climate

Article

Opportunities for Post−COP26 Governance to Facilitate the Deployment of Low−Carbon Energy Infrastructure: An Open Door Policy

Muhammad Imran [1], Shiraz Khan [2], Khalid Zaman [1,*], Muhammad Siddique [3] and Haroon ur Rashid Khan [4]

1 Department of Economics, The University of Haripur, Haripur 22620, Pakistan
2 Department of Management Sciences, The University of Haripur, Haripur 22620, Pakistan
3 Department of Economics, Government Post Graduate College (GPGC) No. 1, Abbottabad 22060, Pakistan
4 Faculty of Business, The University of Wollongong in Dubai, Dubai 20183, United Arab Emirates
* Correspondence: khalid.zaman@uoh.edu.pk

Abstract: Temperatures worldwide continue to climb, while carbon emissions have exceeded previous records. To achieve environmental sustainability, countries with the Kyoto Protocol and Paris Agreement (COP26) demonstrate sophisticated technical expertise and deploy environmentally driven technologies, such as greenfield investment and renewable energy infrastructure. This proposal presents an intriguing opportunity for policymakers to identify the distinct characteristics of institutional reforms and green energy sources that may be used to mitigate carbon emissions. Governance regulatory factors, foreign direct investment (FDI), renewable energy consumption (REC), research and development expenditures, urbanization, and carbon emissions are examined in Pakistan. The study estimated the short- and long-run association between the variables using the ARDL bounds testing method for 1996Q1 to 2020Q4. In the short run, in terms of carbon emissions and economic output, the country has an upturned cord environmental Kuznets curve (EKC). The race-to-the-bottom concept holds for countries with U-shaped EKCs in the long term. The negative correlation between overseas investment and environmental damage supports the environmental halo hypothesis. Investment in research and technology may reduce emissions, even though urbanization increases them. Future and present REC are often intertwined with carbon footprints. Carbon emissions are also strongly connected with indicators of institutional quality (IQ), such as procedural efficiency, administrative effectiveness, and political unrest. The research findings demonstrated unidirectional Granger causality running from urbanization, government effectiveness, economic growth, and R&D expenditures to carbon emissions to validate urban-led emissions, institutional-led emissions, growth-led emissions, and innovation-led emissions in a country. Furthermore, R&D expenditure Granger causality was linked to inbound FDI, while government effectiveness Granger causality was linked to REC and R&D expenditures. Following the COP26 guidelines for achieving shared prosperity, the study concluded that good governance reforms, R&D expenditures, greenfield investment, and REC promote environmental sustainability and maintain air quality.

Keywords: carbon emissions; renewable energy demand; governance indicators; R&D expenditures; inbound FDI; urbanization; ARDL bounds estimates

Citation: Imran, M.; Khan, S.; Zaman, K.; Siddique, M.; Khan, H.u.R. Opportunities for Post−COP26 Governance to Facilitate the Deployment of Low−Carbon Energy Infrastructure: An Open Door Policy. *Climate* **2023**, *11*, 29. https://doi.org/10.3390/cli11020029

Academic Editor: Chris Swanston

Received: 3 December 2022
Revised: 17 January 2023
Accepted: 18 January 2023
Published: 19 January 2023

1. Introduction

COP26 was held in Glasgow, UK, from 1 to 12 November 2021. Legislators have agreed to decarbonize the planet by mid-century and limit the temperature rise to 1.5 degrees by 2030. During COP26, the UN Secretary-General urged governments to cut global emissions by half by 2030. The nations have ambitious goals and action channels to reduce global emissions. Conventional energy structures and transformation patterns make lowering emissions difficult, which was the conference's focus. Currently, the countries are working together in the clean energy transition to ensure that clean power is the most appealing choice for new power production in all nations and to assist nations in achieving an equitable transition away from coal. Governments may assist by phasing out coal power, expanding the REC, and enhancing energy efficiency [1]. The emphasis of good governance and improving IQ remains a part of the COP26 discussion that helps to improve environmental quality and deploy green energy infrastructure worldwide. The optimal aspect of institutional quality is crucial for estimating the connection between economic development and environmental sustainability. The most significant factor is the quality of political institutions, which discourages large-scale investment in economies that boost per capita economic growth (EG) and environmental performance [2]. A lack of quality of institutions might hinder economic progress with increased environmental externalities and other pollutants associated with the development process [3]. In a period of rapid growth, social and environmental observers have shown the connection between urbanization, institutional quality, and the environment. In emerging nations with a solid commitment to environmental sustainability, IQ plays a significant role in preserving the optimal degree of environmental sustainability [4]. Financial and legal institutions successfully promote economic development. In addition, Asian countries may increase their economic development by implementing a solid and efficient financial and legal structure [5].

Carbon emissions and the energy transition are the lynchpins of every economy's attempts to create a sustainable future. The practical assessment of reducing carbon emissions from various economic activities is resulting in the development of infrastructure for the generation of energy from clean sources [6,7]. Future growth based on sustainable development and community efforts to mitigate climate change substantially influences the environment [8]. In recent years, tremendous progress has been achieved in decarbonizing power networks regarding the global energy transition. Increased economies of scale and technological advancement have made REC and production considerably more inexpensive and dependable [9]. The passage of time affects the new facilities that continue to pursue vital energy and industry transition initiatives and remain committed to their low-carbon economic development objectives [10]. According to the IEA [11], REC has the potential to reduce carbon emissions and the economy's reliance on fossil fuels over the medium and long term. Numerous replacements and unpredictability affect the renewable sources. With the passage of time and technological advancement, the significance of renewables and the energy transition in humanizing energy security and establishing efficiency in reducing carbon emissions has grown. The continued growth gives the appropriate motivation to develop REC and its sources, while maintaining the potential of achieving our worldwide climate objectives. Compared to other developed economies, the UNEP [12] estimates that carbon emissions have decreased in advanced economies. In 2020, carbon emissions decreased by an astonishing 5.4%, although they grew by 1.3% from 2010 to 2019. In 2019, fossil fuel carbon emissions grew by 37.9 GtCO2, but decreased to 36.0 GtCO2 in 2020. Since 2010, carbon emissions from various sources have accounted for ten per cent of cumulative GHG emissions and may fluctuate dramatically, owing to the climatic conditions and environmental deterioration.

According to Hepburn et al. [13], proper management and a significant decrease in carbon emissions would enhance environmental competitiveness by improving energy efficiency, transportation, and rural and urban growth. Concerning South Asian countries, Pakistan has the greatest urbanization rate, and most of the country's population is concentrated in metropolitan areas [14]. The IQ and EG hold great potential, enhancing productivity and increasing incomes in different sectors of the economy. The prosperity of any country depends on its institutions. In the absence of strong and stable institutions, both the public and private sector focus on the search for profit at the expense of the general population. Institutions are important because they help in attaining growth by reducing the cost of transactions, risk and uncertainty [15]. Urbanization is the main channel used to generate new ideas, innovations and economies of scale, as well as the income of the overall economy. Furthermore, it has a significant impact on national GDP and the local governance system [16]. According to the Sustainable Development Goals agenda for 2030, to reach a greater degree of sustainability and EG, eradicating poverty, ensuring the suitable living standards of all members of society, and providing services to all victims are essential. Weak environmental control, increased population expansion, and weak political institutions are defining characteristics of the environmental issues in expanding economies. Poor institutional quality undermines environmental regulation by infusing bias into the execution of environmental legislation. The IQ may have both direct and indirect effects on environmental sustainability, demonstrated by the significance of the judicial system, property rights, the law, and regulations in one dimension of institutional quality. On the other side, institutional quality regulates the negative impact of various entities on the environment [17].

The following research questions are necessary for environmental regulation and focus on comprehensive ways to limit emission consequences in a given nation: first, to what extent do governance factors help to mitigate carbon emissions? It is evident that administration efficiency and rigorous pollution controls would be helpful to reduce negative environmental externalities and improve air quality levels. Second, does REC and greenfield investment help to improve environmental quality? Green energy sources remain vital to achieve the zero carbon emissions target, while greenfield investment forms a bridge between public and private entities to take sustainable financing actions that improve ecological indicators. Third, does an increase in R&D expenditures in carbon mitigation functions allow us to achieve the green COP26 agenda? The recent COP26 conference widely encouraged investment in green and clean energy initiatives that help to stabilize the planet's average temperature below 1.5 degrees Celsius. Finally, do inbound FDI, continued EG, and urbanization hinder the achievement of ecological sustainability? The wide phenomenon of the pollution haven (PH) hypothesis is quite viable in many parts of the globalized world that need to implement stringent environmental regulations, urban development, and sustainable economic development to reach some of the decisive solutions on the clean and green agenda.

Based on the given research questions, the study's objectives are as follows:

(i) To investigate the relationship between IQ and carbon emissions in Pakistan.
(ii) To determine the relationship between urbanization, REC, R&D expenditures and inbound FDI and their resulting impact on environmental quality in Pakistan.
(iii) To test the regulations–emissions nexus, the race-to-the-bottom hypothesis, the EKC hypothesis, and the PH hypothesis in a given nation.

The research objectives recommended some policy implications for environmental regulation in light of the empirical results of the study.

2. Literature Review

A large number of studies are available on IQ, inbound FDI, renewable energy (RE) use, and CO_2 emissions, which are directly related to a nation's economic proclivity and environmental sustainability. Shera et al. [18] investigated the effect of corruption on EG in 22 developing nations, using empirical data from 2001 to 2012. The findings demonstrated a negative association between corruption and economic development. Additionally, there is a negative association between public spending productivity and the extent of corruption. Policymakers need a solid foundation to eradicate corruption through stringent laws and regulations. Using data from 1970 to 2013, Shahbaz et al. [19] analyzed the relationship between urbanization, industrial growth, and financial development (FD) in India and China. The results found a positive association between the stated variables, and a negative relationship between IQ, government size, and financial growth. The study recommended that both economies improve the fundamental factor (IQ) to advance the financial sector. Younas [20] investigated the link between institutional transformation and economic development in Pakistan. According to the data, controlling corruption, the rule of law, and privatization are the primary causes of institutional change in Pakistan. Moreover, a considerable positive correlation exists between institutional reform and EG. A positive relationship also exists between exports and IQ, while a negative relationship exists between macroeconomic instability and IQ. The study recommended that governments introduce high-quality programs to improve the quality of their country's institutions.

Ibrahim and Law [21] investigated the relationship between trade openness, IQ, and carbon emissions in forty Sub-Saharan African nations. According to the study's findings, low IQ negatively correlates with trade openness and environmental quality. Trade openness and IQ also support each other and reduce a country's pollution levels. A good institutional structure and improved commerce and economic development compatible with environmental sustainability are also important. Abid [22] analyzed the effects of EG, FD, IQ, and carbon emissions in 25 Sub-Saharan African nations between 1996 and 2010. According to this research, CO_2 emissions are negatively correlated with political quality, government efficacy, democracy, and corruption control. Conversely, there is a positive correlation between regulatory and legal quality and carbon emissions. Furthermore, the investigation revealed no evidence of the EKC hypothesis across the countries. IQ directly reduces a country's emission levels, while indirectly influencing EG and trade openness. The study suggested that economic development and trade openness must be accelerated to manage the unobservable influence of a country's institutions.

Using data from 2002 to 2012, Peres et al. [23] investigated the connection between IQ and FDI in 110 developed and developing countries. In developed economies, income per capita has a fairly higher correlation with infrastructure, market size, and FDI inflow. Furthermore, developed countries have a positive relationship between FDI and governance, and there is a negative correlation between FDI and governance in emerging nations. The results conclude that developed economies are responsible for resource management, while emerging nations must improve their institutional framework and macroeconomic environment. Lau et al. [24] analyzed the existence of the EKC hypothesis in various emerging and developing nations, focusing on the importance of IQ. The results indicate an inverted U-shaped link between per capita income and carbon missions in emerging nations. At the same time, no inverted U-shaped EKC relationship was found in developing nations. In addition, all the nations demonstrated a favorable association between the rule of law and environmental quality. Additionally, FDI increases the amount of emissions in low-income nations, while reducing emissions in high-income nations. The research concluded that an appropriate economic and environmental strategy must be designed to achieve sustained long-term economic development across the countries.

Sarkodie and Adam [25] examined the association between energy consumption (EC), urbanization, IQ, and environmental degradation in South Africa from 1971 to 2017. The findings indicate that IQ improves social and economic preparedness and mitigates climate risk. Additionally, REC improves environmental sustainability and air quality. The results indicated that a country's industrial sector must undergo a clean structural transformation to achieve environmental sustainability. Nguyen et al. [26] assessed the relationship between economic integration, trade openness, and FDI inflows in relation to carbon emissions in developing nations by analyzing the period between 2002 and 2015. The results indicate a positive correlation between economic integration and carbon emissions, verifying the PH hypothesis. Furthermore, IQ and FDI inflow negatively affect trade openness and CO_2 emissions. The research concluded that increasing the quality of institutions will increase EG and FD in all nations; thus, good governance reforms are pivotal for long-term sustained growth across countries. Hassan et al. [27] examined the link between IQ and carbon emissions in Pakistan from 1984 to 2016. The results show a bidirectional Granger causal relationship between institutional quality and carbon emissions. In addition, there is a positive correlation between a country's income level and its carbon emissions. The research proposes that a solid institutional foundation may reduce a country's economic and environmental risk.

Hayat [28] examined the relationship between FDI inflow, IQ, and economic development in 104 countries. The research results revealed a significant positive association between corruption control, law and government efficiency, and economic development, whereas a negative relationship exists between regulatory quality and EG. Similarly, the better quality of institutions increases the amount of FDI and economic development in high-income nations. In contrast, the median impact of institutional quality on FDI and EG can be observed in low-income economies. In order to increase FDI and economic development, the research recommended that the governments allocate the necessary time and resources to improve regulatory quality, legislation, and efficacy, as well as combat corruption. Salman et al. [29] examined the relationship between IQ, EG and carbon emissions in three Asian nations from 1990 to 2016. The results show a positive relationship between CO_2 emissions and IQ, indicating that IQ is crucial for increasing GDP per capita at the expense of increasing carbon emissions. Short-term causation exists between IQ and EG, carbon emissions and EC, and trade openness and carbon emissions. There is a one-way causal relationship between EC and trade openness and energy use and carbon emissions over the long term. There is a need for feedback in the economic development field associated with institutional quality and environmental emissions. In addition, it is essential to fortify the position of local institutions as the primary factor in controlling CO_2 emissions during economic development.

The latest studies confirmed the importance of IQ and regulatory function in protecting economic and environmental resources [30]. Furthermore, they help to develop green energy infrastructure to mitigate carbon emissions [31]. Greenfield investment in the form of sustainable inbound FDI would be possible by improving governance indicators [32]. FD and human capital reduce environmental risks that can be improved through stringent environmental regulations [33,34]. Based on the significance of IQ in improving environmental quality, the study's first hypothesis is as follows:

Hypothesis H1. *Institutional quality is likely to improve environmental quality and achieve the low carbon emission agenda goals.*

Hypothesis H1a. *Regulatory quality will likely ensure the implementation of stringent environmental regulations to mitigate carbon emissions.*

Hypothesis H1b. *Government effectiveness is likely to improve environmental quality through the reduction in abatement costs.*

Hypothesis H1c. *Political stability will likely reduce carbon emissions through sustainable environmental policies.*

Godil et al. [35] analyzed the association between FD, information technology, IQ, and carbon emissions in Pakistan from 1995 to 2018. The research results indicate that, over the long term, there is a positive correlation between EG, IQ and carbon emissions. Additionally, there is a negative correlation between FD and carbon emissions, and there is a negative correlation between information and communication technology and CO_2 emissions. In addition, EKC hypothesis validation has been found in the case of Pakistan. According to the research findings, ICT is the primary indicator for reducing emissions at the lowest possible abatement cost and helps to increase technological spillover in a country. From 1971 to 2014, Malik et al. [36] analyzed data on the relationship between crude prices, FDI, EG, and air pollution in Pakistan. The results point to a positive short-term correlation between fuel prices and CO_2 emissions, but a detrimental long-term correlation between the two variables. Granger causation exists between a country's economic development and CO_2 emissions. In Pakistan, the results of the study verified the EKC hypothesis. The study proposed identifying the clean and green energy mix for the industrial and residential sectors to lower a country's total emissions.

Anser et al. [37] studied the effects of urbanization, per capita GDP, population size, and carbon emissions in SAARC nations from 1994 to 2013. The results show a positive correlation between the stated variables. In addition, the link between urbanization and carbon emissions is diminishing. Carbon footprint and urban sprawl have a cord connection. The research indicates that a robust national strategy is required to mitigate the impact of increased gas prices. Between 1996 to 2018, Yang and Khan [38] investigated the impact of venture capital, natural wealth, and democracy on SAARC's sustainable development and environmental devastation. The ecological environment and wealth creation are significantly linked, and bidirectional causality exists between capital, ecological degradation, ecosystems and administration. As is the case with environmental damage and assets, natural resources and productivity expansion have a bidirectional causal link. According to the research, project finance in the power and transportation sectors reduces carbon emissions and advances the digital economy. Wang et al. [39] examined the link between IQ, FDI and economic development in African nations from 1999 to 2017. The research results indicate a substantial positive association between EG, FDI, and institutional quality in countries that do not produce oil. However, no meaningful relationship exists in oil-producing economies. Furthermore, long-term causality exists between IQ and EG. In addition, there is a one-way causal relationship between FDI and EG in the short run. The implementation of stringent environmental regulations would be beneficial for improving ecological indicators across countries.

Haldar and Sethi [40] examined the influence of EC, FDI, capital creation, financial growth, and population growth on carbon emissions in emerging nations from 1995 to 2017. The findings indicate a moderate association between EC and carbon emissions in the long run, while a negative relationship between EC and emission levels exists in the short run. In addition, the EKC hypothesis can be applied to the situation of IQ in different nations. In the event of increased energy use, the study concluded that policymakers must improve the quality of their institutions and implement a suitable policy to mitigate climate risk. Mehmood et al. [41] analyzed the link between IQ, economic development, FDI, and EC in Pakistan, India, and Bangladesh from 1996 to 2016. The results suggest that EG is responsible for increasing carbon emissions. IQ and economic development are positively correlated in Pakistan, while EG and carbon emissions are negatively correlated in India and Bangladesh. In addition, an inverted U-shaped EKC exists in Pakistan, while India and Bangladesh lack evidence of an EKC. The study advised that emerging nations should investigate the impact of IQ on distinct economic sectors to move towards sustainable development.

The significance of R&D expenditures in the deployment of low-carbon energy infrastructure remains essential to mitigate climatic vulnerability. The recent literature widely encourages the need for energy innovation [42] that helps to achieve energy efficiency to minimize carbon damage [43]. The residential patent rights in developing green energy sources are helpful in moving forward toward the goals of the sustainability agenda [44]. In this regard, the role of governance remains essential to provide synergy to the innovation systems [45] that help to reduce fossil fuel dependency [46] and move forward toward RE transition [47]. Based on the stated discussion, the study hypothesizes the second research hypothesis, i.e.,

Hypothesis H2. *An increase in energy innovation in the deployment of low-carbon energy infrastructure is likely to be helpful in achieving the decarbonization agenda goals.*

Hypothesis H2a. *It is likely that an increase in the research and development expenditures for the energy transition will be helpful in building a resilient energy system to reduce environmental concerns.*

Hypothesis H2b. *It is likely that an increase in the share of renewable energy consumption in the national grid will be helpful to sustain economic and environmental resources that provide a path to the low-carbon agenda.*

Murshed et al. [48] examined the correlation between IQ, economic development and REC in 19 developing economies from 2002 to 2019. According to the research findings, there is a substantial positive correlation between institutional effectiveness, EG, exports, and REC. In addition, a unidirectional causal link exists between EG, exports and EC.

Granger causation exists in one direction between energy usage and corruption control. The report recommends that emerging nations place a greater emphasis on anti-corruption policies to attain their goals. Khan et al. [49] investigated the effect of IQ on carbon emissions in various heterogeneous countries, using data from the years 2002 to 2019. The results indicate a favorable correlation between EC, FDI, and environmental quality. In addition, a negative correlation exists between FD, economic expansion, and environmental quality. Consequently, there is evidence of the EKC and pollution halo hypotheses across these countries. The research concluded that stringent environmental regulations are necessary to limit environmental harm.

Yang et al. [50] evaluated the relationship between income inequality and IQ with regard to carbon emissions in 42 developing economies from 1984 to 2016. The results indicate a substantial positive correlation between increased income and carbon emissions. In addition, a strong positive correlation exists between EG, EC, industrialization, and institutional quality, and a positive correlation exists between trade openness and carbon emissions. The study concluded that greater environmental sustainability is required to accomplish the Sustainable Development Goals (SDGs) for sustained growth. Cao et al. [51] examined the connection between IQ, EG, EC, and carbon emissions in OECD nations from 1985 to 2018. The findings reveal a negative association between global EC and carbon emissions that enhances environmental quality in the short run. Additionally, there is evidence of a favorable long-term correlation between FD, the stock market, energy use, and EG. The results suggested that OECD nations should reduce their pollution levels, particularly in the industrial and EC sectors, and move toward cleaner technology production. Covering the period from 1998 to 2019, Yuan et al. [52] examined the association between urbanization, EG and ecological quality in China. The results indicate a substantial negative correlation between urbanization and EG. In addition, there is a negative correlation between urbanization and ecological quality in regions with high incomes. The study suggested that effective planning is necessary to prevent the detrimental impact of urban growth on economic development.

Khan et al. [53] examined the relationship between IQ, FDI and carbon emissions in 107 developing countries from 2002 to 2019. The study's findings indicate a weaker association of governance indicators with air pollution and a moderate relationship with governance transparency and carbon output. There is a negative correlation between FD and CO_2 emissions. According to the findings, significant and robust policy changes and institutional reforms are required to improve environmental quality. Tripathy et al. [54] analyzed the influence of FDI inflow, IQ, and carbon emissions in 19 selected G20 nations from 2009 to 2017. The data show that FDI is inversely related to carbon footprint and positively related to macroeconomic performance. There is also a special bond between a country's IQ and the quality of their surrounding environment. The study's recommendations were to increase research and development in the clean and green energy field to reduce emissions and boost EG. Between 2002 and 2019, Rahman and Sultan [55] analyzed the link between IQ, economic development, exports, and EC in 19 emerging nations. The findings indicate a substantial positive association between EG and EC and a unidirectional causal connection between EG, exports, and EC. In addition, a significant positive relationship exists between institutional effectiveness and EC, as well as unidirectional Granger causality between corruption control and EC. A positive correlation exists between exports and EC. To achieve sustained EG, the emerging nations must be transparent in their economic activities and reduce corruption, which helps to attract more foreign investors to a country.

Greenfield energy investment is essential for encouraging public and private entities to contribute to building resilient environmental systems. The environmental concerns that arise from the increasing influx of inbound FDI that is associated with pollution production confirmed the PH hypothesis. Greenfield initiatives minimize the adverse environmental consequences and shift toward cleaner production technologies that support the natural ecological indicators [56]. The continued EG and urbanization put pressure on economic and environmental resources to escalate ecological footprints [57,58]. Clean energy resources limit environmental degradation and improve sustainable development worldwide. Decoupling urbanization from natural resources, FD, and trade leads to transformed human capital that can mitigate ecological footprints [59]. Based on the stated discussion, the study's final research hypothesis is as follows:

Hypothesis H3. *Socio-economic factors are likely to cause an increase in environmental damage.*

Hypothesis H3a. *Unsustainable inbound overseas investment is likely to harm the natural environment, verifying the pollution haven hypothesis.*

Hypothesis H3b. *The significant urbanization pressure affects the environmental sustainability agenda, negating the population ingenuity principle.*

Hypothesis H3c. *The continued economic growth is likely to increase adverse environmental externalities, verifying the environmental Kuznets curve hypothesis at later stages of economic growth.*

The contribution of this study is significant in several ways. Firstly, it utilizes three different governance indicators, namely regulatory quality, political instability, and government effectiveness, to substitute IQ in the analysis of the pollution damage function. This is a unique approach, as previous studies have mainly focused on using one or two governance indicators to assess their role in mitigating carbon emissions [60–62]. This study contributes to the ongoing COP26 agenda that aims to address the importance of governing reforms in tackling climate change and building a resilient environmental system.

Secondly, the study uses R&D expenditures and inbound FDI as substitutes for innovation factors and greenfield investment to create an energy innovation system. This approach is novel, as earlier studies have mainly limited their discussion to economic development and FD, whereas this study has a broader scope that can help to propose sound policy inferences for reaching the COP26 governance agenda goals [63–65].

Lastly, the study uses controlled variables such as REC, urbanization, and EG, which replace green energy sources, population control, and economic development in the implementation of low-carbon energy infrastructure. This approach is different from earlier studies that have used green energy sources with different economic and environmental factors, but it remains necessary to cope with the global environmental issues [66–68].

Overall, the study contributes to the ongoing discourse on the importance of governance in addressing climate change and provides valuable insights for policymakers and stakeholders working towards the COP26 goals.

3. Theoretical Framework

Before creating the econometric model, we constructed the theoretical framework of this research to support the model's variables. The IQ indicator was developed by Kaufman et al. [69]. They used six indicators from the World Bank's global governance indicators [70]. During the NAFTA conference, Copelan and Taylar [71] established the PH concept. The PH hypothesis asserts that companies will attempt to overcome strict environmental laws (and high energy costs) by locating manufacturing in nations with less strict environmental controls. Levinson and Taylor [72] provided the core formula and enlarged version of the pollution refuge hypothesis, which are as follows:

$$Yi = \alpha Ri + Xi\beta i + \varepsilon i \tag{1}$$

$$Yit = vi + \alpha Rit + vTit + \theta RitTit + X\beta it + \varepsilon it \tag{2}$$

where Y is the output level, R is the environmental control, X is the other total value that affects Y, T is trade liberalization, ε is the error term, and '*it*' is the random time period.

Equation (2) of the PH hypothesis shows that the cost of inputs for pollution-intensive manufacturing rises as a result of external laws, reducing a company's competitive advantage and restricting its relocation to a jurisdiction with lower environmental standards. Simon Kuznets's curve demonstrates the link between income inequality and economic development. Grossman and Krueger [73] describe the modified version of the basic Kuznets curve in the environment. The EKC theory provides an example of the theoretical connection between ecological well-being and monetary growth. The EKC explains that economic indicators harm the environment, until a specific average income level is reached throughout the period of economic expansion. The conventional EKC N-shape is calculated according to Sinha et al.'s [74] equation, which is as follows:

$$P = \alpha_0 + \alpha_1 Y + \alpha_2 Y^2 + \alpha_3 Y^3 + \varepsilon_i \quad (3)$$

where Y is the output level and P is the environmental control.

The I-PAT theory was proposed by ecologist Paul Ehrlich and environmentalist John Holdren [75]. The I-PAT theory describes the connection between the human population, wealth, and technology. The I-PAT equation demonstrates the traditional link between the human population and the environment. Suburbanization is the apex of urban growth, a concept founded by Eppink et al. [76]. According to this paradigm, suburbanization is the subsequent stage of city expansion in a nation following urbanization. When cities expand, the surrounding regions are also impacted by the high population density, a dramatic increase in urban property prices, improved transportation and communication infrastructure, and environmental contamination.

Porter and Van der Linde [77] formulated this environmental theory. According to Porter's premise, stringent environmental restrictions may promote economic efficiency and inspire innovations that boost business competitiveness. Environmental development is slowed by the fixed balance between environmental regulation and economic productivity, increasing unnecessary costs. In the first phase, strict environmental regulations encourage the development of cleaner technologies, while in the second phase, environmental development with an innovation impact increases the clean resource yield.

4. Materials and Methods

The study uses the time series quarter data from the year 1996Q–2020Q. The major data sources include the World Development Indictors [78] and Worldwide Governance Indicators [79] from the database of the World Bank. The following variables were employed to explain the relationship between IQ, environmental regularity, FDI, urbanization, income per capita, and carbon emissions in Pakistan. The dependent variable was CO_2 emissions (metric tons per capita). The independent variables included different governance indicators (index value: −2.5 to 2.5), REC (% of total final EC), FDI net inflows (% of GDP), GDP per capita (constant 2015 USD), R&D expenditures (% of GDP), and urbanization (share of urban population in total population). Table 1 represents the list of variables organized for reference.

Table 1. List of Variables and Measurements.

Factors	Variables	Symbol	Measurement (Units)	Sources
Low-Carbon Infrastructure	Carbon emissions	CO_2	Metric tons per capita	WDI
	Renewable energy consumption	REC	% of total final EC	WDI
	Research and development expenditures	RND	% of GDP	WDI

Table 1. *Cont.*

Factors	Variables	Symbol	Measurement (Units)	Sources
Institutional Quality	Government effectiveness	GEF	−2.5 (weak) to 2.5 (strong) performance	WGI
	Regulatory quality	RQ	−2.5 (weak) to 2.5 (strong) performance	WGI
	Political instability	PINS	−2.5 (weak) to 2.5 (strong) performance	WGI
Control Variables	Foreign direct investment	FDI	Net inflows (% of GDP)	WDI
	GDP per capita	GDPPC	Constant 2015 USD	WDI
	Urbanization	URB	Share of urban population in total population	WDI

Source: WDI [78] and WGI [79].

The research begins with estimating the unit root test results using the ADF technique and the AR(1) model for evaluating the time-varying stationary series of the corresponding variables, which helps to determine one of three possible results. First, the variable series is level stationary; next, it is difference stationary, and finally, it is neither level nor difference stationary. Pesaran et al. [80] created the autoregressive distributed lag (ARDL) method, which was used in this study. The ARDL technique is more unified than other methods. It determines the short- and long-run connection between variables based on whether the underlying independent variables are I(0), simply I(1), or mutually co-integrated. The ARDL description is shown by Equation (4), i.e.,

$$\begin{aligned} In(CO_2) = \alpha_0 \quad & +\sum_{i=0}^{p}\gamma\Delta In(CO_2)_{t-1} + \sum_{i=0}^{p}\gamma\Delta In(RQ)_{t-1} + \sum_{i=0}^{q}\gamma In(PINS)_{t-1} + \sum_{i=0}^{r}\gamma In(GEF)_{t-1} \\ & +\sum_{i=o}^{S}\gamma In(REC)_{t-1} + \sum_{i=0}^{u}\gamma In(RND)_{t-1} + \sum_{i=0}^{v}\gamma In(FDI)_{t-1} \\ & +\sum_{i=o}^{w}\gamma(GDPPC)_{t-1} + \sum_{i=0}^{x}\gamma(SQ\_GDPPC)_{t-1+}\sum_{i=0}^{z}\gamma(URB)_{t-1} + \varnothing_1 In(RQ)_t \\ & +\varnothing_2 In(PINS) + \varnothing_3 In(GEF)_{t_t} + \varnothing_4 In(REC)_t + \varnothing_5 In(RND)_t \\ & +\varnothing_6 In(FDI) + \varnothing_7 In(GDPPC)_{t_t} + \varnothing_8 In(SQ\_GDPPC)_t + \varnothing_9 In(URB)_t + \varepsilon_t \end{aligned} \tag{4}$$

where 'p' shows the optimal lag length.

Wald F-statistics were employed to explore the null and alternative hypotheses, i.e.,

$$H_0;\ \varnothing_1 = \varnothing_2 = \varnothing_3 = \varnothing_4 = \varnothing_5 = \varnothing_6 = \varnothing_7 = \varnothing_8 = \varnothing_9 = 0$$

$$H_0\ ;\varnothing_1 \neq \varnothing_2 \neq \varnothing_3 \neq \varnothing_4 \neq \varnothing_5 \neq \varnothing_6 \neq \varnothing_7 \neq \varnothing_8 \neq \varnothing_9 \neq 0$$

Now, to check whether the study variables were employed the long run, the error correction term was added to Equation (5) to obtain the convergences of the model towards the equilibrium, i.e.,

$$
\begin{aligned}
In(CO_2) = \alpha_0 \quad & + \sum_{i=0}^{p} \gamma \Delta In(CO_2)_{t-1} + \sum_{i=0}^{p} \gamma \Delta In(RQ)_{t-1} + \sum_{i=0}^{q} \gamma In(PINS)_{t-1} + \sum_{i=0}^{r} \gamma In(GEF)_{t-1} \\
& + \sum_{i=o}^{S} \gamma In(REC)_{t-1} + \sum_{i=0}^{u} \gamma In(RND)_{t-1} + \sum_{i=0}^{v} \gamma In(FDI)_{t-1} \\
& + \sum_{i=o}^{w} \gamma (GDPPC)_{t-1} + \sum_{i=0}^{x} \gamma (SQ\_GDPPC)_{t-1+} \sum_{i=0}^{z} \gamma (URB)_{t-1} + \varnothing_1 In(RQ)_t \\
& + \varnothing_2 In(PINS) + \varnothing_3 In(GEF)_{t_t} + \varnothing_4 In(REC)_t + \varnothing_5 In(RND)_t \\
& + \varnothing_6 In(FDI) + \varnothing_7 In(GDPPC)_{t_t} + \varnothing_8 In(SQ\_GDPPC)_t + \varnothing_9 In(URB)_t + \omega ECT_{t-1} + \varepsilon_t
\end{aligned} \quad (5)
$$

where ECT_{t-1} represents the first lagged variable of the error correction term, and ω shows the model's adjustment parameter.

After estimating the results, the VAR Granger causality test was applied and obtained the following four different results, among which one would be true regarding the variable's association:

(i) Unidirectional causality: CO_2 Granger causality exists for FDI, GDPPC, GEF, REC, RND, RQ, PINS, and URB, but this causality does not exist in the reverse form.
(ii) Reverse causality: FDI, GDPPC, GEF, REC, RND, RQ, PINS, and URB Granger causality exists for CO_2, but not vice versa.
(iii) Bidirectional causality: the studied variables established two-way associations between them.
(iv) Neutrality: No cause–effect association has been recognized in the given analysis.

Lastly, the variance decomposition investigation was carried out on the data set to forecast the estimates over a time period.

5. Results

Descriptive statistics describe the characteristics of each variable's data. Table 2 contains the descriptive statistics in natural logarithm form. Carbon emissions (metric tonnes per capita) have a minimum value of 0.018 and a maximum value of 0.402, with a mean value of 0.240. The standard deviation value is 0.132, corresponding to negative skewness and high kurtosis. The lowest value of FDI net inflow as a percentage of GDP is 0.375, and the largest is 3.668. The mean value is 1.159, the standard deviation is 0.876, and the skewness and kurtosis values are positive and high. In addition, the smallest value of constant 2015 USD GDP per capita is 6.911, which is associated with a mean of 7.098 and a standard deviation of 0.131, with low skewness and mild kurtosis.

Table 2. Descriptive Statistics (with natural logarithm).

Variables	CO_2	RQ	GEF	PINS	FDI	GDPPC	REC	RND	RQ	SQ_GDPPC	URB
Mean	0.240	0.437	0.792	0.481	1.159	7.098	3.855	1.360	0.437	3.919	3.531
Median	0.258	0.446	0.752	0.459	0.819	7.122	3.854	1.402	0.446	3.926	3.518
Maximum	0.402	0.466	2.171	1.033	3.668	7.315	3.954	2.214	0.466	3.979	3.645
Minimum	0.018	0.332	0.019	0.098	0.375	6.912	3.731	0.458	0.332	3.866	3.468
Std. Dev.	0.123	0.030	0.556	0.368	0.876	0.131	0.071	0.473	0.030	0.036	0.059
Skewness	−0.459	−2.466	0.534	0.273	1.787	0.025	−0.378	−0.025	−2.466	0.003	0.476
Kurtosis	2.144	7.730	2.606	1.397	5.075	1.778	2.150	2.504	7.730	1.767	1.854

Source: Author's estimate based on WDI [78] and WGI [79] database.

Similarly, the minimum values for GEF, RQ, and PINS are 0.019, 0.332, and 0.098, respectively, with the highest values of 2.17125, 0.466, and 1.331. The variables' standard deviations are 0.556, 0.030, and 0.308, and their respective means are 0.798, 0.437, and 0.4818. In addition, the REC percentage of total final EC has a mean of 3.855, a standard deviation of 0.071, a negative skewness value, and a high kurtosis value. The variable R&D percent of GDP per capita has a standard deviation of 0.473 and a mean value of 1.360, but is also negatively skewed and positively kurtosis. In conclusion, the mean value of urbanization is 3.531, and the standard deviation value is 0.059, with a skewness value of 0.476 and a kurtosis value of 1.584.

The correlation matrix describes the direction of the variables shown in Table 3. There is evidence of a negative link between CO_2 emissions and FDI inflows, such that as FDI inflow increases, so does the value of carbon emissions in a country. The results linked to previous studies [81–83] recommended that the government should continue to increase incentives for internal and external economic mediators, provide guidelines to restore the ecological balance of the environment, and establish environmental protection in many international settlements and domestic regulations, while promoting international trade under the WTO.

Table 3. Correlation Matrix.

Variables	CO_2	FDI	GDPPC	GEF	REC	RND	RQ	SQ_GDPPPCURB	PINS
CO_2	1								
FDI	−0.142	1							
GDPPC	−0.937	−0.009	1						
GEF	−0.247	−0.395	0.254	1					
REC	0.991	−0.074	−0.953	−0.275	1				
RND	0.460	−0.633	−0.462	0.404	0.452	1			
RQ	−0.356	0.059	0.443	0.023	−0.373	−0.570	1		
SQ_GDPPC	−0.936	−0.005	0.999	0.249	−0.952	−0.468	0.446	1	
URB	−0.883	−0.218	0.960	0.349	−0.904	−0.234	0.334	0.958	1	
PINS	−0.789	−0.225	0.913	0.299	−0.814	−0.182	0.312	0.912	0.951	1

Source: Author's estimate based on the WDI [78] and WGI [79] database.

Similarly, there is a negative correlation between carbon emissions, GDP per capita, and SQ_ GDP per capita, suggesting that increasing the value of GDP per capita would reduce the value of carbon emissions in the future. The outcomes of previous research are consistent with various studies [84–87]. These studies propose that a mix of GDP-led green FDI may grow the economy by increasing employment opportunities, while also improving the country's environmental performance. Additionally, a positive association exists between CO_2 emissions and R&D, indicating that the greater the level of R&D expenditures, the higher the value of CO_2 emissions in a nation.

In addition, the efficacy of the government, the quality of the monarchy, and political instability have a negative link with per capita CO_2 emissions. The greater the value of institutional quality variables (GF, RQ, and PINS), the lower the value of a country's carbon emissions. These research studies are connected to the previous study [21,29,40]. These studies indicate that the IQ with REC reduces carbon emissions and that the quality of institutions must be improved to achieve long-term sustainable objectives to encourage more REC for final consumption.

Finally, there is a positive correlation between CO_2 emissions and REC, indicating that the higher the level of REC, the higher the CO_2 emissions. These research findings, coupled with previous studies [88–90], advised that the present government should be more determined to execute energy efficiency initiatives to increase REC. In addition, these energy-efficiency programs must coordinate with other economic factors, to achieve the lowest possible CO_2 emission levels, while maintaining environmental sustainability.

The unit root test assesses whether or not variables are stationary. The ADF unit root test has been completed for the level and first difference of the variables. The unit root results of the study indicate that inbound FDI and urbanization are stationary at a specific level, while the other variables are difference stationary. The mixed order of integration is shown by the fact that the first difference series are I(1), and the level stationary series are zero integrated, i.e., I(0). Therefore, the ARDL bounds testing strategy was validated, since it performed well under the heterogeneous order of integration. Table 4 demonstrates the unit root (ADF) results.

Table 4. ADF Unit Root Estimates.

Variables	Level		First Difference		Decision
	Constant	Constant and Trend	Constant	Constant and Trend	
CO_2	−0.315 (0.914)	4.334 (0.076)	−5.440 (0.000)	−5.263 (0.000)	I(1)
FDI	−4.458 (0.0010)	−4.377 (0.006)	−4.302 (0.0016)	−4.536 (0.004)	I(0)
GDPPC	−2.031 (0.272)	−2.162 (0.497)	−4.172 (0.002)	−4.510 (0.004)	I(1)
GEF	−2.405 (0.143)	−2.573 (0.293)	−7.609 (0.000)	−7.594 (0.000)	I(1)
REC	0.989 (0.650341)	−2.191 (0.4828)	−5.569 (0.0000)	5.697 (0.0001)	I(1)
RND	−1.414 (0.572)	−1.258 (0.892)	−9.825 (0.000)	−9.817 (0.000)	I(1)
RQ	−3.106 (0.033)	−3.317 (0.076)	−4.530 (0.000)	−4.497 (0.004)	I(1)
SQ_GDPPC	−2.244 (0.194)	−2.089 (0.537)	−4.244 (0.001)	−4.689 (0.002)	I(1)
URB	−3.278 (0.022)	−2.749 (0.223)	−1.317 (0.612)	−2.471 (0.340)	I(0)
PINS	−0.595 (0.865)	−1.595 (0.649)	−10.443 (0.000)	−9.995 (0.000)	I(1)

Note: Small bracket shows probability value. Source: Author's estimate.

The ARDL model chooses distinct AIC, SIC, and HQ lag criteria. According to several lag section criteria, the lag length with the smallest value among the four lag lengths is optimal for our model. Table 5 displays the outcomes of various lag selection criteria. Based on the AIC value, which indicates the appropriateness of other lag selection criteria, the findings suggest that the optimal lag duration is 5.

The ARDL short-term and long-term estimates are shown in Table 6. In the short run, the findings indicate a positive relationship between GDP per capita and CO_2 emissions and a negative correlation between SQ_ GDP per capita and CO_2 emissions. Both coefficients have extremely significant values, which indicate the existence of an inverted U-shaped EKC hypothesis. These data suggest that CO_2 emissions rise during the first phase of a nation's per capita GDP growth, but then decrease when the economy reaches its turning point. After achieving the tipping threshold of 1 USD growth in GDP per capita, carbon emissions dropped by −51.120 tonnes. The greatest GDP per capita for the investigated period (1996–2020) is 1,448,112 US dollars, whereas the EKC turning point is 2652.00 US dollars. The EKC turning points highlighted which nation negatively impacted the environment the most to achieve the highest GDP per capita. The existence of an EKC in a nation explains three separate carbon emission impacts. The scale effects of an EKC that is compatible with GDP per capita and SQ_ GDP per capita findings indicate that a country's emission level rises at a particular level of GDP per capita. However, it decreases as the level of GDP per capita rises. The structural impact of the EKC is consistent with the regulatory quality and political stability findings, indicating that institutional structure change decreases the emission levels in a country. In fact, the impacts of the EKC are compatible with the R&D expenditures and EC findings, which demonstrate that R&D and EC lower a country's carbon emission levels. These findings are consistent with previous research that examines the link between GDP per capita and CO_2 emissions, such as the work of Bilgili et al. [91] and Hanif [92]. The results indicate that the process of choosing RE alternatives improves air quality by reducing carbon emissions. Moreover, utilizing RE alternatives facilitates the attainment of sustainable development goals. Moreover, Chen et al. [93] and Shahbaz et al. [19] also reveal that if economies follow sustainable policies, they can successfully limit global warming.

Table 5. Lag Length Selection Criteria.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1887.492	NA	−39.9679	3.55×10^{29}	−79.594	−79.594
1	2809.598	1648.02	6.04×10^{37}	−57.8638	−55.42872 *	−56.8802
2	2827.632	28.77755	2.41×10^{36}	−56.5241	−51.8975	−54.6553
3	2864.707	52.06249	6.89×10^{36}	−55.5895	−48.7713	−52.8355
4	3119.925	309.52	2.14×10^{37}	−59.2963	−50.2865	−55.657
5	3309.492	193.5997 *	3.24×10^{38} *	−61.60621 *	−50.4049	−57.08169 *
6	3343.391	28.12934	1.79×10^{37}	−60.6041	−47.2112	−55.1943

Source: Authors' estimation. Note: * indicates a significant lag length at the 5% confidence interval.

Table 6. ARDL Short- and Long-Term Estimates.

Variables	Coefficient	Std. Error	t−Statistic	Prob.
FDI(−1)	−0.01782	0.003572	−4.98768	0.0000
GDPPC(−1)	−0.45623	0.148116	−3.08021	0.0031
GEF(−1)	0.006402	0.002682	2.386786	0.0200
REC(−1)	0.548698	0.113683	4.826581	0.0000
RND	−0.01929	0.007926	−2.43298	0.0178
RQ(−1)	−0.05337	0.062311	−0.85658	0.3949
SQ_GDPPC(−1)	0.613143	0.329364	1.861593	0.0673
URB(−1)	−0.32409	0.201295	−1.61001	0.1124
PINS(−1)	0.028133	0.01154	2.437819	0.0176
D(FDI)	−0.01245	0.00305	−4.08238	0.0001
D(FDI(−1))	0.012092	0.002909	4.156578	0.0001
D(FDI(−2))	0.012092	0.002909	4.156578	0.0001
D(FDI(−3))	0.012092	0.002909	4.156578	0.0001
D(GDPPC)	13.55818	5.068431	2.675025	0.0095
D(GDPPC(−1))	19.07498	4.777181	3.992936	0.0002
D(GDPPC(−2))	19.07498	4.777181	3.992936	0.0002
D(GDPPC(−3))	19.07498	4.777181	3.992936	0.0002
D(GEF)	0.012587	0.003121	4.032524	0.0002
D(REC)	1.250213	0.074516	16.77773	0.0000
D(RQ)	0.104873	0.061548	1.703914	0.0933

Table 6. *Cont.*

Variables	Coefficient	Std. Error	t−Statistic	Prob.
D(RQ(−1))	0.129691	0.047625	2.723182	0.0084
D(RQ(−2))	0.129691	0.047625	2.723182	0.0084
D(RQ(−3))	0.129691	0.047625	2.723182	0.0084
D(SQ_GDPPC)	−51.1203	18.29753	−2.79384	0.0069
D(SQ_GDPPC(−1))	−69.2152	17.08028	−4.05235	0.0001
D(SQ_GDPPC(−2))	−69.2152	17.08028	−4.05235	0.0001
D(SQ_GDPPC(−3))	−69.2152	17.08028	−4.05235	0.0001
D(URB)	4.824353	0.994008	4.853436	0.0000
D(URB(−1))	5.22613	0.946009	5.524396	0.0000
D(URB(−2))	5.22613	0.946009	5.524396	0.0000
D(URB(−3))	5.22613	0.946009	5.524396	0.000
D(PINS)	0.044955	0.015151	2.967155	0.0042
Long−Term Elasticities				
FDI	−0.036984	0.007071	−5.230238	0.0000
GDPPC	−0.947094	0.296818	−3.190819	0.0022
GEF	0.013291	0.005682	2.338876	0.0225
REC	1.139058	0.107899	10.55670	0.0000
RND	−0.040033	0.016326	−2.452050	0.0170
RQ	−0.110801	0.129907	−0.852927	0.3969
SQ_GDPPC	1.272840	0.718956	1.770400	0.0815
URB	−0.672783	0.430430	−1.563050	0.1231
PINS	0.058402	0.022931	2.546819	0.0133

Source: Author's estimate.

In the long run, there is a negative relationship between GDP per capita and CO_2 emissions and a positive relationship between SQ_ GDP per capita and CO_2 emissions. The value of both coefficients is statistically significant, confirming the existence of a U-shaped EKC, confirming the race-to-bottom hypothesis. In the short–long run, a negative relationship exists between FDI inflows and CO_2 emissions in a country, verifying the pollution halo hypothesis. The result implies that FDI inflows increase with environmental regulation and move towards cleaner production technologies. In the short and long run, there is a negative relationship between R&D expenditures and CO_2 emissions and a positive relationship between urbanization and carbon emissions, verifying the I-PAT hypothesis. In the short and long run, there is a positive relationship between REC and CO_2 emissions in a country. The results imply that a country has inadequate green energy sources, leading to increased carbon emissions. In the short and long run, there is a significant and positive relationship between IQ variables such as RQ, GEF, PINS and carbon emissions. Table 7 represents the ARDL bounds testing estimates.

The value of F-statistics is 5.171, which is greater than the extreme boundaries of a 1 percent significance level. The greater determination value of the F-statistics beyond the upper bound limit indicates a long-term link between the variables. The diagnostic tests were performed to verify the stability of the model. These diagnostic tests consist of serial correlation, heteroskedasticity, model normality and stability. The model accepted all of the tests depicted in Table 8. The LM test describes the serial correlation of the factor, indicating that the probability (0.828) is greater than the 5% significance threshold and proving that there is no serial correlation. The heteroskedasticity test assesses the issue of heteroskedasticity; the probability value is (0.107) greater than the 5% threshold of significance, which shows that heteroskedasticity does not exist in the model. The stability of the variable estimates obtained using the Ramsey RESET test (prob. F, t-statistics; 0.386, 0.386) is higher than the 5 percent significant threshold, and the model stays stable throughout the analysis. The *p*-value of the normality test statistics (0.353) is larger than the significance threshold of 5%, showing the normality of the model.

Table 7. ARDL Bounds Estimates.

Test Statistic	Value	k
F-statistic	5.171	9
	Critical Bounds Value	
Significance	**I(0) Bound**	**I(1) Bound**
10%	1.63	2.75
5%	1.86	3.05
1%	2.37	3.68

Source: Author's estimate.

Table 8. Diagnostic Test Estimates.

		LM Test		Hypothesis
F-statistic	0.188	Prob. F(2,51)	0.828	Accept Ho
Obs*R-squared	0.698	Prob. Chi-Square(2)	0.705	
		Heteroskedasticity Test		
F-statistic	1.439	Prob. F(35,59)	0.107	Accept Ho
Obs*R-squared	43.755	Prob. Chi-Square(35)	0.147	
Scaled explained SS	51.808	Prob. Chi-Square(35)	0.033	
		Ramsey RESET Test		
	Value	d.f	Prob.	Accept Ho
t-statistic	1.305	52	0.197	
F-statistic	1.704	(1, 52)	0.197	
		Jarque–Bera normality test		Accept Ho
Jarque–Bera value		0.850		
Prob.		0.653		

Source: Author's estimates.

After investigation of the diagnostic tests, the study employed the Granger causality test to investigate the causality between the variables shown in Table 9.

The study's results established unidirectional Granger causation between GDP per capita and URB; and GEF and CO_2 emissions, indicating that urbanization and adequate institutional reforms are the leading causes of carbon emissions in a country. There is unidirectional causality between REC, R&D expenditures, and CO_2 emissions, suggesting that inadequate green energy sources and meager R&D expenditures raise a country's level of CO_2 emissions.

Table 10 displays the VDA's calculations and suggests that the GDP per capita and FDI will vary by 75.66 and 40.68 percent, respectively, to achieve the optimal level, and thereby polluting the environment, during the next decade. It is followed by URB, RQ, and R&D expenditures with associated variance error shocks of 68.4 percent, 96.73 percent, and 54.69 percent, respectively. At the same time, government effectiveness will have the least influence on carbon emissions over time.

Table 9. Granger Causality Estimates.

Null Hypothesis	F−Statistic	Prob.
GDPPC → CO_2	5.75067	0.0025
CO_2 → GDPPC	1.67983	0.1365
RND → FDI	6.34073	0.0025
FDI → RNDS	0.29517	0.9376
URB → CO_2	2.13929	0.0576
CO_2 → URB	0.00121	1.0000
SQ_GDPPC → CO_2	5.67713	0.0005
CO_2 → SQ_GDPPC	1.68649	0.1348
GEF → CO_2	7.13937	0.00406
CO_2 → GF	0.30236	0.9345
RND → CO_2	6.34073	0.0025
CO_2 → RND	0.29517	0.9376
REC → GEF	0.85973	0.5282
GF → REC	5.51936	0.0005
RND → GEF	1.54199	0.1751
GEF → RND	5.97276	0.0005
SQ_GDPPC → REC	2.78855	0.0162
REC → SQ_GDPPC	0.97322	0.4488

Source: Author's estimates.

Table 10. VDA Estimates.

Years	S.E.	CO_2	FDI	GDPPPC	GEF	REC	RND	RQ	SQ_GDPPC	URB	PINS
2022	0.020	100	0	0	0	0	0	0	0	0	0
2023	0.025	99.505	8.00×10^5	0.001	0.175	0.061	0.0009	0.086	0.038	0.129	2.26×10^5
2024	0.029	93.880	0.203	1.509	3.786	0.099	0.0037	0.102	0.138	0.117	0.158
2025	0.033	84.468	0.564	3.994	9.575	0.268	0.0187	0.220	0.343	0.122	0.422
2026	0.037	74.205	0.844	7.3166	15.257	0.428	0.0613	0.416	0.680	0.138	0.651
2027	0.041	64.794	0.993	10.951	19.860	0.516	0.1405	0.635	1.145	0.175	0.786
2028	0.044	56.801	1.015	14.600	23.233	0.547	0.244	0.820	1.665	0.240	0.831
2029	0.048	50.249	0.951	18.070	25.564	0.547	0.355	0.937	2.170	0.344	0.809
2030	0.051	44.953	0.851	21.262	27.110	0.535	0.458	0.980	2.607	0.491	0.747
2031	0.054	40.685	0.756	24.120	28.097	0.524	0.546	0.967	2.946	0.684	0.671

Source: Author's estimates.

6. Discussion

These findings supported the EKC hypothesis that the relationship between carbon emissions and per capita income follows an inverted U shape. There are several ways to evaluate the EKC's economic effects, which are as follows:

I. According to the EKC, environmental deterioration will worsen as a country's economy develops. Reduced productivity and higher medical expenses are only two ways in which this may harm the economy.

II. The EKC indicates that, above a certain wealth threshold, more prosperity may result in less environmental harm. Increased productivity, better health, and more tourists are all ways in which this might boost the economy.

III. The EKC implies that governments must strike a balance between economic development and preventing environmental deterioration, since economic development has reached a threshold of diminishing returns regarding environmental deterioration.
IV. The EKC suggests that environmental rules and policies may be more successful in nations with higher incomes.
V. Finally, the EKC may be used to determine the optimum amount of environmental control for a particular economic growth state.

The study outcomes are associated with different previous studies, including those by Dogan and Inglesi-Lotz [94], Azlina et al. [95], and Ogundipe et al. [96]. These studies suggested that a green economy demands internal and external initiatives in power, economic projects and conservation efforts. Authorities should exchange and embrace industry standards for producing sustainable financial derivatives and policies that promote the use of green technologies to reduce domestic energy reliance and develop eco-responsible behavior are imperative for long-term development.

The research also found that greater levels of FDI are linked to lower CO_2 emissions. This finding lends credence to the pollution halo concept, which proposes that MNCs move their operations to nations with stricter environmental requirements to escape the negative publicity associated with being based in places with low environmental performance. This finding has significant economic implications because it suggests that countries with stricter environmental regulations may be more appealing to MNCs, which can thereby avoid the reputational risks associated with operating in countries with poor environmental restrictions. This indicates that nations with stricter environmental restrictions may attract more FDI, which may benefit the economy, including, but not limited to, higher employment and growth. This finding further supports the idea that enforcing stricter environmental rules is a viable strategy for lowering CO_2 emissions and combating climate change. The fact that FDI favors investment in nations with superior environmental rules lends credence to the argument that environmental restrictions may be utilized to attract FDI. Another implication of the negative correlation is that the environmental performance of a nation is an essential factor for overseas investors. Zhang and Zhou [97] and Kisswani and Zaitouni's [98] scholarly work supported the pollution halo hypothesis that FDI inflow reduces the level of carbon emissions in a country and suggests that external firms can export greener technologies from industrialized to unindustrialized economies to conduct environmentally friendly activities. The research findings of Ostic et al. [99]; Essandoh et al. [100], and Li et al. [101] contribute consistent results with the current study measures that ensure EG and FDI would promote the transfer of high emission-intensive production units and achieve emission reduction and integration of nationwide social awareness programs through environmental policies. Furthermore, foreign capital is used to build sustainable plans and policies. Dietz et al.'s [102] study results confirm the IPAT hypothesis, revealing that the global driving forces and populations with EG increase the level of greenhouse gas emissions.

This research demonstrates that ineffectual administration, political unpredictability, and lax regulation contribute to rising carbon emissions. The inability to enforce and comply with current rules and the absence of adequate policies may be to blame. Consequently, this finding has significant economic ramifications, as higher carbon emissions and the costs of climate change are a direct outcome of ineffective governance. Investors may be discouraged by a country's weak governance and excessive carbon emissions, which might make the investment climate in that country less favorable. It also suggests that nations with excellent governance, typified by efficiency, stability, and high-quality rules, would be better equipped to execute measures to reduce carbon emissions and advance sustainable development. Investors are more willing to invest in a nation with a stable government and minimal carbon emissions. More effective laws and regulations to reduce emissions are essential in the battle against climate change, highlighted by these findings. Additionally, the importance of regulatory compliance and enforcement for achieving the desired emission reductions is emphasized. The outcomes of the past studies of

Zhang [103]; Ohlan [104]; and Lee et al. [105], which are associated with the current study results, indicated the importance of encouraging countries to increase their soft policies to stimulate research and development expenditure and expand cities to limit the urbanization effects on environmental quality. Moreover, developing an optimum population stabilization policy assists in reducing CO_2 emissions and sustaining long-run EG. Mohsin et al. [106], Muhammad and Khan [107], Naz et al. [108], and Polcyn et al. [109] propose that there should be an emphasis on environment-friendly tools to decrease carbon emissions and improve alternative energy sources, using clean technologies to curb CO_2 emissions. Furthermore, local climate policy and clean energy can safeguard the environment. Godil et al. [35], Mehmood et al. [41], and Obobisa et al. [110] concluded that we must improve the quality of power structures and develop more sustainable power to accomplish the long-term emission targets. Investing more in clean initiatives would be helpful in meeting sustainability objectives. Azlina et al. [95], Saidi and Mbarek [111], and Raihan and Tuspekova [112] indicated that a nation's competitiveness and environmental deterioration could be averted, without sacrificing its ability to meet its energy demands and protect the environment.

7. Conclusions

Energy transformation is key to attaining the 1.5-degree Celsius objective and COP26's agenda, which aims to phase out carbon fuels and create clean electricity. Energy supplies, asymmetrical capacity utilization, and financial damage will hamper the energy transition. Governments may use economic legislation and government frameworks to manage decarbonization. Following COP26, low-carbon energy adjustment governance is crucial. This study investigates the link between IQ, FDI, REC, R&D expenditures, urbanization, and CO_2 emissions in Pakistan, using time series data from 1996Q1 to 2020Q4. An inverted U-shaped EKC with turning points exists in the short term. Long-term evidence of a U-shaped EKC based on the raise-to-bottom theory was also discovered in of the models. According to the pollution halo hypothesis, a negative link exists between FDI influx and CO_2 emissions in a nation. In addition, there is a negative link between R&D expenditures and CO_2 emissions and a positive relationship between urbanization and CO_2 emissions. There is also a positive association between REC and CO_2 emissions in the short-to-medium term, owing to a lack of research and development and inefficient legislation. Additionally, there is a significant and positive association between IQ factors and carbon emissions throughout the medium to long term. In addition, the results of the study established unidirectional Granger causation between (i) GDP per capita and urbanization, (ii) government effectiveness and carbon emissions, and (iii) REC, R&D expenditures and carbon emissions, which imply that low sources of REC and meager research and development expenditures increase the level of emissions. Lastly, legislative measures should promote global collaboration for the promotion of clean and sustainable energy sources, as well as environmental sustainability and long-term development.

Policy Repercussions

The government in Pakistan should promote social stability in the foundation of EG, develop an effective tool for IQ that accelerates the quality of sustainable development, and establish a global partnership for promoting clean and sustainable energy sources and environmental sustainability. Public and commercial international finance institutions boost energy transitions, energy access, clean and green technology development, and global job possibilities. The public financial institutions invest specifically in clean energy alternatives and create new micro-and macro-scale energy transformation choices. Investing in unchecked fossil fuel-related energy projects implies significant social and economic risks, especially in the form of stranded assets, and negatively affects government income, local jobs, taxpayers, utility customers, and public health. The government should improve the consumption and production recycling waste management systems and develop green industry solutions that combat the problem of sustaining the environment, cease the exploitation of natural resources, and strengthen the government's institutional structures with transparent natural resources tax laws. Furthermore, they must build a legislative system that is sustainable and ecologically beneficial to stimulate green investment.

The government should encourage stakeholders to create an alternative energy source that pollutes the environment less and reduces the strain on natural resources, as well as improve and encourage green investors to participate in green EG initiatives. Additionally, they should assist IQ improvement organizations in achieving a greater degree of environmental sustainability and in comprehending the intricacy of people, the environment, and development. The governments should create environmentally friendly technologies for conserving air, water quality, and environmental resources to improve ecological indicators. Measures may be enforced to create a more harmonious relationship between urban and rural populations, the environment, and EG. In addition, unique analytical indicators should be developed to attain a greater economic and environmental sustainability level. They should also develop policies and plans for long-term viability. There is a need for special assistance development in the economic, social, and cultural relationship with innovation to strengthen the less developed member states and aid with the cooperation of high investment in research and development, supportive financial arrangements, and innovative infrastructure road maps for higher environmental sustainability.

The government should design a resource governance structure that permits economic development and increases social welfare and environmental sustainability, in addition to sustaining the economy, enhancing human welfare, providing jobs, and establishing health facilities to ensure ecological sustainability. The government should strengthen the urban–rural local governance quality and focus more on the weak components of local governance, to expand the public service facilities via efficient government regulations. Furthermore, they must pay greater attention to independent innovation in the higher education system to promote a better quality of human capital, which creates the highest quality of institutional performances in the living environment with higher quality and sustained economic growth.

Author Contributions: Conceptualization, M.I., S.K., K.Z., M.S. and H.u.R.K.; methodology, M.I. and K.Z.; software, M.I.; validation, M.I., S.K., K.Z., M.S. and H.u.R.K.; formal analysis, M.I. and K.Z.; investigation, M.I., S.K., K.Z., M.S. and H.u.R.K.; resources, M.I., S.K., K.Z., M.S. and H.u.R.K.; data curation, M.I.; writing—original draft preparation, M.I. and K.Z.; writing—review and editing, M.I., S.K., K.Z., M.S. and H.u.R.K.; visualization, M.I., S.K., K.Z., M.S. and H.u.R.K.; supervision, K.Z.; project administration, S.K., M.S. and H.u.R.K.; funding acquisition, H.u.R.K. and K.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data are freely available at World Development Indicators and World Governance Indicators published by the World Bank (2022) at https://databank.worldbank.org/source/world-development-indicators (accessed on 12 October 2022).

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

COP26	26th Conference of Parties
REC	Renewable energy consumption
ARDL	Autoregressive distributed lag
EKC	Environmental Kuznets curve
IQ	Institutional quality
RND	R&D expenditures
EG	Economic growth
PHH	Pollution haven hypothesis
EC	Energy consumption
FD	Financial development
ICTs	Information and communication technologies

CO_2	Carbon dioxide
SDGs	Sustainable Development Goals
GEF	Government effectiveness
RQ	Regulatory quality
PINS	Political instability
URB	Urbanization
ECT	Error correction term

References

1. United Nations. COP26: Together for Our Planet. 2022. Available online: https://www.un.org/en/climatechange/cop26 (accessed on 18 June 2022).
2. Saadaoui, H.; Chtourou, N. Do institutional quality, financial development, and economic growth improve renewable energy transition? Some Evidence from Tunisia. *J. Knowl. Econ.* **2022**. [CrossRef]
3. Lin, T.; Wang, L.; Wu, J. Environmental Regulations, Green Technology Innovation, and High-Quality Economic Development in China: Application of Mediation and Threshold Effects. *Sustainability* **2022**, *14*, 6882. [CrossRef]
4. Ikram, M.; Ferasso, M.; Sroufe, R.; Zhang, Q. Assessing green technology indicators for cleaner production and sustainable investments in a developing country context. *J. Clean. Prod.* **2021**, *322*, 129090. [CrossRef]
5. Ellahi, N.; Kiani, A.K.; Awais, M.; Affandi, H.; Saghir, R.; Qaim, S. Investigating the institutional determinants of financial development: Empirical evidence from saarc countries. *SAGE Open* **2021**, *11*, 21582440211006029. [CrossRef]
6. Bugden, D. Technology, decoupling, and ecological crisis: Examining ecological modernization theory through patent data. *Environ. Sociol.* **2022**, *8*, 228–241. [CrossRef]
7. Wade, F.; Webb, J.; Creamer, E. Local government capacities to support net zero: Developing comprehensive heat and energy efficiency strategies in Scotland. *Energy Res. Soc. Sci.* **2022**, *89*, 102544.
8. Godil, D.I.; Yu, Z.; Sharif, A.; Usman, R.; Khan, S.A.R. Investigate the role of technology innovation and renewable energy in reducing transport sector CO_2 emission in China: A path toward sustainable development. *Sustain. Dev.* **2021**, *29*, 694–707. [CrossRef]
9. Ahmed, S.F.; Mofijur, M.; Nuzhat, S.; Rafa, N.; Musharrat, A.; Lam, S.S.; Boretti, A. Sustainable hydrogen production: Technological advancements and economic analysis. *Int. J. Hydrogen Energy* **2021**, *47*, 37227–37255. [CrossRef]
10. Guilhot, L. An analysis of China's energy policy from 1981 to 2020: Transitioning towards to a diversified and low-carbon energy system. *Energy Policy* **2022**, *162*, 112806. [CrossRef]
11. IEA. *Renewable Power Is Set to Break Another Global Record in 2022 Despite Headwinds from Higher Costs and Supply Chain Bottlenecks*; IEA: Washington, DC, USA, 2022.
12. UNEP. The Heat Is on: A World of Climate Promises Not Yet Delivered. Emissions Gap Report 2021, United Nations Environment Programme. 2021. Available online: https://www.unep.org/resources/emissions-gap-report-2021 (accessed on 18 June 2022).
13. Hepburn, C.; Qi, Y.; Stern, N.; Ward, B.; Xie, C.; Zenghelis, D. Towards carbon neutrality and China's 14th Five-Year Plan: Clean energy transition, sustainable urban development, and investment priorities. *Environ. Sci. Ecotechnol.* **2021**, *8*, 100130. [CrossRef]
14. Qayyum, U.; Sabir, S.; Anjum, S. Urbanization, informal economy, and ecological footprint quality in South Asia. *Environ. Sci. Pollut. Res.* **2021**, *28*, 67011–67021. [CrossRef] [PubMed]
15. Nayal, K.; Raut, R.D.; Yadav, V.S.; Priyadarshinee, P.; Narkhede, B.E. The impact of sustainable development strategy on sustainable supply chain firm performance in the digital transformation era. *Bus. Strategy Environ.* **2022**, *31*, 845–859. [CrossRef]
16. Hong, T.; Yu, N.; Mao, Z.; Zhang, S. Government-driven urbanisation and its impact on regional economic growth in China. *Cities* **2021**, *117*, 103299. [CrossRef]
17. Dash, D.P.; Behera, S.R.; Rao, D.T.; Sethi, N.; Loganathan, N. Governance, urbanization, and pollution: A cross-country analysis of global south region. *Cogent Econ. Financ.* **2020**, *8*, 1742023. [CrossRef]
18. Shera, A.; Dosti, B.; Grabore, P. Corruption Impact on Economic Growth: An Empirical Analysis. *J. Econ. Dev. Manag. IT Financ. Mark.* **2014**, *6*, 57–77.
19. Shahbaz, M.; Solarin, S.A.; Sbia, R.; Bibi, S. Does energy intensity contribute to CO_2 emissions? A trivariate analysis in selected African countries. *Ecol. Indic.* **2015**, *50*, 215–224. [CrossRef]
20. Younas, F. Institutional Change and Economic Growth in Pakistan. MRPA Paper no. 72938. 2015. Available online: https://mpra.ub.uni-muenchen.de/72938/ (accessed on 19 June 2022).
21. Ibrahim, M.H.; Law, S.H. Institutional Quality and CO_2 Emission–Trade Relations: Evidence from Sub-Saharan Africa. *S. Afr. J. Econ.* **2016**, *84*, 323–340. [CrossRef]
22. Abid, M. Impact of economic, financial, and institutional factors on CO_2 emissions: Evidence from sub-Saharan Africa economies. *Util. Policy* **2016**, *41*, 85–94. [CrossRef]
23. Peres, M.; Ameer, W.; Xu, H. The impact of institutional quality on foreign direct investment inflows: Evidence for developed and developing countries. *Econ. Res.-Ekon. Istraz.* **2018**, *31*, 626–644. [CrossRef]
24. Lau, L.S.; Choong, C.K.; Ng, C.F. Role of institutional quality on environmental Kuznets curve: A comparative study in developed and developing countries. In *Advances in Pacific Basin Business, Economics and Finance*; Emerald Publishing Limited: Bingley, UK, 2018.

25. Sarkodie, S.A.; Adams, S. Renewable energy, nuclear energy, and environmental pollution: Accounting for political institutional quality in South Africa. *Sci. Total Environ.* **2018**, *643*, 1590–1601. [CrossRef]
26. Nguyen, C.P.; Nguyen, N.A.; Schinckus, C.; Su, T.D. The ambivalent role of institutions in the CO_2 emissions: The case of emerging countries. *Int. J. Energy Econ. Policy* **2018**, *8*, 7–17.
27. Hassan, S.T.; Khan, S.U.D.; Xia, E.; Fatima, H. Role of institutions in correcting environmental pollution: An empirical investigation. *Sustain. Cities Soc.* **2020**, *53*, 101901. [CrossRef]
28. Hayat, A. Foreign direct investments, institutional quality, and economic growth. *J. Int. Trade Econ. Dev.* **2019**, *28*, 561–579. [CrossRef]
29. Salman, M.; Long, X.; Dauda, L.; Mensah, C.N. The impact of institutional quality on economic growth and carbon emissions: Evidence from Indonesia, South Korea and Thailand. *J. Clean. Prod.* **2019**, *241*, 118331. [CrossRef]
30. Nwani, C.; Adams, S. Environmental cost of natural resource rents based on production and consumption inventories of carbon emissions: Assessing the role of institutional quality. *Resour. Policy* **2021**, *74*, 102282. [CrossRef]
31. Acheampong, A.O.; Dzator, J.; Savage, D.A. Renewable energy, CO_2 emissions and economic growth in sub-Saharan Africa: Does institutional quality matter? *J. Policy Model.* **2021**, *43*, 1070–1093. [CrossRef]
32. Udemba, E.N. Mitigating environmental degradation with institutional quality and foreign direct investment (FDI): New evidence from asymmetric approach. *Environ. Sci. Pollut. Res.* **2021**, *28*, 43669–43683. [CrossRef] [PubMed]
33. Sheraz, M.; Deyi, X.; Mumtaz, M.Z.; Ullah, A. Exploring the dynamic relationship between financial development, renewable energy, and carbon emissions: A new evidence from belt and road countries. *Environ. Sci. Pollut. Res.* **2022**, *29*, 14930–14947. [CrossRef]
34. Ahmad, M.; Ahmed, Z.; Yang, X.; Hussain, N.; Sinha, A. Financial development and environmental degradation: Do human capital and institutional quality make a difference? *Gondwana Res.* **2022**, *105*, 299–310. [CrossRef]
35. Godil, D.I.; Sharif, A.; Agha, H.; Jermsittiparsert, K. The dynamic nonlinear influence of ICT, financial development, and institutional quality on CO_2 emission in Pakistan: New insights from QARDL approach. *Environ. Sci. Pollut. Res.* **2020**, *27*, 24190–24200. [CrossRef]
36. Malik, M.Y.; Latif, K.; Khan, Z.; Butt, H.D.; Hussain, M.; Nadeem, M.A. Symmetric and asymmetric impact of oil price, FDI and economic growth on carbon emission in Pakistan: Evidence from ARDL and non-linear ARDL approach. *Sci. Total Environ.* **2020**, *726*, 138421. [CrossRef] [PubMed]
37. Anser, M.K.; Alharthi, M.; Aziz, B.; Wasim, S. Impact of urbanization, economic growth, and population size on residential carbon emissions in the SAARC countries. *Clean. Technol. Environ. Policy* **2020**, *22*, 923–936. [CrossRef]
38. Yang, Y.; Khan, A. Exploring the role of finance, natural resources, and governance on the environment and economic growth in South Asian countries. *Environ. Sci. Pollut. Res.* **2021**, *28*, 50447–50461. [CrossRef] [PubMed]
39. Wang, M.L.; Ntim, V.S.; Yang, J.; Zheng, Q.; Geng, L. Effect of institutional quality and foreign direct investment on economic growth and environmental quality: Evidence from African countries. *Econ. Res.-Ekon. Istraz.* **2021**, *35*, 4065–4091. [CrossRef]
40. Haldar, A.; Sethi, N. Effect of institutional quality and renewable energy consumption on CO_2 emissions—An empirical investigation for developing countries. *Environ. Sci. Pollut. Res.* **2021**, *28*, 15485–15503. [CrossRef]
41. Mehmood, U.; Tariq, S.; Ul-Haq, Z.; Meo, M.S. Does the modifying role of institutional quality remains homogeneous in GDP-CO_2 emission nexus? New evidence from ARDL approach. *Environ. Sci. Pollut. Res.* **2021**, *28*, 10167–10174. [CrossRef]
42. Ulucak, R. Analyzing energy innovation-emissions nexus in China: A novel dynamic simulation method. *Energy* **2022**, *244*, 123010.
43. Anser, M.K.; Godil, D.I.; Khan, M.A.; Nassani, A.A.; Askar, S.E.; Zaman, K.; Salamun, H.; Sasmoko; Indrianti, Y.; Abro, M.M.Q. Nonlinearity in the relationship between COVID-19 cases and carbon damages: Controlling financial development, green energy, and R&D expenditures for shared prosperity. *Environ. Sci. Pollut. Res.* **2022**, *29*, 5648–5660.
44. Ghorbal, S.; Farhani, S.; Youssef, S.B. Do renewable energy and national patents impact the environmental sustainability of Tunisia? *Environ. Sci. Pollut. Res.* **2022**, *29*, 25248–25262. [CrossRef]
45. Mehmood, U. Renewable energy and foreign direct investment: Does the governance matter for CO_2 emissions? Application of CS-ARDL. *Environ. Sci. Pollut. Res.* **2022**, *29*, 19816–19822. [CrossRef]
46. Adebayo, T.S. Environmental consequences of fossil fuel in Spain amidst renewable energy consumption: A new insights from the wavelet-based Granger causality approach. *Int. J. Sustain. Dev. World Ecol.* **2022**, *29*, 579–592. [CrossRef]
47. Hamid, I.; Alam, M.S.; Kanwal, A.; Jena, P.K.; Murshed, M.; Alam, R. Decarbonization pathways: The roles of foreign direct investments, governance, democracy, economic growth, and renewable energy transition. *Environ. Sci. Pollut. Res.* **2022**, *29*, 49816–49831. [CrossRef] [PubMed]
48. Murshed, M.; Nurmakhanova, M.; Al-Tal, R.; Mahmood, H.; Elheddad, M.; Ahmed, R. Can intra-regional trade, renewable energy use, foreign direct investments, and economic growth mitigate ecological footprints in South Asia? *Energy Sources B Econ. Plan. Policy* **2022**, *7*, 808–821. [CrossRef]
49. Khan, H.; Weili, L.; Khan, I. The role of institutional quality in FDI inflows and carbon emission reduction: Evidence from the global developing and belt road initiative countries. *Environ. Sci. Pollut. Res.* **2022**, *29*, 30594–30621. [CrossRef] [PubMed]
50. Yang, B.; Ali, M.; Hashmi, S.H.; Jahanger, A. Do income inequality and institutional quality affect CO_2 emissions in developing economies? *Environ. Sci. Pollut. Res.* **2022**, *29*, 42720–42741. [CrossRef] [PubMed]

51. Cao, H.; Khan, M.K.; Rehman, A.; Dagar, V.; Oryani, B.; Tanveer, A. Impact of globalization, institutional quality, economic growth, electricity and renewable energy consumption on Carbon Dioxide Emission in OECD countries. *Environ. Sci. Pollut. Res.* **2022**, *29*, 24191–24202. [CrossRef]
52. Yuan, B.; Li, C.; Yin, H.; Zeng, M. Green innovation and China's CO_2 emissions—The moderating effect of institutional quality. *J. Environ. Plan. Manag.* **2022**, *65*, 877–906. [CrossRef]
53. Khan, H.; Weili, L.; Khan, I. Institutional quality, financial development and the influence of environmental factors on carbon emissions: Evidence from a global perspective. *Environ. Sci. Pollut. Res.* **2022**, *29*, 13356–13368. [CrossRef]
54. Tripathy, P.; Khatua, M.; Behera, P.; Satpathyy, L.D.; Jena, P.K.; Mishra, B.R. Dynamic link between bilateral FDI, the quality of environment and institutions: Evidence from G20 countries. *Environ. Sci. Pollut. Res.* **2022**, *29*, 27150–27171. [CrossRef]
55. Rahman, M.M.; Sultana, N. Impacts of institutional quality, economic growth, and exports on renewable energy: Emerging countries perspective. *Renew. Energy* **2022**, *189*, 938–951. [CrossRef]
56. Agboola, P.O.; Hossain, M.; Gyamfi, B.A.; Bekun, F.V. Environmental consequences of foreign direct investment influx and conventional energy consumption: Evidence from dynamic ARDL simulation for Turkey. *Environ. Sci. Pollut. Res.* **2022**, *29*, 53584–53597. [CrossRef] [PubMed]
57. Addai, K.; Serener, B.; Kirikkaleli, D. Empirical analysis of the relationship among urbanization, economic growth and ecological footprint: Evidence from Eastern Europe. *Environ. Sci. Pollut. Res.* **2022**, *29*, 27749–27760. [CrossRef] [PubMed]
58. Chen, X.; Liu, C.; Yu, X. Urbanization, Economic Development, and Ecological Environment: Evidence from Provincial Panel Data in China. *Sustainability* **2022**, *14*, 1124. [CrossRef]
59. Dada, J.T.; Adeiza, A.; Noor, A.I.; Marina, A. Investigating the link between economic growth, financial development, urbanization, natural resources, human capital, trade openness and ecological footprint: Evidence from Nigeria. *J. Bioecon.* **2022**, *24*, 153–179. [CrossRef]
60. Sohail, M.T.; Majeed, M.T.; Shaikh, P.A.; Andlib, Z. Environmental costs of political instability in Pakistan: Policy options for clean energy consumption and environment. *Environ. Sci. Pollut. Res.* **2022**, *29*, 25184–25193. [CrossRef]
61. Liu, C.; Xin, L.; Li, J. Environmental regulation and manufacturing carbon emissions in China: A new perspective on local government competition. *Environ. Sci. Pollut. Res.* **2022**, *29*, 36351–36375. [CrossRef]
62. Yasmeen, R.; Tao, R.; Shah, W.U.H.; Padda, I.U.H.; Tang, C. The nexuses between carbon emissions, agriculture production efficiency, research and development, and government effectiveness: Evidence from major agriculture-producing countries. *Environ. Sci. Pollut. Res.* **2022**, *29*, 52133–52146. [CrossRef]
63. Shaheen, F.; Zaman, K.; Lodhi, M.S.; Nassani, A.A.; Haffar, M.; Abro, M.M.Q. Do affluent nations value a clean environment and preserve it? Evaluating the N-shaped environmental Kuznets curve. *Environ. Sci. Pollut. Res.* **2022**, *29*, 47267–47285. [CrossRef]
64. Xin-Gang, Z.; Jin, Z. Impacts of two-way foreign direct investment on carbon emissions: From the perspective of environmental regulation. *Environ. Sci. Pollut. Res.* **2022**, *29*, 52705–52723. [CrossRef]
65. Shahzadi, I.; Yaseen, M.R.; Khan, M.T.I.; Makhdum, M.S.A.; Ali, Q. The nexus between research and development, renewable energy and environmental quality: Evidence from developed and developing countries. *Renew. Energy* **2022**, *190*, 1089–1099. [CrossRef]
66. Anwar, A.; Sinha, A.; Sharif, A.; Siddique, M.; Irshad, S.; Anwar, W.; Malik, S. The nexus between urbanization, renewable energy consumption, financial development, and CO_2 emissions: Evidence from selected Asian countries. *Environ. Dev. Sustain.* **2022**, *24*, 6556–6576. [CrossRef]
67. Chien, F.; Hsu, C.C.; Ozturk, I.; Sharif, A.; Sadiq, M. The role of renewable energy and urbanization towards greenhouse gas emission in top Asian countries: Evidence from advance panel estimations. *Renew. Energy* **2022**, *186*, 207–216. [CrossRef]
68. Sun, Y.; Li, H.; Andlib, Z.; Genie, M.G. How do renewable energy and urbanization cause carbon emissions? Evidence from advanced panel estimation techniques. *Renew. Energy* **2022**, *185*, 996–1005. [CrossRef]
69. Kaufmann, D.; Kraay, A.; Mastruzzi, M. The worldwide governance indicators: Methodology and analytical issues. *Hague J. Rule Law* **2011**, *3*, 220–246. [CrossRef]
70. WGI. *World Governance Indicators*; World Bank: Washington, DC, USA, 2008.
71. Copeland, B.R.; Taylor, M.S. North-South trade and the environment. *Q. J. Econ.* **1994**, *109*, 755–787. [CrossRef]
72. Levinson, A.; Taylor, M.S. Unmasking the pollution haven effect. *Int. Econ. Rev.* **2008**, *49*, 223–254. [CrossRef]
73. Grossman, G.M.; Krueger, A.B. *Environmental Impacts of a North American Free Trade Agreement*; National Bureau of Economic Research Working Paper 3914; NBER: Cambridge, MA, USA, 1991. [CrossRef]
74. Sinha, A.; Shahbaz, M.; Balsalobre, D. N-Shaped Environmental Kuznets Curve: A Note on Validation and Falsification. 2018. Available online: https://mpra.ub.uni-muenchen.de/99313/ (accessed on 19 June 2022).
75. Ehrlich, P.R.; Holdren, J.P. Impact of Population Growth: Complacency concerning this component of man's predicament is unjustified and counterproductive. *Science* **1971**, *171*, 1212–1217. [CrossRef]
76. Eppink, F.V.; van den Bergh, J.C.; Rietveld, P. Modelling biodiversity and land use: Urban growth, agriculture and nature in a wetland area. *Ecol. Econ.* **2004**, *51*, 201–216. [CrossRef]
77. Porter, M.E.; Van der Linde, C. Toward a new conception of the environment-competitiveness relationship. *J. Econ. Perspect.* **1995**, *9*, 97–118. [CrossRef]
78. WDI. *World Development Indicators*; World Bank: Washington, DC, USA, 2022.
79. WGI. *World Governance Indicators*; World Bank: Washington, DC, USA, 2021.

80. Pesaran, M.H.; Shin, Y.; Smith, R.J. Bounds testing approaches to the analysis of level relationships. *J. Appl. Econ.* **2001**, *16*, 289–326. [CrossRef]
81. Shao, Y. Does FDI affect carbon intensity? New evidence from dynamic panel analysis. *Int. J. Clim. Chang. Strateg. Manag.* **2017**, *10*, 27–42. [CrossRef]
82. Zaman, K.; Moemen, M.A.E.; Islam, T. Dynamic linkages between tourism transportation expenditures, carbon dioxide emission, energy consumption and growth factors: Evidence from the transition economies. *Curr. Issues Tour.* **2017**, *20*, 1720–1735. [CrossRef]
83. Zubair, A.O.; Samad, A.R.A.; Dankumo, A.M. Does gross domestic income, trade integration, FDI inflows, GDP, and capital reduces CO_2 emissions? An empirical evidence from Nigeria. *Curr. Res. Environ. Sustain.* **2020**, *2*, 100009. [CrossRef]
84. Tariq, G.; Sun, H.; Haris, M.; Kong, Y.; Nadeem, A. Trade liberalization, FDI inflows economic growth and environmental sustanaibility in Pakistan and India. *J. Agric. Environ. Int. Dev.* **2018**, *112*, 253–269.
85. Ali, R.; Ishaq, R.; Bakhsh, K.; Yasin, M.A. Do Agriculture Technologies Influence Carbon Emissions in Pakistan? Evidence based on ARDL technique. *Environ. Sci. Pollut. Res.* **2022**, *29*, 43361–43370. [CrossRef]
86. Saleem, H.; Khan, M.B.; Shabbir, M.S.; Khan, G.Y.; Usman, M. Nexus between non-renewable energy production, CO_2 emissions, and healthcare spending in OECD economies. *Environ. Sci. Pollut. Res.* **2022**, *29*, 47286–47297. [CrossRef]
87. Yokoi, R.; Watari, T.; Motoshita, M. Future greenhouse gas emissions from metal production: Gaps and opportunities towards climate goals. *Energy Environ. Sci.* **2022**, *15*, 146–157. [CrossRef]
88. Ekwueme, D.C.; Zoaka, J.D.; Alola, A.A. Carbon emission effect of renewable energy utilization, fiscal development, and foreign direct investment in South Africa. *Environ. Sci. Pollut. Res.* **2021**, *28*, 41821–41833. [CrossRef]
89. Nawaz, M.A.; Hussain, M.S.; Kamran, H.W.; Ehsanullah, S.; Maheen, R.; Shair, F. Trilemma association of energy consumption, carbon emission, and economic growth of BRICS and OECD regions: Quantile regression estimation. *Environ. Sci. Pollut. Res.* **2021**, *28*, 16014–16028. [CrossRef]
90. Wang, R.; Mirza, N.; Vasbieva, D.G.; Abbas, Q.; Xiong, D. The nexus of carbon emissions, financial development, renewable energy consumption, and technological innovation: What should be the priorities in light of COP 21 Agreements? *J. Environ. Manag.* **2020**, *271*, 111027. [CrossRef]
91. Bilgili, F.; Koçak, E.; Bulut, Ü. The dynamic impact of renewable energy consumption on CO_2 emissions: A revisited Environmental Kuznets Curve approach. *Renew. Sustain. Energy Rev.* **2016**, *54*, 838–845. [CrossRef]
92. Hanif, I. Impact of economic growth, nonrenewable and renewable energy consumption, and urbanization on carbon emissions in Sub-Saharan Africa. *Environ. Sci. Pollut. Res.* **2018**, *25*, 15057–15067. [CrossRef] [PubMed]
93. Chen, Y.; Wang, Z.; Zhong, Z. CO_2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. *Renew. Energy* **2019**, *131*, 208–216. [CrossRef]
94. Dogan, E.; Inglesi-Lotz, R. The impact of economic structure to the environmental Kuznets curve (EKC) hypothesis: Evidence from European countries. *Environ. Sci. Pollut. Res.* **2020**, *27*, 12717–12724. [CrossRef] [PubMed]
95. Azlina, A.A.; Law, S.H.; Mustapha, N.H.N. Dynamic linkages among transport energy consumption, income and CO_2 emission in Malaysia. *Energy Policy* **2014**, *73*, 598–606. [CrossRef]
96. Ogundipe, A.; Olurinola, O.; Odebiyi, J.T. Examining the Validity of EKC in Western Africa: Different Pollutants Option. 2014. Available online: https://ssrn.com/abstract=2512152 (accessed on 15 September 2022).
97. Zhang, C.; Zhou, X. Does foreign direct investment lead to lower CO_2 emissions? Evidence from a regional analysis in China. *Renew. Sustain. Energy Rev.* **2016**, *58*, 943–951. [CrossRef]
98. Kisswani, K.M.; Zaitouni, M. Does FDI affect environmental degradation? Examining pollution haven and pollution halo hypotheses using ARDL modelling. *J. Asian Pac. Econ.* **2021**. [CrossRef]
99. Ostic, D.; Twum, A.K.; Agyemang, A.O.; Boahen, H.A. Assessing the impact of oil and gas trading, foreign direct investment inflows, and economic growth on carbon emission for OPEC member countries. *Environ. Sci. Pollut. Res.* **2022**, *29*, 43089–43101. [CrossRef]
100. Essandoh, O.K.; Islam, M.; Kakinaka, M. Linking international trade and foreign direct investment to CO_2 emissions: Any differences between developed and developing countries? *Sci. Total Environ.* **2020**, *712*, 136437. [CrossRef]
101. Li, J.; Jiang, T.; Ullah, S.; Majeed, M.T. The dynamic linkage between financial inflow and environmental quality: Evidence from China and policy options. *Environ. Sci. Pollut. Res.* **2022**, *29*, 1051–1059. [CrossRef]
102. Dietz, T.; Rosa, E.A. Effects of population and affluence on CO_2 emissions. *Proc. Natl. Acad. Sci. USA* **1997**, *94*, 175–179. [CrossRef] [PubMed]
103. Zhang, J. Environmental Kuznets curve hypothesis on CO_2 emissions: Evidence for China. *J. Risk Financ. Manag.* **2021**, *14*, 93. [CrossRef]
104. Ohlan, R. The impact of population density, energy consumption, economic growth and trade openness on CO_2 emissions in India. *Nat. Hazards* **2015**, *79*, 1409–1428. [CrossRef]
105. Lee, H.S.; Moseykin, Y.N.; Chernikov, S.U. Sustainable relationship between FDI, R&D, and CO_2 emissions in emerging markets: An empirical analysis of BRICS countries. *Russ. J. Econ.* **2021**, *7*, 297–312.
106. Mohsin, M.; Kamran, H.W.; Nawaz, M.A.; Hussain, M.S.; Dahri, A.S. Assessing the impact of transition from nonrenewable to renewable energy consumption on economic growth-environmental nexus from developing Asian economies. *J. Environ. Manag.* **2021**, *284*, 111999. [CrossRef] [PubMed]

107. Muhammad, B.; Khan, M.K. Foreign direct investment inflow, economic growth, energy consumption, globalization, and carbon dioxide emission around the world. *Environ. Sci. Pollut. Res.* **2021**, *28*, 55643–55654. [CrossRef]
108. Naz, S.; Sultan, R.; Zaman, K.; Aldakhil, A.M.; Nassani, A.A.; Abro, M.M.Q. Moderating and mediating role of renewable energy consumption, FDI inflows, and economic growth on carbon dioxide emissions: Evidence from robust least square estimator. *Environ. Sci. Pollut. Res.* **2019**, *26*, 2806–2819. [CrossRef]
109. Polcyn, J.; Us, Y.; Lyulyov, O.; Pimonenko, T.; Kwilinski, A. Factors influencing the renewable energy consumption in selected european countries. *Energies* **2021**, *15*, 108. [CrossRef]
110. Obobisa, E.S.; Chen, H.; Mensah, I.A. The impact of green technological innovation and institutional quality on CO_2 emissions in African countries. *Technol. Forecast. Soc. Chang.* **2022**, *180*, 121670. [CrossRef]
111. Saidi, K.; Mbarek, M.B. Nuclear energy, renewable energy, CO_2 emissions, and economic growth for nine developed countries: Evidence from panel Granger causality tests. *Prog. Nucl. Energy* **2016**, *88*, 364–374. [CrossRef]
112. Raihan, A.; Tuspekova, A. Dynamic impacts of economic growth, energy use, urbanization, tourism, agricultural value-added, and forested area on carbon dioxide emissions in Brazil. *J. Environ. Sci. Stud.* **2022**, *12*, 794–814. [CrossRef]