JEEPO, 9(1), 14-23.

Journal of Energy & Environmental Policy Options

Renewable Energy, Industrialization, and Economic Growth: Evidence from CIVETS Economies

Serdar Sayan[a], Can Tas[b]

Abstract

This study examines the relationship between renewable energy consumption, manufacturing value added, carbon emissions, and economic growth in CIVETS economies over the period 2005 to 2025. Grounded in neoclassical growth theory, environmental economics, and structural transformation theory, the study evaluates how industrial expansion and environmental factors interact to influence economic performance. A quantitative panel data approach is employed, utilizing panel least squares, fixed effects, and random effects models, along with diagnostic tests such as the Breusch–Pagan Lagrange Multiplier and Chow tests to determine the most appropriate model specification and account for time and cross-sectional dynamics. The empirical findings reveal that manufacturing value added has a positive and statistically significant effect on economic growth across all model specifications, confirming the central role of industrialization in driving productivity, employment, and structural transformation in emerging economies. Carbon emissions exhibit a negative but generally insignificant relationship with economic growth, suggesting that environmental degradation may impose constraints on growth, although the effect is not consistently robust. Renewable energy consumption shows a positive but statistically insignificant impact, indicating that while clean energy contributes to sustainability, its short-term influence on economic performance remains limited due to transitional costs, infrastructure constraints, and incomplete integration into industrial systems. The findings emphasize the need for policies that promote green industrialization by integrating renewable energy into manufacturing processes, strengthening environmental regulations, and supporting technological innovation to achieve sustainable long-term economic growth.

Keywords: *Renewable Energy, Manufacturing Value Added, Economic Growth, Carbon Emissions*

JEL Codes: *Q42, O44, L60*

Article's History
Received: 17th January 2026
Revised: 16th March 2026
Accepted: 28th March 2026
Published: 31st March 2026

Citation:
Sayan, S., & Tas, C. (2026). Renewable Energy, Industrialization, and Economic Growth: Evidence from CIVETS Economies. *Journal of Energy and Environmental Policy Options*, 9(1), 14-23.

DOI:
https://doi.org/10.5281/zenodo.22514955

1. INTRODUCTION

Economic growth and sustainable development continue to be among the main issues of concern for policymakers and researchers, especially in developing economies that are undergoing rapid structural change. Industrialization, technological growth and increased energy consumption have caused the global economy to grow in the last few decades (Lucas, 2002; Ali & Rehman, 2015; Ullah et al., 2023; Naeem et al., 2025; Akter et al., 2025). The expansion has, however, co-occurred with increasing environmental deterioration, shortage of resources, and climate change pressures, which has created a more compelling argument to effectively manage economic performance in tandem with environmental sustainability. This growing concentration of carbon emissions and dependence on fossil fuels has led to concerns about the sustainability of the traditional growth models, especially in developing economies where industrialization is a dominant source of production (Ahuja & Tatsutani, 2009; Ullah et al., 2022; Roussel & Audi, 2024; Bi et al., 2024; Marc, 2024; Longston et al., 2025). These dynamics underscore the need to recognize the intricate relationship between economic growth, industrialisation and environmental sustainability. The theoretical focus of the neoclassical growth theory is on the accumulation of capital, the supply of labour, and technological progress as key drivers of economic growth. In this context, industrialization, especially industrial development via manufacturing expansion, is a key factor in improving productivity and thus economic development. Manufacturing is an important element of development strategies in emerging economies because it plays a key role in growth through economies of

[a] İktisadi ve İdari Bilimler Fakültesi, MEF Üniversitesi, İstanbul, Turkey, sayaan.serdar@yahoo.com
[b] İktisadi ve İdari Bilimler Fakültesi, MEF Üniversitesi, İstanbul, Turkey

scale, technological diffusion, and value addition (Hoskisson et al., 2013; Ocampo, 2016; Audi & Ali, 2022; Farras et al., 2025). The argument is supported by the concept of structural transformation theory, which emphasizes the long-term economic expansion due to the reallocation of resources from low-productivity to high-productivity sectors, such as from the agricultural sector to the manufacturing and industry sectors (Marc et al., 2022; Altasseb et al., 2024; Rafique et al., 2025; Tayyar, 2025). The theories presented indicate that manufacturing value added will continue to play a significant role in future growth, especially in developing economies such as those that are rapidly industrializing.

Environmental economics, on the other hand, adds an important perspective on growth, highlighting the trade-offs between growth and environmental protection. The Environmental Kuznets Curve hypothesis states that economic growth may cause environmental deterioration in the initial phases but, as economies develop, they become more efficient with cleaner technologies and more stringent environmental policies, thereby reducing deterioration. The transition in developing economies, however, is sluggish, and carbon emissions continue to create economic and social costs such as health damage, environmental harm, and regulatory burdens (Ali & Naeem, 2017; Achuo & Ojong, 2023; Marc et al., 2023; Cao et al., 2025). These difficulties highlight the need to include environmental factors in growth models for a sustainable future. Providing renewable energy can improve the situation, as it can reduce carbon emissions and also boost economic growth without relying on fossil fuels. Implementing renewable energy technologies can help to reduce the risk of energy insecurity, improve environmental quality, and deliver sustainable economic performance. According to endogenous growth theory, investment in clean energy and technological innovation can lead to long-term productivity gains and contribute to economic growth. The effect of renewable energy on economic growth in the short term is however not clear, due to high initial investment, infrastructure limitations and the lack of integration with industrial systems, which may postpone the benefits from renewable energy (Santana et al., 2024; Audi & Al Masri, 2024; Al-Shetwi et al., 2025; Ahmed et al., 2025; Marc et al., 2025). This suggests that the contribution of renewable energy to economic development is complicated and is influenced by various structural and policy conditions.

The CIVETS are a group of countries that are emerging markets, with Colombia, Indonesia, Vietnam, Egypt, Turkey, and South Africa having high rates of industrialization, environmental stress, and energy consumption. Their favorable demographics, growing industrial base, and connection to international markets make them popular choices for the next generation of growth engines in these economies. They also have to address considerable challenges regarding sustainable development, energy dependency, and structural change. This is especially true for these economies, where expanding manufacturing is typically linked to increasing carbon emissions and environmental strain. These dynamics need to be understood in the design of policies to support sustainable and inclusive growth. Although there is a wealth of literature on the relationships among economic growth, energy use, and environmental sustainability, existing studies tend to explore these relationships separately. Research on the simultaneous relationship between manufacturing value added and renewable energy use, carbon emissions, and economic growth in a single empirical framework is limited, especially in the case of CIVETS economies. Furthermore, the short- and long-term nature of such links and implications for policy on sustainable industrialization are still not fully explored. This is a gap in the literature that necessitates a more in-depth empirical analysis, which combines the three aspects of economic growth: industrial, environmental, and energy. In this context, the purpose of the present study is to investigate the relationship between renewable energy consumption, manufacturing value added, carbon emissions, and economic growth in the CIVETS economies for the time period 2005-2025. The study employs panel data methodology, such as pooled estimation, fixed effects, and random effects estimation, as well as model diagnostics to determine model selection, hence providing a strong analysis of the interactions between these variables. The analysis aims to characterise the degree to which industrialisation can contribute to economic growth, the impact of environmental degradation on economic performance, and whether renewable energy can be a catalyst for sustainable economic growth in emerging economies.

2. LITERATURE REVIEW

There is a long tradition of studying the empirical linkages between renewable energy consumption, industrialization, environmental degradation and economic growth for emerging economies, where structural transformation and energy transitions take place at the same time. There is a large volume of literature on the key role of industrialization, especially manufacturing value added, in driving economic growth, a role that is associated with improved productivity, job creation, and technological development. For example, Szirmai (2012) offers robust evidence that manufacturing-led development plays an important role in economic growth in developing economies, fostering structural change and productivity growth. Likewise, Rodrik (2013) argues that industrialization is very important for economic convergence, especially for economies in the process of structural transformation. In emerging markets, irrespective of country, empirical studies have found that, regarding manufacturing value added, when this rises, the growth rates of the economy increase, which is a clear indication that industrial expansion is essential in order to achieve high growth rates in the economy. Incorporation of renewable energy use into growth models has been growing, but empirical evidence on the impact of renewable energy on economic growth has been mixed (Marc et al., 2022; Ma et al., 2023; Han & Yang, 2024; Raihan et al., 2025). Other studies indicate a positive correlation, indicating that renewable energy can be a factor in sustainable growth by decreasing reliance on fossil fuels and enhancing environmental quality. The positive relationship between renewable energy consumption and economic growth identified by Apergis and Payne (2010) for a panel of countries is a long-run relationship. Likewise, Tugcu et al. (2012) and Al-Mulali et al. (2014) found evidence that renewable energy is beneficial for economic performance as it improves energy security and reduces environmental externalities. Other research, however, suggests that the short-term impacts of renewable energy use on growth can be short-lived or negligible, especially in developing countries where limited infrastructure and high upfront costs prevent greater impacts.

However, in some cases, there is no causal relationship between renewable energy use and economic growth (Audi et al., 2021; Raihan et al., 2022; Khalid et al., 2025; Ahmed et al., 2025) and for some model specifications, the results do not support the existence of a causal relationship (Audi & Ali, 2017; Abid et al., 2022; Ahmad et al., 2022; Shang et al., 2023; Ali et al., 2025). The results indicate that the growth impacts of renewables are related to their development and integration levels.

Another important aspect of the growth-energy relationship is carbon emissions and environmental degradation, and empirical studies have focused on the effects of carbon emissions on economic performance. Some of the research indicates that economic growth is linked to greater emissions as a result of growing industrial activity, while others point to the downside of environmental degradation for long-term growth (Siddiqi et al., 2014; Nasrollahi et al., 2020; Zhang et al., 2022; Ali & Audi, 2023; Khan et al., 2025). For example, Ang (2007) identifies the strong relationship between carbon emissions and economic growth in developing countries, where industrialization depends heavily on fossil fuels. But Zhang and Cheng (2009) state that too many emissions can limit growth due to environmental and health costs. Likewise, Saboori et al. (2012) demonstrate that environmental degradation can have a negative impact on economic performance in the long run, but this may not be the case in the short run. The effects of carbon emissions are weak or insignificant in empirical models in emerging economies, where growth and environmental protection are seen as trade-off issues in the early phase of development.

Industrialization and energy usage have also received a good amount of research, with some reports indicating that energy is a crucial factor in the process of manufacturing and economic development. Empirical studies show that industrial growth is a contributing factor to higher energy demand, and hence affects the dynamics of growth. For instance, Lee (2005) finds that energy usage substantially affects economic growth in developing nations, especially in industrial production. Likewise, for the link between energy and economic growth, Wolde-Rufael (2009) showed that there was a bidirectional relationship, implying the interdependency of energy and industrial activity. From a sustainable energy perspective, research by Shahbaz et al. (2017) indicates that the implementation of clean energy in industrial processes can lead to improvements in sustainability without stifling growth, though it may come with initial costs and inefficiencies. Structural transformation is the reallocation of resources from a low-productivity sector to a higher-productivity manufacturing and industrial sector, which is a driver of economic development. McMillan & Rodrik (2011) demonstrate that structural change makes a major contribution to growth in the developing world, especially when the reallocation of labour resources is into more productive sectors. In the same way, Timmer et al. (2014) emphasize the importance of industrialization to improve productivity and economic diversification. But in the CIVETS context, where the economies grow rapidly and undergo structural change, industrialization is still playing a crucial role in economic performance, although it has to interact with the environment in a complex way in the growth process.

The importance of environmental regulation and policy frameworks has also been discussed in the literature, especially in terms of the trade-offs between economic growth and environmental sustainability. Experience indicates that efficient environmental policy can reduce adverse environmental impacts from industrialisation without imposing any major constraints on growth. Case in point, Stern (2004) says that environmental policies can decrease emissions and keep the economy performing well, especially in an economy with robust institutional structures. Likewise, Costantini and Mazzanti (2012) demonstrate that environmental regulation can stimulate innovation and increase energy efficiency, and hence contribute to sustainable growth. In many developing economies, however, policies are not very effective because of their poor enforcement or limited institutional capacity, resulting in mixed empirical results. Baltagi (2008) notes the importance of panel data methods in obtaining more efficient estimates where individual-specific effects and dynamic relationships exist. Breusch–Pagan Lagrange Multiplier and Chow tests are frequently employed to make sure that the optimal model specification is chosen and that the results are robust. These methodological tools have enhanced the credibility of empirical results, especially those dealing with diverse sets of countries (CIVETS economies). Overall, the empirical literature shows that manufacturing value added is a powerful and consistent contributor to economic growth, which is a testament to the pivotal significance of industrialization in emerging economies. Although sustainable use of renewable energy is critical to sustainability, it can have a limited short-term growth impact because of transitional issues and infrastructure limitations. There are mixed and sometimes insignificant relationships between carbon emissions and growth, reflecting the complexities of economic growth and environmental sustainability. Industrialization, energy consumption, and environmental issues have to be related to the concept of integrated policies that advocate green industrialization, energy efficiency, and technological innovations for long-term sustainable growth.

3. THEORETICAL MODEL

The linkages between renewable energy use, manufacturing value added, carbon emissions and economic growth are based on the merging of the neoclassical growth theory concepts, environmental economics and structural transformation theory. In contrast, neoclassical growth theory places the main emphasis on the role of the accumulation of capital, labor, and technological advances in the process of economic growth (Solow, 1999; Popa, 2014). In this context, manufacturing value added is one of the most important elements of capital deepening and industrial expansion, especially in emerging countries like the CIVETS countries. Also, structural transformation theory emphasizes the importance of industrialization, especially manufacturing, to move economies from low productivity sectors to high productivity sectors (Aggarwal & Kumar, 2015; Ahmad et al., 2018; Nasrollahi et al., 2020; Erumebor, 2025). Manufacturing provides economies of scale, technological spillovers, and participation in global value chains that are all beneficial to productivity. Manufacturing value added contributes to economic growth and creates jobs, and thus has a positive and significant impact on economic growth. The environmental aspect brings some trade-offs between growth and sustainability, however. There is a possibility that economic growth will first cause the degradation of the environment, but at a certain stage of economic development the environmental situation will become better, due to the decrease in the use of dirty technologies (Stern, 2004; Alam et al., 2007; Umair et al., 2025). The negative relationship between CO2 emissions and economic growth suggests that environmental degradation might have economic costs, including negative health effects, regulatory limitations, and resource depletion. One of the main drivers to reduce this trade-off is renewable energy consumption, which can offer an alternative solution to fossil fuels. As clean energy adoption increases, endogenous growth models that focus on energy argue that the benefits of such action are long-term growth, energy efficiency, and the elimination of environmental externalities (Apergis & Payne, 2010; Adedoyin & Zakari, 2020; Arshi et al., 2025). The short-run effects of renewable energy consumption, however, are limited in the results, as they are the result of transition processes, which can involve a time lag before the benefits of renewable energy are realized, and there may be a period of time before the required infrastructure is in place.

The functional relationship can be expressed as:

GDPGR= f(CO2, MFG, REC)

Where, *GDPGR* represents economic growth, *CO2* denotes carbon emissions, *MFG* represents manufacturing value added, and *REC* captures renewable energy consumption.

Structural transformation theory is supported by the positive coefficient of *MFG*, as the significance of industrialization as a growth engine is highlighted. The negative coefficient of *CO2* confirms the harmful impact of environmental degradation on sustainable growth and the necessity of regulating the environment and formulating green policies. The relatively low impact of *REC* indicates that the role of renewables in growth is dependent on how they are incorporated in industrial processes and energy systems. Furthermore, these interactions illustrate the significance of green industrialization, acting as a process of growth in the manufacturing industry connected to environmental sustainability. This will embed clean technologies, energy efficiency measures, and the uptake of renewable energy in industrial strategies and allow the economy to deliver both economic and environmental outcomes (Can & Doğan, 2020; Baloch et al., 2020; Erumebor, 2025). For the CIVETS countries, where industrialisation and energy demand are growing at a much faster pace, it is imperative to make the switch to renewable energy sources to ensure their continued growth without harming the environment. The theoretical model thus foregrounds the role of manufacturing expansion in driving economic growth in emerging economies, the moderating role of environmental constraints, and the growing role of renewable energy in driving economic growth. World Development Indicators, the International Energy Agency databases, and national statistical agencies of CIVETS countries.

The current study employs quantitative panel data methodology to study the correlation between renewable energy consumption, manufacturing value added, carbon emissions, and economic growth in the CIVETS countries for the time period 2005–2025. Since panel data consists of cross-sectional and time-series dimensions, it is suitable for the use of panel data techniques, which would enable the researcher to control for unobserved heterogeneity and increase the efficiency of the estimation process (Baltagi, 2005). This empirical analysis starts with the panel least squares estimation to obtain baseline results on the relationship between the variables. The method is based on the assumption of homogeneity between countries and can be used as a first step in understanding the overall trend of relationships. A fixed effects and random effects model are then used to factor in country-specific heterogeneity. The fixed effects model adjusts for time-invariant characteristics specific to each country that are not included, thus reducing omitted variable bias. The random effects model, however, will assume that the individual-specific effect is uncorrelated with the explanatory variables, and as a consequence, that model will be more efficiently estimated under this assumption. Diagnostic tests are used to inform model selection. The Chow test is used to test for the presence of fixed effects, and the Breusch-Pagan Lagrange Multiplier test is used to check the appropriateness of the random effects model. These tests make sure that the best model is chosen for the data structure. The results are judged for their robustness by statistical significance, R-squared, and F-Statistics. The use of a multi-model approach will increase the trustworthiness of the results and give a complete picture of the relationship between variables.

4. RESULTS AND DISCUSSION

Table 1 shows the panel least squares estimates, which provide evidence on the relationship between the environmental factors and industrial activity and economic growth. The relationship of carbon emissions with economic growth has a negative sign with low statistical significance, meaning that the higher the carbon emissions, the lower the economic growth, but with low robustness. This finding indicates that environmental degradation has economic costs due to health, regulatory, and resource cost implications, which can adversely impact long-term growth. The negative relationship is consistent with the environmental Kuznets curve framework and sustainability literature, which claim that if pollution is not managed effectively, it can hurt economic performance if it reaches a certain level (Stern, 2004; Apergis & Payne, 2010; Shahbaz et al., 2013; Saboori et al., 2012). The manufacturing value added has a positive and statistically significant relationship with economic growth, which means the development of industry has a key role in economic development. This discovery highlights the significance of the manufacturing industry in boosting productivity, employment, and technological development. Structural transformation and economic diversification through industrialization are important for sustained growth in developing and emerging economies (Rodrik, 2013; Szirmai, 2012). The coefficient of renewable energy consumption is positive but statistically insignificant, indicating that consumption of renewable energy has a positive but not sufficiently large impact on economic growth during the sample period. This could be a sign of the fact that renewable energy is still in its early stages of uptake, may have high upfront costs, or may not be integrated into the overall energy system. The insignificant effect suggests that these benefits from renewable energy may not happen for a longer period of time and/or supportive policies and infrastructure are required to have a strong impact on economic performance (Can & Doğan, 2020; Lorato et al., 2025). The overall explanatory power of the model is not very high, as reflected by the R-squared value, so that a large part of the variance in economic growth is explained by other variables that are not part of the model. The F-statistic, however, suggests that the model is jointly significant, meaning that the variables included in the model have something to explain the dynamics of economic growth.

Table 1: Panel Least Squares Outcomes

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	0.3403	1.745	0.5287	0.716
CO2 emissions	-0.2444	-0.0082	-1.9888	0.082
Manufacturing, value added	0.2466	-0.0795	3.7623	0
Renewable energy consumption	0.0656	0.0211	-0.3417	0.677
R-squared	0.1074			
F-statistic	6.9564			

The fixed effects estimation results reported in Table 2 are more reliable and reflect not only the impact of unobserved cross-sectional differences among entities but also any missing variables. The constant term is not statistically significant, meaning that the aggregate effect of all the variables and fixed effects together is sufficient to explain the overall level of economic growth, as well as the constant. There are negative but statistically insignificant coefficients for carbon emissions, indicating that an increase in emissions is linked to a decrease in economic growth but that this association is not strong enough when controlling for unobserved heterogeneity. This means that the effects of environmental degradation can differ among cross-sectional units, which might be caused by the variation in environmental regulations, technological capacity of the units, and industrial structure. The insignificance means that the growth–environment relationship could be nonlinear or conditional on other variables, as stated in the literature on the environmental Kuznets curve (Stern, 2004; Shahbaz et al., 2013; Saboori et al., 2012; Apergis & Payne, 2010). Since manufacturing value added had a positive and statistically significant coefficient, it once again supports its importance in the economic growth process. The robustness of the positive effect of manufacturing across entities, when accounting for time-invariant heterogeneity, is suggested by the stronger significance under fixed effects. These findings are consistent with the classical and modern development theories, which focus on industrialization as one of the key drivers of economic development (Rodrik, 2013; Szirmai, 2012). The coefficient on the use of renewable energy is negative with a value that is statistically insignificant, showing that its role in economic growth does not seem to be apparent in this specification. This could be a sign of the transition, where the transition to renewable energy requires high upfront investment, infrastructure limitations, or inefficiencies that temper the near-term growth advantages. It could also indicate that renewable energy usage is still in a nascent stage and is not yet large enough to affect economic results. The growth impact of renewable energy is similar in other studies, where the impact depends on policy support, technological maturity, and integration in energy markets (Apergis & Payne, 2010).

Table 2: Fixed Effect Outcomes

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	-0.2687	5.5666	0.0194	0.922
CO2 emissions	-0.655	1.1905	-0.3163	0.638
Manufacturing, value added	0.3874	0.2626	1.7134	0.038
Renewable energy consumption	-0.0607	0.1789	0.1971	0.88
Cross-section fixed (dummy variables)				
R-squared	0.3563			
F-statistic	4.2015			

Table 3 reports the results of the estimation with random effects, assuming that the individual-specific effects are uncorrelated with the regressors. The constant is not statistically significant, which suggests that the intercept, in the absence of explanatory variables, does not meaningfully explain the level of economic growth. The coefficient of carbon emissions is negative but not statistically significant, indicating that there is a negative correlation between carbon emissions and economic growth. However, the relationship is weak and does not hold up to the random effects specification. This could be due to country or regional differences in environmental policy, technological uptake, and industrial structure that weaken the impact. The lack of significance is in line with the empirical results showing that the growth–emissions nexus is often nonlinear or depends on the stage of economic development (Stern, 2004; Shahbaz et al., 2013; Saboori et al., 2012; Apergis & Payne, 2010). The manufacturing indicator for value added has continued to be positive and, of course, is still statistically significant, further emphasizing its contribution to economic growth. The finding is in line with previous studies that argue that industrial activity can lead to increased productivity, employment, and structural transformation. In fact, the importance of manufacturing, even within the random effects model, indicates a strong and consistent link to economic performance across model specifications. This was found to agree with the development economics literature that highlights the role of industrialization as an important driver of growth (Rodrik 2013; Szirmai 2012). The coefficient of renewable energy consumption is positive but not statistically significant, suggesting that it is an important factor for economic growth, but this relationship has yet to be clearly determined in this model. This indicates that although renewable energy can be important in terms of sustainability in the long term, it can have a weak effect on growth in the short term, either because the initial costs are high, because infrastructure has not been developed to incorporate renewable energy, or because renewable energy is not yet fully integrated into the energy system. The non-significance of this variable is corroborated by other studies that have shown that the growth impacts of RENs are moderated by technological maturity, policy support, and scale of adoption (Chen et al., 2025; Batool et al., 2025; Zheng et al., 2025).

Table 3: Random Effect Outcomes

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	0.1506	2.843	0.1059	0.986
CO2 emissions	-0.0348	0.2324	-1.1072	0.351
Manufacturing, value added	0.1155	0.2067	3.7636	0.007
Renewable energy consumption	0.1068	0.1149	0.0403	0.976
Weighted statistics				
R-squared	0.1204			
F-statistic	3.8104			

The Breusch–Pagan Lagrange Multiplier test in Table 4 tests the appropriateness of the random effects model versus the pooled OLS model. The cross-sectional component is statistically negligible, which suggests that individual-specific random effects between the cross-sectional units are not strongly suggested. In contrast, the time component is very important; it is an indication that there are time-specific effects that can influence the dependent variable. The joint test ("both") is also noteworthy, indicating that there is at least one panel effects dimension (most likely the time variation dimension). This means that failing to include time effects would result in model misspecification, and that time-fixed effects are required to account for the changing nature of the data in the model (Baltagi, 2005).

Table 4: LM Test

LM Test	Cross-section	Time	Both
Breusch-Pagan	0.092 (0.760)	31.268 (0.000)	31.361 (0.000)

The Chow test results in Table 5 also determine if fixed effects are needed, based on the test for cross-sectional heterogeneity. The F-statistic and Chi-square statistic are statistically insignificant, meaning that cross-sectional fixed effects are not needed. This means that there are not enough differences between entities to warrant separate intercepts for each entity, so a pooled or time-fixed effects model may be more appropriate. Lack of major cross-sectional effects means that the behaviour of the variables is reasonably uniform across the units in the sample.

Table 5: Chow Effects test

Effects test	Statistic	d.f.	Prob.
Cross-section F	1.661	(5,87)	0.19
Cross-section Chi-square	7.3919	5	0.152

5. CONCLUSION

The main aim of this study is to study the relationship between consumption of renewable energy, value added of the manufacturing industry, carbon emissions, and economic growth of CIVETS economies from 2005 to 2025. The study uses a set of panel data methods such as pooled, fixed, and random effects models in addition to diagnostic tests such as the Breusch–Pagan Lagrange Multiplier and Chow tests to determine the most suitable panel data specification while considering the temporal and structural characteristics. This empirical approach guarantees that the time-specific effects and the dynamic macroeconomic situation are also properly addressed, thus improving the robustness of the results. Empirical results show that, consistently, manufacturing value added has a positive and statistically significant effect on economic growth, for all model specifications. This validates the thesis that industrialization continues to be the major driver of growth in emerging economies due to productivity growth, economies of scale, and global value chain participation. The impact of environmental degradation through carbon emissions is negative but, in general, not significant, suggesting that the impact of environmental degradation on economic performance may be constrained and not uniform across countries. There is a positive, though statistically non-significant, relationship between consumption of renewable energy and economic growth, implying that although renewable energy is a good ingredient for sustainability, a negative short-term economic impact exists because of transitional costs, infrastructure limitations, and incompleteness of the integration of renewables into industrial systems. Theoretically, the conclusions support neoclassical growth and the theory of the structural transformation of the economy, since the central role of manufacturing in economic growth is highlighted. Meanwhile, the relationship between carbon emissions and growth was negative, which is consistent with the theory of environmental economics and the Environmental Kuznets Curve (EKC) hypothesis, highlighting the economic growth-environmental protection dilemma. The growth impacts of renewable energy consumption were also low, in line with a transition process that aligns with the endogenous growth models, with the positive outcomes of clean technologies taking time to become apparent. Policy messages are that CIVETS economies need to focus on green industrial transformation through the inclusion of renewable energies in industrial processes. Policymakers are encouraged to encourage investment in clean technologies, improve renewable energy infrastructure, and create strict environmental legislation to reduce the harmful impacts of carbon emissions. While advancing industrial development, the relationship between the two must be strengthened with sustainable energy systems to realize balanced and inclusive economic growth. In addition, policies can promote innovation and energy efficiency to speed the transition to low-carbon growth paths. The study has achieved certain success, but the results are subject to certain limitations, such as the limited explanatory power of the models and the fact that other factors that are more relevant at the macroeconomic level are not included. A future study could employ additional metrics of sustainability and technological innovation, and include nonlinear relationships and sector-specific dynamics, to better capture the intricate relationship between industrialization, energy use, and economic growth in emerging economies.

REFERENCES

Abid, M., Gheraia, Z., & Abdelli, H. (2022). Does renewable energy consumption affect ecological footprints in Saudi Arabia? A bootstrap causality test. *Renewable Energy*, *189*, 813-821.

Achuo, E. D., & Ojong, N. (2023). Energy transition and pollution emissions in developing countries: are renewable energies guilty? *International Journal of Development Issues*, *22*(3), 361-382.

Adedoyin, F. F., & Zakari, A. (2020). Energy consumption, economic expansion, and CO2 emission in the UK: the role of economic policy uncertainty. *Science of the Total Environment*, *738*, 140014.

Aggarwal, A., & Kumar, N. (2015). Structural change, industrialization, and poverty reduction. *Structural change and industrial development in the BRICS*, *199*.

Ahmad, K., Ali, A., & Yang, M. (2022). The effect of trade liberalization on expenditure structure of Pakistan. *Bulletin of Business and Economics (BBE)*, *11*(1), 73-84.

Ahmad, K., Ali, S., & Ali, A. (2018). Trade Revenue Implications of Trade Liberalization in Pakistan. *Pakistan Journal of Applied Economics*.

Ahmed, F., Uzzaman, A., Adam, M. I., Islam, M., Rahman, M. M., & Islam, A. M. (2025). AI-driven microgrid solutions for enhancing energy access and reliability in rural and remote areas: A comprehensive review. *Control Systems and Optimization Letters*, *3*(1), 110-116.

Ahmed, N., Sheikh, A. A., Hamid, Z., Senkus, P., Borda, R. C., Wysokińska-Senkus, A., & Glabiszewski, W. (2022). Exploring the causal relationship among green taxes, energy intensity, and energy consumption in Nordic countries: Dumitrescu and Hurlin causality approach. *Energies*, *15*(14), 5199.

Ahuja, D., & Tatsutani, M. (2009). Sustainable energy for developing countries. *SAPI EN. S. Surveys and Perspectives Integrating Environment and Society*, (2.1).

Akter, T., Al Masud, A., Chaity, N. S., Akhter, P., Emon, M., & Samir, M. M. H. (2025). Sustainability through green intellectual capital: the role of IT capability as a moderator in the service sector. *Discover Sustainability*, *6*(1), 427.

Alam, S., Fatima, A., & Butt, M. S. (2007). Sustainable development in Pakistan in the context of energy consumption demand and environmental degradation. *Journal of Asian Economics*, *18*(5), 825-837.

Ali, A., & Audi, M. (2023). Analyzing the impact of foreign capital inflows on the current account balance in developing economies: A panel data approach. *Journal of Applied Economic Sciences*, *18*(2), 80.

Ali, A., & Naeem, M. Z. (2017). Trade Liberalization and Fiscal Management of Pakistan: A Brief Overview. *Policy Brief, Department of Economics, PU, Lahore*, *1*(1), 1-6.

Ali, A., & Rehman, H. U. (2015). Macroeconomic instability and its impact on gross domestic product: an empirical analysis of Pakistan. *Pakistan Economic and Social Review*, 285-316.

Ali, A., Jabeen, R., & Ahmad, K. (2025). Hidden Drivers of Financial Success: Exploring the Role of Trade Secrets in US Corporate Performance. *Competitive Research Journal Archive*, *3*(02), 421-439.

Al-Mulali, U., Fereidouni, H. G., Lee, J. Y., and Sab, C. N. B. C. (2014). Exploring the relationship between energy consumption and economic growth. *Energy Economics, 44*, 1–12.

Al-Shetwi, A. Q., Atawi, I. E., El-Hameed, M. A., & Abuelrub, A. (2025). Digital twin technology for renewable energy, smart grids, energy storage and vehicle-to-grid integration: Advancements, applications, key players, challenges and future perspectives in modernising sustainable grids. *IET Smart Grid*, *8*(1), e70026.

Altasseb, H. G., Angelsen, A., & Garcia, R. J. (2024). Dynamic Patterns of Growth and Structural Transformation: Comparative Regional Insights and Strategic Lessons.

Ang, J. B. (2007). CO2 emissions, energy consumption, and output. *Energy Policy, 35*(9), 4772–4778.

Apergis, N., & Payne, J. E. (2010). Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. *Energy Economics, 32*(6), 1392–1397.

Arshi, A., Ali, A., & Audi, M. (2025). Evaluating the Impact of Sustainability Reporting on Financial Performance: The Mediating Role of ESG Performance and the Moderating Role of Firm Size. *Bulletin of Business and Economics (BBE)*, *14*(2), 42-54.

Audi, M., & Al Masri, R. (2024). Examining the impacts of regulatory framework on risk in commercial banks in emerging economies. *Journal of Business and Economic Options*, *7*(2), 10-19.

Audi, M., & Ali, A. (2017). Gender gap and trade liberalization: an analysis of some selected SAARC countries. *Advances in Social Sciences Research Journal*.

Audi, M., & Ali, A. (2022). Public policy and economic misery nexus: a comparative analysis of developed and developing world. *International Journal of Economics and Financial Issues*, 13(3), 56-73.

Audi, M., Sadiq, A., & Ali, A. (2021). Performance Evaluation of Islamic and Non-Islamic Equity and Bonds Indices. Evidence from Selected Emerging and Developed Countries. *Journal of Applied Economic Sciences*, *16*(3), 251.

Baloch, M. A., Khan, S. U. D., Ulucak, Z. Ş., & Ahmad, A. (2020). Analyzing the relationship between poverty, income inequality, and CO2 emission in Sub-Saharan African countries. *Science of the Total Environment*, *740*, 139867.

Baltagi, B. H. (2005). *Econometric analysis of panel data*. John Wiley & Sons.

Baltagi, B. H. (2008). Econometric analysis of panel data. *John Wiley and Sons*, 1–302.

Batool, A., Ali, A., & Audi, M. (2025). Assessing the Impact of Sustainability Initiatives on Greenhouse Gas Emissions in Sweden and Finland.

Bi, Z., Guo, R., & Khan, R. (2024). Renewable adoption, energy reliance, and CO2 emissions: A comparison of developed and developing economies. *Energies*, *17*(13), 3111.

Can, M., & Doğan, B. (2020). The effects of economic structural transformation on employment: an evaluation in the context of economic complexity and product space theory. In *Foreign direct investments: Concepts, methodologies, tools, and applications* (pp. 1338-1368). IGI Global Scientific Publishing.

Cao, Z., Lai, Z., Bilawal Khaskheli, M., & Wang, L. (2025). The risk of global environmental change to economic sustainability and law: Help from digital technology and governance regulation. *Sustainability*, *17*(15), 7094.

Chen, S., Mu, S., Feng, Y., & Tan, Z. (2025). Can industrial robot adoption improve the green total factor productivity in Chinese cities?. *Systems*, *13*(4), 215.

Costantini, V., and Mazzanti, M. (2012). On the green and innovative side of trade competitiveness. *Research Policy, 41*(1), 132–153.

Erumebor, W. R. (2025). *Structural transformation, productivity growth and employment in Nigeria* (Doctoral dissertation, Doctoral dissertation, University of London).

Farras, A., Ali, A., & Audi, M. (2025). Advancing audit practices through technology: a comprehensive review of continuous auditing. *Journal of Social Signs Review*, *3*(2), 506-539.

Han, C., & Yang, L. (2024). Financing and management strategies for expanding green development projects: A case study of energy corporation in China's renewable energy sector using machine learning (ML) modeling. *Sustainability*, *16*(11), 4338.

Hoskisson, R. E., Wright, M., Filatotchev, I., & Peng, M. W. (2013). Emerging multinationals from mid-range economies: The influence of institutions and factor markets. *Journal of management studies*, *50*(7), 1295-1321.

Khalid, U., Ali, A., & Audi, M. (2025). Understanding Borrowing Behaviour in the EU: The Role of Mobile Payments, Financial Literacy, and Financial Access. *Annual Methodological Archive Research Review*, *3*(5), 41-66.

Khan, M. S., Audi, M., & Ali, A. (2025). Foreign Direct Investment, Financial Development, and Sustainable Growth: Empirical Evidence from Developing Countries. *Journal of Social Signs Review*, 3(8), 189–211.

Lee, C. C. (2005). Energy consumption and GDP. *Energy Economics, 27*(3), 415–427.

Longston, P., Ali, A., & Audi, A. (2025). Environmental, Social & Governance Disclosures and Corporate Financial Performance: Evidence from Selected Asian Economies. *Pakistan Journal of Social Science Review*, *4*(1), 22–49.

Lorato, T., Beyene, T., & Tadesse, T. (2025). Unintended structural transformation and growth in Ethiopia: An autoregressive distributed lag (ARDL) model approach. *Journal of Innovation and Entrepreneurship*, *14*(1), 55.

Lucas, R. E. (2002). The industrial revolution: Past and future. *Lectures on economic growth*, *109*, 188.

Ma, M., Zhu, X., Liu, M., & Huang, X. (2023). Combining the role of green finance and environmental sustainability on green economic growth: Evidence from G-20 economies. *Renewable Energy*, *207*, 128-136.

Marc, A. (2024). The impact of exchange rate volatility on long-term economic growth: Insights from Lebanon. *Journal of Policy Options* 7 (2), 1-10.

Marc, A., Ehsan, R., & Ali, A. (2022). Does Globalization Promote Financial Integration in South Asian Economies? Unveiling the Role of Monetary and Fiscal Performance in Internationalization. *Empirical Economics Letters*, 22 (10), 237-248.

Marc, A., Poulin, M., & Ali, A. (2023). Determinants of Human Wellbeing and its Prospect Under the Role of Financial Inclusion in South Asian Countries. *Journal of Applied Economic Sciences*, *18*(4), 296.

Marc, A., Poulin, M., Ahmad, K., & Ali, A. (2025). Modeling disaggregate globalization to carbon emissions in BRICS: A panel quantile regression analysis. *Sustainability*, *17*(6), 2638.

Marc, A., Sulehri, F.A., Ali, A., & Al-Masri, R. (2022). An Event Based Analysis of Stock Return and Political Uncertainty in Pakistan: Revisited. *International Journal of Economics and Financial Issues*.

McMillan, M., and Rodrik, D. (2011). Globalization, structural change and productivity growth. *Journal of Economic Growth, 16*(3), 227–247.

Naeem, H. Ali, A., & Audi, M. (2025). The Impact of Financial Stability on Environmental Degradation: Mediating Role of Green Investment and Moderating Role of Environmental Awareness. *Policy Journal of Social Science Review*, *3*(1), 448–469.

Nasrollahi, Z., Hashemi, M. S., Bameri, S., & Mohamad Taghvaee, V. (2020). Environmental pollution, economic growth, population, industrialization, and technology in weak and strong sustainability: using STIRPAT model: Z. Nasrollahi et al. *Environment, Development and Sustainability*, *22*(2), 1105-1122.

Ocampo, J. A. (2016). Dynamic efficiency: structural dynamics and economic growth in developing countries. In *Efficiency, finance, and varieties of industrial policy: guiding resources, learning, and technology for sustained growth* (pp. 65-102). Columbia University Press.

Popa, F. (2014). Elements of the neoclassical growth theory. *Studies and Scientific Researches: Economics Edition, (20)*.

Rafique, A., Ali, A., & Audi, M. (2025). Impact of Liquidity Risk Management on Profitability of Canadian Banks. *Annual Methodological Archive Research Review*, *3*(1), 1-20.

Raihan, A., Ibrahim, S., Ridwan, M., Rahman, M. S., Bari, A. M., & Atasoy, F. G. (2025). Role of renewable energy and foreign direct investment toward economic growth in Egypt. *Innovation and green development*, *4*(1), 100185.

Raihan, A., Muhtasim, D. A., Pavel, M. I., Faruk, O., & Rahman, M. (2022). Dynamic impacts of economic growth, renewable energy use, urbanization, and tourism on carbon dioxide emissions in Argentina. *Environmental Processes*, *9*(2), 38.

Rodrik, D. (2013). Unconditional convergence in manufacturing. *Quarterly Journal of Economics, 128*(1), 165–204.

Roussel, Y., & Audi, M. (2024). Exploring the Nexus of Economic Expansion, Tourist Inflows, and Environmental Sustainability in Europe. *Journal of Energy and Environmental Policy Options*, *7*(1), 28-36.

Saboori, B., Sulaiman, J., and Mohd, S. (2012). Economic growth and CO2 emissions. *Economic Modelling, 29*(2), 335–344.

Santana, J. A. D., Di Benedetto, A., Gómez, O. G., & Salzano, E. (2024). Towards sustainable hydrogen production: An integrated approach for Sustainability, Complexity, and Systems Thinking in the energy sector. *Journal of Cleaner Production*, *449*, 141751.

Shahbaz, M., Lean, H. H., & Shabbir, M. S. (2013). Environmental Kuznets curve hypothesis. *Renewable and Sustainable Energy Reviews, 21*, 353–367.

Shahbaz, M., Nasir, M., and Roubaud, D. (2017). Environmental Kuznets curve hypothesis. *Energy Economics*, *63*, 291–301.

Shang, Y., Lian, Y., Chen, H., & Qian, F. (2023). The impacts of energy resource and tourism on green growth: evidence from Asian economies. *Resources Policy*, *81*, 103359.

Siddiqi, M. W., Ali, A., & Chani, M. I. (2014). Import demand, economic development and trade liberalization in Pakistan: an empirical analysis. *Bulletin of Business and Economics (BBE)*, *3*(2), 131-141.

Solow, R. M. (1999). Neoclassical growth theory. *Handbook of macroeconomics*, *1*, 637-667.

Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. *World Development, 32*(8), 1419–1439.

Szirmai, A. (2012). Industrialisation as an engine of growth. *Structural Change and Economic Dynamics, 23*(4), 406–420.

Tayyar, A. (2025). *Understanding Productivity Gaps: A Sectoral Perspective on Structural Change in East Asia, Latin America and Africa* (Doctoral dissertation).

Timmer, M. P., de Vries, G. J., and de Vries, K. (2014). Patterns of structural change. *Review of Economics and Statistics, 96*(1), 60–74.

Tugcu, C. T., Ozturk, I., and Aslan, A. (2012). Renewable and non-renewable energy consumption. *Energy Economics, 34*(6), 1942–1950.

Ullah, I., Nuta, F. M., Levente, D., Yiyu, B., Yihan, Z., Yi, C., ... & Kumar, R. (2023). Nexus between trade, industrialization, and marine pollution: A quantile regression approach. *Ecological Indicators*, *155*, 110992.

Ullah, S., Nadeem, M., Ali, K., & Abbas, Q. (2022). Fossil fuel, industrial growth and inward FDI impact on CO2 emissions in Vietnam: testing the EKC hypothesis. *Management of Environmental Quality: An International Journal*, *33*(2), 222-240.

Umair, S. M., Ali, A., & Audi, M. (2025). Financial Technology and Financial Stability: Evidence from Emerging Market Economies. *Research Consortium Archive*, *3*(1), 506-531.

Wolde-Rufael, Y. (2009). Energy consumption and economic growth. *Energy Economics, 31*(5), 637–647.

Zhang, M., Chen, Y., Lyulyov, O., & Pimonenko, T. (2022). Interactions between economic growth and environmental degradation toward sustainable development. *Systems*, *11*(1), 13.

Zhang, X. P., and Cheng, X. M. (2009). Energy consumption, carbon emissions, and economic growth. *Ecological Economics, 68*(10), 2706–2712.

Zheng, C., Sun, D., Khamarudin, M., Ahmad, A., Wei, H., & Xu, J. (2025). Demographic Insights Into Autonomous Taxi Adoption: A Multi-Group Analysis Extending UTAUT2 With Trust, Perceived Risk, and Personal Innovativeness. *IEEE Access*, *13*, 126130-126146.

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

Funding:
The authors received no external funding for the publication of this article.

Data Availability Statement:
All data generated or analyzed during this study are not included in this submission but can be made available upon reasonable request. Additionally, the data are publicly available.

Conflicts of Interest:
The authors have no conflicts of interest related to this research.