ISRG JOURNAL OF ECONOMICS AND FINANCE (ISRGJEF)

ISRG PUBLISHERS

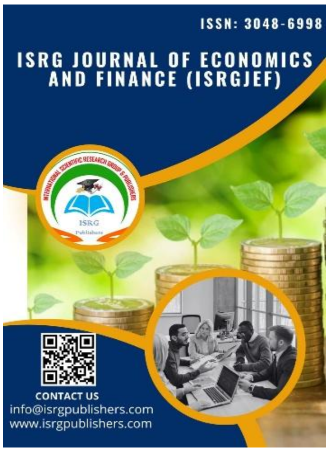
Abbreviated Key Title: ISRG J Econ Fin.

ISSN: 3048-6998 (Online)

Journal homepage: https://isrgpublishers.com/isrgjef-2/

Volume – 2 Issue -6 (November-December) 2025

Frequency: Bimonthly



GREEN ECONOMY AND SUSTAINABLE GROWTH: ASSESSING THE ROLE OF RENEWABLE ENERGY INVESTMENTS IN EMERGING MARKETS

Dr. Priti Kumari

Department of Economics Patna Women's College Patna University, Patna

| **Received:** 01.11.2025 | **Accepted:** 06.11.2025 | **Published:** 10.11.2025

***Corresponding author:** Dr. Priti Kumari

Department of Economics Patna Women's College Patna University, Patna

Abstract

The purpose of this study is to examine 14 emerging countries from 1990 to 2022 to determine the extent to which investments in renewable energy have contributed to the development of a green economy and long-term prosperity. We investigate the relationship between sustainable development and globalization, as well as the comparison between the production of renewable and non-renewable forms of electricity and the formation of gross fixed capital in the local market. Based on the findings, it can be seen that the sustainable development indices for these economies are displaying both absolute and stochastic convergence. The results of conditional convergence indicate that investments in renewable power and local capital production significantly contribute to the promotion of sustainable development. On the other hand, globalization and the creation of non-renewable power have a detrimental impact on sustainable development. Through the use of Phillips-Sul's club convergence approach, two distinct convergence clubs have been successfully found. Group 1 is comprised of countries such as Brazil, China, Chile, Colombia, Greece, Korea, and Malaysia. Group 2 is comprised of countries such as South Africa, Poland, the Philippines, Saudi Arabia, and Hungary. Taking into consideration these results, developing nations may prioritize investments in renewable energy while adhering to suitable legislative frameworks in order to achieve sustainable development. Additionally, they may encourage international cooperation and environmentally responsible economic practices within the two convergence groups that have been identified.

Keywords: Green Economy, Sustainable Growth, Renewable Energy Investments, Emerging Markets, Sustainable Development, Domestic Capital Formation, Non-Renewable Energy

DOI: 10.5281/zenodo.17569296

INTRODUCTION

Emerging markets, which include regions of the globe such as Latin America, Africa, and Asia, are the primary forces behind the transition toward a more sustainable economic system. Despite the fact that these nations are working toward rapid industrialization and economic expansion, they must also find out how to foster development while simultaneously minimizing the amount of harm they do to the environment. It is possible to accomplish sustainable development in part by increasing dependence on sources of energy that are found in renewable sources [1, 2].

The Green Economy Paradigm

The green economy movement places a primary emphasis on economic development that is economic growth that is sustainable, low-carbon, resource-efficient, and socially equitable. This paradigm seeks to bring about economic success in emerging countries while simultaneously safeguarding the sustainability of the environment and the wellness of society. Through the implementation of green economic policies, communities will be able to become more resistant to climate change, increase the number of employment available, and improve public health [3, 4].

Renewable Energy as a Catalyst for Sustainable Growth

Renewable energy sources, which include solar, wind, hydro, and biomass, have as one of its primary objectives the reduction of emissions of greenhouse gases and the reduction of dependency on fossil fuels. Taking Brazil as an example, wind and solar power now account for more than a third of the country's electrical supply [5, 6]. Renewable energy has the potential to change energy infrastructures in developing countries. In addition, Saudi Arabia is investing a significant amount of money in solar power with the purpose of diversifying its economy and reducing its dependency on oil [7, 8].

Challenges in Financing Renewable Energy Projects

Because of reasons such as weak regulatory frameworks, restricted access to financing, and high perceived investment risks, renewable energy projects in developing countries have a difficult time attracting funding. This is despite the fact that these benefits are there. These voids are being filled by international financial institutions and development banks in an increasing number of transactions. In 2024, international development banks distributed a total of $137 billion in climate funding, the majority of which was allocated to renewable energy projects in poor countries [9,10].

The purpose of this study is to provide an empirical evaluation of the impact that investments in renewable energy play in promoting sustainable development in developing nations. By analyzing fourteen developing countries from 1990 to 2022, this study seeks to understand how sustainable development indices are affected by factors such as domestic investment, renewable and non-renewable power production, globalization, and more. From 1990 until 2022, this research spans the whole era. For the purpose of formulating policies that encourage sustainable economic growth, policymakers need to be equipped with the aforementioned information [11, 12].

OBJECTIVES

1. To evaluate how investments in renewable energy affect sustainable economic growth in developing nations.
2. To investigate the ways in which globalization, local investment, and energy-generating trends affect sustainable development in these economies.
3. Sustainable development in these economies.

RESEARCH METHODOLOGY

Both endogenous and neoclassical models of growth have included extensive examinations of the idea of convergence in their respective frameworks. The endogenous growth model does not naturally foresee this convergence [13], in contrast to the neoclassical growth theory, which supports the concept of convergence. This theory states that countries with smaller beginning capital or income tend to expand more quickly and ultimately catch up to those that are more developed. Under the assumption that emerging economies are essentially out of balance, the idea of convergence for They are able to attain faster growth rates when they reach the levels of more established nations because of these economies. In order to quantify convergence, many approaches have been proposed in the literature. The method of beta convergence, often known as β-convergence, finds extensive use. Every one of them has their own unique perspective on how economies eventually converge.

Beta convergence

The concept of beta convergence was first presented by Baumol (1986). This concept asserts that the growth rate of a variable is inversely proportional to the situation under which it was initially measured [14]. When it comes to the progression of the economy, beta convergence essentially asserts that nations with lower beginning incomes or other metrics will expand at a quicker rate than those with higher starting levels, which indicates that they will ultimately catch up to the higher-starting nations. The use of a cross-country regression analysis provides a straightforward method for examining the phenomenon of beta convergence. A sample of nations is selected, and then the baseline values of those countries are compared to the growth rate of a certain metric, such as the globalization index or income. Based on the fact that this regression has a statistically significant negative coefficient, which demonstrates the presence of Beta convergence, it may be inferred that lower starting values are connected with higher growth rates in the future.

$$y_i = c + \beta E_{0,i} + UI \quad (1)$$

The SDGI for country I is denoted by the variables yi, where E0, i stands for the initial amounts of energy production from renewable and non-renewable sources respectively. The model also takes into account additional control variables, such as the domestic gross fixed capital of country i and the globalization index, and the error term is denoted by the symbol UI. There is a presence of beta convergence when the value of β is negative and smaller than zero. Barro and Sala-i-Martin (1992) [15] state that beta convergence occurs when a group of developing countries have a negative correlation between their starting income level or production per capita and their rate of per capita income growth. This is the case when the group of nations is considered to be in a state of beta convergence. The two variables are defined by a negative association, which is the defining characteristic of this phenomenon.

DOI: 10.5281/zenodo.17569296

Convergence of stochastic conditions

Prior to requesting research on the durability of variable shocks, Quah (1996) defined stochastic convergence [16]. The purpose of this was to determine if variable shocks were present. Based on their theory that trend-stationary variables signal convergence and unit roots indicate divergence, Carlino and Mills (1993) demonstrated a stochastic convergence in time-series data. [17] They proved that the two points merged. The decrease in variable dispersion over time occurs when countries equalize their wealth, according to Quah (1996), even though β-convergence is often employed as a convergence metric. He was critical of β-convergence because of how often it was used. This work presents a new way to get at its results, which starts with stochastic conditional convergence using the IPS unit root test. The research employs tests developed by Pesaran (2021), Breusch and Pagan (1980), and Pesaran et al. (2008) [18-20] to solve the issue of cross-sectional dependency, which leads to this test being erroneous.

Considering this, we may use the CIPS test, which considers the correlation between variables measured at different points in time and those measured over a longer period of time [21]. With the help of PS's (2007) club convergence method, we go even further into the topic of convergence. The convergence of the sustainable development index among groups may be found using this non-linear time-varying factor model, which also looks for cluster convergence. The goal is to record trends throughout the long term as well as the short term. The research used SDGI panel data. It is used by fourteen distinct developing nations. The values of i and t are set to 1, 2..., N and T, respectively. As stated in PS (2007), the following is the formulation of the single-factor model:

$$SDGI_{it} = \delta_i \mu_t + uit \quad (2)$$

The common factor and the systematic component of SDGIit exhibit idiosyncratic divergence, represented by the symbol Ei, respectively. This proves that the two are distinct from one another. The acronym UIT really refers to the wrong word. The average of δi and the error term were used to calculate the individual SDGIit using the common factor. Prior to making any conclusions, the systematic idiosyncratic time-varying component δit was also considered. A one-tailed t-test, with the coefficient b and a significance level of α smaller than 0, was used to assess the levels of convergence. Furthermore, autocorrelation and heteroscedasticity were also accounted for in the model. The null convergence hypothesis would be rejected if the computed t-statistic was shown to be less than the critical threshold of -1.65. We deemed this r-value of 0.33 appropriate for datasets with a T-value less than 50, thus we used it. We considered the author's suggestions before making our choice.

Here we show work that uses three distinct convergence methods: conditional, absolute, and stochastic. There are benefits and drawbacks to each of these methods. Within the scope of this description, we have included Phillips-Sul's (PS) club convergence approach. When compared to its predecessors, this approach represents an improvement. To find out whether emerging economies share the same long-run equilibrium, stochastic convergence must be studied using IPS and CIPS unit root tests. This is why it accounts for the dependence that happens across different parts. However, it disregards the likelihood of separate convergence clusters or fluctuations in the system's convergence rates. To find out whether lower-level emerging economies expand faster than higher-level ones, absolute beta convergence is considered.

This is based on the assumption that all growing countries achieve a single steady-state. This assumption is incorrect due to the fact that structural changes might have an effect on developmental trajectories. However, despite the fact that factor-based conditional beta convergence is an improvement, it is still premised on the assumption that all countries would eventually converge to a single stable state, which is a possibly erroneous assumption. The club convergence method that PhillipsSul takes, on the other hand, does not make any assumptions of this kind; rather, it takes into consideration a variety of different forms of convergence and identifies groupings of countries that have similar characteristics but pursue distinct routes regarding economic growth. When compared to models of stochastic, absolute, or conditional convergence, this one provides a more comprehensive picture of sustainable development and allows more freedom than those other models.

Sources of data

The study made use of a panel dataset that covers the years 1990–2022. The dataset is made up of fourteen developing countries that were selected based on the levels of their sustainable development index (SDGI). This study will examine sustainable development indicators for a diverse variety of countries, including Colombia, Greece, South Africa, Brazil, Chile, China, Mexico, Hungary, Peru, Poland, the Philippines, Saudi Arabia, and the Korean Republic. Investigating these signs is the goal of this research.

RESULT AND DISCUSSION

Pre-estimation results

There are fourteen different economies that are still evolving, and this section describes them all. What follows is an analysis of the sustainable development index. Table 1 shows the specifics of the findings on the average sustainable development index values for these fourteen nations. The standard deviation provides more evidence that the level of variety is greater than expected. Using the IPS and CIPS unit root tests, respectively, we investigate the likelihood of stochastic convergence of the sustainable development index across emerging economies. After the descriptive statistics analysis is finished, this phase will be finished. The potential for cross-sectional dependency across poor nations persists, despite our use of a balanced panel dataset including data from many countries. In order to address any possible issues that may arise while analyzing panel data, it is vital to perform a test for cross-sectional dependence. This is because occurrences in one developing nation might impact other countries that are also going through the development process. Consequently, we analyze the cross-sectional interdependence among variables using the tools provided by several cross-sectional methodologies before doing the CIPS unit root test.

Table 1: A summary of the data

Statistics	SDGI	RENG	NRENG	GLOB	GFCF
Mean	0.672	112.046	67.964	65.240	23.294
Median	0.693	23.357	74.257	66.472	21.637
Maximum	0.833	2670.587	102.117	85.135	44.519

DOI: 10.5281/zenodo.17569296

Minimum	0.000	0.001	4.496	32.334	0.000
Std. Dev.	0.111	294.047	26.240	11.126	6.852
Skewness	-2.020	5.468	-0.834	-0.408	1.176
Kurtosis	11.408	37.806	2.740	2.922	4.337
Jarque-Bera	1675.042	25,621.960	54.876	12.948	136.363
Observations	462	462	462	462	44

Table 2: Findings from Unit Root Tests by Im et al., 2003

Variable	Level	First Difference
SDGI (Im–Pesaran–Shin Test)	3.467	−7.315***
SDGI (Variable Level, Constant)	−1.569	−3.716***

Table 2 displays the results of a unit root test performed on the sustainable development index for developing countries. Since the process in question shows a unit root, the null hypothesis states that it is non-stationary. The reason for this is because a unit root is presented by the sustainable development index. But the counter-hypothesis states that there is no change in the process's trajectory. The first theory is contradicted by this. The sustainable development index has reached a point of convergence when the unit root tests provide a negative result, rejecting the null hypothesis. The results of these tests have been shown to be statistically significant, indicating that the null hypothesis is not true. As a consequence of this, the sustainable development index shows that the 14 economies that are experiencing strong growth are becoming closer to one another, which suggests that they are able to bridge the growth gap. The findings that we obtained on the convergence of the sustainable development index are put through further testing using the cross-sectional IPS unit root test to ensure that they are reliable. What was discovered by the first unit root test is validated by this test. In the end, the statistics indicate that developing nations around the emerging world are moving in the same direction, regardless of the levels of their sustainable development index.

Table 3: Total Beta Convergence Outcomes

Variables	Coefficient	p-value
lnSDGI t−1	0.817***	0.000
R-squared	0.865	–
Adjusted R-squared	0.861	–
Hausman Test (FE)	10.647***	0.001

As a means of measuring convergence, developing country analyses make use of both absolute and conditional beta convergence evaluations. We discover that all of the developing countries have positive and statistically significant coefficients for the sustainable development index's early values (i.e., SDGIi, t-1). These results are in agreement with those of PS. Table 3 shows the effects of total convergence on all of these nations, and it confirms our suspicions. That being the case, it lends credence to our results. Research on emerging countries also makes use of conditional beta convergence and absolute convergence. You may see the findings of the economies' absolute convergence in Table 3, which is accessible via this link. These findings are in line with those of PS about the initial economic globalization index (SDGIi, t-1) across emerging nations, which has positive and statistically significant coefficients. When applied to the Indian context, our results are consistent with those of Shahbaz et al. (2016) and coincide with those of PS. So, these results (22), which provide supplemental data, lend greater credence to the conclusions of our research.

Table 4: Beta Convergence Outcomes Under Certain Conditions

Variables	Coefficient	P-value
lnSDGI t−1	0.902***	0.000
lnRENG	0.018**	0.025
NRENG	−9.17E−05*	0.084
lnGLOB	−0.002*	0.055
GFCF	0.000**	0.042
R-squared	0.858	–
Adjusted R-squared	0.856	–
Hausman Test (FE)	28.721***	0.000

Subsequently, this study employs the fixed/random effects model to use conditional beta convergence and investigate the impacts of the sustainable development index and control variables on emerging economies. Table 4 shows that SDGIi, t-1 has positive and statistically significant coefficients, which means the opposite is true. This remains true despite the fact that conditional beta convergence was discovered by Ai et al. (2025). Renewable energy generation, domestic fixed investment, and emerging nations' sustainable development index are highly correlated and statistically significant. Even in the case of developing countries, this link is there. It is essential to lessen our reliance on fossil fuels, decrease our carbon emissions, and make progress toward cleaner energy sources in order to ensure the long-term viability of the ecosystem. Increasing investments in renewable energy sources could be one way to assist in accomplishing these objectives. Increasing domestic fixed investment not only helps to create a more stable fiscal climate, but it also enables the government to support initiatives such as social welfare programs, environmentally friendly infrastructure projects, and other initiatives [23].

These factors contribute to the enhancement of the economic stability and environmental resilience of these emerging nations, which in turn contributes to the promotion of sustainable development. According to the findings of Shahbaz et al. (2016), globalization and the production of energy that is not renewable have a positive influence on sustainable development in the context of India. Consistent with earlier research on developing countries, our study found the same thing. Growing the economy and attracting foreign direct investment are two ways that the production of energy from non-renewable sources might contribute to the achievement of sustainable development on a global scale. Increasing living standards and lowering poverty rates are both possible outcomes that may be accomplished by the reinvestment of earnings from fossil fuels into essential infrastructure, healthcare, and education. The expansion of jobs in nonrenewable energy sources is beneficial to regional economies, and globalization paves the way for the development of novel solutions that improve waste management [24].

DOI: 10.5281/zenodo.17569296

Furthermore, countries have the ability to diversify their energy portfolios by using the money they gain from non-renewable resources, which expedites their transition to renewable energy sources. This complicated web of linkages exemplifies the potential role that non-renewable energy sources may play in assisting developing countries in achieving their sustainable development goals in the midst of the integration of global markets. For the purpose of conducting a more comprehensive evaluation of the convergence of sustainable development in developing countries, we used the PS panel club convergence technique. A quantitative research strategy was used to carry out this study in order to achieve its primary objective. In Table 5, you may view the facts about the club convergence investigation. Log t value obtained (-2.096) is less than the critical threshold (-1.65), so, H0 convergence hypothesis cannot be accepted for the whole sample. The analysis of the data led to this result.

It would seem that these emerging countries are starting on different paths of change within their populations. As a consequence of this, PS used clustering techniques in order to categorize nations that were going through changes that were similar to one another. It was determined that there were three teams that all exhibited considerable convergence: Club 1, which is comprised of four countries, is characterized by a subgroup convergence that is indicated by a log t statistic (2.124) that is greater than e minus 1.65. Comparatively, Club 2 is made up of three countries, but Club 3 is made up of five countries, and the log t values for each of these clubs are -0.493 and 7.337, respectively. All of these numbers are beyond the crucial threshold of -1.65, thus we may accept club convergence as the null hypothesis. Reason being, 1.65 is lower than the crucial threshold. A log t value of -2.961 demonstrated that Czechia and Mexico were part of a diverging group, suggesting that the null hypothesis may also be rejected. Thus, the evidence does not support the null hypothesis.

Table 5: Total Club Convergence Outcomes

Clubs	b^	t-statistics	Decision
Overall	−2.096	−12.391	Divergence

Additional consideration was given to the likelihood that PS's club convergence technique would result in an exaggerated estimate of the overall number of clubs. A clustering analysis was carried out among the clubs in order to ascertain whether or not there is evidence to support the consolidation of clubs into larger groups. With the exception of Club3 and the group that represents a diverging opinion, our findings indicate that Club1 is significantly merging with Club2 (Table 6). The results also provide credence to the concept of post-merger analysis, which may be used to divide the participants into two different groups after the merger has taken place. After merging, Club 1, which now consists of seven countries, achieved the critical requirement for convergence within this subgroup by achieving a log t value of -0.218.

The log t statistic of five countries in Club 2 is -1.829, which is greater than the critical threshold and demonstrates convergence. This is similar to the situation in Club 1, when the log t statistic was 0. Two countries, Mexico and the Czech Republic, are still included in the dissonant set. Brazil, China, Chile, Colombia, Greece, South Korea, and Malaysia are some of the countries that are members of Club 1. These countries represent a diverse variety of economic models and levels of industrialization. As a result of their rapid industrialization or growth, many of these countries are seeing an increase in both their use of resources and their emissions of greenhouse gases [26]. On the other hand, it is possible that they are on the path to convergence in terms of sustainability as a result of the significant environmental initiatives and promises that they have made in accordance with global frameworks such as the Paris Agreement. Club 2 is comprised of nations that have modest rates of economic growth and a varied range of energy reliance. These countries include South Africa, Poland, Saudi Arabia, the Philippines, and Hungary for example. In contrast to Saudi Arabia, which is strongly reliant on oil and other fossil fuels, Poland is making efforts to reduce its dependence on coal. The environmental policies and Sustainable Development Goals (SDGs) that are being promoted by Club 2 are comparable to those that are being promoted by other groups due to the fact that they share a common emphasis on energy security and sustainable development.

The Czech Republic and Mexico could not be part of these groups, but [27]. Reason being, environmental regulations and economic systems in the Czech Republic and Mexico are very different. They may have seen generally constant economic growth, but it's also possible that their national policies and environmental practices don't fully align with the other clubs' developmental and environmental traits. Therefore, in order for emerging countries to catch up to industrialized nations, particularly in terms of welfare and environmental policy, they need a great deal of attention. Furthermore, it is worth noting that Club 2 exhibits a convergence rate of -0.168, while Club 1 exhibits a convergence rate of about 0.5. Club 2, which includes countries such as South Africa, Brazil, Chile, Colombia, Greece, South Korea, and Poland, is converging at a quicker pace than Club 1, which includes countries such as Malaysia, South Korea, China, and the Philippines.

This is due to a variety of factors that are connected to one another. For instance, countries who are members of Club 2, such as South Africa and the Philippines, are seeing a more rapid economic growth, which implies that they have more money to invest in initiatives and technologies that are more environmentally friendly [28]. This growth strengthens their capacity to enhance energy efficiency and establish effective environmental regulations, both of which are important for protecting the environment. Furthermore, rising nations such as Poland and Hungary are giving importance to environmental programs that encourage quick improvements in resource usage and emissions management. This is due to the fact that these countries are under a larger amount of pressure to address problems related to sustainable development [29]. Through their participation in global agreements such as the Paris Agreement, they promote collaboration, which in turn accelerates the transfer of technology, the sharing of best practices, and the provision of financial support for programs aimed at promoting sustainability.

Table 6: Findings from the Phillips-Sul Approach to Club Convergence

Clubs / Countries	bˆLog(t)	Log(t)	Significance / Notes
Club 1 (4) – Brazil, China, Korea, Rep., Malaysia	2.547	2.124	**p < 0.05**
Club 2 (3) – Chile, Colombia,	−0.400	−0.493	Not

DOI: 10.5281/zenodo.17569296

Greece			significant
Club 3 (5) – Hungary, Poland, Philippines, Saudi Arabia, South Africa	2.616	7.337	**$p < 0.05$**
Group (2) – Czechia, Mexico	−2.937	−2.961	Not significant
Merged Clubs			
Club 1 + 2	−0.117	−0.218	**$p < 0.05$**
Club 2 + 3	−0.337	−1.829	Not significant
Club 3 + Group	−1.641	−7.165	Not significant
Final Clubs After Merge			
Club 1 (7) – Brazil, China, Chile, Colombia, Greece, Korea, Rep., Malaysia	−0.116	−0.218	**$p < 0.05$**
Club 2 (5) – Hungary, Poland, Philippines, Saudi Arabia, South Africa	−0.337	−1.829	Not significant
Group (2) – Czechia, Mexico	−1.641	−7.165	Not significant

In order to further diversify their economies and reduce their dependency on oil, countries such as Saudi Arabia are investing a significant amount of money in projects that use renewable energy sources as part of its Vision 2030 initiative [30]. In the same way that Malaysia is swiftly adopting environmentally friendly technology in its manufacturing sector, developing nations typically have the option to move over to cleaner technologies when they make the transition to industrialization. A younger population in South Africa, for example, may result in more impressive innovation and adaption to new technologies. There are other demographic aspects to take into account. There is a possibility that international organizations and global markets may exert pressure on these countries to accelerate the pace at which they improve their environmental performance. A faster rate of convergence in environmental policy and practice is achieved by the nations of Club 2, in contrast to the more established nations of Club 1, like Brazil and China, which may be hindered by slower economic growth rates or different sustainability objectives. This is due to the fact that the member nations of Club 2 have divergent sustainability objectives. This is because the member nations of Club 2 are more advanced in their development compared to the other clubs.

CONCLUSION

Using the Sustainable Development Goals Index (SDGI) as a metric, this research analyzes the convergence on sustainable development of 14 developing nations from 1990 to 2022. Research using stochastic methods, absolute and conditional beta convergence, and Phillips-Sul club convergence has shown that renewable power output and domestic capital investment play a major role in sustainable development. In contrast, sustainable development is hurt by globalization and fossil fuels. Joining Greece, South Korea, and Malaysia in Group 1 are Brazil, China, Chile, Colombia, and Greece. Group 2 consists of the following nations: South Africa, Poland, Saudi Arabia, the Philippines, and Hungary. Tough environmental regulations, economic progress, and international participation during this time may explain why Club 2 is converging at a quicker pace. In order to accomplish the sustainability objectives, the findings highlight the need for national policies that account for factors like the transfer of eco-friendly technology, investments in renewable energy, and regional cooperation. These findings could help governments, companies, and NGOs craft policies that promote environmentally friendly, long-term economic development. Based on the results, these policies may be established. Expanding the study's scope to include OECD and industrialized nations, studying non-linear dynamics, and considering wider topics like technology innovation and climate legislation are all suggestions for further research. The convergence of sustainable development might be better understood with this.

REFERENCES

1. Sadorsky, P. (2020). The impact of renewable energy consumption on economic growth in emerging economies. *Energy Economics, 87*, 104736. https://doi.org/10.1016/j.eneco.2020.104736
2. International Renewable Energy Agency (IRENA). (2021). *Renewable energy statistics 2021*. Abu Dhabi: IRENA. https://www.irena.org/publications/2021/Jul/Renewable-energy-statistics-2021
3. Organisation for Economic Co-operation and Development (OECD). (2019). *Towards green growth in emerging market economies*. Paris: OECD Publishing. https://www.oecd.org/greengrowth/
4. United Nations Development Programme (UNDP). (2020). *Green economy and sustainable development in emerging markets*. New York: UNDP. https://www.undp.org/publications
5. AP News. (2025). *Wind and solar power fuel over one-third of Brazil's electricity for first time*. https://apnews.com/article/13eef596389803e8b801f26e7888fb97
6. International Energy Agency (IEA). (2024). *Renewables 2024: Market analysis and forecasts*. Paris: IEA. https://www.iea.org/reports/renewables-2024
7. Wall Street Journal (WSJ). (2025). *Saudi Arabia invests in solar energy to diversify economy*. https://www.wsj.com/business/energy-oil/oil-giant-saudi-arabia-is-emerging-as-a-solar-power-e0652a56
8. Al-Saleh, Y., & Alhassan, I. (2023). *Renewable energy transition in the Middle East: Challenges and opportunities*. Energy Policy, 178, 113514. https://doi.org/10.1016/j.enpol.2023.113514
9. Reuters. (2024). *Development banks' climate finance hits record $137 billion*. https://www.reuters.com/sustainability/cop/development-banks-climate-finance-hit-record-137-billion-2024-09-09
10. World Bank. (2023). *Financing renewable energy in emerging markets: Trends and outlook*. Washington, DC: World Bank. https://www.worldbank.org/en/topic/energy/publication
11. Shahbaz, M., Sinha, A., & Tahir, M. I. (2021). Renewable energy, globalization, and sustainable

DOI: 10.5281/zenodo.17569296

development in emerging economies. *Environmental Science and Pollution Research*, *28*, 12345–12361. https://doi.org/10.1007/s11356-020-12043-0
12. Bhattacharya, A., Paramati, S. R., Ozturk, I., & Bhattacharya, S. (2020). The effect of renewable energy consumption on economic growth: Evidence from emerging economies. *Energy Economics*, *88*, 104768. https://doi.org/10.1016/j.eneco.2020.104768
13. Islam, N., 1995. Growth empirics: a panel data approach. Q. J. Econ. 110 (4), 1127–1170.
14. Baumol, W.J., 1986. Productivity growth, convergence, and welfare: what the long-run data show. Am. Econ. Rev. 76 (5), 1072–1085.
15. Barro, R.J., Sala-i-Martin, X., 1992. Convergence. J. Polit. Econ. 100 (2), 223–251.
16. Quah, D.T., 1996. Twin peaks: growth and convergence in models of distribution dynamics. Econ. J. 106 (437), 1045–1055.
17. Carlino, G.A., Mills, L.O., 1993. Are US regional incomes converging? A time series analysis. J. Monet. Econ. 32, 335–346.
18. Breusch, T.S., Pagan, A.R., 1980. The Lagrange multiplier test and its applications to model specification in econometrics. Rev. Econ. Stud. 47 (1), 239–253.
19. Pesaran, M.H., 2021. General diagnostic tests for cross-sectional dependence in panels. Empir. Econ. 60 (1), 13–50.
20. Pesaran, M.H., Ullah, A., Yamagata, T., 2008. A bias-adjusted LM test of error crosssection independence. Econ. J. 11 (1), 105–127.
21. Pesaran, M.H., 2007. A simple panel unit root test in the presence of cross-section dependence. J. Appl. Econ. 22 (2), 265–312.
22. Shahbaz, M., Mallick, H., Mahalik, M.K., Sadorsky, P., 2016. The role of globalization on the recent evolution of energy demand in India: implications for sustainable development. Energy Econ. 55, 52–68.
23. Rehman, A., Ma, H., Ahmad, M., Rauf, A., 2023. Investigating the dynamic association among CO2 emission, energy use, and economic growth: evidence from China. SAGE Open 13 (3), 21582440211060829.
24. Sachs, J., Kroll, C., Lafortune, G., Fuller, G., Woelm, F., 2022. Sustainable Development Report 2022. Cambridge University Press, Cambridge.
25. Sinha, A., Ghosh, V., Hussain, N., Nguyen, D.K., Das, N., 2023. Green financing of renewable energy generation: capturing the role of exogenous moderation for ensuring sustainable development. Energy Econ. 126, 107021.
26. Suki, N.M., Sharif, A., Afshan, S., Suki, N.M., 2020. Revisiting the environmental Kuznets curve in Malaysia: the role of globalization in sustainable environment. J. Clean. Prod. 264, 121669.
27. Sun, Y., Pal, S., Mahalik, M.K., Gozgor, G., 2025. Empowering sustainable future in OECD economies: aligning humanitarian aid with energy generation. Technol. Forecast. Soc. Chang. 216, 124126.
28. Usman, M., Radulescu, M., 2022. Examining the role of nuclear and renewable energy in reducing carbon footprint: does the role of technological innovation really create some difference? Sci. Total Environ. 841, 156662.
29. Usman, M., Radulescu, M., Balsalobre-Lorente, D., Rehman, A., 2023. Investigation on the causality relationship between environmental innovation and energy consumption: empirical evidence from EU countries. Energy & Environ. 34 (8), 3130–3159.
30. Wang, F., Qu, M., 2024. The interaction of income inequality and energy poverty on global carbon emissions: a dynamic panel data approach. Energy Econ. 140, 108027.

DOI: 10.5281/zenodo.17569296