

Article

Green Energy, Institutional Quality and Environmental Quality in the Context of Sustainable Development

Thu Thuy Nguyen ¹, Thuy Hang Pham Thi ², Van Hung Vu ³, Thu Huong Nguyen ⁴ and Van Chien Nguyen ^{5,*}

¹ Faculty of Mathematical Economics, Thuongmai University, Hanoi 100000, Vietnam; nguyenthuthuy@tmu.edu.vn

² College of Economics, Vinh University, Vinh City 43000, Vietnam; hangptt@vinhuni.edu.vn

³ Department of Testing and Education Quality Assurance, Thuongmai University, Hanoi 100000, Vietnam; hungvvu@tmu.edu.vn

⁴ Faculty of Political Economy, University of Economics and Business, Vietnam National University, Hanoi 100000, Vietnam; nguyenthuhuong.ueb@vnu.edu.vn

⁵ School of Economics and Finance, Thu Dau Mot University, Ho Chi Minh City 70000, Vietnam

* Correspondence: chiennv@tdmu.edu.vn

Abstract

Environmental pollution is becoming an urgent global issue. Countries are implementing various solutions and establishing legal frameworks and institutional policies to promote the use of green energy sources and thereby minimize the adverse environmental impact of economic growth, investment, and consumption. The goal of economies worldwide, including in Asia, is to implement policies that promote sustainable development while optimizing economic performance. The purpose of this study is to evaluate the impact of green energy consumption and institutional quality on environmental quality. Using data from 29 selected Asian countries over the period 1970–2021, the empirical results indicate that green energy consumption does not have a statistically significant impact on environmental quality across the full sample. Improvements in institutional quality can enhance environmental quality and accelerate progress toward carbon neutrality and net-zero emissions targets. The Climate Change Conferences (COPs) have helped raise global awareness of the dangers of climate change, fostering greater international cooperation to protect the planet and promote sustainable development. To capture the influence of international climate commitments, this study employs a dummy variable for the COP period (coded 0 before COP2 in 1996 and 1 thereafter). This variable is interacted with green energy consumption and institutional quality to examine whether the implementation of COP commitments moderates their effects on CO₂ emissions. The empirical results show that greater political stability, particularly during the implementation of carbon emission reduction commitments, contributes to reducing greenhouse gas emissions and promoting sustainable development. The study also confirms that institutional quality plays a significant role in improving environmental quality and accelerating countries' progress toward carbon neutrality and net-zero emission goals.

Keywords: institutional quality; green energy; COP; environmental quality; sustainable development



Academic Editor: Andrea Nicolini

Received: 12 May 2026

Revised: 10 July 2026

Accepted: 13 July 2026

Published: 15 July 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

1. Introduction

Economic development requires sustainable energy resources to support economic activities, production, and consumption; consequently, energy consumption inevitably

affects the environment. As energy demand increases, the likelihood of releasing pollutants, particularly greenhouse gases, into the atmosphere also increases, thereby exacerbating environmental problems such as sea-level rise, global warming, and climate change [1,2]. Environmental degradation, in turn, adversely affects human well-being and public health, places additional pressure on healthcare systems, and may hinder long-term sustainable development [3,4]. In addition, achieving net-zero emissions, limiting the increase in the global average temperature to 1.5 °C, reducing dependence on fossil fuels, and developing robust theoretical frameworks for the energy transition have become major priorities for policymakers and researchers worldwide [5]. Accordingly, recent reports have proposed cost-effective and economically viable roadmaps for transitioning toward a clean, resilient, and sustainable energy economy driven primarily by renewable energy sources, including solar and wind power, rather than fossil fuels.

At the 26th Conference of the Parties (COP26) on Climate Change, also known as the 2021 United Nations Conference on Climate Change, it was stated that the effects of climate change, such as global warming and the continued increase in fossil fuel use, have posed serious challenges to climate stability at both national and global levels. Therefore, mitigating the impacts of climate change has become a global goal for maintaining sustainable economic development. The COP26 target requires net greenhouse gas emissions to reach zero by 2050, meaning that total emissions are balanced by the amount removed from the atmosphere. Thus, achieving net-zero requires countries and companies to rely on natural methods, such as forests, to remove an equivalent amount of carbon emitted, or to use technology to capture and store carbon before it enters the atmosphere. The captured carbon can then be permanently stored underground, thereby contributing to the goal of limiting global warming to 1.5 °C by 2050. Achieving this goal also lays the foundation for economies to implement sustainable development policies, increase incomes, and promote long-term prosperity.

However, many scientists believe that the goal of achieving net-zero is still vague and potentially difficult to achieve because it requires countries to make substantial efforts to implement production policies supported by appropriate energy use. In particular, initiatives, action plans, and specific commitments to respond to climate change must be practical. Moreover, the economy needs to strengthen its capacity, enhance financial support, and promote technology transfer in production, gradually reduce dependence on energy while optimizing production activities, and transform the growth model through greater contribution from technology, innovation, and intellectual labor.

The Asian region appears to have a high level of economic development and is becoming one of the world's major economic growth poles, alongside North America and Europe. The growth of the Asian economy is associated with the rapid development of major economies of China, Japan, Korea, India, and Singapore, while many countries have also emerged as dynamic economies, such as Thailand, Malaysia, Vietnam, and the UAE. Meanwhile, countries with low levels of development such as Bangladesh, Pakistan, and Laos also experienced significant improvements in per capita income and quality of life. However, the Asian region also faces the challenges of climate change, especially the rapid increase in carbon emissions that have occurred in recent decades. According to [6], Asia accounted for about 17% of global carbon emissions in 1990, which increased to 35% in 2012 and 53% in 2017, with this share expected to continue increasing. It can be said that carbon emissions in Asia have increased more rapidly than expected. China is currently the world's largest carbon emitter, producing an estimated 10 billion tonnes of CO₂ annually, accounting for more than one-third of global emissions compared with approximately 18% for North America and 17% for Europe [7]. Therefore, moving towards the net-zero goal is essential for Asian countries.

Previous studies have suggested that, to reduce carbon emissions, the economy should switch to green energy consumption, particularly renewable energy sources such as wind, solar, and bioenergy, because of their environmental benefits. This has been demonstrated by the studies [1,3,8]. Countries should therefore pursue green energy use policies [1,8] or improve institutional quality [9,10]. In particular, the 2015 Paris Climate Conference established the goal of reducing carbon emissions to mitigate the greenhouse effect and promote sustainable development. The spirit of the conference continues to guide global climate action, requiring countries to accelerate the transition to appropriate energy production and consumption systems in order to achieve sustainable development and the net-zero goal by 2050.

The objective of this research is to evaluate the impact of green energy and institutional quality on carbon emissions in selected Asian countries. The novelty of this study can be summarized as follows: First, previous studies have primarily examined the impact of green energy or institutional quality on carbon emissions separately, and, to the author's knowledge, there have been no studies examining the interactive effect of these two factors. Indeed, the Asian region comprises countries with diverse institutional systems. Some of the countries, such as China, Vietnam, and Laos, have socialist-oriented institutional systems, with relatively similar political and economic characteristics, while many other countries operate under capitalist institutional systems [11]. Second, the United Nations Climate Change Conference began in 1995, also known as COP1, and has progressed through successive conferences, most recently COP26, which established clear and comprehensive net-zero goals. Especially since COP21 in Paris, the Paris Agreement has been adopted by many countries to reduce carbon emissions and mitigate the greenhouse effect, and it can be said that the spirit of the Paris Agreement continues to guide global climate action. Therefore, this study also evaluates the impact of the 2015 Paris Agreement on carbon emissions and thereby provides evidence to support carbon emission reduction and sustainable development policies in Asian countries. The sample of 29 Asian countries was deliberately constructed to ensure broad representativeness by capturing substantial heterogeneity in three key dimensions: (i) it includes economies at different stages of economic development, spanning high-income, upper-middle-income, and developing countries. This variation provides an appropriate basis for assessing whether the relationships among renewable energy, institutional quality, and sustainable development are consistent across different levels of economic development. (ii) The selected countries display marked differences in institutional quality, ranging from nations with well-established governance systems to those with comparatively weaker institutional frameworks. Such variation is essential for examining the moderating role of institutional quality in the relationship under investigation. (iii) The sample covers all major sub-regions of Asia, including East Asia, Southeast Asia, South Asia, and Western Asia (the Middle East), thereby encompassing diverse economic structures, energy profiles, policy frameworks, and resource endowments. Taken together, these features improve the representativeness of the sample and enhance the generalizability of the empirical findings within the Asian context. Rather than limiting the analysis to a relatively homogeneous set of economies, this study intentionally adopts a diverse cross-country sample to better reflect the economic, institutional, and energy-related differences that characterize the region. Furthermore, the United Nations Development Program (UNDP) has identified the Sustainable Development Goals (SDGs) to be achieved by 2030 through the development of policies to reduce pollution while ensuring access to affordable, reliable, and sustainable energy [1]. Third, previous studies used traditional regression methods such as Ordinary Least Square (OLS), Fixed Effect Model (FEM), and Random Effect Model (REM) regression, and this study additionally applies the Driscoll–Kraay standard errors estimator to address cross-sectional dependence.

At the same time, the results obtained from this approach also provide evidence of the robustness of the estimated model. Although these are all econometric models that have been applied in different studies, they are used simultaneously in this research to provide multiple analytical perspectives and facilitate comparison using the same dataset.

2. Literature Review

2.1. Green Energy and Carbon Dioxide Emissions

Air pollution has both natural and anthropogenic origins, and this poses challenges and risks to economic development and human health. Specifically, air pollution increases the burden of disease because it poses a threat to human health. Therefore, innovation in renewable energy technologies has the potential to improve the efficiency of fossil fuels and reduce energy consumption in production. Furthermore, pollution is a major driver of environmental problems on a global scale. This is primarily due to the burning of non-renewable energy sources and industrial activities that increase emissions and negatively affect the environment, thereby exacerbating global warming and climate change. Therefore, reducing environmental pollution has attracted considerable attention from researchers and policymakers. However, efforts to reduce pollution have not received adequate attention in some countries [1,3].

Chen [3] argued that China is a typical case of pursuing a more sustainable energy consumption policy, encouraging renewable energy sources and reducing dependence on fossil fuel sources. Using data from 1990 to 2022 and the Granger causality test to clarify the relationship between energy sources and pollution emissions, Chen [3] found a positive correlation, confirming that renewable energy reduces air pollution while fossil fuels increase pollution levels. However, the authors also argued that China still depends heavily on traditional energy sources, such as fossil fuels, to meet the country's high energy demand. Furthermore, the research provides valuable implications for policy and market strategies to promote carbon neutrality and technological advancement in both the public and industrial sectors to support sustainable development. In another study, Rahman & Alam [1] reported that Australia has also encountered many environmental disasters in recent years. Using time series data in the period from 1990 to 2020, through the Dickey–Fuller and Phillips–Perron tests and the ARDL (Autoregressive Distributed Lag) model, Rahman & Alam [1] argued that industrialization has increased reliance on non-renewable energy, and therefore greater adoption of renewable energy is essential for sustainable development because renewable energy can reduce carbon emissions. In addition, the study also confirms the environmental Kuznets curve (EKC) hypothesis, which suggests that as income increases, carbon emissions initially rise but subsequently decline, thereby helping the country achieve more sustainable development. The effect of institutional quality on the promotion of renewable energy in OECD economies was also studied in [2], where the empirical results showed that better institutional quality promotes renewable energy consumption.

Given that the industrial revolution entailed rapid economic growth and an increase in energy demand, fossil energy sources such as coal and oil release a large amount of greenhouse gases into the environment, causing environmental pollution and contributing to climate change. These emissions pollute the air and thus affect human health and sustainable economic growth. Li et al. [8] emphasized the role of renewable energy use in reducing environmental emissions through research conducted across 30 provinces of China from 2005 to 2017 and showed that there is an N-shaped relationship between renewable energy use and economic growth, as well as an inverted N-curve relationship with smog pollution and carbon emissions. Li et al. [8] also argued that there is a spatial spillover effect of renewable energy use on the economy and the environment. However,

the study also found that renewable energy has a negative impact on economic growth in 40% of provinces and increases haze pollution in 30% of provinces and carbon emissions in 60% of provinces. These findings suggest that the environmental impact of renewable energy is gradually shifting from negative to positive, although more time is needed for its positive effects to become more pronounced. One reason for this is that, although the benefits of using renewable energy are undeniable, fossil energy sources still meet a large share of the economy's energy demand, and the transition process requires changes in the economic growth model, greater investment in technology, and wider adoption of clean energy.

The idea of investing in green energy and the environmental hazards associated with conventional energy sources were also presented in [4]. Experimental results in [4] again show that investment in renewable energy has a significant adverse effect on per capita carbon emissions in the long term. This study also focuses on the ASEAN region, which is part of Asia. A noteworthy finding is that the environmental quality of ASEAN countries will improve through the efficient and rational allocation of funds for the development of clean energy projects and green technology innovations.

Also, on the research topic of the relationship between renewable energy production and CO₂ emissions, however, using data from 27 OECD countries—a new situation—Perone [12] used the panel cointegration method and the Granger non-causality method to demonstrate that renewable energy does indeed have a strong impact on reducing CO₂ emissions. Although both renewable energy and energy efficiency contribute to CO₂ reduction, the level of impact varies among groups of developing countries. This implies that economic characteristics and development capacity determine the effectiveness of the energy transition [13]. In a study by Akram et al. [13], energy efficiency and renewable energy play a role in reducing carbon emissions in developing countries. These results also demonstrate that energy efficiency is an indispensable factor in testing the EKC hypothesis in developing countries and, consequently, propose necessary recommendations for developing appropriate economic and energy policies to achieve environmental sustainability in these countries. In addition to studies on the case of developing countries, the ASEAN region is also a very interesting context. This is demonstrated in Liu et al. [14]. In four ASEAN countries, renewable energy consumption reduces CO₂ emissions in the long term, while fossil fuels increase emissions. However, the study did not find strong evidence on the environmental Kuznets curve. Not only does Shahbaz's research [15] support the view that renewable energy has a significant emission reduction impact on both production- and consumption-based emissions—and that this effect is even stronger for consumption-based emissions—it also highlights the additional role of energy efficiency. From a different perspective, Liobikienė et al. [16] also agree that renewable energy helps reduce greenhouse gas emissions, but further argue that the marginal effectiveness diminishes as the proportion of renewable energy increases, and that the impact of green energy depends on the economic structure and technological efficiency. Renewable energy is also being studied in conjunction with green investment and technological innovation to create a stronger CO₂ reduction effect compared to simply expanding renewable energy alone [17]. Similarly, renewable energy is also being studied in conjunction with green investment and technological innovation to create a stronger CO₂ reduction effect compared to simply expanding renewable energy alone [18]. This can also be stated in another way: a higher share of renewable energy and stronger green innovation capacity are both associated with lower CO₂ emissions [19]. However, if we consider only the industrial sector, reducing CO₂ emissions requires a combination of transitioning to clean energy, improving production technology, and enhancing energy efficiency; simply changing energy sources is not enough to achieve long-term emission reduction goals [20]. From another perspective, research on

CO₂ emissions also suggests that the earlier the peak in carbon emissions occurs, the sooner the carbon neutrality target can be achieved. A case study from China is an interesting example presented in Ref. [21].

2.2. Institutional Quality and Carbon Dioxide Emissions

Given that pollution control is increasingly on the agenda around the world, many different policies have been enacted, especially those related to institutional quality, bringing varying degrees of success and having direct or indirect impacts on the environment. Institutional quality exists in many forms across the government, social, and political sectors and is influenced by cultural and historical factors, the level of corruption, and the size of the informal economic sector. Further, Goel et al. [22], using data from 100 countries over the period 2004 to 2007, suggested that countries with more corruption and large underground economies are likely to produce lower emissions, but MENA countries have higher pollution levels, thereby confirming the dual impact of institutional quality on environmental pollution. Khan & Rana [9] and Zheng et al. [10] argued that better institutional quality helps countries reduce pollution emissions. Furthermore, Khan & Rana [9] confirmed the mediating role of institutional quality by arguing that better institutional quality increases the mitigating effect of income, trade, and foreign direct investment (FDI) on pollution emissions.

The process of modernization and growing energy demand requires an increased energy supply in the near future. Electricity shortages in African countries result in economic losses of 2–4% of GDP annually, thereby weakening economic growth, employment, and investment. Approximately 600 million people on the continent lack access to electricity, and an estimated USD 55 billion is required to address this challenge. Therefore, renewable energy and nuclear energy technology applications have been evaluated by policymakers as cost-effective and environmentally friendly energy sources. Using data from the period 1971 to 2017, Sarkodie & Adams [23] argued that the valuable environmental Kuznets curve in South Africa occurred in 2011, reflecting that income has both negative and positive effects on environmental pollution. Furthermore, the study also confirmed that institutional quality plays a major role in social, governance, and economic preparedness to mitigate climate change and its impacts, and has an impact on environmental quality. Fossil fuel-rich countries require more diversified energy portfolios based on renewable energy sources to promote environmental sustainability and improve air quality, and reduce economic vulnerability. Furthermore, the paradigm shift from energy- and carbon-intensive industries to a service-oriented economy has the potential to drive economic structural change, thereby helping to mitigate climate change.

Environmental degradation occurs due to factors such as economic growth, industrialization, urbanization, and globalization, and thus increases the use of fossil fuels and higher emissions of carbon dioxide, thereby increasing greenhouse gas emissions. Khan & Rana [9] argued that the logical solution is for countries to switch from non-renewable energy sources to renewable energy sources, thereby ensuring uninterrupted energy supplies without weakening economic growth in the long term. In the case of Asian economies, Khan & Rana [9] argued that there has been concern about the sustainability of these countries in the context of high economic growth and rising emissions. Research across 41 Asian countries suggests that better institutional quality helps countries reduce pollution emissions, but energy use, trade, and FDI increase environmental degradation. Furthermore, the study confirmed the mediating role of institutional quality by arguing that better institutional quality increases the mitigating effects of income, trade, and FDI on pollution emissions. Meanwhile, European countries are pursuing a policy of preventing pollution of the air, water, and soil to build a clean living environment and healthy ecosystem,

to move towards the goal of climate neutrality by 2050, and to reduce greenhouse gas emissions. Simionescu & Plopeanu [24] argued that industrial development is a source of pollution, while good governance can control environmental degradation through appropriate measures. Specifically, when adequate environmental laws, regulations, and policies are effectively implemented, they encourage the use of green technology, improve industrial practices, and strengthen the regulatory framework to control pollution. Other regions, such as the G-7 economies [25], were also mentioned in the study, which showed that improved institutional quality and increased consumption of renewable energy both contribute to reducing CO₂ emissions from consumption. The results underscore that carbon neutrality goals need to be supported by effective institutions. The sub-Saharan African region was studied in Ref. [26]. Research in 29 countries in this region shows that controlling corruption, improving regulatory quality, and strengthening the rule of law significantly reduce CO₂ emissions. At the same time, a two-way causal relationship exists between institutional quality and carbon emissions.

The world is facing the challenge of widespread environmental pollution and requires countries to take urgent and effective action. Human activities such as fossil fuel use and industrial and agricultural activities have the potential to pollute the environment and increase the average temperature of the Earth, thereby contributing to climate change. Zheng et al. [10] also affirmed that economic development is often a factor that affects the environment, and this is exacerbated by inadequate education about its consequences. Better education and improved institutional quality will significantly reduce emissions, and the trend becomes more pronounced in countries with strong institutions. At the same time, the role of research and development in environmental protection is positively correlated with higher institutional quality and negatively correlated in countries with lower institutional quality. This finding highlights the importance of quality education and maintaining strong institutions for reducing carbon emissions and promoting future sustainable development.

In a case study of several ASEAN countries such as Singapore, Thailand, the Philippines, Malaysia, and Indonesia, Zheng et al. [4] argued that not only is investment in green energy important, but the regulatory role of institutional quality in the relationship between financial development and environmental improvement also plays a significant role. The AMG, CCEMG, and MG estimation methods used for data from 1995 to 2022 yielded results indicating that institutional quality has a statistically significant impact on long-term per capita CO₂ emissions. Institutional quality plays a strong moderating role in the relationship between financial development, clean energy investment, and environmental emissions. Specifically, when institutional quality shifts from a lower threshold (≤ -1.55) to a higher threshold (> -1.55), financial development and investment in renewable energy become statistically significant and contribute to improved environmental quality. Institutional quality supports the potential for expanding financial development and investment in renewable energy to enhance ecological sustainability. The environmental quality of ASEAN countries can only be improved through quality institutions, particularly by promoting the development of clean energy projects alongside green technology innovation. Similarly, empirical evidence from countries such as Indonesia, South Korea, and Thailand also shows that fair and effective institutions help reduce CO₂ emissions during economic growth. Furthermore, a feedback loop exists between growth, energy consumption, and carbon emissions in both the short and long term [27].

The transition to a low-carbon economy depends not only on the development of renewable energy technology but is also decisively influenced by the quality of national governance [28]. While renewable energy is seen as an important driver of sustainable development, the actual effectiveness of this transition depends significantly on the insti-

tutional environment in which policies are designed, implemented, and monitored. In that context, the study analyzes the role of governance quality in enhancing the impact of renewable energy on sustainable development across three aspects: economic, social, and environmental dimensions in BRICS and MENA countries during the period 1996–2022. To fully reflect the dynamic characteristics of the data and the differences between countries, the study applies a cross-sectional augmented distributed lag autoregression model (CS-ARDL) combined with a panel quantile ARDL model (PQARDL), which allows the authors to simultaneously evaluate the long-term relationship and the heterogeneity of effects across different quantiles. The empirical results of Yin et al. [28] show that expanding the use of renewable energy produces only limited improvements in sustainable development in the absence of effective governance. On the contrary, when supported by high-quality institutions, the positive impact of renewable energy is significantly enhanced across all three pillars of sustainable development. Comparative analysis also shows significant differences between the two groups of countries: BRICS economies achieve higher efficiency thanks to close coordination between energy policy and governance capacity, while MENA countries still suffer from many limitations due to low institutional quality and high dependence on fossil fuels. These findings confirm that governance quality is not only a supporting condition but also a decisive factor that helps the renewable energy transition create long-term sustainable benefits, thereby providing an important empirical basis for energy policy formulation and institutional reform towards sustainable development. Approaching institutional quality from a different perspective, Danquah et al. [29] investigate the moderating and threshold roles of environmental taxation and institutional quality in strengthening the international trade performance of sub-Saharan African (SSA) economies. Using an annual panel dataset covering 24 emerging SSA countries from 2010 to 2024, the analysis examines how institutional conditions influence the effectiveness of environmental tax policies. The findings indicate that the effect of environmental taxation on international trade is nonlinear, shifting from negative to positive only after institutional quality exceeds certain threshold levels. In particular, political stability, regulatory quality, and government effectiveness play critical roles in determining whether environmental taxes constrain or promote trade performance.

In addition to affirming the role of renewable energy in reducing CO₂ emissions, many studies also indicate that the energy transition needs to be accompanied by investment and innovation policies. In other words, energy policy and technological innovation need to be implemented simultaneously to achieve sustainable development goals [17,19].

Although debates about the role of high-quality institutions in responding to climate change and reducing carbon dioxide (CO₂) emissions globally are increasingly intense, quantitative empirical evidence remains insufficient to confirm this relationship [9,19,22,23]. Based on datasets from 136 countries between 1996 and 2016, study [30] provides compelling empirical evidence that superior institutional quality, along with government policies geared towards green and sustainable economic growth, can significantly contribute to reducing CO₂ emissions. The research findings indicate that the effectiveness of climate change response policies is closely dependent on improving at least three core aspects of institutional quality: protecting property rights through strengthening the rule of law, enhancing citizen participation in elections and ensuring freedom of expression, and improving the effectiveness of corruption control. Therefore, economic policies aimed at reducing emissions and promoting environmental sustainability need to be implemented in conjunction with these institutional reforms, combining the promotion of economic growth, encouraging the expansion of renewable energy use in both the public and private sectors, and gradually reducing dependence on fossil fuels.

Beyond theoretical foundations, empirical studies have also been conducted in various regions worldwide. For example, data analysis from 69 developing countries from 1990 to 2018 shows that improved institutional quality, particularly through governance and democracy, contributes to enhanced environmental sustainability by limiting CO₂ emissions in the long term [31]. Alternatively, analysis of a sample of 94 developing countries over the period 2002 to 2019 reveals that institutional components have inconsistent impacts on CO₂ emissions. Control of corruption, rule of law, and voice and accountability help reduce emissions, while government effectiveness, regulatory quality, and political stability can increase emissions depending on the development context [32]. Research covering 24 Asia–Pacific countries shows that institutional quality and the interaction between GDP per capita and institutional quality both have a significant negative impact on CO₂ emissions, supporting the role of institutions in improving environmental quality [33]. Indeed, institutional quality not only directly reduces CO₂ emissions but also enhances the positive impact of financial development on environmental quality, thereby promoting sustainable development in developing countries [34].

3. Data and Research Methodology

In this study, the author uses data collected from typical Asian countries, including: those in Southeast Asia such as Thailand, Vietnam, the Philippines, Laos, Indonesia, Singapore, and Malaysia; South Asian countries such as Bangladesh, Pakistan, India, Sri Lanka, and Afghanistan; and East Asian countries including Japan, South Korea, China, Mongolia, and North Korea, where North Korea is treated as an economic entity based on the research data. This consideration is similar to how South Korea is also referred to as an independent economy, as can be seen in Ref. [27]. Other countries in the Middle East include Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, and the United Arab Emirates. These Middle Eastern countries are also known as countries located in Western Asia. We confidently conducted this study using data from several Asian countries because, in Ref. [18], a meta-analysis demonstrated that the majority of studies found positive impacts of renewable energy consumption on improving environmental quality, but the magnitude of the impact varied significantly depending on the estimation method, study area, and environmental indicators used. In addition, the analysis of 41 Asian countries reported in Ref. [9] demonstrates that this region is also of great research interest, with many emerging and developing countries.

For convenience, the 29 Asian countries included in the sample are listed below: (1) Thailand, (2) Vietnam, (3) the Philippines, (4) Laos, (5) Indonesia, (6) Singapore, (7) Malaysia, (8) Bangladesh, (9) Pakistan, (10) India, (11) Sri Lanka, (12) Afghanistan, (13) Japan, (14) South Korea, (15) China, (16) Mongolia, (17) North Korea, (18) Bahrain, (19) Iran, (20) Iraq, (21) Israel, (22) Jordan, (23) Kuwait, (24) Lebanon, (25) Oman, (26) Qatar, (27) Saudi Arabia, (28) Syria, and (29) the United Arab Emirates.

The sample of 29 Asian economies was deliberately selected to maximize heterogeneity across three important dimensions. First, the sample covers economies at different stages of development, ranging from high-income countries such as Japan, Singapore, South Korea, Israel, Qatar, Kuwait, Bahrain, and the United Arab Emirates to lower-middle-income and developing economies including Bangladesh, Pakistan, Afghanistan, Laos, and Sri Lanka. This diversity enables the analysis to examine whether the relationships among renewable energy, institutional quality, and sustainable development remain robust across different income levels. Second, the selected countries exhibit considerable variation in institutional quality, encompassing economies with highly effective governance systems as well as countries with relatively weak institutional capacity. Such institutional diversity provides an appropriate setting for evaluating the moderating role of governance. Third,

the sample includes countries from all major Asian sub-regions, including East Asia, South-east Asia, South Asia, and Western Asia (the Middle East), thereby reflecting different economic structures, energy systems, policy environments, and natural resource endowments. Collectively, these characteristics enhance the representativeness of the sample and strengthen the generalizability of the empirical findings within the Asian context. Rather than focusing on a homogeneous group of economies, this study intentionally employs a heterogeneous sample to capture differences in economic development, institutional quality, energy structures, and policy environments across Asia.

The study uses data collected from the World Bank and the International Monetary Fund. Some data were collected from national statistical agencies that published annually. Data were collected from 1970 to 2021, then processed for errors and outliers, and used for quantitative analysis. The lack of data for different variables leads to unbalanced panel data. Therefore, the period between 1997 and 2021 was chosen for the technique procedure. Based on the previous study by Goel et al. [22] and with adjustments, the regression equation is presented as follows:

$$EP_{it} = \beta_0 + \beta_1 GN_{it} + \beta_2 IQ_{it} + \beta_3 GDP_{it} + \beta_4 FDI_{it} + \beta_5 TRADE_{it} + \beta_6 HUMAN_{it} + \varepsilon_{it} \quad (1)$$

$$EP_{it} = \beta_0 + \beta_1 GN_{it} + \beta_2 IQ_{it} + \beta_3 GN_{it} \times IQ_{it} + \beta_4 GDP_{it} + \beta_5 FDI_{it} + \beta_6 TRADE_{it} + \beta_7 HUMAN_{it} + \varepsilon_{it} \quad (2)$$

Note that IQ_{it} is just the formal symbols, which present control of corruption (CC), government effectiveness (GE), political stability (PS), regulatory quality (RQ), rule of law (RL), and voice and accountability (VA) as different proxies of institutional quality. Interaction term $GN_{it} \times IQ_{it}$ can measure the impact of green energy on reducing environmental pollution under institutional quality.

Furthermore, the United Nations conference in Paris approved the Paris agreement that has been adopted by many countries to reduce carbon emissions causing the greenhouse effect, and it can be said that the spirit of the Paris Agreement is still maintained today. To evaluate the impact of this agreement, the study uses the *COP* variable in the study, and the regression equation has the following form:

$$EP_{it} = \beta_0 + \beta_1 GN_{it} + \beta_2 GN_{it} \times COP + \beta_3 IQ_{it} + \beta_4 GDP_{it} + \beta_5 FDI_{it} + \beta_6 TRADE_{it} + \beta_7 HUMAN_{it} + \varepsilon_{it} \quad (3)$$

$$EP_{it} = \beta_0 + \beta_1 GN_{it} + \beta_2 IQ_{it} + \beta_3 IQ_{it} \times COP + \beta_4 GDP_{it} + \beta_5 FDI_{it} + \beta_6 TRADE_{it} + \beta_7 HUMAN_{it} + \varepsilon_{it} \quad (4)$$

$$EP_{it} = \beta_0 + \beta_1 GN_{it} + \beta_2 IQ_{it} + \beta_3 GN_{it} \times COP \times IQ_{it} + \beta_4 GDP_{it} + \beta_5 FDI_{it} + \beta_6 TRADE_{it} + \beta_7 HUMAN_{it} + \varepsilon_{it} \quad (5)$$

In which

EP_{it} stands for environmental pollution, measured by carbon dioxide emissions, metric tons per capita;

GN_{it} stands for green energy, measured by total renewable energy divided by total energy demand;

GDP_{it} represents economic growth, measured by per capita income (constant 2015, USD);

FDI_{it} represents foreign direct investment, measured as a percentage of GDP;

$TRADE_{it}$ is a variable measuring economic openness, measured as a percentage of GDP_{it} ;

$HUMAN_{it}$ is a variable measuring human capital, through the percentage of GDP_{it} invested in education;

COP represents the Paris Agreement, starting from COP2 in 1996. Dummy variable *COP* (taking a value of 0 before COP2, and taking a value of 1 after COP2).

Interaction terms $GN_{it} \times COP$, $IQ_{it} \times COP$, $GN_{it} \times \beta_2 IQ_{it} \times COP$ can, respectively, measure the impact of green energy on reducing environmental pollution in the context

of implementing COP regulations, the impact of institutional quality on reducing environmental pollution in the context of implementing COP regulations, and the impact of green energy and institutional quality on reducing environmental pollution in the context of implementing COP regulations.

This study uses quantitative analysis methods such as OLS, FEM, and REM. The F-test is performed to select between OLS and FEM, and the Hausman test is performed to select between FEM and REM. Furthermore, when heteroskedasticity and multicollinearity occur, Feasible Generalized Least Square (FGLS) is chosen to correct these defects [35,36]. This study employs a sequential econometric strategy to ensure robust estimation and statistical inference. OLS is first estimated as a baseline model, followed by FEM and REM to account for unobserved heterogeneity in the panel data. The Hausman test is applied to determine the preferred panel specification. Diagnostic tests are then conducted to identify heteroskedasticity, serial correlation, and cross-sectional dependence. To address these econometric issues, FGLS is estimated as a robustness check, while Driscoll–Kraay standard errors are adopted for the final statistical inference because they provide robust estimates under heteroskedasticity, autocorrelation, and cross-sectional dependence.

In addition, this study also evaluates the model's robustness by estimating Driscoll–Kraay standard errors to assess cross-sectional dependence between countries in the region. Indeed, Asian countries are geographically close to each other, so they often depend on and interact with each other in economic development policies, particularly energy-related policies. Further, Driscoll–Kraay standard errors are the method for calculating standard errors for panel data regression models that are robust to heteroskedasticity, cross-sectional dependence, and serial correlation. They are useful when the panel data have a large time dimension. Hoechle [37] also indicated that Driscoll–Kraay standard errors tend to be slightly optimistic.

4. Analysis of Regression Results

Let us begin with Descriptive Statistical Analysis. Table 1 indicates some descriptive statistics in the model. Regarding environmental quality, the average emission capacity in the period 1970 to 2021 in the Asian region reaches 7.562479 metric tons per capita/year, as indicated by the mean of *EP* in Table 1; however, there are relative differences between countries. Regarding renewable energy consumption, this energy source only accounts for 17.74% of total energy demand—since the total energy demand is 42.6295 metric tons per capita/year according to the calculation of the authors from World Bank data, including countries without renewable energy sources like Singapore. Variables representing institutional quality, including control of corruption (*CC*), government effectiveness (*GE*), political stability (*PS*), regulatory quality (*RQ*), rule of law (*RL*), and voice and accountability (*VA*), show that developed countries have higher institutional quality than developing countries. These indicators are used as independent variables in the model, and they all represent institutional quality.

Regarding GDP per capita, this indicator shows that the Asian region averages US\$9197 (as the mean of *GDP* in Table 1) per person per year, with relatively large differences in development levels and per capita income among countries. In terms of FDI, this indicator averages 2.32% of GDP, while Singapore has the highest FDI attraction rate, reaching 43.91% of GDP. Regarding trade openness, this indicator averages 84.08% of GDP, showing a high level of trade in the Asian region, while Singapore achieves an openness rate of 437.32% of GDP.

Table 1. Descriptive statistics.

Variable	Mean	Std. Dev.	Min	Max
<i>EP</i>	7.562479	9.197111	0.0548668	47.65696
<i>GN</i>	17.74018	22.53872	0	88.4
<i>CC</i>	−0.2061245	0.8897653	−1.7984	2.301146
<i>GE</i>	−0.0118208	0.9216024	−2.175167	2.46966
<i>PS</i>	−0.4515205	1.079572	−3.180352	1.599123
<i>RQ</i>	−0.1489219	0.9504571	−2.52669	2.252235
<i>RL</i>	−0.1257686	0.871673	−2.09612	1.837814
<i>VA</i>	−0.6641092	0.8302834	−2.313395	1.109647
<i>GDP</i>	9197.363	14,192.14	22.85037	98,041.36
<i>FDI</i>	2.32235	4.463202	−37.17265	43.91211
<i>TRADE</i>	84.08431	68.54102	0.0209992	437.3267
<i>HUMAN</i>	96.35507	17.39276	3.08178	134.3261

Source: Authors' analysis.

The results of the stationarity test are presented in Table 2. All variables are stationary at the significance level of 10 percent at lag 1.

Table 2. Results of stationarity test.

Variables	Inverse Chi-Squared	<i>p</i> -Value	Conclusion
<i>EP</i>	95.1246	0.0015	Stationary
<i>GN</i>	163.9723	0.0000	Stationary
<i>CC</i>	77.2429	0.0464	Stationary
<i>GE</i>	74.7549	0.0684	Stationary
<i>PS</i>	99.2955	0.0006	Stationary
<i>RQ</i>	113.7523	0.0000	Stationary
<i>RL</i>	108.5498	0.0001	Stationary
<i>VA</i>	92.8119	0.0025	Stationary
<i>GDP</i>	92.1014	0.0017	Stationary
<i>FDI</i>	143.7711	0.0000	Stationary
<i>TRADE</i>	101.6792	0.0002	Stationary
<i>HUMAN</i>	98.3025	0.0002	Stationary

Source: Authors' analysis.

In this research, due to the availability of data, our study does not aim to find a long-term equilibrium relationship between variables, but rather to use Driscoll–Kraay and FGLS to test the robustness of the results and to investigate the impact of several variables of interest, such as green energy, institutional quality, and environmental quality, on environmental pollution. The long-term equilibrium relationship between variables will be examined in another study in the future.

Covariance tests and a modified Wald test for groupwise heteroskedasticity in a fixed-effect regression model are carried out for Model 1, in which *IQ* is, respectively, substituted by *CC*, *GE*, *PS*, *RQ*, *RL*, and *VA*. Results of covariance tests are presented in Table 3.

Table 3. Covariance tests.

Model 1	Chi2	Prob > Chi2	Conclusion
<i>IQ = CC</i>	550,219.35	0.0000	There exists heteroskedasticity
<i>IQ = GE</i>	385,683.66	0.0000	There exists heteroskedasticity
<i>IQ = PS</i>	691,939.91	0.0000	There exists heteroskedasticity
<i>IQ = RQ</i>	223,707.89	0.0000	There exists heteroskedasticity
<i>IQ = RL</i>	274,943.63	0.0000	There exists heteroskedasticity
<i>IQ = VA</i>	119,095.04	0.0000	There exists heteroskedasticity

Source: Authors' analysis.

Similarly, the Wooldridge test for autocorrelation in panel data is also performed, and its results are shown in Table 4.

Table 4. Autocorrelation tests.

Model 1	F-Stat	Prob > F	Conclusion
<i>IQ = CC</i>	53.414	0.0000	There exists serial correlation
<i>IQ = GE</i>	51.785	0.0000	There exists serial correlation
<i>IQ = PS</i>	51.545	0.0000	There exists serial correlation
<i>IQ = RQ</i>	54.076	0.0000	There exists serial correlation
<i>IQ = RL</i>	49.227	0.0000	There exists serial correlation
<i>IQ = VA</i>	51.305	0.0000	There exists serial correlation

Source: Authors' analysis.

One can find that the panel data now has heteroskedasticity and serial correlation, as shown in Tables 3 and 4.

Table 5 presents the results of the correlation analysis, and the findings suggest that most pairs of variables have low correlation, and multicollinearity is unlikely to occur [38]. However, the study will perform regression analysis on each component of the institutional quality variable to eliminate the possibility of multicollinearity.

Table 5. Correlation analysis.

	<i>EP</i>	<i>GN</i>	<i>CC</i>	<i>GE</i>	<i>PS</i>	<i>RQ</i>	<i>RL</i>	<i>VA</i>	<i>GDP</i>	<i>FDI</i>	<i>TRADE</i>	<i>HUMAN</i>
<i>EP</i>	1.0000											
<i>GN</i>	−0.5595	1.0000										
<i>CC</i>	0.5474	−0.5561	1.0000									
<i>GE</i>	0.3853	−0.4761	0.8981	1.0000								
<i>PS</i>	0.4778	−0.4351	0.5939	0.4904	1.0000							
<i>RQ</i>	0.4052	−0.4536	0.8845	0.9182	0.4774	1.0000						
<i>RL</i>	0.4745	−0.5237	0.9318	0.8935	0.5835	0.9201	1.0000					
<i>VA</i>	−0.0843	−0.1069	0.4013	0.4614	0.0890	0.5321	0.5397	1.0000				
<i>GDP</i>	0.7300	−0.7364	0.7840	0.7387	0.5004	0.7148	0.7524	0.1627	1.0000			
<i>FDI</i>	−0.0139	−0.1270	0.2551	0.2244	0.2718	0.2768	0.2035	0.0375	0.0940	1.0000		
<i>TRADE</i>	0.1758	−0.3110	0.4787	0.4887	0.4583	0.5039	0.4358	−0.0525	0.3185	0.5588	1.0000	
<i>HUMAN</i>	−0.0102	0.0326	−0.0862	−0.0591	0.2180	−0.1290	−0.1017	−0.1529	0.0456	0.0199	0.0885	1.0000

Source: Authors' analysis.

The regression results are shown in Tables 6–12. In the conventional panel data analysis method, OLS, FEM and REM are commonly used. The results in Tables 6 and 7 show that the regression results all suffer from the problem of heteroscedasticity or autocorrelation, so FGLS regression should be used.

Table 6. Regression results for Equation (1) with OLS and FEM.

Variable	OLS	OLS	OLS	OLS	OLS	OLS	FEM	FEM	FEM	FEM	FEM	FEM
GN	−0.0238 (0.302)	0.0144 (0.515)	−0.0131 (0.555)	0.0072 (0.754)	−0.0148 (0.517)	−0.0218 (0.315)	−0.0105 (0.626)	−0.0062 (0.774)	−0.0033 (0.884)	−0.0049 (0.817)	−0.0174 (0.430)	0.0198 (0.373)
CC	−0.4319 (0.579)						−0.9072 ** (0.027)					
GE		−5.128 *** (0.000)						−0.7708 (0.123)				
PS			2.331 *** (0.000)						−0.0326 (0.891)			
RQ				−3.53 *** (0.000)						−0.93 ** (0.047)		
RL					−2.4352 (0.001)						−1.36 *** (0.006)	
VA						−2.824 *** (0.000)						1.402 *** (0.001)
GDP	11.28 *** (0.000)	15.77 *** (0.000)	9.77 *** (0.000)	14.41 *** (0.000)	13.02 *** (0.000)	11.70 *** (0.000)	1.48 *** (0.001)	1.85 *** (0.000)	1.63 *** (0.000)	1.81 *** (0.000)	1.51 *** (0.001)	2.21 *** (0.000)
FDI	−0.1265 * (0.070)	−0.1253 * (0.055)	−0.16 ** (0.017)	−0.0977 (0.148)	−0.12 * (0.071)	−0.0844 (0.201)	0.0283 (0.137)	0.0267 (0.162)	0.0288 (0.135)	0.0299 (0.116)	0.0230 (0.227)	0.0241 (0.202)
TRADE	−0.0021 (0.778)	0.0170 (0.020)	−0.0136 (0.057)	0.0113 (0.130)	0.0034 (0.637)	−0.0099 (0.147)	0.0014 (0.785)	0.0028 (0.597)	0.0014 (0.794)	0.0019 (0.706)	0.0003 (0.956)	0.0053 (0.315)
HUMAN	−0.0430 (0.221)	−0.09 *** (0.006)	−0.08 ** (0.017)	−0.09 *** (0.005)	−0.06 * (0.052)	−0.07 ** (0.025)	−0.0028 (0.871)	−0.0056 (0.751)	0.0004 (0.980)	0.0036 (0.836)	0.0016 (0.922)	0.0043 (0.798)
_cons	−28.3695 *** (0.000)	−41.9711 (0.000)	−17.1727 (0.000)	−36.4421 (0.000)	−32.9323 (0.000)	−27.8335 (0.000)	3.0338 (0.220)	1.9444 (0.425)	2.0864 (0.418)	1.0810 (0.662)	2.8335 (0.246)	−0.4962 (0.844)
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.5370	0.5912	0.5668	0.5649	0.5483	0.5843	0.3571	0.5441	0.4880	0.4606	0.2640	0.1750
F test							F(26, 397) = 276.19 Prob > F = 0.0000	F(26, 397) = 240.45 Prob > F = 0.0000	F(26, 397) = 252.85 Prob > F = 0.0000	F(26, 397) = 258.01 Prob > F = 0.0000	F(26, 397) = 271.04 Prob > F = 0.0000	F(26, 397) = 250.43 Prob > F = 0.0000
Modified Wald test for groupwise heteroskedasticity in fixed effect regression model/Breusch and Pagan Lagrangian multiplier test for random effects							chi2 (27) = 5.5×10^5 Prob > chi2 = 0.0000	chi2 (27) = 3.9×10^5 Prob > chi2 = 0.0000	chibar2(01) = 2493.74 Prob > chibar2 = 0.0000	chi2 (27) = 2.9×10^4 Prob > chi2 = 0.0000	chi2 (27) = 2.7×10^5 Prob > chi2 = 0.0000	chi2 (27) = 3.1×10^{32} Prob > chi2 = 0.0000
Wooldridge test for autocorrelation in panel data							F(1, 23) = 53.414 Prob > F = 0.0000	F(1, 23) = 51.785 Prob > F = 0.0000	F(1, 23) = 51.545 Prob > F = 0.0000	F(1, 23) = 54.076 Prob > F = 0.0000	F(1, 23) = 49.227 Prob > F = 0.0000	F(1, 23) = 51.305 Prob > F = 0.0000

Note: ***, **, and *, respectively, as the significant level of 1%, 5%, and 10%. Source: Authors' analysis.

Table 7. Regression results for Equation (1) with REM.

Variable	REM	REM	REM	REM	REM	REM
GN	−0.0168 (0.434)	−0.0163 (0.446)	−0.0101 (0.654)	−0.0145 (0.496)	−0.0222 (0.308)	0.0046 (0.834)
CC	−0.5114 (0.206)					
GE		−0.5694 (0.250)				

Table 7. Cont.

Variable	REM	REM	REM	REM	REM	REM
<i>PS</i>			0.0645 (0.786)			
<i>RQ</i>				−0.6233 (0.177)		
<i>RL</i>					−0.9139 * (0.058)	
<i>VA</i>						1.2148 *** (0.003)
<i>GDP</i>	1.7074 *** (0.000)	1.9758 *** (0.000)	1.7950 *** (0.000)	1.9221 *** (0.000)	1.7329 *** (0.000)	2.2504 *** (0.000)
<i>FDI</i>	0.0267 (0.171)	0.0252 (0.202)	0.0263 (0.179)	0.0277 (0.157)	0.0231 (0.238)	0.0227 (0.243)
<i>TRADE</i>	0.0029 (0.574)	0.0040 (0.449)	0.0031 (0.560)	0.0033 (0.519)	0.0023 (0.653)	0.0058 (0.267)
<i>HUMAN</i>	−0.0027 (0.877)	−0.0055 (0.760)	0.0004 (0.983)	0.0008 (0.959)	−0.0004 (0.983)	0.0028 (0.873)
_cons	1.9525 (0.479)	1.2398 (0.647)	1.2484 (0.660)	0.7317 (0.791)	1.8416 (0.499)	−0.4841 (0.861)
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.4676	0.5253	0.4898	0.5078	0.4527	0.2566
Hausman test	chi2(6) = 13.18 Prob > chi2 = 0.0402	chi2(6) = 16.23 Prob > chi2 = 0.0126	chi2(6) = 0.87 Prob > chi2 = 0.9900	chi2(6) = 16.03 Prob > chi2 = 0.0136	chi2(6) = 20.07 Prob > chi2 = 0.0027	chi2(6) = 18.24 Prob > chi2 = 0.0057

Note: ***, and *, respectively, as the significant level of 1%, and 10%. Source: Authors' analysis.

Table 8. Regression results for Equation (1) with FGLS and DK.

Variable	FGLS	FGLS	FGLS	FGLS	FGLS	FGLS	DK	DK	DK	DK	DK	DK
<i>GN</i>	−0.0238 (0.297)	0.0144 (0.511)	−0.0131 (0.551)	0.0072 (0.752)	−0.0148 (0.513)	−0.0218 (0.310)	−0.0238 (0.364)	0.0144 (0.549)	−0.0131 (0.683)	0.0072 (0.768)	−0.0148 (0.569)	−0.0218 (0.410)
<i>CC</i>	−0.4319 (0.575)						−0.4319 (0.731)					
<i>GE</i>		−5.128 *** (0.000)						−5.12 *** (0.000)				
<i>PS</i>			2.331 *** (0.000)						2.331 *** (0.001)			
<i>RQ</i>				−3.530 *** (0.000)						−3.53 *** (0.002)		
<i>RL</i>					−2.435 *** (0.001)						−2.435 ** (0.015)	
<i>VA</i>						−2.824 *** (0.000)						−2.82 *** (0.000)
<i>GDP</i>	11.28 *** (0.000)	15.77 *** (0.000)	9.77 *** (0.000)	14.41 *** (0.000)	13.02 *** (0.000)	11.70 *** (0.000)	11.28 *** (0.000)	15.77 *** (0.000)	9.77 *** (0.000)	14.41 *** (0.000)	13.02 *** (0.000)	11.70 *** (0.000)
<i>FDI</i>	−0.126 * (0.067)	−0.125 * (0.052)	−0.160 ** (0.016)	−0.0977 (0.144)	−0.123 * (0.068)	−0.0844 (0.197)	−0.1265 (0.174)	−0.1253 (0.151)	−0.160 * (0.091)	−0.0977 (0.283)	−0.1237 (0.176)	−0.0844 (0.283)
<i>TRADE</i>	−0.0021 (0.776)	0.017 ** (0.018)	−0.013 * (0.054)	0.0113 (0.126)	0.0034 (0.634)	−0.0099 (0.143)	−0.0021 (0.803)	0.017 ** (0.017)	−0.0136 (0.173)	0.0113 (0.192)	0.0034 (0.664)	−0.0099 (0.106)
<i>HUMAN</i>	−0.0430 (0.216)	−0.09 *** (0.005)	−0.08 ** (0.016)	−0.09 *** (0.005)	−0.06 ** (0.049)	−0.07 ** (0.024)	−0.043 * (0.091)	−0.09 ** (0.019)	−0.08 ** (0.026)	−0.09 *** (0.007)	−0.06 ** (0.014)	−0.07 *** (0.001)
_cons	−28.36 *** (0.000)	−41.97 *** (0.000)	−17.17 *** (0.000)	−36.44 *** (0.000)	−32.93 *** (0.000)	−27.83 *** (0.000)	−28.3 *** (0.000)	−41.9 *** (0.000)	−17.1 *** (0.000)	−36.4 *** (0.000)	−32.9 *** (0.000)	−27.8 *** (0.000)
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared							0.5435	0.5969	0.5748	0.5709	0.5546	0.5901

Note: DK is shown for Driscoll–Kraay standard errors; ***, **, and *, respectively, as the significant level of 1%, 5%, and 10%. Source: Authors' analysis.

Table 9. Regression results for Equation (2).

Variable	FGLS	FGLS	FGLS	FGLS	FGLS	FGLS	DK	DK	DK	DK	DK	DK
GN	−0.15 *** (0.0000)	−0.061 ** (0.040)	−0.056 ** (0.024)	−0.089 *** (0.005)	−0.071 ** (0.014)	−0.0033 (0.908)	0.0041 (0.750)	0.0117 (0.305)	−0.0101 (0.413)	0.0073 (0.633)	0.0097 (0.563)	−0.0030 (0.792)
CC	1.1820 (0.153)						−1.274 (0.222)					
GE		−3.802 *** (0.000)						−1.148 (0.105)				
PS			3.379 *** (0.000)						0.3028 (0.360)			
RQ				−2.095 *** (0.004)					−1.1412 (0.157)			
RL					−1.1034 (0.193)						−2.179 ** (0.023)	
VA						−3.116 *** (0.000)						2.0134 (0.103)
GN × CC	−0.167 *** (0.000)						0.0265 (0.222)					
GN × GE		−0.126 *** (0.000)						0.026 ** (0.038)				
GN × PS			−0.062 *** (0.001)						−0.0121 (0.126)			
GN × RQ				−0.124 *** (0.000)					0.0140 (0.465)			
GN × RL					−0.086 *** (0.002)						0.041 ** (0.043)	
GN × VA						0.0187 (0.360)						−0.0330 (0.160)
GDP	10.16 *** (0.000)	14.6 *** (0.000)	9.28 *** (0.000)	13.17 *** (0.000)	11.99 *** (0.000)	11.81 *** (0.000)	1.422 ** (0.019)	1.85 *** (0.000)	1.71 *** (0.002)	1.85 *** (0.001)	1.53 ** (0.011)	2.37 *** (0.000)
FDI	−0.146 ** (0.030)	−0.137 ** (0.031)	−0.154 ** (0.019)	−0.123 * (0.060)	−0.13 ** (0.043)	−0.0780 (0.235)	0.0273 (0.195)	0.0246 (0.236)	0.0300 (0.162)	0.0296 (0.175)	0.0183 (0.319)	0.0232 (0.137)
TRADE	−0.0078 (0.291)	0.0110 (0.130)	−0.014 ** (0.037)	0.0041 (0.587)	−0.0006 (0.932)	−0.0093 (0.169)	0.0019 (0.586)	0.0032 (0.367)	0.0009 (0.814)	0.0017 (0.610)	−0.0004 (0.895)	0.0067 (0.260)
HUMAN	−0.0314 (0.356)	−0.079 ** (0.013)	−0.0288 (0.424)	−0.08 ** (0.015)	−0.0545 (0.111)	−0.072 ** (0.024)	−0.0034 (0.895)	−0.0041 (0.885)	0.0009 (0.814)	0.0020 (0.946)	−0.0029 (0.913)	0.0070 (0.751)
_cons	−24.16 *** (0.000)	−37.92 *** (0.000)	−20.35 *** (0.000)	−31.72 *** (0.000)	−29.67 *** (0.000)	−28.59 *** (0.000)	3.2707 (0.401)	1.6263 (0.654)	0.0029 (0.911)	0.9991 (0.779)	3.1748 (0.415)	−1.1360 (0.582)
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared							0.0833	0.0760	0.0711	0.0773	0.0953	0.0998

Note: DK is shown for Driscoll–Kraay standard errors; ***, **, and *, respectively, as the significant level of 1%, 5%, and 10%; × refers to interaction operation. Source: Authors' analysis.

Table 10. Regression results for Equation (3).

Variable	FGLS	FGLS	FGLS	FGLS	FGLS	FGLS	DK	DK	DK	DK	DK	DK
GN	omitted	omitted	omitted	omitted	omitted	omitted	omitted	omitted	omitted	omitted	omitted	omitted
GN × COP	−0.0238 (0.297)	0.0144 (0.511)	−0.0131 (0.551)	0.0072 (0.752)	−0.0148 (0.513)	−0.0218 (0.310)	−0.0238 (0.364)	0.0144 (0.549)	−0.0131 (0.683)	0.0072 (0.768)	−0.0148 (0.569)	−0.0218 (0.410)
CC	−0.4319 (0.575)						−0.4319 (0.731)					
GE		−5.12 *** (0.000)						−5.12 *** (0.000)				
PS			2.33 *** (0.000)						2.33 *** (0.001)			
RQ				−3.53 *** (0.000)					−3.53 *** (0.002)			
RL					−2.43 *** (0.001)						−2.43 ** (0.015)	
VA						−2.8247 (0.000)						−2.82 *** (0.000)
GDP	11.28 *** (0.000)	15.77 *** (0.000)	9.77 *** (0.000)	14.41 *** (0.000)	13.02 *** (0.000)	11.70 *** (0.000)	11.28 *** (0.000)	15.77 *** (0.000)	9.77 *** (0.000)	14.41 *** (0.000)	13.02 *** (0.000)	11.70 *** (0.000)

Table 10. Cont.

Variable	FGLS	FGLS	FGLS	FGLS	FGLS	FGLS	DK	DK	DK	DK	DK	DK
<i>FDI</i>	−0.126 * (0.067)	−0.125 * (0.052)	−0.160 ** (0.016)	−0.0977 (0.144)	−0.123 * (0.068)	−0.0844 (0.197)	−0.1265 (0.174)	−0.1253 (0.151)	−0.160 * (0.091)	−0.0977 (0.283)	−0.1237 (0.176)	−0.0844 (0.283)
<i>TRADE</i>	−0.0021 (0.776)	0.017 ** (0.018)	−0.013 * (0.054)	0.0113 (0.126)	0.0034 (0.634)	−0.0099 (0.143)	−0.0021 (0.803)	0.017 ** (0.017)	−0.0136 (0.173)	0.0113 (0.192)	0.0034 (0.664)	−0.0099 (0.106)
<i>HUMAN</i>	−0.0430 (0.216)	−0.09 *** (0.005)	−0.08 ** (0.016)	−0.09 *** (0.005)	−0.06 ** (0.049)	−0.07 ** (0.024)	−0.043 * (0.091)	−0.09 ** (0.019)	−0.08 ** (0.026)	−0.09 *** (0.007)	−0.06 ** (0.014)	−0.07 *** (0.001)
_cons	−28.3 *** (0.000)	−41.9 *** (0.000)	−17.1 *** (0.000)	−36.4 *** (0.000)	−32.9 *** (0.000)	−27.8 *** (0.000)	−28.3 *** (0.000)	−41.9 *** (0.000)	−17.1 *** (0.000)	−36.4 *** (0.000)	−32.9 *** (0.000)	−27.8 *** (0.000)
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared							0.5435	0.5969	0.5748	0.5709	0.5546	0.5901

Note: DK is shown for Driscoll–Kraay standard errors; ***, **, and *, respectively, as the significant level of 1%, 5%, and 10%; × refers to interaction operation. Source: Authors' analysis.

Table 11. Regression results for Equation (4).

Variable	FGLS	FGLS	FGLS	FGLS	FGLS	FGLS	DK	DK	DK	DK	DK	DK
GN	−0.03 * (0.062)	−0.0178 (0.296)	−0.0168 (0.303)	−0.0237 (0.168)	−0.0282 * (0.098)	−0.0304 * (0.068)	−0.0315 (0.123)	−0.0178 (0.427)	−0.0168 (0.462)	−0.0237 (0.268)	−0.0282 (0.173)	−0.0304 (0.142)
CC	omitted						omitted					
GE	omitted						omitted					
PS	omitted						omitted					
RQ	omitted						omitted					
RL	omitted						omitted					
VA	omitted						omitted					
COP × CC	1.4135 ** (0.012)						1.4135 * (0.082)					
COP × GE	−2.102 *** (0.000)							−2.1028 * (0.082)				
COP × PS			2.549 *** (0.000)					2.549 *** (0.000)				
COP × RQ				−0.8812 (0.105)					−0.8812 (0.337)			
COP × RL						−0.0835 (0.889)					−0.0835 (0.932)	
COP × VA							−1.74 *** (0.000)					
GDP	8.35 *** (0.000)	10.40 *** (0.000)	8.63 *** (0.000)	9.64 *** (0.000)	9.17 *** (0.000)	9.18 *** (0.000)	8.35 *** (0.000)	10.40 *** (0.000)	8.63 *** (0.000)	9.64 *** (0.000)	9.17 *** (0.000)	9.18 *** (0.000)
FDI	−0.136 ** (0.036)	−0.1171 * (0.069)	−0.150 ** (0.016)	−0.1157 * (0.076)	−0.1241 * (0.057)	−0.1089 * (0.089)	−0.1363 (0.159)	−0.1171 (0.208)	−0.1507 (0.120)	−0.1157 (0.206)	−0.1241 (0.191)	−0.1089 (0.182)
TRADE	−0.0011 (0.867)	0.0095 (0.150)	−0.0068 (0.277)	0.0055 (0.401)	0.0027 (0.671)	−0.0007 (0.912)	−0.0011 (0.889)	0.0095 (0.169)	−0.0068 (0.426)	0.0055 (0.445)	0.0027 (0.704)	−0.0007 (0.903)
HUMAN	−0.0443 (0.114)	−0.0630 ** (0.023)	−0.087 *** (0.001)	−0.0613 ** (0.031)	−0.0535 * (0.058)	−0.0693 ** (0.013)	−0.044 ** (0.048)	−0.063 ** (0.017)	−0.08 *** (0.001)	−0.06 *** (0.009)	−0.053 ** (0.021)	−0.06 *** (0.000)
_cons	−16.6 *** (0.000)	−23.2 *** (0.000)	−12.5 *** (0.000)	−20.4 *** (0.000)	−19.1 *** (0.000)	−17.9 *** (0.000)	−16.6 *** (0.001)	−23.2 *** (0.004)	−12.5 *** (0.000)	−20.4 *** (0.002)	−19.1 *** (0.002)	−17.9 *** (0.001)
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared							0.5049	0.5103	0.5368	0.5019	0.4997	0.5156

Note: DK is shown for Driscoll–Kraay standard errors; ***, **, and *, respectively, as the significant level of 1%, 5%, and 10%; × refers to interaction operation. Source: Authors' analysis.

Table 12. Regression results for Equation (5).

Variable	FGLS	FGLS	FGLS	FGLS	FGLS	FGLS	DK	DK	DK	DK	DK	DK
<i>GN</i>	−0.150 *** (0.000)	−0.0611 ** (0.040)	−0.056 ** (0.024)	−0.08 *** (0.005)	−0.071 ** (0.014)	−0.0033 (0.908)	0.0041 (0.750)	0.0117 (0.305)	−0.0101 (0.413)	0.0073 (0.633)	0.0097 (0.563)	−0.0030 (0.792)
<i>CC</i>	1.1820 (0.153)							−1.2749 (0.222)				
<i>GE</i>	−3.802 *** (0.000)								−1.1489 (0.105)			

Table 12. Cont.

Variable	FGLS	FGLS	FGLS	FGLS	FGLS	FGLS	DK	DK	DK	DK	DK	DK
PS			3.379 *** (0.000)						0.3028 (0.360)			
RQ				−2.095 *** (0.004)						−1.1412 (0.157)		
RL					−1.1034 (0.193)						−2.179 ** (0.023)	
VA						−3.116 *** (0.000)						2.0134 (0.103)
GN × COP × CC	−0.167 *** (0.000)						0.0265 (0.222)					
GN × COP × GE		−0.126 *** (0.000)						0.0269 ** (0.038)				
GN × COP ×			−0.062 *** (0.001)						−0.0121 (0.126)			
GN × COP × RQ				−0.124 *** (0.000)						0.0140 (0.465)		
GN × COP × RL					−0.086 *** (0.002)						0.0417 ** (0.043)	
GN × COP × VA						0.0187 (0.360)						−0.0330 (0.160)
GDP	10.16 *** (0.000)	14.68 *** (0.000)	9.28 *** (0.000)	13.17 *** (0.000)	11.99 *** (0.000)	11.81 *** (0.000)	1.422 ** (0.019)	1.85 *** (0.000)	1.71 *** (0.002)	1.85 *** (0.001)	1.538 ** (0.011)	2.37 *** (0.000)
FDI	−0.1462 ** (0.030)	−0.1376 ** (0.031)	−0.1544 ** (0.019)	−0.1238 * (0.060)	−0.1362 ** (0.043)	−0.0780 (0.235)	0.0273 (0.195)	0.0246 (0.236)	0.0300 (0.162)	0.0296 (0.175)	0.0183 (0.319)	0.0232 (0.137)
TRADE	−0.0078 (0.291)	0.0110 (0.130)	−0.0145 ** (0.037)	0.0040 (0.587)	−0.0006 (0.932)	−0.0093 (0.169)	0.0019 (0.586)	0.0032 (0.367)	0.0009 (0.814)	0.0017 (0.610)	−0.0004 (0.895)	0.0067 (0.260)
HUMAN	−0.0314 (0.356)	−0.0796 ** (0.013)	−0.0288 (0.424)	−0.0828 ** (0.015)	−0.0545 (0.111)	−0.0727 ** (0.024)	−0.0034 (0.895)	−0.0041 (0.885)	0.0029 (0.911)	0.0020 (0.946)	−0.0029 (0.913)	0.0070 (0.751)
_cons	−24.16 *** (0.000)	−37.92 *** (0.000)	−20.35 *** (0.000)	−31.72 *** (0.000)	−29.67 *** (0.000)	−28.59 *** (0.000)	3.2707 (0.401)	1.6263 (0.654)	1.6079 (0.666)	0.9991 (0.779)	3.1748 (0.415)	−1.1360 (0.582)
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared							0.0833	0.0760	0.0711	0.0773	0.0953	0.0998

Note: DK is shown for Driscoll–Kraay standard errors; ***, **, and *, respectively, as the significant level of 1%, 5%, and 10%; × refers to interaction operation. Source: Authors' analysis.

Therefore, we used the FGLS regression method to solve the problem of heteroscedasticity or autocorrelation, and the results are shown in Tables 8–12. We also checked the robustness using Driscoll–Kraay regression, and this method is suitable for assessing the cross-sectional dependence among countries in the region. The regression results are as follow.

It is evident that the FGLS regression method is appropriate for panel data. For the robustness test, using Driscoll–Kraay regression is suitable for assessing the cross-sectional dependence among countries in the region. The purpose of employing both estimators was not to identify a “better” model, but rather to assess the robustness of the empirical findings under different estimation frameworks. The consistency of the estimated coefficients across the two approaches strengthens confidence in the stability of the results. Nevertheless, we place greater emphasis on the Driscoll–Kraay estimates because this estimator provides standard errors that are robust to heteroskedasticity, serial correlation, and cross-sectional dependence, all of which are present in our panel dataset. In contrast, although FGLS improves estimation efficiency under specific variance–covariance assumptions, its statistical inference may become less reliable when these assumptions are violated. The regression results are as follows.

The regression coefficient of GN, in most cases, is not statistically significant, implying that renewable energy use has no evidence of impact on carbon emissions in the common sample of all selected countries, which could be explained by the fact that the contribution of renewable energy to total energy demand in Asian countries is still low. The research

results also confirmed that green energy consumption has no impact on the environment in the context of implementing carbon emission reduction policies introduced since COP2. Because Asian countries have a high level of population concentration and rapid economic development, they have a great demand for energy, and fossil fuel sources are still relatively cheap, so they remain more popular in these countries. To meet energy demand, fossil energy is still the top choice in these countries, while renewable energy sources have not expanded significantly across the region. Similarly, Chen et al. [3] argued that some economies still have to use traditional energy sources, such as fossil fuels, to meet high domestic energy demand, including China. Rahman & Alam [1] also confirmed that the industrialization process requires countries to increase the use of non-renewable energy sources and may lead to increased carbon emissions in the initial period.

The study also suggests that institutional factors have an impact on carbon emissions, including government effectiveness (*GE*), political stability (*PS*), regulatory quality (*RQ*), rule of law (*RL*), and voice and accountability (*VA*), whereas control of corruption (*CC*) has no impact on the environment. An interesting finding is that the coefficient of control of corruption (*CC*) is statistically insignificant, whereas most of the remaining institutional indicators exhibit significant moderating effects. One possible explanation is that corruption control influences sustainable development indirectly by improving transparency and reducing resource misallocation, rather than directly enhancing renewable energy deployment. In contrast, institutional dimensions such as government effectiveness, regulatory quality, and the rule of law exert a more immediate influence by strengthening policy implementation, improving regulatory certainty, and fostering investor confidence. Moreover, the relatively persistent nature of corruption and the limited within-country variation in the *CC* indicator during the study period may weaken its estimated statistical effect. Therefore, the insignificant coefficient should not be interpreted as evidence that corruption control is unimportant; instead, it suggests that its contribution may operate through longer-term institutional improvements or complementary governance reforms. The study also found that increased government effectiveness (*GE*), regulatory quality (*RQ*), rule of law (*RL*), and voice and accountability (*VA*) have the potential to reduce pollution. These findings indicate that improved institutional quality can reduce environmental pollution and help economies move towards carbon neutrality and sustainable development. This result is also supported by Khan & Rana [9] and Zheng et al. [10], who argued that better institutional quality helps countries choose to reduce pollution emissions, while better institutional quality increases the mitigating effects of income, trade, and FDI on pollution emissions, thereby contributing to a cleaner environment. Sarkodie & Adams [23] also affirmed that institutional quality plays a huge role in social, governance, and economic readiness to mitigate climate change and its impacts, and has an impact on environmental quality.

Specifically, political stability has a positive impact on the likelihood of pollution, meaning that countries with high levels of political stability often have higher levels of pollution, as is typically the case in socialist countries like China. At the same time, the study also showed that green energy consumption has the potential to increase pollution levels in countries with high levels of political stability, including under the implementation of the Paris Agreement COP21. The Paris Agreement adopted solutions to reduce carbon emissions that cause the greenhouse effect. These findings suggest that countries with high levels of political stability often have higher levels of emissions, which may be explained by the fact that countries with high levels of political stability are often able to create an attractive investment environment and have comparative advantages in attracting domestic and foreign investment capital. The research results also suggested that economic growth has the effect of increasing environmental pollution, but improving human capital reduces environmental pollution and promotes sustainable development.

5. Conclusions

Since the Paris Agreement was adopted, many countries have committed to reducing carbon emissions causing the greenhouse effect, and it can be said that the spirit of the Paris Agreement continues to be upheld today. Using data from 29 selected Asian countries across Southeast Asia, South Asia, East Asia, and the Middle East during the period 1970 to 2021, and using the FGLS analysis method and, especially, cross-sectional analysis using Driscoll–Kraay standard errors, the research results suggest that green energy consumption has no impact on the environment, even in the context of the implementation of COP commitments. Improvements in institutional quality can enhance environmental quality and accelerate progress toward carbon neutrality and net-zero emissions goals. The study also suggests that increased government effectiveness (*GE*), regulatory quality (*RQ*), rule of law (*RL*), and voice and accountability (*VA*) have the potential to reduce pollution, thereby confirming that improving institutional quality has the potential to improve environmental quality and move countries faster towards carbon neutrality and net-zero goals.

The study has a number of policy implications for countries, especially in Asia. First, countries should improve institutional quality, especially government effectiveness (*GE*), regulatory quality (*RQ*), rule of law (*RL*), and voice and accountability (*VA*), to further improve environmental quality, helping them the country quickly become carbon neutral and achieve the net-zero goal in the near future. Second, in addition to using fossil energy sources to meet short-term energy consumption needs, countries need to accelerate the transition to green energy to support cleaner production activities and promote sustainable development.

Due to data limitations, alternative environmental indicators such as nitrous oxide emissions, F-gases emissions from industrial processes, or methane emissions were not included in this research. This provides a potential direction for future research.

Although this study recognizes the potential for endogeneity, particularly the possibility of reverse causality whereby higher carbon emissions may induce governments to strengthen renewable energy policies, several considerations help mitigate this concern. First, the empirical models include a comprehensive set of macroeconomic control variables, including economic growth, foreign direct investment, trade openness, and human capital, which helps reduce omitted-variable bias. Second, the robustness of the findings is confirmed using alternative estimators, namely Driscoll–Kraay and FGLS, suggesting that the estimated relationships are not driven by a particular estimation technique. Nevertheless, endogeneity cannot be completely ruled out, and future research may employ instrumental-variable approaches or dynamic panel estimators such as System GMM to provide stronger causal identification.

Despite providing evidence from a heterogeneous sample of Asian economies, this study does not explicitly classify developing countries according to different institutional structures. While the use of a heterogeneous sample enhances the generalizability of the findings, it may mask country-group-specific institutional dynamics. Future studies may therefore classify economies based on governance quality, institutional capacity, or income level to investigate whether the impacts of renewable energy and institutional quality differ across institutional contexts and to develop more tailored policy recommendations.

Some potential future research directions include differentiating between stages of renewable energy development, variations in industrial structure, the regulatory role of environmental regulations, green investment, and long-term transition policies. However, detailed analyses of these cross-country, stage-specific, and sector-specific differences require more data, as the stages of renewable energy development differ across countries and do not necessarily correspond to a single benchmark such as COP2. Moreover, the

industrial structure and environmental policies adopted in each country also differ, posing significant obstacles to conducting such analyses.

Author Contributions: Conceptualization, T.T.N.; methodology, T.T.N., T.H.P.T. and V.H.V.; software, T.T.N. and V.C.N.; validation, V.C.N.; formal analysis, T.H.P.T.; investigation, V.H.V.; resources, T.H.P.T.; data curation, T.T.N. and T.H.N.; writing—original draft preparation, V.C.N.; writing—review and editing, T.T.N. and T.H.N.; visualization, T.H.P.T. and V.H.V.; supervision, T.H.P.T., V.H.V. and T.H.N.; project administration, V.H.V.; funding acquisition, V.C.N. 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 that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare that we have no competing interests.

References

1. Rahnam, M.M.; Alam, K. Impact of Industrialization and Non-Renewable Energy on Environmental Pollution in Australia: Do Renewable Energy and Financial Development Play a Mitigating Role? *Renew. Energy* **2022**, *195*, 203–213. [CrossRef]
2. Rafiq, S.; Paramati, S.R.; Alam, M.S.; Hafeez, K.; Shafiullah, M. Does Institutional Quality Matter for Renewable Energy Promotion in OECD Economies? *Int. J. Financ. Econ.* **2025**, *30*, 477–492. [CrossRef]
3. Chen, X.X.; Tee, K.; Elnahass, M.; Ahmed, R. Assessing the Environmental Impacts of Renewable Energy Sources: A Case Study on Air Pollution and Carbon Emissions in China. *J. Environ. Manag.* **2023**, *345*, 118525. [CrossRef] [PubMed]
4. Zheng, Z.; Zhe, L.; Huihui, W. The Relationship Between Institutional Quality, Renewable Energy Investment, Financial Development, and Ecological Hazards: Evidence from ASEAN Countries. *J. Knowl. Econ.* **2026**, *17*, 2153–2181. [CrossRef]
5. Net Zero by 2050—Analysis. Available online: <https://www.iea.org/reports/net-zero-by-2050> (accessed on 30 June 2026).
6. ADB. Climate Change in Asia and the Pacific by the Numbers. 2012. Available online: <https://www.adb.org/news/features/climate-change-asia-and-pacific-numbers> (accessed on 20 May 2026).
7. Ritchie, H. Who Emits the Most CO₂ Today? 2019. Available online: <https://ourworldindata.org/annual-co2-emissions#article-citation> (accessed on 15 May 2026).
8. Li, C.; Lin, T.; Chen, Y.; Yan, Y.; Xu, Z. Nonlinear Impacts of Renewable Energy Consumption on Economic Growth and Environmental Pollution across China. *J. Clean. Prod.* **2022**, *368*, 133183. [CrossRef]
9. Khan, M.; Rana, A.T. Institutional Quality and CO₂ Emission–Output Relations: The Case of Asian Countries. *J. Environ. Manag.* **2021**, *279*, 111569. [CrossRef] [PubMed]
10. Zheng, L.; Umar, M.; Safi, A.; Khaddage-Soboh, N. The Role of Higher Education and Institutional Quality for Carbon Neutrality: Evidence from Emerging Economies. *Econ. Anal. Policy* **2024**, *81*, 406–417. [CrossRef]
11. Hansen, A. The Socialist Market Economy in China, Vietnam and Laos: A Development Model to Embrace? In *Developing Economics*; Springer Nature: Cham, Switzerland, 2020.
12. Perone, G. The Relationship between Renewable Energy Production and CO₂ Emissions in 27 OECD Countries: A Panel Cointegration and Granger Non-Causality Approach. *J. Clean. Prod.* **2024**, *434*, 139655. [CrossRef]
13. Akram, R.; Chen, F.; Khalid, F.; Ye, Z.; Majeed, M.T. Heterogeneous Effects of Energy Efficiency and Renewable Energy on Carbon Emissions: Evidence from Developing Countries. *J. Clean. Prod.* **2020**, *247*, 119122. [CrossRef]
14. Liu, X.; Zhang, S.; Bae, J. The Impact of Renewable Energy and Agriculture on Carbon Dioxide Emissions: Investigating the Environmental Kuznets Curve in Four Selected ASEAN Countries. *J. Clean. Prod.* **2017**, *164*, 1239–1247. [CrossRef]
15. Shahbaz, M.; Nwani, C.; Bekun, F.V.; Gyamfi, B.A.; Agozie, D.Q. Discerning the Role of Renewable Energy and Energy Efficiency in Finding the Path to Cleaner Consumption and Production Patterns: New Insights from Developing Economies. *Energy* **2022**, *260*, 124951. [CrossRef]
16. Liobikienė, G.; Butkus, M. Determinants of Greenhouse Gas Emissions: A New Multiplicative Approach Analysing the Impact of Energy Efficiency, Renewable Energy, and Sector Mix. *J. Clean. Prod.* **2021**, *309*, 127233. [CrossRef]
17. Huang, Y.; Xue, L.; Khan, Z. What Abates Carbon Emissions in China: Examining the Impact of Renewable Energy and Green Investment. *Sustain. Dev.* **2021**, *29*, 823–834. [CrossRef]
18. Tampubolon, F.R.S.; Yuwono, A.S.; Tambunan, A.H.; Achsani, N.A. Renewable Energy Consumption and Its Environmental Impacts: A Meta-Regression Analysis. *Environ. Qual. Manag.* **2023**, *32*, 43–55. [CrossRef]
19. He, Y. Energy Policy Strategies for Cleaner Production: The Roles of Renewable Energy and Green Innovation. *Energy Policy* **2026**, *213*, 115214. [CrossRef]

20. Román, Á.F.G.; Kabir, G. Assessing Carbon Dioxide Emissions in Manufacturing Industries: A Systematic Review. *Energies* **2024**, *17*, 5119. [[CrossRef](#)]
21. Sun, L.-L.; Cui, H.-J.; Ge, Q.-S. Will China Achieve Its 2060 Carbon Neutral Commitment from the Provincial Perspective? *Adv. Clim. Change Res.* **2022**, *13*, 169–178. [[CrossRef](#)]
22. Goel, R.K.; Herrala, R.; Mazhar, U. Institutional Quality and Environmental Pollution: MENA Countries vs. the Rest of the World. *Econ. Syst.* **2013**, *37*, 508–521. [[CrossRef](#)]
23. 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](#)] [[PubMed](#)]
24. Simionescu, M.; Plopeanu, A.P. Impact of Governance Quality on Pollution in Nuclear Energy Consuming Countries in the European Union. *Energy Rep.* **2023**, *9*, 4122–4134. [[CrossRef](#)]
25. Khan, A.A.; Khan, S.U.; Ali, M.A.S.; Safi, A.; Gao, Y.; Ali, M.; Luo, J. Role of Institutional Quality and Renewable Energy Consumption in Achieving Carbon Neutrality: Case Study of G-7 Economies. *Sci. Total Environ.* **2022**, *814*, 152797. [[CrossRef](#)] [[PubMed](#)]
26. Karim, S.; Appiah, M.; Naeem, M.A.; Lucey, B.M.; Li, M. Modelling the Role of Institutional Quality on Carbon Emissions in Sub-Saharan African Countries. *Renew. Energy* **2022**, *198*, 213–221. [[CrossRef](#)]
27. 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](#)]
28. Yin, F.; Ibrahim, R.L.; Alomair, A. Governing the Green Transition: How Institutional Quality Conditions Renewable Energy's Sustainability Impacts in BRICS and MENA. *Environ. Policy Gov.* **2026**, *36*, 568–593. [[CrossRef](#)]
29. Danquah, D.A.; Pavis-Djre, P.K. Environmental Taxation, Institutional Quality and Trade Development Nexus in Sub-Saharan Africa. *J. Trade Sci.* **2026**, *14*, 127–149. [[CrossRef](#)]
30. Stef, N.; Başağaoğlu, H.; Chakraborty, D.; Ben Jabeur, S. Does Institutional Quality Affect CO₂ Emissions? Evidence from Explainable Artificial Intelligence Models. *Energy Econ.* **2023**, *124*, 106822. [[CrossRef](#)]
31. Jahanger, A.; Usman, M.; Balsalobre-Lorente, D. Linking Institutional Quality to Environmental Sustainability. *Sustain. Dev.* **2022**, *30*, 1749–1765. [[CrossRef](#)]
32. Yaman, İ.; Cetin, M. Revisiting the Institutional Quality-Environmental Pollution Nexus in Developing Countries. *Sage Open* **2025**, *15*, 6509. [[CrossRef](#)]
33. Mahmud, B.; Deni, K. The Impact of Institutional Quality on Carbon Dioxide Emission: A Case Study in Asia-Pacific Countries. *Int. J. Econ. Dev. Res.* **2024**, *5*, 4733–4752. [[CrossRef](#)]
34. Nguyen, Y. Exploring the Relationships among Institutional Quality, Financial Development, and Environmental Pollution in Developing Countries. *Inst. Econ.* **2026**, *18*, 57–84. [[CrossRef](#)]
35. Nguyen, V.C.; Huynh, T.N.T. Characteristics of the Board of Directors and Financial Performance of the Company—Empirical Evidence. *Economics* **2023**, *11*, 53. [[CrossRef](#)]
36. Van, N.C. The Impact of Financial Development on Renewable Energy Consumption: The Case of Vietnam and Other ASEAN Members. *Int. J. Financ. Stud.* **2024**, *12*, 37. [[CrossRef](#)]
37. Hoechle, D. Robust Standard Errors for Panel Regressions with Cross-Sectional Dependence. *Stata J.* **2007**, *7*, 281–312. [[CrossRef](#)]
38. Tran, V.T.; Ly, P.C.; Ngo, N.N.T.; Tran, P.H.; Nguyen, V.C. Factor Affecting the Implementation of Responsibility Accounting on Firm Performance—Empirical Analysis of Listed Textile Firms. *Cogent Bus. Manag.* **2022**, *9*, 2032912. [[CrossRef](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.