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CATALYSING GREEN ENERGY IN ASIA: THE IMPACT OF GREEN INVESTMENT AND GREEN ECONOMIC GROWTH

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Abstract:

In recent years, a growing body of empirical evidence has documented the role of green energy in facilitating the transition to low-carbon development and mitigating environmental degradation. To advance green energy development across Asian countries, this study investigates how green investment and green economic growth influence green energy consumption over the period of 2010 to 2021. Adopting generalised method of moments (GMM) estimators, the empirical results reveal that green investment and green growth are positive and statistically significant determinants of green energy. This study contributes to the formulation of informed and effective policy measures aimed at strengthening the green energy sector and support long-term sustainable development goals. Empirical evidence suggests that translating green development gains into measurable outcomes is associated with a stronger contribution of green investment and green economic growth to the expansion of the green energy sector.

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Keyword:

Dynamic Panel GMM Analysis, Green Energy, Green Growth, Green Investment

Introduction

To curb the environmental deterioration resulting from fossil fuel consumption, nations around the world are confronted with substantial challenges in pursuing an energy transition that prioritizes clean energy replacement and enhanced energy efficiency (Li et al. 2022b; Meng et al., 2022). Asia, especially China and India have become a major source of global CO_2 and SO_2 emissions, largely due to rapid industrial expansion, substantial population size, and persistent coal dependence (ESCAP, 2024). Collectively, developing Asian economies generate nearly half of the world's carbon dioxide emissions and face serious air pollution challenges, with significant implications for public health and climate stability (Gaspar & Rhee, 2021). Asia is increasingly committed to restructuring its energy system through the expansion of green energy sources such as solar, wind, hydropower, and biomass. This transition is largely motivated by the region's urgent need to address climate change, strengthen energy security, and promote sustainable economic growth (Kilinc-Ata & Proskuryakova, 2024). In fact, Asia has maintained its leading position in renewable energy expansion in recent years, accounting for 71% of global additions to new renewable capacity in 2024. Europe and North America followed at a considerable distance, contributing 12.3% and 7.8% respectively. Specifically, Asia's total installed renewable energy generation capacity has reached approximately 2,500,000 MW, significantly surpassing Europe's roughly 1,000,000 MW and North America's 700,000 MW. This expansion places Asia as the leading region globally, accounting for slightly more than half of the world's total renewable generation capacity (IRENA, 2025).

As the world's most populous region, and one experiencing rapid economic expansion alongside a rising share of global greenhouse gas emissions, Asia faces heightened vulnerability to climate-related risks. In response, many Asian economies have begun adopting policy measures aimed at promoting low-carbon, green growth (Anbumozhi & Yao, 2015). An increasing number of emerging Asian economies are transitioning toward a sustainable development model that reduces energy poverty, supports the expanding demand for advanced technologies, and enhances industrial competitiveness (ADB-ADBI, 2013). The concept of green economic growth, first introduced in 2005, is defined as a development approach that emphasizes low-carbon, sustainable, and environmentally responsible economic progress (ESCAP, 2005a). As green economic development continues to advance, the green energy sector has begun to grow at an even faster pace (Schmalensee, 2012). Alongside green economic growth, advancing green energy still relies heavily on strong and consistent financial investment to support its development (Yang et al., 2020; Li et al., 2022c). This is because the energy sector relies on steady and adequate financial support to keep its production and operations running efficiently (Zhang et al., 2022). Green investment involves directing financial resources toward environmentally friendly technologies and projects that minimize ecological impact and support sustainable development. Such investment opportunities are available to both developed and developing countries (Mi, 2023). Green investment can contribute to lowering emissions and pollution, enhancing energy efficiency, promoting renewable energy development, and reducing dependence on finite natural resources (Heredia-R et al., 2021). In 2024, the Asia-Pacific region attracted more than US$528 billion in renewable energy investment, representing over 60 percent of global investment in this sector. However, these investments remain heavily concentrated in a few major economies, while many developing countries continue to struggle to attract sufficient funding due to high perceived project risks and limited institutional capacity (ESCAP, 2025b). China has taken a leading role in advancing renewable energy. Its proactive and forward-looking clean-energy strategy enabled the country to achieve its 2030 goal of installing 1,200 GW of solar and wind capacity six years earlier than planned. In India, the National Solar Mission outlines an ambitious plan to install 500 GW of renewable energy capacity by 2030. Current projections suggest that India’s annual renewable capacity additions will increase more than fourfold, reaching approximately 62 GW per year by 2030 (IEA, 2024).

A substantial body of empirical literature has examined the role of financial investment in the development of green energy, as well as the relationship between renewable energy adoption and green economic development. However, the existing evidence remains mixed and inconclusive regarding the interlinkages among green investment, green growth, and green energy consumption. Nevertheless, studies that jointly analyse the nexus between green economic growth, green investment, and green energy within a unified analytical framework remain limited, particularly in the context of Asian countries. In 2024, clean electricity made up only 34% of Asia’s power mix, which is noticeably lower than the global average of 41% from low-carbon sources, including renewables and nuclear energy (Lolla & Sucahyo, 2025). As a result, a clear gap still persists between the present level of green energy development and the goals that have been set. Since many Asian countries still need greater support to speed up their green energy transition, it is important to study how green economic growth, green investment, and green energy are linked. By considering both green economic growth and green investment, a clearer understanding of their relationships can be achieved, enabling the development of a more effective model for promoting green energy consumption. To address this gap, the study investigates the impacts of green investment and green economic growth on green energy consumption.

This study offers several key contributions to the existing literature. First, based on the existing literature, although numerous studies have investigated how green renewable energy contributes to green economic development, far fewer have examined the reverse relationship namely how green economic development influences the expansion of green renewable energy. Therefore, this study empirically examines whether green economic growth and green investment support the development of the green renewable energy industry. This provides a more comprehensive understanding of how these three dimensions interact, which has been largely overlooked in existing literature. Second, by focusing on Asian countries, the study offers region-specific empirical evidence that can guide policymakers in designing strategies to strengthen the renewable energy sector through coordinated green growth and green investment initiatives. Third, the variables for green investment and green economic growth are likely endogenous, potentially due to feedback effects from green energy back to green investment and economic growth. Therefore, this study uses more advanced dynamic panel econometric technique namely generalized method of moments (GMM) estimations to deal with endogeneity and simultaneity bias. Finally, the study advances the environmental–energy growth nexus by explicitly incorporating green investment and green economic growth into the analysis of green energy consumption. Whereas conventional frameworks primarily emphasize aggregate economic growth and energy use, this approach refines the theoretical perspective by differentiating the quality of growth specifically, green growth from traditional growth measures.

Literature Review

The Nexus between the Green Investment and Green Energy

Growing concerns over escalating pollutant emissions and rising greenhouse gas levels have intensified global interest in green investment, drawing significant attention from researchers and policymakers alike (Mushafiq, 2023). Green investment broadly denotes the allocation of financial resources to initiatives that advance sustainable development and environmental protection, thereby fostering ecological preservation, lowering emissions, and supporting the shift toward a low-carbon economic structure (Eyraud et al., 2013). More specifically, green investment includes the provision of financial resources to sectors such as clean energy, ecological conservation, pollution mitigation, and green technological innovation. These investments hold substantial potential not only to generate environmental benefits but also to stimulate economic growth (Huang & Lei, 2021; Ren et al., 2022). The fundamental purpose of green investment is to allocate financial resources to environmentally responsible projects, thereby easing the resource pressures and environmental impacts generated by conventional production and consumption patterns. As a result, green investment has assumed an increasingly prominent position in global financial markets (Liu et al., 2025). Green finance includes the overall system of financial instruments and policies aimed at directing capital toward sustainable development, whereas green investment specifically refers to the allocation of these funds to concrete environmentally focused projects. Accordingly, green investment can be viewed as a specific component within the broader framework of green finance (Liu et al., 2025).

While green investment and green energy focus on different aspects, they are fundamentally linked, as green investment provides the essential funding and incentives to drive the shift toward low-carbon energy production and sustainable consumption patterns. Therefore, examining the influence of green investment on green energy is essential to ensure that sustainability policies translate into effective and measurable outcomes. Sartzetakis (2021) highlights that green investment, particularly through instruments like green bonds, has directly supported the initiation and expansion of clean energy projects across various countries, providing a strong foundation for the global shift toward a low-carbon economy. Chen and Lei (2018) further emphasize that public investment in renewable energy R&D plays a crucial role for meeting future energy needs through greener and more sustainable energy supply systems. This result aligns with Sinha et al. (2020), who emphasize that sustained investment in energy innovation is necessary for countries to finance research and development in green technologies, which is essential for advancing the energy transition. This result is further reinforced by Godawska and Wyrobek (2021), who found that government subsidies aimed at strengthening the domestic renewable energy sector positively influence total renewable energy output, thereby substantially enhancing the overall supply of green energy. Ahmed et al. (2022) indicate that greater public investment in renewable-energy development and technological innovation is essential for increasing the share of renewable energy in the energy supply and for achieving long-term reductions in carbon dioxide emissions across G7 countries. Liu et al. (2025) demonstrate that green investment plays a significant role in promoting the adoption of renewable energy across 30 provinces in China. They suggest that strengthening government support for green investment is essential and can be achieved through mechanisms such as green financial instruments, tax incentives, and the creation of specialized green funds to promote active engagement in the renewable energy sector. Mavlutova et al. (2025) demonstrates that green digital investments substantially promote the expansion of renewable energy by facilitating increased capital inflows to renewable energy projects, reducing financing costs, and improving the efficiency of energy markets in European countries. These enhancements are especially critical in light of the EU’s urgent challenges in transitioning to green energy, such as integrating renewable energy into the grid, increasing renewable energy production and consumption, and reducing the carbon intensity of electricity generation, all of which necessitate substantial investment.

The Nexus between Green Growth and Green Energy

In recent years, numerous studies have investigated the relationship between economic activity and energy consumption (Stern, 1993; Zhang & Cheng, 2009). Excessive reliance on traditional fossil fuels may compromise the economic benefits of the energy sector, as it often involves significant environmental degradation (Hao et al. 2020). As a sustainable and environmentally friendly energy source, the relationship between green renewable energy and economic development has been widely examined in the literature, with scholars offering varying perspectives on its effects (Wang & Yi, 2021). Menyah and Wolde-Rufael (2010) contend that economic development and energy demand are not causally linked, consistent with the neutral hypothesis. Conversely, Assi et al. (2021) argue that economic growth fosters the expansion of the renewable energy sector, which subsequently contributes to further economic development. Apergis and Payne (2010) find that renewable energy and economic growth exhibit a bi-directional causal relationship, both in the short run and the long run. Similar findings have been reported in another studies (Pao & Fu, 2013; Lin & Moubarak, 2014) indicating a bi-directional relationship between economic development and renewable energy. However, these studies focus solely on the relationship between economic development and green renewable energy. Some studies have also explored the nexus between green economic growth and green renewable energy, although the majority primarily focus on the impact of green renewable energy on green economic growth (Li et al., 2022a). For example, Schmalensee (2012) emphasizes that prioritizing environmental considerations in the pursuit of sustainable economic growth supports the development of green renewable energy. Similarly, Hao et al. (2021) analyse the effect of green renewable energy on green economic growth in G7 countries and report a positive and significant linkage between them. Sarwar (2022) also finds that the development of green renewable energy contributes positively to sustainable economic growth. Overall, research examining the impact of green economic growth on green renewable energy remains limited.

Literature Gaps

A substantial body of empirical literature has examined the role of financial investment in the development of green energy, as well as the relationship between renewable energy adoption and green economic development. However, the existing evidence remains mixed and inconclusive regarding the interlinkages among green investment, green growth, and green energy consumption. In addition, while several studies have examined the impact of green renewable energy on green economic development, research exploring the reverse relationship remains limited. Being the most populous continent and host to several of the fastest-growing economies, Asian countries are experiencing rapidly rising energy demand. To meet this challenge, the continent is increasingly turning to renewable energy and fostering green economic development. However, a gap remains between the current state of renewable energy development and its targeted objectives. Since economic growth and investment are key drivers of the green renewable energy industry, there is a need for empirical analysis of the interrelationships among green investment, green economic growth, and green energy within an integrated analytical framework, particularly in the context of Asian countries. This approach can help to identify effective pathways to enhance the green renewable energy industry through the combined effects of green economic growth and green investment.

Model, Methodology and Data

Model Specification

The model specification is based on Li et al. (2022a) and Muhammad and Hoffmann (2024). Following these studies, this paper is aimed to explaining the determinants of green energy by testing the role of green investment and green growth in 34 Asian countries. Hence, the study constructed the functional form of the model as below in equation (1).

$$GE_{it} = f\,(GI_{it}\,,\, GG_{it}\,,\, IIE_{it}\,,\, TP_{it}) \qquad (1)$$

where the dependent variable GE represents green energy. Two independent variables are GI and GG denoted as green investment and green growth. Also, two control variables are IIE and TP represent income inequality and total population. All variables employed in the analysis are transformed into natural logarithmic form. In line with the functional form of the model, the equations (1) can be expressed in the econometric specifications as below in equation (2):

$$\mathrm{InGE}_{it} = \beta_0 + \emptyset \mathrm{InGE}_{it-1} + \beta_1 \mathrm{lnGI}_{it} + \beta_2 \mathrm{lnGG}_{it} + \beta_3 \mathrm{lnIIE}_{it} + \beta_4 \mathrm{lnTP}_{it} + \mu_{it} \qquad (2)$$

where t is the time period, i indicates the cross sections (countries). A lagged dependent variable is included to allow for the partial adjustment of GE to its long-run equilibrium value. Hence, all the beta coefficient represents short-run effects, and the long-run effects can be derived by dividing each of the betas by $1 - \emptyset$. The β_0 is the intercept, and $\beta_1, \beta_2, \beta_3, \beta_4$ are the variable coefficients and error term is denoted as μ.

Econometric Methodology

In light of the panel structure of the dataset, panel estimation techniques are used to estimate equation (2). Conventional panel estimators, including pooled OLS and fixed- and random-effects models, are inappropriate in this context because of unobserved country-specific effects and the presence of a lagged dependent variable or potential endogeneity among the regressors. Even if the error terms are assumed to be free of serial correlation, estimators such as OLS and the least squares dummy variable (LSDV) estimator yield biased coefficient estimates (Nickell, 1981). Arellano and Bond (1991) introduce a generalized method of moments (GMM) estimator designed to overcome the limitations discussed above, such as addressing endogeneity, controlling for unobserved heterogeneity, and dealing with heteroskedasticity and autocorrelation. More precisely, the GMM estimator eliminates unobserved country-specific effects and other time-invariant country characteristics by applying first differencing to equation (2). Subsequently, to mitigate the correlation between the lagged dependent variable and the error term generated by first differencing, Arellano and Bond (1991) advocate the use of instrumental variables. More precisely, the differenced lagged dependent variable and other endogenous regressors are instrumented with their lagged levels dated two or more periods earlier, while exogenous variables are treated as self-instrumenting. This estimation strategy, commonly termed the first-difference GMM estimator, can be implemented in either a one-step or a two-step GMM setting. The one-step GMM estimator relies on the assumption of independently distributed errors with constant variance across countries and over time. In contrast, the two-step GMM estimator employs the residuals from the one-step estimation to construct a consistent variance-covariance matrix when the assumptions of error independence and homoskedasticity are not satisfied.

A key limitation of the first-difference GMM estimator, however, is that it ignores potential information contained in the level relationships and in the interactions between levels and first differences (Ahn and Schmidt, 1995). Furthermore, Blundell and Bond (1998) observe that level variables may function as weak instruments for their first differences when these variables display high persistence. To overcome these limitations, Arellano and Bover (1995) recommend estimating the level and first-difference regressions simultaneously, resulting in what is referred to as the system-GMM estimator. During estimation, lagged first-differenced variables serve as instruments for the level equation, while lagged levels are used as instruments for the first-differenced equation. According to Blundell and Bond (1998), the system GMM estimator outperforms the first-difference GMM estimator when the dependent variable exhibits high persistence, the autoregressive parameter is close to one, and the panel has a limited number of time periods. In view of these econometric considerations, we employ the two-step system GMM estimator in our analysis, while also reporting the results from the one-step and two-step first-difference GMM as well as one-step system GMM for comparison.

The consistency of the GMM estimator is evaluated using two specification checks namely the Hansen (1982) J test for over-identifying restrictions and the Arellano and Bond (1991) test for serial correlation in the residuals. If the null hypothesis of the Hansen J test is not rejected, it suggests that the instruments are valid, and the model specification is appropriate. The results of the serial correlation test indicate rejection of the null hypothesis of no first-order serial correlation AR (1), while the null hypothesis of no second-order serial correlation AR(2) cannot be rejected.

The Data

To estimate the effects of green investment, green growth, income inequality, and total population on green energy, this study employs balanced panel data covering the period 2010–2021 for 34 Asian countries: Afghanistan, Armenia, Azerbaijan, Bangladesh, Bhutan, Cambodia, China, Cyprus, Georgia, India, Indonesia, Iran, Iraq, Israel, Japan, Jordan, Kazakhstan, South Korea, Lao PDR, Lebanon, Malaysia, Maldives, Mongolia, Nepal, Pakistan, the Philippines, Singapore, Sri Lanka, Tajikistan, Thailand, Turkey, the United Arab Emirates, Uzbekistan, and Vietnam. The core variables in this study are green investment and green growth on green energy. The dependent variable, green energy (GE) is represented by renewable energy consumption as a percentage of total final energy consumption. It represents the share of energy for electricity generation, heating, and transportation derived from renewable sources such as solar, wind, hydropower, and biomass. This indicator is widely used to assess the degree to which a country adopted and effectively utilized green energy sources. The data of green energy is taken from the World Development Indicators (WDI). The first independent variable, green investment (GI) is proxied by total nuclear, renewables, and other energy production in quad Btu. Green investments involve directing funds toward activities that support sustainable development, such as investment in companies, projects, and financial instruments that help expand renewable energy, develop green technologies, and encourage eco-innovative solutions (Inderst et al. 2012). The data series of green investment was retrieved from the U.S. Energy Information Administration (EIA). The second independent variable, green growth (GG) is measured using the Green Growth Index, reflects how well a country is progressing toward sustainability goals set out in global agreements such as the Sustainable Development Goals, the Paris Climate Agreement, and the Aichi Biodiversity Targets. The index captures performance across four main areas by using resources efficiently and sustainably, protecting natural capital, creating green economic opportunities, and promoting social inclusion. Scores range from 1 to 100, where higher values indicate stronger progress, illustrating how effectively a country is balancing economic development with environmental protection and social well-being. Data for green growth have been obtained from the Global Green Growth Institute (GGGI) database. This study also employs two control variables namely income inequality and total population. Income inequality (IIE) is measured using the Gini index, which indicates how unevenly income is distributed among individuals or households in a society. With values ranging from 0 (perfect equality) to 100 (perfect inequality), the index highlights the gap between high-income and low-income groups. Income inequality reflects differences in earnings, access to opportunities, and overall economic well-being, influenced by factors such as education, skills, globalization, technological change, and tax policies, and it carries important consequences for social cohesion and economic development. Data of income inequality was obtained from World income inequality database (WIID). Total population (TP) is proxied by total people in the population. The total population is the whole number of people or inhabitants in a country or region. Data of total population was collected from World Development Indicator (WDI) database.

Empirical Results and Discussions

Table 1 highlights the descriptive statistics of the variables and shows the mean, standard deviation, the minimum and maximum of the original data for the variables. For example, the mean for the three key variables of green energy, green investment and green growth was 21.5125, 0.4141 and 47.0048, respectively. The correlation matrix as reported in Table 2 shows that the variables of green investment, green growth, income inequality, and total population have a positive and significant correlation with the dependent variable (green energy).

The results obtained from the dynamic panel GMM estimators proposed by Arellano and Bond (1991) and Arellano and Bover (1995) are presented in Table 3. Table 3 reports the results from both the difference and system GMM estimators using one-step and two-step procedures. However, as the system GMM estimator is generally regarded as more robust and efficient than the difference GMM approach, the discussion and interpretation primarily focus on the system GMM results. The system GMM estimates reveal that green investment exerts a positive and statistically significant effect on the adoption of green energy. This result implies that a 1% increase in green investment is associated with an approximately 0.1503% rise in green energy consumption across the sample countries. This finding is consistent with that of Ahmed et al. (2022), Liu et al. (2025), and Mavlutova et al. (2025) who found that green investment increases green energy usage in G7 countries, China, and European countries, respectively. For instance, Liu et al. (2025) confirm that green investment plays a positive role in advancing the renewable energy transition. By strengthening green investment channels, more resources are directed toward renewable energy development, thereby enhancing its adoption and supporting broader sustainable development objectives. The empirical results further show that green growth has a positive and significant impact on green energy consumption. This means that a 1% increase in green growth could increase the green energy consumption by 0.8893%. This finding is in line with the research conducted by Li et al. (2022a) who concluded that green economic growth can positively affect the green renewable energy industry in China. To attain the targeted expansion of the green renewable energy industry, China must continue to advance and deepen its green economic growth efforts. The empirical results further reveal that the control variables, including income inequality and total population, do not have a statistically significant effect on green energy usage.

Generally, the estimated models presented in Table 3 appear to be appropriately specified and demonstrate a satisfactory fit. Specifically, the results from all three diagnostic tests indicate that the model satisfies the required statistical assumptions. The Hansen test confirmed the validity of the over-identification restrictions, as the null hypothesis could not be rejected, indicating that the instruments employed in the model are appropriate and reliable. As anticipated, the null hypothesis of no first-order serial correlation AR (1) was rejected, whereas the null hypothesis of no second-order serial correlation AR(2) could not be rejected. Consequently, the residuals of the level equation (before differencing) are free from serial correlation issues.

Table 1: Descriptive Statistics and Source of All the Selected Variables

Variables	Source	Definitions	Mean	Std Dev	Max	Min
Green energy (GE)	WDI	Renewable energy consumption (% of total final energy consumption)	21.51250	23.35298	87.30000	0.100000
Green investment (GI)	EIA	A proxy of total nuclear, renewables, and other (quad Btu)	0.414119	1.468933	13.51909	0.00000717
Green growth (GG)	GGGI	Green growth index (1-100)	47.00483	7.059792	63.52000	31.30000
Income inequality (IIE)	WIID	Gini Index (0-100)	40.00503	6.698190	54.67500	15.16300
Total population (TP)	WDI	Population, total (people)	125000000	315000000	1414203896	360792

Note: WDI=World Development Indicator; EIA= U.S. Energy Information Administration; GGGI=Global Green Growth Institute; WIID=World income inequality database

Table 2: Correlation Matrix of the Variables

Variables	GE	GI	GG	IIE	TP
GE	1.0000				
GI	0.1310	1.0000			
GG	0.6462	0.3052	1.0000		
IIE	0.7342	0.2848	0.9673	1.0000	
TP	0.2774	0.7521	0.3744	0.4095	1.0000

Table 3: Results of Dynamic Panel GMM Estimations. Dependent Variable: Green Energy (GE)

Variables	Difference GMM		System GMM	
	One-Step	Two-Step	One-Step	Two-Step
In GE$_{it-1}$	0.6249*** (0.0982)	0.6115*** (0.0156)	0.9691*** (0.0070)	0.9686*** (0.0143)
In GI$_{it}$	0.1319** (0.0483)	0.1428*** (0.0126)	0.1601*** (0.0683)	0.1503* (0.0783)
In GG$_{it}$	-1.1881** (0.4781)	-1.1298*** (0.1865)	1.6378* (0.8221)	0.8893* (0.4721)
In IIE$_{it}$	-0.8699* (0.4803)	-0.9116*** (0.0541)	-0.4041 (0.5043)	-0.3184 (0.5568)
In TP$_{it}$	-0.5345* (0.3050)	-0.7659*** (0.2079)	-6.0130 (4.4383)	-1.3137 (2.8923)
Hansen test (p-value)	32.04 (0.990)	32.04 (0.990)	13.81 (1.000)	25.92 (1.000)
Arellano-Bond test for AR(1) (p-value)	-3.54*** (0.000)	-3.23*** (0.001)	-3.42*** (0.001)	-3.47*** (0.001)
Arellano-Bond test for AR(2) (p-value)	0.22 (0.827)	0.26 (0.797)	-0.36 (0.718)	0.20 (0.844)
Sample period	2010-2021	2010-2021	2010-2021	2010-2021
Number of countries (N)	34	34	34	34
Number of time periods (T)	12	12	12	12

Notes: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. The dynamic panel GMM estimator of Arellano and Bond (1991) is applied for the difference GMM estimations and the Arellano and Bover (1995) is used for system GMM estimations. The model is based on two step. Figures in parentheses are standard errors, except for Hansen test and Arellano-Bond test for serial correlation, which are p values. All variables are in logarithm form, and the estimations are based on Stata xtabond2 command. GE = green energy, GI = green investment, GG = green growth, IIE = income inequality, TP = total population.

Conclusions

This study empirically examined the dynamic impact of green investment and green growth on green energy across 34 Asian countries, using dynamic panel GMM estimations. The empirical finding reveals that both green investment and green growth have a positive and statistically significant impact on green energy consumption. This finding suggests that enhancing green investment and fostering green growth can effectively increase the consumption of green energy.

The policy implication based on this finding is that governments should allocate resources and incentives toward green investment initiatives, such as subsidies for renewable energy projects, green infrastructure development, and low-carbon technologies, to accelerate the transition to cleaner energy. Investment in technological innovation and research is also crucial to improve energy efficiency and maximize the impact of green investment. Besides, policymakers should design comprehensive green growth policies that integrate environmental sustainability with economic development, promoting sectors that contribute to renewable energy adoption. Specifically, policymakers should align economic planning with environmental objectives, ensuring that growth strategies directly contribute to increased green energy consumption. Furthermore, policymakers can develop targeted policies for high-impact regions or sectors with lower levels of renewable energy adoption, thereby enhancing the efficiency and overall impact of green energy initiatives.

Finally, this study highlights several promising directions for future research. Future investigations could explore the role of different types of green investments, such as renewable infrastructure, clean technology, or energy-efficient innovations, in driving sector-specific renewable energy adoption. Moreover, investigating the interactions between green finance, digital technology, and policy interventions could provide further insights into accelerating the transition to sustainable energy systems, offering both theoretical contributions and practical guidance for policymakers. Additionally, future studies could analyse threshold or nonlinear effects to identify whether a certain level of green investment or green growth is required to achieve significant increases in renewable energy adoption.

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