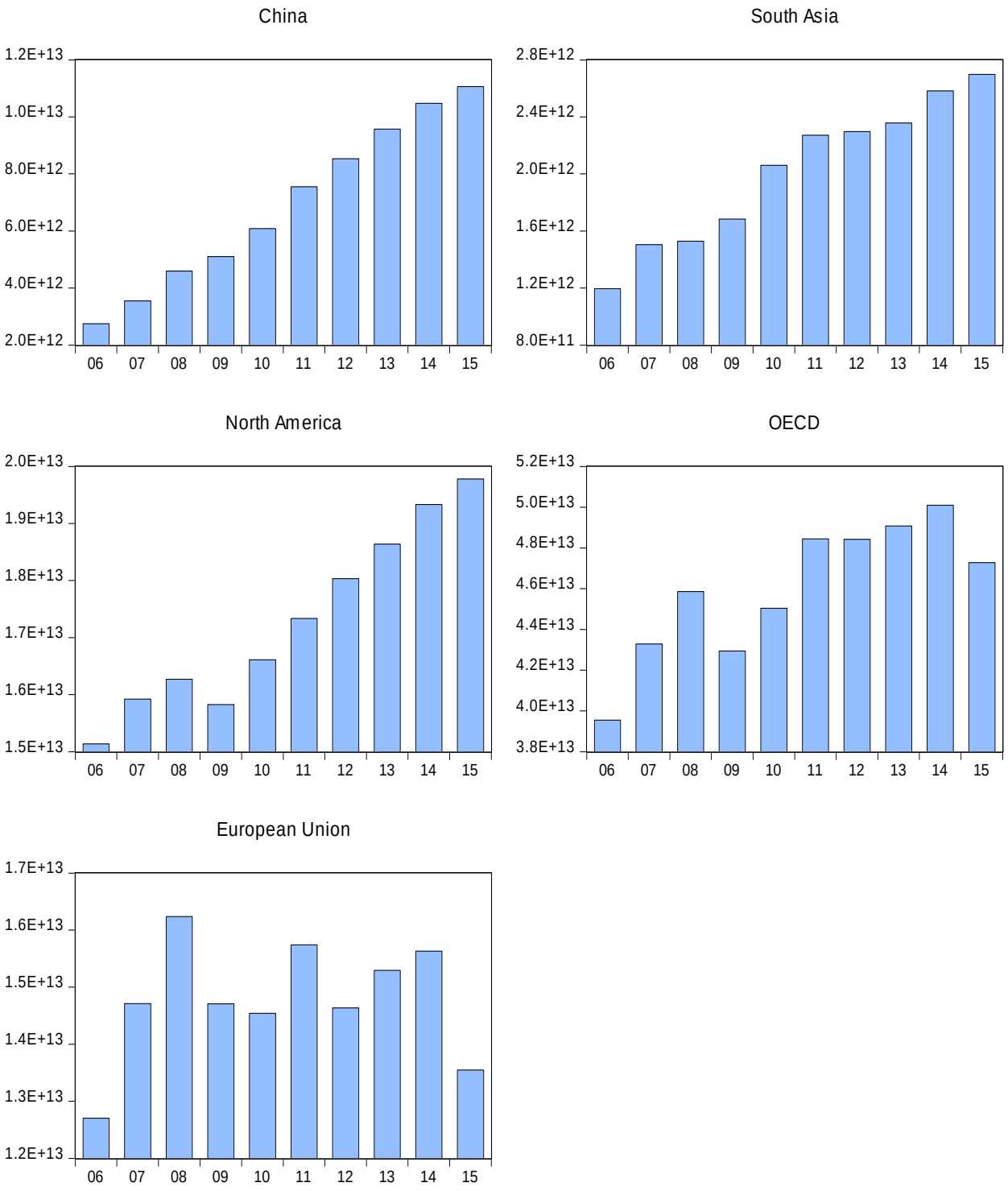

Figure 3: Graphs of GDP

Graphs in Figure 3 described the trend of GDP that is on average increasing for all regions however China is the only country that has consistent increase in GDP throughout the period where as EU and OECD has lowest place at the end of period.

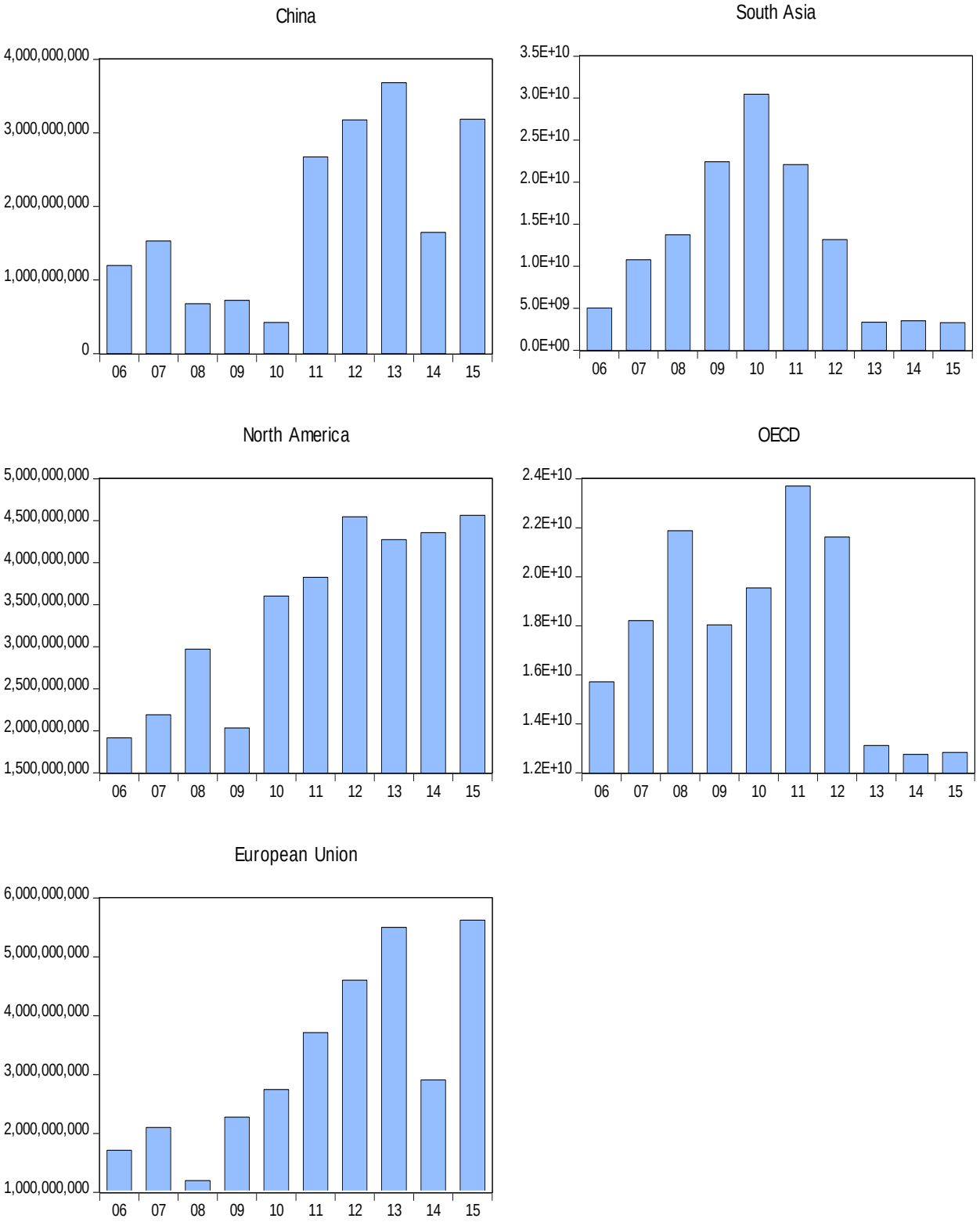

Figure 4: Graphs of Public Private Partnership Investment in Energy (PPE)

Graphs in Figure 4 described that Public private partnership investments in Renewable energy increased on average in EU, North America and China for the research period while it decreased for South Asia and OECD during this time span.

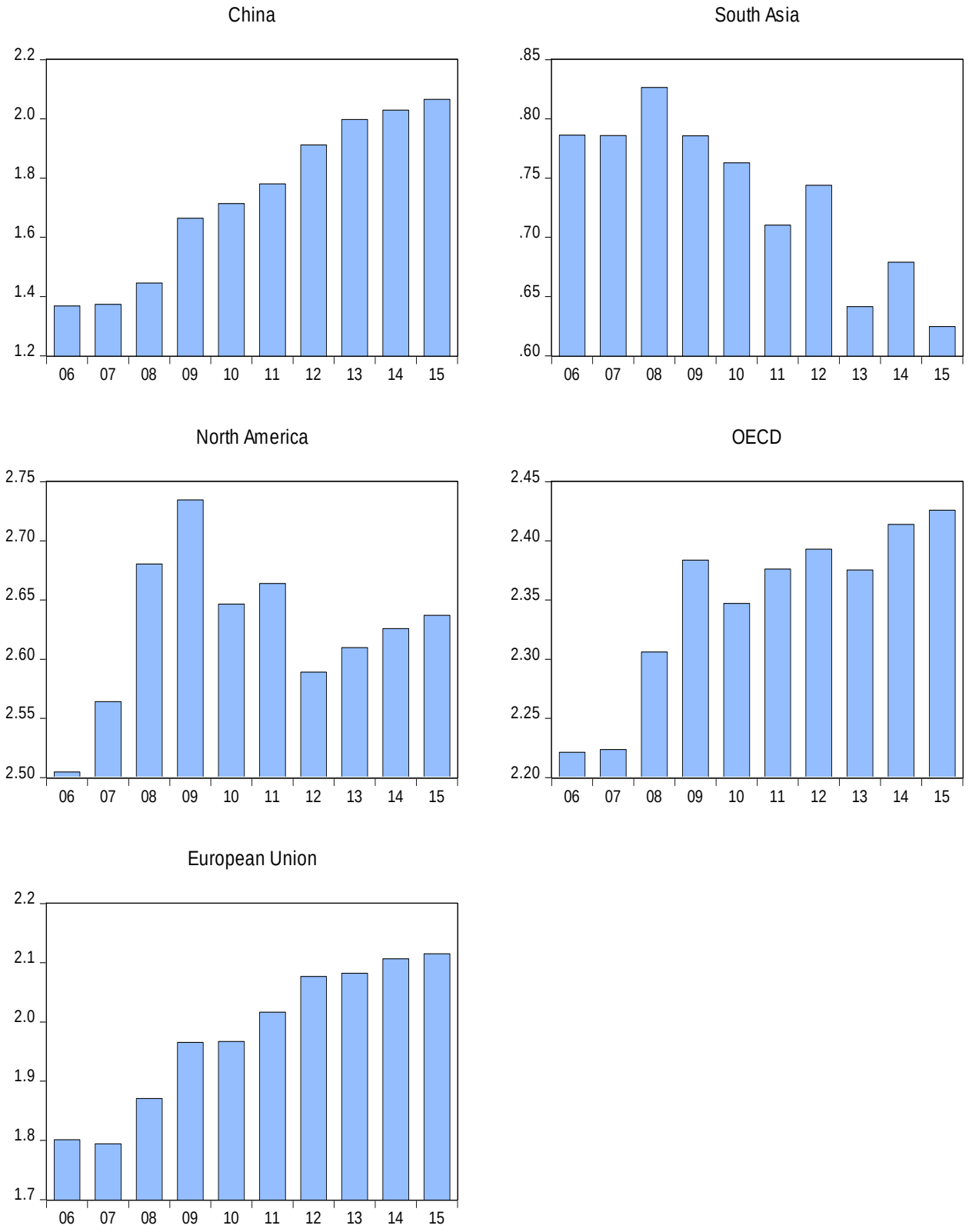

Figure 5: Graphs of Research & Development (R&D)

Graphs in Figure 5 describe the trend in R&D that is decreasing for South Asia. Whereas increasing for China and EU. While there is seen a gradual increase in R&D for OECD & North America.

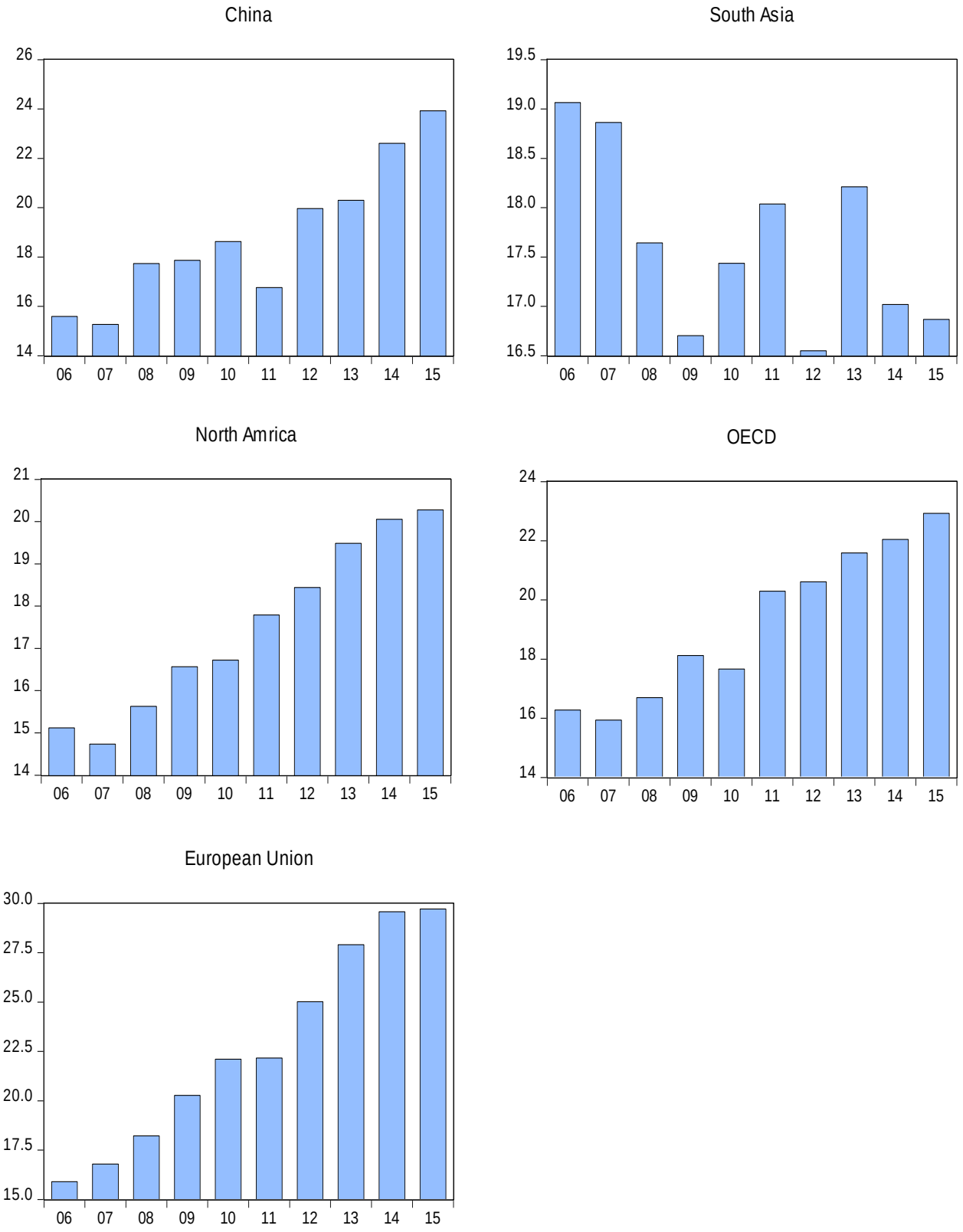

Figure 6: Graphs of Renewable Electricity Output (REO)

Graphs in Figure 6 depicted the REO trends during the selected period. It has increasing trend for all regions except for south Asia. Increase in REO is highest for EU and China.

4.2. Graphical Analysis of Region's Performance in CTV and BTV

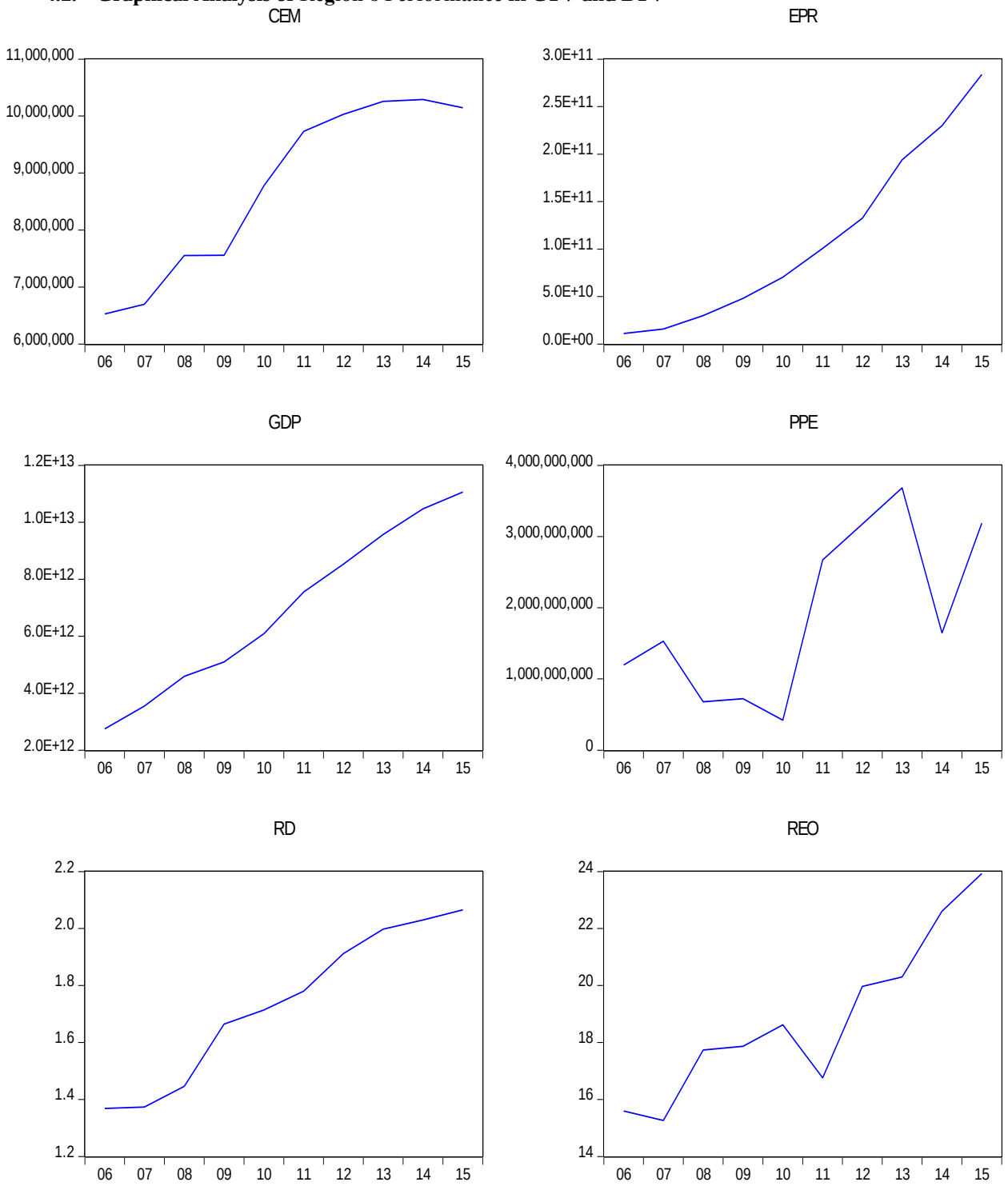

Figure 7: Graphs for China

The analysis of Graphs in Figure 7 above revealed that CO2 Emissions in China increased for the period with having increasing trend. However, its expenditure on R&D and significant increase in REO production compensate the China for CTV. GDP is increasing throughout the period where The Public private partnership investments in energy also increased in China for the said period.

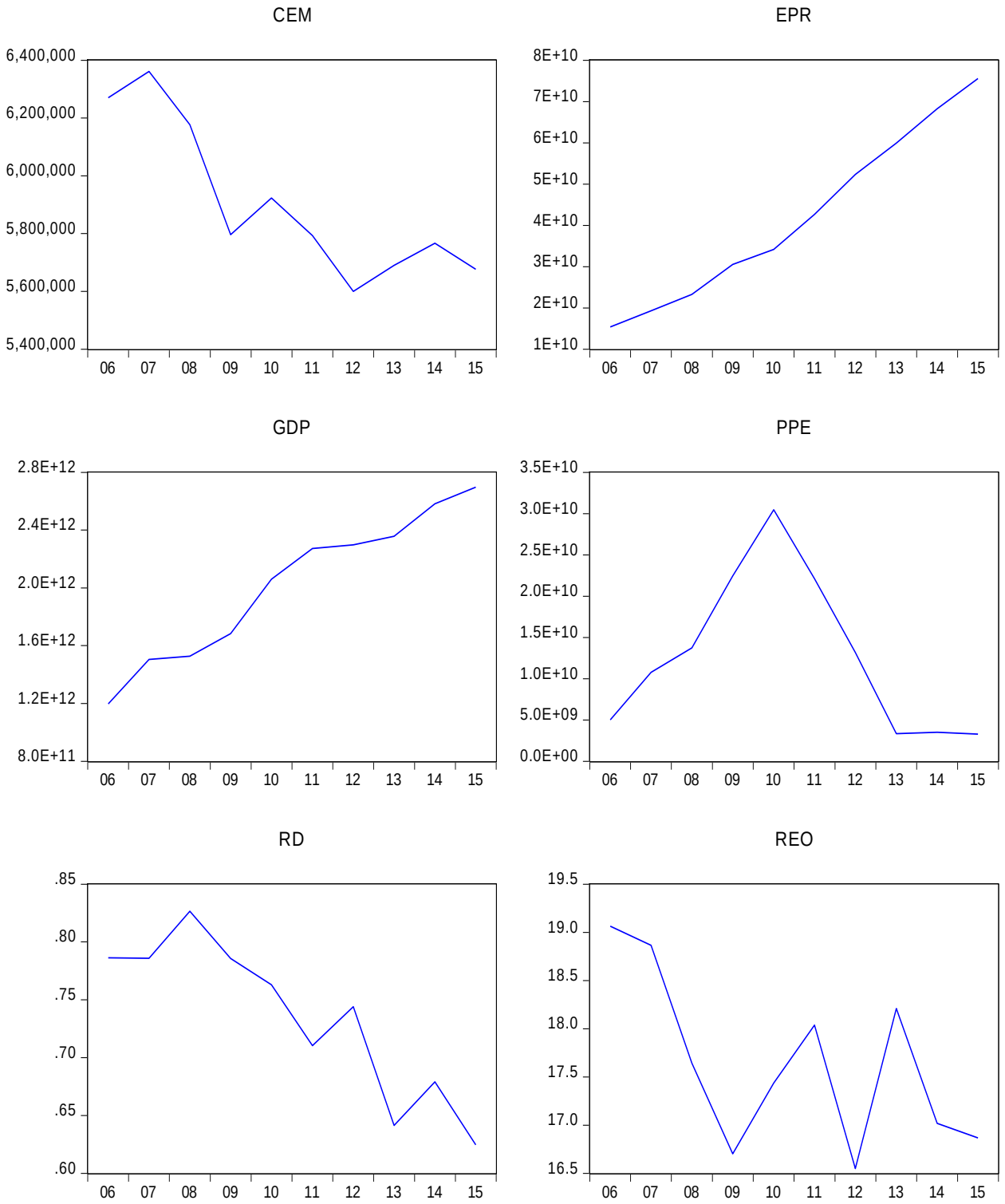

Figure 8: Graphs for South Asia

The analysis of Graphs in Figure 8 above revealed that CO2 emissions is having decreasing trend in South Asia indicating that CO2 is not an issue in these countries. However, South Asia production from renewable sources is lowest in the regions with having lowest and slower increases in GDP among all other regions. Public private partnership investment in energy also decreased for South Asia in said period. REO and R& D are also depicting critical situations. Hence, Though South Asia is performing better in CTV but it is poorest performer in BTV.

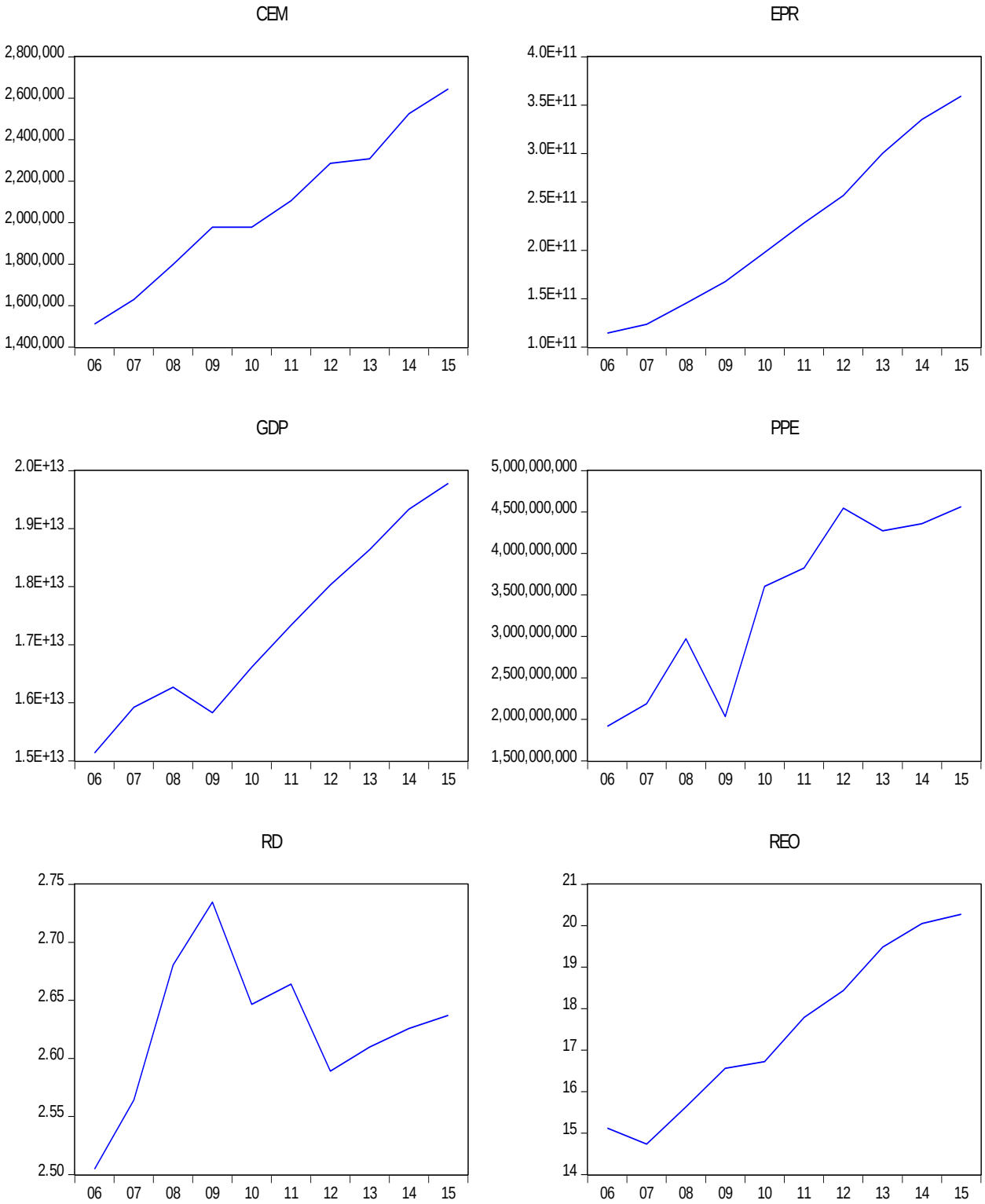

Figure 9: Graphs for North America

The analysis of Graphs in Figure 9 above showed that CO2 Emissions in North America increased yet Electricity production from renewable sources also increased for the period concurrently. GDP reasonably increased for North America. Public private partnership investments in energy, R&D and REO are depicting increasing tendency for the period.

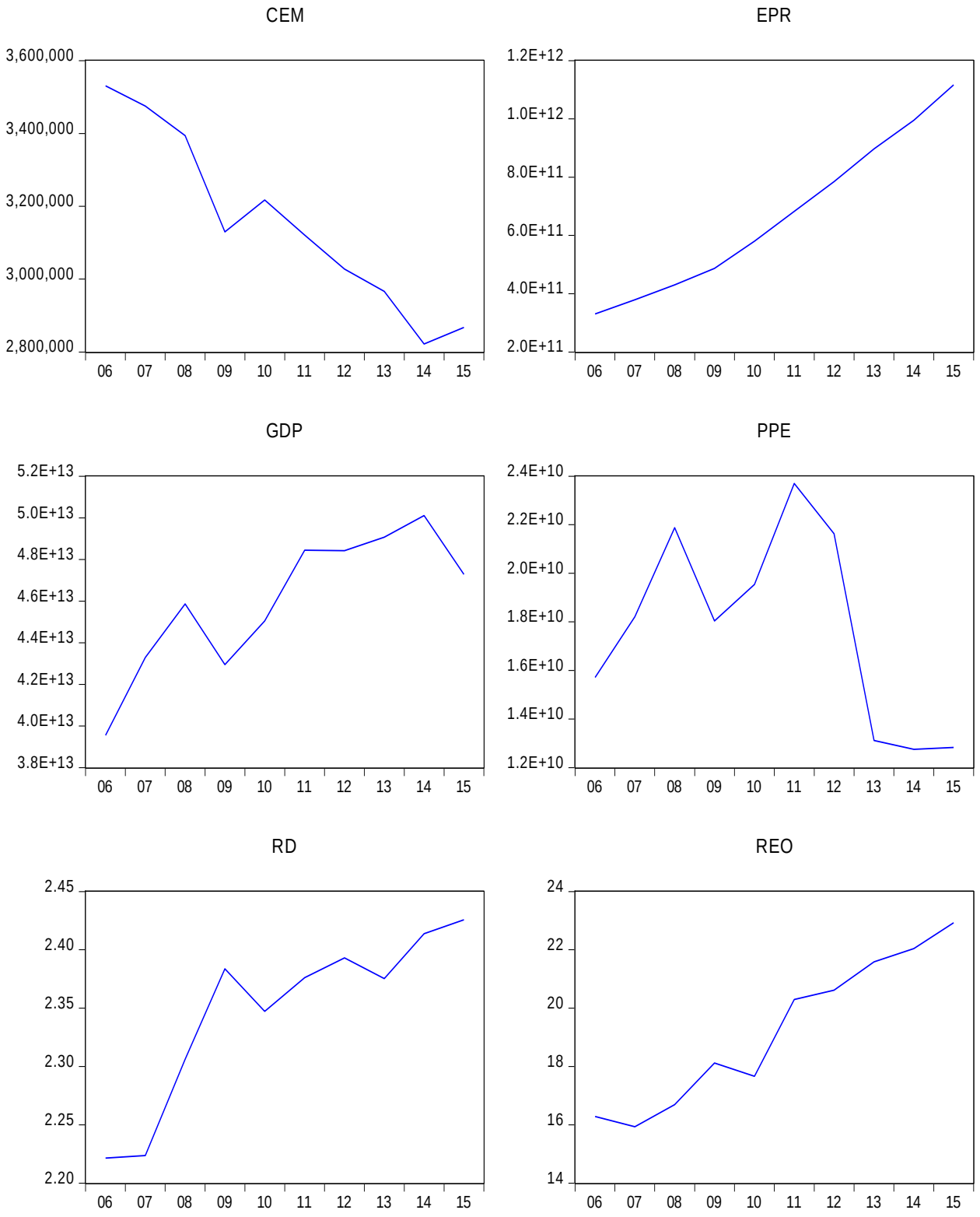

Figure 10: Graphs for OECD

The analysis of Graphs in Figure 10 above presented that CO2 Emissions decreased for OECD for the period of research. Electricity production from renewable sources, REO and R&D has mounting progress. However, Public private partnership investments in energy decreased drastically for OECD in the said period.

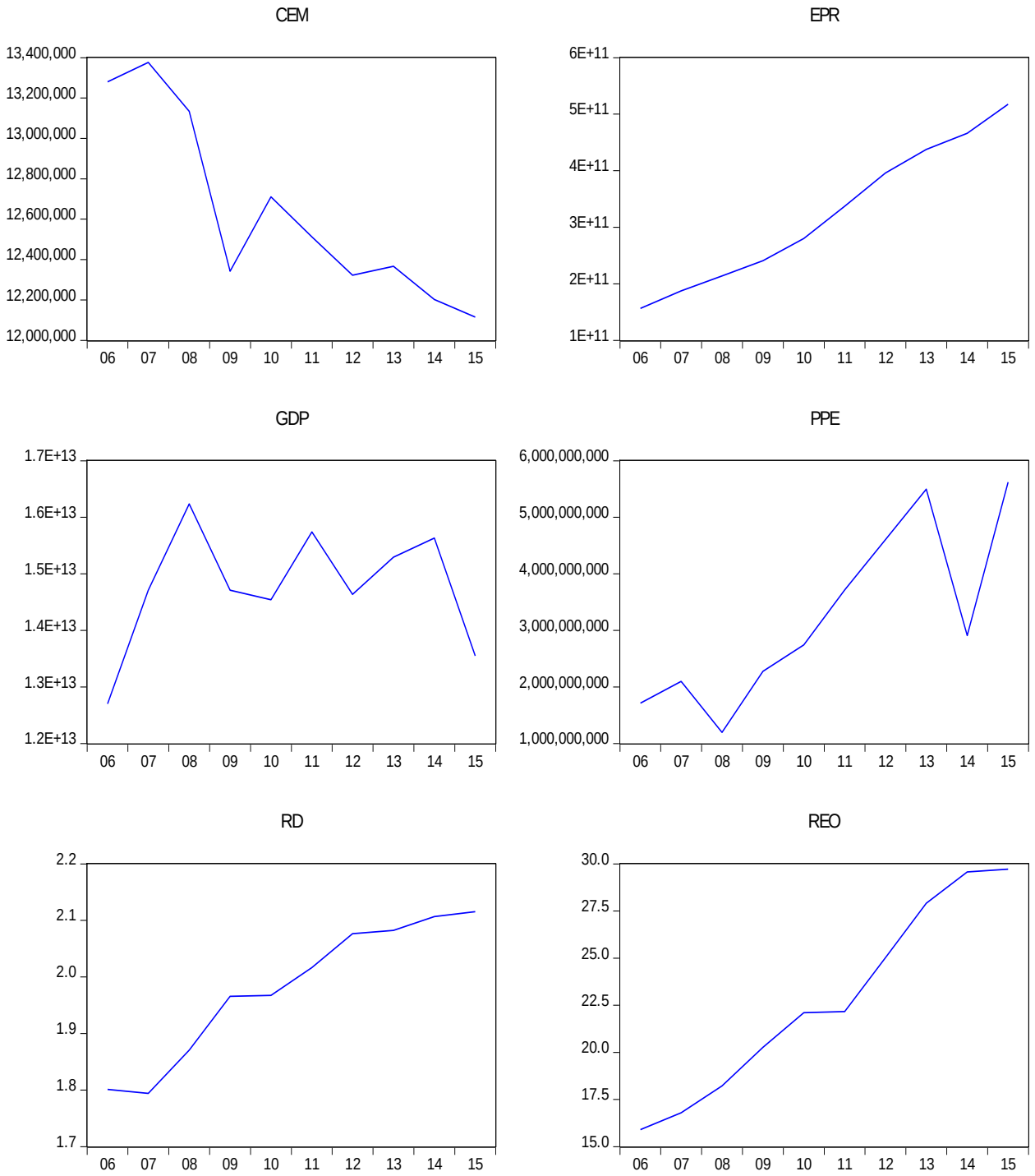

Figure 11: Graphs for European Union

The analysis of Graphs in Figure 11 illustrated that CO2 Emissions decreased for EU for the period. Electricity production from renewable sources show increasing trend in EU and it is 2nd largest producer among all regions. GDP for EU has lowest increase however it still has increasing trend. Public private partnership investments in energy increased overall after a drastic decrease twice during the time span analyzed. REO increased and increase is highest in EU. R&D has also increasing trend.

Table 4: Summary of Region's Performance in CTV & BTV

Variables	Region				
	China	**South Asia**	**North America**	**OECD**	**EU**
CEM	Significantly Increase. 2nd largest Producer	Decrease	Increase	Significantly decrease. Lowest producer	Decrease. Largest producer
EPR	Significantly Increase	Increase. Lowest producer	Increase	Increase. Largest producer	Increase. 2nd largest producer
GDP	Significantly Increase	Increase. Lowest producer	Increase	Increase. Largest producer	Slightly Increase
PPE	Increase	Decrease	Increase	Decrease	Increase
RD	Increase	Decrease. Lowest producer	Slightly Increase. Largest Producer	Slightly Increase	Increase
REO	Increase	Decrease	Slightly Increase	Slightly Increase	Increase

The quantitative analysis of ratings in cost type variables (CTV) and benefit type variables (BTV) summarized in Table 4 ranked Regions based on their performance over time. The region with decreasing CO2 emissions (i.e., CTV) and increasing benefit type variables over the period could be categorized as best in terms of environmental sustainability. It is evident that EU, OECD, and South Asia have a decreasing trend in CO2 emission over the period; however, OECD is categorized as best performing region in terms of environmental sustainability as it has low CO2 emission with decreasing trend. While its benefit type variables have an increasing trend and are highest among EU and South Asia.

The EU is categorized as the 2nd best performing region in terms of environmental sustainability. It has a decreasing trend in CO2 emission. While its benefit type variables have an increasing trend. South Asia is categorized as the poor performing region in terms of environmental sustainability. It has a decreasing trend in CO2 emission. While its benefit type variables like production from renewable sources and GDP has slowest increasing trend and PPE, RD and REO has decreasing trend in being benefit type variables.

4.3. Panel Test for Stationary

Panel unit root test is performed to check the time series data Stationarity as pre-requisite of analysis.

Table 5: Panel Unit Root Test Results

Variables	Lin, Levin & Chu		
	T-Statistics	**P-Value**	**Order of Integration**
CEM	-2.46937	0.0068	I(0)
EPR	3.50048	0.9998	I(1)
GDP	-0.55116	0.2908	I(1)
PPE	-0.72252	0.2350	I(1)
RD	-3.80571	0.0001	I(1)
REO	-0.57737	0.2818	I(1)

Table 5 above contains unit root tests for individual variables. It is verified that data for CEM is stationery at I (0) while all other are stationery at I (1).

4.3.1. Hausman Test

The research analyzed the results of Hausman test to verify that Panel EGLS Random Effect model is the better or fixed effect for research data appraisal.

H0: Select the Random Effect method ($p > 0.05$)

H1: Select the Fixed Effect method ($p < 0.05$)

Table 6: Correlated Random Effects - Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Period random	0.23150	5	1.0000

Table 6, we could not reject the Null hypothesis which states that Random Effect is the suitable method for our data set.

4.4. Panel EGLS Random Effect Model

Relationship results of variables taking CEM as dependent variable has been analyzed through Panel EGLS Random Effect Model. CEM is the only cost-type variable and is being taken as dependent variable and relationship results are analyzed by taking all other benefit-type variables as independent variables.

Table 7 White Cross-Section Panel EGLS (Period Random Effects)

Variable	Co-efficient	Standard Error	T-Stat	P.Value
EPR	-2.90E-06	1.06E-06	-2.730468	0.0094
GDP	1.96E-07	6.19E-08	3.169737	0.0029
PPE	-1.90E-05	9.58E-06	-1.983425	0.0542
RD	4120927.	851881.6	4.837441	0.0000
REO	-62275.57	33996.60	-1.831818	0.0744
C	-2536759.	632701.0	-4.009412	0.0003
R-Squared	0.989622			
Adjusted R-Squared	0.987286			

Table 7 above described the results of relationship between CO2 Emissions and GDP, RD, REO, PPE, EPR. Hypothesis that EPR has significant relationship with CEM has been accepted at ά= 0.05 and it is proved that EPR has significant negative relationship at ά= 0.05 with CEM. These results are consistent with Kirikkaleli and Adebayo, (2021). A region with a higher share of Renewable energy in its total energy mix will be more environmentally sustainable.

Hypothesis that PPE has significant relationship with CEM has been accepted at ά= 0.10 and it is proved that PPE has significant negative relationship at ά= 0.10 with CEM. It means that an increase in Public-Private-Partnership investment in renewable energy will significantly cause a decline in CO2 Emissions. A region with higher Public and Private investment in Renewable energy sources will be more environmentally sustainable. These results are consistent with Ahmad and Raza (2020); Waqih et al. (2019)

Hypothesis that REO has significant relationship with CEM has been accepted at ά= 0.10 and it is proved that REO has significant negative relationship at ά= 0.10 with CEM. It means that an increase in REO will significantly cause a decline in CO2 Emissions. A region with higher REO share in total electricity mix will be more environmentally sustainable. These results are consistent with (Awosusi et al., 2022).

Hypothesis that GDP has significant relationship with CEM has been accepted at ά= 0.05 and it is proved that GDP has significant positive relationship at ά= 0.05 with CEM. It means that an increase in GDP will significantly cause an increase in CO2 Emissions. Adebayo et al. (2022) agreed with these results.

Hypothesis that RD has significant relationship with CEM has been accepted at ά= 0.05 and it is proved that RD has significant positive relationship at ά= 0.05 with CEM. It means that increase/decrease in RD expenses of a region will cause significant impact on CO2 Emissions. These results are consistent with Álvarez-Herránz et al. (2021)

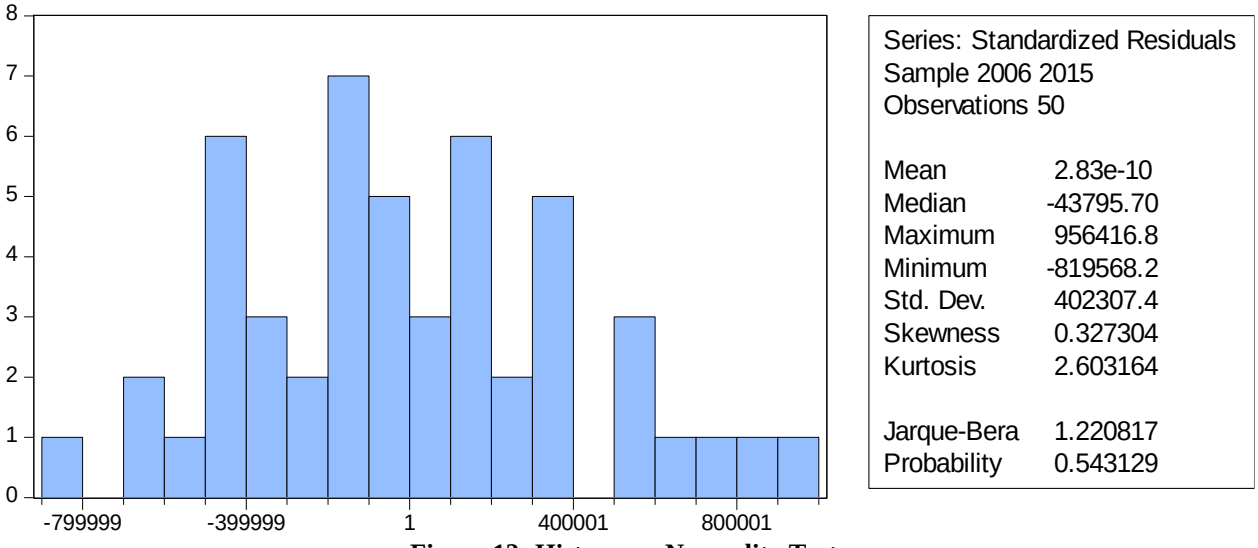

Figure 12: Histogram-Normality Tests

Hair et al. (2010) and Bryne (2010) proved that distribution is normal when Skewness is between -2 to +2 and Kurtosis is between -7 to +7. Normality Test in Figure 12 showed that Skewness of 0.32 and Kurtosis of 2.60 for residuals are within range. Hence distribution of residuals is normal.

4.5 Granger Causality

Table 8: Pairwise Granger Causality Test

Null Hypothesis:	Obs.	F-Statistic	Prob.
LNGDP does not Granger Cause LNCEM	40	0.47833	0.6238
LNCEM does not Granger Cause LNGDP		0.23328	0.57065
LNPPE does not Granger Cause LNCEM	40	13.1286	0.000
LNCEM does not Granger Cause LNPPE		2.31362	0.50987
REO does not Granger Cause LNCEM	40	0.18567	0.8314
LNCEM does not Granger Cause REO		0.69559	0.65554
RD does not Granger Cause LNCEM	40	2.23346	0.1222
LNCEM does not Granger Cause RD		7.25906	5.27377
LNEPR does not Granger Cause LNCEM	40	1.96397	0.1555
LNCEM does not Granger Cause LNEPR		2.39243	0.12295
LNPPE does not Granger Cause LNGDP	40	0.5286	0.5941
LNGDP does not Granger Cause LNPPE		8.91493	0.32567
REO does not Granger Cause LNGDP	40	1.93076	0.1602
LNGDP does not Granger Cause REO		0.40824	3.1608
RD does not Granger Cause LNGDP	40	0.42518	0.657
LNGDP does not Granger Cause RD		0.91723	12.7846
LNEPR does not Granger Cause LNGDP	40	5.8545	0.0064
LNGDP does not Granger Cause LNEPR		3.00655	5.91882
REO does not Granger Cause LNPPE	40	0.3796	0.6869
LNPPE does not Granger Cause REO		0.75309	2.71582
RD does not Granger Cause LNPPE	40	1.0132	0.3735
LNPPE does not Granger Cause RD		5.80361	3.57202
LNEPR does not Granger Cause LNPPE	40	0.79869	0.4579
LNPPE does not Granger Cause LNEPR		1.03355	0.53019
RD does not Granger Cause REO	40	3.19059	0.0534
REO does not Granger Cause RD		1.68995	1.13813
LNEPR does not Granger Cause REO	40	3.36418	0.0461
REO does not Granger Cause LNEPR		1.57162	1.05844
LNEPR does not Granger Cause RD	40	7.02842	0.0027
RD does not Granger Cause LNEPR		3.19059	1.77094

The results of the Pairwise Granger Causality test described Causality between two variables where Null hypothesis states that one variable does not Granger Cause other variable with alternative hypothesis of having Granger Causality (see Table 5). The results are discussed as under:

- Research & development Granger Cause CO2 emissions and same are also true for vice versa.
- GDP Granger Cause Electricity production from renewable source and same is also true for vice versa.
- GDP Granger Cause Research & development.

Except above; Pairwise Causality results for all other variables proved that there is no Granger Causality between variables and the Null hypothesis of no Granger causality could not be rejected (Adebayo et al., 2022).

5. Discussions

The subject of the environment and preserving environmental sustainability was a hot topic of discussion all around the world. The importance of the environment for human life had been recognized by both institutions and consumers. Green finance had gained attraction in both established and emerging nations (Nawaz et al.,2021). Hence to establish the fact for a larger data set this research was conducted .

The research inferred that green finance has a significant impact on environmental sustainability. It has been verified that green Finance through Public-Private-Partnership investments in renewable energy sources is one of the best options to achieve environmental sustainability. The regions focusing on renewable energy resources have higher investment in renewable sources and have attained high levels for environmental sustainability. This result is the same as the findings of Chowdhury et al. (2013). It is also found that the evolution of renewable energy sources has a

significant negative impact on CO2 emission that designate an increase in share of total electricity production through renewable sources is inevitable in future to sustain environment. This result is the same as the findings of (Wang et al., 2016; Murshed et al., 2021).

Further it was found, the evolution of Research & development has a significant impact on CO2 emission that signify the world should increase the expenditure of Research & Development for the evolution of new sources of renewable energy to sustain the environment. This result is the same as the findings of Koçak and Ulucak (2019); Álvarez-Herránz et al. (2021), and Wang et al. (2020).

The evolution of Public-Private-Partnership investment in renewable energy has a significant negative impact on CO2 emission that leads towards the demand of an increase in Public-Private Partnership investment in renewable energy sector. This result is the same as the findings of Ahmad and Raza (2020); Waqih et al. (2019); Balsalobre-Lorente et al. (2019); and Shahbaz et al. (2020) . It is inferred that overall GDP of a region has a significant positive impact on CO2 emission that depicted the production increase is linked with the use of energy. However, it is found that the Renewable energy sources in the overall energy mix should be given more weight and more consideration to overcome the issue. This result is the same as the findings of Nordin et al. (2018).

Environmental sustainability Concern for environment related issues is increasing globally leading to the development of various means of evaluating it. Leading countries are awarded the 'Champion of the Earth Award' based on the adopted environmental performance measures' ranking and classification assessment. As well, financial institutions are given the 'Golden Peacock Climate Management Award', while the 'Global Green Economy Index' and many other evaluation indexes were utilized to rank the global economies recently to encourage the entities for adopting environmental safety measures. To follow the fashion our research accomplished the comparative analysis of regions for ranking them in reference to their response in cost type variables (CTV) and benefit type variables (BTV). It was established that OECD is best performing region in terms of environmental sustainability measures taken, EU is categorized as 2nd best performance region and South Asia is categorized as poor performing region. The South Asia poor performance is not due to CTV but because of less focus on BTV for sustaining the environment. It is probable for low performing regions to achieve the efficient level of sustainability by increasing their focus on the variables, such as R&D, renewable production, renewable electricity output, and financial index. (Gujba et al., 2012, Tian, 2018).

The research also inferred that Green Finance through Public-Private-Partnership investments in renewable energy sources is one of the best options to achieve Environmental Sustainability. There regions focusing on renewable energy resources have higher investment in renewable sources and have attained high levels for environmental sustainability. This result is the same as the findings of Chowdhury et al. (2013). Further it was found, the evolution of Research & development has a significant impact on CO2 emission that signify the world should increase the expenditure of Research & Development for the evolution of new sources of renewable energy to reduce CO2 emission. This result is the same as the findings of Koçak and Ulucak (2019); Álvarez-Herránz et al. (2021), and Wang et al. (2020).

It is also inferred that overall GDP of a region has a significant positive impact on CO2 emission that depicted the production increase is linked with the use of energy and environment degradation. However, it is instituted that Renewable energy sources in the overall energy mix should be given more weight and more consideration to overcome the issue. This result is the same as the findings of Nordin et al. (2018), Wang et al., (2016); Murshed et al., (2021).

6. Implications

As it was indicated in the study of Sun et al. (2020) that It is imperative to extend the future research for larger regions data set to check the evolution of green finance and its connection with environmental sustainability (Sun et al., 2020). Therefore, to fill the gap the current research analyzed that how green finance helped to achieve environmental sustainability from both a market and regulatory standpoint in 05 important regions including South Asia, North America, European Union, OECD, and China for the most recent years 2010 to 2020.

First, the research conducted on five regions has significant contribution by proving that green finance has significant impact on environmental sustainability in all regions. **Second,** the research revealed that increase in production of energy from renewable sources, increase in research and development and the evolution of public private partnership investment in renewable energy can decrease the CO2 emission. **Third,** the research concluded that the overall GDP of a region has significant positive impact on region's carbon emission depicting that as the production increases the use of energy supplementary carbon emission may increase environmental intimidation. Hence substitute of energy technology is inevitable that demand green finance initiative.

6.1. Practical Implications

First and foremost**,** there is a strong need to increase the green finance in renewable sources to target the vindication of global CO2 emissions. **Second,** there should be outside the borders trade of renewable energy in the regions/countries to mitigate CO2 emissions in the globe. **Third,** the ranking of regions on the basis of environmental sustainability may help out the researchers and decision makers to induce foreign direct and private investment in such

regions. **Fourth,** an accurate carbon emissions measurement is critical for developing an appropriate climate strategy to address ecological issues. A meaningful climate policy reaction can be offered based on adjusted statistics of carbon emissions.

7. Recommendations

Green financing has a substantial influence on environmental sustainability, according to the research's conclusions. To meet the world's pledge under the Paris Agreement to keep "the increase in global average heat to well below 2 degree C° above the pre-industrial levels and pursuing exertions to bound the heat increase to 1.5 degree °C above pre-industrial levels" (UNFCCC, 2015, p.3), the research recommends focusing on green finance to accomplish environmental sustainability. Thus, policy channeled towards globalization, economic growth, and renewable energy utilization will have a significant effect on CO2 emissions. There is need to invest more in research and development for technological innovation to curb the environmental degradation.

According to the research, there is a great need to expand the renewable energy and Public private partnership investment in order to reduce global CO2 emissions. Green bonds must also be promoted at the local, provincial, and federal levels across the world. Developed nations should significantly expand their green investments in the renewable energy industry in developing countries. To reduce CO2 emissions throughout the world, there should be outside the borders trading of renewable energy between regions and nations. The future research proposal is to study the link between green finance and region/country participation in corporate social responsibility (CSR).

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