Kor, Sylvia; Qamruzzaman, Md.

Article

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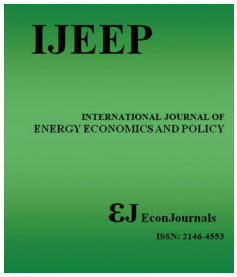

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Nexus between FDI, Financial Development, Capital Formation and Renewable Energy Consumption; evidence from Bangladesh

Sylvia Kor, Md. Qamruzzaman*

School of Business and Economics, United International University, Dhaka 1212, Bangladesh. *Email: qamruzzaman@bus.uiu.ac.bd

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ABSTRACT

This paper examines the interplay among foreign direct investment (FDI), financial development, capital formation, and renewable energy consumption in the context of Bangladesh. The study aims to shed light on the nexus between these variables by utilizing empirical evidence. Panel data analysis techniques investigate the relationship over a specific period. This research provides insights into the dynamic interactions among FDI, financial development, capital formation, and renewable energy consumption in Bangladesh. The study reveals significant positive associations between FDI and renewable energy consumption, indicating that FDI inflows contribute to the growth and utilization of renewable energy sources. Moreover, the analysis uncovers a positive relationship between financial development and renewable energy consumption, suggesting that a well-developed financial sector facilitates the financing and implementation of renewable energy projects. Additionally, the study highlights the role of capital formation in promoting renewable energy consumption. The positive relationship between capital formation and renewable energy consumption indicates that investment in physical infrastructure and productive assets supports the expansion and utilization of renewable energy sources. This analysis provides empirical evidence of the interdependencies among FDI, financial development, capital formation, and renewable energy consumption in the context of Bangladesh. Overall, the findings suggest that fostering FDI, improving financial sector development, and promoting capital formation are crucial for enhancing renewable energy consumption in Bangladesh. The study's conclusions have implications for policymakers and stakeholders in designing and implementing strategies to promote sustainable and renewable energy sources in the country.

Keywords: Renewable Energy Consumption, FDI, Financial Development, Capital Accumulation
JEL Classifications: O11, F60, K32

1. INTRODUCTION

In recent years, renewable energy consumption has grown in importance as nations strive to shift away from fossil fuels and toward more sustainable kinds of energy. According to the International Energy Agency (IEA), global renewable energy consumption has increased significantly over the past few years. A study by Akpanke et al. (2023) agrees that renewable energy sources such as solar, wind, and hydroelectric power have numerous advantages, including reduced greenhouse gas emissions, improved air quality, and increased energy utility.

Mitigating greenhouse gas emissions and other pollutants is one of the critical advantages of utilizing renewable energy. Unlike traditional fossil fuel sources, renewable energy sources do not generate pollutants or greenhouse gases during energy production, Kang et al. (2021). This emission reduction can have a substantial effect on air and water quality, as well as the overall health of ecosystems. In addition, using renewable energy sources can help mitigate the adverse effects of climate change, including sea level rise, more frequent and severe weather events, and biodiversity loss.

The paper of Lin et al. (2016) conveyed that employing renewable energy can also have substantial economic effects. Implementing renewable energy sources can create new jobs in the renewable energy sector, fostering economic growth and expansion. In addition, the lowering cost of renewable energy technologies makes them increasingly competitive with traditional fossil fuel

sources, which can result in reduced energy bills for individuals and companies. In addition to attracting investment and generating new markets, renewable energy projects can stimulate further economic activity. Renewable energy consumption can also have positive social impacts. Renewable energy sources can enhance energy security by decreasing reliance on volatile international oil and other energy markets. Moreover, renewable energy projects can be located in rural or isolated places, bringing energy access to formerly energy-deprived populations. The revenue generated by renewable energy projects and the creation of new employment possibilities can also benefit the local communities. In 2020, renewable energy accounted for 29% of global electricity generation. Between 2010 and 2019, global renewable energy consumption grew at an average annual rate of 13.7%. In 2019, the top five countries in terms of renewable energy consumption were China, the United States, Brazil, India, and Germany. The use of renewable energy for electricity generation is expected to grow, reaching 80% by 2050, according to the IEA (Qamruzzaman and Kler, 2023).

There are hurdles and barriers to its acceptance, despite renewable energy consumption offering several advantages. The intermittent nature of some renewable energy sources, such as solar and wind power, is one of the most significant obstacles. This variability can make it challenging to rely on renewable energy sources for baseload power, particularly in regions with high energy demand. In addition, the initial expenses of establishing infrastructure for renewable energy can be substantial, although they are dropping with time. In nations where fossil fuels have historically been the primary energy source, there may be governmental or political constraints to adopting renewable energy sources. Environmental, economic, and state welfare characterize the vast majority of the impacts of renewable energy consumption. As part of a more considerable effort to address climate change and advance sustainable development, policymakers should continue to prioritize using renewable energy sources. Although there are obstacles and challenges to adopting renewable energy sources, they may be addressed with growing investments, innovation, and supportive legislation. As the globe continues to transition towards a more sustainable energy future, the effects of renewable energy usage will become increasingly essential for fostering a more equal, wealthy, and productive world for all (Abbasi et al., 2022; Ju et al., 2023; Islam et al., 2023; Lin and Qamruzzaman, 2023).

A group of researchers has found a list of macro fundamental that positively influenced REC, for instance, FDI (Akpanke et al., 2023), economic growth (Rezagholizadeh et al., 2020), financial development (Shahbaz et al., 2021). For the global context (lower-income, lower-middle income, and upper-middle-income countries), Qamruzzaman (2022a) established a relationship between renewable energy (RE), foreign direct investment (FDI), agro-productivity (AP), and carbon emissions. Further evidence can be found in the study of Shah et al. (2022) for China. The study exposed that FDI inflow positively influences mortality and RE, with unidirectional causality from RE and pollution to mortality. Another line of evidence can be found dealing with the positive effects of REC, for example, GDP per capita, trade openness, financial development, the share of fossil fuel in energy consumption, economic development (Lin et al., 2016), green finance (Wei et al., 2022). Also, capital-embodied material footprints (MFs), induced carbon emissions, and fixed-capital formation (Hata et al., 2022; JinRu et al., 2023; Qamruzzaman et al., 2023) favorably affect RE.

Due to rising awareness of climate change and the significance of sustainable energy practices, the worldwide adoption of renewable energy sources has been on the rise. Economic, technological, environmental, social, and financial issues have all influenced the widespread adoption of renewable energy sources. This paper tries to identify the determinants of renewable energy consumption, including financial development, foreign direct investment, and capital formation, among other rational and indirect determinants. Renewable energy lowers emissions in the long run. In contrast, gross capital formation increases emissions. India must integrate its economic and energy policies to meet its INDC targets (Rej and Nag, 2022). The rising use of renewable energy is attributable primarily to the rapid growth of related technologies. The efficiency and cost-effectiveness of renewable energy sources are increasing due to advancements in renewable energy technologies. (Karim et al., 2023) referred to technological advances that have facilitated the increased reliance on renewable resources in this area, including solar, wind, hydropower, and geothermal energy. Renewable energy sources have been widely adopted in response to environmental concerns like climate change and air pollution. Increased demand for renewable energy sources, which have lower ecological implications than conventional energy sources like greenhouse gas emissions, directly results from these emissions. Renewable energy sources such as wind, solar, and hydro are cleaner and release fewer greenhouse gases, making them more desirable than conventional energy sources, Wei et al. (2022) exposed. Economic variables, including prices, subsidies, and market incentives, also considerably impact the adoption of renewable energy sources. Government incentives and grants have helped make renewable energy more accessible and affordable. Improvements in renewable energy usage can be attributed to the growing awareness of the benefits of using renewable energy and the lowering costs of renewable energy sources. Renewable energy use is also affected by social variables like public awareness, beliefs, and literacy (ref: Qamruzzaman, 2022a).

Demand for renewable energy has surged due to public education initiatives highlighting the drawbacks of traditional energy sources and the advantages of renewable alternatives. The spread of renewable energy sources is primarily due to public awareness campaigns touting its many benefits. The adoption of renewable energy sources is also influenced by economic factors such as financial development, foreign direct investment, and capital formation. Increasing the flow of investment in renewable energy projects can be facilitated by financial development, including the availability of finance and financial intermediaries like banks and stock exchanges. FDI from overseas can bring in much-needed funds and cutting-edge equipment to help ramp up renewable power generation, research by Qamruzzaman (2022b) also stated. The rise in renewable energy consumption might be attributed to the capital formation that enables businesses to invest in renewable energy technologies. Policy factors, including government laws

and regulations, can greatly affect the use of renewable energy. Renewable energy targets, feed-in tariffs, and tax incentives are just a few of the policies governments can use to boost the use of renewable energy. These regulations encourage the widespread use of renewable energy by providing financial incentives for their implementation. Technological, environmental, economic, social, financial, and policy issues shape the demand for renewable energy. The ability of policymakers to effectively encourage sustainable energy practices relies on their knowledge of these determinants. Policies aimed at boosting the use of renewable energy should consider all factors affecting how much of that type of energy grows. Renewable energy consumption is one step toward a more sustainable energy future, which may be facilitated by policies supporting technological progress, incentives for renewable energy, and financial growth, Lin et al. (2016) recommended so.

The study considered FD, FDI and capital formation in the energy consumption equation. Why FD, FDI and capital formation? Researchers have attempted to identify the causal mechanism(s) linking energy use and economic growth for decades. Rising energy consumption is a typical byproduct of economic development and negatively influences the environment. Multiple elements can affect the correlation between energy consumption and economic growth. This research examines how financial development, FDI, and capital formation evolved to be considered significant factors in analyzing energy consumption patterns.

When we refer to a country's financial development, we are referring to how well its financial system, stock exchange, and other financial institutions have grown and functioned. Businesses need access to capital from a flourishing financial sector to engage in new ventures and grow existing ones. Financial development is significant to energy consumption because it affects the cost and accessibility of investment for renewable energy projects. Economies with more advanced financial systems would have a simpler way of securing financing for renewable energy projects, which might increase the prominence of such initiatives. The cost of financing renewable energy projects can be reduced through financial growth, making them more appealing to both developers and investors. Economic growth is essential when analyzing energy usage since it can expedite the shift toward a greener energy system (Qamruzzaman, 2023b).

Foreign direct investment (FDI) refers to investment by foreign enterprises in domestic businesses or assets. FDI can be an essential source of finance for firms, particularly in emerging nations where domestic sources of capital may be restricted. Samour et al. (2022) recommend integrating IT with financial development in renewable energy initiatives. Economic growth, FDI, financial development, and renewable energy use in the UAE. The report emphasizes financial development and environmentally conscious financing for UAE's sustainable energy growth. In the context of energy consumption, FDI is relevant since it can help to encourage investment in renewable energy projects. For example, multinational corporations may be more eager to engage in renewable energy projects in nations with favorable rules and incentives, which can help to drive the adoption of renewable energy sources. The five leading countries for renewable energy FDI in 2019 were China, the United States, Japan, Germany, and the United Kingdom. Foreign direct investment (FDI) also has the potential to stimulate innovation and growth in the renewable energy industry by introducing cutting-edge technologies and skilled professionals to the field, a study by Yu et al. (2022) illustrated. The World Bank states that renewable energy deployment requires funding. By 2020, 151 nations will have renewable energy funding policies. According to the United Nations Conference on Trade and Development (UNCTAD), global FDI in renewable energy reached $282.2 billion in 2019, up 1% from 2018. As such, FDI is a crucial variable in the study of energy consumption since it can help to drive the shift towards a more sustainable energy future.

The term "capital formation" is frequently associated with generating new forms of capital, such as money, tools, and labor. Capital formation is vital for economic growth and development, allowing businesses to invest in new initiatives and expand their operations. With this line, a study conducted by Hassan et al. (2020) investigates the impact of energy consumption and natural resources on the economic growth of Pakistan. The study establishes a reciprocal causal connection between gross capital formation and natural resources, underscoring their importance to the country's economy. The results hold significant policy ramifications for installing Pakistan's resource-efficient and environmentally sustainable economy. The International Energy Agency (IEA) reports a decade-long renewable energy capacity investment growth. The study by Hata et al. (2022) also examines the material investments made for fixed-capital formation, which have led to notable carbon emissions. Renewable energy capacity investment grew by 2% to $303.5 billion in 2020. Capital formation is essential for energy consumption because it motivates investors to invest in renewable energy projects. Firms with access to finance can aid the development of renewable energy sources and are thus more likely to invest in renewable energy projects. Both public and private investments have played a role in driving renewable energy deployment. The IEA reports that in 2019, private investment in renewable energy reached $304.9 billion, while public investment reached $149.6 billion. Furthermore, the availability of capital formation can fuel innovation and development in the renewable energy sector by providing the resources needed to invest in new technologies and research. Capital formation is a crucial variable in studying energy consumption, as it can help drive the transition towards a more sustainable energy future.

To sum up, the availability and cost of financing for renewable energy projects can be affected by financial development, FDI, and capital formation; these factors can stimulate investment in renewable energy projects; and aid innovation and development in the renewable energy sector. Rafindadi and Mika'Ilu (2019) suggest an inverted U-shaped pattern of energy consumption intensifying with financial market development and reducing after a threshold level. The study shows a bidirectional causal relationship between sustainable energy use, financial market resilience, and economic growth. A report by the International Renewable Energy Agency (IRENA) states that the number of renewable energy companies globally incremented by 50% between 2012 and 2018, reaching over 11,000 companies. In creating a more sustainable and

equitable energy future, policymakers and academics should continue to address these factors when examining the connection between energy consumption and economic development. Overall, capital formation has played an important role in supporting the growth of renewable energy deployment by increasing investment in renewable energy, improving access to finance, and driving the growth of renewable energy companies.

The remaining portion of the body is outlined below. The literature addresses the target nexus as presented in section II. Section III defines variables, measurements, and econometric tools for analyzing the nexus. The explanation of the estimation and interpretation of the empirical model can be found in Section IV. A comprehensive analysis of the study can be found in section V. Section VI provides a comprehensive explanation of the conclusion and offers policy suggestions.

2. LITERATURE SURVEY

2.1. Financial Development and Capital Formation

Most research studies on financial development and human capital formation underline the role of financial development in fostering economic progress and human capital accumulation. The result of financial institutions, markets, and infrastructure can promote the effective allocation of resources, encourage entrepreneurship and innovation, and boost economic output. Human capital, including education, skills, and health, determines economic growth and development. The increased human capital formation can result in greater worker productivity, innovation, and technological progress, further stimulating economic growth. Thus, policymakers must prioritize financial development and human capital production to promote sustainable economic growth and development. Using data from 1984 to 2018, Pal (2022) analyzes the relationship between remittance, financial development, and human capital formation in India and China. The results indicate that remittances favorably affect the financial development of both nations, albeit the impact varies amongst financial institutions and markets. Unskilled human capital hinders economic growth, whereas skilled human capital promotes it. Enhanced institutional quality and competent human resources are required to use remittances and other financial flows efficiently. This study by Hong Vo et al. (2021) also explores the relationship between financial development and human capital in nine Southeast Asian emerging nations between 1990 and 2018, utilizing econometric approaches and three financial development proxies. The results reveal a positive and statistically significant association between financial development and human capital accumulation and bidirectional interaction between the two variables. Enhancing and expanding financial development should be a top priority for policymakers to support human capital accumulation. Using data from 83 countries between 2002 and 2017, Sarwar et al. (2021) explore the relationship between financial development, human capital, and economic growth in 83 economies from 2002 to 2017. Financial development and human capital have positive and significant effects on economic growth, and their interaction has a positive and considerable impact on economic growth in emerging economies. Nevertheless, the study's shortcomings include a limited dataset of rising countries and a limited time. This article by Sethi et al. (2019) studies the influence of market size and financial development indices on human capital in selected south Asian economies from 1984 to 2015. Using panel unit-root tests, cointegration methods, and Granger causality tests. Findings indicate that market size and financial development significantly impact human capital generation, underscoring the need for policymakers to consider these aspects. This study contributes to the existing body of knowledge by analyzing the market size and growth rate. Zaidi et al. (2019) investigate the impact of financial development moderators-Globalization, natural resources, and human capital - on economic development in OECD nations from 1990 to 2016 while controlling for economic growth and capital. Cointegration and second-generation econometric methodologies were utilized, and the results indicate that Globalization, natural resources, and human capital have a favorable and significant impact on financial development. Recommended are policies that promote worldwide culture and efficient use of natural resources. This study by Ibrahim and Sare (2018) investigates the factors of financial sector development in 46 African nations between 1980 and 2015 using the generalized system method of moments. Human capital substantially impacts financial development, although trade openness is more significant for private credit. The many relationships between transparency, human capital, and African financial development suggest their substitutability. This paper by Bekhet et al. (2017) explores the dynamic relationship between financial development, economic growth, energy consumption, CO_2 emissions, and gross fixed capital formation in Malaysia between 1970 and 2013. The results demonstrate the cointegration of all variables, a long-and short-run link between energy use and economic development, and unidirectional Granger causation. Effective energy policies should be prioritized by policymakers to minimize emissions and boost financial growth.

This study by Adeniyi et al. (2015) explores the relationship between financial development, foreign direct investment (FDI), and economic growth in Sub-Saharan Africa. Utilizing three measures of financial development and an instrumental variable estimator, it is determined that financial development positively affects economic growth in the presence of FDI, and this relationship is nonlinear. The analysis indicates that persistent financial reforms can increase the region's growth advantages from international capital flows. The research by Abubakar et al. (2015) explores the financial-growth nexus in the ECOWAS region through the human capital accumulation channel using panel cointegration and FMOLS/DOLS spanning the years 1990 to 2014 and includes 15 nations. Findings indicate that bank and domestic private lending contribute directly and indirectly to growth via human capital. This study by Castel-Branco (2014) examines the connection between foreign direct investment, economic growth, and poverty reduction in Mozambique. Due to an emphasis on capital inflows without political conditionality, poverty reduction has been limited despite the steady economic expansion. The paper emphasizes economic openness as a critical factor in encouraging state-mediated links between domestic and international capital. This research by Shahbaz and Islam (2011) examines the relationship between financial development, income inequality, and the Greenwood and Jovanovich hypothesis in Pakistan. Utilizing data from 1971 to 2005, the study demonstrates

that financial development reduces income disparity, whereas financial instability exacerbates it. The article also indicates that economic expansion affects income distribution and that trade liberalization exacerbates the problem. In addition, the study finds no support for the GJ relationship. The research suggests that developing a well-organized banking sector in Pakistan can help reduce income disparity.

Contradicting these studies' findings, Kong et al. (2020) research investigate the relationship between financial development, gross fixed capital formation, and economic growth in 39 African nations between 1997 and 2017. The Bank Deposit to GDP ratio has a considerable negative impact on growth. In contrast, the Gross Domestic Savings to GDP ratio has a favorable effect. The result of financial development on growth varies depending on the metric utilized. Gross fixed capital formation positively impacts and has a bidirectional causal relationship with economic growth. Financial systems in African nations are frequently weak, and financial intermediation is restricted, which may harm the Bank Deposit to GDP ratio's impact on economic growth. In addition, the study's emphasis on gross fixed capital formation as a driver of economic expansion helps explain the positive relationship between capital formation and growth. An investment in physical capital can lead to greater productivity and output. It is crucial to recognize that the relationship between financial development, capital formation, and economic growth can vary among settings and may be influenced by factors such as the level of economic development, the quality of institutions, and the policies pursued by policymakers.

2.2. FDI and Capital Formation

This study by Zaman et al. (2021) evaluates the effect of IT exports, gross capital formation, foreign direct investment, and trade openness on sustainable economic growth in BRI countries using annual panel data from 2013 to 2018. Control variables include the trade freedom index, the investment freedom index, the real interest rate, and inflation. The two-step GMM approach is implemented. Findings indicate that foreign direct investment and gross capital formation favor economic growth. In contrast, IT exports and trade openness have a negative but minor impact. The study also concludes that China's outbound FDI has stimulated economic growth in BRI nations. Similarly, Adarov and Stehrer (2021) explore the effect of foreign direct investment, capital dynamics, and structure on establishing global value chains (GVC) in European countries between 2000 and 2014. The analysis reveals that FDI and capital accumulation significantly benefit GVC involvement, notably in high-tech manufacturing and the textile and apparel industries, with inward FDI enabling backward connections and outward FDI facilitating forward participation. Capital accumulation intensifies production sharing in most industries. ICT capital plays a crucial role in specific industries' backward GVC integration. Similarly, Boamah et al. (2018) investigated the relationship between Financial Depth, Gross Fixed Capital Creation, and Economic Development for 18 Asian nations from 1990 to 2017. The method employed is panel data analysis. Gross Fixed Capital Creation has a favorable impact on economic growth, whereas Financial Depth inhibits economic growth. Economic growth is proven to be positively affected by FDI inflows. This paper by Amighini et al. (2017) uses data from the industry level to look at how foreign direct investment (FDI) affects investment in developing countries. The study reveals that FDI positively influences total investment solely in manufacturing production and that foreign investors from developed nations have a more significant positive impact than those from developing economies. Findings are insensitive to other FDI measurements and endogeneity concerns. The study examines several emerging countries and uses instrumental variable techniques. This study by Hsu et al. (2015) examines the relationship between Taiwanese OFDI and domestic investment from 2000 to 2015. The study uses a location-specific approach to evaluate the influence of OFDI on Heckscher-Ohlin (H-O) and Schumpeter businesses. OFDI in China favors domestic investment in H-O industries. In contrast, OFDI in other nations harms domestic investment in the same sectors. Only OFDI from other countries has a good influence on Schumpeter industries. In the same year, Solarin and Shahbaz (2015) examine the correlation between natural gas consumption, economic growth, foreign direct investment, capital formation, and trade openness in Malaysia between 1971 and 2012. The research uses the structural break unit root test and combined cointegration test. The results demonstrate a positive correlation between natural gas consumption, foreign direct investment, capital formation, trade openness, and economic growth in Malaysia, justifying the feedback hypothesis. The policy implications are addressed. This article by Omri (2014) assesses an econometric model to examine the relationship between foreign direct investment (FDI), domestic capital, and economic growth in 13 MENA countries from 1990 to 2010 using a "growth model" framework and simultaneous-equations models estimated by the Generalized Method of Moments (GMM). The results reveal a bi-directional causal relationship between FDI and economic growth, domestic capital and economic development, and a uni-directional causal relationship from FDI to domestic capital for the entire MENA region. This research by Arazmuradov (2011) investigates the relationship between foreign aid (ODA), foreign direct investment (FDI), and local investment in five landlocked and rising Central Asian economies from 2000 to 2016. Resource plays a favorable function in encouraging FDI inflows, and FDI complements local investment. In contrast, according to a study that employs seemingly unrelated regression techniques, ODA has a negative impact. The relationship between ODA and FDI is stronger in nations with low GDP per capita and economic growth. The results indicate that Central Asian economies require improved aid arrangements and public-private partnerships. Adhikary (2011) also uses time series analysis to explore the relationship between FDI, trade openness, capital formation, and economic growth rates in Bangladesh from 1986 to 2008. The Johansen-Juselius test examines the cointegrating relationship between variables, followed by a vector error correcting model. FDI and capital formation have a considerable positive effect on changes in real GDP. In contrast, trade openness has a negative but diminishing effect on GDP growth rates. The findings indicate that policies driven by FDI and higher levels of capital formation can boost economic growth in Bangladesh.

An old paper by Krkoska (2002) explores the role of foreign direct investment (FDI) in financing gross fixed capital formation and

its relationship to other sources of finance in transition nations using data from 26 countries between 1996 and 2006. The study applies econometric research to examine the influence of FDI on financing capital formation and the significance of natural resources and privatization revenues as determinants of FDI. The results indicate that FDI is a significant source of capital formation finance and is favorably correlated with foreign credit, whereas state subsidies have no meaningful effect. Capital formation and economic growth can be stimulated through enhancements to the local investment climate and financial sector. There is a theoretical and empirical basis for the positive relationship between foreign direct investment and capital formation. This explains why most research studies find a positive correlation between FDI and capital formation. Foreign direct investment can provide additional financial resources, technology, management expertise, and access to foreign markets, stimulating local investment and capital development. In addition, FDI can improve the efficiency and productivity of indigenous enterprises, which has a favorable effect on economic growth. Furthermore, FDI can generate spillover effects, whereby knowledge and technology transfer from foreign enterprises can benefit domestic firms, resulting in additional investment and capital formation. These arguments explain why FDI and capital formation have a positive relationship and why most studies have found evidence of this positive relationship. Foreign direct investment (FDI), capital formation, trade openness, and economic growth in various countries and periods are the focus of most of the studies discussed in the previous paragraphs. The results indicate that FDI and gross capital formation have a favorable effect on economic growth. Still, IT exports, trade openness, and financial depth can harm growth. In addition, outward FDI can facilitate forward participation, and inward FDI can promote backward links in global value chains, resulting in increased engagement in the high-tech manufacturing and textile and clothing industries.

Moreover, the data reveal that FDI inflows positively influence total investment, particularly in the industrial sector, and that foreign investors from developed nations have a more significant positive impact than those from developing economies. In addition to natural gas consumption, foreign direct investment, capital formation, and trade openness, Malaysian economic growth is positively correlated with foreign direct investment. However, foreign aid detrimentally influences domestic investment in Central Asian economies. In contrast, trade openness negatively but diminishingly impacts Bangladesh's GDP growth rates.

These studies underline the significance of foreign direct investment and gross capital formation for economic growth and the need to build a suitable investment climate and finance sector to attract more FDI and encourage local investment. In addition, they believe that policies that allow backward and forward linkages in global value chains increase a country's participation in particular industries and support economic growth.

2.3. FDI and Renewable Energy Consumption

The common thread of these papers is examining the relationship between foreign direct investment (FDI) and renewable energy (RE) use or consumption in various nations or regions. Most papers also examine the influence of other factors, such as GDP, government debt, financial sector development, and environmental legislation, on RE consumption. Several studies use econometric methods such as panel ARDL models, GMM, and regression analysis to investigate the long-term and short-term correlations between the variables. In addition, a few publications suggest policies and strategies to boost FDI and RE use for sustainable development while reducing environmental and health consequences. This paper by Akpanke et al. (2023) appraises the influence of foreign direct investment (FDI) on the use of renewable energy (RE) in 15 West African nations between 1990 and 2021. Using panel ARDL models and second-generation data analysis techniques, this study concludes that GDP has no substantial impact on RE. Still, FDI and public sector credit have a considerable positive effect on RE use over the long term. The report emphasizes the significance of encouraging FDI inflows to promote renewable energy growth in low-resource nations. Also, this study by Qamruzzaman (2022b) explores the relationship between renewable energy (RE), foreign direct investment (FDI), agro-productivity (AP), and carbon emissions from 1985 to 2019 in lower-income, lower-middle, and upper-middle income nations and worldwide model. GMM, System-GMM, ARDL, and heterogeneous causality tests are used in the study. The results show a favorable and statistically significant relationship between RE, FDI, and AP and a carbon emission mixed effect. The feedback hypothesis explains the causation between RE and AP and FDI and AP in lower-income and upper-middle-income nations. In all empirical estimations, asymmetric shocks in RE and FDI show a positive and statistically significant correlation. The research of Shah et al. (2022) examines FDI, renewable energy (RE), and human mortality in China from 1998 through 2020. A nonlinear ARDL technique estimates that FDI inflow positively influences mortality and RE, with unidirectional causality from RE and pollution to mortality. The report recommends policies to increase FDI and RE use to mitigate environmental and health impacts. Similarly, the research of Qamruzzaman (2022a) examines the impact of foreign direct investment (FDI) and government debt on the growth of renewable energy from 1990 to 2020 in multiple nations. The link is analyzed using a cross-sectional dependence, Panel-ARDL framework with symmetry and asymmetry. Long-term data indicate a favorable and statistically significant correlation between government debt, FDI, and the expansion of renewable energy. The study also identified asymmetries between government debt and foreign direct investment concerning renewable energy use. Finally, the directional causality test determines unidirectional causality from government debt to renewable energy and bidirectional causality between foreign direct investment and the use of renewable energy. This research by Wei et al. (2022) explores the relationship between green financing, foreign direct investment (FDI), and gross domestic product (GDP) in 30 Chinese provinces from 2000 to 2019. Employing autoregressive distributed lag approaches with Pooled Mean Group, Mean Group, and Dynamic Fixed Effect estimate models, the study concludes that renewable energy has a significant and negative influence on greenhouse gas emissions. Still, FDI has only a long-term favorable impact. The research indicates that more strategic thinking is required to deploy

renewable energy and enhance green finance for sustainable development. An article by Tan and Uprasen (2022) examines BRICS foreign direct investment (FDI) and renewable energy usage from 1990 to 2015. Environmental regulation reduces and sets a regulatory threshold in the study. Empirical estimations using the panel threshold technique and generalized method of moments (GMM) models reveal that FDI initially reduces renewable energy consumption when regulatory stringency is low but promotes it once it exceeds the threshold. The data show that stronger environmental regulation can boost renewable energy consumption. The paper of Fan and Hao (2020) employs an array of econometric techniques to evaluate the link between renewable energy use, foreign direct investment (FDI), and gross domestic product (GDP) in 31 Chinese provinces from 2000 to 2015. The findings suggest a long-term and stable equilibrium between per capita GDP, per capita FDI, and per capita renewable energy consumption. Nevertheless, while FDI has no significant impact on renewable energy consumption in the short term, a targeted rise in FDI and a modest slowdown in GDP growth can result in a substantial increase in China's renewable energy consumption over a long time. This study by Rezagholizadeh et al. (2020) examines the effect of foreign direct investment (FDI) and financial sector development on renewable energy consumption in Iran over the period 1978-2016 using the Auto-Regressive Distributed Lag (ARDL) bounds test method. The study finds a causal association between foreign direct investment, stock market development, and renewable energy consumption, demonstrating that a rise in FDI and stock market development leads to an increase in renewable energy consumption, reducing CO_2 emissions over time. However, increased FDI and stock market growth may also increase CO_2 emissions due to economic expansion. The study of Ergun et al. (2019) employs random-effects generalized least squares regression to examine the factors of renewable energy usage in 21 African nations from 1990 to 2013. Higher per capita GDP and the Human Development Index are associated with lower renewable energy integration. In contrast, foreign direct investment is associated with higher integration. Integration of renewable energy is unaffected by a country's level of democracy. These findings add to the limited body of research regarding the topic. Khandker et al. (2018) study analyzes the relationship between foreign direct investment (FDI) and renewable energy use in Bangladesh from 1980 to 2015 using time series data. The study uses Johansen's cointegration and Granger's causality tests to examine the variables' long- and short-run correlations. Long-term bidirectional causality is found between FDI and renewable energy consumption, implying that policies aiming to attract more FDI could promote increased investment in Bangladesh's renewable energy sector. Doytch and Narayan (2016) study examines the link between disaggregated foreign direct investment (FDI) and industrial energy demand from 1985 to 2012 for 74 countries. The study finds that FDI has differing effects on renewable and non-renewable energy sources, with sectoral FDI significantly impacting energy consumption by employing a Blundell-Bond dynamic panel estimator. These findings have consequences for policymakers that seek to encourage FDI and promote sustainable energy consumption simultaneously.

There are some conflicting findings as well. This paper by Elheddad et al. (2022) aims to evaluate the impact of foreign direct investment (FDI) on renewable and non-renewable energy consumption and CO_2 emissions in Bangladesh, employing both parametric and non-parametric methods. The findings indicate that FDI inflows cause an increase in CO_2 emissions and discourage the use of renewable energy, with the negative effect on renewable energy consumption being more prominent than the positive effect on CO_2 emissions. The study implies that FDI's sectoral impact on pollution requires more exploration. This research is limited to Bangladesh and incorporates GMM, IV estimations, and quantile regression. Also, the study of Kang et al. (2021) evaluated the relationship between urban population, carbon dioxide emissions, trade openness, GDP, foreign direct investment, and renewable energy in Pakistan, Bangladesh, India, and Sri Lanka from 1990 to 2019. FMOLS and DOLS models. Panel cointegration analyses show a long-run equilibrium nexus between chosen variables. FDI has a significant negative association with renewable energy usage in the region, whereas GDP has an essential positive relationship. Financial institutions should use GDP and FDI to promote environmental sustainability and renewable energy investment by financial institutions.

The negative correlation between foreign direct investment (FDI) and renewable energy use may be attributable to foreign investors placing a higher value on profits than on sustainability. Thus, they may invest more in fossil fuel-based companies, which offer larger returns on investment than renewable energy. The paper of Lin et al. (2016) explores the factors affecting the proportion of renewable electricity in China's overall electricity consumption using data from 1980 to 2011. It employed the Johansen cointegration technique and vector error correction model. The findings reveal a long-term correlation between renewable electricity consumption and per capita GDP, trade openness, foreign direct investment, financial development, and fossil fuel consumption share. Economic and financial development encourage renewable electricity consumption, whereas foreign direct investment, trade liberalization, and conventional energy lobbying weaken it. The study recommends measures to improve the proportion of renewable energy sources in electricity consumption. In addition, renewable energy infrastructure may require substantial up-front expenditures, which may not align with the short-term profit objectives of foreign investors. However, government policies and incentives that encourage sustainable investments and prioritize renewable energy may assist in overcoming this stigma. A summary of the literature survey is displayed in Table 1.

3. VARIABLES DEFINITION AND METHODOLOGY OF THE STUDY

3.1. Model Specification

$$REC| FD, FDI, GCF \quad (1)$$

The above equation (1) can be transformed into a regression equation to derive the elasticity of the explanatory variables. The baseline equation is as follows.

Table 1: List of summary literature survey

Author	Sample (period)	Methodology	Explanatory variable (s)	Remarks
Pal (2022)	India and China (1984-2018)	ARDL bounds test model	REM, IQ, HCD, FDI	FD→CF; +ve
Hong Vo et al. (2021)	(1990-2018)	DOLS, FMOLS	HCD; GDP	FD→CF; +ve
Sarwar et al. (2021)	83 emerging countries (2002-2017)	Two-step System Generalized Method of Moments	human capital, economic growth	FD→CF; +ve
Kong et al. (2020)	39 African countries (1997-2017)	AMG and Common Correlated Effects Mean Group estimation techniques	GCF	FD→CF;-ve
Sethi et al. (2019)	Selected South Asian economies (1984-2015)	Panel co-integration, PDOLS and FMOLS techniques, panel granger causality	Market size, financial development indicators, human capital	FD→CF; +ve
Zaidi et al. (2019)	(OECD) countries (1990-2016)	PUR; WPCT; CS-ARD	GLO; NRR HCD	FD→CF; +ve
Ibrahim and Sare (2018)	46 African countries (1980-2015)	System Generalized Method of Moments	Financial sector development, trade openness, human capital	FD→CF; +ve
Bekhet et al. (2017)	Malaysia (1970-2013)	ARDL	Y; GCF; CO_2.	FD→CF; +ve
Adeniyi et al. (2015)	Selected Sub-Saharan Africa (SSA) countries	Instrumental variable (IV)	FDI, economic growth	FD→CF; +ve
Abubakar et al. (2015)	ECOWAS (1990-2014)	FMOLS, DOLS	DCP; HCD	FD→CF; +ve
Castel-Branco (2014)	Mozambique	Qualitative data	FDI; GCF; HCD	FD→CF; +ve
Shahbaz and Islam (2011)	Pakistan (1971-2005)	ARDL	IQ; FD	FD→CF; +ve
Zaman et al. (2021)	BRI countries (2013-2018)	Two-step system GMM	FDI; TO interest rate, Inflation	FDI→CF; +ve
Adarov and Stehrer (2021)	European countries (2000-2014)	Empirical assessment	CSD; GVC	FDI→CF; +ve
Boamah et al. (2018)	18 Asian countries (1990-2017)	Panel data analysis	GCF; FDI	FDI→CF; +ve
Amighini et al. (2017)	53 developing nations	IV	INV; GCF	FDI→CF; +ve
Hsu et al. (2015)	Taiwan, China, and other countries (2000-2015)	Regression analysis	FDI; GCF	FDI→CF; +ve
Solarin and Shahbaz (2015)	Malaysia (1971-2012)	ARDL	NGC; TO; FO	FDI→CF; +ve
Omri (2014)	13 MENA (1990-2010)	GMM	GCF; Y	FDI→CF; +ve
Arazmuradov (2011)	Five landlocked and emerging economies of Central Asia (2000-2016)	Seemingly regression on regional and country level	Foreign aid (ODA), Domestic investment	FDI→CF; +ve
Adhikary (2011)	Bangladesh (1986-2008)	VECM	TO. GDP	FDI→CF; +ve
Krkoska (2002)	26 countries (1996-2006)	Empirical analysis	GDP; GCF; DCP	FDI→CF; +ve
Akpanke et al.	15 West African nations (1990-2021)	Panel ARDL models with second-generation methods of data analysis	GDP, public sector credit	FDI→REC; +ve
Qamruzzaman (2022a)	Lower-income, lower-middle-income, and upper-middle-income countries, as well as a global model (1985-2019)	GMM, System-GMM, Nonlinear ARDL, and heterogeneous causality test	agro-productivity (AP), carbon emissions	FDI→REC; +ve
Muhammad Haroon Shah (2022)	China (1998-2020)	Nonlinear ARDL approach	human mortality	FDI→REC; +ve
Qamruzzaman (2022b)	Emerging economies, rising economies, and transition economies (1990-2020)	Cross-sectional dependency, Panel-ARDL with symmetry and asymmetry framework	Govt. debt	FDIREC; +ve
Tan and Uprasen (2022)	BRICS countries (1990-2015)	Panel threshold technique, GMM models	Environmental regulation	FDI→REC; +ve
Elheddad et al. (2022)	Bangladesh	GMM, IV estimations, and quantile regression		FDI→REC; -ve

$$REC = FD + FDI + GCF \quad (2)$$

Where REC, FD, FDI, and GCF stand for renewable energy consumption, financial development, foreign direct investment and gross capital formation, respectively. The coefficients of β, γ and δ explained the magnitudes of FD, FDI, and GCF, respectively, on REC. The measurement of research variables is exhibited in Table 2.

After transformation, the above equation (2) can be reported in the following regression equation for extracting the elasticities of explanatory variables on institutional quality.

$$REC_t = \alpha_0 + \beta_{1t} FD_t + \gamma_{1t} FDI_t + \gamma_{1t} GCF_t + \epsilon_t \quad (3)$$

Where the coefficients of $\beta_{1t}, \beta_{1t}, \gamma_{1t}$ and δ_{1t} explain the magnitudes of financial development, foreign direct investment, and gross

Table 2: Variables definition and proxy

Variables	Notation	Proxy	Sources
Renewable energy consumption	REC	Renewable energy consumption as a % of total energy	world development indicators (WDI)
Financial development	FD	Financial development index	IMF (IFS)
Foreign direct investment	FDI	Inflows of FDI as a % of GDP	WDI
Capital formation	CF	Gross capital formation as a % of GDP	WDI

Table 3: The null hypotheses for all three tests are defined as follows

Cointegration test	Null hypothesis	Alternative hypothesis
F-bound test	$\gamma_1=\gamma_2=\gamma_3=\gamma_4=\gamma_5=\gamma_6=0$	Any, $\gamma_1,\gamma_2,\gamma_3,\gamma_4,\gamma_5,\gamma_6\neq0$
A t-test on the lagged dependent variable	$\gamma_1=0$	$\gamma_1\neq0$
F-test on the lagged independent variable	$\gamma_2=\gamma_3=\gamma_4=\gamma_5=\gamma_6=0$	Any, $\gamma_2,\gamma_3,\gamma_4,\gamma_5,\gamma_6\neq0$

capital formation on Renewable energy consumption. The intercept and white noise report in α_0 and α_0.

3.2. Theoretical Development

It is anticipated that the coefficient of FD on REC would be positive in sign, indicating that financial development positively affects REC. A group of researchers, including Samour et al. (2022) and Yu et al. (2022), found that ICT moderates the relationship between financial development and renewable energy consumption. They also unveiled that Fintech has made renewable energy project financing easier and cheaper, which boosts investment and uptake. ICT has improved renewable energy generation and distribution. Smart grids using ICT to manage energy generation and delivery have increased renewable energy integration. ICT has also helped people and businesses improve energy use and reduce waste, encouraging renewable energy adoption. Financial development can also provide renewable energy project financing options. Green bonds, carbon credits, and renewable energy certificates are examples. Financial organizations can increase REC by sponsoring renewable energy projects with these products, Shahbaz et al. (2021) analyzed so. Financial development may boost renewable energy sectors, creating jobs and economic prospects. Renewable energy consumption can rise as more individuals work in the industry and have access to technologies, Wang and Dong (2021). FDI also has a positive effect on REC. Qamruzzaman (2022a) demonstrates that foreign direct investment promotes the growth of renewable energy by bringing in capital and technology. At the same time, government debt provides the necessary financial support for renewable energy initiatives. Wei et al. (2022) discovered that while renewable energy has a significant and negative effect on greenhouse gas emissions, foreign direct investment has a long-term positive effect on sustainable development. The study suggests deploying renewable energy with more strategic forethought and bolstering green finance Fan and Hao (2020) discovered a stable and long-lasting equilibrium between per capita GDP, per capita FDI, and renewable energy consumption. While FDI has no immediate effect on China's renewable energy consumption, a targeted increase in FDI and a modest decline in GDP growth can substantially increase China's renewable energy consumption over the long term. Rezagholizadeh et al. (2020) discovered a causal relationship between foreign direct investment, stock market development, and renewable energy consumption in Iran, indicating that an increase in FDI and stock market development leads to a rise in renewable energy consumption, thereby reducing CO_2 emissions over time. Ergun et al. (2019) found that higher per capita GDP and the Human Development Index are associated with less renewable energy integration. In contrast, foreign direct investment is associated with greater integration. The level of democracy in a nation has no bearing on the integration of renewable energy. Khandker et al. (2018) discovered a long-term bidirectional causal relationship between foreign direct investment (FDI) and renewable energy consumption in Bangladesh, implying that policies designed to attract more FDI could promote increased investment in the country's renewable energy sector. Financial development can fund renewable energy projects. This makes investing in solar panels, wind turbines, and hydroelectric power plants easier for businesses and people. More renewable energy projects can be funded and implemented, increasing REC. Doytch and Narayan (2016) found that FDI has different effects on renewable and non-renewable energy sources, with sectoral FDI having a substantial impact on energy consumption. Likewise, capital formation also has a positive impact on REC. Gross capital formation and natural resources are bidirectional causative, underscoring their economic importance. Hassan et al. (2020). The study exposed that capital formation involves acquiring physical and financial assets for economic progress. Capital formation includes investment in plant and equipment, research and development, infrastructure, and human capital. Fang (2011)'s study evaluates sound and robust renewable energy policy is essential for increasing economic welfare and capital development. Apergis and Payne (2011a) stated that real gross fixed capital creation, renewable energy consumption, and real GDP are in long-term equilibrium. Capital formation and renewable energy usage are interdependent. Capital development can boost consumer adoption of rooftop solar panels and electric automobiles. Increased adoption leads to more investment and infrastructure development, making renewable energy even more accessible and inexpensive Hata et al. (2022).

3.3. Estimation Strategies

In order to document the stationary properties, we have implemented Four commonly used unit root tests the Augmented Dickey-Fuller (ADF) test, Phillips-Perron (P-P) test, Elliot-Rothenberg-Stock (ERS) Generalized Least Squares Dickey-Fuller (GF-DLS) test, and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test offered by (Elliott et al., 1996; Kwiatkowski et al., 1992; Phillips and Perron, 1988; Dickey and Fuller, 1979). The ADF test is a commonly employed unit root test that expands upon the Dickey-Fuller test. This test

aims to evaluate the null hypothesis of a unit root compared to the alternative hypothesis of stationarity. The test equation incorporates lagged differences of the variable, thereby accommodating the presence of serial correlation in the data. The ADF test offers critical values that can be compared to the test statistic to ascertain the presence or absence of a unit root. The P-P test is comparable to the ADF test but addresses the possibility of serial correlation in the residuals. The provided estimation assesses the autoregressive coefficient in the test equation. It utilizes a modified t-statistic to examine the existence of a unit root. The P-P test is frequently employed to identify non-stationarity in time series data. The GF-DLS test is an extension of the ADF test, which employs a generalized least squares regression framework. This model accommodates heteroscedasticity and serial correlation in the residuals of the test equation. The GF-DLS test offers more efficient estimates of the test statistics, thereby enhancing the power of the unit root test. The KPSS test is a supplementary test to the ADF and P-P tests. This test aims to evaluate the null hypothesis of stationarity compared to the alternative hypothesis of a unit root. The KPSS test is primarily concerned with detecting deterministic trends within the data. It is commonly employed to assess the stationarity of macroeconomic and financial time series. The test statistic is compared to critical values to draw an inference regarding the stationarity of the data.

For long-run assessment, the present study implemented the novel combined cointegration test, familiarized by Bayer and Hanck (2013), with the null hypothesis of a no-cointegration test, the following Fishers' equation is considered in deriving the test statistics for detecting long-run association.

$$EG\text{–}JOH = -2\,[LN\,(PEG) + LN\,(PJOH)] \tag{4}$$

$$EG\text{–}JOH\text{–}BO\text{–}BD = -2[LN\,(PEG) - ln(PJPH) + ln(PBO) + ln(PBDM)] \tag{5}$$

Furthermore, the Maki (2012) cointegration test has deployed with an unknown structural break. The test statistics for long-run assessment have been tested by executing the following equation.

3.4. Autoregressive Distributed Lagged (ARDL)

The ARDL approach has become popular among empirical researchers studying long-term connections since then (Qamruzzaman and Jianguo, 2020; Qamruzzaman and Jianguo, 2018; Karim et al., 2022; Pu et al., 2021; Yang et al., 2021; Nawaz et al., 2021). One advantage of ARDL estimation over standard cointegration testing is that it produces a consistent estimate regardless of sample size (Ghatak and Siddiki, 2001). 2) capable of handling mixed-order variable integration with delayed requirements for improved model stability and efficiency (Pesaran et al., 2001). Finally, long-term and short-term elasticity tests should be conducted objectively. Based on Banerjee Banerjee et al. (1993). Following Pesaran et al. (2001), the generalized ADRL model for the study was considered for detecting long-run and short-run coefficients by performing the following equation and and the testing of hypotheisis is displayed in table 3.

$$\begin{aligned}\Delta lnREC_t &= \alpha_0 + \sum_{i=1}^{n}\mu_1\Delta lnREC_{t-i} + \sum_{i=0}^{n}\mu_2\Delta lnFD_{t-i} \\ &+ \sum_{i=0}^{n}\mu_3\Delta lnFDI_{t-i} + \sum_{i=0}^{n}\mu_4\Delta lnGCF_t + \gamma_1 lnREC_{t-i} \\ &+ \gamma_2 lnFD_{t-1} + \gamma_3 lnFDI_{t-1} + \gamma_4 lnGCF_{t-1} + \omega_{1t}\end{aligned} \tag{6}$$

The study implemented the following equation with error correction terms to capture the short-run dynamics.

$$\begin{aligned}\Delta lnREC_t &= \alpha_2 + \sum_{i=1}^{n}\beta_1\Delta lnREC_{t-i} + \sum_{i=0}^{n}\beta_2\Delta lnFD_{t-i} \\ &+ \sum_{i=0}^{n}\beta_3\Delta lnFDI + \sum_{i=0}^{n}\beta_6\Delta lnGCF_t + \rho ECT_{t-1} + \omega_{1t}\end{aligned} \tag{7}$$

We used several approaches to narrow down the potential diagnoses. The Harvey test was first used to determine whether the residuals from the refined ARDL model were heteroscedastic. Following this, we used the Breusch-Godfrey Serial Correlation LM test to look for serial correlation in the residuals. We then used the Ramsey RESET test to ensure our model parameters were correct. The Jarque-Bera normality test was then used to check whether the model residuals were normally distributed. In conclusion, the CUSUM and CUSUM of squares tests were used to demonstrate the stability of the model.

The following nonlinear equation to be implemented for exploring the asymmetric elasticities of government debt, Globalization, foreign direct investment, and financial development on institutional quality which is derived by following the asymmetric framework introduced by Shin et al. (2014).

$$\begin{aligned}REC_t &= (\pi^+ FD_{1,t}^+ + \pi^- FD_{1,t}^-) + (\beta^+ FDI_{1,t}^+ + \beta^- FDI_{1,t}^-) \\ &+ (\gamma^+ GCF_{1,t}^+ + \gamma^- GCF_{1,t}^-) + \varepsilon_t\end{aligned} \tag{8}$$

Where π^+, π^-, β^+,β^-, and γ^+, γ^- Stands for the long-run asymmetric coefficient of government debt, economic Globalization, Renewable energy, and Foreign Direct investment. The decomposition of explanatory variables can be derived in the following manner.

$$\begin{cases} POS(FD)_{1,t} = \sum_{k=1}^{t} lnFDI_k^+ = \sum_{K=1}^{T} MAX(\Delta lnFDI_k, 0) \\ NEG(FD)_t = \sum_{k=1}^{t} lnFD_k^- = \sum_{K=1}^{T} MIN(\Delta lnFD_k, 0) \\ POS(FDI)_{1,t} = \sum_{k=1}^{t} lnFDI_k^+ = \sum_{K=1}^{T} MAX(\Delta lnFDI_k, 0) \\ NEG(FDI)_t = \sum_{k=1}^{t} lnFDI_k^- = \sum_{K=1}^{T} MIN(\Delta lnFDI_k, 0) \end{cases}$$

$$\begin{cases} POS(GCF)_{1,t} = \sum_{k=1}^{t} lnGCF_k^+ = \sum_{K=1}^{T} MAX(\Delta lnGCF_k, 0) \\ NEG(REGCF)_t = \sum_{k=1}^{t} lnGCF_k^- = \sum_{K=1}^{T} MIN(\Delta lnGCF_k, 0) \end{cases}$$

The following equation documents the asymmetric coefficients in the long- and short-run assessments.

$$\Delta REC_t = \partial U_{t-1} + (\pi^+ FD^+_{1,t-1} + \pi^- FD^-_{1,t-1}) + (\beta^+ FDI^+_{1,t-1} + \beta^- FDI^-_{1,t-1}) + (\gamma^+ GCF^+_{1,t-1} + \gamma^- GCF^-_{1,t-1}) + \sum_{j=1}^{m-1} \lambda_j \Delta REC_{t-j0} + \sum_{j=1}^{n-1} (\pi^+ \Delta FD^+_{1,t-1} + \pi^- \Delta FD^-_{1,t-1}) + \sum_{j=1}^{n-1} (\mu^+ \Delta FDI^+_{1,t-1} + \mu^- \Delta FDI^-_{1,t-1}) + \sum_{j=0}^{m-1} (\beta^+ \Delta GCF^+_{1,t-1} + \beta^- \Delta GCF^-_{1,t-1}) + \varepsilon_t \quad (9)$$

The error correction term of the above equation is as follows

$$\Delta REC_t = \partial e_{t-1} + \sum_{j=1}^{m-1} \lambda_j \Delta REC_{t-j0} + \sum_{j=1}^{n-1} (\pi^+ \Delta FD^+_{1,t-1} + \pi^- \Delta FD^-_{1,t-1}) + \sum_{j=1}^{n-1} (\mu^+ \Delta FDI^+_{1,t-1} + \mu^- \Delta FDI^-_{1,t-1}) + \sum_{j=0}^{m-1} (\beta^+ \Delta GCF^+_{1,t-1} + \beta^- \Delta GCF^-_{1,t-1}) + \varepsilon_t + \varepsilon_t \quad (10)$$

4. ESTIMATION AND INTERPRETATION

4.1. Unit Root Test

The order of variable integration is considered crucial information when choosing econometric instruments for empirical analysis. We conducted a unit root test based on the methodologies proposed by Dickey and Fuller (1979), Elliott et al. (1996), and Phillips and Perron (1988) to test for non-stationarity. Additionally, we used the approach Kwiatkowski et al. (1992) suggested to test for stationarity. Table 4 displays the findings of the unit root analysis. The test statistic indicates that all variables become stationary after the first difference, which is desirable for model selection. Furthermore, the Ng-Perron unit root test has revealed a comparable set of stationary characteristics.

4.2. Cointegration Test

The cointegration test utilized in the research drew upon the works of Bayer and Hanck (2013) and Maki (2012). Its purpose was to establish evidence of a long-term relationship between the explained and explanatory factors. All test statistics in the study exhibit significance at the 5% level, indicating a long-term association following the researchers' rejection of the null hypothesis of no cointegration. The results of the cointegration test are presented in Table 5.

4.3. Symmetric and Asymmetric Estimation

Next, the long-run association between financial development, foreign direct investment gross capital formation, and renewable energy consumption has been assessed by employing a standard Wald test with a null of no-cointegration under symmetric and asymmetric frameworks. Referring to the test statistics and the critical value offered by Pesaran et al. (2001), Narayan (2005) and Sam et al. (2019), it is found that the test statistics, that is, $F_{overall,}$ $t_{DV,}$ and $F_{IDV,}$ have exposed higher than the critical value at a 1% level see Table 6. It is disclosing a long-run association.

4.4. Long-run and Short-run Coefficients: Symmetric and Asymmetric Assessment

The results of long-run and short-run coefficients displayed in Table 7 consisting long-run coefficinets in Panel –A, short-run coefficients in Panel –B and residual diagonestic test statistics in Panel –C, respectively.

In the long run, the coefficients of explanatory variables, that is financial development (a coefficient of 0.1479), foreign direct investment (coefficients of 0.0495) and domestic capital formation (a coefficient of 0.0875) reveled positive and statistically significant at a 1% level, explaining a contributory role in the development of clean energy inclusion in the energy mix in Bangladesh. More precisely, the coefficient of financial development (0.1479) indicates a statistically significant and positive correlation between the inclusion of renewable energy in Bangladesh and financial development. This finding implies that a robust financial sector, characterized by effective institutions and accessible capital, is crucial in promoting the growth of renewable energy initiatives. The statement aligns with the findings of (Murshed et al., 2020; Qamruzzaman, 2023c; Qamruzzaman, 2023a; Qamruzzaman and Kler, 2023), highlighting the importance of financial development

Table 4: Results of unit root test

Variables	At level				After first difference			
	ADF	GF-DLS	PP	KPSS	ADF	GF-DLS	PP	KPSS
REC	−1.2902	−0.894	−2.3887	0.55***	−7.8505***	−9.4394***	−8.1455***	0.0216
FD	−1.4809	−2.21	−1.8969	0.7719***	−7.0355***	−9.5543***	−9.3262***	0.0195
FDI	−1.4817	−1.3895	−1.6395	0.5801***	−8.3833***	−7.0413***	−9.4284***	0.02
CF	−0.6159	−2.0455	−1.3286	0.8919***	−6.1147***	−8.6485***	−8.4631***	0.0187
Panel –B: Ng−Perron Unit root test								
	At level				At first difference			
	MZa	MZt	MSB	MPT	MZa	MZt	MSB	MPT
REC	−2.7231	−0.8484	0.3496	7.9034	−17.814	−5.5018	0.1353	4.3712
FD	−2.7117	−1.4731	0.3512	9.1326	−25.124	−5.3686	0.15	3.8184
FDI	−1.762	−0.6899	0.3155	7.3436	−16.705	−5.2837	0.1597	3.5827
CF	−2.3445	−1.3227	0.2894	8.5825	−21.358	−4.5404	0.1339	4.5142

in supporting sustainable energy transitions. Similarly, the coefficient of foreign direct investment (0.0495) demonstrates a statistically significant and positive correlation between the inclusion of renewable energy and foreign direct investment. The outcome mentioned above implies that foreign direct investment (FDI) inflows into Bangladesh play a significant role in fostering the advancement and implementation of renewable energy technologies and infrastructure. This aligns with the findings of the study (Islam et al., 2023; Islam et al., 2022; Qamruzzaman, 2015), which highlights the significance of foreign investment in advancing renewable energy initiatives and fostering sustainable development goals. Furthermore, the coefficient of domestic capital formation (0.0875) demonstrates a positive and statistically significant correlation with including renewable energy. The finding mentioned above implies that domestic investments in clean energy infrastructure, technologies, and research and development play a significant role in fostering the growth of renewable energy in Bangladesh. This finding is supported by the reference study conducted by (Muneeb et al., 2022; Djellouli et al., 2022; Qamruzzaman et al., 2022; Jia et al., 2021; Pu et al., 2021), which highlights the importance of domestic capital formation in achieving sustainable energy goals.

Table 5: Results of the cointegration test

Panel A: Bayer-Hanck Combined cointegration without structural Break	
Test	**Statistics**
EG-JOH	12.331
EG-JOH-BO-BDM	34.81
Panel-B: Maki Cointegration with structural Break	
	Test statistics (Break year)
Level shift with Trend	−7.4978 (2004:2002:2005)
Regime shifts	−10.7355 (2005:2010:2007)
Regime Shifts with Trend	−10.8837 (2002:2004:2007)

Table 6: Results of long-run cointegration

long-run cointegration	$F_{overall}$	t_{DV}	F_{IDV}
ARDL	14.847***	−5.902***	10.357***
NARDL	8.277***	−6.124***	7.612***

4.5. Nonlinear Estimation

According to the findings of this study, it has been observed that there exists an asymmetry in the long-term relationships between financial development, foreign direct investment (FDI), capital formation, and renewable energy consumption in Bangladesh. The study demonstrates that these variables exhibit positive and negative coefficients about renewable energy consumption, thereby suggesting their association with adopting and utilizing these energy sources.

The positive coefficients associated with financial development, foreign direct investment, and capital formation suggest a positive correlation between renewable energy consumption and these specific factors. This finding suggests that renewable energy consumption increases when these variables undergo positive impacts or enhancements. The statement proposes that a robust financial sector, heightened foreign direct investment, and increased capital formation all play a significant role in

Table 7: Results of long-run and short-run coefficients

Variables	Coefficient	t-stat	SE		Coefficient	t-stat	SE
Panel –A: long-run coefficients							
FD	0.1479	0.0112	−13.2053	FD^+	0.089	0.0086	10.3488
FDI	0.0495	0.0076	−6.5131	FD^-	0.0709	0.0075	9.4533
CF	0.0875	0.009	−9.7222	FDI^+	0.0262	0.0039	6.7179
				FDI^-	0.081	0.0047	17.234
				CF^+	0.027	0.0091	2.967
				CF^-	0.1106	0.0042	26.3333
				W_{LR}^{FD}		7.036	
				W_{LR}^{FDI}		9.231	
				W_{LR}^{CF}		2.806	
Panel–B: Short-run coefficients							
FD	0.096	0.0065	14.7692	FD^+	−0.0496	0.0092	−5.3913
FDI	0.0402	0.0051	7.8823	FD^-	−0.051	0.0115	−4.4347
CF	0.0278	0.0101	2.7524	FDI^+	0.0303	0.0117	2.5897
				FDI^-	0.055	0.008	6.875
				CF^+	0.0712	0.0076	9.3684
				CF^-	0.02	0.0088	2.2727
				W_{LR}^{FD}		5.521	
				W_{LR}^{FDI}		8.089	
				W_{LR}^{CF}		5.077	
Panel –C: Residual Diagnostic test							
Breusch-Godfrey LM test		0.888			0.799		
Breusch-Pagan-Godfrey test		0.643			0.748		
ARCH test		0.745			0.635		
Ramsey RESET Test		0.496			0.736		
Jarque-Bera test							

fostering the adoption and utilization of renewable energy sources within Bangladesh. The above findings align with previous research emphasizing the positive correlation between financial development, foreign direct investment, capital formation, and renewable energy consumption.

Negative coefficients in financial development, foreign direct investment, and capital formation imply a negative correlation between renewable energy consumption and adverse disruptions or deterioration in these variables. The statement posits that instances of adverse disruptions or declines in financial development, foreign direct investment, or capital formation have a corresponding effect of reducing renewable energy consumption. This finding suggests that unfavorable conditions in these factors could potentially hinder Bangladesh's adoption and utilization of renewable energy sources.

The study's findings indicate positive and negative asymmetries in the relationship between financial development, foreign direct investment, capital formation, and renewable energy consumption in Bangladesh. These findings underscore the importance of positive shocks or advancements in these factors in promoting renewable energy consumption. Conversely, negative shocks or deteriorations may hinder its development. Policymakers and stakeholders can employ these insights to improve financial growth, attract foreign direct investment, and promote capital formation to facilitate the adoption and utilization of renewable energy sources in Bangladesh. This, in turn, will contribute to the country's sustainable development goals.

5. DISCUSSION

Financial development has played a crucial role in supporting the growth of renewable energy consumption worldwide. As renewable energy sources have become more affordable and cost-effective, countries with strong financial systems have been able to invest more in renewable energy projects (Ref: Yu et al., 2022) This has led to a virtuous circle of financial development and renewable energy growth, which has benefited both developed and developing countries alike. One of the key ways in which financial development influences renewable energy consumption is through the availability of financing. Development banks and other financial institutions are critical in providing capital for renewable energy projects. In many cases, these institutions can offer low-interest loans or other forms of support that can make these projects more viable (Ref: Sarwar et al., 2021). As a result, countries with strong financial systems tend to have an easier time accessing the financing necessary to grow their renewable energy sectors. In addition to financing, another important way that financial development affects renewable energy consumption is by creating policies and regulations that encourage investment in this sector. For example, many countries have implemented tax breaks or other incentives for businesses that invest in renewable energy. By creating an environment conducive to investment, these countries can attract more private capital into the renewables space, which leads to increased growth in this sector. Overall, it is clear that financial development plays a vital role in supporting the growth of renewable energy consumption worldwide (Ref: Zaidi et al., 2019). Our findings indicate an essential and beneficial connection between financial development and renewable energy consumption. This suggests that countries with a robust financial sector are more likely to consume more renewable energy. A robust financial system enables the development, installation, and expansion of clean energy infrastructure by facilitating access to financing for renewable energy initiatives (Ref: by Abubakar et al., 2015). Improved access to various financial instruments and institutions encourages investments in renewable energy technologies, which encourages renewable energy consumption.

The analysis demonstrates a significant positive correlation between foreign direct investment (FDI) and consumption of renewable energy (REC). This suggests that countries receiving more FDI tend to increase their use of renewable energy sources, Akpanke et al. (2023). Foreign direct investment provides host nations with additional capital and resources to be allocated to renewable energy initiatives. These investments are essential for financing renewable energy infrastructure's construction, expansion, and technological advancement (Wei et al., 2022). In addition, FDI frequently entails technology transfer, knowledge sharing, and market expansion, all of which contribute to the adoption and diffusion of renewable energy technologies and ultimately result in greater renewable energy consumption (Ref: Shah et al., 2022).

Our findings reveal a significant positive correlation between capital formation and renewable energy consumption. Countries with greater capital formation typically utilize renewable energy sources to a greater extent (Ref: Hata et al., 2022). The capital formation provides the financial resources necessary for developing and expanding renewable energy infrastructure. Investments in manufacturing facilities, power plants, research and development activities, and human capital development facilitate renewable energy initiatives (Ref: Olopade, 2020). In addition, capital formation stimulates technological advancements in the renewable energy sector, developing and implementing more efficient and cost-effective renewable energy technologies. These factors contribute to increased renewable energy consumption (Ref. Hassan et al., 2020). Our findings indicate that financial development, foreign direct investment, and capital formation all significantly promote renewable energy consumption. A robust financial sector provides access to financing and risk mitigation tools, encouraging investments in renewable energy initiatives (Ref: Apergis and Payne, 2011b). Foreign direct investment provides opportunities for capital, technology, and market expansion opportunities, which drives the adoption of renewable energy sources. Renewable energy infrastructure can be constructed, expanded, and technologically advanced due to capital formation. Together, these factors foster the development and utilization of renewable energy, thereby contributing to environmentally responsible and sustainable energy practices.

Policymakers need to recognize the positive effects of financial development, foreign direct investment, and capital formation on renewable energy consumption. Policy interventions should

strengthen financial systems, attract foreign investment, and promote capital formation to increase the adoption of renewable energy further (Ref: Salim et al., 2014). The transition to a greener energy mix can be facilitated by increasing access to finance, providing incentives for renewable energy investments, and fostering research and development efforts. In addition, creating supportive regulatory frameworks, enhancing institutional capacities, and promoting public-private partnerships are essential policy considerations for accelerating renewable energy consumption and achieving sustainable development objectives (Ref: Hassan et al., 2020). Nevertheless, it is essential to recognize the limitations of our investigation. The analysis relies on panel data and causal inferences. However, it is necessary to consider country-specific factors, policy contexts, and potential endogeneity issues. Future research should delve deeper into these facets and execute country-specific analyses to understand better the relationships between financial development, foreign direct investment, capital formation, and renewable energy consumption.

6. CONCLUSION AND POLICY SUGGESTIONS

This study examined the connections between capital formation, renewable energy consumption, financial development, and foreign direct investment (FDI). Our research found a clear causal link between capital formation, FDI, financial development, and renewable energy consumption. The findings show that financial growth favors capital formation and FDI inflows, which encourages using renewable energy sources. This indicates the critical role that financial institutions and markets play in promoting capital development, investments, and growing acceptance of renewable energy sources. In addition, our analysis showed a bidirectional causal relationship between FDI and capital formation, meaning that FDI inflows encourage capital investments. In contrast, strong capital formation draws foreign investors. This demonstrates how FDI and capital formation work together to promote sustainable energy practices.

Based on the study's findings, several policy recommendations may be made to strengthen the beneficial effects of financial growth and FDI on the use of renewable energy through the channel of capital formation:

First, Financial institutions, capital markets, and banking systems should all be developed by governments with a strong emphasis on efficiency. This calls for expanding financial inclusion, strengthening financial rules, and creating an atmosphere encouraging financial innovation. A robust financial system can draw in domestic and foreign money, helping raise funds for renewable energy projects.

Second, Government officials should implement measures to draw global capital into the renewable energy industry. Tax incentives, faster investment processes, and helpful regulatory frameworks can all help achieve this. Countries can gain from more significant FDI inflows by fostering a favorable investment climate, resulting in technological transfers, knowledge exchange, and capital accumulation in the renewable energy industry.

Third, Policies that promote capital creation and investment in renewable energy infrastructure should be given top priority by governments. This entails encouraging public-private collaborations, offering financial incentives for renewable energy initiatives, and assisting with research and development initiatives for clean energy technologies. Strong capital development can aid in filling the funding gap and enabling the larger-scale implementation of renewable energy projects.

Fourth, Deploying renewable energy projects requires solid institutional structures. Clear laws, rules, and incentives from the government should help the renewable energy sector expand. This entails creating feed-in tariffs or other pricing mechanisms, defining renewable energy targets, and encouraging the integration of renewable energy sources into the grid. A favorable environment for greater renewable energy consumption can be created by strengthening the organizations in charge of planning, regulating, and monitoring renewable energy.

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