

Governance and Green Finance: Examining Renewable Energy Investments for Carbon Reduction in Asian Economies

ABSTRACT

Introduction: This paper explores the relationship between renewable energy investments and governance in Asian countries, emphasizing the need to balance economic growth with environmental sustainability. As rapid industrialization and population growth heighten energy demand, Asian countries face unique challenges in reducing carbon emissions while continuing to develop economically. The study's primary objective is to analyze how renewable energy investments, moderated by governance quality, impact carbon reduction in the region. **Background:** Asian countries, especially major economies like China and India, contribute significantly to global carbon emissions. Despite contributing approximately 50% of global emissions, these countries also have immense potential to lead in sustainable practices due to their significant influence on both global GDP and environmental policies. Current pressures on nations to meet climate goals underscore the urgency of sustainable development in these regions. This paper addresses the research question: How does governance quality affect the success of renewable energy investments in reducing carbon emissions in Asian countries? **Recency:** The paper provides timely insights, utilizing data from 2019 to 2023, a period marked by substantial shifts in renewable energy policies and green financing mechanisms within Asia. Previous research often overlooks the complex and potentially nonlinear relationships between governance, green finance, and renewable energy investments, which this paper aims to explore in depth. **Research Methods:** The study uses a panel dataset covering Asian countries from 2019 to 2023, focusing on variables such as carbon emissions, renewable energy consumption, green finance, and government effectiveness. Advanced econometric tools, including Cross-Sectional Augmented Dickey-Fuller and Common Stochastic Trends tests, are employed to capture the dynamic interactions between these factors. These methods help reveal the nonlinear aspects of renewable energy investments, particularly how governance can amplify or limit the environmental benefits of such investments. The study's rigorous methodology allows for a detailed exploration of the complexities in Asia's transition to sustainable energy.

Keywords: *Sustainable development, Governance, Renewable energy investment, Asian*

INTRODUCTION

Over the past thirty years, the balance between economic growth and environmental sustainability has come under increasing scrutiny. The rapid economic growth of developing countries has led to an increase in emissions in Asia (Esquivias et al., 2022). With rapid industrialisation and growing populations, emerging economies face a unique paradox: how can they sustain their economic growth while reducing the environmental costs traditionally associated with such growth? (Tian et al., 2020). The focus of this issue is the transformational potential of renewable energy investments. This potential offers a ray of hope for a greener future (Yadav et al., 2024). The actual impact of these investments in lowering carbon emissions depends not only on financial resources, but also on the complex relationship between strong governance and targeted green financing. This study seeks to explore these dynamics in depth, offering a comprehensive perspective on the diverse strategies required for a successful energy transition in Asian countries.

Efforts to achieve economic growth, once seen as the cornerstone of national progress, are now fundamentally intertwined with the urgent need for effective environmental management (Halkos & Gkampoura, 2021). The selection of Asian countries for this study was based on their significant collective impact on the global economy and environment. Asian countries as a whole account for about 30-35% of the world's total GDP. China and India are the two major economic powers in Asia, with China accounting for more than 15% of global GDP. Other countries such as Japan, South Korea, and ASEAN members also contribute significantly to this figure. This growth path is accompanied by an

increase in energy demand, which is expected to increase by an average of 2.5% annually (GSR2022_Full_Report, n.d.).

In addition, Asian countries contribute about 50% of the world's total carbon dioxide emissions. China, as the largest emitter, accounts for about 28%, while India accounts for about 7%. This is particularly important given the increasing pressure on companies to contribute to national and regional climate change mitigation goals (Handoyo et al., 2024). Given their significant and growing influence on the global economy and environment, Asian countries are an important focus for analysing the dynamics of renewable energy investment, the interplay between governance and green finance, and their broader impacts on sustainable development and carbon emissions reduction (Handoyo et al., 2024).

Renewable energy investments can be a key foundation in this endeavour (Murshed, 2024). The transition from fossil fuels to renewable energy sources, such as solar and wind energy, provides a solution to reduce carbon emissions while promoting sustainable economic growth (Santosh et al., 2024). Research by (Chebotareva et al., 2020a) has emphasised the effectiveness of renewable energy investments in reducing the impacts of climate change, as well as identifying these investments as a key strategy in the global sustainability agenda. Compared to conventional energy, including fossil fuels, renewable energy is considered more sustainable, more efficient and more environmentally friendly (He et al., 2019). High energy consumption contributes to the development of green industries through structural effects, and plays a role in reducing greenhouse gas emissions (Zhang et al., 2022). Immediate action is needed to lower carbon and greenhouse gas emissions to ensure a comfortable life for humans in the future, given the environmental risks that have been seen over the past decades (Lin et al., 2022).

In addition, the existence of sustainable and adequate climate finance remains considered an important foundation for achieving significant carbon emission reductions. (Yuan et al., 2024) suggests that formal institutions governing government-led green finance policies can positively influence corporate environmental responsibility, supporting sustainable development, especially in the context of the 7th and 13th Sustainable Development Goals (SDGs). This synergy between good governance and green finance creates a foundation that supports effective renewable energy investment and positive environmental impact.

However, the success of renewable energy investments is not only determined by financial resources, but also relies heavily on effective governance interactions that support the implementation of policies and regulations appropriate to the energy project (Yadav et al., 2024). This complex relationship is critical to ensure that the investment not only grows, but also delivers the expected environmental benefits. (M. T. Huang & Zhai, 2021) observed that a strong policy framework, combined with a concerted whole-of-government approach, will be instrumental in driving the transition of sectors towards the stated goal of carbon neutrality.

The synergy between good governance and green finance is the foundation that enables successful renewable energy investments that have a positive impact on the environment. However, the success of renewable energy investments depends not only on financial resources, but also on governance policies that have a significant influence on environmental sustainability. This emphasises the need for effective governance frameworks to drive beneficial ecological outcomes. When examined further, the importance of good governance is seen in its ability to create a favourable environment for renewable energy projects. This includes not only policy-making, but also ensuring compliance and facilitating innovation in the renewable energy sector.

Recent studies have begun to unravel the diverse dynamics between renewable energy investment and carbon emissions, suggesting both linear and non-linear complex relationships. For example, research focussed on China shows that investments in renewable energy do not necessarily reduce carbon emissions (W. Chen et al., 2021). Similarly, analysis across five Asian countries from 1980 to 2018 shows the impact of foreign direct investment (FDI) and quality of governance on renewable energy consumption is positive, suggesting that increased FDI and improvements in governance will boost renewable energy consumption (Y. Huang et al., 2022). These findings emphasise the importance of exploring more than a linear relationship to fully understand the potential of renewable energy investment in reducing carbon emissions. As such, this research seeks to explore non-linear relationships, proposing that the impact of renewable energy investment on CO₂ emissions may experience diminishing returns or threshold effects at higher levels of investment, requiring more in-depth analysis to support effective policy formulation. Although existing research (S. Khan et al.,

2022; Shabir et al., 2022; Zheng & Jin, 2023) While these elements have been explored separately, the impact of climate finance in achieving carbon neutrality targets remains largely unexplored in research. Previous studies (F. Chen et al., 2022; Han et al., 2023; Zheng & Jin, 2023) also discusses the impact of government effectiveness on carbon emissions reduction. This study provides new insights into how the quality of governance and availability of green finance in Asian countries affect the effectiveness of renewable energy investments in reducing carbon emissions. This study addresses this gap by providing new insights into how the quality of governance and availability of green finance in Asian countries affect the effectiveness of renewable energy investments in reducing carbon emissions. By unravelling these dynamics, this study offers a deeper understanding of the multifaceted approach needed to achieve success in sustainable energy in Asian countries.

As such, this research underscores the complexity of these dual interactions, offering a comprehensive perspective that is important for the success of the energy transition in Asian countries. The research has two main objectives: first, to examine in depth the extent to which the effectiveness of renewable energy investments in reducing carbon emissions is affected by the strength of governance structures in these countries. Second, to study the role of green finance by investigating how its availability can amplify the positive impact of renewable energy investments under the moderation of good governance. This dual approach is not only innovative from an academic point of view, but also has significant practical implications. The research aims to equip policymakers and key stakeholders with information on whether the impact of renewable energy investments on CO₂ emissions increases or decreases at higher investment levels, potentially indicating diminishing returns or threshold effects. Recognising the importance of this research in the broader context of sustainable development, this study innovatively combines analyses of governance quality and the availability of green finance to evaluate their impact on the success of renewable energy investments in Asian countries. By exploring the synergistic effects of these two factors, this study not only fills a significant gap in the existing literature, but also offers practical insights for policymakers, investors and stakeholders looking to accelerate the transition to sustainable energy. The significance of this research lies in its potential to guide policy formulation, encourage sustainable investment practices, and ultimately contribute to global efforts to mitigate climate change. Through this exploration, the research aims to inspire a paradigm shift in approaches to renewable energy investment, highlighting the need for collaboration between governance structures and financial strategies to achieve sustainable development goals.

LITEATURE REVIEW

Asian countries are among the regions most affected by climate change globally, facing significant social and economic impacts over the past two decades. The region's rapid economic growth, accompanied by population increase, rapid urbanisation and industrialisation, has led to an ever-increasing surge in energy demand. In this context, efforts to reduce carbon emissions and increase the use of renewable energy are critical to achieving sustainability and reducing the risks faced due to climate change (ASEAN Renewables_Investment Opportunities and Challenges, n.d.). Initially, these countries focused on fossil fuel-dependent industrial growth, which resulted in significant contributions to greenhouse gas emissions. This prompted a re-evaluation of their energy strategies at the turn of the century, with more and more countries starting to adopt policies that favour the use of renewable energy and sustainability. This transformation is crucial to mitigating the impacts of climate change and achieving more ambitious emissions reduction targets (J. Chen et al., 2023). The global commitment to sustainable energy is further strengthened through collaboration at the regional and subregional levels, including within the framework of the Asia-Pacific Energy Forum. Members and associates of the UN Economic and Social Commission for Asia and the Pacific (ESCAP) have agreed to accelerate the achievement of Sustainable Development Goals (SDG) 7 targets, covering energy access, renewable energy use and energy efficiency. The initiative aims to ensure all countries in the region can implement sustainable energy solutions and contribute to global efforts to address the challenges of climate change (Roseberry, 2021). In assessing the impact of renewable energy investments on carbon emissions, Asian countries show a mixed picture. Research by (Chapungu et al., 2022) showed that India's investment in solar energy significantly reduced the country's carbon footprint, despite challenges in storage technology and grid integration. These findings are in line with analyses by (Song et al., 2022) on

China's renewable energy sector, emphasising its rapid expansion, but also pointing out problems with policy inconsistency and renewable energy infrastructure management. Both highlight the importance of integrated strategies and stable policies to achieve sustainability goals. (Quacoe et al., 2023) analyses the interaction between entrepreneurship and green growth through the Quintuple Helix Innovation Model, using Ordinary Least Squares (OLS) and Generalised Linear Models (GLM) techniques. This research emphasises the importance of prioritising entrepreneurship in supporting the transition to sustainable development. Findings indicate significant challenges in the speed and effectiveness of the renewable energy transition, underscoring the need for focused efforts to overcome barriers. With this approach, the researcher proposes a more holistic strategy to accelerate the integration of renewable energy in the green economy.

Governance plays a crucial role in formulating policies and attracting investment in the renewable energy sector, as recent studies have made clear. For example, a study by (Chebotareva et al., 2020b) highlights the impact of governance structures on the success and implementation of renewable energy initiatives. This research shows that a more solid policy framework and comprehensive regulatory process are needed to support an effective and sustainable energy transition.

The linkages between governance, renewable energy investment, green finance and CO₂ emissions have been documented in various literatures. Several previous studies have empirically assessed the potential of renewable energy in driving green growth using various proxy indicators of green growth. (Usman et al., 2021) explores the dynamic influence of financial development, trade openness, and non-renewable energy and renewable energy on CO₂ emissions covering the period 1990 to 2017. The empirical findings show that renewable energy significantly accelerates environmental improvement, while economic growth, trade openness, and non-renewable energy are more responsible for environmental deterioration in the long run. (Nyambuu & Semmler, 2020) proving that renewable energy can effectively address climate change issues with a dynamic growth model.

In addition to renewable energy, previous research has shown that good governance can help improve the quality of institutions. This can help green economic growth. (Murshed, 2024) explains that good governance has the effect of increasing the growth of economic output while reducing the growth rate of CO₂ emissions in N11 countries.

Moreover, as there is a link between globalisation and green growth, many studies have looked at how the influx of Foreign Direct Investment (FDI) and increased openness to international trade can affect the greening process in global economic growth. (A. Khan et al., 2021) used the generalised method of moments (GMM) to detect the effect of GDP, technological innovation, and foreign direct investment on renewable energy consumption. According to their results, technological innovation and GDP have a negative impact on renewable energy consumption, suggesting that the pollution haven hypothesis increases aggregate CO₂ emissions and harmful environmental degradation.

In the Indian context, research by (Shaktawat & Vadhera, 2021) shows that while the country has ambitious targets for renewable energy, governance incoherence at different levels of government is often an obstacle to achieving these targets. The research emphasises the importance of consistency in policy and inter-agency coordination to ensure that renewable energy initiatives are effectively realised. Similarly, in China, a study by (Xu et al., 2022) extending the analysis into practical applications in the renewable energy sector. This research focuses on a sample of companies in the geothermal, wind and solar energy industries to evaluate the factors that influence the performance and adoption of renewable energy technologies. The findings from this study provide insights into the challenges and opportunities companies face in implementing sustainable energy solutions.

(Lau et al., 2023) indicates a new but growing interest in green finance, with an emphasis on developing innovative financing mechanisms to support the growing renewable energy sector. These efforts aim to attract the investments needed to accelerate the transition to more sustainable and environmentally friendly energy sources. (Yafi et al., 2021) found that the promotion of green finance enhances corporate social responsibility, strengthens environmental protection, and helps companies plan the use of funds for environmental initiatives more effectively. In addition, it promotes the achievement of environmental, social, and governance (ESG) goals by supporting the implementation of environmentally friendly projects. As such, green finance contributes to sustainable development and creates synergies between corporate interests and environmental sustainability. (Dafermos & Nikolaidi, 2021) found that green differentiated capital affects the transmission channels of credit supply and lending spreads in a dynamic framework. Green funds have the potential to slow the pace of global

warming by supporting environmentally friendly projects and reducing barriers to corporate financing. Thus, green finance not only contributes to environmental sustainability, but also creates opportunities for firms to gain better access to funds. (Muganyi et al., 2021) Using the semi-parametric difference-in-differences method, the study shows that green finance has significantly reduced industrial waste gas emissions in 290 Chinese cities over the 2011-2018 period. The research emphasises the need for the government to accelerate innovation in green finance products and services, as well as enhance the green credit capacity of financial institutions. In addition, the development of green finance and increased consumption of clean energy are expected to help reduce overall carbon intensity.

While the existing literature has provided foundational theories, there is still a gap in comprehensive analyses of green finance governance and interactions in the context of Asian economies. To address this gap, this study aims to provide new theoretical and empirical insights that can enrich the discussion on sustainable development.

DATA METHODOLOGY

Data and its source

The study uses a panel dataset covering five years, from 2019 to 2023, with a focus on Asian countries, including Afghanistan, Armenia, Azerbaijan, Bahrain, Bangladesh, Bhutan, Brunei, Cambodia, China, Cyprus, Georgia, India, Indonesia, Iran, Iraq, Israel, Japan, Jordan, Kazakhstan, North Korea, South Korea, Kuwait, Kyrgyzstan, Laos, Lebanon, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Oman, Pakistan, Philippines, Qatar, Russia, Singapore, Sri Lanka, Syria, Tajikistan, Thailand, Turkmenistan, United Arab Emirates, Uzbekistan, Vietnam, and Yemen. The study collated data from various secondary sources, as shown in . Notably, Southeast Asian countries have experienced remarkable economic growth in recent decades. Their combined Gross Domestic Product (GDPPC) has jumped from \$4,000 in 2019 to around \$5,200 in 2023. Correspondingly, their share of global GDPPC has increased from 3.5% in 2019 to 4.1% in 2023. The strong economic growth potential in Southeast Asian countries presents significant environmental challenges, prompting us to conduct an environmental impact assessment. In this evaluation, we have selected carbon dioxide (CO₂) emissions as the main dependency variable. CO₂ is a major contributor to greenhouse gas emissions and a major factor in environmental degradation. This analysis aims to understand the relationship between economic growth and its negative impact on the environment, particularly in the context of carbon emissions.

In this study, in addition to CO₂ emissions, we consider a number of key independent variables, namely renewable energy consumption (RENE), green finance (GF), government effectiveness (GG), economic growth (GDP), renewable energy investment (RI), and energy intensity (EI). Each of these variables is important for understanding environmental dynamics and sustainable development. Growth in renewable energy consumption has significant potential to mitigate climate change and improve public health. However, to maximise this potential, large investments in environmentally friendly and sustainable technologies are required. This is where the role of green finance becomes crucial, as it facilitates investment in low-carbon technologies. In addition, investment in technical innovation through research and development also contributes to sustainable environmental practices.

Government policy effectiveness, measured by the Government Effectiveness (GG) variable, is an important factor in dealing with global warming and climate change, making it an integral part of this analysis. This research also explores the efficient use of energy resources and the impact of economic growth on sustainable development. Hence, energy intensity (EI) and GDP growth are important variables in our analysis.

To ensure the reliability and completeness of the data and variables used, we have followed a systematic data collection and analysis methodology. presents specific information on variables and their sources.

Table 1

Variable description.

Variables	Abbreviation	Source
CO ₂ emission (kt)	CO ₂	WDI, 2023*
Renewable energy consumption (% of total final energy consumption)	RENE	WDI, 2023*
Green finance (overseas funds received for clean energy in millions of constant US\$)	GF	Our World in Data (2022)**
Government Effectiveness: Estimate (It measures public service quality, civil service independence from political constraints, policy formulation and implementation, and the government's commitment to such policies). It is a proxy of Good Governance.	GG	WDI, 2023*
GDP (annual growth rate)	GDP	WDI, 2023*
Share of renewable electricity over the years	RI	Climate Action Tracker
Energy intensity level of primary energy (MJ/\$2017 PPP GDPPC) (Lower ratio indicates that less energy is used to produce one unit of output). It is used as proxy for Energy efficiency.	EI	WDI, 2023*

Authors' compilation.

Data Source: *1. <https://data.worldbank.org/>

**2. <https://ourworldindata.org/>

***3. <https://climateactiontracker.org>

Model formulation

This study explores the complex relationship between renewable energy investment (RI) and government effectiveness (GG), with the aim of uncovering their potential in decoupling economic growth from environmental impacts. For this analysis, we utilise advanced econometric techniques, such as Cross-Sectional Augmented Dickey-Fuller (CADF) and Common Stochastic Trends (CST) tests, to understand the dynamic interactions in the context of Southeast Asian economies. The investigation is conducted through four different model specifications, each highlighting unique aspects of these complex interactions.

SUGGESTION FOR FUTURE RESEARCH

This research will explore the relationship between renewable energy investment and governance effectiveness in Asian countries. Using a dataset from 2019-2023, it is expected to reveal emerging trends and the long-term impact of these investments on carbon emissions and economic growth. Comparative analyses across Asian countries with different levels of governance structures, such as in Southeast Asia, South Asia and East Asia, could also improve understanding of how local policy frameworks affect the effectiveness of renewable energy initiatives. Incorporating the latest data from global sources such as the World Bank, Our World in Data and the Climate Action Tracker will

enable a more comprehensive assessment of renewable energy consumption, green finance, government effectiveness, GDP growth and energy intensity in relation to CO₂ emissions. In addition, the use of advanced econometric models that capture linear and nonlinear relationships can shed light on potential diminishing returns or threshold effects in renewable energy investments.

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