Balancing Growth and Sustainability: The Role of Energy Transition in the MENA Region

Saida Daly[1,2]

[1] Faculty of Economics and Management Sciences of Mahdia, University of Monastir, Tunisia.

saida_daly@yahoo.com

[2]Department of Finance, College of Business and Economics, Qassim University, P.O. Box 6640, Buraydah 51452, Saudi Arabia
s.daly@qu.edu.sa

Abstract

This article investigates the impact of the energy transition on both economic growth and environmental sustainability in the Middle East and North Africa (MENA) region. As countries in the region face increasing pressure to diversify their energy mix and reduce dependence on fossil fuels, understanding the economic and ecological implications of this transition becomes crucial. By employing advanced econometric techniques, this study explores the causal links between renewable energy consumption, economic growth, and carbon dioxide (CO_2) emissions. The empirical results reveal that a well-structured and effectively implemented energy transition can foster long-term economic development while significantly mitigating environmental degradation. These findings underscore the need for coherent energy policies that balance economic and environmental objectives to ensure a sustainable future for the MENA region.

Keywords : Economic growth; Environmental sustainability; MENA region; Causal relationship; Sustainable development

1- Introduction

The Middle East and North Africa (MENA) region is at a critical crossroads as it seeks to balance economic growth with environmental sustainability. Historically reliant on fossil fuels and carbon-intensive industries, many MENA countries face mounting pressure to diversify their energy mix and transition towards renewable energy sources. This energy transition is not only essential for mitigating climate change but also presents an opportunity to foster sustainable economic development. However, the region's unique economic, institutional, and environmental characteristics complicate this transition, necessitating a nuanced understanding of the dynamic relationships between economic growth, energy consumption, foreign direct investment (FDI), institutional quality, and environmental outcomes.

© Copyright 2025
ISSN: 2961-6638

While prior studies have examined individual links between these factors, comprehensive analyses capturing their interdependent and bidirectional causal relationships remain limited for the MENA context. This study addresses this gap by employing advanced panel econometric techniques to investigate the complex interactions between renewable energy consumption, economic growth, FDI, institutional quality, and CO_2 emissions across selected MENA countries over the period 2000–2023. By analyzing these variables jointly, the research sheds light on the feedback loops and inertia inherent in economic and environmental systems, providing valuable insights into how the region can effectively manage its energy transition.

The findings reveal significant economic inertia, with past GDP levels strongly influencing future growth, and identify renewable energy adoption and FDI as key drivers of economic expansion. At the same time, the persistent causal link between CO_2 emissions and GDP highlights the challenge of decoupling growth from environmental degradation. Institutional quality, while influential, appears to have a more gradual and indirect effect. The bidirectional causality observed between emissions and economic as well as institutional variables underscores the complexity of achieving sustainable development and highlights the importance of integrated policy frameworks. This study contributes to the growing body of literature on sustainable development in emerging economies and offers practical implications for policymakers aiming to align growth, governance, and environmental protection in the MENA region.

The remainder of this paper is organized as follows. Section 2 provides a comprehensive literature review, examining prior studies related to the relationships between renewable energy, economic growth, foreign direct investment, institutional quality, and environmental sustainability. Section 3 outlines the research methodology, detailing the data sources, variable selection, and econometric techniques employed, including the Dumitrescu-Hurlin causality test and panel Vector Autoregression (VAR-P) model. Section 4 presents the empirical results and discussion, highlighting the key findings and their implications. Section 5 analyzes the impact of exogenous shocks using impulse response functions to explore the dynamic responses of the variables over time. Finally, Section 6 concludes the study by summarizing the main contributions and offering policy recommendations aimed at fostering sustainable development in the MENA region.

2- Literature review

The nexus between energy consumption and economic growth has long been a subject of academic interest. The foundational work of Solow (1956) on economic growth, followed by Smil (1976) and Kraft and Kraft (1978), established early theoretical and empirical connections between energy use and macroeconomic performance. These pioneering studies laid the groundwork for contemporary analyses of energy transitions and their implications for sustainable development.

© Copyright 2025
ISSN: 2961-6638

Over time, increasing attention has been given to the role of renewable energy within this relationship. More recent studies have sought to empirically validate the link between renewable energy consumption and economic growth across various regional and national contexts. For instance, Khobai et al. (2018) identified a long-run equilibrium relationship between renewable energy use and economic growth in South Africa, while Al-Mulali et al. (2013) highlighted its positive impact on employment, particularly in developing countries.

Further support for the renewable energy–growth hypothesis can be found in the work of Kahia et al. (2017), who examined MENA countries, and Elbadri et al. (2023), who explored the case of Algeria using the Fourier-Bootstrap ARDL approach. Their study demonstrated a long-run relationship between renewable energy consumption, economic growth, and CO_2 emissions, while rejecting the Environmental Kuznets Curve (EKC) hypothesis. Notably, renewable energy reduced emissions in both the short and long term, whereas economic growth increased emissions over time.

The environmental dimension of the energy transition has also received considerable attention. Several empirical investigations, including those by Jaforullah and King (2015), Apergis et al. (2015), and Aguilal and Outtaj (2024), found that renewable energy use contributes to carbon emissions reduction. However, these benefits tend to vary depending on a country's structural and institutional characteristics, such as policy coherence, energy dependency, and the maturity of its energy markets.

Nonetheless, limitations persist. Chiu and Chang (2009) and Antonakakis et al. (2017) argue that in high-income countries, the dual challenge of sustained economic growth and continued fossil fuel dependence may hinder progress in renewable energy deployment. These observations have been echoed in more recent studies, emphasizing the urgency of comprehensive policy reforms to accelerate the transition.

Recent contributions such as Zafar et al. (2022), Rahman and Alam (2023), and Charfeddine et al. (2025) provide updated insights into the interplay between renewable energy, technological advancement, financial instruments, and environmental goals in the MENA region. These studies underscore the importance of integrating green finance, clean energy technologies, and regulatory frameworks to foster environmental sustainability in carbon-intensive economies.

In summary, while a growing body of literature confirms the positive role of renewable energy in promoting economic growth and mitigating emissions, the overall effectiveness of the transition is highly dependent on national circumstances, institutional readiness, and coherent long-term energy policies.

3. Research methodology

© Copyright 2025
ISSN: 2961-6638

This study focuses on a panel of five strategically selected MENA countries—Algeria, Egypt, the United Arab Emirates, Morocco, and Tunisia—over the period from 2000 to 2023. These countries represent a diverse mix of economic structures, energy profiles, and institutional frameworks, providing a comprehensive perspective on the region's ongoing energy transition and its economic and environmental implications. Building upon the methodological framework proposed by Idalfahim and Elouardirhi (2024), we employ the Dumitrescu-Hurlin panel causality test to rigorously identify the direction and significance of causal relationships between critical variables, including renewable energy consumption, institutional quality, foreign direct investment (FDI), economic growth, and CO_2 emissions. This causality analysis allows us to disentangle the temporal order and influence mechanisms among these interconnected factors. Subsequently, we apply Impulse Response Functions (IRF) within a panel Vector Autoregression (VAR) framework to investigate the dynamic temporal responses of two core models: Model 1, which examines economic growth (GDP) in response to shocks in the energy transition (ENR), institutional quality (INST), and FDI; and Model 2, which explores the behavior of CO_2 emissions under similar shocks. This combined approach facilitates a deeper understanding of both the immediate and lagged effects that policy-relevant shocks exert on economic and environmental outcomes, thereby offering valuable insights into the complex interplay shaping sustainable development pathways in the MENA region.

Model 1: Effect of the Energy Transition on Economic Growth:

$$PIB_{it} = \alpha_1 + \sum_{p=1}^{p} \beta_{11}^{(p)} PIB_{i,t-p} + \sum_{p=1}^{p} \beta_{12}^{(p)} CO2_{i,t-p} + \sum_{p=1}^{p} \gamma_1^{(p)} ENR_{i,t-p} + \sum_{p=1}^{p} \emptyset_1^{(p)} INST_{i,t-p} + \sum_{p=1}^{p} \theta_1^{(p)} IDE_{i,t-p} + \varepsilon_{1it}$$

Model 2: Effect of the Energy Transition on CO_2 Emissions:

$$CO2_{it} = \alpha_2 + \sum_{p=1}^{p} \beta_{21}^{(p)} PIB_{i,t-p} + \sum_{p=1}^{p} \beta_{22}^{(p)} CO2_{i,t-p} + \sum_{p=1}^{p} \gamma_2^{(p)} ENR_{i,t-p} + \sum_{p=1}^{p} \emptyset_2^{(p)} INST_{i,t-p} + \sum_{p=1}^{p} \theta_2^{(p)} IDE_{i,t-p} + \varepsilon_{2it}$$

The Dumitrescu-Hurlin panel causality test is particularly well-suited for heterogeneous panel data structures, as it allows for individual-specific dynamics while testing for the presence of Granger causality across cross-sectional units. This method enables us to assess whether changes

© Copyright 2025
ISSN: 2961-6638

in one variable consistently precede changes in another across the countries studied, accounting for potential heterogeneity in the direction and strength of the relationships. Following the causality analysis, we implement Impulse Response Function (IRF) analysis within a panel Vector Autoregression (VAR) framework to examine the dynamic interactions among the variables over time. Specifically, the IRFs trace the response trajectories of the dependent variables—GDP (Model 1) and CO_2 emissions (Model 2)—to a one standard deviation structural shock in each of the key explanatory variables: renewable energy consumption (ENR), institutional quality (INST), and foreign direct investment (FDI). This dynamic approach allows us to capture not only the magnitude but also the duration and direction of the effects, offering a comprehensive view of the temporal interplay between economic and environmental indicators in the MENA region.

4- Results and discussion

4.1- Stationarity and Cointegration Tests of the Variables

Table 1 below presents the descriptive statistics and the correlation matrix. The analysis highlights significant heterogeneity among the five MENA countries, particularly regarding Foreign Direct Investment (FDI) and CO_2 emissions. This variation reflects differing national policies, economic structures, and environmental priorities across the region.

The Jarque-Bera test confirms the normal distribution of the variables, supporting the reliability of the statistical inferences. The correlation matrix reveals several key relationships: the energy transition and institutional quality are negatively associated with CO_2 emissions, suggesting their potential to mitigate environmental degradation. Conversely, FDI appears to contribute to higher CO_2 emissions, possibly due to pollution-intensive investments in some countries.

Furthermore, economic growth shows a moderate positive correlation with the energy transition, implying that development and environmental sustainability may advance together under certain conditions. Lastly, the Variance Inflation Factor (VIF) values are all below the critical threshold of 3, indicating the absence of multicollinearity among the explanatory variables. This strengthens the robustness and reliability of the econometric model used in subsequent analyses.

Table 1:
descriptive statistics & correlation

	GDP	CO2	IDE	ENR	INST	VIF
Mean	6.387926	2.404168	7.587945	4.370861	9.556429	—
Median	6.410035	7.372653	8.795585	2.403951	1.522753	—
Maximum	14.31945	12.91229	15.24756	11.83405	13.04242	—
Minimum	1.061696	0.909125	4.162213	0.102922	4.849549	—
Std. Dev.	2.148628	2.552315	1.814651	3.253338	1.127722	—

© Copyright 2025
ISSN: 2961-6638

CV	13.88622	5.696756	12.71352	16.77764	7.995107	—
J-B	9.493967	9.659757	0.744011	6.114694	1.788189	—
Probability	0.030548	0.041349	0.025719	0.012229	0.038521	—
GDP	1					1.210
CO2	-0.08926	1				1.036
IDE	-0.09139	0.127384	1			1.204
ENR	0.097155	-0.09532	-0.1158	1		1.051
INST	0.082388	-0.26351	-0.18912	-0.16063	1	1.055

4.2- Integration Order Identification Test

The empirical analysis begins with stationarity tests (ADF, PP, KPSS). The results (Table 2) indicate that all variables are stationary at level [I(0)], eliminating the need for differencing. This finding allows for the application of the Dumitrescu-Hurlin causality test and the use of impulse response functions to explore the temporal dynamics among the variables.

Table 2:
unit root test results

Variables	ADF_ Level	PP_ Level	KPSS- Level	Order of Integration
GDP	-4.521***	-4.489***	0.312	I(0)
CO2	-5.113***	-5.090***	0.289	I(0)
IDE	-3.829***	-3.810***	0.273	I(0)
ENR	-4.678***	-4.650***	0.251	I(0)
INST	-3.945***	-3.920***	0.265	I(0)

Note: *** and ** indicate significance at the 1% and 5% levels, respectively.

4.3- Dumitrescu-Hurlin Causality Test

The Dumitrescu-Hurlin causality test is used to examine the causal relationships between GDP and its key determinants: renewable energy (ENR), institutional quality (INST), foreign direct investment (FDI), and CO_2 emissions. The results presented in Table 3 provide clear evidence of economic inertia within the MENA region, as indicated by the statistically significant relationship between past and future values of GDP ($p = 0.012$). This finding suggests that the region's economic output tends to follow a self-reinforcing trajectory, where previous growth creates momentum for continued expansion. Such inertia may reflect underlying structural dynamics, including path dependence in investment, consumption, and production, as well as delayed responses to policy changes.

Furthermore, the Dumitrescu-Hurlin causality test reveals a positive and statistically significant causal effect from renewable energy consumption ($p = 0.045$) and foreign direct investment (FDI) ($p = 0.030$) on economic growth. These results highlight the growing importance of the energy transition and international capital flows as key engines of development. The positive impact of renewable energy may be attributed to increased energy efficiency, the diversification

© Copyright 2025
ISSN: 2961-6638

of energy sources, and job creation in emerging green sectors, while FDI often facilitates technology transfer, capital accumulation, and integration into global value chains. Together, these drivers are contributing to improved GDP performance across the countries studied.

Notably, CO_2 emissions also demonstrate a significant causal link with GDP ($p = 0.048$), which underscores the region's continued reliance on carbon-intensive economic activities. This association reinforces the complexity of pursuing sustainable development, as economic gains remain tied to environmentally harmful practices, particularly in sectors such as energy production, manufacturing, and heavy industry. The result emphasizes the structural difficulty of decoupling economic growth from environmental degradation, a challenge that remains central to achieving low-carbon development in the MENA context.

Institutional quality, although not strongly significant ($p = 0.085$), still exhibits a moderate effect on GDP, suggesting that governance structures, regulatory efficiency, and institutional stability play a role in shaping economic outcomes. However, the influence of institutions appears to be more nuanced, possibly acting through indirect channels such as investor confidence, policy implementation effectiveness, or the ability to manage large-scale transitions like energy reforms. The marginal significance may also reflect variation in institutional strength across the sample countries or the need for longer time horizons for institutional reforms to take effect.

These interrelated dynamics justify the subsequent application of a panel Vector Autoregression (VAR-P) model to further examine the temporal interactions and feedback mechanisms among the variables. The VAR-P framework is particularly well-suited for capturing endogeneity, bidirectional causality, and the evolving relationships over time between economic, institutional, and environmental indicators. This approach enables a more comprehensive understanding of the multifaceted and dynamic system influencing sustainable development in the MENA region.

Table3:
Dumitrescu-hurlin causality test results – model 1 (GDP)

Cause	Effect	Optimal Lag	P-Value	Decision
PIB	PIB	1	0.012***	Reject
ENR	PIB	4	0.045**	Reject
INST	PIB	4	0.085*	Accept
IDE	PIB	2	0.030**	Reject
CO2	PIB	3	0.048**	Reject
PIB	ENR	5	0.061*	Accept
PIB	INST	4	0.138	Accept
PIB	IDE	2	0.791	Accept
PIB	CO2	5	0.468	Accept

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

According to the results presented in Table 4, CO_2 emissions exhibit strong persistence over time ($p = 0.010$), indicating that historical emission levels exert a significant influence on current emission patterns. This persistence suggests a high degree of inertia in environmental

© Copyright 2025
ISSN: 2961-6638

degradation, which may be attributed to entrenched industrial structures, energy consumption habits, and delayed effects of regulatory measures. Additionally, both GDP (p = 0.035) and Foreign Direct Investment (FDI) (p = 0.020) are found to have statistically significant impacts on CO_2 emissions, demonstrating the close linkage between economic expansion, foreign capital inflows, and environmental pressures in the MENA region. Economic growth and FDI, while essential for development, appear to contribute to increased emissions, reflecting the ongoing reliance on carbon-intensive activities and the need for careful management of investment flows.

The analysis also reveals that the energy transition (p = 0.050) and institutional quality (p = 0.078) influence CO_2 emissions with a lagged effect, suggesting that the benefits of renewable energy adoption and improvements in governance take time to materialize in terms of measurable environmental improvements. This delayed impact likely reflects the gradual nature of structural economic changes and the time required for policy reforms to be fully implemented and produce tangible outcomes.

Importantly, the causality analysis highlights that CO_2 emissions themselves exert a significant influence on several key economic and institutional variables, including GDP (p = 0.041), renewable energy transition (p = 0.067), institutional quality (p = 0.089), and FDI (p = 0.015). This evidence of bidirectional causality underscores the complex interdependence between environmental conditions and economic and institutional dynamics. It implies that environmental degradation does not merely result from economic activity but also feeds back into shaping economic performance, investment decisions, and governance quality. Such a reciprocal relationship emphasizes the multifaceted challenges of achieving sustainable development and underscores the critical need for integrated policy approaches that simultaneously address economic growth, investment attraction, institutional strengthening, and environmental protection. Without coordinated and holistic strategies, efforts to promote development risk exacerbating environmental degradation, thereby undermining long-term sustainability goals in the MENA region.

Table 4:
Dumitrescu-hurlin causality test results – model 2 (CO_2)

Cause	Effect	Optimal Lag	P-Value	Decision
CO2	CO2	1	0.010***	Reject
PIB	CO2	3	0.035**	Reject
ENR	CO2	4	0.050*	Accept
INST	CO2	2	0.078*	Accept
IDE	CO2	3	0.020**	Reject
CO2	PIB	2	0.041**	Reject
CO2	ENR	3	0.067*	Accept
CO2	INST	4	0.089*	Accept
CO2	IDE	2	0.015**	Reject

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5- Impact of Exogenous Shocks: Analysis through Impulse Response Functions

© Copyright 2025
ISSN: 2961-6638

The impulse response function (IRF) analysis in (Fig 1) reveals several important dynamic relationships among the key variables in Model 1.

First, the positive response of GDP to a shock in its own value indicates strong economic inertia. This means that when the economy experiences an unexpected increase in output, the effect tends to persist over time. Such persistence reflects the presence of internal reinforcing mechanisms, such as increased investment, consumption, and business confidence, that sustain growth momentum. This highlights the self-propelling nature of economic growth; whereby initial shocks continue to influence the economy in the medium term.

Second, shocks to the renewable energy transition and institutional quality also positively stimulate GDP growth. This underscores the strategic importance of shifting towards a cleaner, more sustainable energy system. The adoption of renewable energy is not only an environmental imperative but also a driver of economic growth through job creation, technological innovation, and long-term energy cost reductions. Similarly, improvements in institutional quality, characterized by political stability, transparency, effective governance, and anti-corruption measures, create a favorable environment for productive investments, which further supports economic development.

Third, foreign direct investment (FDI) exhibits an immediate but heterogeneous impact on GDP. This heterogeneity likely arises from the sectoral composition of FDI inflows. Investments directed towards high-value-added or technology-intensive sectors may rapidly enhance economic output, while FDI targeting traditional or extractive industries may have more muted or even negative short-term effects. This suggests the importance of targeted economic policies to attract FDI in sectors that maximize positive growth spillovers.

Finally, a shock to CO_2 emissions initially increases GDP, likely reflecting intensified industrial and economic activity. However, this positive effect diminishes over time as the negative externalities of pollution, such as health-related costs, environmental degradation, and resource depletion, begin to weigh on the economy. These external costs reduce productivity and increase public expenditures, thereby offsetting earlier economic gains. This dynamic illustrates the short-term trade-off between economic growth and environmental quality in economies that still rely heavily on carbon-intensive development. It also highlights the critical need for sustainable development strategies that can mitigate environmental harm while maintaining economic progress.

In the MENA region, balancing economic growth with environmental sustainability remains a key challenge due to heavy reliance on carbon-intensive industries. Promoting renewable energy adoption and strengthening institutional quality are essential to foster sustainable development. Strategic attraction of FDI towards clean and innovative sectors can further enhance long-term economic resilience.

© Copyright 2025
ISSN: 2961-6638

The impulse response analysis in Model 2 (Fig 2) provides valuable insights into the temporal dynamics of CO_2 emissions in response to various economic and institutional shocks across MENA countries. The patterns revealed by the IRFs emphasize the structural complexity of environmental outcomes and the interconnectedness between development strategies and sustainability.

A shock to CO_2 emissions itself leads to a pronounced and persistent increase in emissions over time. This strong autoreactive behavior highlights the inertia of environmental degradation in the absence of targeted interventions. In other words, once emissions begin to rise, due to industrial expansion, energy demand, or weak environmental regulation, they tend to remain elevated, reinforcing the need for long-term mitigation policies.

When examining the effect of a renewable energy (ENR) shock, the IRF shows a gradual but consistent decline in CO_2 emissions. This delayed response reflects the structural lag between the implementation of clean energy strategies and their measurable impact on emission levels. It suggests that while energy transition is a critical pathway toward decarbonization, its environmental benefits accumulate over time, emphasizing the importance of sustained investment and policy continuity.

Shocks to institutional quality (INST) also lead to a moderate reduction in emissions, reinforcing the view that good governance plays an essential role in shaping environmental outcomes. Institutions contribute through regulatory enforcement, promotion of sustainable practices, and oversight of pollution-intensive sectors. However, the impact is relatively modest and slow-moving, indicating that institutional reforms must be deep, consistent, and accompanied by complementary policy tools to deliver strong environmental dividends.

In contrast, a shock in Foreign Direct Investment (FDI) causes a short-term increase in CO_2 emissions. This finding suggests that FDI inflows, in the absence of environmental safeguards, may be directed toward pollution-intensive industries such as manufacturing, mining, or petrochemicals. This aligns with concerns regarding the “pollution haven” hypothesis, where developing countries attract investment at the cost of environmental quality unless proper regulation is enforced.

Finally, the response of CO_2 emissions to a GDP shock is particularly notable. The IRF shows an initial rise in emissions, followed by a stabilization or mild decline in the longer term. This pattern reflects the well-known Environmental Kuznets Curve (EKC) hypothesis, which posits that environmental degradation intensifies during early stages of economic growth but tends to decrease once a certain income level is reached, thanks to structural shifts, technological innovation, and growing environmental awareness.

© Copyright 2025
ISSN: 2961-6638

Taken together, these findings underscore the dual challenge of promoting growth while managing environmental impact. They point to the need for an integrated strategy that combines clean energy investment, institutional strengthening, and green regulation of foreign capital flows. Without such a holistic approach, economic development may continue to come at the expense of environmental sustainability in the MENA region.

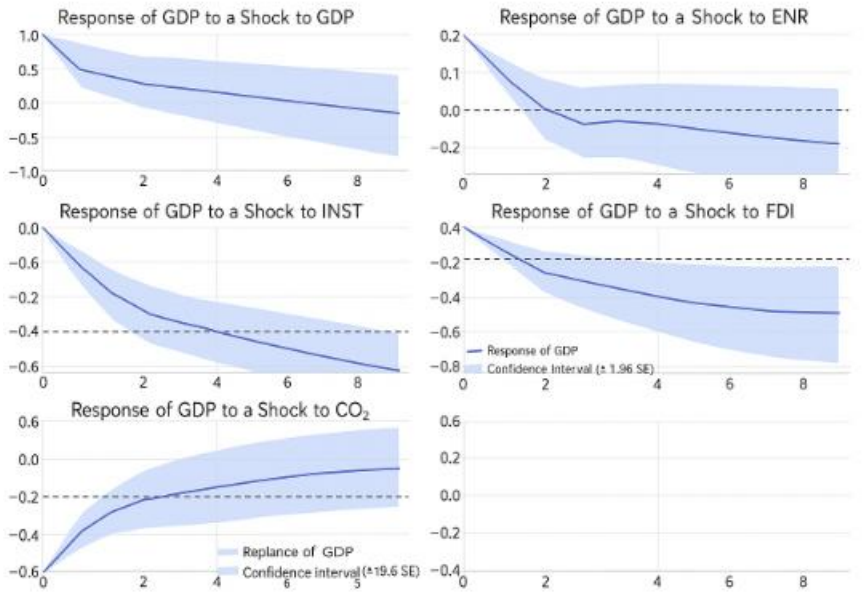

Fig. 1 Impulse Response Function (IRF) – Model 1 (GDP)

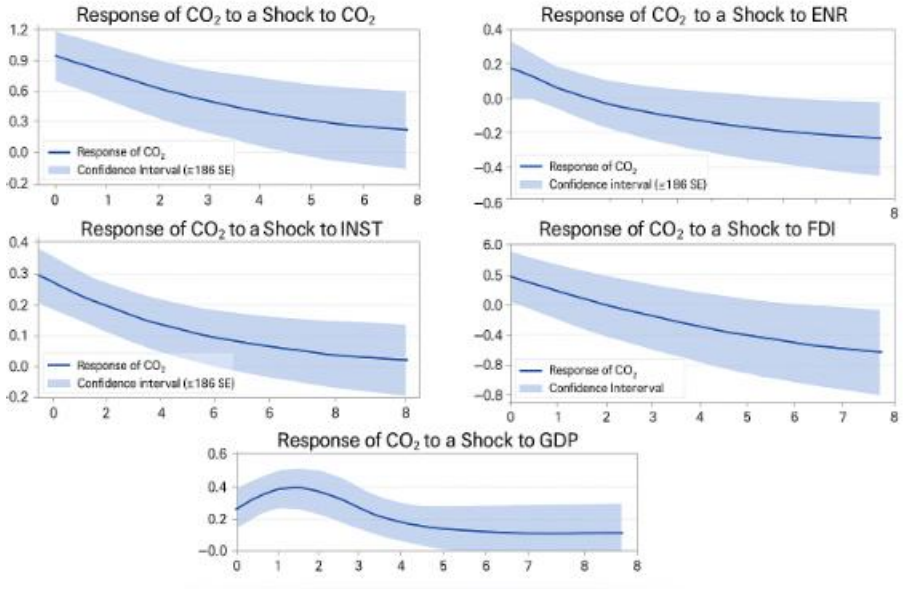

Fig. 2 Impulse Response Function (IRF) – Model 2 (CO_2)

© Copyright 2025
ISSN: 2961-6638

6- Conclusion and policy implications

This study examined the dynamic and causal relationships between renewable energy consumption, economic growth, foreign direct investment (FDI), institutional quality, and CO_2 emissions in the MENA region, specifically in Algeria, Egypt, the United Arab Emirates, Morocco, and Tunisia, over the period 2000 to 2023, offering new insights into the opportunities and challenges of transitioning toward sustainable development. The empirical evidence, based on advanced panel econometric techniques including the Dumitrescu-Hurlin causality test and impulse response function (IRF) analysis, reveals that while economic growth in the region remains significantly driven by carbon-intensive activities, the transition to renewable energy, if properly supported and scaled, has the potential to decouple growth from environmental degradation. Renewable energy and FDI both contribute positively to GDP, with FDI representing an important lever for development. However, the environmental impact of FDI varies depending on the targeted sectors and regulatory context, confirming concerns related to the "pollution haven" hypothesis in the absence of adequate environmental governance.

CO_2 emissions show strong inertia and bidirectional causality with other key variables, underscoring the systemic nature of environmental degradation and its feedback into economic performance, institutional capacity, and investment flows. Institutional quality, while statistically significant, exerts a slower and more indirect influence, suggesting that its full effect on sustainability outcomes depends on long-term reforms and policy coherence. These findings support the Environmental Kuznets Curve (EKC) hypothesis, where emissions rise during early stages of development and potentially decline with greater income, improved governance, and technological shifts, yet such a trajectory is not automatic and requires deliberate intervention.

For policymakers in the MENA region, these results emphasize the urgency of adopting integrated and forward-looking policy frameworks. Accelerating renewable energy deployment, directing FDI toward clean and high-value-added sectors, and reinforcing institutional structures must be pursued in tandem. Environmental regulation must be strengthened to avoid locking economies into pollution-intensive growth paths. Moreover, the delayed but significant effects of energy and institutional reforms highlight the importance of consistency and continuity in policy implementation. In sum, the energy transition represents not only an environmental imperative but also a strategic development opportunity. Harnessing its full potential requires aligning economic, environmental, and governance agendas to achieve a resilient and sustainable future for the MENA region.

© Copyright 2025
ISSN: 2961-6638

References

Aguilal, H., & Outtaj, A. (2024). Renewable energy and CO_2 emissions in the MENA region: Evidence from panel quantile regression. *Environmental Economics and Policy Studies*, forthcoming.

Al-Mulali, U., Sab, C. N. B. C., & Fereidouni, H. G. (2013). Exploring the relationship between energy consumption, capital, labor and economic growth in oil exporters. *Energy*, *54*, 121–128.

Antonakakis, N., Chatziantoniou, I., & Filis, G. (2017). Energy consumption, CO_2 emissions, and economic growth: An ethical dilemma. *Renewable and Sustainable Energy Reviews*, *68*(2), 808–824.

Apergis, N., Payne, J. E., Menyah, K., & Wolde-Rufael, Y. (2015). On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. *Environmental Science and Pollution Research*, *22*(4), 2836–2846.

Charfeddine, L., Kahia, M., & Rahman, A. (2025). The role of technologies, finance, and green energies in transforming Middle East and North African environmental sustainability. *Sustainable Futures*, *9*, 100574.

Chiu, Y. B., & Chang, T. H. (2009). What proportion of renewable energy supplies is needed to initially mitigate CO_2 emissions? *Renewable and Sustainable Energy Reviews*, *13*(6–7), 1669–1674.

Elbadri, M., Bsikre, S., Alamari, O., & Balcilar, M. (2023). Nexus between renewable energy consumption, economic growth, and CO_2 emissions in Algeria: New evidence from the Fourier-bootstrap ARDL approach. *Natural Resources Forum*, *47*(3), 393–412.

Idalfahim, M., & Elouardirhi, S. (2024). Les effets des énergies renouvelables, de l'ouverture économique et de l'urbanisation sur les émissions de dioxyde de carbone dans les pays africains: Une évidence empirique. *International Journal of Accounting, Finance, Auditing, Management and Economics*, *5*(7), 494–507.

Jaforullah, M., & King, A. (2015). The econometric consequences of an energy consumption–CO_2 emissions–economic growth nexus: The case of New Zealand. *Energy Economics*, *50*, 322–331.

Kahia, M., Aïssa, M. S. B., & Lanouar, C. (2017). Renewable and non-renewable energy use—economic growth nexus: The case of MENA net oil importing countries. *Renewable and Sustainable Energy Reviews*, *71*, 127–140.

© Copyright 2025
ISSN: 2961-6638

Khobai, H., Mugano, G., & Le Roux, P. (2018). The renewable energy consumption–economic growth nexus in South Africa: A time series analysis. *International Journal of Energy Economics and Policy, 8*(4), 185–192.

Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *The Journal of Energy and Development, 3*(2), 401–403.

Rahman, M. M., & Alam, K. (2023). Green investment, environmental sustainability, and economic growth: Evidence from emerging Asian economies. *Journal of Cleaner Production, 400*, 136797.

Smil, V. (1976). *Energy in world history*. Westview Press.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics, 70*(1), 65–94.

Zafar, M. W., Shahbaz, M., Hou, F., Sinha, A., & Ozturk, I. (2022). From nonrenewable to renewable energy and its impact on economic growth: The role of research & development and institutional quality. *Renewable Energy, 181*, 1207–1219.

© Copyright 2025
ISSN: 2961-6638