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Financial Development, Green Finance, and Carbon Emissions: Renewable Energy as a Mediating Mechanism in a Green Economy Framework

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In the past five years, there has been an increasing interest in green financing as many companies, nations, and organizations view the green economy as essential to achieving the Paris Agreement objective of 1.5°C global warming and below 2°C. Today, however, the production of non-renewable energy is a CO_2 demanding process, contributing about 2% of world CO_2 emissions. We cannot advance toward a green economy by maintaining processes that produce greenhouse gases. Energy production must be done as cheaply and with the least amount of greenhouse gas emissions feasible, most likely necessitating the usage of renewable energy sources. The study about modeling aims to comprehend how renewable energy use mediates the effects of foreign direct investment, green finance, economic growth, natural resources rent, international trade, and urbanization on environmental degradation while examining the moderation of financial development by employing a two-stage moderated mediation model in the particular case of 79 nations. The selection of the sample period and countries is based on the availability of annual data covering the twenty-one years 1999-2019. We obtained the necessary data for our variables from reputable sources, namely the World Bank, (2022) and the OECD, (2022). With the insights gained from our study, government agencies, institutions, policymakers, and other organizations could implement more sensible, suitable, and effective measures to promote environmental safety. The findings of the study state that green financing have positive impact on reducing pollution. Hence, modernization increases CO_2 emissions, which cause a threat to environmental quality. The researchers suggest that there must be a standardized measure of production, distribution, and consumption. There is a need for green economy measures, and the government must initiate steps towards green-friendly products/ projects. Those are less harmful to the economy.

1. Introduction

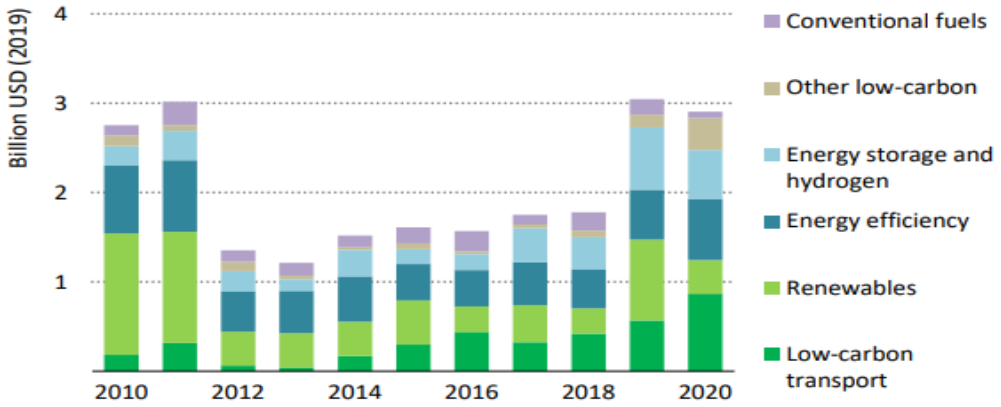
Global efforts are being made to pursue ecological sustainability while reducing the effects of environmental degradation. The change of energy structure is speeding up in relation to achieving global carbon neutrality. More and more countries are actively introducing laws and programs to stimulate the expansion of the renewable energy sector, which has bright possibilities. Solar, wind, biofuels, nuclear, and hydro-power are some of the REU sources. The primary source of non-renewable energy today is the reforming of fossil fuels, primarily natural gas, without the use of any technology that would mitigate or lower greenhouse gas (GHG) emissions. Currently, these operations are responsible for 2% or more of all CO_2 emissions worldwide. So, after the industrial revolution, it has been noted that every country is striving for high economic growth by using its sources of energy; however, the vast use of fossil fuels has created an urgent issue due to excessive widespread carbon emissions, which end up causing the sea level to rise by an additional 10–20 cm than anticipated. In the 21st century, the world's air temperature increased from 1.0° to 3.5°. The present climate debate is focused on finding ways to attain net-zero emissions by 2050. Most transformative routes rely on "hard-to-avoid" emissions, like those from industry, agriculture, and aircraft, to be offset by positive emissions. The extinction of ecosystems, permafrost, or the cryosphere might result from even a gradual rise in global temperature of 1.5°C. Going "below zero" with large negative emissions is necessary to reduce the atmospheric CO_2 concentration and climate forcing (Desing, 2022).

This worrying situation has led nations to focus on REU sources, which are essential to achieving sustainable development worldwide. This study adds to several previously published literary works. In this analysis, the following research issues are prioritized. Does FD moderate the conditional effect of green finance, FDI, and other economic variables on CO_2 emissions through renewable energy use? How much did moderating and mediating factors, like FD and REU, influence GFN, FDI, and other economic variables to have an impact on CO_2? There is no easy solution, but there are hints and cues we can use to build a plausible story about how this will pan out.

First, it is obvious that we will need to use all possible low-carbon paths in order to ensure that renewable energy plays the expected part in the energy transition; the magnitude and rate of decarbonization compel this. Although the use of power ships and LNG tankers can reduce air pollution emissions through the use of emission control technologies and international regulations, many of the nations that are adopting power ships lack the necessary environmental regulations or the enforcement mechanisms (Marais, et al., 2022). If we can rely on several energy vectors rather than just one, such as electricity, biomass, and natural gas, we will be considerably more likely to achieve our goals.

Second, we must address the obstacles to the widespread adoption of the green economy. With regard to electrolysis, this is now constrained by the cheap, plentiful supply of renewable electricity. Since system analyses indicate that in an environment where non-renewable energy sources predominate in the electricity mix, the majority of new renewable energy should be used for decarbonizing the electricity mix, the question is not whether electrolysis should be powered by renewable energy but rather how (Van et al., 2022).

Figure No 1: Investments in start-ups of sustainable energy technology on a global scale



Source: World Energy Investment, 2021

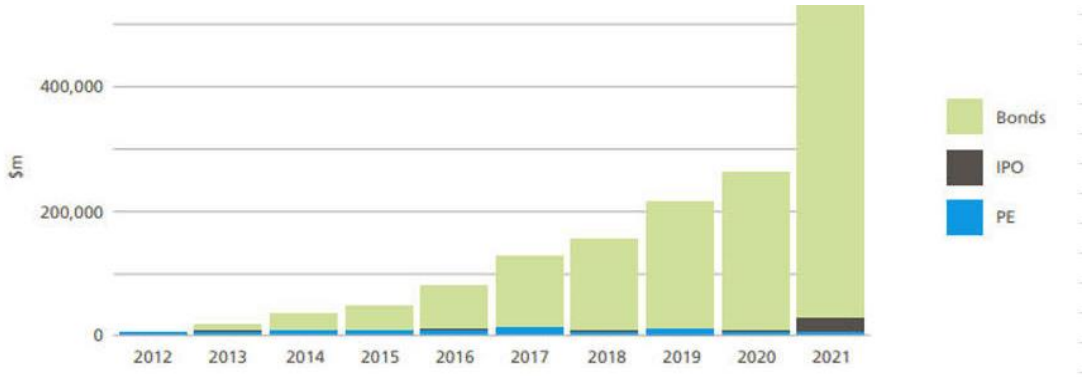
Third, the important factor that increases damage on environment is carbon emissions because 92% of CO_2 emissions are dominated by gas-to-electricity (Marais, E. A, et al., 2022). The natural carbon cycle has become unbalanced due to excessive CO_2 emissions from the burning of fossil fuels, which has produced a progressive warming of the world's temperature as well as environmental issues. According to Kali et al. (2022), the transportation, industrial, and energy generation sectors are responsible for the most CO_2 emissions. Globally, the main emission sectors are comparable. Power plants and CO_2-emitting industries like steel, iron, and cement production are consequently important point sources. In ambient settings, artificial photocatalysis offers an alternative for converting CO_2 to compounds utilizing renewable solar energy. One of the promising photocatalysts for reducing CO_2 is silicon carbide (Wang, B et al., 2022). "If serious steps are not taken, the continued increase in environmental pollution could double by 2035" (Yu et al., 2021). However, in the conference of the Paris Agreement, the target for temperature has set below 2°C (Dong et al., 2022). Global development continues to be threatened by the issue of climate change.

Fourth, Environmental experts are now debating how to navigate the intersection between carbon emissions and green finance (GFN). The SDGs of the UN focused attention on the rising concern over environmental degradation and the high usage of natural resources, which opened a door for the introduction of contemporary ideas like sustainable growth. The financial sector previously disregarded the ecosystem, but it has started to take environmental concerns more seriously and has launched many financial products that are explicitly aimed at environmental conservation, such as green bonds and 255 products in the OECD, which is the largest basket of green products. The following 10 primary categories make up the OECD list (Li et al., 2022)

- Control of air pollution
- Environmentally friendly or resource-wiser technology and goods
- Products that are environmentally desirable based on features of end-use
- Controlling energy and heat equipment for “environmental monitoring, analysis, and assessment.”
- The maintenance of natural resources
- Reduction of noise pollution

- Renewable energy facility and "Solid waste management, hazardous waste management, and recycling systems."
- Soil and water treatment or cleanup
- Waste water management and treatment of potable water

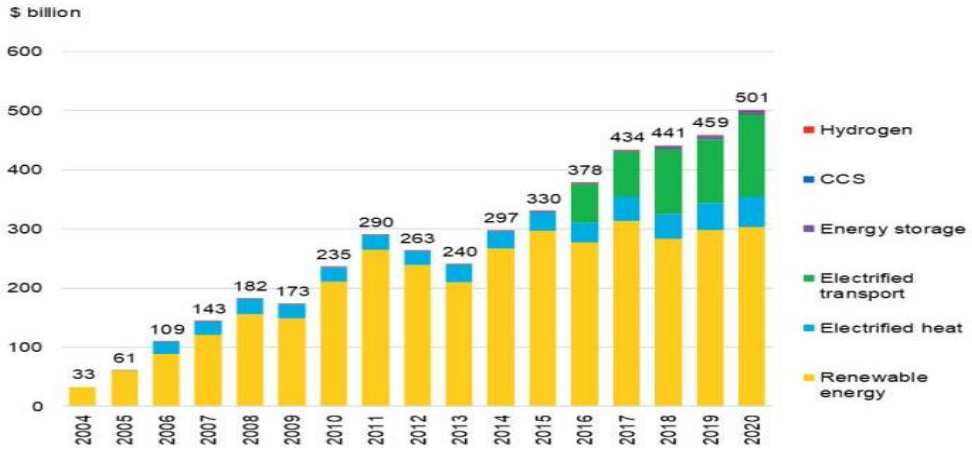
Figure No 2: Global Green Finance



Source: "Global green finance rises over 100-fold in the past decade -study, 2022"

According to the data, between 2012 and 2021, green bonds made up 93.1% of all green financing globally. In 2021, $511.5 billion in green bonds were issued globally, up from $2.3 billion in 2012. Fifth, there has been increasing agreement regarding the need for worldwide climate change action and low-carbon energy. The world's energy demand is always rising, and because of the devastating results for world climate degradation, it is a major challenge of 21st century (Umar et al., 2022; Liu et al., 2021). The increasing use of energy becomes a crucial part of smooth growth that would address poverty. The main focus of the economies is on the development of the economy, irrespective of environmental degradation. It is not possible to ignore the energy use as all human and economic activities highly depend on the energy sector. Since 1995, the "International Energy Agency" has observed that energy consumption of 50% in worldwide energy consumption. Fossil fuels (FF) supply 80% in energy consumption of the world that makes energy sector an important contributor to greenhouse gas (GHG) emissions (IEA, 2013), which account for almost two-thirds of all emissions globally (Umar et al., 2021).

Figure: No 3: Energy Transition Investment



Source: Energy Transition Investment Hit $500 Billion, 2020

Finally, utilizing renewable energy has a number of advantages, including increased energy security, continued economic growth, and a considerable decrease in greenhouse gas emissions. Variations in solar radiation and wind speed have an impact on solar and wind power, respectively, which hinders the stable operation of these systems and increases output volatility. Contrarily, due to their highly renewable and sustainable character, biofuels are attracting substantial interest and have become recognized as a viable alternative to conventional fuels. Additionally, biofuels are carbon neutral, easily produced from biomass and other waste, biodegradable, and environmentally benign.

Therefore, the excess use of non-renewable resources like fossil fuels leads to a decrease in environmental quality and its negatively effect on the development of a green economy. Academics stress the importance of achieving sustainable economic growth and putting sustainable environmental policies in place. Little research has connected economics and ecology until now. According to Wang and Zhi (2016), creating financing for solar energy can help achieve environmental sustainability. Clearly, the discussion above contains a lot of assumptions. The amount of area available for renewable energy generation is anticipated to have a substantial impact on how quickly the decarbonization of renewable energy will progress. The price is thought to have been affected thus far by the switch from coal to natural gas in the production of energy. It is envisaged that new targets would assist a low-carbon economy and the eventual removal of CO_2 from the environment in the future.

1.1 Aim, Scope, and Paper Organization

The contribution of the study consists of the integration of the moderating impact of the financial system and the mediator (REU) in the analysis of the effects of FDI, GFN, EG, NRR, IT, and URB on CO_2 emissions. Second, most studies have included financial development as a stimulant factor for several purposes. In this model, financial development is included as a conditional factor. By using a moderated mediation technique, our study was able to investigate whether a sound financial system can lower pollution by looking at the effects of REU, GFN, EG, NRR, IT, and URB on CO_2 emissions. Several studies have studied the macro factors of the economy that contributes in the growth of the economy. Those macro variables are foreign direct investments, urbanization, renewable energy use, human capital, trade openness, population size, and globalization, etc. Among these variables, the Researcher will incorporate some of them in this study to check the impact of these variables on CO_2 emissions. Additionally, there are conflicting findings regarding how these variables affect environmental pollution. This flaw is filled with sample selection as well as the methodology used in the modelling that linked the GFN, FDI, URB, EG, IT, and NRR, with CO_2 emissions. Finally, Prior research ignored the impacts of FD on REU and focused only on the moderating effects of financial development between these factors and pollution (Husam Rjoub et al., 2021).

The scope of this study is to improve the understanding of the damaging effects of these chosen variables on the ecosystem for the Researcher. The findings will assist policymakers in promoting economic development and trade with the least amount of environmental damage. The findings state regarding sustainable economic development, management authorities must establish environmentally friendly policies and control environmental pollution. Government and other interested parties may create strategies and processes to address these issues. With

the insights gained from our study, government agencies, institutions, policymakers, and other organizations could implement more sensible, suitable, and effective measures to promote environmental safety. The government can provide funds and concessions to promote the development of REU technologies. Governments, on the other hand, play a crucial role in energy usage by assisting citizens in changing their lifestyles and behavior towards lowering energy demand through policy guidance.

The structure of our study is as follows: first, we gave a theoretical background, objectives, and problem statement. Second, Literature has focused particularly on the connections between the variables, the research gap, and questions. Third, we described our research methodology, framework, empirical model, and analysis. Finally, we presented our findings together with the analysis results and conclusion.

2. Literature Review

In this section, the literature of past studies related to the study variables shows the relationship between carbon dioxide emissions, urbanization, financial development, economic growth, international trade, green finance, natural resource rent, financial direct investment and renewable energy use.

2.1 Environmental Factors-CO_2 Emission Nexus

2.1.1 Sustainable Growth-CO_2 Emission Nexus

Several studies have studied on the macro factors of economy that contributes in the growth of economy. Mulali Al et al. (2018) and Muhammad, B et al. (2019) employed a panel model and a cointegration test to investigate the relationship between CO_2 emissions, energy usage and economic growth in Middle Eastern nations (1990-2008). In Middle East, they discovered a long-term link between CO_2 emissions, power usage and economic growth. Gorus et al. (2019) studied on MENA countries, a panel causality test to investigate the causative link between EG, energy usage and CO_2 emissions (1975-2014). They discovered that energy conservation measures negatively affect economic growth in the long term. Those macro variables are FDI, urbanization, renewable energy use, Human capital, trade openness and population size, etc. Among these variables we will incorporate some of them along with economy growth in our study to investigate the impact of economic variables on reduction of CO_2 emissions. Although in China Xu et al. (2025) found the environmental trade-off, the result is that economic development continues to be at the forefront of emitting CO_2, and the integration of green technological innovation and human capital is starting to decouple growth and environmental degradation.

2.1.2 International Trade-CO_2 Emission Nexus

The study investigated the effects of trade on CO_2 with nations that export oil between 1995 and 2013 and discover evidence supporting the beneficial impacts of GDP-Imports nexus (Hasanov et al., 2018). On other side, the negative effect is noted by exports. When GDP is increasing and CO_2 increases in the region, both imports and exports have similar positive effects. The Ding et al. (2021) an analysis of the G7 economies' 1990–2018 period's environmental impacts on commerce, REU and Eco-innovation. This is the first in a brief report on a few strands of the literature. The results show that the consumption of REU, Eco-

innovation, and productivity in energy reduce the increase in CO_2 while imports and GDP raise it. Another study on the G7 economies, exports turn seems to as a bad CO_2 prediction. Production and commerce operations especially use more resources (Wang et al.,2022). The researcher conducting this study to check the effect of IT on CO_2 emission is really important. Correspondingly, Cendekia Niaga (2025) reverted to ASEAN-China trade, which showed that as trade is opened, CO_2 emission tends to increase. The paper recommends holistic carbon pricing and green trading environments to reduce the adverse environmental effects of local free trade agreements.

2.1.3 Green finance-CO_2 emission nexus

GFN was defined by Yao et al. (2016), the incorporation of finance-economics choices is most advantageous to environmental preservation. It increases the quality of environment by shifted finance on more innovative technology rather than in the industry. Green finance improves and managed the sustainable development and its major focus is on the environment quality by reducing CO_2 emissions. Without the support of the capital market, it is impossible to provide secure and sufficient funding for the research and development of green products (Cline et al., 2020). Green finance made it possible to starts investments in the environmentally friendly projects and it also raise funds for this cause (Muganyi et al., 2021). In a similar vein, Wang et al. (2021) hypothesized that green finance aids in reducing environment degradation by encouraging business investments in technology, such as (renewable innovation opportunities for investment), which upholds the quality of environment. In ten countries, GFN-CO_2 relation has been studied by Saeed Meo and Karim, (2021). These countries have huge investments in green financing. According to their research, GFN and EVP have an antagonistic relationship. According to their research, GFN is a useful strategy for improving environmental quality by reducing CO_2 emissions. This study checks the relationship of GFN-CO_2 with the conditional effect of financial development through REU. Muchiri et al. (2025) used a Panel Robust Fixed Model to confirm a hypothesis that green financing is practical in reducing carbon emissions in the entire world. Their study identifies that green bonds are considerably amplified in the effects of the amount of government expenditure on environmental protection towards achieving a low-carbon economy.

2.1.4 Natural Resource Rent-CO_2 Emission Nexus

NRR is crucial to the development of most nations, especially emerging economies. Negative ecological effects result from exceeding NRR (Solarin et al., 2017). According to Hassan et al, (2019) NRR enhances protection for environment which benefits growth of economy. Additionally, Ibrahim & Ajide, (2021) reported that in the countries like BRICS. Financial development and NRR leads to EVP. Interestingly, Tufail et al. (2021) discovered among the 10 most recently industrialized nations, NRR helps to reduce environmental pollution. Natural resources are becoming scarcer and NRR is regarded as a more environmentally friendly source of power. Many countries are compelled by EG to use their NRR resources are not work efficiently which leads to environmental damage such as destruction of land and EVP (Li et al., 2022). This only serves to highlight a gap in the current efforts to use NRR as a viable policy tool to reduce CO_2 emissions. Frontiers in Environmental Science (2025) evaluated G7 countries and discovered that coal and natural gas rents to green

growth have an undesirable effect. Conversely, the research also supports the view that, as much as oil rent might offer short-term growth, it only increases the impediment to the introduction of a sustainable and low-carbon economy.

2.1.5 Urbanization-CO_2 emission nexus

People moving from rural to urban regions is known as urbanization. It is anticipated that the 50% of this population residing in cities will utilize 50% of energy in the world and increase CO_2 emissions by more than 60%. (Shahbaz et al., 2015). URB is now universally acknowledged as one of the prerequisites for global growth. However, the numerous negative effects linked with URB, a significant portion of which are CO_2 emanations, have shown this idea to be fruitless (Behera & Dash, 2017). According to Fan et al. (2019) URB and EG essential transitional function mostly in EVP and social advancement of countries. Musah et al. (2021) looked on link URB-EVP among W.A nations. They discovered that URB had a direct and advantageous impact on EVP. Numerous academics are still investigating their effect on each other because it's a pertinent topic (Zhang et al., 2021). This study checks the relationship of URB-CO_2 with the conditional effect of financial development through REU. In their analysis, Sun et al. (2025) investigated 286 cities in China, and they discovered that the urbanization-CO_2 relationship is non-linear. Although the early city development was regarded as an emission rate of growth, there is a point examined as the beginning of a new type of urbanization that concentrates on condensed cities and the quality of the forests, where emissions start to be reduced.

2.1.6 FDI-CO_2 Emission Nexus

Numerous investigations into the connection between FDI and CO_2 excretions have been conducted. However, results have been inconsistent. (Huang et al., 2019) looked into how FDI and CO_2 emissions in Chinese provinces are related. The study's findings confirmed that FDI is a factor that negatively affects CO_2 emission. Minh, (2020) identified FDI as a significant source of CO_2 emissions conducted on Vietnam. Ahmad et al. (2020) investigated a study on the region like OECD and found that FDI is a critical factor in the promotion of CO_2 emissions. Guzel et al. (2020) discovered that FDI was a major factor in the promotion of CO_2 excretions in ASEAN nations. This information is really valuable, although the study was only done in ASEAN nations. Consider the idea that established financial institutions entice FDI, which encourages R&D, increases revenue, and lowers pollutant emissions. The researchers additionally emphasis how developing countries' adoption of new technology will contribute towards environmental safety (Wang et al., 2021). The researcher conducting this study to check the effect of FDI on environment is really important. The paper by Manhas (2025) examines the topic of the Pollution Haven Hypothesis and resembles the studies of other researchers by introducing the idea that the increase in the inflow of FDI by 1% plays off a 0.59% increment in CO_2 emissions in India. The paper puts emphasis on the significance of stringent environmental norms to sieve capital to green technologies.

2.1.7 Renewable energy usage-CO_2 emission link

Research has shown that REU has a major impact on EG, which has a long-term impact on EVP. Agbede et al. (2021) investigation into the relationship of REU-CO_2 in the four-

country group. The study investigated energy usage quickens the growth rate of economy and will cause environment deterioration in nations. While renewable energy is generally the best choice for lowering carbon dioxide said by Ibrahim et al. (2021). "If serious steps are not taken the continues increase in environmental pollution could double by 2035" (Yu et al., 2021). According to IRENA (2026), although energy conversion to renewable energy is accelerating, the energy-water-carbon nexus exposes the fact that poor localities confront resource efficiency issues. Nevertheless, any decrease in carbon emissions up to 2030 is projected to highly depend on the continued affordability of solar/wind. This research taking REU as a mediator in moderated mediation model using a big sample of 79 countries over the time span of 1999–2019.

2.1.8 Financial development-CO_2 emission nexus

Financial development is a significant environmental quality indicator. Globalization drives financial development, according to Mishkin, (2009) and Shahbaz et al. (2018) but few studies contend that FD also raises emissions like CO_2 because it loosens economic credit limitations and increases GDP, both of which lead to higher CO_2 emissions. Another study team supports financial growth, the reason is that it encourages spending on innovative technology that might reduce emissions like CO_2 (Zafar et al., 2019). In addition to analyzing the energy efficiency and CO_2 emissions, this study also discusses financial development. The validity of the empirical findings may be questioned if this important component is ignored. There is insufficient empirical evidence to support any of these opposing theories. More study needed on the financial development (Khan et al., 2021). MDPI (2025) defines a non-linear affiliation in which financial development initially strengthens economic growth but experiences a threshold effect. The economic benefits of financial excavating take a short time to begin to decrease as soon as it reaches a certain peak, requiring carbon-oriented financial instruments. This research taking FD as a moderator in moderated mediation model using a big sample of 79 countries over the time span of 1999–2019.

3. Methodology

3.1 Variables, Data Collection, and Measurement Units

The study aims to comprehend how REU mediates the effects of FDI, GFN, EG, NRR, IT, and URB on CO_2 emissions while examining the moderation of financial development by employing a two-stage moderated mediation model in the particular case of 79 countries. The availability of annual data was the main basis considered to choose the sample period and nations for the entire study. The study uses a quantitative approach and secondary data covering the years 1999-2019. The dataset for the variables is taken from the World Bank, (2022) and OECD, (2022). The following factors are included in the data: CO_2 emissions were calculated using tons of CO_2 per person, inflow of FDI (% of GDP), economic growth (constant 2015 US$), NRR (% of GDP), and URB was calculated against the total urban population (% of total population). The proportion of GDP that is exported and imported was used to gauge international trade and green finance (Environmental protection products by residents). REU is calculated as a percentage of energy consumption. FD is calculated as domestic and foreign loans to the private sector. The total labor force of populations was used to calculate the labor force. Infrastructure was determined by the number of mobile subscriptions per 100 persons,

while saving was calculated as a percentage of GDP. Merchandise trade was calculated as the number of exports and imports of goods, which are some of the factors that are taken into consideration. The chosen variables are shown in Table 1.

Table No 1: Description of Variables

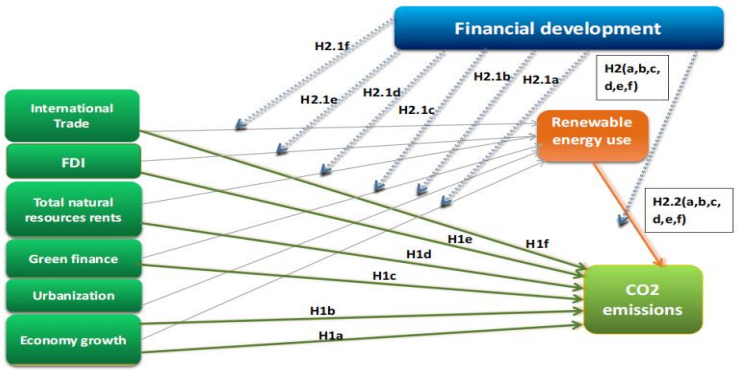
Dependent Variables	Notation	Indicator	Database
Carbon dioxide emission	CO2	CO2 Emissions	WDI
Independent Variables			
Green Finance	GFN	Environmental Protection Product by Resident	OECD
Natural Resourse Rent	NRR	Total Natural Resourse Rent % of GDP	WDI
Economic Growth	EG	% Annual Growth of GDP	WDI
Urbanization	URB	% of total Urban population	WDI
International Trade	IT	Exports, Imports	WDI
Foreign Direct Investment	FDI	FDI net flow	WDI
Control variables			
Merchandise Trade	MT	Amount of exports and imports of goods	WDI
Labour Force	LF	Total labour force of populations	WDI
Infrastructure	INF	Number of mobile subscriptions per 100 persons	WDI
Gross savings	GNS	% of GDP	WDI
Other Variables			
Renewable Energy Use	REU	Renewable energy consumption % total energy	WDI
Financial Development	FD	Domestic & foreign loan to private sector	WDI

Foreign direct inflows, natural resource rents, urbanization, international trade, Economic growth and green finance are explanatory variables in the study (Li et al., 2022). Carbon dioxide emission has been taken into consideration as dependent variables to ascertain their interactions. Financial development serves as a moderator, and Renewable energy use serves as a mediator. The labor force, trade in goods, infrastructure, and savings served as the study's control variables (Sher Khan et al., 2020).

3.2 Theoretical Framework

In Fig. 3.1, which depicts our conceptual model of moderated mediation, these conditional impacts of GFN, FDI, URB, EG, IT, and NRR on CO_2 emissions through REU are illustrated.

Figure No 1: Conceptual Model: Both Side Moderated Mediation of FD



Source: Adapted from Tarek Bel Had, 2021

3.3 Hypothesis

These hypotheses are constructed using the data presented above and go as follows:

H_1: NRR, IT, EG, URB, FDI, and GFN have a direct relation with CO_2 emissions.

H_2: REU mediates the effects of NRR, IT, EG, URB, FDI, and GFN on the country's pollution levels.

H_3: The conditional effect of FD moderates the REU mediation on NRR, IT, EG, URB, FDI, and GFN on the country's pollution levels.

3.4 Empirical Model

3.4.1 Mediation model

The indirect influence of REU on NRR, IT, EG, URB, FDI, and GFN's effect on CO_2 emissions was examined using the SEM. According to Atahau et al. (2021), this model made it possible to analyze both indirect and direct effects. Equations (1) and (2) are drawn from the above Model, where CO_2 emissions are the outcome variable, renewable energy use is the mediator, and MV is used with the mediator. NRR, IT, EG, URB, FDI, and GFN are the exposure variables.

$$CO_{2_{it}} = \beta_0 + \beta_1 GFN_{it} + \beta_2 NRR_{it} + \beta_3 FDI_{it} + \beta_4 IT_{it} + \beta_5 EG_{it} + \beta_6 URB_{it} + \mu_{it} \dots\dots\dots\dots\dots\dots (1)$$

$$CO_{2_{it}} = \beta_0 + \beta_1 GFN_{it} + \beta_2 NRR_{it} + \beta_3 FDI_{it} + \beta_4 IT_{it} + \beta_5 EG_{it} + \beta_6 URB_{it} + MV_{it}\partial_1 REU_{it} \dots\dots (2)$$

Where I and t stand for individual nations and eras, respectively. The erroneous term is (μit). Equation (1) shows the overall effect of the independent variables on the CO_2 emissions. Equation (2) shows the indirect/Mediating effect of the exposure factors on the CO_2 emissions through REU. The variables GFN stands for green financing, FDI for foreign direct investment flows, URB for urbanization, EG for economic growth, IT for international trade, NRR for natural resources rent, FD for Financial development, REU for usage of renewable energy sources and CO_2 is for carbon dioxide emissions in Equations (1) and (2).

3.4.2 Moderated mediation model

This study aims to analyze the first stage moderation by determine the relationship between urbanization, green financing, economic growth, foreign direct inflows, international trade, natural resources on REU with the moderation of FD in Equation (3) and second stage moderated mediation by determine the relationship between REU-CO_2 with the moderation of FD in Equation (4) Where I and t stand for individual nations and eras, respectively. The erroneous term is (μit). The variables GFN stands for green financing, FDI for foreign direct investment flows, URB for urbanization, EG for economic growth, IT for international trade, NRR for natural resources rent, FD for Financial development, REU for usage of renewable energy sources, and CO_2 is for carbon dioxide emissions. Where MO is used with the moderator.

$$REU_{it} = \beta_0 + \beta_1 GFN_{it} + \beta_2 NRR_{it} + \beta_3 FDI_{it} + \beta_4 IT_{it} + \beta_5 EG_{it} + \beta_6 URB_{it} + MO_{it}\partial_1 FD_{it} + C_1 GNS_{it} + C_2 INF_{it} + C_3 MT_{it} + C_4 LF_{it} \quad \text{.....(3)}$$

$$CO_{2_{it}} = \beta_0 + \beta_1 REU_{it} + MO_{it}\partial_1 FD_{it} + C_1 GNS_{it} + C_2 INF_{it} + C_3 MT_{it} + C_4 LF_{it} \quad \text{.....(4)}$$

4 Result and Discussions

4.1 Descriptive Statistics

Table 2 shows the finding of mean, observation and standard statistics, etc. The standard deviation of the variables used in the study is fairly high. So, according to the average statistics for the variables, CO_2 (1.597), NRR (9.148), IT (.739), EG (1.515), URB (1.416), FDI (22.931), GFN (7.416), REU (19.756), and FD are the variables (46.105). The average figures demonstrate that the highest average values are for FDI and FD. The statistical finding in Table 2 shows for the panel data from 1999 to 2019, statistical descriptive profile details about the countries.

Table No 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ID	1659	40	22.81	1	79
Years	1659	2009	6.057	1999	2019
CO_2	1659	11.229	1.597	7.208	16.186
NRR	1659	5.131	9.148	.001	58.92
IT	1659	.676	.737	0	5.701
EG	1659	9.103	1.515	.673	11.63
URB	1659	8.027	1.415	3.009	10
FDI	1659	7.084	22.9	.001	449.083
GFN	1659	12.41	7.416	.84	92.59
REU	1659	20.524	19.756	.009	91.31
FD	1659	70.04	46.185	.186	255.31
LF	1659	15.856	1.586	11.941	20.5
GNS	1659	23.771	9.149	.657	66.884
INF	1659	4.148	1.059	.013	5.36
MT	1659	4.07	.541	2.753	5.839

4.2 Correlation Matrix

We first verify the correlations of all the variables, and the findings are shown in Table 2, before looking at the results of GFN-CO_2. At the 5% level of significance, all tests related to the correlation between the independent factors and the CO_2 emissions are significant, proving the validity of the variables used in this study. Further evidence that international trade, foreign direct investment, and green financing may have a detrimental impact on CO_2 emissions comes from the fact that IT, FDI, and GFN have negative correlations with the dependent variables. However, further estimate is necessary for more precise results. Additionally, the majority of the results of the correlation tests between these factors are lower than 0.8, which indicates that there isn't a significant Multicollinearity problem between the variables.

Table No 3: Matrix of Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CO_2	1.000						
NRR	0.172***	1.000					
IT	-0.114***	-0.074***	1.000				
EG	0.066***	0.000	0.161***	1.000			
URB	0.071***	0.101***	0.161***	0.466***	1.000		
FDI	-0.213***	-0.050**	0.234***	0.042*	0.118***	1.000	
GFN	-0.101***	0.336***	-0.091***	-0.083***	-0.026	-0.030	1.000

**** p<0.01, ** p<0.05, * p<0.1*

4.3 GMM

The null hypothesis for the Hausman test is in favor of random effect, and the alternative is in favor of fixed effect but the value of p in this test is significant which means we refused the null hypothesis and for this study we use fixed effect model as our base model. So, we will do further analysis by taking a fixed-effect model as our base model. NRR, IT, EG, URB, FDI, and GFN were tested for their impact on CO_2 using the Difference GMM - two-step technique. At a significance level of 1%, the results demonstrate that NRR, IT, EG, and GFN values with a negative sign indicate an inverse connection with CO_2. The findings of URB and FDI demonstrate a positive correlation between them and CO_2.

4.4 Panel Root Test

In order to analyze our econometric model, this part first calculated the SHT and tested for unit roots for the variables. Table 5 shows the slope of heterogeneity, in which the results show that we have variation in the economies because the SHT H_0 is rejected. Additionally, the result shows that our research's following steps will use a valid method for calculating the Difference GMM. The unit root test was examined using CADF and CIPS tests in the study. As shown in Table 6, none of the series (NRR, IT, EG, URB, FDI, and GFN) was stationary at the level. In light of this, following the initial difference I, all of the candidates' series are represented as stationary (1). This technique can be used to check for long-run cointegration in the series used in this investigation.

4.5 Cointegration Test

We utilized these methodologies introduced by Westerlund in 2007 to investigate the existence of long-term cointegration interaction among the research variables. The outcomes represent that the variables interact via cointegration. Additionally, the only criterion and panel statistics used for this study are used to evaluate their possible consequences. With a very significant level of 1%, Table 6 demonstrates that one class (Gt) is statistically significant.

Table No 4: GMM.

CO_2	FE	RE	GMM
L			.908***
			(.007)
NRR	.004***	.004***	-.001***
	(.001)	(.001)	(0)
IT	.03**	.028**	-.039***
	(.013)	(.013)	(.003)
EG	.396***	.384***	-.038***
	(.016)	(.016)	(.012)
URB	.023***	.022***	.035***
	(.006)	(.007)	(.013)
FDI	0**	0*	0***
	(0)	(0)	(0)
GFN	.001*	.001*	-.001***
	(.001)	(.001)	(0)
REU	-.028***	-.028***	
	(.001)	(.001)	
FD	.001***	.001***	
	(0)	(0)	
Constant	7.868***	7.985***	
	(.148)	(.203)	
LF			-.005***
			(.013)
GNS			.001***
			(0)
INF			.007***
			(.002)
MT			.057***
			(.009)
Observations	1,659		
Hausman test	75.505***		

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table No 5: Slope of Heterogeneity Result

H0: slope coefficients are heterogeneity			
adj.	**p-value**	**adj.**	**p-value**
33.699	0	26.514	0

Note *** (1%) denotes the level of significance.

Table No 6: Panel; Second Generation Test for Unit Root

Series	CIPS		CADF		Order of Integration
	Level	First difference	Level	First difference	I (1)
CO_2	-2.179	-4.281***	-1.837	-2.948***	I (1)
NRR	-1.853	-3.929***	-1.930	-2.814***	I (1)
IT	-2.398	-3.687***	-2.630	-3.133***	I (1)
EG	-1.978	-3.126***	-1.917	-2.153***	I (1)
URB	-4.738	-4.349***	-1.315	-2.092***	I (1)
FDI	-3.259	-5.534***	-2.488	-4.114***	I (1)
GFN	-3.628	-5.702***	-2.965	-3.986***	I (1)

Note *** (1%) denotes the level of significance.

Table No 7: Cointegration Test (Westerlund 2007)

Statistic	Z-value	P-value
Gt	-109.151	0.000
Ga	8.822	1.000
Pt	5.924	1.000
Pa	5.584	1.000

Note: *** (1%) denotes the level of significance.

4.6 Mediation Model Findings

The correlation matrix and VIF statistics are used to test for the presence of Multicollinearity, and the results show that these phenomena are not of concern. To save space, the findings are not shown, but they are available to the authors upon request. The Sobel (1982) test is shown in Table 8 along with the direct, indirect, and overall effects. This was carried out by Baron and Kenny's (1986) method, which uses the "ratio of indirect to total effect" to test for mediation.

To check the reliability of results, the Sobel (1982) test was used. According to Baron and Kenny (1986), a few prerequisites must be met to create a mediated relationship: The dependent variable and the mediator must both be considerably influenced by the independent variable in order for there to be a meaningful relationship between them.

Table No 8: Direct, Indirect, and Total Effects, and Sobel Test Results

Variables	Direct effect (NRR, IT, EG, URB, FDI, GFN → CO2 emissions)	Indirect effect (NRR, IT, EG, URB, FDI, GFN influences CO_2 emissions via REU)	Total effect (NRR, IT, EG, URB, FDI, GFN → REU → CO_2 emissions)	Sobel test
NRR	0.029***	.008***	0.037***	0.216
	(0.004)	(.002)	(0.004)	
IT	-0.232***	.046***	-0.186***	-0.247
	(0.050)	(.018)	(0.053)	
EG	0.028	.018*	0.046*	0.391
	(0.026)	(.009)	(0.028)	
URB	-0.074**	.144***	0.070**	2.057
	(0.030)	(.014)	(0.030)	
FDI	-0.016***	.002***	-0.014***	0.142
	(0.002)	(.001)	(0.002)	
GFN	-0.035***	-.004**	-0.039***	0.102
	(0.005)	(.002)	(0.005)	

Notes: *** means statistical significance at the 1% level.

This mediation analysis shows the direct effect of NRR, IT, EG, URB, FDI, and GFN. The results show that, except for the EG, all other variables have a direct relationship with CO_2 emissions. NRR has a positively significant impact on CO_2 emissions, which means any change in NRR will bring a change in CO_2 as well. The results of IT, URB, FDI, and GFN has negatively significantly impact on CO_2 emissions, which means the inverse link found with CO_2 emissions. This test verifies *H1* for all the variables except for EG because EG does not have a direct relationship with CO_2 emissions. According to the Sobel test, REU mediates 21.6% of NRR-CO_2. REU mediates -0.247 of IT-CO_2. REU mediates 0.391 of EG-CO_2. REU mediates 2.057 of URB-CO_2. REU mediates 0.142 of FDI-CO_2. REU mediates 0.102 of GFN-CO_2. NRR, IT, EG, URB, FDI, and GFN influence country-level CO_2 emissions via REU in a statistically significant way, corroborating *H2*.

4.7 Moderated-Mediation Model Findings

This moderated mediation model was employed in an effort to shed light on how financial development affects the mediating effect of NRR, IT, URB, FDI, and GFN on CO_2 in various economies. Table 9 displays the Difference GMM-based moderated mediation effects. In the initial step of moderated mediation, the latter was produced by an interaction between all independent variables and the suggested moderator. We will create an interaction between the mediator and the moderator, REU and FD, in the second stage to examine the conditional effect of FD on this model.

The Difference GMM proves the presence of conditional effects on countries, contradicting the null hypothesis that there is no evidence of such an impact. This index shows

that the interaction of FD with all exposure variables on the renewable energy use in countries is strongly significant by 1%.

Table No 9: Moderated-Mediation Model Results

Variables (REU)	First stage GMM	Variables (CO_2)	Second stage GMM
L	1.002***	**L**	.473
	(.002)		(.046)
NRR_FD	0***	**REU_FD**	0
	(0)		(0)
IT_FD	.006***		
	(0)		
EG_FD	.005***		
	(.001)		
URB_FD	-.006***		
	(.001)		
FDI_FD	0***		
	(0)		
GFN_FD	0***		
	(0)		
LF	.083		
	(.174)		
GNS	.043***		
	(.006)		
INF	-.009		
	(.061)		
MT	-.703***		
	(.049)		
Mean dependent var	20.553	**SD dependent var**	19.586
Number of obs	1501	**Chi-square**	.

*** p<.01, ** p<.05, * p<.1

5. Conclusion

Environmental experts, the government, and researchers are now focused on finding a solution to this threat, as achieving environmental quality is a significant global task. By investigating the connections between natural resource rent, international trade, economic growth, foreign direct investment, green finance, renewable energy usage, urbanization, financial development, and CO_2 emissions influence in the economies, this study enhances the existing literature. Theoretically, our work contributes to existing knowledge on the causes of environmental pollution in many countries.

This study employed the difference GMM approach to assess moderated mediation after validating the direct and indirect relationship between the series. The results show that, except for the EG, all other variables have a direct significant relationship with CO_2 emissions. REU mediates all variables. FD moderates the relationship between REU and all variables. The existing body of literature makes the assumption that expanding energy consumption, primarily from non-renewable energy sources, is what is causing increased CO_2 emissions. Therefore, this study looks at how renewable energy usage can lower the effects of other factors, including NRR, IT, EG, URB, FDI, and GFN, on CO_2 emissions. In order to mitigate the positive impact

of EG on CO_2 emissions, the study suggests that policymakers concentrate their focus on local consumption, particularly for the developing sectors that employ energy's conventional sources to produce goods and services. Second, we also suggested that to ensure the best possible use of the nation's natural resources, policymakers should lay out comprehensive plans. Third, there is a need to raise awareness of the concept of GFN among various stakeholders and policymakers due to the negative impact of green finance on environmental degradation. Similar to this, businesses and entrepreneurs should be encouraged to support green business and participate in green securities, green lending, and green investments. Future research can potentially tackle the limitations of our study and shed light on important issues. Specifically, our study did not consider certain key factors that could impact environmental pollution, such as the quality of governance, which includes the rule of law, regulatory effectiveness, and government investment in research and development. These factors warrant further investigation in future studies. By including these variables and using environmental theories, the researchers will expand the future scope of this study.

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