

CAPITAL UNIVERSITY OF SCIENCE AND
TECHNOLOGY, ISLAMABAD



**Nexus between Financial
Development, Economic Growth
and Renewable Energy
Consumption: An Updated
Solution to an Old Quest**

by

Asma Amin

A thesis submitted in partial fulfillment for the
degree of Master of Science

in the

Faculty of Management & Social Sciences
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*I want to dedicate this achievement to my parents, teachers and friends who
always encourage and support me in every crucial time*



CERTIFICATE OF APPROVAL

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Praise be to God, the Cherisher and Sustainer of the worlds. All thanks to Almighty **Allah**, The Lord of all that exist, who bestowed me with His greatest blessing i.e. knowledge and Wisdom to accomplish my task successfully. Thousands of salutations and benedictions to the Holy prophet **Hazrat Muhammad (PBUH)** the chosen-through by whom grace the sacred Quran was descended from the Most High.

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Abstract

The aim of the study is to investigate the indirect effect of renewable energy consumption between financial development and economic growth as none of the studies tested the indirect effect of renewable energy consumption. The sample includes 161 countries out of the total 266 countries and these countries are selected based on data availability. Annual panel data of all these countries is used in analysis ranging from the period of 1990 to 2022. All the data is collected from World Development Indicators. To capture the indirect effect present study employed Structural equation modeling and further for robustness check Generalized methods of moments is used. The findings reveal that financial development has a negative impact on economic growth and renewable energy consumption. Renewable energy consumption is also found to be negatively related with economic growth. Further it is also found that renewable energy consumption mediates the relationship between financial development and economic growth. The study has practical implications based on the results as it is suggested that governments should focus renewable energy consumption and work on its development along with financial development in order to achieve economic growth in the long term.

Keywords: Financial Development, Renewable Energy Consumption, Economic Growth, World Bank, Generalized Methods of Moments, Structural Equation Modeling.

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Abbreviations

EG	Economic Growth
ER	Exchange Rate
FD	Financial Development
GDP	Gross Domestic Product
GMM	Generalized Methods of Moments
INT	Interest Rate
REC	Renewable Energy Consumption
SEM	Structural Equation Modeling

Chapter 1

Introduction

[Kuznets \(1973\)](#) defined economic growth as the country's development in providing goods to the people and meeting all the demands. This improvement is based on the development in technology and the changes in institution and ideas. According to literature [Goldsmith \(1969\)](#) was the first to explore the linkage between development of financial sector and economic growth for 35 countries. His main focus was on the proportion of assets held by financial institutions relative to country's economic performance. The economic development within a country also influences renewable energy consumption.

It's widely understood that both producing and using renewable energy are crucial for the economy and the environment. Understanding how consumption of clean energy consumption is connected to economic growth and how it is important for shaping the policies for environment and energy. Many studies in the literature have explored this relationship, looking at various countries, time periods, variables, and using different methods of analysis. However, there is no agreement among these studies on the results, as they suggest different directions of causality. Yet, knowing the type of connection among clean energy use and economic growth is essential for making effective policy decisions. The association between renewable energy consumption and economic growth can be understood through four hypotheses, each has important suggestion for the policies of energy.

First hypothesis is Growth that says the variation in energy usage leads to change in gross domestic product. In simpler terms, rise in the consumption of energy

positively influences economic growth. Second is conservation hypothesis that suggests decrease in consumption of energy may or may not influence economic growth. Additionally, it supports the idea that if the real GDP of country increases it would lead to a rise in consumption of energy. Third is feedback hypothesis and it proposes a two-way relationship between energy consumption and economic growth. It means that both will mutually influence each other. Saving energy negatively influences economic growth, and decrease in GDP also has a negative influence on energy usage. It implies a reciprocal relationship. Fourth is the neutrality hypothesis, that says there is no association between consumption of energy and economic growth. In simple terms, changes in consumption of energy doesn't impact economic growth. This implies that either energy consumption increases or decrease it will have no influence on economic growth (Ocal & Aslan, 2013). These hypotheses help to understand how alterations in energy consumption and economic growth may be related and have implications for making decisions in energy policy.

Energy has been the main focus of researchers and scholars in recent years because of the increase in its demand in recent years and is still increasing. Energy is the most important element that is used in manufacturing goods and services. Countries need energy for growth and improvement of lifestyle. This is because the population is growing, factories are developing, and countries want to be more competitive economically (Eren, Taspinar, & Gokmenoglu, 2019). The strong interest of big economic powers in securing access to energy-rich areas worldwide shows that energy will continue to be a significant priority in the future. Energy use is dependent on the stage at which the country is in terms of development. The huge demand of energy consumption can also slow down the growth of the economy. As some fast-growing Asian economies didn't have enough energy because of this huge increase in consumption, and this created big problems for their development plans (Fan & Hao, 2020).

International Energy Agency predicted that from 2005 to 2030, the world's need for primary energy would increase by approximately 1.8% each year. Developing economies were expected to be responsible for 74% increase in demand of energy worldwide during that period. According to International Energy Agency (IEA,

2022) 66% of the whole demand of energy is fulfilled from fossil fuel resources. Burning of fossil fuel is responsible for the release of carbon dioxide (CO₂) in the environment. This contributes to adverse environmental consequences such as global warming. Panwar et al. (2011) reported that over the past two centuries, worldwide CO₂ emissions have surged by 31%, and the Earth's average temperature increases by 0.4–0.8 °C during the past century. Fossil fuel usage in daily life, the significant emissions of smoke from factories, and the use of wood as an energy source have important environmental implications. These emissions badly effect the economy and various sectors like agriculture and forestry (Shahbaz, Loganathan, Zeshan, & Zaman, 2015).

Combustion of fossil fuels is mainly responsible for the carbon dioxide emissions (Pilatowska, Geise, & Włodarczyk, 2020). The worst effects on environment caused by global warming and greenhouse gases made people worry about using fossil fuels. This results in, renewable energy sources becoming a pivotal element in the global energy consumption. Clean energy sources are beneficial in diminishing carbon dioxide pollution and play significant role in protecting the environment (Ocal & Aslan, 2013). Transition from fossil fuels to renewable energy sources also reduces the dependence on Organization of the Petroleum Exporting Countries (OPEC) make less vulnerable to energy market problems. However, switching can be hard because it's expensive. It costs more to build and run the infrastructure for renewable energy. To make this transition smoother, a strong financial system is needed that can provide funding, make sure there's enough money in the market, and manage risks (Eren et al., 2019). That's why developed nations tend to be more successful in shifting from coal and fossil fuels to renewable energy sources. As in 2019, New Zealand used renewable energy for 40% of its total energy consumption. Australia generated 24% of its electricity from renewables, and over 50% of South Australia's use energy generated from clean energy sources. Canada and Japan also had significant proportions of their energy mix from renewables, with 17.3% and 18.5%, respectively (Vo, Tran, & Tran, 2022).

In financially developed countries, borrowing costs are lower, and there's improved access to financial capital, enhancing transparency for both borrowers and creditors. This facilitates investment flow between nations, leading to better technology

access. As a result, there's increased demand for energy due to increased business investment and energy use. Additionally, financial development boosts investor confidence, attracting local and foreign investment for expanding plants, hiring workers, and acquiring machinery and technology. This, in turn, spurs industrial growth and the development of new infrastructure, leading to greater renewable energy consumption (Zhang & Kumar, 2011). Also financial development contributes to diversified asset allocation, creating a wealth effect which lifts businesses and increases the confidence of consumers. Therefore, financial development plays a major part in driving a country's overall development and thus influence energy consumption (Farhani & Solarin, 2017).

1.1 Theoretical Background

In the theoretical background the first theory that explains the nexus among financial development and economic growth is financial intermediation theory. Financial intermediation theory is a cornerstone of modern finance, providing insights into the role and function of financial intermediaries in the flow of funds between lenders and borrowers within an economy. This theory explores how financial intermediaries, such as banks, insurance companies, mutual funds, and pension funds, play a very important role in mobilizing savings, allocating capital, managing risks, and promoting economic growth.

Financial intermediaries transform the maturity structure of assets and liabilities, matching the preferences of savers and borrowers. For example, banks accept deposits for short time from lenders and use those funds to provide long-term loans to borrowers, such as homebuyers or businesses. By bridging the gap between short-term liabilities and long-term assets, financial intermediaries reduce liquidity risk for depositors and facilitate long-term investment for borrowers. Financial intermediaries transform the maturity structure of assets and liabilities, matching the preferences of savers and borrowers. For example, banks accept short-term deposits provided by lenders and use those funds to provide loans to borrowers, such as homebuyers or businesses. By bridging the gap between short-term liabilities and long-term assets, financial intermediaries reduce liquidity risk for depositors

and facilitate long-term investment for borrowers. Financial intermediaries help overcome information asymmetry between savers and borrowers by leveraging their expertise, reputation, and access to information. Intermediaries have specialized knowledge of financial markets and borrowers' creditworthiness, allowing them to assess and monitor risks more effectively than individual savers. This reduces the costs of information acquisition and monitoring for savers while enhancing the efficiency of resource allocation. Financial intermediaries provide liquidity services by offering depositors the ability to withdraw funds on demand while simultaneously extending longer-term loans to borrowers. This liquidity transformation function enhances the efficiency of financial markets by allocating capital to productive investments while meeting the short-term liquidity needs of savers. Central banks also play a crucial role in providing financial support to financial intermediaries during financial stress periods.

Financial intermediaries also involved in maintaining financial stability by mitigating risks, managing liquidity, and allocating capital efficiently. However, their interconnectedness and exposure to systemic risks can also pose challenges to financial stability, as demonstrated during periods of financial crisis. Effective regulation and supervision are essential for maintaining stability and strength of financial intermediaries and the broader financial system. Financial intermediaries facilitate access to finance for individuals, businesses, and governments by providing a wide range of financial products and services, such as loans, mortgages, insurance, and investment funds. Access to finance promotes economic growth, entrepreneurship, and poverty reduction by enabling productive investments, consumption smoothing, and risk management. Financial intermediation theory suggests that well-functioning financial intermediaries can contribute to economic development by mobilizing savings, allocating capital to productive investments, and fostering innovation and entrepreneurship. Countries with efficient and inclusive financial systems tend to experience higher levels of investment, employment, and income growth, leading to overall improvements in living standards and welfare.

The second theory that explains the association between development in financial sector and renewable energy consumption is technological innovation theory.

Technological innovation theory explores the role of innovation in driving economic growth, productivity improvement, and societal progress. This theory posits that technological advancements play a very important role in shaping the trajectory of economic development by fostering innovation, entrepreneurship, and the implementation of new technologies.

At the heart of technological innovation theory is the recognition that technological change is a primary driver of economic growth. Technological advancements lead to improvements in productivity, efficiency, and competitiveness across industries, driving increases in output, income, and living standards over time. Innovations such as the steam engine, electricity, the internet, and biotechnology have transformed economies and societies, creating new opportunities for growth and development. Technological innovation theory draws on the insights of economist Joseph Schumpeter, who emphasized the crucial role of entrepreneurs in making economy better by introducing new products, processes, and business models. Schumpeterian entrepreneurship involves the process of creative destruction, where entrepreneurs disrupt existing industries and markets by introducing innovations that replace outdated technologies and practices. This process of creative destruction creates opportunities for new entrants, fosters competition, and spurs innovation-driven growth. Technological innovation theory also considers the diffusion of innovations within economies, whereby new technologies are adopted, adapted, and disseminated throughout society. The diffusion process follows an S-shaped curve, starting slowly, accelerating as adoption spreads, and eventually reaching saturation as the technology becomes widely adopted. Factors influencing the diffusion of innovations include the characteristics of the innovation itself, the social and economic context, and the actions of early adopters and opinion leaders. Technological innovation theory recognizes the presence of feedback mechanisms and network effects that amplify the impact of innovation on economic growth. Positive feedback loops can occur when innovations lead to productivity gains, cost reductions, and increased demand, stimulating further investment in research and development and fostering a virtuous cycle of innovation-driven growth. Additionally, network effects, where the value of a technology increases with the number of users, can accelerate the adoption and diffusion of innovations, leading to rapid

expansion of markets and industries. Technological innovation theory highlights the potential of innovation to address environmental problems, such as climate change, resource depletion, and social inequality. Sustainable development goals, such as clean energy, environmental conservation, and inclusive growth, can be advanced through technological innovations that promote resource efficiency, renewable energy adoption, and social innovation. Innovations in areas such as clean technology, circular economy, and social entrepreneurship contribute to sustainable development outcomes.

The third theory that explains the link between clean energy consumption and economic growth. The Environmental Kuznets Curve (EKC) theory is an economic hypothesis that suggests a non-linear relationship between environmental degradation and economic development. This theory's name was taken from the economist Simon Kuznets, who suggested a similar curve for income inequality, the EKC theory posits that environmental quality initially effected as countries grow and economies industrialize but then it gets better as income levels rise and societies prioritize environmental protection. The Environmental Kuznets Curve theory suggests that during the early stages of economic development environmental degradation is worse as countries industrialize and urbanize.

During this phase, economic growth is typically accompanied by increased pollution, resource extraction, and environmental stress as industries expand, energy consumption rises, and natural habitats are degraded to meet growing demand for goods and services. As economies progress and income levels rise, the theory posits that societies become increasingly concerned about environmental issues and prioritize environmental protection measures. Higher incomes enable individuals and governments to invest in cleaner technologies, environmental regulations, and conservation efforts, leading to improvements in environmental quality and resource management over time. The Environmental Kuznets Curve theory emphasizes the role of structural changes in the economy, such as shifts from agriculture and manufacturing to services, in influencing environmental outcomes. As economies transition from resource-intensive industries to knowledge-based and service-oriented sectors, they may experience reductions in pollution intensity, resource use, and environmental impact per unit of output. Technological innovation

and policy interventions have a very important role in shaping the trajectory of the Environmental Kuznets Curve. Investments in research and development. Additionally, regulatory measures, such as emissions standards, pollution taxes, and environmental permits, can incentivize firms to adopt cleaner production methods and internalize environmental costs. The Environmental Kuznets Curve theory underscores the importance of technological innovation in driving environmental improvements and green growth. Policies that support research and development, technology transfer, and innovation ecosystems can stimulate the development and adoption of clean technologies, sources of renewable energy, and resource-efficient practices, leading to more sustainable and resilient economies.

1.2 Problem Statement

Although many researchers have studied the association between financial development, economic growth and clean energy consumption but the results of these studies are inconclusive (Komal & Abbas, 2015; Shahbaz et al., 2015; Salman & Atya, 2014; Vo et al., 2022; Fan & Hao, 2020; Arouri, Youssef, M'henni, & Rault, 2012). A paper written by Eren et al. (2019) also explored the nexus between these variables and provided a model. In this research we will explain that model and extend Eren et al. (2019) work by concluding the results regarding the association between financial development, economic growth and renewable energy consumption. Secondly none of the studies examined this nexus by collecting data from all type of countries. As previous studies have only focused on particular regions so to get the reliable information and complete picture of the relationships the study collected data from all regions. Thirdly none of the studies tested this relationship using mediation analysis that either these variables which depends on each other mediates each other or not. Lastly none of the studies used SEM technique to test this nexus.

1.3 Research Questions

Following questions are addressed in this research:

- What is the impact of financial development on economic growth?
- What is the impact of financial development on renewable energy consumption?
- What is the impact of renewable energy consumption on economic growth?
- Does renewable energy consumption mediate the relationship between financial development and economic growth?

1.4 Research Objectives

Below are the objectives for this research:

- To investigate the impact of financial development on economic growth.
- To investigate the impact of financial development on renewable energy consumption.
- To investigate the impact of renewable energy consumption on economic growth.
- To investigate mediating effect of renewable energy between financial development and economic growth.

1.5 Significance of the Study

This research provides valuable information into the interconnected dynamics of financial development, economic growth and clean energy consumption. The study can contribute to the achievement of SDGs, particularly those related to cheap and green energy, economic growth, and industry, innovation, and infrastructure. Findings from the study can provide understanding to policymakers about the importance of financial development in increasing clean energy consumption and fostering economic growth. This knowledge is crucial for the development and implementation of policies that support a sustainable and resilient energy future. Investors and financial institutions can benefit from insights into how financial development impacts clean energy projects and influences economic growth. This understanding can guide investment decisions, risk assessments, and portfolio management in the context of clean energy investment. As the world shifts towards a

low-carbon economy, the study can contribute to the discourse on green finance. Understanding how financial development fosters technological innovation in the renewable energy sector is crucial for identifying pathways for sustainable and environmentally friendly economic growth. The study can provide insights into how countries can strategically position themselves in the global arena by embracing sustainable and innovative energy solutions. The study adds to the academic literature by providing a clear understanding of relationships between financial development, economic growth, and renewable energy consumption that are very complex. It can provide a foundation for future research and discussions on sustainable development and energy transition.

1.6 Study Scheme

The further study is organized as follows; Chapter 2 comprises the literature review for the research and the hypotheses. Chapter 3 encompasses the methodology, description of the variables and data. Chapter 4 incorporates the results and discussion. Chapter 5 incorporates conclusion, recommendations, limitations of the current study and also the direction of the future research.

Chapter 2

Literature Review

Certainly, one of today's biggest issues of the modern world is global warming. Human activities, especially energy consumption, are recognized as primary contributors to this climate change. Energy is the most important element for the production of goods, services which in turn contributes to the economic growth. Most of the energy demand is fulfilled through the combustion of fossil fuels and because of its impact on the environment renewable energy emerges as a key determinant to reduce environmental pollution.

Development in the financial institution and financial markets requires energy and this development also promotes economic growth. This shows that renewable energy consumption, economic growth and financial growth are all interlinked with each other. Studies conducted in different parts of world also verified interrelationship between these variables. Existing literature tries to study the nexus between financial development, renewable energy consumption and economic growth and for that purpose the literature is divided in to six parts. The first part explains the nexus between financial development and renewable energy consumption. Next part deliberates the connection between financial development and economic growth. Third part explores growth-renewable energy nexus Fourth part studies the nexus between renewable energy and economic growth. Fifth part examines the mediating role of renewable energy between financial development and economic growth. Lastly sixth part explores the mediating role of economic growth between financial development and renewable energy.

2.1 Financial Development and Renewable Energy Consumption

Traditionally factors like trade openness, urbanization, and industrialization have been considered important determinants of energy consumption (Li & Lin, 2015; Koengkan, 2018; Lv & Wu, 2019) but the recent studies suggest financial development as a significant factor that can influence energy consumption. Financial development is referred as “the development of the size, efficiency and stability of financial markets along with increased access to the financial markets” (Guru & Yadav, 2019). Financial development is the progress in the financial industry including heightened activity within the banking sector and increased trading and investment in stock and bond markets (Pradhan, Arvin, Nair, Bennett, & Hall, 2018). Financial development is gaining recognition for its impact on energy usage (Ma & Fu, 2020). The advancement of financial systems within a nation can lead to several transformations, such as decreased financial uncertainties and lower borrowing expenses, enhanced transparency in relationships between lenders and borrowers, increased availability of financial resources, cross-border investment opportunities, and the availability of energy saving products and the technologies. All of these factors can influence energy consumption and also manage fixed investments of business (Sadorsky, 2010). Sadorsky (2011) highlighted that financial development influence energy consumption by three ways. Firstly, a well-developed financial system allows people to borrow money more easily and at lower costs, encouraging them to buy things like cars, machines and other appliances, which increases the usage of energy in an economy. Secondly, a modernly developed financial system can offer businesses with low-interest loans through various channels, encouraging them to produce more goods and expand their operations, indirectly leading to higher energy consumption. Lastly, at a broader level, the stock market, an essential part of financial development, seen as an indicator of economic situations. A lively capital market boosts the trust of consumers and investors, leading to increased activity in the economy and energy usage.

Because of the impact of combustion of fossil fuels to meet the demand of energy consumption renewable energy consumption emerges as a key determinant

to reduce environmental pollution. Advancement in the finance sector notably influence consumption of clean energy. As projects in renewable energy sector are associated with high expenses, heavy initial investments, prolonged payments of debt, and continual investments in research and development, financial sector development emerges as a key determinant in the adoption of renewable energy (Somntag-O & Usher, 2004).

Many research studies suggest that the growth in the finance sector plays a very important role in advancing clean energy industry and boosting the demand for clean energy. These studies argue that strong financial institutions can provide affordable loans for projects related to renewable energy. Also, a well-developed stock market can efficiently channel funds towards environmentally friendly industries, encouraging the development and use of clean energy (Lahiani, Mefteh-Wali, Shahbaz, & Vo, 2021; Chang, 2015; Anton & Nucu, 2020). Growth in financial sector is crucial for the transformation from traditional energy sources to clean energy sources (Vo et al., 2022). A well-established financial system efficiently supports the renewable energy industry by facilitating credit flow. Conversely, an underdeveloped financial system hinders the emergence of new projects, despite existing demand.

Although the studies regarding the development in financial sector and clean energy are limited but some past studies like (Brunnschweiler, 2010) test the effect of development in financial industry on clean energy usage. He used a sample of 119 non-Organization for Economic Cooperation and Development countries in his study and reported significant positive association between the variables. Another study assessed the influence of development in financial sector on renewable energy progress using a GMM technique. The results indicated a positive significant effect of financial development on clean energy consumption (Omojolaibi, 2016). Wu and Broadstock (2015) stated that Institutional quality and financial sector development both have a direct effect on clean energy use in 22 countries having emerging economies. Lin, Omoju, and Okonkwo (2016) directed a study in China that supported a significant positive effect of financial sector development on clean energy consumption. Eren et al. (2019) also supported the idea that financial development influences clean energy consumption. Another study on the data of

137 countries to test the impact of financial capital on diverse energy type concluded that in wealthy nations strong financial support encourages the transition to cleaner, renewable energy. Additionally, both local private debt instruments and private loans from bank were identified as factors that boosts clean energy consumption. Stock market development influences clean energy consumption (Kutan, Paramati, Ummalla, & Zakari, 2018). Another study also confirmed the positive influence of financial development on clean energy consumption in Gulf Cooperation Council nations (Wu & Broadstock, 2015). Anton and Nucu (2020) confirmed that financial sector development influences clean energy consumption in 29 countries that are the members of European union. Research conducted in 15 renewable energy consumption nations confirmed that development in financial industry increases power consumption (Raza et al., 2020). A study on how the quality of governance influences the nexus between using green energy, development in financial sector, and performance of the economy in 123 countries spanning five continents verified a two-way relationship between using sustainable energy and financial development. However, in Middle East and North Africa (MENA), Sub-Saharan Africa (SSA), and America, the study indicated a unidirectional causality. (Khan, Khan, & Binh, 2020) confirmed positive relationship amid development in financial sector and green energy consumption.

Also, a well-developed stock market can efficiently channel funds towards environmentally friendly industries, encouraging the development and use of clean energy (Lahiani et al., 2021; Chang, 2015; Anton & Nucu, 2020). Growth in financial sector is crucial for the transformation from traditional energy sources to clean energy sources (Vo et al., 2022). Some studies also reported negative association among financial sector development and sustainable energy usage. Study by Ankrah and Lin (2020) in Ghana using vector error correction model reported that development in financial sector weakens sustainable energy usage. It is also emphasized that financial development is negatively associated with sustainable energy usage in Nigeria (Saibu & Omoju, 2016). A study carried out in Russia explored the connections among development in financial sector, economic growth, clean energy usage. Study found none evidence supporting the concept that the green energy consumption causes an impact on financial sector development.

TABLE 2.1: FD-REC Nexus

Author	Period	Countries	Methodology	Findings
Brunnschweiler	1980-2006	Non-OECD countries	Generalized least squares Generalized methods of moments	Development in financial sector positively influences green energy.
Hassine and Har-rathi	1980-2012	Gulf cooperation council countries	Panel cointegration approach	Development in financial sector of the country has a positive influence on green energy consumption.
Lin et al.	1980-2011	China	Johansen cointegration technique and VEC model	Unidirectional causality from FD to REC.
Vo et al.	1971-2020	11 CPTPP countries	Granger causality test	Bilateral causality among FD and REC.
Eren et al.	1971-2015	India	DOLS estimation Granger causality test under VECM	Unidirectional causality that runs from FD to REC.
Dimnwobi et al.	1981-2019	Nigeria	ARDL	Development in financial sector encourage transition towards clean energy.
Wu and Broadstock	1990-2010	22 emerging countries	Generalized method of moments	FD promotes REC.

Continued Table 2.1: FD-REC Nexus

Author	Period	Countries	Methodology	Findings	
Omojolaibi	1980-2008	Nigeria	Generalized method of moments	Positive impact of FD on REC	
Saibu and Omju	1981-2011	Nigeria	VEC model	FD negatively effects REC.	
Ankrah and lin	1980-2015	Ghana	VEC model	FD reduces REC.	
Kutan et al.	1990-2012	China, Africa, Brazil	South India,	Panel econometric techniques	Development in stock market influences REC.
Raza et al.	1997-2017	Top 15 REC countries	PSTR model	FD positively influences REC.	
Khan et al.	1980-2018	192 countries	Panel root test Cointegration Panel quantile regression test	FD positively influences REC.	
Anton and Nucu	1980-2017	European countries	union	Generalized methods of moments	Development in financial sector positively influences clean energy usage.

2.2 Financial Development and Economic Growth

[Kuznets \(1973\)](#) defined economic growth as the country's development in providing goods to the people and meeting all the demands. This improvement is based on the development in technology and the changes in institution and ideas. According to literature [Goldsmith \(1969\)](#) was the first to investigate the linkage among development of financial sector and economic growth for 35 countries. His main focus was on the proportion of assets held by financial institutions relative to country's economic performance. He believed the efficiency of financial industry operation is dependent on the size of financial industry. In the findings the author didn't conclude the causal relationship. Financial sector significantly influences the economic development of the nation ([Salman & Atya, 2014](#)).

According to literature development in financial industry fosters growth in the economy through two channels accumulation of capital and total factor productivity ([S. M. Ahmed & Ansari, 1998](#)). Financial intermediaries have a very important part in the growth of economy by assisting the effective distribution of money to its most productive purposes ([Levine, 1997](#)). Deregulation of financial market is linked to strong economic growth. The endogenous growth theory demonstrates that development in financial sector significantly influences long-term economic growth via its effect on services provided by finance industry and technological innovation ([Fung, 2009](#)).

Financial systems play a crucial role in enabling trading, risk management, resource allocation, managerial oversight, corporate control, aggregate savings, and facilitation of goods and services exchange ([Levine, 1997](#)). This leads to increased Foreign Direct Investment (FDI), vitality in stock and banking markets, a favorable legal environment, and access to local loans for the private sector. Thus, well-developed financial market contributes positively to economic growth. Economic development is stimulated by stock market expansion, advancements in the banking sector, greater domestic and foreign direct investments, financial deregulation through liberalization. These factors collectively contribute to promoting

economic growth. Banks have an important influence in fostering economic growth in the initial phases of development in the economy and in limited institutional support (Levine, 1997).

A study reported significant positive association among development in financial industry and growth in the economy (King & Levine, 1993). A study by (Agbetsiafa, 2004) confirmed a positive nexus among development in financial sector and growth in the economy in South Africa, Togo, Zambia, Ghana, Nigeria, Senegal, but negative association was found in Cote d'Ivoire and Kenya. A study conducted in India, Bangladesh and Pakistan using Granger causality test found significant positive association among development in financial industry and economic growth and reported that financial development causes economic growth (S. M. Ahmed & Ansari, 1998).

Research conducted by (De Gregorio & Guidotti, 1995) using OLS regression method in 98 countries supported that development in finance contributes to the growth in the economy of the country but this association changes with region, income level and time period. This association is stronger in middle- and low-income countries. Also, in the absence of adequate regulation financial development slows down economic growth. Beck and Levine (2004) examined this relationship in 13 European countries using OLS regression and GMM technique. Findings revealed that growth in the economy is stimulated via banks as well as stock market. A study conducted by Rioja and Valev (2004) confirmed that financial development impacts economic growth.

A study reported that development in financial sector fosters growth in the economy of the country, material asset accumulation and also improves economic effectiveness (King & Levine, 1993). An investigation regarding finance-growth nexus conducted by (Boulila & Trabelsi, 2004) in 16 MENA countries reported that the real economy influences the development in financial sector. Another research in 2008 supported a bidirectional relationship among development in financial sector and economic growth (Abu-Bader & Abu-Qarn, 2008). Shan and Morris (2002) reported that there is no connection between financial sector development and growth in the economy in China and 19 OPEC countries.

TABLE 2.2: FD-EG Nexus

Author	Period	Countries	Methodology	Findings
Ibrahim and Alagidede	1980-2014	Sub-Saharan African countries	Sample splitting, Threshold estimation approach	For long term growth FD is necessary.
Hassine and Harrathi	1980-2012	GCC countries	Panel cointegration technique	FD reduces EG.
Komal and Abbas	1972-2012	Pakistan	System Generalized methods of moments	FD influences EG
Vo et al.	1971-2020	CPTPP countries	Panel cointegration approach	Bilateral causality exists between FD and EG.
Sehrawat et al.	1971-2011	India	ARDL technique Co-integration Error correction method Vector error correction model	One-way relationship exists that runs from ED to EG.
Kassi et al.	1971-2011	Cote d Ivoire countries	VECM model ARDL technique	In the long run unidirectional relationship exists between FD and EG.
Hao et al.	1995-2014	China	VAR approach	FD has a negative impact on GDP.
Salman and Atya	1980-2010	North Africa	Error correction approach	FD and EG have a significant positive relationship in Algeria.
Mahalik and Mallik	1971-2009	India	Granger causality technique ARDL technique	FD doesn't promote EG.
Cao et al.	1980-2018	South Asian countries	ARDL technique	FD has a significant and positive influence on EG.
Rafinadi and Ozturk	1970-2012	Japan	ARDL technique	FD positively impacts EG.

Continued Table 2.2: FD-EG Nexus

Author	Period	Countries	Methodology	Findings
Usman et al.	1991-2019	Asia	Johanasen cointegration technique VEC model Granger causality test DSUR model	Bidirectional relationship exists between FD and EG.
Guru and Yadav	1993-2014	BRICS countries	GMM technique	FD has a strong and positive association with EG.
Bojanic	1940-2010	Bolivia	Granger causality test	One-way relationship exists from FD to EG.
Ahmed	1981-2009	Sub Saharan african countries	Error correction model System Generalized methods of moments	Negative association between FD and EG.
Khan et al.	1971-2004	Pakistan	ARDL approach, Error correction model	Results showed that positive association exists among financial development and economic growth.
Rufael	1966-2005	Kenya	VAR technique	Bidirectional causality exists among financial development and economic growth.
Anwar and Sun	1970-2007	Malaysia	TodaYamamoto Dolado Lutkephol causality test Generalized methods of moments technique	Level of financial development influence the capital stock which impacts economic growth.

Continued Table 2.2: FD-EG Nexus

Author	Period	Countries	Methodology	Findings
Ahmed and Ansari	1973-1991	Asian countries	Granger causality technique	Results indicated that financial development leads to economic growth.
Wu et al.	1976-2005	13 European countries	Panel unit root test	In long run development in financial sector negatively impact economic growth.
Beck and Levine	1976-1998	40 countries	Pooled mean group method Ordinary least square method	Development in stock market and banks encourage economic growth.
King and Levine	1960-1989	80 countries	Generalized methods of moments approach Correlation analysis	Increase in financial development of a country increases economic growth.
Ang	1960-2003	Malaysia	Ordinary least square method ARDL approach	Results revealed that there is a two-way relationship among development in financial sector and economic growth.
Gregorio and Guidotti	1960-1985	98 countries	Unrestricted error correction model Dynamic ordinary least square method Ordinary least square method	In middle- and low-income countries development in financial sector encourages economic growth.

2.3 Renewable Energy Consumption and Economic Growth

Energy is crucial for both the rise and development of the economy. Energy is considered as the driving force behind the progress of industries and overall economy (Usman, Rasheed, Mahmood, Riaz, & Bashir, 2023). It is indicated that the energy usage relies on the phase of development of the economy of the country. Nations growing rapidly consume more energy. As energy is essential for processes like industrialization, urbanization and transportation which in turn contribute to economic growth (Mahalik & Mallick, 2014). Many past studies investigated the nexus among growth of the economy and the green energy usage but studies regarding these two variables are still scarce. Research by Sadorsky (2009) in 18 emerging economies confirmed positive association among green energy consumption and earnings per capita. He reported that if income per capita is increased by 1% the green energy usage will be increased by 3.5% and also confirmed a two-way relationship among the variables. A study reported that clean energy usage influences growth in the economy. If there is a rise of 1% in green energy usage it will increase economic growth by 0.219%. Adoption of green energy positively influences growth in the economy in 85 countries (Bhattacharya, Churchill, & Paramati, 2017). A study on emerging economies confirmed positive association among green energy usage and growth in the economy. Biomass energy usage has a very important association with economic growth in G7 countries (Ozturk & Bilgili, 2015). In European Union green energy and growth in the economy are positively related to each other (Alper & Oguz, 2016).

Study by Apergis and Payne (2010) in 20 OECD nations confirmed that green energy usage and growth in the economy are positively related to each other. He further reported that both variables are also mutually related with each other. Study in, Philippines, India, China, Brazil, Indonesia, and Turkey show that green energy usage effects growth in the economy and also change in the growth of the economy leads to change in clean energy consumption (Salim & Rafiq, 2012). Koçak and Şarkgüneşi (2017) study in 9 Black Sea and Balkan nations confirmed association among green energy usage and growth. (Dumitrescu & Hurlin, 2012) also

reported the same results. [Lin and Moubarak \(2014\)](#) found a bidirectional association among sustainable energy usage and economic growth in China. [Shahbaz et al. \(2015\)](#) conducted study in Pakistan and identified a two-way association among growth in the economy and green energy usage. Another study verified that the clean energy usage and growth in the economy depend on each other, still this connection varies across countries and G7 nations. [Al-Mulali, Fereidouni, Lee, and Sab \(2013\)](#) conducted research in 85 countries and reported a two-way relationship, direct association that runs from growth in the economy to green energy usage in 3 countries, and no association in 20 countries regarding green energy usage and growth in the economy out of 108 countries ([Cho, Heo, & Kim, 2015](#)) verified a bidirectional association among green energy usage and growth in the economy in developing countries, whereas one-way relationship was found in developed nation. [Sebri and Ben-Salha \(2014\)](#) also reported a bidirectional causality in BRICS countries. Research conducted in 80 developing and developed nations reported that the use of sustainable energy, GDP are interdependent ([Apergis & Danuletiu, 2014](#)). A study by [Fang \(2011\)](#) using OLS method in China verified a unidirectional relationship between sustainable energy and economic growth. [Adams, Klobodu, and Apio \(2018\)](#) also confirmed a positive association among green energy consumption and growth in the economy in 30 Sub-Saharan African countries. He further reported that change in green energy by 10% results in 0.27% change in growth. A study on G7 countries by [Zafar, Shahbaz, Hou, and Sinha \(2019\)](#) in Asia Pacific Economic Cooperation (APEC) also supported positive association among the variables. He reported that renewable energy causes growth in the economy so, countries should concentrate more on green energy as it will promote economic growth and also beneficial for the environment. Some studies also confirmed negative association among growth in the economy and green energy. Another research discovered that green energy usage doesn't strongly influence economic growth ([Bhattacharya, Paramati, Ozturk, & Bhattacharya, 2016](#)). A study by [Ocal and Aslan \(2013\)](#) in Turkey using ARDL approach also verified negative impact of growth on green energy usage. [Maji, Sulaiman, and Abdul-Rahim \(2019\)](#) also confirmed negative association among green energy usage and growth in the economy. Lee and Jung also reported negative impact of green energy usage on growth.

TABLE 2.3: REC-EG Nexus

Authors	Period	Countries	Methodology	Findings
Hwang	1975-2018	Brazil, Chile and Argentina	ARDL approach	Unidirectional relationship exists between EG and REC.
Hassine and Har-rathi	1980-2012	GCC countries	Panel cointegration technique	REC increases the EG in Gulf cooperation countries.
Sardosky	Panel cointegration	18 emerging economies	Panel cointegration technique	Increase in GDP results in increased renewable energy consumption.
Lin and Moubarak	1971-2011	China	ARDL approach	Two-way causality exists between REC and EG.
Li and Leung	1985-2018	7 European countries	Granger causality test	One-way causality exists that is EG has an impact on REC
Vo et al.	1971-2020	11 CPTPP countries	Granger causality test	On-way causality exists that runs from EG to REC
Ocal and Aslan	1990-2010	Turkey	ARDL approach	REC negatively influences EG.
Ingelsi-Lotz	1990-2010	34 OECD countries	Panel data techniques	REC positively impact EG.
Hamit-Haggar	1971-2007	11 SSA countries	Panel unit root	REC and EG are correlated with each other.
			Granger causality test	Unidirectional causality exists that runs from REC to EG.
Tiwari	1960-2009	India	Structural VAR technique	Positive effect on REC increases GDP.
Eren et al.	1971-2015	India	Dynamic ordinary least square method	Two-way relationship exists between REC and EG.
			Granger causality test	

Continued Table 2.3: REC-EG Nexus

Authors	Period	Countries	Methodology	Findings
Adams et al.	1980-2012	30 SSA countries	Panel cointegration Panel error correction test	Increase in REC increases EG.
Chica-Olmo et al.	1991-2015	26 European countries	Spatial durbin model	Increase in 1% REC leads to increase in EG by 0.054%.
Apergis and Payne	1980-2006	USA	Panel error correction model	Bidirectional causality exists between REC and EG.
Salim and Rafiq	1980-2006	India, China, Turkey, Philippines, Indonesia, Brazil	Granger causality method	EG has an influence on REC.
Payne	1949-2006	United states	Toda Yamamoto	No relationship exists between REC and EG.
Pao and Fu	1980-2012	Brazil	Error correction technique	Bidirectional causality exists between EG and REC.
Sari and Soytas	1969-1999	Turkey	Variance	Increase in REC increases GDP.
Bowden and Payne	1949-2006	USA	Toda Yamamoto	Results verified that there is bidirectional linkage between REC and EG.
Apergis and Payne	1985-2005	20 OECD countries	Panel cointegration test	Results show that there is a two-way association between REC and EG.
Apergis et al.	1984-2007	19 Developed and developing economies	PE correction Granger causality test	Negative relationship between REC and EG.

Continued Table 2.3: REC-EG Nexus

Authors	Period	Countries	Methodology	Findings
Tugcu et al.	1980–2009	G7 countries	ARDL approach	Results showed that renewable energy consumption matters for economic growth.
Menegaki	1997–2007	27 European countries	Causality test by Hatemi-J Dynamic ordinary least square method	Increase in renewable energy consumption increases economic growth and causality runs from renewable energy consumption to economic growth.
Fang	1978–2008	China	Granger causality test OLS Model	Increase in renewable energy consumption increases economic growth.
Sari et al.	1969–1999	USA	Autoregressive Distributed Lag approach	Renewable energy positively influences economic growth. Increase or decrease in renewable energy consumption increases or decreases economic growth.
Menyah and Wolde-Rufael	1960–2007	United states of America	Granger causality test	Results indicate that one-way relationship exists and that runs from renewable energy consumption to economic growth.
Sadorsky	1980–2005	G7 countries	Panel cointegration test	Increase in Renewable energy consumption has a negative effect on economic growth.
Yildirim et al.	1949–2011	USA	Toda Yamamoto Causality test by Hatemi-J	Results showed that there is no causality between renewable energy consumption and economic growth.

Continued Table 2.3: REC-EG Nexus

Authors	Period	Countries	Methodology	Findings
Al-mulali et al	1980-2010	108 countries	Ordinary least square method	Results showed that bidirectional relationship between renewable energy and economic growth is found in 79% of the countries, no relationship in 19% of the countries and in 2% unidirectional relationship is found.
Śmiech and Pa- pież	1993 – 2011	United states of Amer- ica	Granger causality test	No association exists between renewable energy and economic growth.
Alam and Murad	1970–2012	25 Organization for economic coopera- tion and development countries.	Panel cointegration test	Economic growth has an influence on re- newable energy consumption.
Fan and Hao	2000–2015	China	Vector error correction model	Results showed that there is no influence of renewable energy consumption on eco- nomic growth.
Kasperowicz et al.	1995–2016	29 EU nations	Panel vector error correc- tion model	Results showed that relationship exists and causality runs from renewable en- ergy to economic growth
Ozcan and Oz- turk	1991–2016	17 emerging countries	Bootstrap panel causality test	No relationship exists among renewable energy and economic growth.
Amri	1990–2013	72 nations	Dynamic simultaneous equation	Two-way causality exists between renew- able energy consumption and economic growth.
Kahia et al.	1980–2012	MENA countries	PVECM	Bidirectional relationship exists between renewable energy consumption and eco- nomic growth.

2.4 Mediating Role of Renewable Energy Consumption between Financial Development and Economic Growth

Green energy has many benefits like it reduces pollution, is inexhaustible and also it is widely available. Because of its benefits countries are now working to decrease their dependence from traditional sources of energy and shift to green energy sources. The renewable energy industry requires heavy investment, especially in the beginning. The research and development of the necessary technology also face a lot of uncertainty, making the investment quite risky. Financial institutions development, including banks and investment firms, contribute to the renewable energy cause by offering specialized financial products. These may include project finance, green bonds, and other innovative instruments which promote green energy usage. Also, renewable energy usage in turn promotes growth as rise in consumption of green energy leads to the growth of this sector, which creates job opportunities and contributes to overall employment rates. This in turn stimulates economic activity and fosters innovation. Moreover, financial development also contributes to the research and development (R&D) aspect of green energy. The stock market, a component of financial development, serves as both an indicator and a facilitator of renewable energy consumption. A thriving stock market provides companies in the renewable energy sector with opportunities to raise capital through shares issuance. This capital inflow can be used to fund expansion, research, and development, contributing to the overall growth of the industry. These investments in turn influence overall growth in the economy. Financial development also extends its influence to government policies and regulatory frameworks. Financial institutions often wield significant influence on policymakers, and their support for renewable energy projects can shape the development of favorable policies. Incentives such as subsidies, tax breaks, and supportive regulatory environments are more likely to be implemented and sustained when financial institutions actively champion renewable energy initiatives. This increase in renewable energy consumption makes countries less dependent on foreign energy sources and

countries can achieve greater energy independence, leading to a more stable and resilient economy. Development in financial sector impacts green energy usage by providing access to different financing options. Institutions can offer loans or financing plans for individuals and businesses that are eager to purchase and use green energy systems i.e, solar panels or wind turbines. This ultimately increases the green energy usage and this will decrease the pollution and leave a healthier impact on public. Healthier populations are more productive, leading to increased workforce participation and economic growth. Many past studies provided evidence for the relationship among development in financial sector and green energy consumption (Brunnschweiler, 2010; Raza et al., 2020; Omojolaibi, 2016; Wu & Broadstock, 2015; Lin et al., 2016; Kutan et al., 2018; Anton & Nucu, 2020; Khan et al., 2020; Ankrah & Lin, 2020; Saibu & Omoju, 2016; Eren et al., 2019; Hassine & Harrathi, 2017; Burakov & Freidin, 2017). Also some past studies confirmed the nexus among renewable energy consumption and economic growth (Sadorsky, 2009; Inglesi-Lotz, 2016; Bhattacharya et al., 2017; Kutan et al., 2018; Ozturk & Bilgili, 2015; Alper & Oguz, 2016; Tugcu, Ozturk, & Aslan, 2012; Apergis & Payne, 2010; Salim & Rafiq, 2012; Koçak & Şarkgüneşi, 2017; Zafar et al., 2019; Dumitrescu & Hurlin, 2012; Chen, Pinar, & Stengos, 2020; Lin & Moubarak, 2014; Al-Mulali et al., 2013; Sebri & Ben-Salha, 2014; Apergis & Danuletiu, 2014; Shahbaz et al., 2015; Fang, 2011; Adams et al., 2018).

TABLE 2.4: Mediating Role of REC in FD-EC Nexus

Authors	Period	Countries	Methodology	Findings
Eren et al.	1971-2015	India	DOLS estimation	Unidirectional relationship from FD to REC.
Dimnwobi et al.	1981-2019	Nigeria	Granger causality test under VECM ARDL	Development in financial sector encourage transition towards clean energy.
Hassine and Har-rathi	1980-2012	GCC countries	Panel cointegration approach	FD has a positive influence on REC.
Lin et al.	1980-2011	China	Johansen cointegration technique and VEC model	Unidirectional causality from FD to REC.
Vo et al.	1971-2020	11 CPTPP countries	Granger causality test	Bilateral causality among FD and REC.
Raza et al.	1997-2017	Top 15 REC countries	PSTR model	FD positively influences REC.
Khan et al.	1980-2018	192 countries	Panel root test Cointegration Panel quantile regression test	FD positively influences REC.
Sardosky	Panel cointegration	18 emerging economies	Panel cointegration technique	Increase in GDP results in increased renewable energy consumption.
Lin and Moubarak	1971-2011	China	ARDL approach Granger causality test	Two-way causality exists between REC and EG.
Li and Leung	1985-2018	7 European countries		Results showed that one-way relationship exists that runs from EG to REC.

Continued Table 2.4: Mediating Role of REC in FD-EC Nexus

Authors	Period	Countries	Methodology	Findings
Bowden and Payne	1950-2006	USA	Toda Yamamoto	No relationship exists between REC and EG.
Apergis and Payne	1985-2005	OECD countries	Panel cointegration test	Results showed that two-way relationship exists between REC and EG.
Vo et al.	1971-2020	11 CPTPP countries	Granger causality test	Unidirectional causality exists that runs from EG to REC
Sari and Soytaş	1969-1999	Turkey	Variance	Increase in REC increases GDP.
Adams et al.	1980-2012	30 SSA countries	Panel cointegration Panel error correction test	Increase in REC increases EG.
Chica-Olmo et al.	1991-2015	26 European countries	Spatial durbin model	Increase in 1% REC leads to increase in EG by 0.054%.
Apergis and Payne	1980-2007	6 American countries	Panel error correction model	Bidirectional causality exists between REC and EG.
Salim and Rafiq	1980-2006	India, China, Turkey, Philippines, Indonesia, Brazil	Granger causality method	EG has an influence on REC.
Payne	1949-2007	United states	Toda Yamamoto	Results showed that no relationship exists between REC and EG.
Pao and Fu	1980-2012	Brazil	Error correction technique	Bidirectional causality exists among EG and REC.
Sari and Soytaş	1969-1999	Turkey	Variance	Increase in REC increases GDP.
Bowden and Payne	1949-2006	USA	Toda Yamamoto	Results showed that there is no association between REC and EG.

Continued Table 2.4: Mediating Role of REC in FD-EC Nexus

Apergis and Payne	1985-2005	20 OECD countries		Panel cointegration test		Results show that bidirectional relationship exists between REC and EG.
Apergis et al.	1984-2007	Developed and developing economies		PE correction causality test	Granger	Negative relationship between REC and EG.
Tugcu et al.	1980-2009	G7 countries		ARDL approach	Causality test by Hatemi-J	Results showed that renewable energy consumption matters for economic growth.
Menegaki	1997-2007	27 European countries		Dynamic ordinary least square method	Granger causality test	Results indicate that increase in clean energy consumption increases economic growth and causality runs from clean energy consumption to economic growth.
Fang	1978-2008	China		OLS method		Results showed that increase in renewable energy consumption increases economic growth.
Sari et al.	1969-1999	United states of America		Autoregressive Lag approach	Distributed	Renewable energy has a positive impact on economic growth. Increase in renewable energy consumption increases economic growth.
Menyah and Wolde-Rufael	1960-2008	USA		Granger causality test		Causality runs from consumption of clean energy to economic growth.
Sadorsky	1980-2006	G7 countries		Panel cointegration test		Increase in Renewable energy negatively influence economic growth.
Yildirim et al.	1949-2011	USA		Toda Yamamoto, Causality test by Hatemi-J		Results showed that there is no association between renewable energy consumption and economic growth.

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Continued Table 2.4: Mediating Role of REC in FD-EC Nexus

Al-mulali et al	1980-2010	108 countries	Ordinary least square method	Results showed that bidirectional relationship between renewable energy and economic growth is found in 79% of the countries, no relationship in 19% of the countries and in 2% unidirectional relationship is found.
Śmiech and Papież	1993 – 2011	USA	Granger causality test	No relationship exists between clean energy and growth in the economy.
Alam and Murad	1970–2013	25 OECD countries	Panel cointegration test	Causality runs from economic growth to renewable energy consumption.
Fan and Hao	2000–2015	China	VECM	No relationship exists between renewable energy and economic growth.
Kasperowicz et al.	1995–2016	29 EU nations	Panel vector error correction model	Results showed that relationship exists and causality runs from renewable energy to economic growth
Ozcan and Ozturk	1990–2017	17 emerging economies	Bootstrap panel causality test	No relationship exists between renewable energy and economic growth.
Amri	1990–2012	72 countries	Dynamic simultaneous equation	Results showed that bidirectional relationship exists between renewable energy consumption and economic growth.
Kahia et al.	1980–2012	MENA countries	Panel vector error correction model	Results indicate that two-way association exists between renewable energy consumption and economic growth.

2.5 Hypotheses

H1: Financial development has a significant impact on renewable energy consumption.

H2: Financial development has a significant impact on economic growth.

H3: Renewable energy consumption has a significant impact on economic growth.

H4: Renewable energy consumption mediates the relationship among financial development and economic growth.

2.6 Theoretical Framework

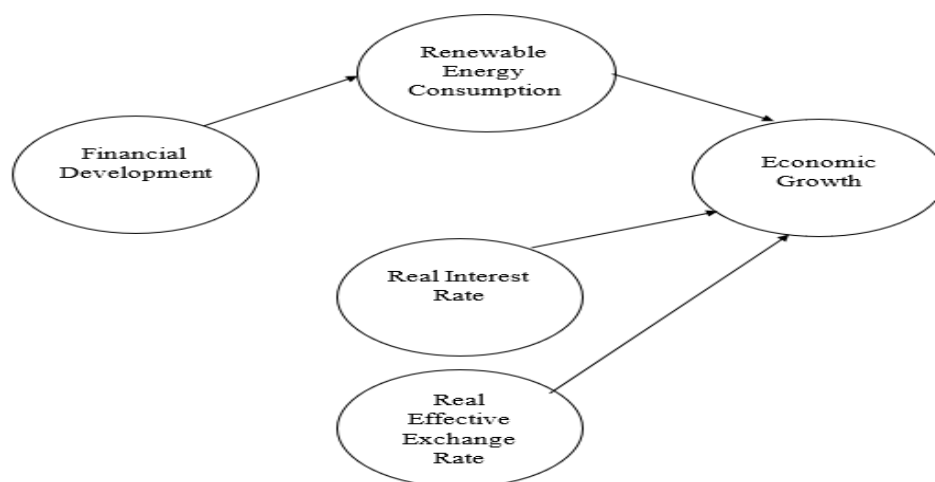


FIGURE 2.1: Research Model

Chapter 3

Research Methodology

3.1 Data

This chapter outlines the process for acquisition of data and the source through which the data was obtained. All the data that is used in the study was collected from World Development Indicator (WDI) published by World Bank.

The methodology used aims to assess the indirect effect that how financial development influence economic growth via renewable energy consumption. The study covers all the countries worldwide, containing all the different economies Developed economies, emerging economies and Developing economies.

3.2 Population

The population for this study includes all the countries worldwide.

3.3 Sample

The sample include 161 countries out of the total 266 countries reported in Table 3.1 and these countries are chosen based on data availability. Countries having non-availability of data ranging from 10-15 years of any variable are excluded. Annual data of all these countries is used in analysis ranging from the period of

1990 to 2022. These years are selected in the sample because many countries were not reporting regular data before 1990 and some countries don't even existed.

TABLE 3.1: List of Countries

Albania	Congo Rep (COG)	Hungary
Algeria	Costa Rica	Haiti
Angola	Cote d' Ivoire	Iceland
Antigua and Barbuda	Comoros	India
Argentina	Croatia	Iran
Armenia	Cyprus	Iraq
Aruba	Czech Republic	Ireland
Australia	Dominica	Italy
Austria	Djibouti	Indonesia
Azerbaijan	Denmark	Israel
Bahrain	Dominican Republic	Jordan
Bangladesh	Ecuador	Jamaica
Barbados	Equatorial Guinea	Japan
Belarus	Egypt	Kenya
Belgium	Eritrea	Kazakhstan
Belize	Darussalam	Kuwait
Benin	El Salvador	Korea
Bhutan	Eswatini	Kyrgyz Republic
Bolivia	Fiji	Latvia
Bosnia and Herzegovi	France	Lebanon
Botswana	Finland	Luxembourg
Brazil	Georgia	Lithuania
Brunei	Gabon	Liberia
Bulgaria	Gambia	Lao PDR
Burkina Faso	Germany	Lesotho
Burundi	Grenada	Libya
Cambodia	Guinea	Macao SAR, China
Cameroon	Guyana	Madagascar
Canada	Guinea-Bissau	Malawi
Cabo Verde	Ghana	Malaysia
Chile	Honduras	Mali
China	Greece	Mauritania
Central African Re- public	Guatemala	Mauritius
Colombia	Hong kong SAR, China	Micronesia, Fed. Sts.
Maldives	Rwanda	UAE
Mexico	Samoa	Uganda
Moldova	Saudi Arabia	United Kingdom

TABLE 3.2: List of Countries

Mongolia	Seychelles	United States
Morocco	Russian Federation	Uruguay
Mozambique	Senegal	Vanuatu
Myanmar	Sierra Leone	Venezuela, RB
Nepal	Singapore	Viet Nam
Namibia	Solomon Islands	Yemen, Rep.
Newzeland	South Africa	Zambia
North Macedonia	Spain	Zimbabwe
Niger	Sri Lanka	
Netherlands	St. Kitts and Nevis	
Nicaragua	St. Lucia	
Nigeria	St. Vincent and the Grenadines	
Norway	Suriname	
Oman	Sweden	
Pakistan	Switzerland	
Paraguay	Tajikistan	
Poland	Tanzania	
Panama	Thailand	
Papua New Guinea	Tunisia	
Philippines	Togo	
Peru	Trinidad and Tobago	
Portugal	Tonga	
Qatar	Türkiye	
Romania	Ukraine	

3.4 Data Sources and Measures Used

Secondary data is used in the study that is readily available for use. GDP per capita (constant 2015 US\$) is used to measure economic development. Renewable energy consumption (% of total energy consumption) is used to measure renewable energy consumption. To measure financial development different researchers uses different proxies as (King & Levine, 1993) uses M₂ but it included the currency and not captures the development of financial sector. Liquid liabilities another proxy is also used in some studies (Claessens, Demirgüç-Kunt, & Huizinga, 2001; Creane, Goyal, Mubarak, & Sab, 2006) but it only shows the financial industry size and is doesn't measure financial development completely. Unlike other measures domestic credit to private sector provides a clear picture of the actual savings provided to productive investment ventures. So, domestic credit to private sector

(% of GDP) is used to measure development in financial sector and all the data is collected from World Development Indicators (WDI) which is published by World Bank.

3.5 Variables Description

In this paper financial development is taken as an independent variable and economic growth is taken as dependent variable. To identify the indirect effect renewable energy consumption is taken as a mediator.

3.5.1 Economic Growth (GDP)

[Kuznets \(1973\)](#) defined economic growth as the country's development in providing goods to the people and meeting all the demands. This improvement is based on the development in technology and the changes in institution and ideas. Increase in the economic growth in turn increases the production of the goods and services, expansion in industries and technological advancements which results in increase in renewable energy consumption. The proxy used for measuring economic growth is GDP per capita (constant 2015 US\$).

3.5.2 Renewable Energy Consumption (REC)

Renewable energy consumption is the utilization of energy obtained from natural sources that are replenishing and sustainable over a long time period. Solar energy, wind energy and geothermal are all the sources of renewable energy consumption. Increase in the consumption of clean energy leads to an increase in long term economic growth. As it creates more jobs in the energy sector, promotes technological innovation and provide energy security ([Al-Mulali et al., 2013](#)).

3.5.3 Financial Development

Financial development impact the country in many ways. As in countries with well-developed and advanced financial system the cost of borrowing money is low.

This accessibility to affordable funds increases transparency between lenders and borrowers. These factors lead to the movement of investments between countries, facilitating access to better technology. Additionally, developed financial sectors promote cross-border investment flows and promote the use of energy-efficient products and advanced technology. These activities stimulate energy demand through increased energy consumption and business investments.

Financial growth provides cost-effective loans to producers, enabling them to acquire innovative technologies and tools. This, in turn, boosts energy consumption. Some research suggests a positive and long-term association between finance and energy, indicating a mutual influence. Other studies show that financial factors, such as the money supply and market capitalization, are connected to energy demand (Gould, Melecky, & Panterov, 2016; Law & Singh, 2014; Yang, Hui, Yasmeen, Ullah, & Hafeez, 2020; Saud, Danish, & Chen, 2018; King & Levine, 1993). Overall, financial development has a very important part in shaping a country's economic situation, influencing energy consumption, and fostering technological advancement.

3.6 Control Variables

To study the relationship between financial development, renewable energy consumption and economic growth researchers also use some control variables that may impact economic growth. So, following previous studies present study also uses some control variables.

3.6.1 Interest Rate

An interest rate is the borrowing cost of funds or the investment return on the money lend expressed as a percentage of the principal amount (Apergis & Payne, 2010). It is essentially the price of money, representing the compensation that a lender receives for allowing someone else to use their funds for a specific period. Fluctuation in interest rate influences various components of an economy, influencing borrowing, spending, investments, and overall economic activity. It is measured by lending interest rate (%).

TABLE 3.3: Source of Data and Variable Description

Variables	Description	Symbol	Unit	Source	Reference
Economic Growth	Gross domestic product divided by midyear population (GDP per capita)	GDP	Constant 2015 US\$	WDI	World development indicators. Washington, D.C.:The World Bank.
Renewable Energy Consumption	Renewable energy consumption is the share of renewable energy in total final energy consumption.	REC	Renewable energy consumption (% of total energy consumption)	WDI	World development indicators. Washington, D.C.:The World Bank
Financial Development	Financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment.	FD	Domestic credit to private sector (% of GDP)	WDI	World development indicators. Washington, D.C.:The World Bank
Real Interest rate	Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator.	INT	lending interest rate (%)	WDI	World development indicators. Washington, D.C.:The World Bank
Real Effective Exchange rate	Real effective exchange rate is the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs.	ER	Real effective exchange rate index (2010 = 100)	WDI	World development indicators. Washington, D.C.:The World Bank

3.6.2 Exchange Rate

Real exchange rate is a measure that indicates the value of one currency compared to another by taking in to account the inflation of the countries. In other words, it represents the actual purchasing power of a currency in terms of goods and services (Kıpıcı & Kesriyeli, 1997). It is measured by real effective exchange rate index (2010 = 100).

3.7 Structural Equation Modeling

Structural Equation Modeling is a statistical method that helps us understand complex relationships among different variables. Unlike simple regression models where we have clear independent and dependent variables, SEM involves a network of linked equations, forming a path diagram. In SEM, a variable can play different roles—sometimes it's like a "cause," and at other times, it acts like an "effect" depending on the specific relationships within the model. In simpler terms, while regression focuses on clear cause-and-effect relationships, SEM allows for more complexity. Variables can influence each other in various ways, creating a dynamic web of connections. This flexibility helps SEM uncover not just direct relationships but also indirect and reciprocal ones, providing insights into the causal connections within a system of variables. It integrates elements of factor analysis and many regressions analysis to test and estimate causal relationships, making it a versatile tool in various scientific disciplines, including psychology, sociology, economics, and more. SEM allows researchers to explore intricate networks of connections among observed and latent variables, providing a comprehensive understanding of underlying structures. One of the distinctive features of SEM is that it can easily handle latent variables. Latent variables are constructs that cannot be directly measured but are interpreted from observed variables. These constructs represent underlying concepts or traits that may influence or be influenced by other variables in a model. SEM enables researchers to account for the complexity of real-world phenomena by incorporating these latent variables into their analyses. SEM provides fit indices to evaluate how well the model aligns with the observed

data. Common fit indices include the chi-square statistic, Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and others. A well-fitting model indicates that the proposed relationships are consistent with the observed data, while discrepancies may suggest areas for model refinement.

Researchers often use SEM to explore and refine theories, especially when dealing with complex systems involving multiple variables. The methodology is particularly valuable when studying latent constructs such as intelligence, personality traits, or socioeconomic status. By incorporating latent variables, SEM goes beyond traditional statistical techniques, offering a more refined and overall whole understanding of the intricate interplay among variables. SEM has applications in various fields. In psychology, for example, researchers might use SEM to investigate the relationships between latent constructs like self-esteem, anxiety, and academic achievement. In economics, SEM can be employed to model the complex interactions between economic factors and outcomes. Social scientists use SEM to analyze intricate social networks and the factors influencing social behaviors.

3.8 Econometric Models

Present study employs Generalized methods of moments technique to test the nexus between financial development, renewable energy consumption and economic growth. The following economic equations are projected to investigate how financial development influences economic growth in 161 countries.

$$GDP_{it} = \beta_o + \beta_1 GDP_{it}(-1) + \beta_2 GDP_{it} + \beta_3 Int_{it} + \beta_4 ER_{it} + \epsilon_{it} \quad (3.1)$$

This is the base line model without mediator where Gross domestic product is used to measure economic growth, i represents the country and t represents the year. FD_{it} variable demonstrates the financial development of country i at year t . Int_{it} is the real interest rate of country i at year t and ER_{it} is the real exchange rate of country i at year t both of which are the other variables. Below are the paths to investigate either REC mediates the relationship between FD and economic growth:

Path a

Path a is developed to investigate either financial development influences renewable energy consumption or not and the econometric model is as follows:

$$REC_{it} = \beta_o + \beta_1 REC_{it}(-1) + \beta_2 FD_{it} + \epsilon_{it} \quad (3.2)$$

If the coefficient of financial development is significant than it means FD has a significant influence on renewable energy consumption and this satisfies the first condition of mediation. But if the results are not significant it means that REC doesn't mediate the nexus between FD and economic growth.

Path b

Under path b the influence of renewable energy consumption on economic growth is examined and the econometric model for this effect is as follows:

$$GDP_{it} = \beta_o + \beta_1 GDP_{it}(-1) + \beta_2 REC_{it} + \beta_3 Int_{it} + \beta_4 ER_{it} + \epsilon_{it} \quad (3.3)$$

If the coefficient of REC is significant than it means that REC has a significant influence on gross domestic product which is a proxy of economic growth. Also, now REC can be used as a mediating variable.

Path c

Path c is established to analyze the mediating role of REC in the FD-growth relationship. Path c is the main objective or purpose of this study and to test the mediating effect econometric model that is estimated is as follows:

$$GDP_{it} = \beta_o + \beta_1 GDP_{it}(-1) + \beta_2 REC_{it} + \beta_3 FD_{it} + \beta_4 Int_{it} + \beta_5 ER_{it} + \epsilon_{it} \quad (3.4)$$

If the estimate of REC is significant and the estimate of FD appears insignificant, then this indicates that full mediation exists and REC fully mediate the FD-growth

nexus. If the estimates of both REC and FD are significant then it means that partial mediation exists and REC partially mediates EF-growth relationship. If the estimates of both REC and FD are insignificant it shows that REC has no mediating effect in the relationship between FD and economic growth.

Present study employs Generalized methods of moments technique to test the relationship between financial development, renewable energy consumption and economic growth in EViews software. To apply GMM it is necessary to check either the variables under study are stationary or not because panel data is always non-stationary as it has a trend in it and can't be used for estimation. Panel unit root test is used to check the stationarity for every variable at level. To check the stationarity of every variable present study runs panel unit root test at level using Levin, Lin & Chu t^* and PP- Fisher Chi- Square method. **Table 3.4** shows the results of panel unit root test at level including the statistic and probability for every variable.

TABLE 3.4: Panel Unit Root Test at Level

Variables	Levin, Lin & Chu t^*		PP - Fisher Chi-Square	
	Statistic	Probability	Statistic	Probability
Gross domestic product	6.66987	1	81.0852	1
Financial development	-2.06772	0.0193	280.104	0.9556
Renewable energy consumption	1.1581	0.8766	398.113	0.0019
Interest rate	-14.4893***	0.0000	1322.70***	0.0000
Exchange rate	-3.77157	0.0001	351.993	0.0000

*** $p < .05$.

Results of Panel unit root test shows that none variable except interest is stationary as the probability value of every variable except interest is greater than .05. To make all the variables stationary present study run unit root test at first difference and the results of the panel unit root test are presented in Table 8.

TABLE 3.5: Panel Unit Root Test at First Difference

Variables	Levin, Lin & Chu t*		PP - Fisher Chi-Square	
	Statistic	Probability	Statistic	Probability
Gross domestic product	-27.2881***	0.000	2418.92***	0.000
Financial development	-25.8329***	0.000	1948.70***	0.000
Renewable energy consumption	-18.6941***	0.000	2920.52***	0.000
Interest rate	-36.0336***	0.000	3752.51***	0.000
Exchange rate	-24.8180***	0.000	1501.21***	0.000

***p < .05.

When we run panel unit root test at difference all the variables that were non-stationary earlier becomes stationary as the probability values of all variables are less than .05 which means that they all are stationary at first difference. Present study took a log difference of every variable to make all variables stationary and now can be used for estimation. In panel data estimation pooled ordinary least square is used. POLS assumes that all the cross sections in the data sample are same while in reality heterogeneity exists in every sample so, fixed effect model is used first to capture heterogeneity. If you apply fixed effect model on dynamic panel structure it will create the problem of endogeneity. As independent variable should not correlate with its error term in fixed effect model. To detect the endogeneity of independent variables present study first used Wald test. Under Wald test if the probability of any independent variable is less than .05 it means that variable is endogenous. To determine whether a variable is endogenous or not we applied a Wald test and the results of Wald test are presented in **Table 3.5**.

Results show that all variables except interest rate is endogenous so, it is necessary to apply model other than OLS. Under fixed effect model the results may be biased.

TABLE 3.6: Wald Test

Variables	t-statistics		F-statistics		Chi-square	
	Value	Probability	Value	Probability	Value	Probability
Financial development	13.506	0.000	182.417	0.000	182.417	0.000
Renewable energy consumption	10.038	0.000	100.763	0.000	100.763	0.000
Interest rate	-1.833	0.067	3.359	0.067	3.359	0.067
Exchange rate	11.404	0.000	130.054	0.000	130.054	0.000

To capture this endogeneity problem, generalized methods of moments is applied as under GMM lag of independent variable is used as an instrumental variable.

3.9 Descriptive Statistics

Descriptive statistics outline and explain the main characteristics of data set. It tells about the average value in the data set, middle value, standard deviation the deviation from the average, maximum value and minimum value in a data set.

Results descriptive statistics are presented in **Table 3.7**. In the Descriptive stats table mean value of every variable, standard deviation that is deviation from mean value, maximum and minimum values of every variable for 161 countries is reported.

TABLE 3.7: Descriptive Statistics

	N.	Mean	Std. Dev	Max.	Min.
GDP	1492	0.041719	0.118859	0.569162	-1.061309
REC	1492	0.004169	0.266389	7.835975	-4.574711
FD	1492	0.017104	0.231958	7.174911	-0.811064
ER	1492	2.027412	1.659715	273.0092	36.81303
INT	1492	6.724075	10.45259	139.9637	-69.10636

GDP = Gross domestic product, FD = Financial development, REC = Renewable energy consumption, ER = Exchange rate, INT = Interest rate

Results indicate that GDP has a mean value of -0.041719 which means that the average value of GDP in the data set is 4.1719%. The standard deviation of GDP is 0.118859 which means that variation in the data set from the mean value is 11.8859% as GDP can increase or decrease by 11.8859% from country to country and from year to year. The minimum value is -1.061309 and the maximum value is 0.569162. Mean value of REC is 0.004169 as the average value of REC is 0.4169%. The standard deviation of REC is 26.6389%. The maximum value of REC is 0.569162 and the minimum value is -1.061309. The mean value of FD is 0.017104 as the average value of FD is 1.7104%. The standard deviation of FD is 23.1958%. The maximum value is 7.174911 and the minimum value is -0.811064. The mean, standard deviation of other variables is also reported in Table 3.7. As the mean value of ER is 2.027412. The standard deviation of ER is 1.659715 and the maximum and minimum values of ER are 0.552721 and -9.227311. For interest rate the mean value is 6.724075. The standard deviation is 10.45259. The maximum value of INT is 139.9637 and the minimum value is -69.10636.

3.10 Correlation Analysis

Correlation analysis is a technique used to evaluate that either there is a connection between two variables or not and if yes then how strong that relationship is. In other words, it indicates whether and to what extent change in one variable is related to the change in another variable. The result of a correlation analysis is expressed as a correlation coefficient, which ranges from -1 to +1. Correlation coefficient close to +1 shows strong positive relationship between the variables. Correlation coefficient close to -1 shows strong negative relationship and 0 indicates no relationship.

To determine the relationship between all study variables a correlation analysis was performed. Results of the correlation analysis are reported in **Table 3.8**.

GDP = Gross domestic product, FD = Financial development, REC = Renewable energy consumption, ER = Exchange rate, INT = Interest rate

TABLE 3.8: Correlation

	1	2	3	4	5
GDP	1				
FD	-0.178	1			
REC	-0.0529	0.0057	1		
ER	0.0031	0.0113	0.1278	1	
INT	0.0603	0.1307	0.0315	0.1762	1

The above stated results are showing that GDP a proxy of economic growth is negatively correlated with financial development, renewable energy consumption and positively correlated with exchange rate and interest rate. Financial development is positively correlated with renewable energy consumption, exchange rate and interest rate. Renewable energy also shows positive connection with exchange rate and interest rate. Lastly exchange rate also shows positive relationship with interest rate. Lastly exchange rate also has a negative influence on economic growth and all these things are under this shelf or roof and all the world made papers are under them to still them in this world and all these things for it is used.

3.11 Generalized Methods of Moments (GMM)

The Generalized Method of Moments (GMM) is a powerful statistical and econometric technique used to estimate parameters and test hypotheses in complex models. Developed by Lars Peter Hansen and Kenneth J. Singleton in the late 1970s and early 1980s, GMM has become a fundamental tool in the fields of economics, finance, and statistics. GMM is particularly well-suited for addressing issues of endogeneity, heteroscedasticity, and other challenges that arise in empirical research. The core idea behind GMM is the use of moments, which are functions of the data and model parameters. Moments capture information about the characteristics of the data distribution. There are two types of moments: sample moments, calculated from the observed data, and population moments, derived from the theoretical model. GMM seeks to align these two sets of moments by choosing parameters that make the sample and population moments as close as possible. GMM is used for estimating the parameters of a model by selecting values that match observed moments to their theoretical counterparts.

This is achieved by minimizing a criterion function, known as the GMM objective function. The criterion function penalizes discrepancies between sample and population moments, and the estimation process involves finding the parameter values that minimize this function.

GMM often involves the use of instrumental variables (IVs), which are external variables and they correlate with the endogenous variables but uncorrelated with the error term. IVs help address endogeneity issues, allowing researchers to obtain consistent estimates of parameters. GMM provides a framework for choosing optimal instruments to improve the efficiency of parameter estimates. GMM allows researchers to test the validity of their models by assessing over-identifying restrictions. These restrictions involve specifying more moments than necessary for identification. If the model is correctly specified, the additional moments should be close to zero. Failure to reject these restrictions provides evidence in favor of the model's validity.

Apart from advantages GMM also has some disadvantages as GMM relies on the correct specification of moments, and misspecification can lead to biased estimates. Researchers must carefully choose moments that are theoretically relevant and appropriate for the specific research question. The effectiveness of GMM often depends on the choice of instrumental variables. Researchers need to identify instruments that are both relevant and exogenous to the model. GMM estimation can be computationally intensive, particularly for large models or datasets. Researchers may need to employ numerical optimization techniques to find the minimum of the GMM objective function. The success of the optimization process in GMM can be sensitive to the initial values chosen for the parameters. Researchers may need to explore different starting values to ensure convergence to the global minimum.

Chapter 4

Results and Analysis

4.1 Results

For testing the direct and indirect effects present study conducted regression analysis using structural equation modeling in R studio. As SEM doesn't run on data with empty cells so the first thing, the study did is to highlight all the missing cells and fill the mean value of the series in all these cells. After that the next problem in running structural equation modeling is the variation in the data set as there are countries having much higher GDP and then there are countries with struggling economy so it was necessary to rescale the variables. To rescale the variables the formula that present study used is:

$$\frac{(X - Mean)}{(StandardDeviation)}$$

After rescaling the study specified path c, path a and then path b. Path a indicate the impact of financial development on renewable energy consumption, path b indicate the impact of renewable energy consumption on economic growth and path c indicate the impact of financial development on economic growth. After that present study run structural equation modeling and the results of the SEM for model 1 the estimate, standard error, z value, p value for the direct effects is presented in **Table 4.1**.

TABLE 4.1: Direct Effect

	Estimate	Standard Er- ror	z- value	P(> z)
GDP2R (c) FD1R	0.555	0.018	31.488	0.000
RECR (a) FD1R	-0.418	0.014	-29.099	0.000
GDP2R (b) RECR	-0.099	0.011	-8.901	0.000

GDP = Gross domestic product, FD = Financial development, REC = Renewable energy consumption.

The above stated results are showing that the financial development has a significant positive impact on economic growth. As its p value is less than .05 and positive sign of β supports the positive relationship. This means that if financial development increases, then the economic growth of the country will also be increased. The second hypothesis of the study that financial development has a significant influence on renewable energy consumption is also supported. As its p value is less than .05 and negative sign β of supports negative relationship. This means that if financial development increases renewable energy consumption will be decreased. Then the third hypothesis of the study that renewable energy consumption has a significant effect on economic growth is also supported. As its p value is less than .05 and negative sign of β supports negative effect on economic growth.

4.2 Mediation Analysis

Mediation analysis is a statistical technique that is used to explore underlying mechanisms or the path through which an independent variable effect a dependent variable. It aims to understand the mechanism through which the IV influences the DV by introducing a mediator variable. In other words, it helps researchers

understand the process or steps by which a variable exerts its effect. Under mediation two effects exist and that are direct and indirect effect. Direct effect is the path through which independent variable effects the mediator and also the impact of mediator on dependent variable. Indirect effect is the path in which independent variable effects dependent variable through a mediator. To test the significance of these relationships and effects statistical methods, such as regression analysis or structural equation modeling, are used in the mediation analysis.

Baron and Kenny (1986) were the first to capture the mediation analysis. They provide four steps to estimate the indirect effect. These are basically the four regressions that should be run to get the results. According to Baron and Kenny if one step is insignificant it means that no mediation exists. Future studies negate this approach and said that if any regression comes insignificant then still you can run mediation analysis as some mediation still exists. Also, some studies argue that indirect effect is not captured through four steps of Baron and Kenny. So, to capture the indirect effect Jedd and Kenny introduced a difference approach in 1981 and Sobel in 1982 introduced a product approach. Both these approaches produce same results and difference lies only in their regression equations.

Mediation analysis is widely used in various fields, including psychology, sociology, medicine, and economics, to understand the processes through which certain variables influence outcomes. It provides insights into the underlying mechanisms of observed relationships, helping researchers move beyond simple associations to understand the "why" and "how" of these relationships.

To test the indirect effect, present study used Sobel's test and the results of the Sobel test including estimate, standard error, z value and p value for indirect effect is presented below:

TABLE 4.2: Indirect Effect

	Estimate	St. Err	z-value	P(> z)
ab	0.041	0.005	8.495	0.000

Results indicate that indirect effect is significant and positive which means that in a financially developed country there is high consumption of renewable energy

and ultimately this contributes to the growth in the economy. As the p value is less than .05 and sign of β supports positive association among the variables. This is in line with our hypothesis of the study and past studies that renewable energy consumption mediates the relationship between financial development and economic growth.

4.2.1 R-Square

TABLE 4.3: R-Square

	Estimate
GDP2R	0.363
RECR	0.175

GDP = Gross domestic product, REC = Renewable energy consumption.

4.3 Regression Analysis

Present study applied difference Generalized methods of moments as first difference GMM is used to remove country specific effects from data but in difference there is a problem of weak instruments and difference GMM doesn't address this problem. So, to decide either difference GMM is ok or there is a need to go for system GMM we applied fixed effect model and then difference GMM on data set. Results show that difference GMM is ok because the lagged coefficient of difference GMM is greater than lag coefficient of fixed effect that indicates difference GMM is appropriate. Further difference GMM is applied and we run regressions for base line model and path a, b, c. The results of the base line model and of all the paths a, b, c are presented in **Table 4.1**.

n= 161, ***p < .01, **p > .01 < .05, *p < .10.

In Table 9 the first column shows results for base line model without mediator and next columns shows results for path a, b and c. The results of baseline shows that financial development and interest rate both have a significant negative influence on economic growth while exchange rate has a significant positive impact. Results

TABLE 4.4: Regression Results

	Model 1 GDP	Model 2 REC	Model 3 GDP	Model 4 GDP
REC			-0.1374*** -0.0001	-0.1059*** -0.0002
REC(-1)		0.0587*** -0.0001		
GDP(-1)	0.1605*** 0.0000		0.1640*** 0.0000	0.1864*** -0.0001
FD	-0.0343*** 0.0000	-0.0050*** 0.0000		-0.1343*** 0.0000

of path a show that financial development has a significant negative impact on renewable energy consumption. Exchange rate and interest rate both have a significant positive association with renewable energy consumption. Results of path b indicates that renewable energy consumption has a significant negative influence on economic growth while exchange rate and interest rate have a significant positive influence on economic growth. Results of path c indicates that renewable energy consumption and financial development both have a significant negative effect on economic growth while exchange rate and interest rate have a significant positive effect on economic growth.

4.4 Financial Development and Renewable Energy Consumption

Present study investigated the effect of financial development on renewable energy consumption. Results of Structural equation modeling and Generalized methods of moments both revealed that financial development has a direct and negative influence on renewable energy consumption which supports the study's hypothesis H1. This result is consistent with the past studies ([Ankrah & Lin, 2020](#); [Saibu & Omoju, 2016](#)) who also reported direct negative association between financial development and consumption of renewable energy. As Developed financial markets may have strong ties with traditional energy sources, such as fossil fuels. This can result in a reluctance to invest in and transition to renewable energy sources due to existing investments, established infrastructure, and vested interests in the fossil

fuel industry. Investors in financially developed markets may be more risk-averse, favoring established and proven technologies over newer, potentially riskier renewable energy projects. This risk aversion can limit the flow of capital to innovative but less proven renewable energy technologies.

Financially developed nations may have developed energy policies that are dependent on traditional energy sources. Existing subsidies and incentives for fossil fuels can create a barrier to the growth of the renewable energy sector, as investors may be hesitant to shift their focus without comparable financial support. In financially developed economies, powerful fossil fuel industries may exert significant political influence through lobbying efforts. This influence can impact energy policies and regulations, hindering the development and adoption of renewable energy solutions. Financially developed markets may witness a concentration of power and resources in the hands of a few large energy corporations. These corporations may have established interests in maintaining the status quo and resisting the shift to renewable energy, potentially impeding the growth of the renewable sector. Small and innovative renewable energy projects may struggle to secure financing in highly developed financial markets, where larger, more established projects are often favored. This can stifle the growth of smaller players and limit the diversity of renewable energy initiatives. Also, renewable energy technologies have become more cost-competitive over time, the initial costs of setting up renewable energy infrastructure can still be high. In financially developed regions, there may be a preference for short-term gains and quicker returns on investment, leading to a reluctance to invest in projects with longer payback periods.

4.5 Financial Development and Economic Growth

Present study explored the role of financial development on economic growth. The results of both Structural equation modeling and Generalized methods of moments revealed that financial development has a direct and negative influence on economic growth. This result is in line with the study's hypothesis H2. The result is consistent with the past studies ([Hassine & Harrathi, 2017](#); [Mahalik &](#)

Mallick, 2014; A. D. Ahmed, 2013; Agbetsiafa, 2004). As rapid financial development may lead to increased financial instability. This can manifest in the form of speculative bubbles, financial crises, and volatility in asset prices. Such instability can disrupt economic activities and hinder long-term sustainable growth. Financial development can exacerbate income inequality within a society. Access to financial services and investment opportunities might be skewed towards wealthier individuals and corporations, leaving a significant portion of the population excluded. High levels of income inequality can lead to social and economic tensions, negatively affecting overall economic stability and growth. This short-term focus may hinder investments in projects with longer payback periods, including those that contribute to sustainable economic growth.

Excessive financial development may lead to the "financialization" of the economy, where financial activities become more dominant than the real economy. In such a scenario, financial institutions may prioritize speculative trading and complex financial products over productive investments in industries, potentially hindering real economic growth. In some cases, financial systems may allocate credit inefficiently, directing funds towards less productive or speculative sectors rather than areas that contribute to sustainable economic growth. This misallocation of credit can result in economic imbalances and distortions. Highly developed financial markets can attract rent-seeking behavior, where individuals or entities seek to profit from economic activities without contributing to productivity. This can divert resources away from productive sectors, leading to economic inefficiencies and hindering overall growth. Despite financial development, if a significant portion of the population lacks access to financial services, it can limit economic growth. Inclusive financial systems that cater to a broad range of individuals and businesses are more likely to contribute positively to overall economic development.

4.6 Economic Growth and Renewable Energy Consumption

Present study investigated the role of economic growth on renewable energy consumption. The results of both Structural equation modeling and Generalized

methods of moments revealed that renewable energy has a direct and negative impact on economic growth. This result is in line with the study's hypothesis H3. The result is consistent with the past studies (Ocal & Aslan, 2013; Apergis & Danuletiu, 2014). As the initial costs of transitioning from traditional energy sources to renewable energy can be high. For example, there may be costs associated with building new infrastructure, retraining workers, and adapting existing systems. In the short term, these transition costs might be perceived as a burden on economic growth. The intermittent nature of certain renewable energy sources, such as solar and wind, can present challenges in terms of reliability and stability of energy supply. This intermittency may require additional investments in energy storage or backup systems, which could be viewed as a potential constraint on economic growth. Countries heavily dependent on fossil fuel exports might see a negative impact on economic growth if there is a rapid and significant shift toward renewable energy. These countries may face economic challenges due to a decline in demand for their primary export commodities. Industries related to fossil fuels may resist the transition to renewable energy due to concerns about their economic interests. This resistance can manifest in lobbying efforts, policy opposition, and delays in adopting renewable energy technologies. In certain regions, where traditional energy industries are major contributors to the local economy, a rapid shift to renewable energy may lead to short-term economic challenges. This can be particularly true in areas heavily reliant on coal mining or oil extraction.

4.7 Mediating Role of Renewable Energy Consumption between Financial Development and Economic Growth

Present study investigated the mediating role of renewable energy consumption between financial development and economic growth. The results of both Structural equation modeling and Generalized methods of moments revealed that renewable energy consumption fully mediates the relationship between financial development and economic growth. This is the first study to explore the mediating impact of

renewable energy consumption. As financial development, characterized by well-functioning capital markets and institutions, facilitates investment in renewable energy projects. Investors are more likely to support and fund renewable energy initiatives when financial markets provide efficient mechanisms for capital allocation. This influx of capital into the renewable sector can spur economic growth by creating jobs, fostering innovation, and contributing to the development of a sustainable energy infrastructure. Financial markets support the growth of renewable energy, economies can experience a shift towards cleaner and often more cost-effective energy sources. This transition can lead to decrease in energy costs for businesses and households. Lower energy costs contribute to increased competitiveness, allowing businesses to allocate resources more efficiently and invest in other productive activities. This positive effect on economic efficiency can be mediated by the role of financial development in facilitating the financing of renewable energy projects. Financial development supports research and development in the renewable energy sector. Robust financial markets attract investment in innovative technologies and facilitate knowledge transfer within the industry. As a result, renewable energy consumption mediates economic growth by driving technological advancements and increasing productivity. Financial institutions play a crucial role in channeling funds towards research initiatives, fostering a cycle of innovation that benefits economic development. The growth of renewable energy consumption, facilitated by financial development, contributes to the mitigation of environmental externalities associated with traditional energy sources. As economies reduce their reliance on fossil fuels, the negative impacts of pollution and climate change decrease. This environmental sustainability positively influences economic growth by avoiding the long-term costs and damages associated with environmental degradation. Financial institutions, through responsible investment practices, can encourage the transition to cleaner energy sources. The development of renewable energy projects often leads to job creation, providing employment opportunities across various skill levels. Financial development supports this by ensuring that the necessary funding is available for large-scale renewable projects. Job creation not only contributes directly to economic growth but also has positive social impacts by improving living standards and reducing unemployment rates. Financial institutions play a critical role in assessing the viability of

renewable energy projects and mobilizing funds for their implementation.

Renewable energy projects often require substantial upfront investments, and financial institutions can play a crucial role in mitigating risks associated with these projects. Through project financing and risk management strategies, financial institutions make it possible for renewable energy initiatives to attract the necessary funding. This, in turn, ensures the successful implementation of projects that contribute to economic growth while minimizing the financial risks associated with renewable energy investments. Renewable energy consumption, supported by financial development, enhances energy security by diversifying the energy mix. Dependence on a variety of renewable sources reduces problems in supply and change in the prices associated with fossil fuels. This increased energy security contributes to economic stability, allowing businesses and industries to operate with greater certainty and resilience.

Chapter 5

Discussion and Conclusion

5.1 Conclusion

Present study tried to test the relationship between financial development, renewable energy consumption and economic growth while investigating the mediating role of renewable energy consumption by using structural equation modeling and generalized methods of moments by a balanced panel of 161 countries ranging from a period of 1990 to 2022. The countries include developed, underdeveloped and emerging economies. Findings of the study revealed that development in financial sector negatively influence clean energy consumption. As in financially developing regions, individuals and businesses may find it challenging to bear these initial expenses, hindering the widespread adoption of renewable energy solutions. The lack of financial support can be a substantial barrier to the promotion of renewable energy initiatives, particularly in the areas where traditional energy sources dominate. Financially developed regions may have established subsidies that make traditional energy more economically attractive, diverting attention and resources away from renewable alternatives. Second development in financial sector also has a direct and negative influence on economic growth. As excessive financial development without proper regulation results in financial crises which negatively impacts economic growth. Financial development also leads to income and wealth inequality which in turn negatively impact economic growth. Financial institutions may also not efficiently channel funds to productive investments. Issues such as asymmetric information, moral hazard, and adverse selection can hinder the

proper functioning of financial intermediaries. This can result in a misallocation of resources, hindering economic growth. The overreliance on the financial sector also hinders growth of the economy.

Third renewable energy consumption has also a significant negative impact on growth of the economy. As the initial costs for the installation of solar panels, wind turbines are high. In short term businesses and consumers may face increased expenses, potentially effecting the spending on goods and services. This could lead to a temporary slowdown in economic growth. Renewable energy sources depend on weather conditions and this effect industries which require stable power and insufficient storage solution effect economic growth. Some countries also may not have a well-established domestic renewable energy industry and may need to rely on importing technology and equipment which increase dependency on other nations and impact growth in the economy. Fourth renewable energy consumption is also found to mediate the nexus between development in financial sector and growth in the economy.

The study has also certain practical implications based on the results of the study. As government should work on the development of renewable energy consumption and financial development. Government should provide tax subsidies, grants for the infrastructure development of renewable energy consumption. They should also provide Feed-in-tariffs to encourage people to use renewable energy. Further government should also enhance financial inclusion by leveraging technology in financial services and also introduce financial programs in the country to promote financial development and in turn achieve economic growth in the long term.

5.2 Limitations and Directions for Future Research

The study has also some limitations which should be considered while interpreting the results of the present study. First limitation is that present study has a restricted timeframe of 1990-2023 primarily due to the unavailability of data beyond this period in most countries. While attempts were made to extend the sample

period to earlier decades such as 1960-2019 and 1970-2019, the lack of availability of panel data hindered empirical analysis. Secondly the study also ignores the micro level factors like political and economic events which could influence financial development, renewable energy consumption while focusing on macro level factors. Lastly, this study only examines data collected across different countries over time, known as panel data analysis. It doesn't offer specific findings at the individual country level regarding the relationship between energy consumption (EC), financial development (FD), and gross domestic product (GDP). Therefore, these limitations suggest avenues for future research to explore using different methods and statistical techniques.

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