Spillover Effects of Financial Development on Renewable Energy Deployment and Carbon Neutrality: Does GCC Institutional Quality Play a Moderating Role?

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ABSTRACT

When viewed through the lens of sustainable ecology, the importance of financial sustainability increases. Consequently, this thesis investigates the influence of financial development on carbon emissions and renewable energy in Gulf Cooperation Council (GCC) nations during the period from 2005 to 2020.

In addition to controlling for economic growth, technological innovation (mobile subscription), trade openness, and service value added, this study modifies the relationship by considering institutional quality (including regulation quality, rule of law, control of corruption, voice and accountability, and political stability). In contrast, the quantile-on-quantile regression method was employed for the investigation, whereas the fixed effect ordinary least squares (OLS) and Driscoll Kraay OLS methods were utilized as robustness checks.

From model 1 where renewable energy is the dependent variable, it was observed that, there was a positively significant relationship between financial development, urbanization, economic growth, trade openness, service value added as well as institutional quality indicators (governance indicators) with the dependent variable (renewable energy development) while technology innovation (mobile subscription) had a negative connection with the dependent variable (renewable energy).

Nevertheless, it was observed from the Model 2 where carbon emission is the dependent variable, there was a positive connection between financial development, technology innovation (Mobile subscription), and service value added with carbon emission. Moreover, Urbanization, economic growth, trade openness and institutional quality indicators (governance indicators) had a negative connection with the dependent variable (carbon emission). This result suggests that additional investments in renewable energy enterprises serve as an intermediary for the liquidity of banks in the countries under investigation.

Additionally, this research contributes to the existing body of knowledge by conducting a comparative analysis of the financial development, specifically the capital adequacy of banks, in GCC countries that are frontrunners in climate finance. It emphasizes the significance of bank capital adequacy in bolstering environmental legislation and encouraging investments in renewable energy.

Keywords: Financial development, Bank adequacy, Renewable energy, Carbon emission, Institution quality, GCC countries.

ÖZ

Sürdürülebilir ekoloji merceğinden bakıldığında finansal sürdürülebilirliğin önemi artıyor. Sonuç olarak, bu tez, Körfez İşbirliği Konseyi (KİK) ülkelerinde 2005'ten 2020'ye kadar olan dönemde finansal kalkınmanın karbon emisyonları ve yenilenebilir enerji üzerindeki etkisini araştırıyor.

Ekonomik büyümeyi, teknolojik yeniliği (mobil abonelik), ticari açıklığı ve hizmet katma değerini kontrol etmenin yanı sıra bu çalışma, kurumsal kaliteyi (düzenleme kalitesi, hukukun üstünlüğü, yolsuzluğun kontrolü, söz hakkı ve hesap verebilirlik dahil olmak üzere) ve kurumsal kaliteyi dikkate alarak ilişkiyi değiştirmektedir. politik istikrar). Buna karşılık, araştırma için kantil üzerinde kantil regresyon yöntemi kullanılırken, sağlamlık kontrolleri olarak sabit etkili sıradan en küçük kareler (OLS) ve Driscoll Kraay OLS yöntemleri kullanıldı.

Yenilenebilir enerjinin bağımlı değişken olduğu Model 1'den, finansal gelişme, kentleşme, ekonomik büyüme, ticari açıklık, hizmet katma değeri ve kurumsal kalite göstergeleri (yönetişim göstergeleri) ile bağımlı değişken arasında pozitif yönde anlamlı bir ilişki olduğu görülmüştür. değişken (yenilenebilir enerji gelişimi) ile teknoloji yeniliği (mobil abonelik) bağımlı değişken (yenilenebilir enerji) ile negatif bir bağlantıya sahiptir.

Bununla birlikte, karbon emisyonunun bağımlı değişken olduğu Model 2'de finansal gelişme, teknoloji yeniliği (Mobil abonelik) ve karbon emisyonu ile hizmet katma değeri arasında pozitif bir bağlantı olduğu görülmüştür. Ayrıca kentleşme, ekonomik büyüme, ticari açıklık ve kurumsal kalite göstergeleri (yönetişim göstergeleri) bağımlı

değişken (karbon emisyonu) ile negatif bir bağlantıya sahiptir. Bu sonuç, yenilenebilir enerji işletmelerine yapılan ek yatırımların, incelenen ülkelerde bankaların likiditesine aracılık ettiğini göstermektedir.

Ek olarak bu araştırma, iklim finansmanında öncü olan Körfez İşbirliği Konseyi ülkelerindeki finansal gelişmenin, özellikle de bankaların sermaye yeterliliğinin karşılaştırmalı bir analizini yaparak mevcut bilgi birikimine katkıda bulunuyor. Çevre mevzuatının güçlendirilmesi ve yenilenebilir enerji yatırımlarının teşvik edilmesinde banka sermaye yeterliliğinin önemini vurgulamaktadır.

Anahtar Kelimeler: Finansal gelişme, Banka yeterliliği, Yenilenebilir enerji, Karbon emisyonu, Kurum kalitesi, Körfez işbirliği konseyi ülkeleri.

To my lovely family

To my future partner and wife (Appolinaria)

To my family, relatives, friends who fell as martyrs in the genocide in Gaza Oct. 2023 - ∞

To ‘Mohamed Chorbaji’, ‘Maram Shagaleh’ &

‘Hamdan Bohesi’

Rest in Peace

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INTRODUCTION

1.1 Background

Mitigating climate change necessitates a swift and significant overhaul of the international financial system. According to Article 2.1(c) of the Paris Agreement UNFCCC (2015), all financial flows must be "consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.”. Thus, it is imperative to comprehend the current allocation of financial resources, and how it ensures the envisioned low-carbon transition. Research on this subject is mostly tailored on high middle-income nations thus far. This research extends the conversation to additional regions by evaluating exposure to transition risks in Gulf countries, leading producers of fossil oil.

The transition to cleaner energy sources remains a pressing issue for developing nations, particularly those in the Gulf region, due to the persistent financing gap. This challenge is compounded by the underdeveloped green capital markets and limited bank capitalization in many Gulf countries compared to their counterparts in global financial centers. Moreover, the restricted fiscal budgets of Gulf nations hinder their ability to allocate funds toward capital expenditures, including green infrastructure projects. This situation creates an opportunity for industrial countries in Europe Asia, and America, to financially contribute to the low carbon economy envisage in the Gulf region.

With less than a decade remaining to achieve the 2030 Agenda, expediting progress becomes paramount. The disruptions caused by the COVID-19 pandemic, the Russia impasse, and now the Israel and Palestine war have impeded advancements in numerous SDGs, underscoring the heightened importance of attaining these goals. Such prompting requires redefining the country's growth drivers, which will call for a revised contribution from financialization channels. Indications show sustainable funding of clean energy solutions is one of its top priorities. Swiss Re Institute (2021) also spoke on this topic during the 47th Gulf Country Summit in Cornwall. Given the Gulf nations' dismal record in achieving the SDG goals, the consistency of these policy discussions is essential. The Gulf countries are unable to meet the goals of SDG 7 (clean and cheap energy) and SDG 13 (climate action), according to the SDG Progress Report 2021 (Sachs et al., 2021). Out of all the developing countries, the Gulf countries have performed the poorest. The Gulf nations have made some progress toward achieving SDG 7; however, there hasn't been any discernible progress made toward achieving SDG 13. However, the ambiguous position on the Paris Accord has intensified scrutiny of the policy landscape. A cleaner energy transition carried out in accordance with a new SDG-focused policy framework is required to meet this goal. The current study's foundation is this goal. In such cases, creating a new SDG-focused policy framework that includes financial development could be required. The current study's initial step is the necessity of this policy reorientation.

As such, the role of governance cannot be discounted within policy discourse, either internal or external - Ongoing geopolitical tensions brought on by shifting geopolitical dynamics may affect how the energy transition projects are financed. Recent reports Zakeri et al. (2022) and Zheng et al. (2022), informs that the conflict between Russia and Ukraine has hampered the energy transition by restricting investment and trade, which has increased the unpredictability of energy prices (Lee et al., 2023). The occurrence of the Arab Spring seriously disrupted the renewable energy industry by limiting investment channels, according to research published by the International Monetary Fund ten years ago (Ahmed, 2011). All these are antecedents of good governance or otherwise. Also, through the implementation of policy measures like the removal of subsidies of fossil fuel, carbon taxation, institutional quality plays a critical role in mitigating environmental deterioration (Wong et al., 2010). According to Ebeke et al. (2015), efficient resource allocation might enhance environmental quality when supported by a robust institutional framework. Mahjabeen et al. (2020) also emphasized the relevance of institutional setup for economic growth and environmental quality by drawing in foreign investment, mandating the use of green energy, allocating resources efficiently, and strengthening the judicial system. On the other hand, environmental degradation cannot be addressed by a feeble institutional structure. Therefore, it is still necessary to take into account the impact that government institutions have on the quality of the environment.

Given these findings, Gulf countries, as seen in Figure 1, must embark on a comprehensive exploration of the fundamental question: "How can environmental sustainability be achieved?" This endeavor necessitates a paradigm shift in policy orientation, which takes into meticulous consideration both the domain of financial development and the intricacies of renewable energy generation. This policy revision is paramount, as it seeks to rectify the shortcomings of prevailing policies in addressing the complexities of environmental sustainability. This realignment of policy orientation is in harmony with the overarching discourse on international environmental policy, underscoring the exigency of a more robust and sustainable approach.

Figure 1: Cartographic Overview: A Rough Map of the Arabian Gulf Region, Illustrating the Six GCC Arab Countries.

1.2 Aim of the Study

The aim of this study is motivated by the recognition that the intricate issues of clean energy (SDG 7) and climate action (SDG 13) are profoundly intertwined, and their effective resolution necessitates a holistic approach. This study's goal is crucial because it aims to provide light on the connections between sustainable finance and renewable energy use. Understanding the financial implications of adopting renewable energy for manufacturers and the role of sustainable financing in facilitating their transition to more sustainable production practices are garnering substantial interest.is crucial, especially in light of the growing emphasis on decarbonization. Furthermore, using renewable energy in production raises customer awareness of environmental issues. This comprehensive study delves into the energy landscape of the Gulf countries, examining its demographic, environmental, economic, and social dimensions. It underscores the consumption of fossil fuels in the GCC region, considering its impact on population growth, societal development, economic growth, climate change, ecological footprints, and other relevant factors. This analysis aims to provide valuable insights to policymakers, academics, and students across various disciplines, including energy, environmental studies, industrial development, policymaking, socioeconomics, conflict resolution, geopolitics, and related fields.

To achieve the study's objectives, a well-structured and systematic methodological framework was devised and implemented, adhering to established guidelines. Consequently, rigorous analyses were conducted on the available data pertaining to the energy situation in the GCC countries. Additionally, strategies and potential solutions were proposed to address energy challenges in the region. Furthermore, recommendations and proposals are put forth to foster a brighter future and enhanced well-being for the GCC population, the region, and the global community.

Existing research endeavors, exemplified by the works of academics such as (Elahi et al., 2022; Raihan & Tuspekova, 2022), have substantiated this interconnectedness, offering a multitude of policies regarding how pivitol clean energy is in mitigating climate change. As enshrined in the Sustainable Development Goals, these objectives represent a comprehensive roadmap for ushering in a more equitable future. However, the attainment of SDGs 7 and 13, especially in the context of industrial and human activities, demands strategic and conscientious efforts. This research underscores the criticality of clean energy investments, given the backdrop of escalating global energy demand, the imperative of averting energy crises, and the detrimental impacts associated with traditional energy sources.

Throughout history, societies have harnessed non-renewable resources, to meet their energy requirements and catalyze industrialization. While these resources have facilitated economic growth, they have disrupted the environment. Therefore, the research seeks to explore and illuminate the intricate relationship between the pursuit of clean energy and climate action, grounded in empirical evidence, to provide invaluable insights that can inform policy orientations and actions aimed at fostering sustainable goals 7 and 13 in the Gulf countries' context.

The main aim of a study on financial development and the SDGs in the Gulf countries, with particular attention to SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action), would be to:

1. Examine the current status of financial development in the Gulf countries and its impact on the SDGs.

2. Identify the key challenges and opportunities for financial development in the Gulf countries in the context of the SDGs.

3. Develop policy recommendations to promote financial development and the SDGs in the Gulf countries.

Some specific research questions that could be addressed by such a study include:

1. How has financial development in the Gulf countries contributed to progress on SDG 7 and SDG 13?

2. What are the main challenges to financial development in the Gulf countries in the context of SDGs 7 and 13?

3. What are the key opportunities for financial development to support the SDGs in

the Gulf countries?

4. What policy reforms are needed to promote financial development and the SDGs in the Gulf countries?

It is strongly recommended that policymakers and decision-makers in the GCC countries take decisive steps towards the efficient and sustainable utilization of energy resources. This entails enacting policy measures and implementing mechanisms to embrace renewable energy sources, paving the way for the development of green economies.

1.3 Contribution of the Study

The research stands out for its innovative method of investigating the energy transition process toward carbon neutrality in emerging nations. This emphasis on politically stable and strong systems emphasizes the role of political considerations in hastening the transition while reducing its social and economic consequences. The inclusion of participatory democracy and financial inclusion as dependent variables highlights the significance of inclusive governance and financial accessibility in enabling a successful energy transition. These variables contribute to resource mobilization and stakeholder participation, making transitions easier and increasing public acceptance.

This study expands upon literature by examining the multifaceted relationship between financial development, renewable energy, and carbon emissions. It delves beyond the linear relationship and explores the non-linear effects of financial development on renewable energy and carbon emissions. Additionally, it unveils the indirect channels through which financial development influences these two factors. By introducing the moderating role of economic growth and energy consumption, this study extends the current understanding of the complex interplay between these variables. Furthermore, it acknowledges other factors gets the potential for bias arising from the use of a single financial development indicator and employs the financial development index to provide a more comprehensive assessment. Recognizing the potential for heterogeneity, the study incorporates income and regional variations into its analysis. Lastly, it utilizes moment of methods to examine financial development's short and long-run impacts on carbon emissions and renewable energy, employing MMQ and Driscoll Kraay standard errors to mitigate potential endogeneity concerns.

1.4 Structure of the Study

This research is organized into five chapters. Chapter one elucidates the study's framework, expounding upon the significance of the research issue, its historical context, and its overarching objectives. Chapter two provides an economic synopsis of the Gulf nations under examination. Chapter three thoroughly reviews the relevant empirical and theoretical literature in the field. Chapter four delves into the data sources and methodologies employed. Chapter five is dedicated to the presentation and analysis of empirical data. The final chapter, chapter six, consolidates the research findings and furnishes actionable recommendations for future directions in this domain.

Chapter 2

OVERVIEW OF GULF COUNTRIES

2.1 Introduction

Amidst intensifying global climate concerns, policymakers across the Gulf region have openly acknowledged the need for external financial support to expedite their transition to cleaner energy sources and fulfill the ambitious climate goals set forth by the Paris Agreement. The Energy Outlook 2019 report estimates a staggering $2.6 trillion investment between 2019 and 2040 to ensure accessible and clean energy across the Gulf region.

To bridge this financial gap, a consortium of capital market, Bretton Woods institutions the European Union (EU), and high-emitting nations have stepped forward, pledging their financial support for renewable energy investment in the Gulf. These commitments aim to mobilize substantial capital to fuel deployment of renewable energy technologies across the region, enabling a cleaner energy future.

In the dynamic landscape of the Gulf Cooperation Council (GCC) countries, the intersection of economic vitality, energy consumption, and environmental sustainability takes center stage. A region characterized by rapid economic growth over the past four decades, fueled predominantly by abundant oil and gas reserves, the GCC nations – Saudi Arabia, the United Arab Emirates (UAE), Qatar, Bahrain, Kuwait, and Oman – have emerged as significant players in the global economic arena.

However, this prosperity has been accompanied by a substantial environmental footprint, with these nations collectively contributing approximately 8% of the world's carbon dioxide CO_2 (Almasri & Narayan, 2021; Mahmood, 2022).

The GCC countries have undergone a striking economic development trajectory, marked by unprecedented growth rates, soaring electricity consumption, and a concomitant surge in carbon dioxide (CO2) emissions. Notably, the pace of economic expansion and per capita electricity consumption within the GCC has outpaced that of major developed economies belonging to the Organization of Economic Cooperation and Development (OECD). This accelerated development has positioned the Gulf nations as formidable economic players, albeit with a discernible environmental cost, prompting a critical examination of the sustainability of their current growth paradigm.

The impact of the oil shocks in the 1970s left an indelible mark on the energy-mix strategies of major developed economies. In a notable departure from the historical correlation between carbon dioxide (CO2) emissions and economic growth, these economies, faced with escalating oil and gas prices, recalibrated their energy portfolios to insulate themselves from such shocks. This nuanced approach, however, stands in stark contrast to the trajectory of the Gulf Cooperation Council (GCC) countries. Empowered by their abundant and affordable energy resources, GCC governments seized the opportunity to propel rapid economic development, resulting in a surge in domestic energy demand, particularly in the realm of electricity.

Unlike their OECD counterparts, the GCC nations remained insulated from the imperative of diversifying their energy sources in response to the oil shocks. Consequently, three of the six GCC countries have ascended to the summit as the world's highest CO_2 emitters. In light of this stark reality, the imperative for the region to pivot towards sustainable energy policies has assumed paramount importance. The GCC countries, recognizing the urgent need to balance economic growth with environmental stewardship, are faced with the challenge of realigning their energy strategies to embrace sustainability and chart a course toward a low-carbon future. This shift addresses the environmental ramifications of their energy-intensive development and positions the region as a pivotal player in the global drive towards a more sustainable energy landscape.

Remarkably, the GCC nations have witnessed an extraordinary surge in both financial development and energy consumption, with the latter experiencing a staggering increase of over 100% in the last three decades. However, the nuanced relationship between financial development and energy consumption within the GCC remains a terrain untouched by previous studies (Aloqab et al., 2023; Alshubiri et al., 2019; Yang et al., 2021).With a lens focused on the past, present, and future, we delve into the challenges and opportunities these nations face in transitioning towards sustainable practices, particularly in the context of renewable energy deployment. As the global call for environmental responsibility intensifies, the GCC countries find themselves at a pivotal juncture, poised to redefine their role in the global energy landscape and carve a path toward a more sustainable and environmentally conscious future.

Look at the energy resource of Gulf countries in the graph in Figure 2 provides information on the reserves of oil, natural gas, and coal for various countries in the Gulf region. The countries listed include Gulf Countries, Iraq, Kuwait, UAE (United Arab Emirates), Qatar, Oman, Bahrain, and Brunei. The values in each column represent the estimated reserves in arbitrary units (as specific units were not provided) for the respective country and resource.

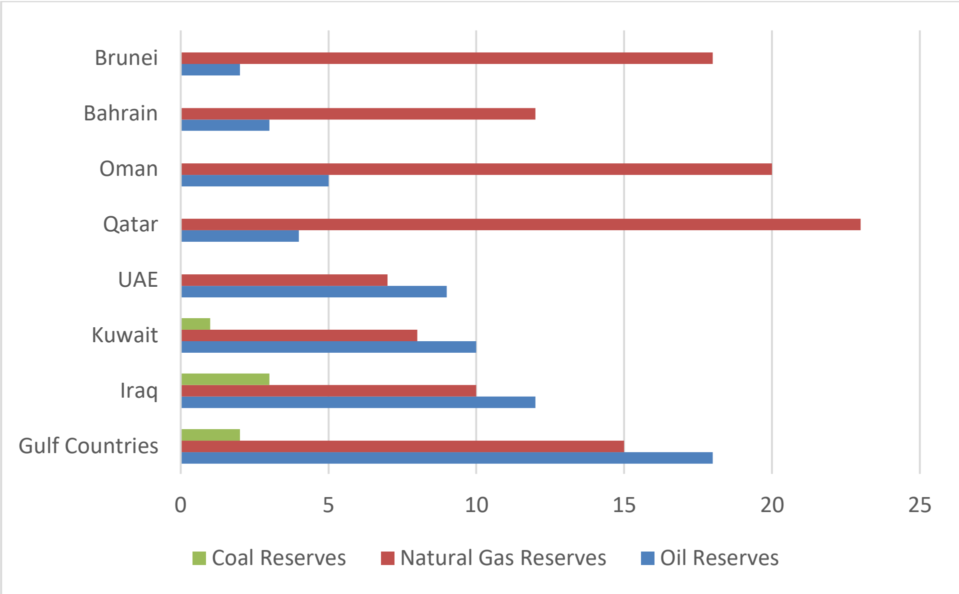

Figure 2: Energy Potential in Gulf Countries

2.2 Overview of Bahrain in the Context of SDG 7 and SDG 13

Bahrain, a high-income, oil-producing nation, has a surprisingly high per capita CO2 emission rate, standing among the world's leaders. This discrepancy arises from its energy-intensive economy, heavily reliant on oil production. Bahrain has prioritized sustainable development as a central tenet of its national agenda, a commitment enshrined in the Government Action Plan. Demonstrating this dedication, Bahrain has implemented robust environmental legislation and embraced the National Environment Strategy, marking significant strides towards a more sustainable and ecologically responsible future. However, looking at Figure 3 comparatively, it seems they have performed better on SDG 7 than on SDG 13, which leads to questions of policy incoherence.

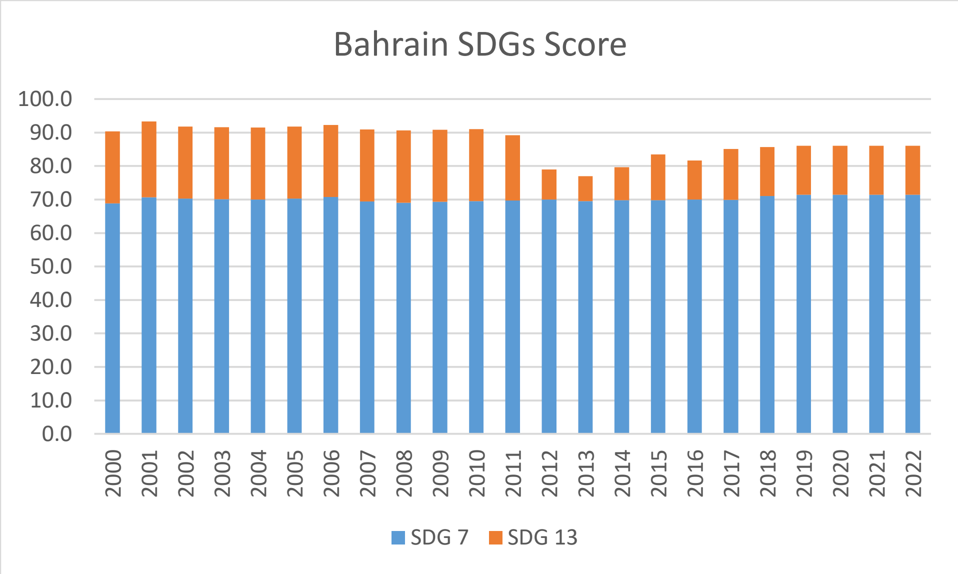

Figure 3: SDG Score in Bahrain

In 2008, Bahrain embarked on a journey towards sustainability with its Economic Vision 2030 launch, aiming to reduce reliance on oil and embrace renewable energy sources. Aligning with the Sustainable Development Goals for 2030, the vision sets an ambitious target to produce 700 MW of renewable energy by 2030. It also establishes a renewable energy roadmap, aiming to achieve 5% and 10% of energy generation from renewables by 2025 and 2035 respectively. Until 2020, natural gas was the exclusive source of electricity generation in Bahrain. However, with the upcoming completion of a 100 MW solar plant in 2021, Bahrain is poised to make significant strides towards its renewable energy goals.

2.3 Overview of Kuwait in the Context of SDG 7 and SDG 13

Kuwait is a global leader in per capita consumption of electricity according to the 2019 Energy Outlook report. This high level of consumption strains power increases environmental pollution, and reduces exports of oil and natural gas. The burning of fossil fuels to meet energy demands has led to elevated CO_2 emissions, reaching 8.9 tons per capita and 21.1 tons of CO_2 per capita. Kuwait has set ambitious renewable energy targets, aiming to integrate 10% renewable energy by 2020 and 15% by 2030. However, the country's renewable energy portfolio currently consists primarily of small-scale demonstration projects. A significant milestone was reached in 2019 with the launch of Shagaya Phase I, Kuwait's flagship renewable energy project.

While Shagaya Phase I has successfully integrated Kuwait's electricity grid, the country still lacks comprehensive regulations and policies explicitly supporting renewable energy adoption. To effectively guide the transition towards a more sustainable energy landscape, the establishment of a dedicated regulatory body is crucial.

Despite the fluctuations in economic competitiveness linked to oil price cycles, Kuwait has unwaveringly pursued the deployment of renewable energy (RE) technologies. This commitment stems from a strong political mandate, a desire to foster knowledge and manpower capacity in new economic sectors, and an unwavering dedication to environmental sustainability and greenhouse gas (GHG) emissions reduction.

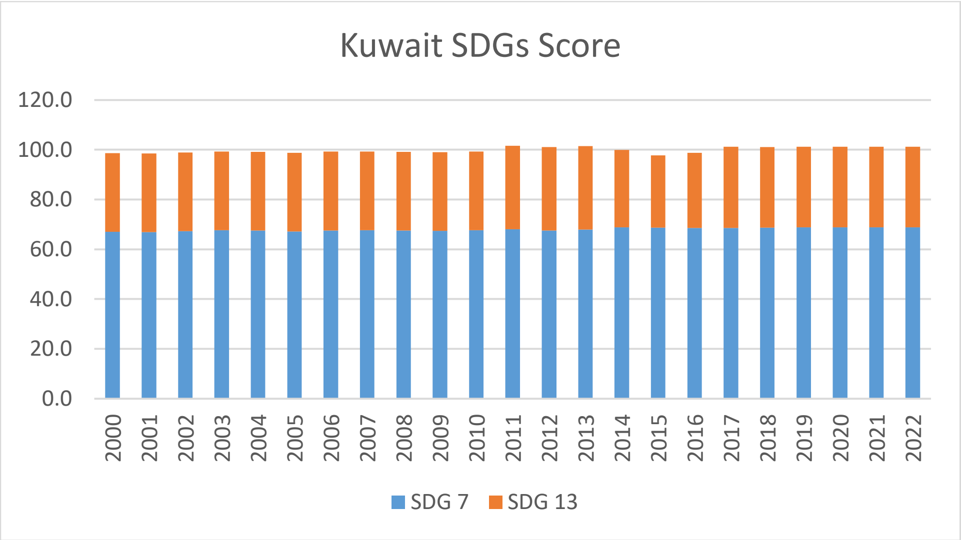

Figure 4: SDG Score in Kuwait

2.4 Overview of Oman in the Context of SDG 7 and SDG 13

Oman has demonstrated a commitment to diversifying its energy mix by actively pursuing renewable energy development. A diverse range of stakeholders, including the government, private entities, academic institutions, and Oman's national oil company (PDO), have collaborated to advance renewable energy projects. In 1995, Oman pioneered renewable energy by establishing a 10-kW wind-solar water desalination plant. This project marked the beginning of a growing interest in harnessing renewable energy sources. In 2008, a comprehensive study assessed Oman's renewable energy potential, further fueling the country's ambition to integrate renewable energy into its energy portfolio. Following this evaluation, the government gave the go-ahead for Al Mazyunah's 303 kW solar power plant, the country's first utility-scale renewable energy project, in 2017. Private investors have acknowledged the potential of renewable energy. For instance, a state-owned electricity distribution company developed a 50-kW photovoltaic rooftop project in 2012, while a private investment firm constructed a 6 MW concentrated photovoltaic (CPV) solar technology project in 2010. In 2012, PDO, the national oil company of Oman, established a 7 MW pilot solar facility in Amal to determine the commercial viability of solar steam generation for enhanced oil recovery. PDO has also been a pioneer in the development of renewable energy.

In response to the potential of rooftop solar power, Oman implemented the Sahim scheme, which permits industrial and commercial entities and homeowners to generate clean electricity. At the outset, the financial burden of solar panel installation fell on householders. With the implementation of Sahim's second phase, customers were relieved of this financial burden as distribution companies assumed responsibility for the systems' procurement, installation, operation, and maintenance. The Oman government's growing enthusiasm and backing for the utilization and investment in renewable energy is evident. The government remains steadfast in its commitment to the ongoing development of the country's human resources.

The regulatory framework in Oman ensures the effective governance of renewable energy development. Renewable energy development and electricity and water services are subject to regulation by the Authority for Public Services Regulation (formerly the Authority of Electricity Regulation). Substantially accountable to the Council of Ministers, it functions with financial and administrative autonomy.

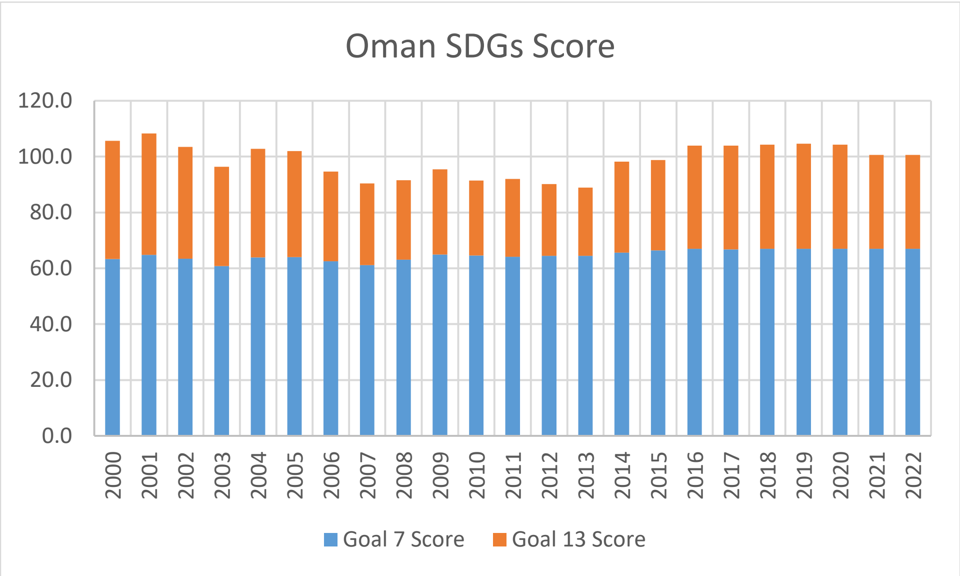

Figure 5: SDG Score in Oman

2.5 Overview of Qatar in the Context of SDG 7 and SDG 13

At the forefront of renewable energy advancements in the Gulf region, Qatar has established itself as a pioneer in this domain. The country proudly houses the only polysilicon manufacturing facility, a crucial component for solar photovoltaic (PV) technologies. Qatar Solar Technologies (QSTec) is located in Ras Laffan Industrial City and demonstrates Qatar's dedication to renewable energy. It is a collaboration between Qatar Solar (a subsidiary of Qatar Foundation), SolarWorld AG from Germany, and the Qatar Development Bank. Further solidifying its position as a leader in renewable energy, Qatar is home to the only operating waste-to-energy facility in the Gulf region, the Mesaieed plant, which has a capacity of thirty megawatts. The first phase of the 800 MW Al Kharsaah solar PV project did not receive financial backing until closer to the end of 2020, even though it was earlier thought that it would be finished by the end of 2020.

Qatar aims to derive 20% of its power from renewable sources by 2030. To achieve this goal, the country has identified the need for a dedicated entity with clearly defined mandates to oversee and support renewable energy development.

Qatar's commitment to renewable energy is further evident in its active participation in the International Solar Alliance (ISA), a global initiative aimed at accelerating the adoption of solar energy. The country has also signed a Memorandum of Understanding (MoU) with the International Renewable Energy Agency (IRENA) to collaborate on renewable energy development and capacity building. Qatar's renewable energy initiatives are driven not only by environmental considerations but also by economic ones. The country envisions a future where renewable energy sources contribute to its energy security and serve as a catalyst for economic diversification and sustainable development. In conclusion, Qatar's dedication to renewable energy is undeniable. The country's strategic investments in polysilicon manufacturing, waste-to-energy facilities, and solar PV projects, coupled with its active involvement in international renewable energy initiatives, demonstrate its unwavering commitment to a sustainable future.

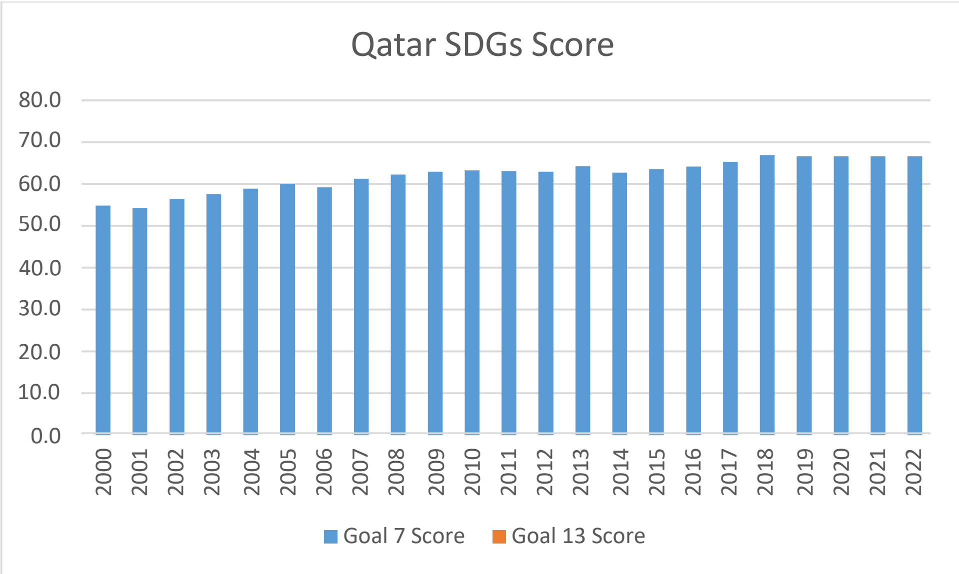

Figure 6: SDG Score in Qatar

2.6 Overview of Saudi Arabia in the Context of SDG 7 and SDG 13

Saudi Arabia's ambitious energy mix targets a 50:50 split between renewable energy sources and natural gas by 2030. The Kingdom's geographical location offers exceptional solar and wind energy production advantages, ranking sixth globally for solar potential and thirteenth for onshore wind potential. In 2021, Saudi Arabia had 700 MW of renewable energy capacity. 400 MW came from wind power (Domat Al-Jandal project), which cost USD 0.199 per kilowatt-hour, and 300 MW came from photovoltaic energy (Sakaka project), which cost USD 0.234 per kilowatt-hour, which was the lowest solar PV supply cost ever. During its G-20 presidency, Saudi Arabia was a key player in proposing the Circular Carbon Economy Initiative (CCE). All G-20 countries agreed it was a complete and workable way to deal with emissions. The

CCE considers the different situations in each country by including many different paths and choices. Its main goal is to lower greenhouse gas emissions while considering the system's efficiency, the resources available in each country, and the political, economic, environmental, and social growth situations that exist. Three ways to protect the environment are used to build the CCE: prevention, removal, reuse, and recycling. It also helps with a fourth approach called "removal," which aims to eliminate all the emissions that have built up in the atmosphere.

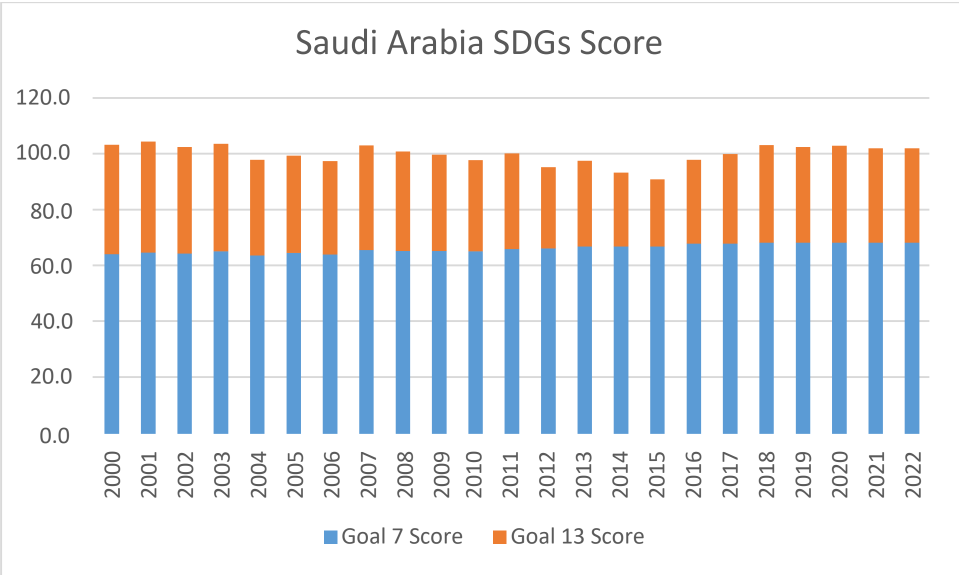

Figure 7: SDG Score in Saudi Arabia

2.7 Overview of United Arab Emirates in the Context of SDG 7 and SDG 13

The UAE has emerged as a frontrunner in renewable energy development in the Gulf region, driven by its ambitious National Energy Strategy 2050. This comprehensive strategy aims to achieve a remarkable 50% energy mix from clean sources, with 44% attributed to renewable sources and 6% to nuclear power, by 2050. Additionally, the

UAE has pledged to reduce its carbon emissions by 70% by the same target year.

The UAE's remarkable renewable energy capacity leading the Gulf region since 2018, is evidence of its dedication to renewable energy. The nation's position as the home of IRENA headquarters, a worldwide forum for promoting renewable energy solutions, further demonstrates its leadership in this field.

Several factors have propelled the UAE's rapid expansion in renewable energy development. One key factor is the strategic adoption of utility-scale auctions ensuring cost efficiency and transpiracy. Dubai, a leading emirate in the UAE, has spearheaded this approach and established itself as a global leader. In 2015, Dubai accomplished a significant achievement by entering into a power purchase agreement (PPA) for its inaugural renewable energy independent power producer This extended Power Purchase Agreement (PPA) involves the establishment of a solar park in its second phase, which will operate for 25 years. This agreement serves as a crucial element in assisting the local electrical authority. DEWA has strides in the success of auctioned projects by having a majority ownership of 51% in the winning project consortia and serving as the power off-taker from an institutional power.

The establishment of the MBR Solar Park stands as an epoch to Dubai’s renewable energy commitment and its efforts to create an enabling environment for renewable energy projects. Government designated locations for renewable energy projects assure investors of the availability of solar resources and the required grid connections. An additional crucial element contributing to Dubai's success is the presence of appealing financing alternatives. The remarkably affordable Power Purchase Agreement (PPA) prices can be linked to the extraordinarily advantageous financing conditions provided by banks in the United Arab Emirates (UAE). These conditions include debt financing over a long haul additionally, minimal to non-existent connection costs and positive projections on efficiency have further contributed to Dubai's success in renewable energy development.

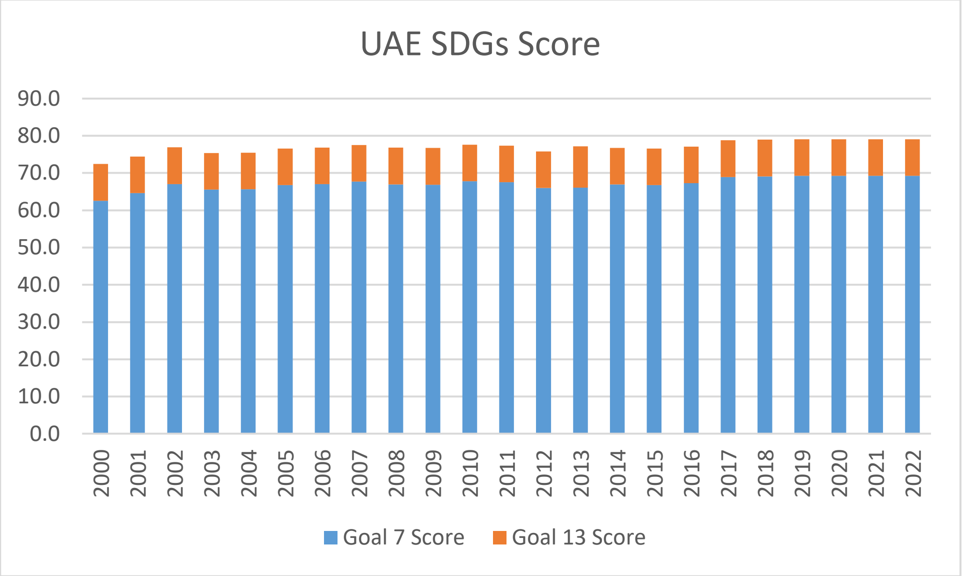

Figure 8: SDG Score in UAE

2.8 Climate Change and the Financial System in Gulf Countries

The introduction of the Sustainable Development Goals (SDGs) (Sachs, 2012), the globe is experiencing a need to refocus its present economic growth pattern to restore ecological balance. To fulfill these objectives outlined in the SDGs and effectively execute the Paris Agreement (PA 2015), both developed and developing nations are compelled to undergo substantial overhauls in various domains and policy reorientation (Höysniemi, 2022; Madurai Elavarasan et al., 2022; Ofori, Hayford, et al., 2023). These transformations necessitate augmented policy formulation, heightened political dedication, and substantial reliance on financial resources (Adedoyin et al., 2023).

Markets and financial intermediaries are essential to global economic activity and ongoing attempts to avert catastrophic climate change (Galaz et al., 2018). Through their support and facilitation of commerce, financial institutions have the capacity to both strengthen and weaken the stability of Earth systems. While business activity can promote growth and well-being, it can also have negative effects on the environment, biodiversity, human health, and climate change (Heal, 2017). (Krausmann et al., 2018). Moe (2010) cautions against businesses playing a significant role in resolving societal issues because they can obstruct structural change to further their agenda.

The business sector is launching a number of initiatives to highlight the significance of sustainable development and ethical business practices, seeing business as a catalyst for change (for a historical summary, see Jones, 2017). As a result, organizations like the World Business Council for Sustainable Development, the UN Global Compact, and the Earth Charter were created. Their existence means businesses will lead in this kind of transition. Financial institutions, in addition to commercial businesses, are very significant in this context, even if their direct environmental impact is relatively small (Gonenc and Scholtens, 2017). In terms of their primary business operations, they saw themselves as at the center of this broader corporate reaction. Examples of explicit expressions of this responsibility include the Principles for Responsible.

Gulf nations' financial systems have a number of distinctive features that might affect how they handle climate concerns. In the Gulf nations, bank lending makes for 50–60% of business finance; stock markets provide the remaining funding. The banking system despite major liberalization over the previous three decades lacks autonomy from the state (Mohan and Ray, 2017). Because state-owned banks in the Gulf region also aim to achieve government goals.

A financial system that is primarily based on state-owned banks, such as those in the Gulf countries, may be more affected by a government's priorities comparatively to privately owned.

According to Short et al. (2021), the Gulf country must invest at least $250 billion yearly by 2030 in order to attain net-zero by 2050. It illustrates the pivotal function of funding in the production of renewable energy. By 2021, private investors will have funded almost 90% of the Gulf nation's renewable energy generating projects (Almasri & Narayan, 2021).

The prospect of renewable energy has gained political and economic traction. Globally, the world's supplies of non-renewable energy sources, including fossil fuels, are running out (IRENA, 2019; Zhao et al., 2022). These sources are also one of the primary contributors to pollution since they release greenhouse gases into the atmosphere (SDG, 2019). Therefore, it is our responsibility to explore and develop alternative energy sources for the future and to figure out a better, more efficient method to use energy without contributing to global warming than we do now. The problem is that traditional non-renewable energy yields higher profits because of ongoing demand and predictability. As a result, market-based mechanisms like carbon trading schemes are necessary to support the growth of the renewable energy markets. Because it will bring stability to the market and create financial incentives, this will benefit it and attract new investment. As a result, without government assistance, investment will go elsewhere since no one will make money in a market that is still developing and unstable compared to other energy markets.

Global initiatives to reduce pollution have been implemented, such as the Kyoto

Protocol; however, it is nearly hard to renew this agreement because many highly polluting nations refuse to join for concern that it would negatively impact their economies. Given the difficulty the international community faces in reaching a consensus, it is not surprising that national boundaries are affected as well.

Chapter 3

LITERATURE REVIEW

3.1 Introduction

This section delves into the existing theoretical and empirical literature on the intricate nexus between financial development, Sustainable Development Goals (SDGs), and governance within the context of Gulf Cooperation Council (GCC) nations. A theoretical underpinning of financial development and its potential impact on SDG 7 (affordable and clean energy) and SDG 13 (climate action). Simultaneously, it examines the empirical evidence on the interplay between financial development, SDGs, and governance, considering the unique characteristics and challenges faced by GCC countries.

The theoretical foundation of financial development emphasizes its role in facilitating the allocation of capital towards productive investments, fostering innovation, and enhancing economic growth. This, in turn, can contribute to achieving SDG 7 by promoting energy efficiency, renewable energy adoption, and sustainable energy infrastructure development. Similarly, financial development can influence SDG 13 by facilitating the expansion of low-carbon industries, promoting carbon pricing mechanisms, and supporting adaptation efforts to climate change impacts.

GCC countries, characterized by their reliance on oil revenues and unique political and economic structures, present a compelling case for examining the impact of financial development on SDGs in the context of governance. The literature suggests that stronger governance institutions can amplify the positive effects of financial development on SDG attainment. Moreover, the role of governance in mitigating the potential negative externalities of financial development, such as excessive resource extraction or environmental degradation, is crucial.

In this study, we employ two econometric models, namely the Environmental Kuznets Curve (EKC) model and the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model, to assess the relationship between financial development, SDG 7, and SDG 13.

3.2 SDG 7 (Affordable and Clean Energy) Prospect

Energy access is crucial for human and economic development (Earsom & Delreux, 2023), Renewable energy generation serves as the cornerstone of a sustainable energy transition. The cruciality of this transition is highlighted by 4 key findings from the IPCC. Firstly, if current trends continue unabated, global warming is projected to raise average temperatures by 1.5–2°C between 2030 and 2052. Secondly, a moderate degree of preservation in the functions of biodiversity, and humankind, is contingent on capping global warming at 1.5°C. Thirdly, limiting global warming to below 2°C is projected to result in a 25% reduction in CO_2 emissions by 2030 and achieve net-zero emissions by 2070. Fourthly, substantial alterations in energy , and industrial systems are indispensable to constrain global warming to 1.5°C without exceeding this threshold.(Ari et al., 2022; IRENA, 2016). According to IRENA, renewable energy stands as a pivotal policy instrument against climate change. Consequently, REN investments have garnered significant traction, holding immense potential to facilitate green development and achieve the aspiration of a low-carbon economy. By mitigating carbon emissions, promoting cleaner production processes, and driving the energy transition, renewable energy investments can effectively pave the way towards a sustainable future.

3.3 SDG 13 (Climate Action)

Climate change, propelled by escalating greenhouse gas emissions, poses a stark and authentic threat to our collective well-being. Its repercussions are already evident and will have catastrophic consequences if we delay action. Through education, innovation, and honoring our climate commitments, we can make the transformative changes needed to safeguard our planet. Our research used carbon emissions as a proxy for SDG 13. Addressing greenhouse gas (GHG) emissions effectively necessitates a dual-pronged approach: curbing emission sources and bolstering GHG sinks. While GHG mitigation efforts offer economic, environmental, and social benefits, they also present potential drawbacks and trade-offs, as studies have shown (Harrison et al., 2021). The pursuit of GHG reduction efforts can lead to unintended consequences, including rising commodity prices, reduced food consumption and increased food insecurity, and pollution leakage, where GHG mitigation in one region indirectly increases fossil fuel use elsewhere. These repercussions are particularly pronounced in areas heavily dependent on agriculture and natural resource extraction. Moreover, implementing GHG reduction strategies can be expensive, requiring a combination of behavioral changes and infrastructure investments. Given these complexities, effective evaluation tools and techniques are essential to assess the multifaceted implications of GHG mitigation efforts, considering both their potential benefits and potential adverse impacts on various community values and resources.

3.4 Theoretical Underpinnings

Financial Development Theories:

Early innovation theories, such as Joseph Schumpeter's, highlighted the crucial role of finance in providing the capital necessary for entrepreneurs to bring their ideas to life. However, these theories often focused on traditional banking institutions as the primary source of financing (Schumpeter, 1939, 114). The Miller-Modigliani theorem, which suggested that the sources of financing (equity or debt) did not significantly impact firms' performance, further downplayed the importance of differentiating between financial actors in innovation (Modigliani and Miller, 1959). Subsequent literature tended to focus on two distinct financial actors: government and venture capitalists (Hall, 2002). The government's role was perceived as addressing underinvestment in research due to the positive externalities generated by knowledge (Arrow, 1962), while venture capitalists were seen as mitigating information asymmetries that hindered investment in product development by new firms (Hall and Lerner, 2009). In this context, finance was often viewed as a passive participant in determining the types of innovations that received funding.

In recent years, researchers have begun to recognize the diverse and dynamic nature of financial actors, acknowledging that their characteristics and investment decisions can significantly influence the types of innovations that emerge. This shift in perspective has led to a growing body of literature that explores the impact of different financial actors on renewable energy development and the transition to a low-carbon economy. For example, the public sector has played a pivotal role in financing breakthrough innovations in renewable energy technologies such as solar, wind, and geothermal power (Mazzucato, 2013). These investments, often undertaken through mission-oriented projects, have helped to establish entirely new industries and accelerate technological progress. In some countries, such as the United States, innovative agencies like ARPA-E (Advanced Research Projects Agency-Energy) have been instrumental in providing early-stage funding for high-risk, high-reward research (ARPA-E, n.d.). Public procurement, a mechanism for financing innovative firms through government contracts, has also proven effective in stimulating renewable energy development. The Department of Energy's Solar Energy Technologies Office (SETO) in the United States, for instance, has been a driving force behind the growth of solar energy companies and the development of cost-competitive solar technologies (SETO, n.d.).

Public banks have emerged as key financial actors supporting the transition to a low-carbon economy (Mazzucato, 2016b; Schapiro, 2012). These institutions have provided patient capital, or long-term funding with flexible terms, to support projects to reduce greenhouse gas emissions and promote renewable energy adoption. Additionally, public banks have played a crucial role in promoting energy efficiency and green infrastructure investments (Shimada, 2017; Griffith-Jones and Cozzi, 2016). Their collaborative efforts with other public institutions have further amplified their impact on the transition to a low-carbon economy (Shimada, 2017).

These examples highlight the critical role that different types of financial actors can play in shaping innovation trajectories and accelerating the transition to a sustainable future. By providing targeted financing and fostering collaboration, financial institutions can help to overcome the barriers to innovation and commercialization that have often hindered the development of clean energy technologies. As the world grapples with the climate crisis, the actions of financial actors will be increasingly crucial in determining the pace and effectiveness of our transition to a low-carbon economy.

Achieving universal electricity access in under-developed countries will necessitate investments estimated at $3.1 trillion between 2016 and 2030 (Global Infrastructure Hub, 2017). Given private investors' high investment risk in developing countries, public finance plays a vital role (IEA, 2019; OECD, 2016).

Financial institutions assume a pivotal role in this ecosystem, wielding the capacity to provide indispensable funding for Ren ventures. This financial backing serves as a catalyst for the proliferation of Contemporary energy services in historically neglected regions, thereby mitigating energy poverty and enhancing overall energy security.

Financial development concurrently fosters a conducive environment for entrepreneurial endeavors and the growth of Indigenous businesses in the energy sector. It facilitates access to a spectrum of financial services, encompassing venture funding, commercial loans, and assistance for business growth. This inclusive ecosystem incubates energy-related enterprises, including energy service companies, Sustainable energy project innovators, and microgrid operators, which collectively contribute to an expanded energy access landscape and job creation in energy-deprived regions.

Furthermore, financial development broadens bridges the financial gap for individuals and communities, and businesses striving to augment their energy accessibility. This empowerment enables energy-insufficient households and enterprises to invest in renewable energy technologies, such as solar home systems and sustainable cooking solutions. This, in turn, diminishes dependence on traditional, inefficient energy sources.

The nexus of financial development also invigorates optimization of energy networks by magnetizing domestic and foreign investments. This influx of capital augments the accessibility of dependable energy sources, fostering energy security. Mitigating financial risks associated with energy infrastructure investments is an inherent facet of financial development, necessitating Introducing measures for sharing risks, insurance solutions, and assurances is designed to shield investors and lenders from possible financial setbacks. Simultaneously, it propels private sector engagement, attracting requisite capital to form robust energy markets. This holistic approach synergizes the objectives of SDG 7 and SDG 13, aligning financial development with the pursuit of carbon neutrality and sustainable energy transformation.

Notwithstanding the RE sector's growth, several obstacles have impeded it historically and in the future, with financial constraints perhaps the most significant (Anton & Nucu, 2020; Lahiani et al., 2021). Compared to the fossil fuels, the renewable energy has higher initial cost and calls for a longer payback time (Adefarati et al., 2023). Because RE investments are sometimes somewhat hazardous, significant funding is needed to realize the many worldwide RE objectives. For smaller ventures utilizing novel technology, venture capital or equity financing could be a good fit, but bank or debt financing might be a better fit for bigger projects (Cairns et al., 2023). These are difficult to do without the support of a reliable financial system. Zhang and Chiu (2023) state that financial development has a major effect on RE consumption because it makes it possible for start-ups in the green energy industry to use stock markets and sophisticated financial institutions to get debt and equity funding. Additionally, there is a chance that low- or zero-carbon projects can be funded at a reduced cost with a well-developed financial system. The claim made by (Hung, 2023) that a robust finance structure promotes the development of the renewable(s) market at a relatively cheap cost is supported by (Ofori, Onifade, et al., 2023).

Financial Sector Development:

After the stabilization of COVID-19 and the growing unpredictability of economic policies have had a negative impact on investment returns in the real economy and have made the financing challenges faced by renewable energy companies more apparent. Renewable energy companies want to spend a portion of their capital in financial markets to increase returns on investment and help alleviate financing limitations impeding their performance. Financial investments that yield high returns are typically associated with significant risks. Creditors may increase the cost of loans to renewable energy companies that invest in financial assets to make up for the significant risks they are taking. This will drive up the cost of loans and drive down the revenues of renewable energy companies. The decline in revenues will unavoidably have an impact on the investments made by renewable energy companies, requiring them to take out more short-term loans, make long-term investments, and contribute less to innovation. Compared to short-term loans, long-term loans include greater risk and uncertainty (Akram et al., 2020). Creditors may convert loan terms to renewable energy companies and favor short-term loans in order to lower credit risks (Al-Hares & Saleem, 2017). Renewable energy companies will be forced to employ more short-term loans as long-term loans decline.

As such, a new look at how the sector works can be made to rise above water will need further relooking. In order to finance long-term investments, renewable energy companies will be forced to employ more short-term loans while long-term loans are reduced. This would worsen the maturity mismatch between financing and investment and stifle technical innovation. It is typically difficult to reap the short-term advantages of technological innovation as it necessitates a significant investment spread across time (Haldar & Sethi, 2022). An essential component of sustainable development is technological innovation (Ofori, Li, et al., 2023). As such, funding companies that produce renewable energy will seriously impede their ability to operate sustainably.

3.5 Empirical Literature Review

Aware of the potential for implicit bias in review methodologies, we adopt a rigorous, transparent, and systematic approach to analyses relevant literature for this paper (Fan et al., 2022; Kunisch et al., 2023). This ensures an unbiased and comprehensive review to identify research gaps and address research questions (Madanaguli et al., 2023; Okoli, 2015; Siddaway et al., 2019).

Siddaway et al. (2019) highlight the necessity for methodological changes in the literature review, but they also emphasize how computational approaches may be a fantastic way to enhance analytical and information processing skills. We first employed the Bibliometric analysis technique using the Bibliometrix R package, which has become more and more popular in recent years (Radha & Arumugam, 2021); using terms related to our study goals, we searched the pertinent literature using the Scopus database. Because it prevents predatory publications and streamlines the research workflow, Scopus is a top database that top academic institutions choose (Mongeon & Paul-Hus, 2016). 255 documents were retrieved by the search query; these are further vetted in accordance with our study goals, and the publications that are deemed relevant are then examined.

We present the most popular subjects in our research field Figure 9 illustrating significant research topics' duration, breadth, and prominence. Notably, renewable energy, climate change, and financial development stand out as a crucial focus. Our study's problem has been meticulously examined, with much of the 2019 research emphasizing aspects such as sustainable development, alternative energy, and environmental degradation.

For instance, Sharma et al. (2021) research has demonstrated the emergence of financial industry played significant role in strengthening long-term association between energy alternatives and overall environmental quality. Similarly, other findings indicate that the expansion of the financial sector had a profound impact on trade expansion and ecological indicators (Habiba et al., 2023; Haldar & Sethi, 2022; Shahbaz et al., 2013).

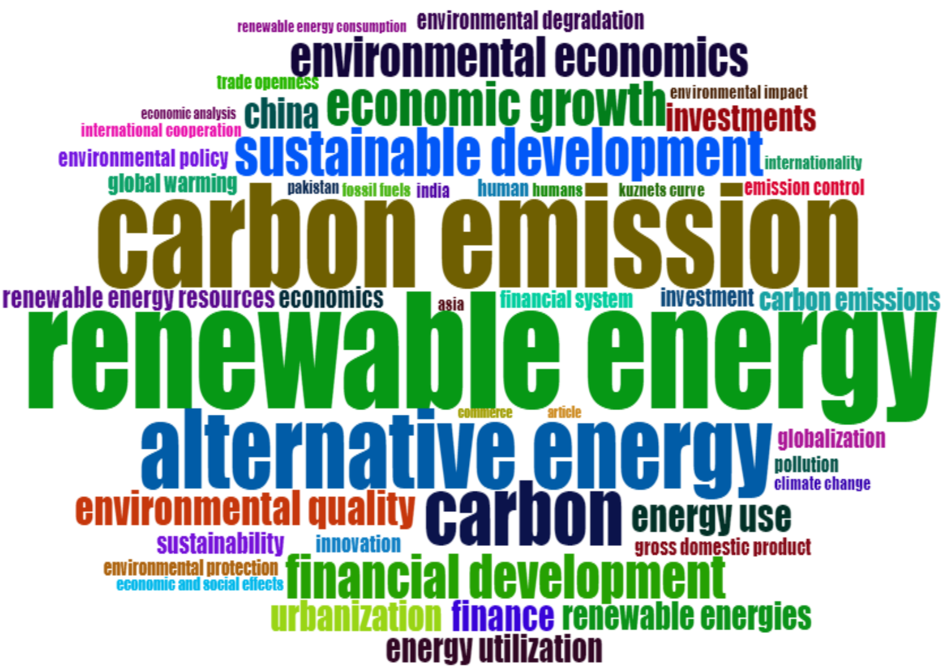

Figure 9 Thematic Areas

Financial development is widely recognized as a pivotal conduit toward the realization of the SDGs. This perspective is informed by varying schools of thought (Ali et al., 2023; Destek et al., 2023; Hung, 2023), some of which assert that financial development can serve as a direct and uncomplicated route to achieving the SDGs, while others underscore its potential to enhance capital markets and foster financial inclusion (Saadaoui & Chtourou, 2022; Wu & Broadstock, 2015). The financial system's maturity, efficiency, and capacity to channel resources toward sustainable projects weigh heavily on the prospects of achieving these goals.

Nevertheless, Gulf nations still encounter a complex dilemma as they strive to balance the necessity of economic growth with the limitations hindering the pursuit of eco-friendly development -such development includes renewable energy (RE).

Renewable energy is progressively pivotal in the global energy landscape, owing to its capacity to enhance energy accessibility, promote a sustainable paradigm, ameliorate energy security concerns. Nonetheless, a staggering 770 million individuals across the globe still grapple with the absence of access to electricity. The significance of securing access to clean energy is widely acknowledged as a fundamental catalyst for socio-economic advancement, yielding immediate dividends across various social domains and augmenting the overall quality of life.

The mutual relationship between financial development and the adoption of renewable energy solutions provides a compelling avenue to address the dual challenges of energy poverty and insecurity.

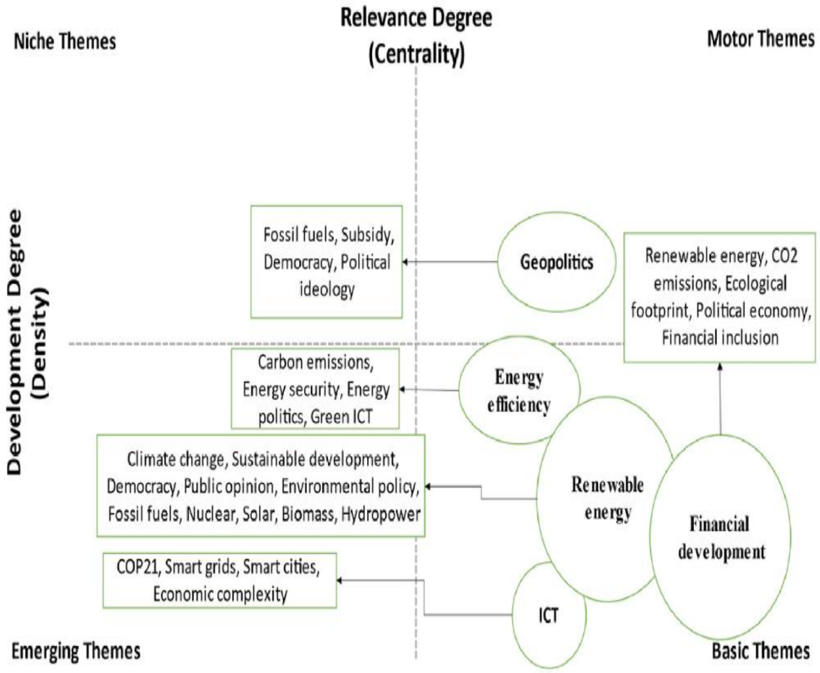

Figure 10 Thematic Areas by Centrality

3.6 Financial Developments on Renewable Energy

Clean energy transitioning is necessary for decarbonization. That is the only practical way to achieve the (already severely difficult) objectives of the Paris Agreement by 2030. Financial circumstances (cost of debt- equity- capital) are critical for the adoption of renewable energy technologies, according to a compelling study by (Egli et al., 2018). According to their analysis, financial markets played a critical role in Germany's net zero transition from 2000 to 2017. Ecological policy use and financial sector growth are closely associated with higher prices of adopting green technology, debt buffer for businesses using both fossil fuels and clean energy, and risky default. Similar works also reported interesting findings.

Empirical findings vary in terms of how energy use responds to changes in financial development. Several research has demonstrated that when financial development grows, so does energy consumption (Adedoyin et al., 2023; Anton & Nucu, 2020; Barth, 2004; Saadaoui & Chtourou, 2022; Sadiq et al., 2022; Sadorsky, 2010, 2011; Shahbaz et al., 2010). The decrease in energy use is due to increased financial development (Mahalik et al., 2017; Shahbaz, Mallick, et al., 2016; Ulucak, 2021). In particular, Barth (2004) noted that financial development may enhance the availability of finance-related products (services) for domestic and foreign businesses, offering efficient financial services in international banking markets, which can foster higher investment in a low carbon economy.

Some authors paid attention to renewable energy and indicated financial development has a high propensity to influence renewable energy consumption, investment, deployment, and development (Aarakit et al., 2022; Aguirre & Ibikunle, 2014; Aluko & Obalade, 2020; Masini & Menichetti, 2013; Sun et al., 2023). Thus, Aluko and Obalade (2020) stated that financial development encourages increased financing for innovative and cost-effective renewable technologies, increasing investment and satisfying the world's energy needs.. With a distinct approach—a two-step system generalized method of moments (GMM)—Le et al. (2020) investigated the impact of inclusiveness and financial development on the adoption of renewable energy across a worldwide sample of 55 nations. They discover that the financial sector's growth significantly influences RE deployment. Similarly, research by Obobisa (2022) shows that as FD rises, so does investment in renewable energy technology, lowering carbon emissions in Europe and America. Previous research has established a connection between specific elements of financial inclusion, such as loan availability and remittances, and the usage of renewable energy technology. In summary, these studies show that financial inclusion is a major factor in supporting the growth of renewable energy sources as well as development in general.

3.7 Financial Development on Carbon Emission

Theoretically, financial growth may have an influence on the environment via the channels of wealth, business, and household effects (Acheampong, 2019). Financial development may make it easier for households to obtain low-cost credit to purchase energy-consuming household goods like cars, homes, and electrical appliances (such as refrigerators, air conditioners, cookers, and washers) (Sadorsky, 2010, 2011). This adversely affects the quality of the environment. Financial development may have a mixed influence on the natural environment via the route of business consequences. Under this situation, financial development can help businesses get the money they need to support R&D projects that could result in the acceptance of green technologies. As a result, the quality of the environment could be enhanced. whereas, financial development may simplify how businesses get inexpensive financing leading to environmental good and also support company expansion by purchasing more inputs (labor and equipment) and constructing new plants (Aluko & Obalade, 2020; Sadorsky, 2010, 2011). The ecology might be lowered by these growth consequence if they result in higher energy consumption (Acheampong, 2019). According to the wealth impact channel, financial growth may improve risk diversification, enabling wealth and might lead to lower environmental quality levels (Obobisa, 2022; Sadorsky, 2010, 2011; Shahbaz et al., 2010). Wealth increases often encourage economic expansion, which raises energy consumption.

Tamazian et al. (2009) Pioneered empirical research on the correlation between environmental quality and financial development. They contended financial liberalization and development are crucial steps in promoting environmental integrity. Tamazian & Rao (2010) subsequently discovered data substantiating their assertion regarding financial liberalization positively impacts the advancement of environmental quality. Ever since there has been a dispute around the discussion of how financial development affects the environment. While some researchers (Acheampong, 2019; Nasir et al., 2019) contend that financial development contributes to the improvement of environmental quality, others (Baloch et al., 2019; Lee & Wang, 2022) contend that the opposite is true.

Continuously several research endeavors have delved into examining the correlation between FD and CO_2 emissions in diverse geographical areas. Abbas et al. (2023) found that, with the exception of about 4 provinces, and Zhejiang, most Chinese provinces saw a proportionate emissions increased due to financial growth. Musa et al. (2021) analyzed data from the EU during the period 2002-2014 and found that financial sectors play a role in reducing CO_2 emissions. These findings suggest that financial development can positively impact environmental sustainability.

However, a significant number of researches contend that financial development is irrelevant for renewable energy development.

3.8 Governance on Renewable Energy and Carbon Emission

The influence of political and governance factors on the development of renewable energy has been examined in literary works. One important aspect influencing the use of renewable energy is the quality of governance (Kassi et al., 2023). Using data from European nations, lobbying actions have been demonstrated to negatively impact the renewable energy development (Simionescu, 2023). According to Bisset (2023), political considerations have a considerable impulse on the use of renewable energy when analyzing the economic, political, and environmental variables that drive the use of renewable energy in countries that are members of the European Union. Using data from ECO member nations, Shabani et al. (2022) studied the institutional and traditional elements promoting renewable energy. It discovered that political stability and corruption had a favorable and negative impact on renewable energy. Furthermore, it has been shown that corruption raises the price of adopting renewable energy through unlawful fiscal activity and stagnates well-designed regulations for renewable energy (Camarero et al., 2013; Chen et al., 2023).

Additionally, it has been discovered that corruption raises the costs of adopting renewable energy through bribes to public officials and unlawful fiscal charges (Lu et al., 2019), which can stall well-designed initiatives (Sinha et al., 2019). Additionally, Sinha et al. (2019) investigated the connection between democracy and renewable energy. According to their research, the use of renewable energy is favorably correlated with all democratic metrics.

3.9 Urbanization on Renewable Energy and Carbon Emission

The influence of demographic on CO_2 has been the subject of extensive research, with numerous studies employing the IPAT and STIRPAT models to investigate these relationships. Prominent examples include (Chertow, 2000; Holdren, 2018; Hubacek et al., 2011; Ma et al., 2017; Song et al., 2011; Waggoner & Ausubel, 2002; Wang et al., 2017; York et al., 2003). These studies have consistently identified population size as a key determinant of CO_2. Additionally, several works have explored the influence of other demographic factors, such as age structure (Liddle & Lung, 2010), on emissions levels.

Urbanization, the phenomenon of population movement from rural to urban centers, has been extensively studied for its environmental implications. Poumanyvong & Kaneko (2010) summarized the theoretical perspectives on urbanization's environmental impacts, highlighting three key theories: ecological modernization, urban environmental transition, and compact city. Shahbaz, Loganathan, et al. (2016) applied these theories to demonstrate the linkages between urban development and environmental aspects at the city level. Madlener and Sunak (2011) delved into the mechanisms through which urbanization influences energy consumption, which in turn affects carbon dioxide emissions. They also emphasized the differential impacts of urbanization on emissions in developing versus developed countries.

Numerous cross-national studies have examined the nexus between urbanization and CO_2 over the past few decades. Initial research generally indicated a positive correlation, with urbanization leading to increased carbon emissions. For instance, Parikh and Shukla (1995) found a positive impact of urbanization on greenhouse gas emissions across 83 developed and developing countries, estimating CO_2. York et al. (2003) arrived at a similar conclusion using a substantially bigger dataset comprising 137 nations. Additionally, Cole and Neumayer (2004) analyzed data from 86 countries and demonstrated that a 10% increase in urbanization resulted in a 7% increase in carbon emissions. However, more recent studies have challenged these findings. Fan et al. (2006) reported a negative relationship between urbanization and CO_2 emissions in developing countries.

Urbanization, the phenomenon of population shifting from rural to urban centers, exerts significant pressure on the agricultural sector, often leading to overproduction. This surge in agricultural output, in turn, drives up energy demand in the agricultural sector, resulting in increased land use and energy consumption (Kalnay & Cai, 2003).

Bryant (2004) identified a complex interplay between urbanization and various factors, these interconnected elements collectively contribute to a rise in energy demand. Hemmati (2006) investigated the impact of urbanization on energy consumption in Iran, employing annual data. He observed that urbanization fosters industrialization and commercialization, which in turn amplifies demand for raw materials and consumer goods, ultimately leading to a surge in energy consumption. York (2007), delving into the influence of demographic factors on energy consumption in European Union countries, concluded that rapid urbanization and industrialization are key drivers of energy demand in these economies. Abouie-Mehrizi et al. (2010) utilized an energy demand function to study the impact of population growth, urbanization, and affluence on energy consumption in Iran. Their empirical results demonstrated a long-run relationship between these variables and energy demand, confirming their role in driving up energy consumption.

3.10 Economic Growth on Renewable Energy and Carbon Emission

Numerous empirical works have extensively examined the interaction between energy consumption and economic growth across various economic regions and countries over the past two decades (Lin & Moubarak, 2014; Mohsin et al., 2022; Mujtaba et al., 2022; Omri et al., 2015; Pao & Fu, 2013; Wei et al., 2022). A significant portion of prior study has concentrated on the relationship between electricity usage and income, often referred to as the energy-income-emissions nexus. These studies suggest a robust relationship between energy usage and economic development, as economic or industrial activities are inherently energy-intensive. Conversely, developing and deploying more efficient energy technologies require the financial backing of a robust economy. Therefore, knowing the causal links between different types of energy usage and economic growth is essential. CO_2 and economic growth are commonly used to assess the validity of the widely recognized EKC hypothesis. This theory posits a positive relationship between these two variables at a nation's initial stage of economic development. However, as a certain level of growth is attained, CO_2 begin to decline as GDP increases, reflecting the country's ability to adopt more efficient technologies. This pattern is often depicted as an inverted U-shaped curve, as evidenced by several past reviews (Ganda, 2019; Kong & Khan, 2019; Narayan et al., 2016; Weimin et al., 2022; Yao et al., 2019).

While numerous studies have supported the EKC, others have challenged its applicability. Studies by (Tao et al., 2008), (Koc & Bulus, 2020), and (Pata & Yurtkuran, 2023) have questioned the hypothesis's validity, while He and Richard (2010) specifically focused on Canada. Conversely, several studies have demonstrated the inverse relationship between the squared growth term and CO_2 emissions, confirming the inverted U-shaped pattern of the EKC hypothesis (Dogan & Inglesi-Lotz, 2020; Mehmood & Tariq, 2020).

In the context of emerging SAARC economies, Li et al. (2021) found evidence supporting the EKC hypothesis, demonstrating the inverted U-shaped relationship between economic growth and CO_2. However, other studies have highlighted the impact of economic growth on environmental sustainability, CO_2 remain unabated despite economic progress. Tugcu et al. (2012) observed that economic boost could exacerbate ecological balance, while Tiwari et al. (2013) identified a positive correlation between GDP and CO_2 in India, further supporting the U-shaped EKC hypothesis. Mensah (2014) also noted the negative environmental consequences of high economic growth, and Al-Mulali et al. (2016) documented the antagonistic relationship between economic growth and CO_2 emissions.

These contrasting findings underscore the complexity of the relationship between economic growth and environmental sustainability. While EKC suggests the possibility of environmental improvement alongside economic development, other studies highlight the potential for environmental degradation associated with economic growth. Further research is needed to fully elucidate this relationship and identify effective strategies for achieving economic prosperity and environmental protection.

3.11 Technological Innovation on Renewable Energy and Carbon Emission

Technological innovation has always played a critical role in renewable energy development. The advancement of renewable energy technologies follows a similar pattern to other technological advancements, characterized by a continuous cycle of research, development, demonstration, and deployment, punctuated by ongoing learning and feedback mechanisms. Technological innovation holds immense potential in steering the energy transition towards renewable sources. Despite current commercial viability concerns stemming from higher costs relative to fossil fuels, technological advancements in renewable energy can invigorate investment and propel the adoption of these sustainable alternatives. As renewable energy technologies evolve, their costs tend to decline, simultaneously expanding their market share. Offshore wind power and concentrated solar power have emerged as significant energy supply options, while ultra-high voltage transmission lines and smart grids are facilitating long-distance electricity transmission. Technological innovation serves as a driving force in augmenting the supply of renewable energy to meet burgeoning energy demands and optimize the energy landscape. Total patent applications and real R&D spending in the energy sector are commonly employed as proxies for technological innovation, while patent stock is widely used to quantify the overall impact of technological advancements.

Early studies on innovation have concluded that market demand is the primary driving force behind the innovation process, suggesting that innovations arise in response to demands for fulfilling specific classes of "needs" (Langrish et al., 1972; Wicki & Hansen, 2019).

Notably, market demand incentives play a crucial role in providing investment incentives for firms, as innovation processes necessitate substantial investments (Schmookler, 1966). In this context, the extent of market demand and price levels have been identified as two key drivers of renewable energy innovation (K. Khan et al., 2022; Wangler, 2013). Research, development, demonstration, and deployment are all steps in the innovation process for renewable energy technologies, just as for conventional technologies. There are also several dynamic feedback loops and ongoing learning throughout these phases. The energy shift to green power is fueled by technological innovation in a number of ways. Because it is now more expensive than fossil fuels, renewable energy is currently less financially feasible. On the other hand, technical advancements in renewable energy might encourage ventures into this field. The cost of green electricity is coming down and its market share is growing as technology progresses in this area. Technologies such as concentrated solar power and offshore turbines have become important sources of energy, while long-distance electricity transmission is made possible by smart grids and ultra-high voltage lines. One of the main factors driving the increase in renewable energy production to fulfill energy demands is breakthrough technology. The rising availability of renewable energy to fulfill energy demands and optimize the energy structure is mostly driven by technological innovation. Actual R&D investment or the total number of patent applications in the energy industry are frequently used as indicators of innovative technologies, and the patent stock is frequently used to gauge the success of the technology process.

Technological innovation has been extensively studied for its impact on carbon emissions, with numerous studies demonstrating its potential to mitigate environmental impact. Balsalobre, lvarez, and Cantos (2015) studied the influence of energy innovation on CO_2 emissions in twenty-eight OECD nations from 1994 to 2010, discovering that innovation effectively cuts carbon emissions. Similar findings were found by Shahbaz, Nasir, and Roubaud (2018), who explored the factors of environmental degradation in France using data from 1955 to 2016. Their research found a negative association between energy research innovations and carbon emissions, demonstrating that spending on research and development in energy innovation improves carbon emission reduction.

Sinha, Sengupta, and Saha (2020) expanded the study to some Asia-Pacific countries using data from 1990 to 2017. They discovered a one-way link between technological progress and environmental damage. To look at even more countries, Sinha, Sengupta, and Alvarado (2020) used data from the same period to do a panel quantile regression study for N10 countries. According to their findings, growth in technology makes air pollution worse when it's already high but better when it's already low or medium.

According to Wang et al. (2020a), the causes that affected carbon emissions in N-11 countries from 1990 to 2017 were as follows: using renewable energy, developing new technologies, and investing in people all decreased carbon emissions. Amin, Aziz, and Liu's (2020) focused on thirteen Asian countries from 1985 to 2019, technology progress greatly lowers CO_2 emissions. According to Shahbaz et al. (2020), who looked at the causes of carbon emissions in the UK using historical data from 1870 to 2017, spending on research and development leads to lower carbon emissions.

Rafique et al. (2020) investigated the influence of FDI, FD and innovation, on CO_2 in the BRICS countries between 1990 and 2017. The researchers discovered an inverse connection between these characteristics and carbon emissions. Khattak et al. (2020) investigated the relationship between innovation, Ren, and CO_2 in the BRICS countries from 1980 to 2016. Their study covered the period from 1980 to 2016. According to their findings, innovation has a significantly positive influence on carbon emissions in all of the BRICS countries, with the exception of Brazil. On the other hand, Khattak et al. (2020) did not investigate the consequences of innovation at the sectoral level, in contrast to the current study.

A study conducted by Afrifaa et al. (2020) investigated the correlation between innovation and CO_2 from 1990 to 2018 using data from twenty-nine developing countries. Their findings demonstrated that innovation input has an adverse effect on carbon emissions. The study conducted by Wang et al. (2020c) examined the effects of ecological innovation, which refers to technological advancements related to the environment, and export diversification on carbon emissions for the G-7 states from 1990 to 2017. According to their findings, ecological innovation decreases CO_2. For 1990-2016, Dauda et al. (2021) analyzed the correlation between innovation and CO_2 African. They discovered an inverted U-shaped phenomenon for variables at the panel level for specific countries.

Meirun et al. (2021) assessed how new green technologies affected CO2 pollution in

Singapore. They found a adverse relationship between new green technologies and CO_2. Wang, Wang, and Qian (2021) looked into the link between innovation and CO_2 using Japan's firm-level statistics. They looked at information from 589 businesses from 2006 to 2014. Their results showed that the expenditure on innovation lowers the energy density.

3.12 Structural Change on Renewable Energy and Carbon Emission

The economic structure of a country has a significant impact on its CO2 emissions. By optimizing economic composition and promoting industries that demonstrate high production efficiency and resource utilization, CO2 emissions can be effectively reduced. Further industrial restructuring and energy structure transformation can further facilitate this decline in carbon emissions. These measures can also increase the likelihood of reaching a peak in CO2 emissions and expedite the process of achieving this peak. The prevailing structural transformation framework suggests that the tertiary sector generates less pollution compared to the secondary sector, consequently improving environmental quality (Grossman & Krueger, 1991). This perspective aligns with the observed shift in economic growth from industry and agriculture towards the service sector. This transition fosters a move away from the environmentally hazardous secondary and primary sectors towards the more ecologically sustainable tertiary sector. Moreover, individuals with low economic income levels tend to migrate to the secondary sector due to higher wages. However, as incomes rise, individuals prioritize environmental quality, leading to a shift towards the service sector (Ali et al., 2020). Similarly, transitioning from an emission-intensive economy to an information-based economy could mitigate environmental degradation in the long run (Panayotou, 1997).

Various methodologies have been employed to evaluate the effectiveness of industrial restructuring in achieving a carbon emissions peak. Among the often-employed methods are simulation models, optimization models, and computable general equilibrium (CGE) models. Through an optimal economic structure alteration executed from 2013 to 2030, Yu et al. (2018) constructed a multi-objective optimization model to study China's ability to sustain an adequate to high GDP increase while attaining its maximum emission level around 2023–2025. Zhang et al. (2016) integrated the China in-global fuel model with a general equilibrium model to perform CO2 simulations. According to their results, carbon emissions may be reduced at the national and industrial levels without affecting GDP growth. A more aggressive approach could make it easier to meet the 2030 peak emissions goal. Zhang et al. (2017) suggested combining scenario analysis with dynamic Monte Carlo simulation as a means of evaluating. Zhang et al. (2017) suggested combining scenario analysis with dynamic Monte Carlo simulation to evaluate how the China Industrial Green Growth Strategy 2016-2020 objectives would affect emission levels in the future. Their findings demonstrate how important industry adjustment is to meeting the 2030 peak emissions target.

3.13 Trade on Renewable Energy and Carbon Emissions

Current projections from global modeling studies indicate a trend contrast to the existing fossil fuel-based system, future alternative power systems will likely move toward less long-distance trading in energy carriers. Scenarios outlining this global transition suggest a reduction in intercontinental trade in energy carriers as renewable energy electricity generation expands (Chen et al., 2023). In essence, highly renewable energy systems are envisioned to be primarily regional. However, this is not an inevitable outcome. On the contrary, intercontinental trade in renewable solar and electric fuels could emerge as a significant option in the coming decades -to this end, several works have been done to test the role trade plays in renewable energy.

Ben Jebli et al. (2016) conducted a groundbreaking study that examined the connections between trade openness, economic development, CO_2 emissions, and the use of renewable and non-renewable energy in 25 OECD nations. A long-term association between energy sources (renewable and non-renewable) and commercial variables (export and import) was shown by the cointegration test findings. But when it came to the relationship between commercial considerations and renewable vs non-renewable energy, the causality test produced no meaningful results.

3.14 Gaps in Literature

According to estimates, investments will need to rise to $500 billion by 2030 in order to meet the CO_2 emission reduction targets set by the Kyoto Protocol (Kyoto Protocol 1997). Additionally, it is estimated that "the amount of funding essential to substitute all the petrol utilized worldwide with alternative fuels is expected to run into dozens of billions of dollars.

The same proponents of renewable energy, especially in Europe, contend that a drastic shift from current practices will be necessary to meet the Kyoto Protocol's emission reduction objectives through the faster implementation of renewable energy technology. It will also call for specific regulations that may encourage renewable energy investments far more successfully by removing obstacles and utilizing all the factors that influence investment decisions. Regretfully, it appears that not all of the variables influencing investment choices in the renewable energy industry have been fully explored in the body of existing literature. We identify two deficiencies in this body of work. First, there is a general dearth of knowledge regarding how non-financial factors influence investment decisions in the sector of renewable energies because research has primarily been framed within the overall canopy of mainstream finance theories. Secondly, most research studies that have examined the factors driving renewable energy investment have only examined them on an aggregated basis. In other words, they haven't given enough thought to how these variables affect investments, particularly technology, or how portfolio diversification is impacted by them. It is worthwhile to fix this gap as well. In light of the significance of diversifying energy portfolios, incentive schemes that direct capital toward a single technology (regardless of its quality) may prove to be ineffective in the long run.

Also, research on renewable energy has devoted a great deal of time to investigating the variables that influence the performance or lack thereof of renewable energy systems, as well as renewable energy investments and adoption hurdles (Lai et al., 2022; Shah et al., 2019). To explain how agents, make decisions amid uncertain possibilities, scholars in this field have generally taken complete rationality as the paradigmatic method. They have also largely concentrated on energy systems' technical and economic characteristics. There have been several proposals for economic barriers to the growth of renewable energy, such as high maintenance and capital expenses (Jacobsson & Johnson, 2000), insufficient expertise with novel energy technologies (Jagadeesh, 2000), and an underestimation of the long-term advantages of environmental expenditures (Acheampong, 2019; Bradshaw & Borchers, 2000). More recently, some academics have pointed out that the explanation of renewable energy dissemination and renewable energy is not limited to a purely rational techno-economic study of energy choices (Adefarati et al., 2023; Ahakwa, Xu, et al., 2023).

In recent times, many academics have observed that the spread and acceptance obstacles of renewable energy sources cannot be fully explained by a purely logical techno-economic examination of energy options. They recommended using a more comprehensive approach and including governance indicators, particularly in a geopolitical context. This viewpoint suggests focusing on how institutional policies affect interests rather than merely looking at interest variables.

The examination of renewable energy investments, consumption, and development has not yet been done using green governance despite the growing respect it is gaining in several disciplines. Therefore, it is necessary to assess the efficacy of renewable energy policies under governance and provide insight into how financial sector participants view policy instruments as influencing their decisions. While the technological advancements and cost-effectiveness of renewable energy sources have undoubtedly contributed to their growing popularity, a purely techno-economic analysis fails to fully capture the complex factors that influence their widespread adoption. In recent years, a growing body of academic research has highlighted the need for a more comprehensive approach that goes beyond techno-economic considerations and encompasses the broader context of governance, geopolitics, and social dynamics.

Governance, encompassing the political, legal, and regulatory frameworks that shape energy markets, plays a critical role in determining the pace and success of renewable energy deployment. Strong governance policies, such as supportive subsidies, tax incentives, renewable portfolio standards, and streamlined permitting processes, can create a conducive environment for renewable energy investments and facilitate the transition to a renewable energy future. Conversely, weak governance characterized by complex regulatory hurdles, inadequate financial support, and political barriers can hinder the adoption of renewable energy, favoring fossil fuel reliance.

Geopolitical considerations also significantly impact renewable energy adoption. Regions with strong geopolitical tensions and conflicts may prioritize energy security over renewable energy sources, fearing the potential disruption of energy supplies. Additionally, geopolitical alliances and trade agreements can influence the availability, affordability, and transfer of renewable energy technologies.

To address these broader barriers and accelerate the transition to a renewable energy future, a more holistic approach is required. This approach should encompass the following key elements:

Strengthened governance frameworks: Governments should implement robust policies that provide clear incentives, streamline permitting processes, and foster innovation in renewable energy technologies.

Addressing geopolitical concerns: Energy policies should consider geopolitical realities and seek to diversify energy sources while minimizing reliance on volatile energy markets.

Enhancing stakeholder engagement: Effective energy policies should involve a broad range of stakeholders, including government agencies, industry players, civil society organizations, and communities, to ensure buy-in and collaboration.

Addressing social and cultural factors: Renewable energy projects may face social opposition due to concerns about visual impacts, noise pollution, or potential environmental harm. Addressing these concerns through comprehensive environmental impact assessments and community engagement is crucial.

Promoting public awareness and education: Raising public awareness about the benefits of renewable energy and dispelling misconceptions can foster public support and encourage individuals to adopt renewable energy technologies in their homes and businesses.

Chapter 4

DATA AND METHODOLOGY

4.1 Conceptual Framework

At COP26, developed nations fell short of meeting their annual commitment of $100 billion to aid developing countries. The Glasgow Agreement reaffirmed this commitment while expressing regret and urging affluent nations to promptly fulfill this financial target. Developed countries voiced their confidence in achieving this objective by the year 2023. Mark Carney, serving as the UN Special Envoy for Climate Action and Finance, described this juncture as a "watershed" moment. He contended that, before this milestone, the global financial resources were inadequate to underwrite the transition towards a net-zero economy. Carney, however, now asserts the existence of an ample financial reserve, amounting to $130 trillion, to support this endeavor. He additionally affirmed that a portion of this wealth will be allocated to benefit emerging and developing economies.

The forthcoming study empirically investigates events preceding and following COP26 to assess the influence of climate finance is theoretically embedded in the turn of events of the financial sector theme financial development. As such qualitative research study was undertaken to assess the current state of progress in the attainment of Sustainable Development Goals (SDGs), with particular emphasis on SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action), within the Gulf Cooperation Council (GCC) countries. This investigation places significant emphasis on the multifaceted role of financial development, as delineated by the International Monetary Fund (IMF), while simultaneously acknowledging the crucial influence of principles of good governance and structural transformations within the economic landscape.

Financial development emerges as a pivotal factor that significantly influences the feasibility of SDGs attainment. The palpable potential of financial development has galvanized influential institutions, including the United Nations Capital Development Fund and the Alliance for Financial Inclusion, to advocate for its expeditious adoption in developing countries. Their proactive engagement underscores the urgency and significance attributed to financial development as an instrument of advancing the SDGs. However, the discourse remains inherently complex, characterized by ongoing scholarly investigation and a requirement for empirical validation regarding the outcomes of projects aligned with these agendas.

This research also highlights the Gulf nations' failure to raise the necessary funds to renew their economic strategy in response to climate change (Sadiq et al., 2022).

4.2 Theoretical Basis and Hypothesis

The STIRPAT framework, in contrast to the IPAT model, offers a more rigorous and comprehensive approach to analyzing the interplay of four primary drivers of environmental impact:

Population (P): The demographic count within a specified geographic area.

Affluence (A): The average economic well-being or income level within a specified geographic area.

Technology (T): The level of technological advancement within a specified geographic area.

Policy (P): Government regulations and measures influencing environmental impact.

The STIRPAT framework is mathematically represented as follows:

$$I = P^a * A^b * T^c * P^d$$

Where:

I represent the environmental impact, specifically focusing on renewable energy consumption.

P stands for the population.

A represents affluence.

T denotes technology.

P symbolizes policy.

a, b, c, and d denote the elasticities, measuring the sensitivity of environmental impact concerning population, affluence, technology, and policy, respectively.

The STIRPAT framework serves as a potent analytical tool for assessing the repercussions of human activities on the environment. Its application extends to diverse environmental issues, encompassing climate change, air pollution, and water pollution. Illustrated below are instances of how the STIRPAT framework can be utilized to examine renewable energy consumption:

Projection of the influence of population growth on renewable energy consumption: By estimating the elasticity of renewable energy consumption concerning population, researchers can forecast the effects of future population growth on the demand for renewable energy.

Evaluation of the impact of economic growth on renewable energy consumption: The elasticity of renewable energy consumption regarding affluence facilitates the assessment of economic growth's impact on the demand for renewable energy.

Assessment of the effects of technological innovation on renewable energy consumption: The elasticity of renewable energy consumption regarding technology offers a quantifiable measure of the influence of technological advancements on the adoption of renewable energy sources.

Appraisal of the role of government policies in renewable energy consumption: The elasticity of renewable energy consumption concerning policy enables the evaluation of the efficacy of governmental policies in promoting renewable energy utilization.

The STIRPAT framework emerges as an invaluable instrument for policymakers and researchers striving to advance renewable energy adoption and diminish environmental impact.

4.3 Data- Variables of Interests

Four basic models for categorizing the dynamic impacts of financial development, the development of renewable energy, and carbon emissions are provided by this study, which is based on actual data and our major hypotheses. As to the research, the advancement of renewable energy in every country is supported by foreign capital, fiscal policy, and financial development. Similar assertions have also been the subject of several investigations conducted throughout the globe. According to a few studies, nations with substantial financial resources can use their influence to promote the development of renewable energy sources and slow down environmental harm. According to (Usman et al., 2022) data, wealthy governments with abundant financial resources may leverage their wealth to hasten renewable energy, in contrast to underdeveloped nations that lack the necessary financial infrastructure. In nations with little financial means, fossil fuel energy, which is often cheap and easy to harvest, is prevalent, suggesting a negative impact on the environment (Doran et al., 2023; Onifade, 2023). Numerous studies in the literature show that establishing sustainable renewable energy projects with the goal of achieving carbon neutrality targets requires financial development (Tong et al., 2022).

Renewable Energy: Climate experts have issued a dire warning that the window to avert catastrophic climate consequences is rapidly shrinking(Owusu & Asumadu-Sarkodie, 2016). In response, a multitude of solutions have been put forward, but the most prominent and widely supported approach is the shift to a low-carbon economy powered by renewable energy sources (IRENA, 2017). As such, renewable energy will be studied as a dependent variable. This data was acquired from the World Development Bank. Studies such as (Ikram et al., 2020) and (Amuakwa-Mensah & Näsström, 2022) used such data to access renewable deployment. . Renewable energy is the most practical alternative for achieving socio-economic and ecological sustainability because energy has a direct correlation with three levels of sustainable development. Minimizing the negative effects of urbanization and guiding its course in a desirable manner is crucial through the utilization of contemporary technology and recording methods. Implementing and documenting urbanization policies can serve as an effective approach to reducing overall energy use and transitioning towards renewable energy sources.

Carbon Emission: To effectively tackle the pressing questions surrounding the path towards a sustainable future with minimized CO_2 emissions, including selecting appropriate measures and quantifying required emission reductions, analyzing and thoroughly understanding the historical relationship between economic development and CO_2 emissions is crucial (Li et al., 2022).

Urbanization: Cities are hubs of human economic and social activity, encompassing approximately 2% of the Earth's surface yet generating around 70% of global GDP, consuming over 60% of energy, and producing a staggering 75% of the world's carbon dioxide emissions (Wang et al., 2020; Xu et al., 2018). Furthermore, it is necessary to focus on improving the quality of regulations and bureaucracy, enhancing control over corruption, and establishing a more democratic system. Nevertheless, in nations with ineffective institutions, it is imperative for governments to actively encourage enhanced collaborations with other global regions to facilitate the advancement of research and the transfer of technology. To achieve economies of scale that attract private sector investments, the GCC area should focus on promoting regionally integrated markets for renewable energy technology.

Real GDP Per Capita: The ramifications of financial development are contingent on the GDP per capita level. Given the pronounced cost differentials between investments in renewable and non-renewable energy sources, the capital-intensive nature of the renewable energy sector underscores a potential reliance on the stability and resilience of the financial system (Awan & Azam, 2022; Rodríguez-Caballero, 2022).

Technology: Policies fostering the development and widespread adoption of low-carbon technologies are at the forefront of global endeavors to mitigate the effects of climate change. Achieving the substantial emissions reductions deemed necessary by most climate models hinges on the widespread deployment of low-carbon technologies. These include energy-efficient appliances, solar and wind energy for power generation, smart grids, advanced transmission networks, and carbon capture and storage.

Trade: Trade has played a central role in driving economic prosperity, but its impact on carbon emissions and the potential of renewable energy sources are complex and multifaceted. The diverse effects of trade activities on the environment continue to be an active research and discussion area. Much attention has been focused on evaluating the environmental repercussions of economic activities driven by trade-related policies. Certain studies have approached the trade-renewable energy nexus indirectly, presuming that a decrease in CO_2 emissions directly translates to the influence of trade on renewable energy consumption.

Service: Nations are increasingly embracing the structural change approach as a viable pathway to tackle environmental pollution and reduce the surge in greenhouse gas (GHG) emissions. This strategy advocates for a transition from manufacturing carbon-intensive sectors, towards less polluting industries, particularly the service sector. Studies have shown that service-led structural change holds promise as an effective solution to mitigate GHG emissions.

Governance: Nations embracing clean energy development as a pillar of their economic strategies demonstrate a commitment to aligning with international energy standards, highlighting the profound influence of governance on policy decisions. A wealth of research has explored the multifaceted role of government and institutions in shaping economic growth. Acemoglu et al. (2003) compellingly argue that weak institutions hinder economic growth by nurturing corruption, political instability, and stifling investments. Easterly and Levine (2003) concur that weak institutions impede economic growth, while Baumol (1990) contends that institutions shape entrepreneurial endeavors, determining their productivity or corruptibility. Chang (2011), however, contests the prevailing notion that institutions exert a direct and substantial positive impact on growth.

4.4 Detailed Model Specification

To have a wholesome assessment of the hypothesis, different models were assessed, paying attention to SDG 7 and SDG 13. Thus, Inspired by previous research (Ang, 2008; M. K. Khan et al., 2022; Qin et al., 2021), a multivariate regression model was employed to investigate the influence of various financial development features and governance quality indicators alongside other control variables, on Renewable energy and CO_2 emissions from 2000 to 2022.

Guided by the aforementioned considerations, Models were formulated. Using these indexes:

Model: $\mathrm{Dep}_{it} = \beta_0 + \beta_1 \mathrm{indep} + \mu \mathrm{Controls}_{it} + \gamma_i + \sigma_{it} + \varepsilon_{it}$ (1)

The first formula is a fixed-effect model, which is a type of panel data model that controls for time-invariant differences between the units of analysis. In this case, the time-invariant differences are captured by the vector of year dummies (Y). The vector of independent variables (indep) includes the factors that the researcher believes are relevant to explaining the dependent variable (Dep), such as GDP per capita, mobile phone penetration rates, trade openness, and the service sector share of GDP. The vector of control variables (controls) includes additional factors that may affect the dependent variable but are not of primary interest to the researcher, such as the regional financial development features and urban city indicators.

4.4.1 Renewable Energy Model.

The amin hypothesis uses panel quantile regression which is represented as:

Model 1: $QRen_{it}\left(\frac{\tau}{X_{it}}\right) = \beta_i^{(\tau)} + \beta_1^{(\tau)}RFD_{it} + \beta_2^{(\tau)}URBAN_{it} + \beta_3^{(\tau)}GDP_{it} +$

$$\beta_4^{(\tau)}Mobile_{it} + \beta_5^{(\tau)}trade_{it} + \beta_6^{(\tau)}service_{it} + \varepsilon_{it} \quad (2)$$

Model 1 is a panel data regression model that estimates the relationship between renewable energy consumption and a set of explanatory variables: regional financial development features, urbanicity indicators, real GDP per capita, mobile phone penetration rates, trade openness measures, and service sector shares in GDP. The model is estimated separately for each time period using panel data that includes observations for multiple units of analysis over time. The model aims to identify the factors contributing to adopting renewable energy technologies.

A more detailed explanation of the equation: QRen_it: This is the dependent variable, which represents the renewable energy consumption for unit i at time τ.β_i^(τ): This is the intercept term for unit i at time τ.β_1^(τ) RFD_it: This is the coefficient on the variable RFD_it, which represents the regional financial development features for unit i at time τ. A positive coefficient would indicate that an increase in regional financial development is associated with an increase in renewable energy consumption. β_2^(τ) URBAN_it: This is the coefficient on the variable URBAN_it, which represents the urbanicity indicators for unit i at time τ. A positive coefficient would indicate that an increase in urbanicity is associated with an increase in renewable energy consumption. β_3^(τ) GDP_it: This is the coefficient on the variable GDP_it, which represents the real GDP per capita for unit i at time τ. A positive coefficient would indicate that an increase in GDP is associated with an increase in renewable energy consumption. β_4^(τ) Mobile_it: This is the coefficient on the variable Mobile_it, which represents the mobile phone penetration rates for unit i at time τ. A positive coefficient would indicate that an increase in mobile phone penetration is associated with an increase in renewable energy consumption. β_5^(τ) trade_it: This is the coefficient on the variable trade_it, which represents the trade openness measures for unit i at time τ. A positive coefficient would indicate that an increase in trade openness is associated with an increase in renewable energy consumption. β_6^(τ) service_it: This is the coefficient on the variable service_it, which represents the service sector shares in GDP for unit i at time τ. A positive coefficient would indicate that an increase in the service sector share is associated with an increase in renewable energy consumption. ε_it: This is the error term for unit i at time τ. It represents the factors that are not included in the model that affect renewable energy consumption for that unit and time period.

4.4.2 Carbon Neutrality Model

Model 2: $QC02_{it}(\tau/X_{it}) = \beta_i^{(\tau)} + \beta_1^{(\tau)}RFD_{it} + \beta_2^{(\tau)}URBAN_{it} + \beta_3^{(\tau)}GDP_{it} +$

$$\beta_4^{(\tau)}Mobile_{it} + \beta_5^{(\tau)}trade_{it} + \beta_6^{(\tau)}service_{it} + \varepsilon_{it} \quad (3)$$

4.5 Cross-sectional dependency Test Equation

$$LM = \sum_{i=1}^{N-1}\sum_{j=i+1}^{N} T_{ij}\hat{p}_{ij}^2 \rightarrow \chi^2 \frac{N(N-1)}{2} \quad (4)$$

$$LM_s = \sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T_{ij}\hat{p}_{ij}^2 - 1) \rightarrow N(0,1) \quad (5)$$

$$CD_p = \sqrt{\frac{2}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N} T_{ij}\,\hat{p}_{ij} \rightarrow N(0,1) \quad (6)$$

$$LM_{BC} = \sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T_{ij}\hat{p}_{ij}^2 - 1) - \frac{N}{2(T-1)} \rightarrow N(0,1) \quad (7)$$

Unit root test:

$$\widehat{CIPS} = \frac{1}{N}\sum_{i=1}^{n} CADF_i \quad (8)$$

Slope Homogeneity Test:

$$\tilde{\Delta}_{SH} = (N)^{\frac{1}{2}}(2k)^{-\frac{1}{2}}\left(\frac{1}{N}\tilde{S} - k\right) \tag{9}$$

$$\tilde{\Delta}_{ASH} = (N)^{\frac{1}{2}}\left(\frac{2k(T-k-1}{T+1}\right)^{-\frac{1}{2}}\left(\frac{1}{N}\tilde{S} - 2k\right) \tag{10}$$

4.6 Variance Decomposition Analysis

Lastly, a variety of methods-based decomposition analysis is used. The applied economics literature uses the Granger causality approach to capture the casual association but does not investigate the relative degree of causal linkage (Shahbaz, 2012). However, using an innovative accounting approach (IAA), the forecast error variance decomposition method (FEVDM) and the impulse response function (IRF) are sophisticated techniques to verify the causal relationship between the variables. Moreover, IAA offers a suitable technique to interpret the predicted linear and non-linear models (Alves & Moutinho, 2013).

Since it generates both the causality direction and link magnitude at various time intervals, the previously indicated technique has been applied (Hassan et al., 2011). Additionally, the FEVDM breaks down each vector's variance into endogenous and exogenous components using the IRF technique, and the VAR method presents the endogenous variable's response. The Granger causality test has a cap on how many exogenous variables may be calculated. The Granger causality approach and IAA do not share the same exogeneity issue since IAA displays the contemporaneous error term of a component and the current value of the endogenous factor (Cloyne, 2013).

Chapter 5

EMPIRICAL RESULTS AND DISCUSSION

5.1 Preliminary Statistic

The data provides a snapshot of the economic, social, and political conditions of the Gulf countries. The variables included in the data set capture various aspects of these countries' development. A closer examination of the data reveals some interesting patterns. For instance, the Gulf countries exhibit a relatively low mean for renewable energy use (lnren), indicating a need for increased investment in clean energy sources. Additionally, the carbon dioxide emissions (lnco2) are relatively low compared to the global average, suggesting that the Gulf countries are taking steps to mitigate climate change.

Financial development index (lnfdi) is relatively high in the Gulf countries, reflecting their attractive investment climate. Urbanization (lnurban) is also high, driven by factors such as economic growth and job opportunities. The gross domestic product (lngdp) of the Gulf countries is relatively high, demonstrating their economic prosperity. Mobile phone subscriptions (lnmobile) are also high, indicating the widespread adoption of mobile technology in the region.

Trade openness (lntrade) is relatively high in the Gulf countries, reflecting their engagement in global trade. The services sector value added (lnser) is also high, indicating the importance of the services sector in the Gulf economies. Government expenditure (lnge) is relatively high in the Gulf countries, reflecting their commitment to public services and infrastructure development.

Regulatory quality (lnrq) is relatively low in the Gulf countries, suggesting a need for improvement in regulatory frameworks. Voice and accountability (lnvoaa) are also relatively low, indicating limited opportunities for citizens to participate in political decision-making. Political stability (lnps) is relatively high in the Gulf countries, providing a conducive environment for economic growth and development.

Control of corruption (lncc) is relatively low in the Gulf countries, suggesting a need for strengthening anti-corruption measures. Rule of law (lnrul) is also relatively low, indicating a need for improving the legal framework and its enforcement.

Overall, the data provides a valuable resource for understanding the economic, social, and political conditions of the Gulf countries. The insights gained from this data can be used to inform policy decisions and promote sustainable development in the region.

Table 1: Description of Data

Variables	Obs	Mean	Std. Dev.	Min	Max	Skew.	Kurt.
lnren	85	-3.163	1.074	-4.605	-0.083	0.103	2.676
lnco2	138	-0.322	0.234	-0.828	0.061	-0.492	2.25
lnfdi	138	-0.852	0.177	-1.33	-0.535	-0.609	3.009
lnurban	138	15.048	1.085	13.341	17.249	0.568	2.455
lngdp	138	10.306	0.46	9.653	11.205	0.499	1.788
lnmobile	138	4.617	0.705	1.854	5.4	-1.687	5.787
lntrade	138	4.639	0.273	3.906	5.257	0.176	2.874
lnser	138	3.819	0.159	3.349	4.235	-0.548	3.515
lnge	115	-0.908	0.857	-4.224	0.409	-1.232	5.49
lnrq	123	-0.936	0.873	-4.071	0.101	-1.666	5.557
lnvoaa	138	0.647	0.213	0.089	0.994	-0.85	3.195
lnps	100	-0.665	0.9	-6.022	0.202	-2.977	16.179
lncc	112	-0.781	0.765	-3.298	0.444	-0.791	3.463
lnrul	134	-0.967	0.815	-4.486	-0.004	-2.211	8.539

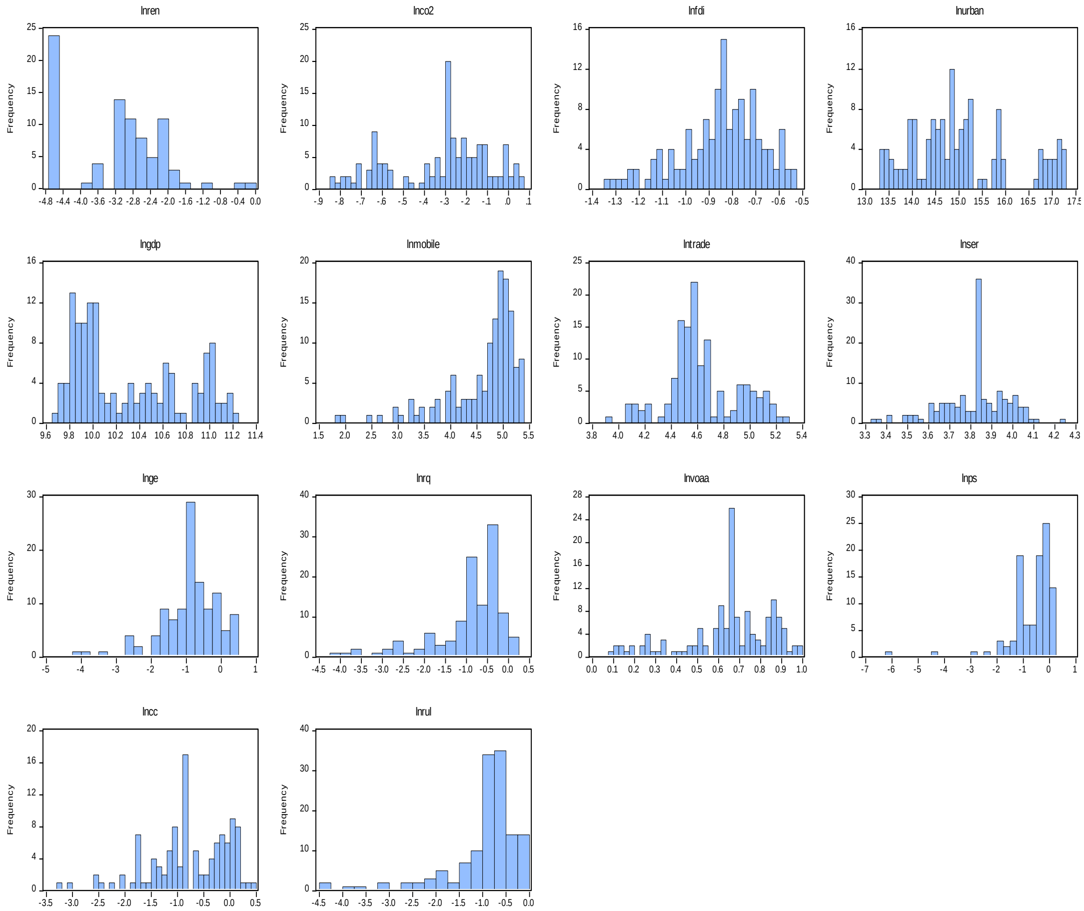

Figure 11: Graph of Data

5.2 Pairwise Correlations

The pairwise correlations among the variables unveil valuable insights into the intricate relationships within the analysis. Notably, there is a robust negative correlation (-0.673*) between renewable energy (lnren) and carbon dioxide emissions (lnco2), suggesting that an increase in renewable energy is associated with a reduction in carbon emissions. Financial development (lnfdi) exhibits positive correlations with various factors, including government expenditure (lnge), GDP growth (lngdp), mobile phone subscriptions (lnmobile), and trade openness (lntrade), indicating potential associations between financial development and these variables. Urbanization (lnurban) demonstrates negative correlations with carbon emissions (-0.223*) and economic indicators such as GDP (-0.628*) and trade openness (-0.037*).

Economic factors, including GDP (lngdp) and trade openness (lntrade), exhibit positive correlations with renewable energy, suggesting that economic growth and open trade may contribute to increase in renewable energy adoption. Additionally, governance indicators, such as government effectiveness (lnge) and control of corruption (lncc), show positive correlations with financial development, emphasizing the complex interplay between economic, urban, and governance factors in influencing the observed relationships. These correlation insights provide a foundation for further exploration and in-depth analysis of the specific dynamics shaping the outcomes of the study.

For specific-lnren (Renewable Energy) and lnco2 (Carbon Dioxide Emissions): There is a strong negative correlation (-0.673*) between lnren and lnco2, suggesting that an increase in renewable energy is associated with lower carbon dioxide emissions. lnfdi (Financial Development) and Other Variables: lnfdi shows positive correlations with lngdp (0.386*), lnmobile (0.383*), lntrade (0.117), lnser (0.058), lnge (0.291*), lnps (0.151), lncc (0.235*), and lnrul (0.032). These correlations indicate potential associations between financial development and these factors.

Urbanization (lnurban) and Other Variables: lnurban exhibits negative correlations with lnco2 (-0.223*), lngdp (-0.297*), lntrade (-0.445*), and lncc (-0.104). This suggests that higher urbanization is linked to lower carbon emissions and trade openness but may be associated with reduced economic output and control of corruption.

Economic Factors (lngdp, lntrade, lnser) and lnco2: lngdp displays a negative correlation with lnco2 (-0.628*), implying that economic growth may contribute to deduction in carbon emissions. lntrade shows a negative correlation with lnco2 (-0.037), suggesting that more open trade is associated with lower carbon emissions. lnser exhibits a positive correlation with lnco2 (0.175*), indicating that a higher value added in the services sector may contribute to increased carbon emissions. Governance Indicators (lnge, lnrq, lnvoaa, lnps, lncc, lnrul) and Other Variables: lnge demonstrates positive correlations with lnfdi (0.291*), suggesting potential links between government effectiveness and financial development. lncc shows positive correlations with lnfdi (0.235*) and lnrq (0.437*), indicating associations with financial development and regulatory quality.

Table 2: Pairwise Correlations

Variables	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13
(1) lnren	1												
(2) lnco2	-0.673*	1											
	0												
(3) lnfdi	0.215*	-0.056	1										
	-0.048	-0.516											
(4) lnurban	-0.455*	-0.223*	-0.01	1									
	0	-0.009	-0.908										
(5) lngdp	0.662*	-0.628*	0.386*	-0.297*	1								
	0	0	0	0									
(6) lnmobile	0.214*	-0.01	0.383*	0.188*	0.119	1							
	-0.049	-0.907	0	-0.027	-0.165								
(7) lntrade	0.664*	-0.037	0.117	-0.445*	0.136	0.319*	1						
	0	-0.666	-0.172	0	-0.113	0							
(8) lnser	0.289*	0.175*	0.058	-0.187*	-0.014	0.182*	0.271*	1					
	-0.007	-0.04	-0.5	-0.028	-0.869	-0.032	-0.001						
(9) lnge	0.621*	-0.514*	0.291*	-0.078	0.460*	0.093	0.421*	0.04	1				
	0	0	-0.002	-0.409	0	-0.324	0	-0.674					
(10) lnrq	0.700*	-0.228*	-0.015	-0.451*	0.318*	0.107	0.495*	0.254*	0.649*	1			
	0	-0.011	-0.868	0	0	-0.241	0	-0.005	0				
(11) lnvoaa	0.549*	-0.102	-0.092	-0.633*	0.413*	-0.184*	0.250*	0.167	0.036	0.329*	1		
	0	-0.232	-0.281	0	0	-0.031	-0.003	-0.051	-0.702	0			
(12) lnps	0.396*	-0.431*	0.151	-0.175	0.416*	0.162	0.133	-0.079	0.350*	0.292*	0.161	1	
	-0.001	0	-0.135	-0.082	0	-0.107	-0.187	-0.436	-0.001	-0.005	-0.11		
(13) lncc	0.650*	-0.618*	0.235*	-0.104	0.628*	-0.035	0.216*	-0.079	0.582*	0.437*	0.369*	0.382*	1
	0	0	-0.013	-0.273	0	-0.711	-0.022	-0.405	0	0	0	0	
(14) lnrul	0.670*	-0.248*	0.032	-0.508*	0.470*	-0.033	0.293*	0.175*	0.450*	0.692*	0.461*	0.408*	0.544*
	0	-0.004	-0.713	0	0	-0.708	-0.001	-0.043	0	0	0	0	0

5.3 Cross Sectional Dependence

The analysis reveals evidence of cross-sectional dependence, indicating interdependence among the variables in the study. The Breusch-Pagan LM test, the Pesaran scaled LM test, and the bias-corrected scaled LM test all consistently demonstrate statistically significant results across various variables. For instance, in the case of renewable energy (lnren), the Breusch-Pagan LM test yields a significant result of 117.0346***, indicating the presence of cross-sectional dependence. This is further supported by the Pesaran scaled LM test and the bias-corrected scaled LM test, both reporting statistically significant values of 18.628*** and 18.492***, respectively.

Similar patterns emerge for carbon dioxide emissions (lnco2), financial development (lnfdi), urbanization (lnurban), GDP growth (lngdp), mobile phone subscriptions (lnmobile), trade openness (lntrade), services sector value added (lnser), government effectiveness (lnge), regulatory quality (lnrq), voice and accountability (lnvoaa), political stability (lnps), control of corruption (lncc), and rule of law (lnrul). Across these variables, all three tests consistently reveal statistically significant results, suggesting a robust presence of cross-sectional dependence.

Table 3: Cross-Sectional Dependence

Variable	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
lnren	117.0346***	18.628***	18.492***	6.395***
lnco2	58.846***	8.005***	7.868***	-2.134***
lnfdi	72.758***	10.545***	10.408***	4.189***
lnurban	320.352***	55.749***	55.613***	17.887***
lngdp	94.935***	14.594***	14.457***	-1.724***
lnmobile	293.458***	50.839***	50.702***	17.098***
lntrade	42.293***	4.983***	4.846***	4.0130***
lnser	163.979***	27.199***	27.063***	12.120***
lnge	54.820***	7.270***	7.133***	-0.934***
lnrq	30.815***	2.887***	2.751***	-0.391***
lnvoaa	124.297***	19.954***	19.818***	8.991***
Lnps	43.897***	5.275***	5.139***	1.752***
Lncc	58.512***	7.944***	7.807***	-0.477***
Lnrul	29.543***	2.655***	2.518***	-0.259***

Overall, the results suggest that most of the variables in the model are stationary. However, there are a few variables that are not stationary, including lnco2, lnrq, and lnps. These variables may need to be transformed before they can be included in a regression model-assisting in the formulation of robust panel data models.

Table 4: Panel Unit Root Test

Variable	**CIPS (0)**	**CIPS (1)**	**CADF (0)**	**CADF (1)**
Lnren	−1.373	−3.038***	0.867	−4.739***
lnco2	−2.946***	−5.275***	−5.634***	−9.648***
Lnfdi	−1.895	−4.357***	−4.642*	−4.642***
Lnurban	−3.038***	−4.357***	−1.350*	−9.609***
Lngdp	−1.382	−4.357***	1.949	−5.841***
lnmobile	−1.370	−4.775***	2.563	−7.617***
Lntrade	−1.433	−3.229 ***	1.329	−7.098***
Lnser	−0.949	−3.038***	1.933	−4.486***
Lnge	−1.862	−3.699 ***	−0.515	−4.192***
Lnrq	−2.214**	−5.018***	−0.837	−7.829***
Lnvoaa	−0.584	−4.057***	5.133	−4.640***
Lnps	−1.703	−3.815***	−0.515	−5.649***
Lncc	−2.428***	−4.691***	−0.506	−4.642***
Lnrul	−2.428***	−4.691***	−0.506	−5.841***

5.4 Cointegration Test-Renewable Energy

The unrestricted cointegration rank tests conducted on the dataset, particularly focusing on renewable energy (lnren) and other variables, reveal significant and robust evidence of long-term relationships among the considered variables. Cointegration implies the existence of stable, equilibrium connections among the variables, suggesting that they move together in the long run.

The trace test and maximum eigenvalue test both consistently reject the null hypothesis of no cointegration across various specifications. The high Fisher statistics and low p-values associated with each test indicate a strong rejection of the idea that there is no cointegration. This implies that at least one cointegrating relationship exists among the variables, suggesting a shared, long-term connection.

The rejection of the null hypothesis for each tested scenario, including cases with up to six cointegrating relationships, underscores the robustness of the findings. The consistently low p-values and high Fisher statistics across different specifications reinforce the conclusion that the variables, including renewable energy and others, exhibit stable, long-term associations.

In practical terms, this implies that changes in the renewable energy variable are not merely temporary fluctuations but are part of a more persistent and enduring relationship with the other variables in the dataset. Understanding these long-term linkages is crucial for policymakers and researchers in developing strategies and models that account for the sustained interactions and dynamics among these important economic and environmental indicators.

Table 5: Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue) – Renewable Energy

Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
None	21.19	0.002	21.19	0.002
At most 1	174.7	0.000	73.41	0.000
At most 2	115	0.000	59.85	0.000
At most 3	70	0.000	39.51	0.000
At most 4	37.37	0.000	25.48	0.000
At most 5	19.44	0.004	12.43	0.053
At most 6	18.68	0.005	18.68	0.005

	t-Statistic	Prob.
ADF	-2.582	0.005
Residual variance	0.211	
HAC variance	0.204	

5.5 Cointegration Test-Carbon Emission

The results provide robust evidence that the carbon emissions variable is cointegrated with other variables in the system. This is an important finding, as cointegration implies a long-term relationship among the variables, and changes in one variable may have a lasting impact on the others. Further analysis and interpretation of the specific variables involved would be necessary to understand the nature of this cointegration and its implications for the system under consideration.

Table 6: Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue) – Carbon Emission

Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
None	76.460	0.000	76.460	0.000
At most 1	316.100	0.000	152.300	0.000
At most 2	206.300	0.000	96.950	0.000
At most 3	132.700	0.000	75.810	0.000
At most 4	69.690	0.000	43.190	0.000
At most 5	41.480	0.000	31.420	0.002
At most 6	31.460	0.002	31.460	0.002

	t-Statistic	Prob.
ADF	-1.592	0.056
Residual variance	0.004	
HAC variance	0.004	
Residual variance	0.004	
HAC variance	0.004	

5.6 Bivariate Relationship between Renewable and Variable of Interest

A scatter plot depicting the relationship between "Renewable" and "Infdi" suggests a positive correlation, indicating that increased financial development (Infdi) is associated with higher levels of renewable energy consumption. This positive association is further supported by the estimated regression coefficient of 0.225, indicating that a one-unit increase in Infdi is associated with an approximate 0.22 unit increase in Renewable. This is consistent with the works of (Akar, 2016).

The correlation between "Renewable" and "Inurban" is also positive, suggesting that a higher percentage of the urban population (Inurban) is associated with increased renewable energy consumption. This positive relationship is evident in the scatter plot and is supported by the regression coefficient of 0.18499, indicating that a one-unit increase in Inurban is associated with an approximate 1.85 unit increase in Renewable agreeing to prior results of (Ahakwa, Tackie, et al., 2023).

The scatter plot depicting the relationship between "Renewable" and "Ingdp" (gross domestic product) suggests a positive correlation, indicating that higher GDP is associated with higher levels of renewable energy consumption as indicated by (Amuakwa-Mensah & Näsström, 2022). This positive association is supported by the estimated regression coefficient of 1.2631 (p-value=0.002), indicating that a one-unit increase in Ingdp is associated with an approximate 1.26 unit increase in Renewable.

The relationship between "Renewable" and "Intrade" (trade openness) appears to be positive, suggesting that increased trade openness is associated with higher levels of renewable energy consumption. However, the scatter plot shows a relatively weak correlation, and the estimated regression coefficient of 1.77 indicates that a one-unit increase in Intrade is associated with a relatively small increase of approximately 1.77 units in Renewable. Relationship between Renewable and Intrade. This is similar to works of (Al-Mulali et al., 2015; Razzaq et al., 2022).

The relationship between "Renewable" and "Inser" (household energy expenditure) appears to be positive, suggesting that higher household energy expenditure is associated with higher levels of renewable energy consumption. This positive correlation is supported by the scatter plot and the estimated regression coefficient of 1.6067 (p-value=0.001), indicating that a one-unit increase in Inser is associated with an approximate 1.61 unit increase in Renewable which is inconsistent with works from (Hayford et al., 2023; Sharma et al., 2021).

Overall, the bivariate regression analysis suggests that several factors, including financial development index (Infdi), urbanization (Inurban), gross domestic product (Ingdp), trade openness (Intrade), and household energy expenditure (Inser), are positively correlated with renewable energy consumption. Mobile subscription (Inmobile) appears to have a negative but relatively weak association with renewable energy consumption. These findings provide valuable insights into the determinants of renewable energy adoption and can inform policies aimed at promoting renewable energy use.

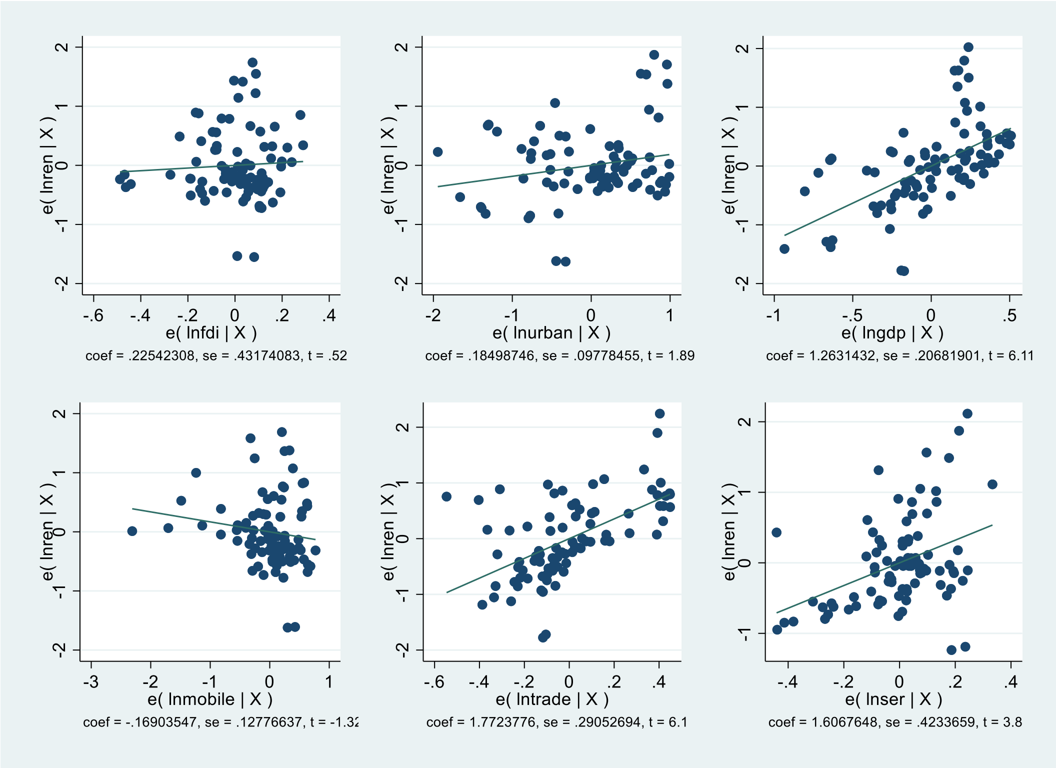

Figure 12: Bivariate Regression between Dependent Variable Renewable and Variables of Interest

5.7 Role of Financial Development on Renewable Energy Deployment – SDG 7

Financial development, as measured by lnfdi, has a positive and statistically insignificant impact on renewable energy deployment across all quantiles except q90. The coefficient on lnfdi is positive at all levels from q30 to q90, ranging from 0.11 in q80 to 0.219 in q60. This suggests that a one-unit increase in lnfdi leads to an increase in renewable energy deployment of between 0.11 and 0.219 units, depending on the quantile, indicating a good financial asset can boost renewable energy developments

(Destek et al., 2023; Habiba et al., 2023; Haldar & Sethi, 2022).

Urbanization, as measured by lnurban, also has a positive and statistically insignificant impact on renewable energy deployment in the upper quantiles (q10, q30, q40, q80 and q90). The coefficient on lnurban is positive and significant at the q20. This suggests that a one-unit increase in lnurban leads to an increase in renewable energy deployment of 0.198 units, depending on the quantile. This shows that population has different effects on renewable energy suggesting results of (Liddle & Lung, 2010; Madlener & Sunak, 2011) are true.

GDP per capita, as measured by lngdp, has a positive and statistically significant impact on renewable energy deployment across all quantiles. The coefficient on lngdp is positive and significant at all levels, ranging from 0.792 in q70 to 1.429 in q10. This suggests that a one-unit increase in lngdp leads to an increase in renewable energy deployment of between 0.792 and 1.429 units, depending on the quantile and leading claims to the role of economic activities has on the environment (Ben Jebli et al., 2016; Rodríguez-Caballero, 2022).

Mobile phone subscriptions per 100 population, as measured by lnmobile, has a negative and statistically significant impact on renewable energy deployment in the upper quantiles (q40, q50, q60, q70, q80, and q90). The coefficient on lnmobile is negative and significant at the 1% level in all of these quantiles, ranging from -0.168 in q50 to -0.354 in q40. This suggests that a one-unit increase in lnmobile leads to a decrease in renewable energy deployment of between 0.168 and 0.354 units, depending on the quantile as stated by priors work (Haldar & Sethi, 2022; Hayford et al., 2023).

Trade openness, as measured by lntrade, has a positive and statistically significant impact on renewable energy deployment across all quantiles implaying good trade policies helps boost renewable energy investments.(Shahbaz et al., 2013; Yazdi & Mastorakis, 2014). The coefficient on lntrade is positive and effective at all levels, ranging from 1.456 in q80 to 2.176 in q30. This suggests that a one-unit increase in lntrade leads to an increase in renewable energy deployment of between 1.456 and 2.176 units, depending on the quantile suggesting confirmation of works by (Zheng et al., 2022).

Services sector value added, as measured by lnser, has a positive and statistically significant impact on renewable energy deployment across all quantiles. The coefficient on lnser is positive and significant at all levels, ranging from 0.911 in q10 to 2.968 in q90. This suggests that a one-unit increase in lnser leads to an increase in renewable energy deployment of between 0.911 and 2.968 units, depending on the quantile.

Overall, the findings suggest that financial development, urbanization, GDP per capita, trade openness, and services sector value added all have a positive impact on renewable energy deployment, while mobile phone subscriptions per 100 population have a negative impact on renewable energy deployment. The constant term has a negative relationship with renewable energy deployment.

Table 7: Role of Financial Development on Renewable Energy Deployment – SDG 7

VARIABLES	(1) q10	(2) q20	(3) q30	(4) q40	(5) q50
Lnfdi	-0.337	-0.151	0.222	0.353	0.192
	(-1.029)	(-0.480)	(0.891)	(1.394)	(0.854)
lnurban	0.267	0.198*	0.217	0.208	-0.0729
	(1.253)	(1.737)	(1.399)	(1.194)	(-0.474)
lngdp	1.429***	1.281***	1.361***	1.418***	0.856**
	(3.310)	(6.468)	(5.025)	(3.878)	(2.415)
lnmobile	-0.161	-0.205	-0.285**	-0.354***	-0.168
	(-1.031)	(-1.575)	(-2.240)	(-2.942)	(-1.413)
lntrade	1.839***	2.092***	2.176***	2.110***	2.132***
	(5.362)	(7.972)	(8.947)	(15.34)	(15.89)
lnser	0.911**	1.026***	1.374***	1.345***	1.518**
	(1.992)	(2.924)	(3.009)	(3.271)	(2.565)
Constant	-34.15***	-32.68***	-34.71***	-34.26***	-25.64***
	(-5.059)	(-8.637)	(-6.540)	(-5.819)	(-5.072)
Obs	85	85	85	85	85

t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0

Table 8: Role of Financial Development on Renewable Energy Deployment – SDG 7

VARIABLES	(6) q60	(7) q70	(8) q80	(9) q90
lnfdi	0.219	0.400	1.110	1.769**
	(0.690)	(0.760)	(1.574)	(2.434)
lnurban	-0.0829	-0.0589	0.173	0.302
	(-0.471)	(-0.274)	(0.673)	(1.269)
lngdp	0.825**	0.792**	1.091***	0.971***
	(2.166)	(2.105)	(2.980)	(2.850)
lnmobile	-0.104	-0.0499	0.0291	-0.168
	(-0.890)	(-0.625)	(0.220)	(-0.840)
lntrade	1.955***	1.924***	1.456**	1.294*
	(6.641)	(4.050)	(2.294)	(1.665)
lnser	1.799***	2.064***	2.947***	2.968***
	(3.157)	(2.775)	(3.153)	(3.014)
Constant	-25.63***	-26.51***	-33.95***	-32.25***
	(-4.052)	(-3.253)	(-3.730)	(-3.716)
Obs	85	85	85	85

t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0

5.8 Economic Governance on Renewable Energy

The regression results provide insights into the relationships between renewable energy (lnren) and various variables. Financial development, represented by lnfdi, demonstrates a positive and statistically significant association with lnren, with coefficients of 1.036** for the linear term, 0.464 for the quadratic term, and 0.601** for the cubic term. These results suggest that increased financial development may contribute to higher levels of renewable energy adoption.

Urbanization, measured by lnurban, does not exhibit a statistically significant relationship with lnren. The coefficients for lnurban are 0.294 for the linear term, 0.195 for the quadratic term, and 0.171 for the cubic term. These findings imply that urban population levels may not be robustly associated with renewable energy usage.

Gross domestic product (lngdp) shows a positive and statistically significant correlation with lnren, with coefficients of 1.025** for the linear term, 1.031** for the quadratic term, and 0.866*** for the cubic term. This indicates that economic growth is linked to increased adoption of renewable energy.

Mobile phone subscriptions (lnmobile) exhibit a negative relationship with lnren, with coefficients of -0.297* for the linear term, -0.220** for the quadratic term, and -0.151* for the cubic term. This suggests that higher mobile phone subscriptions may be associated with lower levels of renewable energy usage.

Trade openness (lntrade) demonstrates a positive and statistically significant relationship with lnren, with coefficients of 1.527*** for the linear term, 1.683*** for the quadratic term, and 1.397*** for the cubic term. These findings imply that countries engaged in more open trade may experience higher levels of renewable energy adoption.

The services sector value added (lnser) shows a positive relationship with lnren, with coefficients of 1.464* for the linear term, 1.521* for the quadratic term, and 1.715** for the cubic term. This suggests that a higher value added in the services sector is associated with increased adoption of renewable energy.

Government effectiveness (lnge) does not exhibit a statistically significant relationship with lnren in this model. The coefficient for lnge is -0.230, indicating a lack of robust association.

Regulatory quality (lnrq) shows a positive and statistically significant correlation with lnren, with coefficients of 0.472*** for the linear term and 0.269** for the quadratic term. This implies that higher regulatory quality may contribute to increased adoption of renewable energy.

Overall, these findings highlight the complex interplay of economic, urban, and governance factors in influencing renewable energy adoption. Further research and consideration of additional factors are crucial for a comprehensive understanding of these relationships.

5.9 Institutional Quality on Renewable Energy

The regression results provide insights into the relationships between renewable energy (lnren) and various economic, urban, and governance factors. Financial development (lnfdi) exhibits a positive and statistically significant association with lnren, with coefficients of 0.302 for the linear term and 0.544** for the quadratic term. These results suggest that increased financial development may contribute to higher levels of renewable energy adoption.

Urbanization, represented by lnurban, also shows a positive relationship with lnren, with coefficients of 0.220* for the linear term and 0.120 for the quadratic term. This implies that higher levels of urbanization may be associated with increased adoption of renewable energy.

Gross domestic product (lngdp) demonstrates a strong positive correlation with lnren, with coefficients of 1.242*** for the linear term and 0.921** for the quadratic term. This indicates that economic growth is linked to higher levels of renewable energy adoption.

Mobile phone subscriptions (lnmobile) do not exhibit a statistically significant relationship with lnren in this model. The coefficients for lnmobile are -0.165 for the linear term and -0.0953 for the quadratic term, suggesting a lack of robust association.Trade openness (lntrade) shows a positive and statistically significant relationship with lnren, with coefficients of 1.719*** for the linear term and 2.004*** for the quadratic term. These findings imply that countries engaged in more open trade may experience higher levels of renewable energy adoption.

The services sector value added (lnser) exhibits a positive relationship with lnren, with coefficients of 1.517* for the linear term and 1.340** for the quadratic term. This suggests that a higher value added in the services sector is associated with increased adoption of renewable energy.

Government effectiveness (lnge) and regulatory quality (lnrq) do not appear to have statistically significant associations with lnren in this model. The coefficients for lnge are 0.299, and for lnrq, it is -0.0153, indicating a lack of robust relationship.

5.10 Political Governance on Renewable Energy

The regression results highlight the relationships between various factors and renewable energy adoption (lnren), with a particular focus on governance indicators.

Control of corruption (lncc) exhibits a positive relationship with lnren, with a coefficient of 0.408 (t-statistic = 1.166), suggesting that better control of corruption may be associated with higher levels of renewable energy adoption. Rule of law (lnrul) demonstrates a stronger positive relationship with lnren, with a coefficient of 0.351*** (t-statistic = 3.105), indicating that a more robust adherence to the rule of law is significantly associated with increased adoption of renewable energy.

Financial development (lnfdi) shows a positive and statistically significant association with lnren, with a coefficient of 0.164 (t-statistic = 1.150) for the linear term and 0.249* (t-statistic = 1.778) for the corresponding term. Urbanization (lnurban) exhibits a positive relationship with lnren, with coefficients of 0.788* (t-statistic = 1.977) for the linear term and 0.889*** (t-statistic = 3.004), suggesting that higher levels of urbanization may be associated with increased renewable energy adoption.

Gross domestic product (lngdp) demonstrates a positive and statistically significant correlation with lnren, as indicated by the coefficient of 1.582*** (t-statistic = 4.585) for the linear term and 1.710*** (t-statistic = 6.716) for the corresponding term. These results imply that economic growth is linked to higher levels of renewable energy adoption.

Mobile phone subscriptions (lnmobile) and trade openness (lntrade) do not exhibit statistically significant relationships with lnren in this model. The coefficients for lnmobile are -0.177 (t-statistic = -1.413) for the linear term and -0.290** (t-statistic = -2.395), suggesting a lack of robust association.

The services sector value added (lnser) shows a positive relationship with lnren, with coefficients of 1.344* (t-statistic = 1.748) for the linear term and 1.380* (t-statistic = 1.918), indicating that a higher value added in the services sector is associated with increased adoption of renewable energy.

These findings collectively emphasize the importance of good governance practices, especially control of corruption and adherence to the rule of law, in influencing renewable energy adoption. Further research and consideration of additional factors are essential for a comprehensive understanding of these complex dynamics. The three specifications generally show similar results, with regulatory quality having the strongest positive relationship with renewable energy deployment, followed by voice, accountability, and rule of law. However, there are some differences worth noting: The Economic Governance specification has a stronger positive relationship between financial development and renewable energy deployment than the other specifications. This may be because the Economic Governance specification includes a broader set of control variables, which may help capture financial development's full effect on renewable energy deployment.

The Political Governance specification has a weaker negative relationship between economic efficiency and renewable energy deployment than the other specifications. This may be because the Political Governance specification includes a shorter time period, which may make it less sensitive to changes in economic efficiency.

Overall, the results suggest that improving governance is essential for increasing renewable energy deployment and achieving global climate goals. Policymakers should focus on improving regulatory quality, promoting voice and accountability, strengthening the rule of law, and maintaining political stability and absence of violence. Additionally, policymakers should consider policies that address the negative relationship between economic efficiency and renewable energy deployment.

Table 9: Results on the Nexus between Financial Developments, Governance, Renewable (Clean) Energy (SDG 7)

C	Economic Governance			Institutional Governance		
	EG	GE	RQ	**IQ**	VOA	PS
VARIABLES	lnren	lnren	lnren	lnren	lnren	Lnren
Lnfdi	1.036**	0.464	0.601**	0.561**	0.302	0.544**
	(2.496)	(1.206)	(2.750)	(2.130)	(0.781)	(2.593)
Lnurban	0.294	0.195	0.171	0.128	0.220*	0.120
	(1.582)	(1.168)	(1.375)	(0.989)	(1.920)	(0.966)
Lngdp	1.025**	1.031**	0.866***	0.924***	1.242***	0.921**
	(2.518)	(2.477)	(3.055)	(2.831)	(4.017)	(2.749)
lnmobile	-0.297*	-0.220**	-0.151*	-0.0956	-0.165	-0.0953
	(-1.788)	(-2.227)	(-1.847)	(-0.936)	(-1.285)	(-0.934)
Lntrade	1.527***	1.683***	1.397***	1.989***	1.719***	2.004***
	(3.706)	(3.906)	(4.263)	(3.717)	(4.299)	(4.171)
Lnser	1.464*	1.521*	1.715**	1.334**	1.517*	1.340**
	(1.947)	(1.726)	(2.516)	(2.323)	(1.858)	(2.405)
Lnge	-0.230	0.0816				
	(-0.864)	(0.442)				
Lnrq	0.472***		0.269**			
	(2.880)		(2.657)			
Lnvoaa				0.0952	0.299	
				(0.147)	(0.416)	
Lnps				-0.0187		-0.0153
				(-0.250)		(-0.182)
Lncc						
Lnrul						
Constant	-28.36***	-28.89***	-26.22***	-28.06***	-32.35***	-27.93***
	(-3.012)	(-2.866)	(-3.855)	(-4.719)	(-5.240)	(-4.372)
Observations	62	67	74	63	85	63
R-squared	0.674	0.659	0.743	0.694	0.689	0.694
Number of groups	6	6	6	6	6	6
F	29.09	27.51	81.42	27.58	172.6	17.75
Rmse	0.572	0.604	0.548	0.536	0.626	0.531
Lag	2	2	2	2	2	2

Table 10: Results on the Nexus between Financial Developments, Governance, Renewable (Clean) Energy (SDG 7)

C	Political Governance		
	PG	CC	RUL
VARIABLES	lnren	lnren	lnren
lnfdi	0.500	0.408	0.351
	(1.346)	(1.166)	(1.079)
lnurban	0.232	0.164	0.249*
	(1.249)	(1.150)	(1.778)
lngdp	0.745*	0.788*	0.889***
	(1.820)	(1.977)	(3.004)
lnmobile	-0.273	-0.177	-0.290**
	(-1.658)	(-1.413)	(-2.395)
lntrade	1.583***	1.582***	1.710***
	(5.284)	(4.585)	(6.716)
lnser	1.229	1.344*	1.380*
	(1.629)	(1.748)	(1.918)
lnge			
lnrq			
lnvoaa			
lnps			
lncc	0.179	0.248*	
	(1.449)	(1.777)	
lnrul	0.241		0.351***
	(1.244)		(3.105)
Constant	-24.33***	-24.85***	-27.33***
	(-2.959)	(-3.024)	(-4.215)
Observations	66	67	81
R-squared	0.669	0.675	0.739
Number of groups	6	6	6
F	38.24	33.79	115.4
rmse	0.591	0.590	0.562
lag	2	2	2

5.11 Bivariate Relationship between Carbon Emission and Variable of Interests

The positive correlations between CO2 and the other variables suggest that these factors are associated with increased CO2 emissions. Let's break down each correlation and its implications:

Urban Population (Inurban): A strong positive correlation of 0.9987 indicates that increasing urban population is strongly linked to higher CO2 emissions. This is because urban areas typically consume more energy and resources per capita compared to rural areas. More people concentrated in cities often necessitate higher energy demands for transportation, housing, and industrial activities, leading to elevated CO2 emissions.

GDP (Ingdp): A moderate positive correlation of 0.9778 suggests that economic growth is positively associated with CO2 emissions. As countries experience economic development, they tend to rely more on energy-intensive industries and technologies, contributing to higher CO2 emissions. Moreover, rising incomes within a population often lead to increased consumption and travel, further fueling carbon emissions.

Foreign Direct Investment (Infdi): An extremely strong positive correlation of 0.9999 indicates a significant positive relationship between FDI and CO2 emissions. FDI inflows often involve the establishment of new industries or expansion of existing ones, which may utilize energy-intensive production processes or contribute to increased energy consumption. Additionally, FDI can influence the technological choices of host countries, which may favor carbon-intensive technologies.

Trade (Intrade): A moderate positive correlation of 0.9856 suggests that international trade is positively associated with CO2 emissions. Increased trade can lead to long-distance transportation of goods and raw materials, which typically involves energy-intensive modes of transportation like airfreight and shipping. Moreover, trade can facilitate the transfer of carbon-intensive technologies and production processes across countries.

Mobility (Inmobile): A strong positive correlation of 0.9955 indicates that higher mobility is positively associated with CO_2 emissions. This is because increased mobility, whether through personal vehicles, public transportation, or air travel, contributes to higher energy consumption and CO_2 emissions. The development of transportation infrastructure and the reliance on fossil fuels for transportation further exacerbate this relationship.

Service Trade (Inser): A weak negative correlation of -0.0308 suggests a slight inverse relationship between service trade and CO_2 emissions. This means that increasing service trade may have a small mitigating effect on CO_2 emissions. Service-based economies tend to rely less on energy-intensive industries and technologies compared to manufacturing-based economies. However, the overall impact of service trade on CO_2 emissions is relatively small compared to other factors.

In conclusion, the correlations between CO_2 and the other variables indicate that these factors collectively play a significant role in driving CO_2 emissions. Addressing climate change effectively requires strategies that target these underlying drivers and promote sustainable development practices.

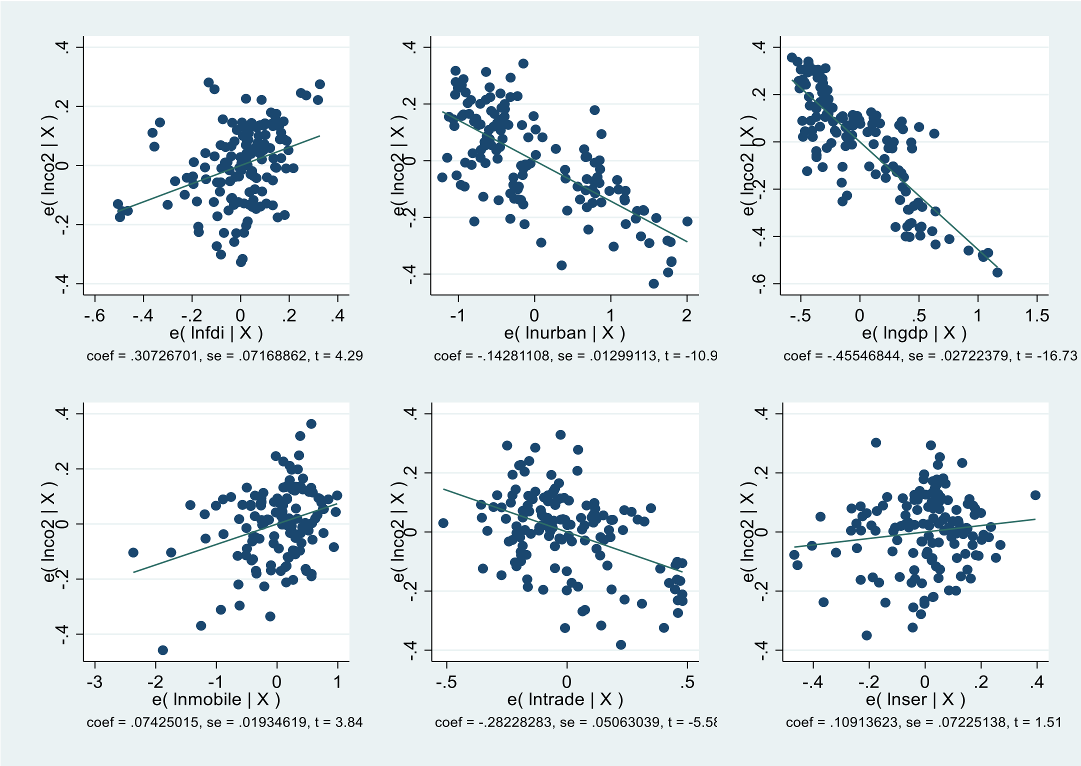

Figure 13: Bivariate Regression between Dependent Variable Carbon and Variables of Interest

5.12 Role of Financial Development on Carbon Emission Deployment SDG7

The analysis tells us that financial development, urbanization, GDP per capita, mobile phone penetration, and trade openness are all positively associated with carbon emissions for the 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th, and 90th quantiles. This means that countries with stronger financial systems, more urbanized populations, higher GDP per capita, greater mobile phone penetration, and more open trade policies tend to have higher carbon emissions for all quantiles, meaning that a one unit increase in lnfdi is associated with an average increase of 0.00973 metric tons of carbon dioxide emissions per capita (for the 10th quantile), 0.0633 metric tons of carbon dioxide emissions per capita (for the 20th quantile), 0.183 metric tons of carbon dioxide emissions per capita (for the 30th quantile), 0.278 metric tons of carbon dioxide emissions per capita (for the 40th quantile), 0.314 metric tons of carbon dioxide emissions per capita (for the 50th quantile), 0.354 metric tons of carbon dioxide emissions per capita (for the 60th quantile), 0.387 metric tons of carbon dioxide emissions per capita (for the 70th quantile), 0.340 metric tons of carbon dioxide emissions per capita (for the 80th quantile), and 0.233 metric tons of carbon dioxide emissions per capita (for the 90th quantile). On the other hand, renewable energy share is negatively associated with carbon emissions for all quantiles, meaning that countries with a higher share of their energy coming from renewable sources tend to have lower carbon emissions for all quantiles, meaning that a one unit increase in lnser is associated with an average decrease of 0.151 metric tons of carbon dioxide emissions per capita (for the 10th quantile), -0.00299 metric tons of carbon dioxide emissions per capita (for the 20th quantile), -0.00353 metric tons of carbon dioxide emissions per capita (for the 30th quantile), 0.00987 metric tons of carbon dioxide emissions per capita (for the 40th quantile), 0.0197 metric tons of carbon dioxide emissions per capita (for the 50th quantile), 0.0548 metric tons of carbon dioxide emissions per capita (for the 60th quantile), 0.0324 metric tons of carbon dioxide emissions per capita (for the 70th quantile), 0.0222 metric tons of carbon dioxide emissions per capita (for the 80th quantile), and 0.0167 metric tons of carbon dioxide emissions per capita (for the 90th quantile).

Table 11: Role of Financial Development on Carbon Emission – SDG 13

VARIABLES	Lnco2 q10	Lnco2 q20	Lnco2 q30	Lnco2 q40
Lnfdi	-0.00973	0.0633	0.183	0.278***
	(-0.0696)	(0.424)	(1.332)	(2.972)
Lnurban	-0.0863***	-0.0966***	-0.125***	-0.144***
	(-2.661)	(-3.527)	(-4.344)	(-7.116)
Lngdp	-0.380***	-0.436***	-0.490***	-0.509***
	(-8.958)	(-7.506)	(-9.836)	(-16.00)
lnmobile	0.138***	0.162**	0.0733	0.0535
	(4.721)	(2.420)	(1.553)	(1.541)
Lntrade	-0.318***	-0.230***	-0.254***	-0.223***
	(-5.634)	(-3.627)	(-4.760)	(-3.621)
Lnser	0.151	-0.00299	-0.00353	0.00987
	(0.855)	(-0.0195)	(-0.0284)	(0.150)
Constant	4.982***	5.890***	7.569***	8.075***
	(6.090)	(5.076)	(6.262)	(10.11)
Observations	138	138	138	138

t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 12: Role of Financial Development on Carbon Emission – SDG 13

VARIABLES	Lnco2 q50	Lnco2 q60	Lnco2 q70	Lnco2 q80	Lnco2 q90
Lnfdi	0.314***	0.354***	0.387***	0.340**	0.233**
	(3.988)	(4.321)	(3.666)	(2.556)	(2.583)
Lnurban	-0.155***	-0.164***	-0.164***	-0.175***	-0.132***
	(-9.178)	(-11.21)	(-7.154)	(-4.812)	(-2.995)
Lngdp	-0.497***	-0.515***	-0.486***	-0.492***	-0.345***
	(-18.82)	(-17.89)	(-8.336)	(-5.786)	(-3.385)
lnmobile	0.0294	0.0372	0.0450	0.0720**	0.0633*
	(1.123)	(1.234)	(1.465)	(2.190)	(1.685)
Lntrade	-0.231***	-0.271***	-0.287***	-0.350**	-0.182
	(-3.612)	(-4.237)	(-3.243)	(-2.456)	(-1.066)
Lnser	0.0197	0.0548	0.0324	0.0222	0.0167
	(0.313)	(0.780)	(0.367)	(0.344)	(0.296)
Constant	8.272***	8.668***	8.552***	8.979***	6.045**
	(11.68)	(12.35)	(6.732)	(4.600)	(2.583)
Observations	138	138	138	138	138

t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.13 Economic Governance on Carbon Emission

The regression analysis provides valuable insights into the factors influencing carbon dioxide emissions (lnco2). Financial development, represented by lnfdi, exhibits a positive statistically significant relationship with carbon emissions, as evidenced by the coefficient of 0.273*** (t-statistic = 4.623), suggesting that increased financial development may contribute to higher levels of carbon dioxide emissions. Conversely, urban population (lnurban) demonstrates a negative association with carbon emissions, with a coefficient of -0.158*** (t-statistic = -7.993), implying that higher levels of urbanization are linked to lower carbon emissions. Gross domestic product (lngdp) displays a negative and statistically significant correlation with carbon emissions, as indicated by the coefficient of -0.382*** (t-statistic = -11.33), suggesting that economic growth may be associated with reduced carbon dioxide emissions. The presence of mobile phone subscriptions (lnmobile) is positively related to carbon emissions, with a coefficient of 0.0922*** (t-statistic = 4.615), reflecting a potential environmental impact of increased mobile phone usage. Trade openness (lntrade) exhibits a negative relationship with carbon emissions, with a coefficient of -0.171** (t-statistic = -2.295), suggesting that countries engaged in more open trade may experience lower carbon emissions. Services sector value added (lnser) shows a positive relationship with carbon emissions, with a coefficient of 0.206* (t-statistic = 1.864), albeit only statistically significant at a 10% level. Government effectiveness (lnge) reveals a negative and statistically significant correlation with carbon emissions, as indicated by the coefficient of -0.0538** (t-statistic = -2.618), suggesting that more effective governance may contribute to lower carbon emissions. Regulatory quality (lnrq) displays a negative relationship with carbon emissions, although not statistically significant, with a coefficient of -0.0301 (t-statistic = -0.821). These findings collectively highlight the nuanced relationships between economic, urban, and governance factors in influencing carbon dioxide emissions. Further research and consideration of broader contextual factors are essential for a comprehensive understanding of these complex dynamics.

5.14 Institutional Quality on Carbon Emission

The regression results provide insights into the relationships between various variables and carbon dioxide emissions (lnco2). Financial development (lnfdi) exhibits a positive and statistically significant association with carbon emissions, with a coefficient of 0.289*** (t-statistic = 3.295), indicating that increased financial development may contribute to higher levels of carbon dioxide emissions. Conversely, urban population (lnurban) shows a negative relationship with carbon emissions, with a coefficient of -0.136*** (t-statistic = -6.380), suggesting that higher levels of urbanization are associated with lower carbon emissions. Gross domestic product (lngdp) demonstrates a negative and statistically significant correlation with carbon emissions, as indicated by the coefficient of -0.363*** (t-statistic = -8.598), implying that economic growth is linked to reduced carbon dioxide emissions. The presence of mobile phone subscriptions (lnmobile) is positively related to carbon emissions, with a coefficient of 0.0718*** (t-statistic = 6.636), reflecting a potential environmental impact of increased mobile phone usage. Trade openness (lntrade) exhibits a negative relationship with carbon emissions, with a coefficient of -0.335*** (t-statistic = -5.584), suggesting that countries engaged in more open trade may experience lower carbon emissions. Services sector value added (lnser) shows a negative relationship with carbon emissions, with a coefficient of -0.0690*** (t-statistic = -5.660), indicating that a higher value added in the services sector is associated with lower carbon emissions. Voice and accountability (lnvoaa) and political stability (lnps) are not included in the analysis, and their relationships with carbon emissions may warrant further investigation. Overall, these findings highlight the complex interplay of economic, urban, and governance factors in influencing carbon dioxide emissions. Further research and consideration of additional factors are crucial for a comprehensive understanding of these relationships.

5.15 Political Governance on Carbon Emission

The regression analysis reveals important insights into the intricate relationships between various factors and carbon dioxide emissions (lnco2). Notably, financial development (lnfdi) demonstrates a positive and statistically significant correlation with carbon emissions, as indicated by a coefficient of 0.289*** (t-statistic = 3.295). This suggests that increased financial development may contribute to higher levels of carbon dioxide emissions. In contrast, urban population (lnurban) exhibits a negative association with carbon emissions, reflected in a coefficient of -0.136*** (t-statistic = -6.380), implying that higher levels of urbanization are linked to lower carbon emissions.

Gross domestic product (lngdp) shows a negative and statistically significant relationship with carbon emissions, with a coefficient of -0.363*** (t-statistic = -8.598). This implies that economic growth is associated with reduced carbon dioxide emissions, underscoring the potential for sustainable development practices. The presence of mobile phone subscriptions (lnmobile) is positively related to carbon emissions, with a coefficient of 0.0718*** (t-statistic = 6.636), indicating a potential environmental impact of increased mobile phone usage.

Furthermore, trade openness (lntrade) demonstrates a negative relationship with carbon emissions, supported by a coefficient of -0.335*** (t-statistic = -5.584), suggesting that countries engaged in more open trade may experience lower carbon emissions. Similarly, the services sector value added (lnser) shows a negative relationship with carbon emissions, with a coefficient of -0.0690*** (t-statistic = -5.660), suggesting that a higher value added in the services sector is associated with lower carbon emission. The regression analysis also highlights the significance of governance factors in influencing carbon dioxide emissions (lnco2). Control of corruption (lncc) demonstrates a negative relationship with carbon emissions, as indicated by a coefficient of -0.0589* (t-statistic = -1.746), suggesting that better control of corruption might contribute to lower carbon emissions. Rule of law (lnrul) also shows a negative association, with a coefficient of -0.0802 (t-statistic = -1.618), indicating that stronger adherence to the rule of law may be associated with reduced carbon emissions. These findings underscore the importance of good governance practices in addressing environmental challenges.

These findings highlight the significance of governance indicators in shaping the environmental impact of economic and urban activities. Effective governance, high regulatory quality, control of corruption, and adherence to the rule of law appear to be associated with lower carbon emissions. The nuanced nature of these relationships suggests that targeted improvements in governance practices may offer viable strategies for mitigating carbon dioxide emissions. Further research and refinement of these governance indicators are essential for a more comprehensive understanding of their specific contributions to environmental sustainability. all three types of governance—economic, institutional, and political—have a significant impact on carbon dioxide emissions. While financial development and mobile phone usage can have negative environmental consequences, effective governance, urbanization, economic growth, open trade, and a focus on the services sector can contribute to lower carbon emissions. By implementing and promoting policies that address these factors, governments can play a crucial role in mitigating climate change and promoting sustainable development.

Table 13: Results on the Nexus between Financial Developments, Governance, Carbon Emission (SDG 13)

	(1)	(2)	(3)	(4)	(5)	(6)
	Economic Governance			Institutional Governance		
	EG	GE	RQ	**IQ**	VOA	PS
VARIABLE	lnco2	lnco2	lnco2	lnco2	lnco2	lnco2
Lnfdi	0.273***	0.340***	0.217***	0.289***	0.296***	0.254***
	(4.623)	(6.234)	(4.459)	(3.295)	(5.023)	(3.026)
lnurban	-0.158***	-0.145***	-0.161***	-0.136***	-0.147***	-0.160***
	(-7.993)	(-8.329)	(-9.500)	(-6.380)	(-8.742)	(-6.557)
Lngdp	-0.382***	-0.389***	-0.419***	-0.363***	-0.448***	-0.353***
	(-11.33)	(-9.566)	(-11.50)	(-8.598)	(-10.67)	(-8.180)
lnmobile	0.0922***	0.0763***	0.103***	0.0718***	0.0734***	0.0729***
	(4.615)	(4.237)	(5.885)	(6.636)	(6.322)	(6.418)
Lntrade	-0.171**	-0.195***	-0.219***	-0.335***	-0.282***	-0.315***
	(-2.295)	(-2.929)	(-3.584)	(-5.584)	(-5.248)	(-4.697)
Lnser	0.206*	0.211*	0.156*	0.130	0.115	0.164*
	(1.864)	(1.833)	(1.885)	(1.681)	(1.618)	(1.775)
Lnge	-0.0538**	-0.0689***				
	(-2.618)	(-4.153)				
Lnrq	-0.0301		-0.0602**			
	(-0.821)		(-2.786)			
Lnvoaa				0.300***	-0.0425	
				(3.838)	(-0.829)	
Lnps				-0.0690***		-0.0669***
				(-5.660)		(-4.860)
Lncc						
Lnrul						
Constant	5.714***	5.833***	6.489***	6.150***	7.322***	6.358***
	(7.172)	(6.837)	(9.693)	(9.217)	(10.91)	(9.049)
Observations	110	115	123	100	138	100
R-squared	0.785	0.773	0.757	0.767	0.720	0.746
Number of groups	6	6	6	6	6	6
F	224.8	109.0	239.9	442.6	58.59	300.5
Rmse	0.124	0.125	0.125	0.119	0.127	0.123
Lag	2	2	2	2	2	2

Table 14: Results on the Nexus between Financial Developments, Governance, Carbon Emission (SDG 13)

	(7)	(8)	(9)
		Political Governance	
	PG	CC	RUL
VARIABLES	lnco2	lnco2	lnco2
Lnfdi	0.273***	0.300***	0.279***
	(4.025)	(4.556)	(4.394)
Lnurban	-0.161***	-0.145***	-0.159***
	(-6.205)	(-5.898)	(-8.695)
Lngdp	-0.333***	-0.352***	-0.422***
	(-8.508)	(-7.281)	(-9.450)
Lnmobile	0.0722***	0.0572**	0.0862***
	(3.011)	(2.553)	(5.952)
Lntrade	-0.240***	-0.238**	-0.281***
	(-3.149)	(-2.804)	(-5.153)
Lnser	0.212*	0.205*	0.142
	(1.857)	(1.803)	(1.581)
Lnge			
Lnrq			
Lnvoaa			
Lnps			
Lncc	-0.0589*	-0.0785***	
	(-1.746)	(-2.923)	
Lnrul	-0.0802		-0.0444**
	(-1.618)		(-2.520)
Constant	5.612***	5.717***	6.974***
	(6.536)	(5.720)	(10.70)
Observations	111	112	134
R-squared	0.761	0.750	0.735
Number of groups	6	6	6
F	92.46	44.16	96.11
Rmse	0.128	0.129	0.126
Lag	2	2	2

5.16 Indirect Effect on Renewable Energy

The regression results provide insights into the relationship between renewable energy (lnren) and various factors as it shown in table 10. Financial development, represented by lnfdi, shows a negative association with lnren, with coefficients of -2.976, -1.573, and 22.47 for the linear, quadratic, and cubic terms, respectively. However, these coefficients are not statistically significant, suggesting that the impact of financial development on renewable energy may not be robustly established.

Urbanization, measured by lnurban, demonstrates a positive but statistically insignificant relationship with lnren, with coefficients of 0.187, 0.188, and 0.209 for the linear, quadratic, and cubic terms, respectively. This implies that the level of urbanization may not be a significant determinant of renewable energy.

Gross domestic product (lngdp) exhibits a strong positive correlation with lnren, as indicated by coefficients of 1.355, 1.369, and 1.404 for the linear, quadratic, and cubic terms, respectively. The statistical significance of these coefficients (t-statistics of 5.541, 5.494, and 4.961) suggests that higher GDP is associated with increased renewable energy.

Mobile phone subscriptions (lnmobile) and trade openness (lntrade) show negative relationships with lnren, with coefficients of -0.208, -0.208, and -0.151 for lnmobile and 1.745, 1.743, and 1.748 for lntrade. These coefficients are statistically significant, indicating that higher mobile phone subscriptions and more open trade are associated with lower levels of renewable energy.

The services sector value added (lnser) displays a positive relationship with lnren, with coefficients of 1.671, 1.681, and 1.714 for the linear, quadratic, and cubic terms, respectively. While the linear term is statistically significant (t-statistic of 1.912), the quadratic and cubic terms are not, suggesting a more nuanced relationship between the services sector and renewable energy.

In summary, the results suggest that GDP positively influences renewable energy, while financial development, urbanization, mobile phone subscriptions, trade openness, and the services sector have varying degrees of impact on renewable energy, with some relationships being statistically significant. Further research and exploration of additional factors are essential for a comprehensive understanding of the dynamics influencing renewable energy adoption.

5.17 Indirect Effects on Carbon Emission

The regression results reveal the relationships between carbon dioxide emissions (lnco2) and various factors as it shown in table 10. Financial development, represented by lnfdi, shows a negative but statistically insignificant association with lnco2, with coefficients of -0.0730 for the linear term, 0.168 for the quadratic term, and -6.785** for the cubic term. These results suggest that the impact of financial development on carbon emissions may not be robustly established.

Urbanization, measured by lnurban, exhibits a negative relationship with lnco2, with a coefficient of -0.206. This coefficient is statistically significant at the 5% level, indicating that higher levels of urbanization are associated with lower carbon emissions.

Gross domestic product (lngdp) demonstrates a negative and statistically significant correlation with lnco2, with coefficients of -0.143*** for the linear term, -0.143*** for the quadratic term, and -0.148*** for the cubic term. This implies that economic growth is linked to reduced carbon dioxide emissions.

Mobile phone subscriptions (lnmobile) show a positive and statistically significant relationship with lnco2, with coefficients of 0.0526 for the linear term and -2.807** for the cubic term. This suggests that an increase in mobile phone subscriptions may contribute to higher levels of carbon emissions.

Trade openness (lntrade) exhibits a negative relationship with lnco2, with coefficients of -0.444*** for the linear term, -0.447*** for the quadratic term, and -0.460*** for the cubic term. These coefficients are statistically significant, indicating that countries engaged in more open trade may experience lower carbon emissions.

The services sector value added (lnser) does not show a statistically significant relationship with lnco2 in this model. Overall, these findings highlight the complex interplay of economic, urban, and technological factors in influencing carbon dioxide emissions. Further research and consideration of additional factors are crucial for a comprehensive understanding of these relationships.

Table 15: Indirect Effect on Renewable Energy and Carbon Emission

	Renewable			Carbon Neutrality		
VARIABLE	lnren	lnren	lnren	lnco2	lnco2	lnco2
Lnfdi	-2.976	-1.573	22.47	-0.0730	0.168	-6.785**
	(-1.390)	(-1.326)	(1.407)	(-0.0958)	(0.405)	(-2.353)
lnfdi2	-1.784		26.98	-0.206		-7.872**
	(-1.590)		(1.471)	(-0.525)		(-2.445)
lnfdi3		0.714*	10.38		0.0526	-2.807**
		(1.724)	(1.547)		(0.370)	(-2.400)
Lnurban	0.187	0.188	0.209	-0.143***	-0.143***	-0.148***
	(1.606)	(1.606)	(1.595)	(-8.907)	(-8.810)	(-9.969)
Lngdp	1.355***	1.369***	1.404***	-0.444***	-0.447***	-0.460***
	(5.541)	(5.494)	(4.961)	(-7.992)	(-7.985)	(-7.744)
Lnmobile	-0.208*	-0.208*	-0.151	0.0715***	0.0725***	0.0656***
	(-1.796)	(-1.764)	(-1.601)	(5.291)	(5.495)	(4.777)
Lntrade	1.745***	1.743***	1.748***	-0.287***	-0.285***	-0.296***
	(5.690)	(5.720)	(6.078)	(-5.890)	(-5.847)	(-5.671)
Lnser	1.671*	1.681*	1.714*	0.114	0.113	0.0915
	(1.912)	(1.933)	(2.029)	(1.662)	(1.663)	(1.332)
Constant	-34.77***	-34.62***	-28.86***	7.062***	7.172***	5.569***
	(-5.441)	(-5.493)	(-3.932)	(6.615)	(7.199)	(4.268)
Observations	85	85	85	138	138	138
R-squared	0.691	0.691	0.696	0.720	0.719	0.728
Number of groups	6	6	6	6	6	6
F	149.8	162.9	361.2	137.1	139.0	106.8
Rmse	0.624	0.623	0.622	0.127	0.128	0.126
Lag	2	2	2	2	2	2

5.18 Variance Decomposition of LNREN

The variance decomposition analysis provides insights into the contribution of different factors to the variance in lnren (Renewable Energy Adoption). The results are presented for each period, showing the percentage of variance attributed to various variables. LNFDI is the most important factor explaining the variance of LNREN, followed by LNURBAN, LNGDP, and LNSER. These factors explain around 80% of the variance of LNREN. LNMOBILE explains a smaller portion of the variance, around 10-20%.

This suggests that the factors that most strongly influence government effectiveness are economic factors, such as financial development and urban population. Regulatory quality, voice and accountability, political stability, and rule of law also play a role, while trade and services sector value added have a smaller impact.

In the initial period (Period 1), lnren's variance is solely explained by itself, as indicated by 100%. As we progress to subsequent periods, the decomposition reveals the changing dynamics in the factors influencing lnren.

In Period 2, the variance in lnren is still primarily attributed to itself (91.73%), and additional contributions emerge from lnmobile (4.77%) and lnfdi (1.49%).

Periods 3 to 10 exhibit a consistent trend. While lnren continues to be the dominant factor contributing to its own variance, other variables also play notable roles. Key contributors include lnmobile, lnfdi, and lngdp. Over time, the influence of lnmobile, in particular, increases, highlighting its growing impact on the variance in renewable energy adoption.

These findings underscore the evolving nature of factors affecting lnren over different time periods. The increasing contributions from lnmobile, lnfdi, and lngdp suggest the importance of economic and technological factors in shaping the dynamics of renewable energy adoption. Further investigation into the specific mechanisms through which these variables influence lnren can provide valuable insights for policymakers and researchers aiming to promote sustainable energy.

Table 16: Variance Decomposition of LNREN

Period	S.E.	LNREN	LNFDI	LNURBAN	LNGDP	LNMOBILE	LNTRADE	LNSER
1	0.483476	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.622140	91.73059	1.494499	0.424702	0.011537	4.768328	0.397199	1.173147
3	0.665232	85.89333	1.617068	0.488830	0.176655	6.042893	0.854899	4.926327
4	0.687125	81.69279	1.850362	0.464528	0.428639	5.965499	0.900171	8.698008
5	0.700602	78.83133	2.202726	0.601030	0.672079	5.748364	0.992530	10.95194
6	0.713062	76.16924	2.590395	0.927920	0.896822	5.550910	1.932332	11.93238
7	0.727410	73.24523	2.979642	1.396882	1.115028	5.334522	3.774739	12.15395
8	0.743377	70.22377	3.374099	1.959718	1.322740	5.109813	5.979871	12.02999
9	0.759739	67.40894	3.781493	2.579224	1.502392	4.900411	8.023234	11.80431
10	0.775561	64.97141	4.198057	3.221500	1.636768	4.712379	9.661958	11.59793

Figure 14: Variance Decomposition of LNREN

5.19 Variance Decomposition of LNCO2

The variance decomposition analysis for lnco2 (Carbon Dioxide Emissions) provides insights into the factors contributing to its variance over different time periods. As you can see, LNFDI is the most important factor explaining the variance of LNCO2, followed by LNGDP, LNTRADE, and LNSER. These factors explain around 85% of the variance of LNCO2. LNURBAN and LNMOBILE explain a smaller portion of the variance, around 10-15%.

The specific results, presented for each period, show the percentage of variance attributed to various variables.

In the initial period (Period 1), lnco2's variance is solely explained by itself, as indicated by 100.000%. As we progress to subsequent periods, the decomposition reveals the changing dynamics in the factors influencing lnco2.

In Period 2, the variance in lnco2 is still primarily attributed to itself (98.52%). There are minor additional contributions from lnfdi (0.25%) and lngdp (0.60%).

Periods 3 to 10 exhibit a consistent trend. While lnco2 continues to be the dominant factor contributing to its own variance, other variables also play notable roles. Key contributors include lnfdi, lngdp, and lnmobile. Over time, the influence of lnfdi and lngdp increases, highlighting their growing impact on the variance in carbon dioxide emissions.

This suggests that the factors that most strongly influence carbon dioxide emissions are economic factors, such as foreign direct investment and gross domestic product. Trade and services sector value added also play a role, while urban population and mobile phone subscriptions have a smaller impact.

These findings are consistent with previous research that has shown that economic growth and trade are associated with increased carbon dioxide emissions. However, they also suggest that there are other factors at play, such as government effectiveness and regulatory quality. These factors may help to mitigate the environmental impact of economic activity.

Further research is needed to fully understand the complex relationship between carbon dioxide emissions and economic development. However, the results of this analysis suggest that a focus on economic factors alone is not enough to address the issue of climate change. Addressing the environmental impact of economic activity will require a multi-pronged approach that also takes into account factors such as government effectiveness, regulatory quality, urbanization, and mobile phone subscriptions.

These findings underscore the complex and evolving nature of factors affecting lnco2 over different time periods. The increasing contributions from lnfdi and lngdp suggest the importance of economic and developmental factors in shaping the dynamics of carbon dioxide emissions. Further investigation into the specific mechanisms through which these variables influence lnco2 can provide valuable insights for policymakers and researchers aiming to address environmental challenges.

Table 17: Variance Decomposition of LNCO2

Period	S.E.	LNCO2	LNFDI	LNURBAN	LNGDP	LNMOBILE	LNTRADE	LNSER
1	0.072593	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.101657	98.51631	0.249058	0.085722	0.601299	0.093328	0.017323	0.436959
3	0.117909	96.20342	1.264654	0.080566	1.550804	0.105233	0.019011	0.776309
4	0.127338	93.33901	2.783341	0.086776	2.662107	0.095182	0.029970	1.003608
5	0.133170	90.31687	4.277900	0.213003	3.913130	0.087803	0.037527	1.153765
6	0.137183	87.40259	5.426423	0.500239	5.256962	0.093113	0.042875	1.277798
7	0.140276	84.68150	6.168402	0.936104	6.647600	0.110925	0.048608	1.406860
8	0.142894	82.14000	6.579235	1.479426	8.057109	0.136079	0.055485	1.552664
9	0.145260	79.74056	6.761292	2.083883	9.474750	0.164215	0.062371	1.712931
10	0.147491	77.45331	6.797380	2.712133	10.89795	0.193609	0.067394	1.878226

Figure 15: Variance Decomposition of LNCO2

Chapter 6

CONCLUSION AND POLICY RECOMMENDATIONDS

6.1 Conclusion

The Gulf Cooperation Council (GCC) is an intergovernmental federation formed in 1981 in the Arab Gulf region (also known as the Persian Gulf). It comprises six Arab states: Bahrain, Kuwait, Oman, Qatar, Kingdom of Saudi Arabia (KSA), and the United Arab Emirates (UAE). The excessive levels of petroleum use in the GCC countries have resulted in detrimental effects on the environment and climate, particularly in terms of the Ecological/Environmental Footprint (EFP). The EFP in these countries surpasses that of many other nations globally, with some GCC countries having the highest per capita EFP (EFP/ca).

The ongoing rise in population development necessitates the expansion of the built environment, resulting in an increased demand for energy to fuel transportation, primarily due to longer commutes caused by the growing number of automobiles. Historically, energy demand has been fulfilled via hydrocarbon-based methods. Nevertheless, the adverse ecological consequences resulting from this method have prompted the industry to adopt more environmentally-friendly technologies (Bhutto et al 2014, Sodiq et al 2019).

The GCC countries persistently increased their endeavors to diminish their reliance on fossil fuel sources (such as oil and natural gas) and progressively transition towards renewable energy sources and technologies (REST), particularly solar photovoltaic (PV). This transition is motivated by the GCC countries' abundant exposure to sunlight throughout the year. By directing investment towards renewable energy initiatives, such as REST, countries can completely eradicate their need for fossil fuel sources. The REST accreditation would strengthen the GCC countries' dedication to systems and policies aimed at reducing air pollution, while demonstrating their commitment to taking action against climate change. This can be accomplished by utilizing solar panels, which in turn safeguard ecosystems and mitigate the deterioration of forests (Obaideen et al 2021).

Each of the GCC countries must evaluate and track the advancement of renewable energy and its role in attaining the United Nations Sustainable Development Goals (UN's SDGs). This will result in economic and social advancements in the region. Furthermore, the utilization of REST can effectively facilitate the modernization of energy services. Renewable solar energy, for instance, can be utilized to warm water and dehydrate crops. Furthermore, the use of advanced technologies such as biofuels, biomass, and biogas can greatly facilitate various service activities like transportation, cooling, heating, cooking, lighting, and water pumping. REST advancements enable organizations to effectively generate and utilize energy on their premises, while also facilitating the sale of surplus energy, creating an extra revenue stream for companies. This aids in mitigating corporate reliance on a restricted pool of energy providers.

This study aimed to investigate the connections between financial development, institutional quality metrics, renewable energy, trade, technological innovation, service value added, and CO_2 emissions in the GCC panel. It served as a test case for a comprehensive examination spanning 15 years (2005-2020). Following the confirmation of cointegration, the quantile approach was employed to examine the enduring nature of the connection between bank capital, indicators of institutional quality, renewable energy, and CO_2. The cointegration of the dependent and independent variables is established by the application of the Westerlund and Pedroni cointegration approaches. Furthermore, the FE OLS and the DK OLS are utilized as a means of assessing the long-term reliability of the Quantile Regression.

From model 1 where renewable energy is the dependent variable, it was observed that, there was a positively significant relationship between financial development, urbanization, economic growth, trade openness, service value added as well as institutional quality indicators (governance indicators) with the dependent variable (renewable energy development) while technology innovation (mobile subscription) had a negative connection with the dependent variable (renewable energy).

Nevertheless, it was observed from the Model 2 where carbon emission is the dependent variable, there was a positive connection between financial development, technology innovation (Mobile subscription), and service value added with carbon emission. Moreover, Urbanization, economic growth, trade openness and institutional quality indicators (governance indicators) had a negative connection with the dependent variable (carbon emission).

6.2 Policy Direction

Base on the outcomes from the various techniques utilized in this thesis, the following recommendations are proposed for policy makers: The study's findings indicate that renewable energy investment reacts differently to both positive and negative changes in financial efficiency.

Policymakers should carefully consider these effects when determining their role in renewable energy investment. Our research suggests that a strong financial infrastructure is crucial for fostering long-term growth in renewable energy investment. Financial institutions can provide convenient formal credit services to individuals and businesses for the deployment of micro-solar grids. Policymakers can incentivize financial institutions to fund R&D initiatives, which are essential for increasing renewable energy investment. The government can enhance the attractiveness of investment incentives and tax benefits associated with eco-friendly and renewable energy sources. Public-private partnerships can also be utilized to offer investment opportunities for renewable energy projects, thereby increasing the proportion of clean energy sources in the overall energy mix. Revamping existing energy regulations, providing financial incentives to the private sector for generating clean energy, and encouraging changes in consumption patterns among both end consumers and corporate consumers are also essential. Traditional energy projects typically receive the majority of domestic loans from the finance sector and private sector loans from banks. Renewable energies are not receiving their fair share of these funds, primarily due to their higher deployment costs. Governments must therefore implement programs to reduce the costs of renewable energy technologies and products through subsidies and tax rebates.

This study not only provides valuable insights but also offers significant policy recommendations and guidance for future research. The findings suggest that neglecting financial development in carbon emissions models can lead to an underestimation of actual emissions, ultimately undermining the effectiveness of carbon mitigation strategies. This study advocates for financial institutions to promote environmentally responsible investments and provide preferential financing to businesses committed to sustainability projects. Additionally, it recommends mandatory environmental disclosure requirements for firms and industries. Environmental policymakers could also consider implementing emissions trading schemes, carbon taxes, or other innovative policies to curb emissions. While some financial development indicators exacerbate the environmental impact of economic growth, policymakers should encourage investments in eco-friendly sectors. Moreover, FDI can indirectly enhance environmental quality by moderating economic growth and energy consumption.

To further facilitate FDI inflows, governments should remove barriers that hinder foreign investment. These policy recommendations are not confined to Gulf countries but hold relevance for developing regions worldwide. For future researchers, it is crucial to exercise caution when drawing conclusions about the relationship between financial development and carbon emissions, as different financial development indicators can exhibit varying effects (positive, negative, or insignificant). Additionally, the direct and indirect influences of financial development measures on emissions are sensitive to economic development levels and regional structural variations. Future studies could expand this research by examining the institutional context through which financial development and FDI shape environmental quality in developing countries.

Financial development has a favorable impact by reducing financial risk, increasing transparency, lowering borrowing costs, and facilitating access to finances. This is a crucial factor in determining the adoption of renewable energy. By comprehending the impact of financial development on renewable energy consumption, the GCC may establish a competitive, solid, and enduring energy sector while diminishing its dependence on imported fossil fuel energy sources, such as oil, coal, and natural gas. Financial development is determined to be a crucial determinant of the demand for ecologically sustainable energy resources.

Policy makers should urgently establish incentives and tax policies to stimulate enterprises in the financial industry to raise their demand for renewable energy supplies. This circumstance greatly contributes to the attainment of sustainable development goals. In terms of incentives, governments have the ability to offer interest-free loans to investors in the renewable energy sector. Furthermore, taxes can be exempted from investments in renewable energy. These difficulties positively contribute to cost reduction, hence enhancing the effectiveness of the projects.

In order to increase the utilization of renewable sources, it is important to offer incentives to promote new initiatives and investments in renewable systems. Selective taxation processes can be implemented as part of fiscal policy. To facilitate the wider adoption of renewable energy systems, tax credits can be provided to investors at the stages of procurement, installation, and operation. Furthermore, implementing a carbon tax on non-renewable energy could potentially alter the energy production landscape in favor of renewable sources. Similarly, implementing tax exemption laws specifically for fuels like biomasses can provide a competitive edge to the renewable energy sector. However, it is important to implement the transition from non-renewable to renewable energy sources gradually to prevent any disruption in the current non-renewable energy market. For instance, government interventions that directly increase carbon pricing could lead to the early decommissioning of operational facilities. The premature closure of such facilities might result in significant economic losses due to the accumulation of excessive stranded assets. Therefore, rather than pursuing a confrontational approach to reduce the consumption of fossil fuels, a more effective method of generating renewable energy can be attained by the implementation of alternative policy instruments, such as fee bates and subsidized loans for green energy power stations.

The most densely populated states want to accelerate their development in order to maximize their revenue. On the other hand, economic expansion takes advantage of natural resources, with the overall impact being more influenced by the size of the economy rather than specific structural or technological factors. Therefore, economies should priorities the use of renewable resources and focus on increasing income levels. This inquiry proposes the incorporation of sustainable energy on a large scale into the energy mix to effectively manage natural resources and regulate the urbanization model for a more environmentally friendly future. The results clearly demonstrate that green energy decreases dirty energy use. Therefore, in light of the increasing economic status, it is advisable to allocate more funds towards the development of sustainable energy. Renewable energy is the most practical alternative for achieving socio-economic and ecological sustainability because energy has a direct correlation with three levels of sustainable development. Minimizing the negative effects of urbanization and guiding its course in a desirable manner is crucial through the utilization of contemporary technology and recording methods. Implementing and documenting urbanization policies can serve as an effective approach to reduce overall energy use and transition towards renewable energy sources.

The influence of positive shocks in Information and Communication Technology (ICT) on carbon dioxide (CO2) emissions differs from that of negative shocks. Therefore, authorities should consider both positive and negative shocks in ICT when formulating regulations connected to the ICT industry and its environmental impact. While negative shocks have been found to significantly decrease CO2 emissions in many countries, promoting this policy should be avoided due to its adverse impact on various sectors and overall economic growth in selected Asian economies, despite potential improvements in environmental quality. The utilization of ICT in the majority of the chosen economies leads to a surge in CO2 emissions, indicating that the ICT industry is not ecologically sustainable. Hence, in order to enhance the environmental sustainability of this sector, our chosen Asian economies should endeavor to endorse intelligent information and communication technology (ICT) goods that facilitate the attainment of energy efficiency. Once these countries adopt smart ICT equipment to lower their intense energy consumption, the adverse environmental impacts of ICT use will diminish. Furthermore, to mitigate CO2 emissions resulting from heightened energy consumption, these nations ought to limit their reliance on non-renewable energy sources and endeavor to cultivate cleaner and more sustainable energy alternatives. ICT alone is insufficient in reducing CO2 emissions unless the energy utilized by the ICT is environmentally friendly and sustainable. Furthermore, Asian economies have the potential to enhance their industrial framework and augment economic efficacy by leveraging ICT. Hence, it is imperative for Asian governments to priorities the adoption of Information and Communication Technologies (ICTs) in order to effectively decrease CO2 emissions and promote inclusive growth. The governments of these nations should augment their Research and Development (R&D) investments, since this would facilitate the creation of Information and Communication Technology (ICT) goods that are environmentally friendly. In addition, it is imperative for the government to impose substantial levies on industries that release CO2 and other greenhouse gases throughout their production processes.

Given the significant spatial correlation in renewable energy consumption across the GCC nations, it is imperative for them to enhance collaboration in the deployment of renewable energy to foster the advancement of this sector. Furthermore, the importance of ICT in our daily lives is growing substantially. The findings of this study demonstrate that ICT has the capacity to not only transform our lives and stimulate economic growth, but also plays a crucial role in the implementation of renewable energy. Therefore, policymakers should priorities the advancement of ICT.

The political leaders of these nations should provide a conducive external environment to foster innovation in renewable energy technology, while considering the technological attributes of information and communication technology (ICT). Furthermore, governments should leverage the information dissemination capabilities of ICT to establish an internet-based knowledge sharing platform, a smart finance platform, and an information disclosure platform. These platforms will enhance the scope and reach of human capital, facilitate efficient and precise allocation of financial capital, and enhance the quantity and quality of information disclosure. Countries should actively encourage the integration and advancement of intelligent financial platforms and platforms for information disclosure. They should establish a smart and environmentally friendly financial service platform that combines financial and environmental information. This platform will ensure ample funding for activities related to innovation in renewable energy technology.

Given that trade has been observed to exert a notable adverse impact on carbon dioxide (CO2) levels when information and communication technology (ICT) is involved, it is advisable for Gulf Cooperation Council (GCC) countries with moderate to high emission levels to acquire environmentally friendly technologies through imports in order to mitigate emissions. In general, information and communication technology (ICT) has positive effects on the environment in developing countries. It is advisable for households, businesses, and financial institutions to incorporate ICT into their economic activities, in addition to implementing energy-transition policies, in order to decrease overall emissions.

Trade policies aimed at promoting the growth of renewable energy should take into account the economic development level. In order to sustain a long-term free trade policy, GCC countries need to incorporate a greater proportion of renewable energy sources into their energy mix. This can be accomplished by increasing the amount of commerce and decreasing trade tariffs. Developing nations should priorities the increased utilization of renewable energy sources and the adoption of renewable energy technologies in their manufacturing processes. Furthermore, in order to optimize the advancement of renewable energy, it is imperative for governments to foster economic growth and enhance investment in research and development. Promote and incentivize researchers to investigate technology pertaining to renewable energy.

The findings of this thesis confirm that the growth of renewable energies, specifically in GCC countries, necessitates efficient and proactive policies that enhance the quality of governance. This will serve as a fundamental basis for a novel economic model that is free from carbon emissions, guaranteeing the welfare of individuals and diminishing disparities. These policies may include both regulatory and finance policy tools. First and foremost, it will be crucial for these countries to enhance the regulatory framework in order to effectively manage energy demand and stimulate investments in energy efficiency. Local governments should establish a well-defined plan, financial benefits, and actively encourage authentic collaborations between the public and private sectors to create and execute renewable energy initiatives.

Furthermore, a significant and fundamental transformation in the economic structure is necessary to bolster governmental initiatives aimed at enhancing environmental quality and individual welfare. To enhance the quality of the environment, it is necessary to replace fossil fuels and introduce a variety of clean and renewable energy solutions. Enhancing the quality of institutions is crucial for bolstering political determination to address climate change. Likewise, enhancing collaborations at the regional and global scale through external funding would enable the development of specialized knowledge and the sharing of exemplary methods.

Furthermore, the location where the national political community's actions have the greatest positive impact on investment in renewable energy. To be more exact, it is necessary to focus on improving the quality of regulations and bureaucracy, enhancing control over corruption, and establishing a more democratic system. Nevertheless, in nations with ineffective institutions, it is imperative for governments to actively encourage enhanced collaborations with other global regions to facilitate the advancement of research and the transfer of technology. To achieve economies of scale that attract private sector investments, the GCC area should focus on promoting regionally integrated markets for renewable energy technology.

Finally, a well-managed carbon market, under government supervision, can have a substantial influence on the advancement of renewable technologies. The thesis proposes the active promotion of the carbon market as a strategy to stimulate the advancement of green technologies. By offering financial assistance to businesses in managing price fluctuations, we can enhance the profitability of investments in renewable energy and encourage additional technological progress. The establishment of carbon financing instruments is essential for enhancing the green market and promoting collaboration between financial institutions and green firms. Policy-makers should promote the development and use of such tools to support the efficient allocation of funds towards new and environmentally friendly technology. The thesis suggests providing financial incentives for reducing emissions in places with lower carbon intensity, in order to promote technical innovation. This incentive aims to stimulate businesses and industry in certain regions to proactively allocate resources towards renewable energy solutions. Strong public-private partnerships are necessary for the successful implementation of these programmers. Governments should proactively collaborate with private financial entities, such as venture capital firms and angel investors, to combine resources and experience in promoting renewable innovation. Regular and systematic monitoring and evaluation of the policy's impact are crucial. Periodic evaluations will provide essential modifications and guarantee the efficacy of the strategy in promoting the advancement of renewable energy. The findings also emphasize the significance of acquiring further financial development index (FDI) in Gulf Cooperation Council (GCC) economies, as FDI enhances management competencies and encourages the adoption of advanced, energy-efficient technologies. Furthermore, the enhancement of economic development necessitates the reestablishment of macroeconomic stability. The rise in financial development index (FDI) will lead to the flourishing of energy-efficient manufacturing and consumer goods in developing Asian nations.

6.3 Limitation and Future studies

This thesis is constrained by the unavailability of data for all GCC economies. Additionally, the research is inadequate for comparing the different economies of the GCC. This illustrates the constrained theoretical significance and influence it has had. Taking these factors into consideration will enhance the generalizability, empirical and theoretical rigor, and practicality of policy ideas. Due to these restrictions, the theoretical significance and influence of our findings have been restricted. In the absence of a comprehensive dataset, our findings and recommendations may fail to encompass the intricacies and subtleties inherent in each GCC economy, potentially resulting in oversights or mistakes. As a result, it is difficult to make general conclusions that can be applied to the entire GCC region or to provide specific policy recommendations for individual countries.

Nevertheless, this assessment approach tends to overlook specific instances in each country to some degree. Future research should focus on exploring the variability of specific cases within certain countries.

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