Renewable Energy and Green Innovation: A Review of the Mitigation Strategies for Climate Change through Reduced Carbon Emissions

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Abstract

The core purpose of the study to investigate the asymmetric effects of Renewable Energy, Green Innovation, GDP and Digital Finance on CO_2 in Pakistan. The study covered the time period 1990 to 2021. This paper examines and synthesizes existing theoretical and empirical literature on said issue. It first draws the overview of the Renewable Energy, Green Innovation, GDP and Digital Finance on CO_2 in Pakistan. Second, it identifies the literature based on the theoretical and empirical insights from the published literature. In addition, this article put light on theoretical methods that describes how/ why these methods work. Third, this article proposes three fruitful dimensions for further research. This paper contributes to the area of Renewable Energy, Green Innovation, GDP and Digital Finance on CO_2 in Pakistan by critically analysing and synthesizing existing theory and research on Renewable Energy, Green Innovation, GDP and Digital Finance on CO_2 in Pakistan.

Keywords: Renewable Energy, Green Innovation, CO_2

1. Introduction

Since efforts to lessen the phenomenon's harmful effects have been made, there has been a noticeable global surge in concern for a sustainable environment in the twenty-first century. This problem mostly stems from the excessive emissions of greenhouse gases, particularly carbon dioxide (CO2), into Earth's atmosphere (Awan, Rahman, Ali, & Zafar, 2023; Ivic, 2023; Seyboth, 2013). Deforestation, industrial activity, and the burning of fossil fuels are the primary human-caused sources of CO2 emissions, which play a major role in the current climate calamity. Researchers and decision-makers are trying to pinpoint the causes of environmental degradation due to the growing trend of environmental deterioration and the depletion of world resources. Several studies have assessed the degree of pollution in the environment by taking into account a range of factors, such as CO2 emissions, a significant greenhouse gas (GHG) that is essential to climate change and global warming (Chaudhary, Nasir, ur Rahman, & Sheikh, 2023; Godil, Sharif, Agha, & Jermsittiparsert, 2020). One of the main goals of modern practices and research, which aims to minimize CO2 emissions to improve the quality of life on Earth, is maintaining a constant level of emissions. Pakistan has been the sixth most affected country by climate change over the previous 20 years, according to the German Watch Report of 2019 (Dawood, ur Rehman, Majeed, & Idress, 2023; Tanveer, Song, Faheem, Daud, & Naseer, 2021; Ali et al., 2021). Significant factors influencing environmental quality include energy use, financial sector development, FDI inflow, and economic expansion (Fatima, Jamshed, Tariq, & Rahman, 2023; H. Khan, Weili, & Khan, 2022; Ali & Audi, 2016; Ali et al., 2021; Audi & Ali, 2017).

One of the developing countries where most people still cook using traditional methods is Pakistan, where this has resulted in a sharp rise in carbon emissions into the atmosphere. In the 19th century, for instance, there was a range of 260 to 290 parts per million of carbon emissions. However, the situation has completely changed due to the rapid growth in CO2 emissions, which have now exceeded 386 items per million annually and have a mean concentration greater than two components per million (Ates, 2023; Shahzad, Ferraz, Nguyen, & Cui, 2022; Usman, Rahman, Shafique, Sadiq, & Idrees, 2023). Pakistan's vulnerability to environmental pollution has raised awareness of it throughout the world. The transportation and energy sectors are the two primary contributors of pollution, contributing to half of all pollution. Pakistan has CO2 emissions that (Farooq, Ozturk, Majeed, & Akram, 2022; Shafqat, Idrees, Zaman, & Ghaffar, 2023; Audi et al., 2020; Ali et al., 2022).

The influence of green money on environmental pollution is significant. As a result, financial actions might be very helpful in stopping deforestation. Effective governance is becoming increasingly important since it has been shown to have a positive and significant impact on the environment (Cadman & Sarker, 2022; Ilyas-Lecturer, Awan, Kanwal-Lecturer, & Banaras, 2023). The current economic measures, which include taxes, levies, and other financial penalties, are insufficient to address the environmental crisis. In a subsequent study, (Ilyas, Banaras, Javaid, & Rahman, 2023; Postula & Radecka-Moroz, 2020) examined the financial strategies used to slow down environmental degradation, even if government spending and taxes constituted the two most important budgetary tools. Second Chinese research that looked at the several ways the framework influences environmental integrity was explored by (Feng, Du, Lin, & Zuo, 2020; S. M. Khan & Saif-ur-Rehman; Audi & Ali, 2023).

Pakistan was one of the top 10 countries most negatively affected by climate change in the last 20 years. Over the previous ten years, Pakistan's annual CO2 emissions per person have increased by an average of 3% (Mukhtar et al., 2023; Shahzadi, Sheikh, Sadiq, & Rahman, 2023). Researchers from Pakistan have come to several conclusions about the relationship between increased economic activity and increased emissions of carbon dioxide. Considering many studies' findings (Khaskheli, Wang, Yan, & He, 2023; Nawaz, Rahman, Zafar, & Ghaffar, 2023). Pakistan's rising GDP is the cause of the country's rising CO2 emissions, according to (Jamil et al., 2021; Qadri et al; Audi & Ali, 2023; Ashiq et al., 2023)

The CO2 volume in the atmosphere is sustained by both natural and human-based sources, including economic activities, social welfare programmes, infrastructure development, and household duties. These human-generated sources include of warmth, lighting, and among other things, heating and cooling buildings, running electrical appliances, and a variety of manufacturing, construction, servicing, and information and communication technologies (Hartani, Haron, & Tajuddin, 2021; Shahid, Gurmani, Rehman, & Saif, 2023). Each of these processes involves some degree of energy consumption, which is the primary source of CO2 emissions (Shahzadi, Ali, Ghafoor, & Rahman, 2023; Shibli, Saifan, Ab Yajid, & Khatibi, 2021). A few examples of green initiatives are green finance, eco-innovation, GDP and the consumption of renewable energy (RE), and digital finance.

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Green finance refers to the financial resources used by both public and commercial organizations to prevent environmental deterioration, eco-innovation, or the environmentally friendly enhancement of products and processes, RE output and consumption, and the improvement of the aforementioned human habits while utilizing less energy. Therefore, it is possible to limit CO_2 emissions and their effects (Stagakis, Chrysoulakis, Spyridakis, Feigenwinter, & Vogt, 2019; Zhang, Li, Sadiq, & Chien, 2023)

The remainder of the paper is organized as follows: the model and the empirical results are presented in the fourth section, the technique is the subject of the third section, and the pertinent literature is presented in the second section. Ultimately, a brief synopsis and conclusions are presented in the final section.

1.1. Problem Statement

Concern for a sustainable environment in the twenty-first century has noticeably increased globally as steps have been taken to mitigate the phenomenon's negative impacts. The primary cause of this issue is the overabundance of greenhouse gas emissions into Earth's atmosphere, especially carbon dioxide (CO_2) (Ivic, 2023; Seyboth, 2013; Shahzadi, Sheikh, et al., 2023). Fossil fuel combustion, deforestation, and industrial activity are the main human-caused sources of CO_2 emissions, which are a key contributing factor to the current climate catastrophe. Due to the global resource depletion and the growing trend of environmental deterioration, researchers and decision-makers are attempting to identify the causes of environmental degradation. Numerous studies have evaluated the level of environmental pollution by accounting for various aspects, including CO_2 emissions, a noteworthy greenhouse gas (GHG) that is crucial for climate change and global warming (Godil et al., 2020; Tabassum, Rahman, Zafar, & Ghaffar, 2023). As per the German Watch Report of 2019, Pakistan has been the sixth most affected country by climate change over the past two decades (Tanveer et al., 2021; Ullah, ur Rahman, & Rehman, 2023). Environmental quality is significantly influenced by energy use, financial sector development, foreign direct investment, and economic expansion (H. Khan et al., 2022; Usman et al., 2023).

- To look into how green innovation and renewable energy asymmetries affect Pakistan's CO_2 emissions.
- To examine the impact of GDP on CO_2 emissions in Pakistan

2. Literature Review

The first component of this section deals with Renewable Energy and CO_2 emission, the second section deals with GDP and CO_2 emission, while the last part summarizes the research gaps and offers the contributions of the study.

2.1. Renewable Energy and CO2 emission

Concerns about climate change and the need to switch to sustainable energy sources have led to a surge in interest in the link between CO_2 emissions and renewable energy. The main conclusions from academic papers, studies, and reports that examine the relationship between the use of renewable energy sources and the decrease of CO_2 emissions are summarized in this review of the literature. The effect of deploying renewable energy on reducing CO_2 emissions at different scales from national to global assessments has been the subject of numerous research. For example, (Cheng, Ren, Wang, & Yan, 2019; Zahra, Nasir, Rahman, & Idress, 2023) discovered a consistent and statistically significant negative link between renewable energy usage and CO_2 emissions across different countries and areas after conducting a meta-analysis of 60 studies. Similarly, (Javaid, Noor, Hassan Iftikhar, Rahman, & Ali, 2023; B. Li & Haneklaus, 2021) showed through panel data analysis that a considerable reduction in CO_2 emissions occurs in both industrialized and developing nations when the proportion of renewable energy in the energy mix is increased. Technological advancements in renewable energy generation and storage have facilitated its integration into existing energy systems. For example, the rapid decline in the cost of solar photovoltaic (PV) and wind power technologies has made them increasingly competitive with fossil fuels (Zhao et al., 2023; Y. Zhu, Taylor, & Wang, 2022). As a result, many countries have experienced substantial increases in renewable energy capacity, leading to notable reductions in CO_2 emissions.

Non-renewable natural resources known as fossil fuels are thought to be the fastest source of energy. CO_2 emissions result from the energy-related usage of these resources, which is increasing the consumption of fossil fuels. On the other hand, using renewable energy sources does not result in the release of any substances that produce CO_2 (Hassan, Sheikh, & Rahman, 2022; Jebli, Farhani, & Guesmi, 2020; Moslehpour et al., 2022), When fossil fuel energy is substituted for the rising RE consumption, CO_2 emissions and other hazardous gases are reduced. (Bilan et al., 2019; Y. Khan, 2022), investigated the effects of RE consumption on CO_2 emissions and proposed that the increasing trend of RE usage for economic and residential purposes contributes to a decrease in the total demand for fossil fuels. It reduces the amount of carbon-containing fuels that, after burning, are likely to generate CO_2. Consequently, it is anticipated that as RE consumption rises, CO_2 emissions would fall. According to (Rehman, Ali, Idrees, Ali, & Zulfiqar, 2022; Saidi & Omri, 2020), there is a negative correlation between RE consumption and CO_2 emissions since countries with higher RE consumption emit fewer CO_2 emissions overall. The studied literature indicates a direct correlation between the use of renewable energy and the decrease of CO_2 emissions, which is reinforced by developments in technology, governmental interventions, and socioeconomic factors. To achieve long-term climate goals, it is still imperative to address the issues surrounding the integration of renewable energy sources and to guarantee that all people have fair access to sustainable energy.

2.2. GDP and CO2 emission

There has been much discussion and study on the complex relationship between economic growth, as indicated by GDP, and carbon dioxide (CO_2) emissions. The purpose of this review of the literature is to give a broad overview of the research that has been done on the relationship between GDP and CO_2 emissions. A deeper comprehension of the intricate interactions between environmental sustainability and economic development will result from the synthesis of research.

This overview of the literature summarizes our growing knowledge of the connection between GDP and CO_2 emissions. The results of this review highlight the need for contextualized and nuanced responses as the world community struggles with issues related to climate change and sustainable development. It is important for future studies to keep looking into new trends, technical advancements, and policy consequences in order to help shape methods for fostering economic growth without sacrificing environmental sustainability (Fávero, Souza, Belfiore, Luppe, & Severo, 2022; D. Li et al., 2022).

The complex relationship between GDP and carbon dioxide (CO_2) emissions has been a major area of study for economists and environmental scientists. The relationship between economic growth and rising emissions was first proposed by early viewpoints,

such as the Environmental Kuznets Curve hypothesis. Subsequent research examined sectoral contributions, causation relationships, and the effects of governmental interventions on this relationship. The quest of sustainable development has emerged as a major issue, exploring how countries might strike a balance between their desires for environmental preservation and economic growth (Bengochea-Morancho, Higón-Tamarit, & Martínez-Zarzoso, 2001; Bilal, Shah, Rahman, & Jehangir, 2022). Cross-national comparisons have added to the body of literature by illuminating the various worldwide experiences with GDP-CO2 emissions dynamics. The summary of these studies emphasizes the necessity of context-specific, nuanced techniques and ongoing investigation of new.

2.3. Green Innovation and CO2 emission

A nation's capacity for ecological innovation determines whether or not it can successfully make the transition from a dirty to a cleaner environment. Thus, (W. Ali, Abdullah, & Azam, 2016; Khoula, ur Rehman, & Idrees, 2022) examined how much technological innovation influences CO2 emissions in Malaysia while accounting for changes in the country's financial and economic systems. The result validated a negligible impact of technological progress on greenhouse gas emissions. While the EKC hypothesis was supported by the results of economic expansion, financial development slows down environmental damage. Similar research was conducted in (Yii & Geetha, 2017; Zulfiqar et al., 2022), who used the traditional ARDL and Toda and Yamamoto to examine how much technological innovation influences CO2 emissions in Malaysia. Their findings indicated that technological innovation improves environmental quality, while income and its square have opposing effects on CO2 emissions. The AMG and CCEMG estimate approach were among the state-of-the-art panel data methodologies employed by (Hafiza et al., 2022; Usman & Radulescu, 2022). Nuclear and renewable energy provide robust protection for environmental quality. The environment is harmed by technological progress, the use of natural resources, and non-renewable energy sources.

Technological innovation and the use of renewable energy both slow and accelerate environmental degradation, according to (Adebayo et al., 2021; Shahid, Muhammed, Abbasi, Gurmani, & ur Rahman, 2022) wavelet effect analysis of the relationship between these two factors and environmental degradation in Portugal. In order to determine the degree to which ecological innovation and financial development affect environmental degradation proxies by consumption and territory-based emissions, (Abbasi, Hussain, Haddad, Salman, & Ozturk, 2022) conducted a recent study in Pakistan using novel dynamic ARDL simulations. They found that financial development stimulates environmental degradation for both proxies. The results of the study, however, showed that ecological innovation slows down environmental deterioration.

(mWaheed Muhammad Waheed, 2022; Obobisa, Chen, & Mensah, 2022) focused on 25 African countries by utilizing augmented mean group and common correlated mean group to explore the effect of green technological innovation, renewable energy utilization, and institutional quality on CO2 emissions and established that green innovation, technological invention and renewable energy usage stimulate environmental quality. However, income, nonrenewable energy usage, and the institutional quality confirmed a disastrous influence on environmental quality. A similar recent study by (M. M. Rahman, Alam, & Velayutham, 2022; A. U. Shahid et al., 2022) in their attempt to study the extent to which technological innovation affects CO2 emissions in 22 countries in addition to renewable energy usage and export quality via the application of non-linear ARDL and established that negative shock of technological innovation, in the long run, stimulate CO2 emissions. But, the study found that renewable energy usage improves environmental quality. The outcome also documented that positive and negative shocks stimulate and retard CO2 emissions.

2.4. Digital Finance and CO2 emission

Academics have long recognized connections between environmental performance and financial development. Academics have long recognized connections between environmental performance and financial development (Grossman & Krueger, 1995; Shahbaz, Li, Dong, & Dong, 2022), and they contend that with lower financing costs, mature financial markets can offer environmental projects better financial backing. The literature claims that financial growth can, in theory, encourage business investment, draw in foreign capital, increase public awareness of environmental issues, and foster technical innovation (Sarwar, Ali, Bhatti, & ur Rehman, 2021; Sha, Zhang, Wang, & Xu, 2022), act as a catalyst for sustained growth and strengthen the impact of environmental regulations. Regulations also help emerging nations perform better environmentally in various ways, which lowers carbon emissions (S. u. Rahman, Chaudhry, Meo, Sheikh, & Idrees, 2022; Yuxiang & Chen, 2011).

The inclusiveness and precision of digital finance make financial services more accessible in small and medium-sized cities, bolstering the cities' industrial carrying capacity and encouraging the conversion of energy-intensive sectors into low-carbon, highly profitable, high-value industries (J. Li & Li, 2022; L. Zhu, Fang, Rahman, & Khan, 2023). Second, digital finance can increase the availability of financial services and effectively ease the financing constraints faced by small, medium, and microenterprises by relying on information technology to expand the sources used in risk assessments, tap into potential user needs, and improve the efficiency of risk pricing (Lu, Wu, Li, & Nguyen, 2022; Younas, Idrees, & Rahman, 2021). By doing this, digital finance lowers the region's carbon intensity and raises the region's overall economic efficiency. Furthermore, digital finance increases consumer demand, actively stimulates improvements to spending, and makes consuming more convenient (Shafique, Rahman, Khizar, & Zulfiqar, 2021; Song, Li, Wu, & Yin, 2020), so encouraging the growth of an ecosystem for green consumption. Over time, digital banking lowers the intensity of carbon emissions by facilitating household consumption, which in turn encourages businesses to increase their output and create agglomeration effects. Lastly, businesses can utilize digital finance to finance technical innovation, particularly the businesses on the tail of the financial risk distribution that have long faced discrimination from funding sources, including micro- and small-scale businesses, creative and innovative organizations, and individuals from other disadvantaged groups. Digital finance can stimulate the creation of new business models and service formats in addition to providing adequate funding for enterprise R&D and creative financing techniques. Digital money thus plays a significant role in enhancing regional ecological settings and can spur regional innovation and growth.

3. Methods

In order to gather and critically evaluate the pertinent literature for this study, the author followed the systematic literature review approach as outlined by (S. Ali, ur Rahman, & Anser, 2020; Lacey, Matheson, & Jesson, 2011), The focus of the paper, bibliographic

details, theory used (where applicable), research philosophy (Bakar, 2019; Zikmund, Babin, Carr, & Griffin, 2013), key findings, methodology, definition of renewable energy, green innovation, green finance, GDP & CO2 research context, geographical location of the study, theoretical and practical review, further conclusion, and reported limitations are all included in the critical review form that the author developed for a thorough and critical analysis of the prior studies.

From November 2017 to April 2018, the author searched the literature for the critical review of this work. The researcher evaluated the relevant papers downloaded from (1) Economics journals listed in the Clarivate analytics (The Master Journal List 2017 and JCR report 2016); (2) Comprehensive databases (Business Source Premier by Ebsco and Scopus); in order to find the most relevant papers possible. (3) Google Scholar; (4) a comprehensive cross-disciplinary CO2 bibliography published in several journals, with multiple references. The author developed the selection criteria for the literature for this study based on the following attributes: for example, the author excluded papers that did not deal with CO2 and that were not empirical or conceptual, such as books, comments, summaries of conference summaries.

4. Conclusion

After the critical review of the literature, it is concluded that, as compare to total value of Renewable energy, GDP, Green Finance & Digital Finance, both the negative and the positive effects are revealed. It is very much interesting to see both the findings are separately fill the gap in the literature. So, the effect of Renewable energy, GDP, Green Finance & Digital Finance on the CO2 Emission is still under discussion and various studies have been conducted to check the impact of Renewable energy, GDP, Green Finance & Digital Finance on the CO2 Emission. The current study made an effort to connect key ideas from the literature with topic-relevant contributions. Furthermore, this study's examination of the variables is lacking. As a result, the primary goal of the study is to present an understandable and thorough overview of earlier research on CO2, including contextual methodologies and practices.

5. Future Direction

There are two reasons why this literature review suggests more research. First off, the RDL model, OLS regression, and GMM method are employed in the majority of research conducted to examine CO2 emissions. It has been noted that only a small number of studies have used a dynamic vector error correction model (VCEM) to conduct the investigation during the literature review. In order to ensure that endogeneity and causation issues are addressed concurrently, the VCEM process helps to capture the time series dynamics under discussion appropriately. Furthermore, any potential indirect impacts and feedback are also recorded using the VECM process. Second, the research was done in the past and was compared to less developed nations while taking into account the economies of Southeast Asian nations like Malaysia and the US as well as the capital and growth in the manufacturing sector in Japan, France, Germany, and the UK. However, throughout South Asia, including Pakistan, not much research has been done.

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