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Green Innovation and Economic Growth Balancing Development and Environmental Protection

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Abstract
Sustainable economic development plays a crucial role in enhancing social welfare. This emphasizes that economic progress should not be a cost of environmental degradation. Instead, it encourages a kind of development that sustains the environment in the present and well into the future to guarantee the enjoyment of a healthy environment now and in the future. To evaluate this relation, Autoregressive Distributed Lag has been used to capture the impact of various economic and environmental predictors. Surprisingly, the findings dispel the hypothesis of green economic growth in correlation with the Environmental Kuznets Curve which states that environmental deterioration rises with economic development and declines after the framework point. Nevertheless, the results show a good convergence of the study with the EKC hypothesis for non-green or conventional growth models, suggesting that there can be a decrease in breath on the environment as economies transition to higher levels of development, given that sustainable consumption patterns are incorporated. The subsequent analysis also corroborates that stimuli like environmentally friendly technological innovation, the use of renewable energy resources, the use of environmental taxes, or investing in human capital are beneficial towards mitigating negative environmental impacts. All these indicate that when growth embraces ecological factors or fosters innovations in environmental conservation then growth is made more sustainable. While there is a statistical nonsignificance of the impact of domestic policies and institutions on environmental degradation, there is evidence pointing to the domestic policies and institutions as facilitating foreign direct investment and accommodating trade openness. This highlights the importance of monitoring these factors and implementing regulatory frameworks that ensure that economic benefits from FDI and trade do not undermine environmental sustainability. Achieving a balance between economic growth and ecological preservation requires a focused policy approach that supports green innovation and energy transition while managing the ecological impacts of foreign investments and open trade.
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1. INTRODUCTION

The green economy is emerging as a promising framework for achieving the necessary economic reforms that align development with environmental sustainability. It is a concept that allows the world to continue producing and consuming goods and services within the limits of ecological capacity. Given the current global economic climate, the idea of a green economy has garnered significant attention from both national and international stakeholders. The European Commission (2010) and the OECD (2011) have highlighted the importance of this approach, especially as concerns about environmental degradation, pollution, and resource scarcity intensify. For instance, it is estimated that welfare losses due to environmental pollution amount to roughly 6.8% of the world's gross domestic product (Nam et al., 2010; Black et al., 2023), while preventable deaths from air pollution alone are estimated to cost 3.6% of GDP globally (OECD, 2017). Such staggering figures reveal the substantial economic impact of environmental issues, underscoring the need for a model that promotes growth without compromising ecological health. The environmental and economic challenges caused by traditional development models emphasize that a shift toward green growth is not only possible but also imperative. Green growth supports economic progress while protecting the natural resources essential for sustainable development. By integrating environmental considerations into economic planning, the green economy adds a new dimension to conventional growth models. This approach focuses on efficient energy and resource use, reducing carbon emissions, and preserving biodiversity. It redefines development by incorporating social, economic, and environmental factors beyond GDP, which has traditionally been seen as the primary measure of economic progress. As a result, the green economy has introduced new focal points that are critical to the well-being of both people and the planet (Adejumobi, 2019; Lorek & Spangenberg, 2014).

Earlier, the global recognition of the green economy started with the World Commission on Environment and Development which produced the report named the 'Our Common Future' – Brundtland report. Of equal importance for the first time, this report integrated economic activities with environmental pressures at the global level. This was "A Global Agenda for

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Change" which outlined international and national cooperation to support goals of the environment to facilitate sustainable development in the future generation. In recent years, several growth indicators have been developed, reflecting the progress in creating a green economy, and a lot of useful publications regarding green growth have been published globally. Green growth involves the emission of clean low percent technologies that cause minimum impacts on the environment while at the same time promoting the wellbeing of the economy. It is viewed as a tool to solve problems like hurricanes, earthquakes, water shortages, and other environmental problems without compromising the key economic aims. To grasp the linkage between green growth indicators and GDP you need to know much about GDP which is still widely used as a development indicator of a particular country (Desiree, 2019; Adrangi & Kerr, 2012; Audi et al., 2023). The green economy is relatively new in the context of ecological modernization, a concept that dates back to the 1970s as a response to growing environmental concerns. Ecological modernization proposes that economic growth and environmental protection can coexist if development is structured to be more sustainable (Ahmad & Ali, 2019; Jänicke & Jörgens, 2023). Green growth, a core aspect of the green economy, promotes sustainable consumption and production practices by encouraging resource-efficient policies and cleaner technologies (Anees & Yan, 2019; Luo et al., 2024). These approaches create economic value while preserving natural capital, the input of the production function that encompasses resources like clean air, water, and biodiversity. By shifting toward green growth, societies can adopt a more sustainable path, balancing economic goals with environmental priorities.

Currently, environmental risks caused by ecological disruptions and climate change are prompting a global transition, especially in developing and underdeveloped regions where economic challenges are exacerbated by environmental vulnerabilities. This transformation has increased the relevance of frameworks like the OECD's Green Growth Indicators report, which offers valuable insights into green growth pathways that promote development without depleting natural resources (OECD, 2017; Bakht, 2020). National measures of green growth are particularly instrumental in evaluating progress within green growth confines; therefore, measures facilitate tracking of sustainable development progress over time (James, 2020; Clark et al., 2020). Green growth indicators fall into five main categories: including environmental and resource efficiency, natural capital, environmental well-being, economic prospects, and political measures of provision and demand. Together, these indicators provide a comprehensive view of the social, economic, and environmental aspects of sustainability. They serve as benchmarks, helping governments, businesses, and organizations track progress and identify areas for improvement in green economy initiatives. Despite this, achieving green development goals is often challenging due to a lack of legally binding frameworks and effective implementation mechanisms. This gap in enforcement has prevented the full realization of green economy objectives, with issues like poverty and inadequate natural resource management still prevalent (Chen, 2021; Wang & Chen, 2021; Kumar et al., 2024; Audi et al., 2020). An important concept that is being implemented In the green economy Is the cutting of carbon emissions which are a major cause of Climate change. Alternatively, Green technologies are aimed at reducing the negative impacts of industrial and economic activities by supporting a low-carbon economy. Renewable energy sources such as wind, solar, and hydropower are part of the low-carbon transition in which transitioning to renewable energy sources is an important step. Renewable energy is not only friendly to the environment since it cuts down on carbon emissions but also preferably to the economy as it breaks the energy monopoly. Also, more funding for environmentally sustainable novelties like improved public transport, and green buildings among others helps sustain the green economy through creating employment opportunities and spurring the general economic growth all this with little adverse effects on the environment.

In this case, the element of economic green incentives also supports the growth of the green economy. Government charges on pollution, grants for renewable power, and programs to promote eco-friendly business help industries develop superior environmental policies. These economic instruments ensure that every developer is rewarded for cutting his/her losses hence ensuring integral goals of both the economy and the ecology are met. For instance, a carbon tax affects the use of carbon, thus encouraging companies to decrease their consumption, while the provision of grants to renewable energy projects can increase their adoption. They assist in the development of a market for environmentally friendly products and services so the growth of green industries is promoted. It is also important to look at the social implications of the green economy. The concept promotes inclusive growth by considering the well-being of all social groups, especially those most vulnerable to environmental risks. For instance, in areas prone to climate-related disasters, green economy initiatives can improve resilience by implementing sustainable land-use practices and investing in disaster-resistant infrastructure. Moreover, by creating green jobs and supporting small-scale, sustainable enterprises, the green economy can contribute to poverty reduction and enhance social equity. Education and training programs that build green skills are essential in this regard, enabling workers to adapt to the changing demands of a green economy (García Vaquero et al., 2021; Sharma et al., 2021; William, 2021).

One of the most significant challenges in implementing a green economy model is the need for global cooperation. Environmental issues like climate change, air pollution, and biodiversity loss do not recognize national boundaries, requiring coordinated international efforts to address them effectively (Petrakis, 2021; Bibi et al., 2024). Agreements such as the Paris Agreement illustrate the importance of global commitments to reduce greenhouse gas emissions and promote sustainable practices. However, achieving meaningful progress requires more than just international treaties; it demands cooperation at all levels of government, industry, and civil society. Businesses are integral to the success of the green economy, as they are both significant contributors to and potential mitigators of environmental impact. These days, it is not uncommon for firms to introduce sustainable systems mainly to have positive impacts on the environment and, at the same time, increase profitability. Being environment friendly and adopting sustainable business principles like waste minimization, energy conservation, and environmentally sound material procurement helps to contain costs while at the same time improving business visibility. In addition, with the latest tendencies, consumers are more willing to work with those companies who care about the environment and are actively working to minimize the negative impact on the environment which makes sustainability a valuable asset in the market. Another reason for the green economy is innovation. Technological improvement has provided new sources for economic development in clean energy sources, better waste disposal systems, and more sustainable farming. For instance, the emergence of electric vehicles and improvements in batteries could greatly lower the emission of greenhouse gases in the transport sector (Dima, 2022; Fuinhas et al., 2021). Likewise, precision agriculture methods enable farmers to optimize resource usage hence resulting in low water usage and minimal use of toxic chemicals. The public needs to increase research and development expenditures to advance technology and bring sustainable technologies to the masses.

The financial sector also has a role in supporting the green economy. Green finance, which includes investments in environmentally sustainable projects, is crucial for funding the transition to a green economy. Financial instruments like green bonds and sustainability-linked loans provide capital for projects that promote environmental goals, such as renewable energy installations, sustainable agriculture, and conservation efforts. By directing capital toward sustainable projects, green finance can accelerate the adoption of environmentally friendly practices and help build a more resilient economy. Education and public awareness are fundamental to the green economy's success. Educating the public about the importance of sustainable practices can foster a culture of environmental responsibility and encourage individuals to make eco-friendly choices in their daily lives. Schools and universities have a particularly important role in shaping the next generation's understanding of sustainability and preparing them to participate in a green economy (Rustamova, 2023). Public awareness campaigns can also motivate people to support policies and initiatives that promote environmental sustainability, creating a societal shift toward greener practices. The transition to a green economy is not without its obstacles. One of the main challenges is the resistance to change from industries that rely heavily on fossil fuels and other non-renewable resources. These industries may oppose regulations and policies that threaten their business models, creating a barrier to the implementation of green economy initiatives. Furthermore, the initial costs of adopting sustainable practices and technologies can be high, deterring some businesses from making the switch. Governments can address these challenges by providing subsidies, tax breaks, and other incentives to ease the transition and encourage sustainable practices. The green economy represents a transformative approach to economic development that prioritizes environmental sustainability, social inclusion, and economic resilience. By integrating green growth indicators into economic planning, societies can achieve a balance between economic progress and environmental preservation. Although challenges remain, the green economy offers a framework for addressing the environmental, social, and economic issues of our time. It requires the collaboration of governments, businesses, and individuals to realize its full potential, fostering a sustainable future for generations to come. As the green economy continues to evolve, it will play an increasingly vital role in guiding global development toward a more sustainable and equitable path.

2. LITERATURE REVIEW

Environmental quality analysis in developed and developing countries has prompted a host of empirical studies on the effect of a variety of variables such as energy consumption, green growth policies, technology advancement, green taxes, GDP, FDI, and trade openness on environmental status in varying economic structures (Altenburg & Assmann, 2017; Ahmed & Azam, 2016). This area of study highlights the pressing reality that the global ecosystem has reached critical limits due to human activity. Environmental degradation, pollution, and resource depletion have led to a consensus that nations worldwide must pivot toward green growth strategies. Green growth, by definition, emphasizes a development model that allows for economic progress while preserving natural resources, thus providing a sustainable foundation for future growth across both industrialized and developing regions. As ecosystems face mounting pressures from industrialization, urbanization, and resource extraction, green growth has become a vital framework for achieving a sustainable balance between economic expansion and environmental health. However, while green growth's normative significance is widely acknowledged, its adaptability also presents challenges, particularly when attempting to establish a standardized assessment methodology. Each nation operates within a unique environmental, social, and economic context, which requires specific approaches to green growth implementation (Khan et al., 2022). Consequently, green growth policies vary considerably across countries, especially among developed nations where comprehensive policy frameworks have been developed to promote renewable energy adoption and eco-friendly practices (Lorek & Spangenberg, 2014). These differences reflect the diverse pathways nations must take to address environmental sustainability, making it essential for international and non-governmental organizations to provide support that aligns with each country's specific developmental stage and ecological needs.

The 'green economy' notion has steadily emerged as a key focus of sustainable development agendas which aims to bring world production/consumption within the planetary bio-physical affordances (Ali et al., 2022). This economic model focuses on the utilization of scarce resources and minimization of wastes, hence the call for the active conservation of resources without degrading the physical environment in an attempt to improve economic production. However, the idea known by the term sustainable development has its roots in the 1970s, the green economy represents an evolved understanding that economic prosperity can, and must, coexist with environmental stewardship. Within this framework, green growth is viewed as a primary objective, focusing on efficient resource use and encouraging the production of environmentally friendly goods. By embracing eco-efficiency and clean technology, green growth aims to provide a pathway to a low-carbon economy that meets economic goals without degrading environmental quality (Hallegatte et al., 2012; Audi & Ali, 2023). The evolution of green growth is influenced by a range of political and economic factors that shape its effectiveness and trajectory. Governments play a vital role in this process by introducing policies that generate revenue while simultaneously conserving or enhancing natural capital. Such policies allow nations to address pressing ecological challenges in ways that not only foster immediate improvements in environmental quality but also create a sustainable foundation for long-term development. This dual approach aligns economic goals with environmental preservation, encouraging growth that is resilient and ecologically sound.

However, climate change—largely fueled by escalating carbon emissions—remains a significant barrier to green growth, amplifying environmental challenges. The rise in extreme weather events, such as floods, droughts, and heat waves, continues to disrupt ecosystems and economies across the globe. These phenomena have wide-reaching consequences, affecting infrastructure, agriculture, public health, and overall economic stability. For instance, prolonged droughts can severely impact food production, leading to economic strain and exacerbating food insecurity in vulnerable regions. Similarly, frequent flooding and storms place immense stress on infrastructure, incurring high repair costs and diverting resources away from essential public services. As climate impacts intensify, the role of governments in mitigating and adapting to these changes becomes increasingly essential. Effective climate action requires comprehensive policy frameworks that focus on both mitigation—reducing greenhouse gas emissions—and adaptation, which involves building resilience against inevitable climate impacts. Governments worldwide are adopting strategies that range from promoting renewable energy adoption to implementing carbon taxes and cap-and-trade systems that financially incentivize emissions reductions. Additionally, investments in climate-resilient infrastructure, early warning systems for extreme weather, and climate-resilient agricultural practices are critical for minimizing the socio-economic impacts of climate change (Song et al., 2020; Audi & Ali, 2023). In this context, green growth serves as a guiding principle, supporting economic progress that does not come at the expense of environmental health. By integrating sustainability into economic planning, green growth provides a pathway for nations to pursue prosperity while actively confronting the challenges posed by climate change.

One of the most pressing aspects of green growth implementation is reducing carbon emissions. Unlike other pollutants, carbon dioxide remains in the atmosphere long after it is released, posing a significant challenge to environmental sustainability efforts. Although advances in technology have made it possible to control some pollutants—such as removing sulfur dioxide and nitrogen oxides through desulfurization and denitrification processes in thermal power plants—carbon dioxide reduction remains particularly challenging. Its persistence in the atmosphere complicates large-scale efforts, which limits the applicability of frameworks like the Environmental Kuznets Curve (EKC). According to the EKC hypothesis, pollution tends to increase with economic growth during the early stages of industrialization but eventually decreases as economies mature and adopt cleaner practices (Song et al., 2020; Chapin et al., 2010). However, carbon emissions do not align neatly with this framework, as current technologies are not yet capable of fully addressing the long-term buildup of CO2. The relationship between economic growth and environmental degradation is complex, as rapid industrial expansion often leads to increased pollution and resource depletion. Environmental degradation not only threatens biodiversity and ecosystem stability but also diminishes the productive capacity of human capital, as pollution adversely impacts health and limits economic productivity (Azam et al., 2016). Carbon dioxide and methane are primary greenhouse gases that contribute to global warming, intensifying climate change's impact on natural and human systems. Numerous studies have found a correlation between greenhouse gas emissions and economic growth, underscoring the need for industrial policies that balance economic goals with environmental considerations (Adebayo, 2021). Energy production and consumption are critical to economic development but also significantly contribute to environmental degradation. Fossil fuels, which remain the predominant energy source worldwide, produce extensive pollution and drive climate change. The environmental impacts of fossil fuel-based energy production are far-reaching, leading to increased greenhouse gas emissions, air pollution, water contamination, and biodiversity loss. In response, renewable energy has gained attention as a sustainable alternative that supports economic and environmental objectives. Renewable energy sources—such as solar, wind, biofuels, and hydropower—offer cleaner options that reduce carbon emissions and mitigate the adverse effects of traditional energy sources (Ahmed & Azam, 2016; Khan et al., 2022).

Adopting renewable energy offers several advantages that extend beyond environmental benefits. Renewable energy contributes to social and economic development by creating jobs, enhancing energy security, and improving public health. By diversifying the energy mix and reducing dependence on fossil fuels, renewable energy not only reduces air pollution but also supports economic stability and community well-being. For instance, the renewable energy sector has generated employment opportunities in areas such as solar panel installation, wind turbine manufacturing, and biofuel production, contributing to sustainable economic growth (Huan & Hong, 2020). For countries seeking green growth, renewable energy provides a comprehensive strategy that aligns with economic, social, and environmental goals. As environmental challenges intensify, renewable energy has become a vital element of sustainable development efforts. Transitioning from fossil fuels to cleaner energy sources—such as wind, solar, and hydropower—significantly lowers the ecological impact of energy production. This shift plays a crucial role in global initiatives to mitigate climate change by reducing greenhouse gas emissions, allowing countries to fulfill their energy demands while safeguarding the environment. As renewable energy production technology continues to advance, these resources have become more accessible and cost-effective, enabling nations to integrate green energy into their development agendas more seamlessly (Khan et al., 2022; Ashiq et al., 2023).

The widespread adoption of renewable energy is driven by a combination of environmental necessity and technological progress. Innovations in solar panel efficiency, wind turbine design, and hydropower systems have transformed renewable energy from a costly alternative to a feasible solution capable of meeting substantial portions of global energy demand. These advancements make it easier for countries to transition to renewable energy without sacrificing economic growth. Moreover, the scalability of renewables allows for both large and small applications, from urban power grids to rural electrification projects, thus addressing energy needs across diverse geographies and socio-economic contexts. By minimizing reliance on carbon-intensive fuels, renewable energy not only helps reduce emissions but also fosters energy security and resilience. Countries that develop robust renewable energy infrastructure are less susceptible to global fossil fuel market fluctuations, which can impact energy prices and availability. In this way, renewable energy supports both environmental and economic stability, positioning itself as an indispensable component of a sustainable development strategy that benefits present and future generations. Environmental challenges like population growth and deforestation compound the urgency for sustainable energy solutions. Population increases place additional demands on energy and natural resources, particularly in agricultural and industrial sectors, which in turn drive emissions of greenhouse gases like CO2, nitrous oxide, and methane. Fossil fuels have historically met this energy demand, accounting for approximately 82% of global energy in 2015. However, renewable energy offers a viable alternative that addresses both energy security and environmental sustainability (Ali & Audi, 2016; Ali et al., 2021; Sohag et al., 2021; Audi et al., 2024). Researchers have noted that replacing fossil fuels with cleaner energy sources can mitigate the environmental impact of economic growth, making it possible to achieve economic expansion without compromising environmental quality. The various studies reviewed here collectively emphasize the complex interplay between energy consumption, economic growth, trade openness, and environmental quality. Research by Kartal (2023), Paramati et al. (2022) underscores the importance of renewable energy and environmental technology as critical components in reducing emissions and promoting green growth. However, studies by Abbasi et al. (2021) and Khan et al. (2020) highlight that economic and industrial growth, while beneficial for development, are positively linked to CO_2 emissions, suggesting the need for balanced regulatory approaches. Furthermore, research on globalization, as presented by Yang et al. (2021) and Khan et al. (2021), illustrates that although economic integration can contribute to environmental degradation, sustainable practices, including renewable energy consumption and green growth initiatives, can offset this impact. The literature reflects a consensus on the positive impact of renewable energy and green growth practices on environmental quality, though economic and industrial growth present challenges to sustainability. Continued research in green technology, efficient energy use, and policy frameworks is essential for shaping a sustainable future.

3. THE MODEL

The relationship between green growth and energy utilization and the effects of environmental quality is another literature gap of significant importance especially focusing on sustainable development. Green growth as an approach entails the achievement of increased economic development while at the same time preserving environmental quality. Energy proves to be one of the important facets, as the utilization of renewable and efficient energy forms can catalyze reducing environmental impacts. The combination of these factors directly determines environmental quality through reduced energy consumption that emits lower carbon and better air and water qualities (OECD, 2011; Ahmad et al., 2022; IPCC, 2021). It is also important to maintain those long-term sustainability goals that are prevalent worldwide. The model of our study becomes as:

$CO_{2it} = \alpha_0 + \alpha_1 GG_{it} + \alpha_2 GG^2_{it} + \alpha_3 EFTI_{it} + \alpha_4 REC_{it} + \alpha_5 ET_{it} + \alpha_6 HC_{it} + \alpha_7 FDI_{it} + \alpha_8 TO_{it} + \mu_{it}$ (1)

$CO_{2it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP^2_{it} + \beta_3 EFTI_{it} + \beta_4 REC_{it} + \beta_5 ET_{it} + \beta_6 HC_{it} + \beta_7 FDI_{it} + \beta_8 TO_{it} + \mu_{it}$ (2)

We have used the panel ARDL technique to estimate the results for the period from 1991 to 2023.
GG = Multifactor environmental adjusted productivity increase (in percent).
GDP = Gross Domestic Product as a percentage of the 1990 level that specific year.
CO2 = Carbon dioxide emission in terms of metric tonnes of CO2
EF = Environment-Friendly Technological Innovation as a percentage of all the technologies.
RE = Renewable Energy Consumption, defined as Ren Energy ConSUmp as a percentage of Total Final Energy Consumption.
ET = Environmental Related Tax (In USD)
HC = Human Capital / Human Capital Wealth which is done by Years of Schooling and Returns to Education.
Investment = FDI, Net Inflows of which was (% of GDP).
TR = Trade Openness (As % of GDP).
The data of selected variables have been taken from the World Bank from 1992 to 2023.

4. RESULTS AND DISCUSSIONS

The table presents descriptive statistics for various environmental and economic indicators, illustrating significant variability across countries in areas such as CO_2 emissions, GDP growth, environmental productivity, and factors contributing to environmental sustainability. CO_2 emissions, measured in metric tons, have a mean of 8.23 and a median of 7.69, indicating that countries produce, on average, around 8.23 metric tons of CO_2. The range from 0.96 to 30.44 metric tons highlights a wide variation in emissions, with the skewness (1.25) and kurtosis (5.42) suggesting a distribution with a few countries showing exceptionally high emissions that raise the mean. This positive skewness points to the existence of extreme outliers in emissions levels, indicating a concentration of higher emissions in certain nations. GDP growth, measured in percentage terms, has a mean of 2.78% and a median close to that at 2.74%, suggesting relatively steady economic growth for most countries. However, the disparity in growth rates is substantial, as evidenced by the range from -14.8% to 37.37%. A high skewness (1.00) and kurtosis (15.06) illustrate that while most countries have moderate GDP growth, there are extreme cases of both rapid growth and economic contraction, resulting in a distribution that is heavily influenced by outliers. The environmental-adjusted multifactor productivity growth (GG), with a mean of 2.52% and median of 2.65%, shows a similar trend. Although the average values are modest, the range from -12.9% to 32.74% and a standard deviation of 3.77 indicate substantial variation in green growth performance across countries. A skewness of 0.72 and high kurtosis (11.54) suggest a distribution where a few countries experience significantly high green growth, marking notable outliers in productivity growth through environmentally friendly practices.

Environment-friendly technological innovation (EF) has a mean of 7031.59, with a median value significantly lower at 832.19. This disparity, along with a large standard deviation of 17,444.34, reflects extreme differences in investments in green technology across countries. The high skewness (3.37) and kurtosis (13.41) reveal that while a few countries invest heavily in green technologies, many others remain well below the average, indicating concentrated outliers among nations that prioritize innovation in environmentally friendly technology. Renewable energy consumption (RE) averages 18.33% of total energy use, with a median of 13.25%, which suggests that renewable energy contributes a moderate share to the energy mix in many countries. The range spans from a minimum of 0.44% to a maximum of 78.49%, indicating substantial differences in renewable energy usage. Positive skewness (1.35) implies that while most countries have moderate renewable energy shares, a few countries have exceptionally high levels, as confirmed by the kurtosis value (4.78) that points to some extreme cases. Environmental-related tax (ET) shows a mean value of 2.32 USD, with a median of 2.38 USD and a range from -1.53 USD to 5.36 USD. The relatively low average suggests that environmental taxes are not particularly high across most countries, and some countries even have negligible or negative values, possibly reflecting subsidies for activities that impact the environment. The neutral skewness (0.00) implies a symmetric distribution, while the kurtosis of 3.91 indicates a slight tendency for values to cluster around the mean, with a few moderate outliers.

Table 1: Descriptive Statistics

	CO_2	GDP	GG	EF	RE	ET	HC	FDI	TR
Mean	8.23	2.78	2.52	7031.59	18.33	2.32	3.14	4.30	86.07
Median	7.69	2.74	2.65	832.19	13.25	2.38	3.22	2.41	71.10
Maximum	30.44	37.37	32.74	86577.07	78.49	5.36	3.93	108.42	380.10
Minimum	0.96	-14.8	-12.9	10.08	0.44	-1.53	1.81	-57.53	15.81
Std. Dev.	4.42	3.86	3.77	17444.34	15.71	0.90	0.43	9.75	50.65
Skewness	1.25	1.00	0.72	3.37	1.35	0.00	-0.78	3.96	2.10
Kurtosis	5.42	15.06	11.54	13.41	4.78	3.91	3.13	35.94	9.74

Human capital (HC), calculated based on years of schooling and returns to education, has a mean of 3.14 and a median of 3.22, suggesting relatively high levels of education on average. The distribution is slightly negatively skewed (-0.78), showing that a few countries have lower levels of human capital. A kurtosis of 3.13 indicates that the distribution is close to normal, with limited extreme values, suggesting that most countries have similar levels of human capital. Foreign direct investment (FDI) as a percentage of GDP shows a mean of 4.30% and a median of 2.41%, with a wide range from -57.53% to 108.42%. This broad range demonstrates high variability in FDI levels across countries. Positive skewness (3.96) and high kurtosis (35.94) indicate that while a few countries receive exceptionally high FDI inflows, the majority have more moderate levels. This suggests that FDI is a substantial source of capital inflow for a select group of economies. Trade openness (TR), with a mean of 86.07% of GDP and a median of 71.10%, varies widely across countries, as indicated by the range from 15.81% to 380.10%. High skewness (2.10) and kurtosis (9.74) point to a distribution with a few highly trade-dependent countries where trade represents a significant share of GDP, while most countries fall within a more moderate range. This variability implies that trade policies and openness levels differ markedly depending on each country's economic strategy. In summary, the table illustrates substantial disparities in economic and environmental metrics across countries, with skewness and kurtosis values indicating a prevalence of outliers in variables like environment-friendly technology, foreign direct investment, and trade openness. This suggests that while some nations have advanced significantly in areas like green growth and technology, others have yet to reach similar progress. The data reveal that while countries generally aim for economic growth, their paths toward sustainability are highly varied, reflecting differences in policy priorities, resource availability, and levels of development.

The correlation matrix in Table 2 presents the relationships between key variables related to CO_2 emissions, economic growth, environmental quality, and sustainability factors over the period from 1991 to 2020. The significance levels indicate whether these relationships are statistically meaningful, with * denoting a 10% significance level, ** a 5% significance level, and *** a 1% significance level. CO_2 emissions are correlated with several variables. The correlation between CO_2 and GDP is positive (0.02) and significant at the 1% level, suggesting a slight but statistically significant relationship between economic growth and emissions. Similarly, CO_2 emissions are positively correlated with green growth (GG) (0.09) and environment-friendly technological innovation (EF) (0.31), both significant at the 1% level. The positive correlation with EF indicates that increased technological innovation can coincide with higher emissions, possibly because innovation alone is insufficient to offset the emissions generated by economic activities. Renewable energy consumption (RE) is negatively correlated with CO_2 emissions (-0.37) and is significant at the 10% level, highlighting that higher renewable energy usage is associated with lower emissions. This supports the understanding that renewable energy helps reduce environmental impact. RE also has a negative correlation with GDP (0.00) and GG (-0.01), both significant at the 1% level, suggesting that while renewable energy reduces emissions, it may have a complex relationship with economic indicators, potentially due to transitional costs or reliance on non-renewable resources for growth.

Table 2: Correlation Matrix of Key Variables (1991-2020

Variables	CO_2	GDP	GG	EF	RE	ET	HC	FDI	TR
CO_2	1.00								
GDP	0.02***	1.00							
GG	0.09***	0.63***	1.00						
EF	0.31***	-0.11***	-0.08**	1.00					
RE	-0.37*	0.00***	-0.01**	-0.27***	1.00				
ET	0.05**	-0.07***	-0.10*	-0.27***	-0.04*	1.00			
HC	0.10***	-0.04	-0.03**	-0.06***	-0.08*	0.04***	1.00		
FDI	0.10***	0.07***	0.06*	-0.11***	-0.09**	0.04***	0.10***	1.00	
TR	0.24*	0.10***	0.04*	-0.32***	-0.08***	0.20***	0.11***	0.35***	1.00

*, **, ***, 10%, 5%, and 1% level of significance.

Environmental-related tax (ET) shows a weak positive correlation with CO_2 emissions (0.05) at the 5% significance level, indicating that environmental taxes may not be sufficient alone to curb emissions. ET is also negatively correlated with EF (-0.27) and RE (-0.04), significant at the 1% and 10% levels, respectively, suggesting that environmental taxes may not always correlate with higher levels of environmental technology and renewable energy adoption. Human capital (HC) has a small positive correlation with CO_2 emissions (0.10) and a slightly negative correlation with EF (-0.06), both significant. This implies that although educational advancements may be occurring, they do not necessarily reduce emissions or foster environmental innovation. HC also has weak negative correlations with RE (-0.08) and GG (-0.03), suggesting a need to integrate environmental consciousness into human capital development. Foreign direct investment (FDI) exhibits a positive correlation with CO_2 emissions (0.10), GDP (0.07), and GG (0.06), all significant, indicating that higher investment inflows may accompany economic growth and increased emissions. FDI has a small but significant negative correlation with EF (-0.11) and RE (-0.09), suggesting that while investment can stimulate growth, it may not always support environment-friendly technological innovation or renewable energy use.

Trade openness (TR) shows positive correlations with CO_2 (0.24), GDP (0.10), and FDI (0.35), all statistically significant, suggesting that more open trade policies are associated with increased emissions, economic growth, and investment flows. However, TR's negative correlations with EF (-0.32) and RE (-0.08) imply that trade openness does not necessarily foster environment-friendly innovation or renewable energy consumption. The matrix indicates complex interactions between economic growth, environmental sustainability, and investment factors. Higher renewable energy consumption and environmental-friendly technology correlate with lower emissions, while GDP growth, FDI, and trade openness generally correspond with higher CO_2 emissions. This suggests that while economic growth and openness are key for development, strategic policies focusing on renewable energy and environmental innovation are essential for reducing environmental impacts.

Table 3: Panel Unit Root Tests

Variables	LLC Test	IPS Test	ADF-Fisher Chi-Square	PP-Fisher Chi-Square
CO2	6.36932***	8.00491***	43.8185***	46.3910***
GDP	-7.79650***	-12.0707***	295.960***	299.943***
GG	-9.77300***	-11.7803***	306.943***	332.551***
EF	-0.83561*	3.54235***	77.6779*	48.7470***
RE	-3.45954***	-1.36910**	120.614***	128.226***
ET	-0.80786*	-0.56221*	102.715**	102.621**
HC	0.38525**	5.18050***	197.451***	248.193***
FDI	-11.6398***	-12.5212***	307.974***	295.769***
TR	-4.26873***	-0.17767*	80.8464*	100.747**

*, **, ***, 10%, 5%, and 1% level of significance.

The panel unit root tests in Table 3 provide insights into the stationarity of the variables across several tests: the Levin-Lin-Chu (LLC) test, Im-Pesaran-Shin (IPS) test, Augmented Dickey-Fuller (ADF-Fisher Chi-Square), and Phillips-Perron (PP-

Fisher Chi-Square). These tests help determine if the data series are stationary, as non-stationary data can produce unreliable econometric outcomes. CO_2 emissions (CO_2) display significant results across all tests at the 1% level, indicating stationarity. In both the LLC and IPS tests, with values of 6.36932 and 8.00491 respectively, and high chi-square values in the ADF (43.8185) and PP (46.3910) tests, it is confirmed that CO_2 data are stable and suitable for further analysis without differencing. GDP growth (GDP) is also stationary across all tests at the 1% significance level, with an LLC test value of -7.79650 and an IPS test value of -12.0707. The high ADF-Fisher (295.960) and PP-Fisher (299.943) chi-square values indicate consistent long-term trends, suggesting GDP data are stable over time and reliable for longitudinal analysis. Green growth (GG) shows stationarity across all tests, with significance at the 1% level, supported by an LLC test value of -9.77300 and an IPS test value of -11.7803, along with very high ADF (306.943) and PP (332.551) chi-square values. This indicates that green growth data remain consistent, making it suitable for use in further econometric models. Environment-friendly technological innovation (EF) shows mixed results, with significance at the 10% level in the LLC (-0.83561) and ADF-Fisher (77.6779) tests, and at the 1% level in the IPS (3.54235) and PP-Fisher (48.7470) tests. While EF data is largely stationary, the varied significance levels suggest a need for careful handling, as certain tests may indicate a degree of instability. Renewable energy consumption (RE) is stationary across all tests, with significance at the 1% level in the LLC (-3.45954) and PP-Fisher (128.226) tests, and at the 5% level in the IPS (-1.36910) and ADF-Fisher (120.614) tests. This supports the consistency of renewable energy data, suggesting it is reliable for further analysis in econometric applications.

Environmental-related tax (ET) also shows mixed stationarity results, with significance at the 10% level in the LLC (-0.80786) and IPS (-0.56221) tests, and at the 5% level in the ADF-Fisher (102.715) and PP-Fisher (102.621) tests. Although the ET variable is generally stationary, the varying significance levels across tests indicate that it may require transformation or further validation in specific models. Human capital (HC) demonstrates mixed stationarity as well, with a 5% significance level in the LLC (0.38525) and 1% in the IPS (5.18050), ADF-Fisher (197.451), and PP-Fisher (248.193) tests. These results imply that HC is largely stationary but may need further testing depending on the specific requirements of the analysis. Foreign direct investment (FDI) is consistently stationary, with significance at the 1% level across all tests, supported by an LLC test value of -11.6398 and an IPS test value of -12.5212, along with high chi-square values in the ADF-Fisher (307.974) and PP-Fisher (295.769) tests. This consistent stationarity indicates that FDI data are reliable for econometric analysis. Trade openness (TR) shows mixed stationarity, with significance at the 10% level in the LLC (-4.26873) and PP-Fisher (100.747) tests, and at the 1% level in the ADF-Fisher (80.8464). This mixed stationarity suggests that while trade openness data are mostly stable, further verification may be necessary in certain analytical contexts. The panel unit root tests reveal that most variables are stationary across tests, with CO_2, GDP, GG, RE, and FDI consistently showing stationarity. Some variables, such as EF, ET, HC, and TR, display mixed results, indicating that while they are generally stable, certain models may require additional testing or transformation to ensure robustness in econometric analysis.

Table 4: Long Run ARDL Results

Dependent Variable: Co2			
Variable	Coefficient	Variable	Coefficient
GG	-0.100030***	GG	0.444933***
GG^2	-0.005492***	GG^2	-0.025041***
EF	-0.000139***	EF	-0.000151***
RE	-0.214115***	RE	-0.169464***
ET	-0.016751**	ET	-0.717735***
HC	-0.531100*	HC	-1.064844***
FDI	0.029002*	FDI	0.085660***
TR	0.041485***	TR	0.023969***

*, **, ***, 10%, 5%, and 1% level of significance.

The long-run ARDL results for environmental quality are as follows in Table 4 where this study has focused on how green and non-green growth has affected CO_2 emissions. The coefficient of both green and non-green growth are found to be positive and statistically significant, meaning that, as common with growth, the green and non-green growth enhances the CO_2 emissions. This finding corroborates an analysis that is often made about the countries of the world, namely for the Environmental Kuznets Curve (EKC). Firstly, we examine the nexus between green GDP and environmental degradation evidenced by a negative association, whereas green GDP rises, degradation shrinks; secondly, we test the relationship between economic development and CO_2 emissions, whereby as the degree of decoupling from green GDP increases, emissions are falling. This trend implies that green GDP—by factoring in environmental impacts—effectively supports environmental sustainability, thus offering an alternative growth pathway that is more compatible with environmental objectives. Conversely, conventional GDP growth initially leads to a rise in CO_2 emissions, which subsequently declines once higher levels of GDP growth are achieved. This validates the EKC hypothesis in a traditional context, where economic development first leads to environmental degradation before improvements in environmental quality occur at more advanced economic stages. This pattern suggests that while conventional growth models may eventually achieve some environmental benefits, the initial stages of growth tend to have a high environmental cost.

Technological innovation for environmentally friendly technological innovation has a negative and significant mean on a green environment under both green and nongreen growth but the impacts are more pronounced under non-green growth contexts. Technology plays a critical role in the renewable energy sector, as advancements lead to more efficient power production and reduced manufacturing costs, ultimately contributing to lower carbon emissions and improved environmental outcomes. In this context, technological innovation refers to advancements in production processes, the development of new patents and ideas, and modifications in manufacturing methods. Cheng et al. (2021) argue that technological innovation is central to addressing environmental challenges and fostering sustainable development by reducing negative externalities, particularly carbon intensity. Energy intensity negates part of the advantages that come with implementing technology. The so-called ‘hybrid technologies’ that promise higher energy efficiency and lesser input of fossil energy have been considered to offer considerable eco benefits by lowering the carbon footprint of material-making processes. The coefficients of renewable energy consumption are statistically significantly negative of CO_2 emissions in both green and non-green growth models, thereby inferring that the utilization of renewable energy causes a reduction in CO_2 emissions. This concurs with the research that has shown that with increasing use of renewable energy, CO_2 emissions decrease, making renewable energy play a part in reducing environmental degradation associated with economic development. This research established that the world’s ever-growing economic development and exclusive reliance on non-renewable energy sources as the leading causes of environmental permissible especially through the burning of fossil fuels that emit CO_2. Khan et al. (2021) emphasize that energy use in industrial and agricultural production processes contributes significantly to emissions of CO_2, nitrous oxide, and methane. To counter these effects, renewable energy sources offer a viable alternative, reducing dependency on fossil fuels and mitigating environmental harm.

Implementing effective regulatory frameworks that restrict environmentally harmful practices in the energy and manufacturing sectors can significantly advance sustainable growth. This demonstrates the potential for energy efficiency policies and technological innovations to drive meaningful environmental improvements across various sectors. Table 4’s findings underscore the complex relationship between economic growth, technological innovation, and environmental quality. While both green and conventional growth contributes to initial increases in CO_2 emissions, the inclusion of environmental factors in green GDP offers a pathway to sustainability that is less carbon-intensive. Technological innovation, particularly within renewable energy, appears to be a powerful tool for mitigating environmental impacts, as it not only enhances energy efficiency but also fosters the development of cleaner production methods. The findings affirm the importance of integrating environmentally friendly practices into economic growth models, supporting the EKC hypothesis in both green and non-green contexts, while emphasizing the transformative role of renewable energy and technological progress in achieving sustainable development.

The result on environmental-related taxes reveals that the coefficient estimate is negative and significant for the green growth and non-green growth models. Besides the reformed regulations, environmental taxes are very important for energy efficiency and sustainability. These taxes reward subsidies of renewable products, increase investment in the development of advanced innovative technologies, and support technological research and development while also helping industries implement measures that are friendly to the environment. Statistics and research data show that emissions of pollutants and greenhouse gases have negative impacts on health, wealth, and nature. Therefore, it becomes more significant to come up with policies that would foster green energy technologies. The role of environmental rules and levies in influencing the structures of energy, as well as energy economics, has gained topicality, especially with the developed economies.

Human capital likewise reveals negative signs with CO_2 emissions in both green and non-green growth analysis. A possibility exists to enhance the dissemination of environmentally friendly technologies through human capital investment especially through education and skills development. It is found that knowledge – or education – does create awareness of sustainability implications, thus promoting green technologies and actions. Population sensitisation therefore rises as a strategy for mitigating CO_2 discharge since people with knowledge act in sustainable ways. The observed outcome indicates that improving human capital can support endeavors to combat emissions by promoting an environmentally sustainable population. Currently, FDI has a positive and highly significant effect indicating that the environment is deteriorating with the increase in FDI both in the green and non-green growth phase. This finding accords with the Pollution Haven Hypothesis that nations with less stringent emission standards lure polluting industries. Such countries may be turned into “pollution havens” since the industries there will be free from effective environmental regulation policies. This may mean that ‘dirty technologies’ are transferred from one developed country to another, and hence worsen the environment of the host country. Trade openness also emerges positively and significantly affecting CO_2 emissions, thus supporting the hypothesis that; increased trade openness increases environmental degradation. The Pollution Haven Hypothesis recommends that countries with relatively liberal trade policies are more prone to higher emissions because they will become popular with industries that pollute at high rates. They give rise to even more CO_2 emissions because industries move where the anti-pollution standards are lower.

Table 5 provides the short-run ARDL results with CO_2 emissions as the dependent variable. The table displays the coefficients and significance levels of various variables impacting CO_2 emissions, with each variable indicating the immediate effect within the short run. The error correction terminates both models and signifies the adjustment speed to long-run equilibrium following a short-run shock. The variable $d(CO_2(-1))$ represents the lagged CO_2 emissions, indicating a persistence in CO_2 levels over time. In the first model, the coefficient for $d(CO_2(-1))$ is 0.008136, which is positive and significant at the 10%

level, showing that previous CO_2 levels have a slight, yet notable, impact on current CO_2 emissions. In the second model, the coefficient for d(CO_2(-1)) is -0.094016 and is also significant, suggesting a weak inverse relationship where higher past emissions may reduce current emissions in the short run. This could be due to temporary corrective environmental policies or seasonal adjustments in production cycles that impact emissions patterns. Green Growth d(GG) has a negative coefficient in both models, with values of -0.03838 and -0.006656, both highly significant at the 1% level. This negative relationship suggests that green growth initiatives help reduce CO_2 emissions in the short run. The squared term of green growth, d(GG2), also has a negative and highly significant coefficient, which may indicate a diminishing marginal impact of green growth on emissions reduction. As green growth intensifies, the rate of reduction in CO_2 emissions becomes less pronounced, showing that while initial green growth efforts are effective in curbing emissions, their impact may decrease over time.

Table 5: Short-Run ARDL Results

Dependent Variable: Co2			
Variable	Coefficient	Variable	Coefficient
d(CO_2(-1))	0.008136*	D(CO2(-1))	-0.094016*
d(GG)	-0.03838***	D(GDP)	0.013327
d(GG^2)	-0.006656***	D(GDP^2)	-0.001792
d(EF)	0.000809*	D(EF)	0.001872
d(RE)	-0.198826***	D(RE)	-0.196769***
d(ET)	0.157299*	D(ET)	0.169901
d(HC)	-4.271506*	D(HC)	-5.706581***
d(FDI)	0.002313*	D(FDI)	-0.003051
d(TR)	0.001688*	D(TR)	0.004381
C	1.957915*	C	1.102705***
ECT	-0.153075***	ECT	-0.095861***

*, **, ***, 10%, 5%, and 1% level of significance.

For GDP growth d(GDP) and its squared term d(GDP2), the results indicate mixed effects. d(GDP) has a positive but insignificant coefficient of 0.013327, suggesting that GDP growth alone does not have a strong short-term impact on emissions. The negative coefficient of d(GDP2), -0.001792, implies a slight deceleration in emissions growth as GDP continues to rise, hinting at the Environmental Kuznets Curve (EKC) effect where higher GDP growth may eventually reduce emissions once a certain economic level is achieved. However, the insignificance of both coefficients suggests that GDP alone may not be a reliable indicator for predicting short-run emissions changes. Environment-Friendly Technological Innovation d(EF) displays positive coefficients in both models (0.000809 and 0.001872), significant at the 10% level in the first model but not significant in the second model. This suggests that, in the short term, environment-friendly technological innovation may not immediately reduce CO_2 emissions. The positive coefficients could indicate that early-stage investments in green technology can sometimes lead to temporary emissions increases due to high energy and resource use during the implementation and adjustment phases. However, if these technologies are well developed, there are chances that the environmental impacts of the technologies are also realized and shown in the long run. Development of Renewable Energy Consumption d(RE) again presents negative and significant signs for both models, with coefficients of -0.198826 and -0.196769, and the significance level of 1%. This means that, for the most part, incremental amounts of renewable power make significant positive impacts in diminishing the emission of CO_2 in the immediate future, and thus, renewable power's benefits in improving environmental quality in the short term are not doubtful. These observations are consistent with the general knowledge that renewable energy diminishes the utilization of fossil fuels, thereby decreasing emissions.

The coefficient for Environmental-Related Tax d(ET) is positive in both models, with values of 0.157299 and 0.169901, significant at the 10% level in the first model but insignificant in the second model. The positive sign suggests that in the short term, environmental taxes may not immediately reduce CO_2 emissions and could even be associated with higher emissions. This could be due to the short-term adjustments required for businesses to adapt to new tax regulations, possibly resulting in temporary increases in emissions as companies make the necessary transitions. Human capital d(HC) has a strong significant negative impact in both models negatively affecting CO2 emissions with the coefficients -4252.05 and -5707.34 hence 10% level of significance in the first model and 1% level in the second model. These results imply that such human capital reforms as education, skill development, or enhancement of human capital, in general, can directly target co_2 emissions in the short run. The negative coefficients demonstrate that costly and educated employees are more willing to follow and implement techniques that are friendly to the environment, which will reduce emissions. However, in the short run, the result of the impact of Foreign Direct Investment on CO_2 emissions is inconclusive. In the first model, the coefficient is positive (0.002313,), meaning that FDI may cause emissions to rise but this was significant only at the 10% level. In the second model, the coefficient is negative (-0.003051) and insignificant. This variability suggests that FDI's impact on emissions may depend on the type of investments or industry focus, with some sectors potentially increasing emissions while others contribute to emissions reduction. It also reflects the potential lag in observing the full environmental impact of foreign investments. Trade Openness d(TR) has positive coefficients in both models (0.001688 and 0.004381), significant at the 10% level in the first model but insignificant in the second. The positive values suggest that increased trade openness could contribute to higher CO_2 emissions in the short term. This result may align with the Pollution Haven Hypothesis, where countries with open trade policies experience higher emissions due to the import or production of emissions-intensive goods. The constant term C is positive and significant in both models, with values of 1.957915 and 1.102705, indicating that baseline emissions levels remain positive in the absence of other influencing variables. This suggests an inherent level of emissions within the economy, reflecting ongoing activities that contribute to CO_2 emissions. The Error Correction Term (ECT) is negative and significant at the 1% level in both models, with coefficients of -0.153075 and -0.095861. These values indicate the speed of adjustment back to long-run equilibrium after a short-run deviation, with about 15.3% and 9.6% of the disequilibrium corrected in each period, respectively. The significance and negative sign confirm the stability of the model, indicating that any short-term deviations in CO_2 emissions are corrected over time, bringing the system back to long-run equilibrium. Table 5 reveals that renewable energy consumption, human capital, and green growth initiatives are effective in reducing CO_2 emissions in the short run. Environmental taxes and trade openness, however, may not immediately reduce emissions and could even lead to temporary increases due to the transitional effects on businesses and trade activities. While technological innovation in the short term may not show immediate emissions reductions, it holds potential for longer-term impacts as the technology matures and becomes more efficient. The results underscore the importance of renewable energy, human capital investment, and green growth strategies as effective tools for achieving immediate reductions in CO_2 emissions while highlighting the need for balanced policy approaches to manage the short-term impacts of economic activities, environmental taxes, and trade.

5. CONCLUSIONS

The current work aimed to investigate the connection between green growth, environmental quality, and energy consumption for the panel data covering OECD countries during 1992-2023 in light of the ARDL method. These results yield the desired sign for green growth along with the quadratic terms for green growth suggesting that green growth endeavors help in decreasing environmental degradation. On the other hand, the findings show that non-green growth and its square have a negative and significant coefficient as expected from the EKC hypothesis meaning that environmental degradation first increases with the scale of non-green growth and then decreases as the scale reaches a certain level. This pattern appears to show that when non-green economic activities first expand, environmental pollution similarly increases, but the subsequent development contributes towards environmental regeneration. Besides FDI and trade, which are positively related to environmental pollution control, other factors are also related negatively. Concerning this, governments can employ carbon taxes or the cap-and-trade technology to internalize external costs of carbon emissions meaning that business organizations should reduce their CO_2 emissions. Investing in the construction of power plants from renewable sources such as solar, wind, and water can be a solution to the prompt use of fossil fuels. Policymakers could also support research and development in green technologies, like carbon capture, sustainable transportation, and eco-friendly agriculture, through incentives, grants, and other funding avenues. Investing in environmental education and training programs related to sustainability and clean energy technology would further enhance human capital aligned with environmental goals. By building expertise in environmental science and sustainable practices, these programs equip a skilled workforce to tackle modern environmental challenges. Additionally, enforcing strict environmental regulations on industries for emissions and waste management is essential to maintaining accountability and ensuring adherence to sustainability standards. Governments could encourage the involvement of other countries by investing in renewable energy and efficient green infrastructure through the provision of incentives and reduced taxes for green projects and technologies. Those dealing with objectives of sustainable development should try to envisage a path of economic growth that is not detrimental to environmental wellbeing. Last, the efforts within the R & D programs aimed at increasing environmental performance or environmental efficiency of the green economy in various sectors can be very useful strategies for making an efficient, low-impact economy. Innovations inspired by such initiatives increase resource productivity, and decrease emissions – something that creates a different, more environmentally friendly model of growth for the countries of the OECD.

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