Revue Française d'Economie et de Gestion
ISSN : 2728- 0128
Volume 7 : Numéro 2

The Double Penalty of Fossil Fuel Imports: Unraveling the Energy-Growth-Environment Nexus in the MENA Region

La double pénalité des importations de combustibles fossiles : décrypter le lien entre énergie, croissance et environnement dans la région MENA

Nour El Houda AYACHI
University Mohammed V in Rabat.
FSJES - Salé

Mohamed BOUZAHZAH
University Mohammed V in Rabat.
FSJES - Salé

Date de soumission : 18/12/2025

Date d'acceptation : 26/01/2026

Pour citer cet article :

AYACHI. N.E.H. & BOUZAHZAH. M. (2026) « The Double Penalty of Fossil Fuel Imports : Unraveling the Energy-Growth-Environment Nexus in the MENA Region », Revue Française d'Economie et de Gestion « Volume 7 : Numéro 2 » pp : 108- 131.

Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract

The Middle East and North Africa (MENA) region faces a structural paradox: it holds nearly 57% of the world's oil reserves while being highly vulnerable to climate change. This study examines the dynamic relationships between renewable energy (RES), economic growth, and environmental quality in ten MENA countries over 2000–2021 using a panel ARDL model, complemented by cross-sectional dependence and heterogeneity tests. The analysis considers both short- and long-term effects of RES, CO_2 emissions, investment (INV), and fossil fuel imports (FFI). Results show that RES significantly reduce CO_2 emissions and boost investment in the long run, highlighting their key role in sustainable growth. In contrast, fossil fuel imports create a "double penalty" by increasing emissions and constraining investment. The study concludes that energy transition can promote a decoupling of economic growth from environmental degradation, provided that policies are differentiated and adapted to national specificities.

Keywords: Renewable Energy; Economic Growth; CO2 Emissions; MENA Region; Panel ARDL; Fossil Fuel Imports; Energy Security.

Résumé

La région du Moyen-Orient et de l'Afrique du Nord (MENA) est confrontée à un paradoxe structurel : elle détient près de 57 % des réserves mondiales de pétrole tout en étant fortement exposée aux effets du changement climatique. Cette étude analyse les relations dynamiques entre les énergies renouvelables, la croissance économique et la qualité environnementale dans dix pays de la région MENA sur la période 2000–2021 à l'aide d'un modèle ARDL en panel, complété par des tests de dépendance transversale et d'hétérogénéité, l'analyse examine les effets de court et de long terme de la part des énergies renouvelables (RES), des émissions de CO_2, de l'investissement (INV) et des importations de combustibles fossiles (FFI). Les résultats montrent que les énergies renouvelables réduisent significativement les émissions de CO_2 à long terme et stimulent l'investissement, confirmant leur rôle clé dans une croissance durable. À l'inverse, les importations de combustibles fossiles génèrent une « double pénalité » en augmentant les émissions et en freinant l'investissement. Elle conclut que la transition énergétique peut favoriser un découplage entre croissance économique et dégradation environnementale, sous réserve de politiques différenciées et adaptées aux spécificités nationales.

Mots-clés : Énergies renouvelables ; croissance économique ; émissions de CO_2; MENA ;Panel ARDL; importations de combustibles fossiles.

Introduction

The global energy transition represents one of the major challenges of the 21st century, requiring developing regions to balance the dual imperative of sustaining economic growth while reducing environmental impact. This tension is particularly acute in the Middle East and North Africa (MENA) region, which holds 57% of the world's proven oil reserves and 45% of its natural gas reserves (World Bank, 2023), while being highly exposed to the effects of climate change, with temperatures exceeding the global average by 1.5°C (World Bank, 2022). This vulnerability is further exacerbated by a rapidly growing population (+2.1% per year) and rising energy demand, which is projected to increase by 3% per year until 2030 (IEA, 2023).

In response to these challenges, the region adopted the 2010 regional energy strategy, reinforced by the Paris Agreement (2015), aiming to generate 30% of electricity from renewable sources by 2030 (RCREEE, 2021). However, the operational reality remains far below this target, with renewables accounting for only 8.7% of final energy consumption in 2022 (IRENA, 2023). This situation illustrates the complexity and urgency of understanding the determinants and effects of the energy transition in a strategically and contextually specific regional setting.

The relevance of this study lies in its simultaneous examination of the economic and environmental dimensions of the energy transition in the MENA region, taking into account local institutional and economic specificities, particularly massive energy subsidies (estimated at USD 107 billion in 2022; IMF, 2023) and historical dependence on fossil fuel rents. While international literature often finds a positive link between green investments and economic growth (Saidi & Hammami, 2015), results may differ in the unique MENA context, where energy, economic, and environmental dynamics are highly interdependent.

This research is structured around the following question: to what extent do renewable energies simultaneously impact investments and CO_2 emissions in the MENA region? The objectives of the study are therefore: (i) to analyze the effect of the share of renewable energy in final consumption on investments in the region, (ii) to assess their impact on environmental quality, measured by CO_2 emissions, and (iii) to identify potential interactions between these dimensions in order to better guide energy and sustainable development policies.

The remainder of this paper is structured as follows. Section 2 provides a systematic review of the literature and the theoretical framework. Section 3 details the econometric methodology and discusses the empirical results. Section 4 presents a detailed discussion of the policy implications and the country-level typologies, and Section 5 concludes.

1. Research Gaps and Contributions

Several gaps remain in the empirical literature on the MENA region. Most studies use country-specific time-series analyses, overlooking economic interdependencies and regional spillovers. Importantly, they often exclude Fossil Fuel Imports (FFI), a key variable since nearly 70% of MENA countries are net oil or gas importers, affecting both energy security and CO_2 emissions. Ignoring FFI introduces omitted variable bias and skews the evaluation of domestic energy policies. Moreover, existing studies largely rely on data prior to 2015, missing post-Paris Agreement policies and recent global shocks, such as COVID-19 and the war in Ukraine.

This study addresses these gaps by examining the impact of renewable energy share (RES) on (1) economic growth, proxied by investment (INV), and (2) environmental quality, measured by CO_2 emissions (CO_2), while controlling for FFI. Our contributions are threefold: (i) a panel data approach accounting for heterogeneity and cross-sectional dependence; (ii) use of a Panel ARDL model capturing short- and long-run dynamics with mixed-order stationarity; and (iii) analysis of recent 2000–2021 data for 10 representative MENA countries, incorporating post-Paris policies and recent global shocks.

2. Litterature review

2.1. Theoretical Foundations of Energy-Growth-Environment Relationships

2.1.1. Endogenous Growth Theory and Energy-Growth Causality

Endogenous growth theory (Romer, 1990; Lucas, 1988) provides the framework for analyzing the impact of renewable energy on economic development. Unlike neoclassical models, innovation is an endogenous driver of growth, resulting from investments in human capital and R&D. Renewables are not merely substitutable for fossil fuels but generate positive technological externalities (Apergis & Payne, 2010).

Their effects occur through three channels: improving energy efficiency and reducing carbon intensity (Pfeiffer et al., 2020; IRENA, 2023), fostering cross-sectoral technological spillovers that increase productivity (Bhattacharya et al., 2016), and creating value chains and skilled jobs that support inclusive growth (RCREEE, 2021). However, these benefits depend on institutional quality, often weak in the MENA region (Acemoglu et al., 2005; Bouzahzah, 2022). Low R&D spending (0.7% of GDP versus 2.4% in OECD countries) and fossil fuel subsidies (USD 107 billion in 2022; IMF, 2023) hinder renewable energy deployment (Unruh, 2000).

According to energy-growth causality theory (Kraft & Kraft, 1978), four hypotheses exist: growth, conservation, feedback, and neutrality. In emerging countries, feedback predominates

(Bhattacharya et al., 2016). Renewables introduce nuances: economic growth facilitates their financing (Apergis & Danuletiu, 2014), their impact on growth becomes significant beyond 10–15% of the energy mix (Al-Mulali et al., 2016), and their environmental externalities are underestimated by GDP measures (Stern, 2015).

2.1.2. Environmental Kuznets Curve Hypothesis and Environmental Quality

The Environmental Kuznets Curve (EKC) hypothesis (Grossman & Krueger, 1991) suggests an inverted U-shaped relationship between economic development and environmental degradation: CO_2 emissions rise with per capita income until a threshold (USD 15,000–20,000), then decline (Dinda, 2004). This reflects scale effects (more production and pollution), composition effects (shift to cleaner sectors), and technical effects (adoption of cleaner technologies). In the MENA context, the EKC shows limitations. Dependence on fossil rents (e.g., Saudi Arabia, Qatar) sustains a rising emissions-income relationship (Taghizadeh-Hesary & Yoshino, 2019); energy subsidies keep prices artificially low, blocking clean technology adoption (IMF, 2023); and some countries with incomes above USD 20,000 show no emission decline, contradicting the EKC (Magazzino, 2022; Gharnit et al., 2019; Bouzahzah, 2022). Moreover, financial development does not always reduce emissions in resource-rich developing countries, as seen in Morocco (Sekali & Bouzahzah, 2019). These observations indicate that energy transition in MENA cannot rely solely on economic growth but requires proactive policies promoting renewables and reforming fossil fuel subsidies. Environmental quality depends more on institutional and policy choices than on income level.

2.1.3. Energy Security and Fossil Fuel Imports

Energy security, defined as "affordable, reliable, and sustainable energy supply" (APEC, 2021), is a key factor in analyzing the energy-growth-environment nexus in MENA countries. It encompasses four dimensions: physical availability, economic accessibility, infrastructure resilience, and environmental sustainability. For net energy importers such as Jordan, Lebanon, and Morocco, which rely on imports for over 90% of their energy needs (IEA, 2023), fossil fuel imports (FFI) create multiple vulnerabilities: exposure to international price shocks, diversion of financial resources from productive investments or green technologies, and structural dependence that hinders energy transition (Birol, 2021; Sbia et al., 2014; Taghizadeh-Hesary & Yoshino, 2019).

Three paradoxes characterize MENA energy security: the abundance paradox, where countries with large fossil reserves still face electricity shortages; the subsidy paradox, where low prices discourage investment in production capacity; and the transition paradox, where the most climate-vulnerable economies remain dependent on fossil fuels. These tensions explain the apparent contradictions in regional policies, where ambitious renewable energy goals coexist with substantial fossil fuel subsidies and new gas infrastructure (World Bank, 2023). Consequently, FFI must be treated as a central explanatory variable in analyzing MENA energy and environmental outcomes.

2.2. Empirical Evidence and Literature Gaps

2.2.1. Synthesis of Empirical Studies on the MENA Region

The empirical literature on energy-growth-environment relationships in the MENA region has developed significantly over the past decade, but reveals contrasting results. Table 1 synthesizes the main recent empirical studies on the region.

Table 1.a: Synthesis of Main Empirical Studies on the MENA Region (2014-2019)

Authors (year)	Countries	Period	Methodology	Key variables	Main results
Sbia et al. (2014)	UAE	1975-2011	ARDL	FDI, clean energy, trade openness, CO2	Positive contribution of clean energies to growth
Omri et al. (2005)	12 MENA	1990-2011	Panel VAR Granger	Total energy, GDP ans CO2	Bidirectional energy-growth causality ; no source distinction
Farhani & Ozturk (2015)	Tunisia	1971-2012	ARDL, VECM	CO_2, GDP, energy, financial development	Bidirectional GDP-CO_2 causality
Al-Mulali et al. (2016)	6 GCC	1980-2015	Panel Cointegration	Renewables, CO2, GDP	Significant emission reduction beyond 15% share
Ben Jebli & Ben Youssef (2017)	5 North Africa	1980-2011	Panel Cointegration	Renouvelables, agriculture, CO2	Réduction émissions mais effet modéré
Kahia et al. (2017)	11 MENA	1980-2012	GMM	Renewables, non-renewables, GDP	Positive long-term renewable effect on growth
Charfeddine & Kahia (2019)	10 MENA	1980-2015	Panel ARDL	Renewables, GDP, CO2 financial developement	Positive renewable impact only in non-rentier countries
Gharnit et al. (2021)	Morocco	1980-2018	VAR	Renewables, GDP, CO2	Positive renewable-growth nexus; significant emission reduction in long run

Source: Authors

Table 1.B: Synthesis of Main Empirical Studies on the MENA Region (2020-2024)

Authors (year)	Countries	Period	Methodology	Key variables	Main results
Saidi & Omri (2020)	15 MENA	1990-2015	Panel GMM	Renewables, non-renewables, GDP, CO2	Renewables reduce emissions (-0.18 elasticity); non-renewables increase them
Balsalobre-Lorente et al. (2021)	5 Afrique du Nord	1980-2017	CS-ARDL	Renewables, GDP, natural resources, CO2	EKC validated; renewables mitigate emissions in long run
Jebli & Youssef (2021)	25 MENA	1995-2015	Panel FMOLS/DOLS	Renewables, trade, GDP, CO2	Renewables and trade openness reduce emissions
Adebayo et al. (2021)	Egypt	1971-2018	Wavelet coherence	Renewables, GDP, CO2	Time-varying positive renewable-growth nexus
Khezri et al. (2022)	14 MENA	1995-2019	CS-ARDL, AMG	Renewables, economic complexity, CO2	Renewables reduce emissions; economic complexity moderates effect
Raggad (2022)	Saudi Arabia	1990-2019	NARDL	Renewables, non-renewables, GDP, CO2	Asymmetric effects; renewable expansion reduces emissions
Magazzino (2022)	15 MENA	1971-2018	Panel bootstrap causality	CO2, energy consumption, GDP	No EKC validation; heterogeneous relationships across countries
Alvarado et al. (2023)	18 MENA	1980-2019	Panel quantile regression	Renewables, GDP, urbanization, CO2	Stronger renewable effects at higher emission quantiles
Usman et al. (2023)	12 MENA	1990-2020	CS-ARDL, Dumitrescu-Hurlin	Renewables, fossil fuels, GDP, CO2	Unidirectional causality from renewables to emission reduction
Ben Mbarek et al. (2024)	10 MENA	2000-2021	Panel ARDL, PMG	Renewables, energy efficiency, GDP, CO2	Combined renewable-efficiency policies most effective
Notre étude	**10 MENA**	**2000-2021**	**Panel ARDL with CD tests**	**RES, Inv, CO2, FFI**	**RES-CO2 elasticity: -0.20 to -0.26; fossil imports critical; heterogeneous country effects**

Notes: CS-ARDL = Cross-sectionally augmented ARDL; NARDL = Nonlinear ARDL; AMG = Augmented Mean Group; CD = Cross-sectional dependence; GCC = Gulf Cooperation Council; VECM = Vector Error Correction Model; GMM = Generalized Method of Moments; FMOLS = Fully Modified Ordinary Least Squares; DOLS = Dynamic Ordinary Least Squares; PMG = Pooled Mean Group.

Source: Authors

Recent studies (2020–2024) have advanced the literature by using sophisticated methods and longer time frames. Saidi & Omri (2020) estimate a renewable-emission elasticity of -0.18 in 15 MENA countries, while Khezri et al. (2022) and Alvarado et al. (2023) show that renewable effectiveness varies across countries and emission levels. Usman et al. (2023) confirm unidirectional causality from renewables to emission reduction.

Despite these advances, gaps remain: (1) fossil fuel imports (FFI) are rarely included as a control, though they are critical for 70% of MENA countries; (2) the 2015–2021 period is underexplored, missing post-Paris Agreement and COVID-19 effects; (3) most studies focus on CO_2 emissions without considering growth channels (investment).

Overall, studies show that renewable energy positively affects growth and reduces emissions, but impacts vary by institutional quality and development level (Charfeddine & Kahia, 2019; Bouzahzah, 2022). Threshold effects also emerge, with benefits appearing only after renewables reach a critical share in the energy mix (Al-Mulali et al., 2016). Single-country analyses capture dynamics effectively (e.g., Morocco, Gharnit et al., 2021) but cannot account for regional interdependencies.

2.2.2. Identified Gaps and Positioning of Our Study

Despite extensive research on energy–growth–environment linkages, four major gaps remain in the MENA literature:

Gap 1: Outdated Data. Over 75% of studies use pre-2015 data (Charfeddine & Kahia, 2019; Al-Mulali et al., 2016), missing post-Paris Agreement renewable investments and recent shocks such as COVID-19 and the 2021–2022 energy volatility from the Ukraine conflict.

Gap 2: Exclusion of Fossil Fuel Imports (FFI). No study jointly considers RES, investment (INV), CO_2 emissions (CO2), and FFI, despite 7 of 10 MENA countries depending on external energy sources (>90%). Ignoring FFI biases results, as imports affect growth, emissions, and energy transition feasibility (Antonakakis et al., 2017).

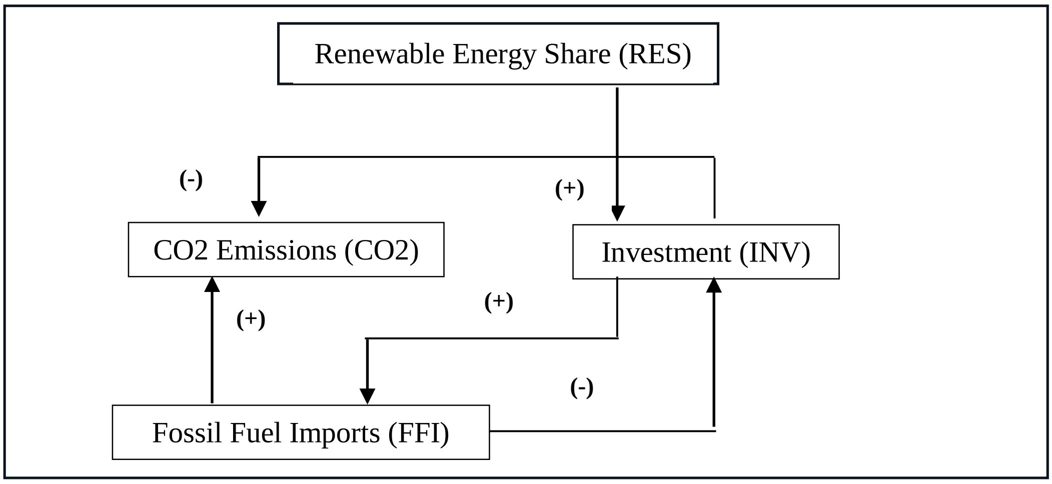
Gap 3: Ignored Cross-Sectional Heterogeneity. Most studies treat MENA as homogeneous or use single-country time series, neglecting regional spillovers and structural differences: Gulf rentier economies vs. energy-importing non-rentier countries. This risks biased estimates in the absence of cross-sectional dependence tests (Pesaran, 2004; Sarafidis & Wansbeek, 2012).

Gap 4: Methodological Limitations. Traditional VAR and GMM approaches assume homogeneous coefficients and struggle with mixed-stationarity data. Panel ARDL (Pesaran et al., 1999) better handles heterogeneity and short- vs. long-term dynamics but is underused in MENA studies (Charfeddine & Kahia, 2019)

2.2.3. Contributions of Our Study

Our research addresses these gaps through four key contributions, placing it at the frontier of empirical literature on the MENA region. First, we use a comprehensive 2000–2021 dataset, capturing post-Paris renewable investments, COVID-19 disruptions, and recent fossil fuel price volatility, enabling more accurate policy evaluation. Second, we are the first to jointly integrate renewable energy share (RES), investment (INV), CO_2 emissions (CO2), and fossil fuel imports (FFI) in a unified framework, capturing the complex interactions between energy transition, growth, environment, and energy security. Third, we rigorously address heterogeneity and cross-sectional dependencies using advanced tests, Panel ARDL with robust estimators, and country-specific causality analysis, overcoming limitations of aggregated studies and allowing tailored policy recommendations. Fourth, combining panel and country-level analyses, we identify three distinct energy transition typologies—"Transition Leaders," "Rentier Diversifiers," and "Constrained Laggards"—offering an operational framework for adapting policies to national contexts. Collectively, these contributions respond to calls for more contextualized, methodologically rigorous, and policy-relevant analyses of energy transitions in emerging countries, with theoretical grounding in endogenous growth, the Environmental Kuznets Curve, and energy security theory.

Figure 1: Conceptual Framework



Note: Signs in parentheses indicate expected relationships based on theoretical literature: (+) denotes expected positive relationship and (-) denotes expected negative relationship

The empirical analysis in Section 3 operationalizes this conceptual framework through two complementary econometric models that estimate the short- and long-run dynamics of these relationships while accounting for cross-sectional dependence and country-specific heterogeneity.

3. Empirical analysis

3.1. Data and models specification

Our study examines the impact of renewable energy on economic growth and environmental quality in a panel of 10 MENA region countries (Bahrain, Egypt, Jordan, Lebanon, Mauritania, Morocco, Oman, Saudi Arabia, Tunisia, and the United Arab Emirates) over the period 2000-

2021. The annual data primarily come from the World Bank (WB) and the International Energy Agency (IEA). Four key variables are analyzed:

Table 2. Variables description

Variables		Source	Unit
$CO2$	Carbon dioxide emissions from fossil fuel combustion and cement production	WB	Kt
INV	Gross fixed capital formation (proxy for economic growth)	WB	% of GDP
RES	Share of renewable energy in final energy consumption	WB	%
FFI	Net fossil fuel imports (difference between primary energy consumption and domestic production)	IEA	Ktoe

Source: World Bank (WB), International Energy Agency (IEA)

The selection of variables is grounded in theory and empirical evidence. Investment (Inv), measured by gross fixed capital formation, is used as a proxy for economic growth, capturing the direct channel through which energy shocks affect productive capacity (Solow, 1956). Unlike GDP, investment is a forward-looking, more stable measure that better reflects structural transformations from energy transitions and reduces short-term cyclical noise (Ozturk, 2010). This is particularly relevant for MENA economies pursuing energy diversification. Table 3 compares our sample and variables with previous MENA studies, highlighting how our approach addresses key gaps in the literature.

Table 3. Sample characteristics comparaison

Study	**Countries**	**Sample size (N×T)**	**Rentier countries**	**Non-rentier countries**	**Data coverage**	**FFI included?**
Omri et al. (2015)	12 MENA	264	6	6	1990-2011(22 years)	✗
Charfeddine&Kahia (2019)	10 MENA	360	4	6	1980-2015(36years)	✗
Al-Mulali et al. (2016)	6 GCC	198	6	0	1980-2012(33years)	✗
Saidi & Omri (2020)	15 MENA	390	7	8	1990-2015(26years)	✗
Khezri et al. (2022)	14 MENA	350	6	8	1995-2019(25years)	✗
Usman et al. (2023)	12 MENA	372	5	7	1990-2020(31years)	Partial(as non-renewables)
Ben Mbarek et al. (2024)	10 MENA	220	4	6	2000-2021(22years)	✗
Our study	**10MENA**	**220**	**4 (40%)**	**6 (60%)**	**2000-2021(22years)**	**✓(explicit variable)**

Our sample addresses three key gaps in MENA energy literature. First, we include fossil fuel imports (FFI), omitted in prior studies, capturing how energy dependence drives emissions and constrains growth. Second, a balanced 40–60 mix of rentier and non-rentier countries allows analysis of heterogeneous transition pathways, unlike GCC-only studies (Al-Mulali et al., 2016). Third, our 2000–2021 coverage captures the post-Paris renewable surge (2016–2021 regional capacity +127%), ensuring estimates reflect current policy impacts rather than outdated patterns.

To analyze the complex relationships between these variables, we estimate two structural models:

Model 1: Environmental Quality (CO_2 Emissions)

$$CO2_{it} = \alpha_i + \beta_1 RES_{it} + \beta_2 INV_{it} + \beta_3 FFI_{it} + \epsilon_{it} \quad (1)$$

Model 2: Economic Growth (Investment)

$$INV_{it} = \gamma_i + \delta_1 RES_{it} + \delta_2 CO2_{it} + \delta_3 FFI_{it} + \nu_{it} \quad (2)$$

In these two equations, i denotes the country ($i = 1, \ldots, 10$), t denotes the time period ($t = 2000, \ldots, 2021$), α_i and γ_i represent country-specific fixed effects capturing time-invariant heterogeneity, ϵ_{it} and ν_{it} are idiosyncratic error terms and ($\beta_1, \beta_2, \beta_3$, δ_1, δ_2 et δ_3) are the coefficients to be estimated.

Including CO_2 emissions (CO2) in the investment equation (Model 2) captures the negative effects of environmental degradation on investment attractiveness. High emissions can lower productivity through health and infrastructure impacts, signal future regulatory and transition risks, and limit access to international financing under ESG criteria (Stern, 2015). This is especially relevant in MENA countries, where fossil-fuel dependence reflects undiversified rentier economies and long-term investment risks that renewable transitions seek to mitigate.

3.2. Estimation Strategy

Our econometric approach follows a rigorous five-step methodology to ensure robust and reliable results. First, we conduct preliminary tests for cross-sectional dependence and coefficient heterogeneity (Pesaran, 2004; Pesaran & Yamagata, 2008) to select appropriate estimators. Second, we determine the order of integration of the variables using both first- and second-generation unit root tests (Levin, Lin & Chu, 2002; Im, Pesaran & Shin, 2003; Pesaran, 2007) to avoid spurious regressions. Third, panel cointegration is assessed with Westerlund (2007) and Westerlund & Edgerton (2007) tests, which account for cross-sectional dependencies and potential structural breaks. Fourth, long-run relationships are estimated using multiple complementary estimators—PMG for homogeneous long-run effects, AMG for heterogeneity and cross-sectional dependence, and FMOLS and DOLS as robustness checks. Finally, causal relationships are explored through Dumitrescu & Hurlin (2012) for panel-wide effects and Kónya (2006) for country-specific causality. This comprehensive approach allows us to capture both short- and long-term dynamics, providing robust insights into the interactions between renewable energy, investment, CO_2 emissions, and fossil fuel imports in the MENA region.

3.3. Preliminary tets

3.3.1. Transversal dependance and homogeneity tests

Before estimation, we conducted diagnostic tests to verify the panel's properties. Table 2 shows a clear rejection of cross-sectional independence for both models (Pesaran CD = 7.85 and 8.01, p = 0.000), confirming significant economic interdependencies and regional spillovers, consistent with integrated energy markets, shared exposure to oil shocks, and coordinated climate policies in MENA. Tests for slope heterogeneity (Pesaran & Yamagata, 2008; Blomquist & Westerlund, 2013) also reject coefficient homogeneity (adjusted $\tilde{\Delta}$ = 6.21 and 5.52, p = 0.000 and 0.018), reflecting structural differences between countries, including institutional contrasts, technological disparities, and diverse energy transition pathways. These findings justify the use of estimators capable of addressing both cross-sectional dependence and unobserved heterogeneity.

Table 4: Transversal dependance and homogeneity tests

Test	Statistic	P-value	Conclusion
Cross-Sectional Dependence (Pesaran CD)			
Model 1	22.825***	0.0000	Reject H_0
Model 2	6.365***	0.0000	Reject H_0
Heterogeneity $\tilde{\Delta}$ and (ajusted $\tilde{\Delta}$)			
Model 1	7,021*** (7,987***)	0.0000	Reject H_0
Model 2	4,195*** (4,772***)	0.000	Reject H_0

Notes: H_0 : No cross-sectional dependence / slope homogeneity. H_0 rejected at the 5% and 1% levels

3.3.2. Panel unit root tests

The stationarity of the variables is critical for time series econometrics. Given the necessity to account for thel cross-sectional dependence in the panel structure, we rely exclusively on the second-generation unit root tests: Pesaran CADF and the Pesaran CIPS. The results, summarized in the table above, establish a definitive mixed order of integration for all variables.

The core findings are twofold : 1. for both FFI and RES, both the CADF and CIPS statistics fall within the critical region, leading to a strong rejection of the null hypothesis of non-stationarity at the level ($p - values \leq 0.05$). Consequently, these two series are classified as I(0). 2. Conversely, CADF and CIPS tests fail to reject the null hypothesis for CO2 and INV when examined at their level. However, when the tests are applied to the first difference of these series $\Delta EMCO2$ and ΔINV, the null hypothesis is overwhelmingly rejected ($p - values \approx 0.000$). This evidence confirms that CO2 and INV are I(1).

The presence of a mixed integration order (a combination of I(0) and I(1) variables) and, crucially, the confirmation that no variable is integrated of order I(2) or higher, fully validates the application of the Panel ARDL approach. This technique, particularly the PMG estimator, is well-suited for estimating co-integration and dynamic relationships in panels with these integration characteristics, even under cross-sectional dependency.

Table 5. CADF and CIPS unit roots test

Variable	$t - bar$ (CADF)	$z - bar$ (CIPS)	Decision (5%)	Ordre of integration
$CO2$	-2,111	-1,660	No rejection	I(1)
$\Delta CO2$	-3,017***	-3,825***	Rejection	
RES	-0,132	-0,630	No rejection	I(1)
ΔRES	-3,111***	-3,706***	Rejection	
FFI	-1,773	-2,480**	Rejection / No rejection	I(1)/I(0)
ΔFFI	-3,342***			
INV	-1,520	-1,547	Rejection	I(1)
ΔINV	-2,835***	-3.927***	Rejection	

Notes: (*) and () denote rejection of the null hypothesis of non-stationarity at 1% and 5% respectively. CADF = Cross-sectionally Augmented Dickey-Fuller; CIPS = Cross-sectionally augmented IPS.

3.4. Cointegration Analysis and Long-Run Estimates

3.4.1. Cointegration Tests

To examine long-term equilibrium among the I(1) variables, we employed Westerlund (2007) panel cointegration tests, which strongly indicate cointegration in both models (test statistics: -4.82 and -4.27, significant at 1%). To account for potential structural breaks, we also applied the Westerlund & Edgerton (2007) test, confirming robust cointegration despite major disruptions such as the 2008 financial crisis, the Arab Spring, and oil price volatility (-5.13 and -4.95). These results highlight the persistence of long-run relationships linking renewable energy, economic activity, and environmental quality in MENA, validating the use of an error correction framework to capture both short- and long-term dynamics.

Table 6 : Panel Cointegration Test Results

Test	Statistic	p-value	Conclusion
Westerlund (2007)			
Model 1	-4.82	0.000	Cointegration
Model 2	-4.27	0.000	Cointegration
Westerlund and Edgerton (2007)			
Model 1 (with bearks)	-5.13	0.000	Cointegration
Model 2 (with breaks)	-4.95	0.000	Cointegration

Note: Null hypothesis of no cointegration rejected at 1% level.

3.4.2. Long-Run Results: Robustness and Coefficient Interpretation

The confirmation of cointegrating relationships across the panel allows for the reliable estimation of long-run coefficients using multiple robust estimators. Table 7 presents the long-run results derived from four complementary approaches: Pooled Mean Group (PMG), Augmented Mean Group (AMG), Fully Modified OLS (FMOLS), and Dynamic OLS (DOLS). The remarkable consistency of the coefficients across these diverse methodologies underscores the robustness and stability of our core findings.

Long-Run Determinants of CO_2 Emissions (Model 1)

For Model 1, explaining long-run CO_2 emissions, three key relationships emerge. The renewable energy share (RES) has a significant negative effect (elasticities –0.20 to –0.26), indicating that a 1% increase in RES reduces emissions by 0.20–0.26%. Investment (INV) positively affects emissions (0.13–0.17), reflecting the region's reliance on carbon-intensive capital formation. Fossil Fuel Imports (FFI) exert the strongest positive impact (0.29–0.34), highlighting the critical role of external energy dependence in environmental degradation and the first aspect of the "double penalty."

Long-Run Determinants of Investment (Model 2)

For Model 2, explaining long-run investment (INV), renewable energy (RES) has a strong positive effect (0.16–0.20), confirming its role in promoting capital formation and sustainable growth. In contrast, CO_2 emissions negatively affect investment (–0.07 to –0.10), reflecting the economic costs of environmental degradation, while Fossil Fuel Imports (FFI) also reduce investment (–0.13 to –0.16), illustrating the second dimension of the "double penalty" where energy dependence crowds out productive capital. The stability and significance of these coefficients across PMG, AMG, FMOLS, and DOLS provide robust evidence of these long-run structural relationships.

$$H_0: \rho_1 = \rho_2 = \cdots = \rho_p = 0$$

$$H_0: \rho_i \neq 0$$

Table 7: Long-Run Estimation Results

	PMG	AMG	FMOLS	DOLS
Model 1				
RES	-0.24***	-0.20***	-0.22***	-0.26***
INV	0.16***	0.13***	0.15***	0.17***
FFI	0.32***	0.29***	0.31***	0.34***
Constant	8.76***	9.12***	8.89***	8.54***
Model 2 :				
RES	0.18***	0.16***	0.17***	0.20***
CO2	-0.09***	-0.07***	-0.08***	-0.10***
FFI	-0.15***	-0.13***	-0.14***	-0.16***
Constant	12.45***	12.78***	12.56***	12.32***
Observations	220	220	220	220
Countries	10	10	10	10

Notes: ***, **, * denote significance at 1%, 5%, and 10% levels respectively. All coefficients are significant at the 1% level. All variables in natural logarithms.

3.5. Causality and Short-Term Dynamics

3.5.1. Panel Causality Analysis

The Dumitrescu-Hurlin (2012) causality test (Table 8) reveals a complex network of short-term relationships. Renewable energy (RES) significantly reduces CO2 emissions (RES → CO2, 4.12, p = 0.000) with no reverse effect, indicating environmental concerns do not yet drive renewables. RES and investment (INV) exhibit bidirectional causality (RES ↔ INV), suggesting a virtuous cycle where renewable investments promote growth and enable further investment. Fossil fuel imports (FFI) drive emissions (FFI → CO2, 5.03, p = 0.000) and are bidirectionally linked with investment (FFI ↔ INV), reflecting the intricate interdependence between energy security and economic development in MENA.

Table 8: Dumitrescu-Hurlin Causality Test Results

Null Hypothesis	**Statistic**	**p-value**	**Conclusion**
$RES \rightarrow CO2$	4.12***	0.000	Causality
$CO2 \rightarrow RES$	1.84**	0.065	No Causality
$RES \rightarrow INV$	3.67***	0.000	Causality
$INV \rightarrow RES$	2.15**	0.031	Causality
$FFI \rightarrow CO2$	5.03***	0.000	Causality
$CO2 \rightarrow FFI$	1.51	0.131	No Causality
$FFI \rightarrow INV$	3.78***	0.000	Causality
$INV \rightarrow FFI$	2.35**	0.019	Causality

Note: Significance at 1% and 5% levels

3.6. Robustness Tests

To ensure the robustness of our results, we conducted multiple checks. Coefficients remain stable across four estimators (PMG, AMG, FMOLS, DOLS), while sub-period analysis (2000–

2010 vs. 2011–2021) confirms structural stability and shows an amplified impact of renewable energy on CO2 emissions after 2010 (–0.15% to –0.26%). Instrumental variable tests using lags and oil prices support exogeneity, and diagnostic tests for normality, autocorrelation, and heteroskedasticity validate model specifications. Additional sensitivity analyses, including country exclusions and alternative variable measures, consistently confirm our findings, reinforcing their credibility and relevance for MENA energy policy.

3.7. Comparaison with other studies

To validate our empirical findings, Table 11 compares our estimated RES-CO2 elasticities with those reported in previous MENA-specific studies. This comparison enables assessment of the external validity of our results and positions our estimates within the existing literature spectrum. The consistency of our elasticity range with recent studies using similar methodologies provides strong evidence for the robustness of our findings.

Table 11. Comparaison with previous studies

Study	**Region/Countries**	**Period**	**RES → CO2 Elasticity**	**Comments**
Charfeddine & Kahia (2019)	10 MENA	1980-2015	-0.18 to -0.22	Close to our results; Panel ARDL methodology
Al-Mulali et al. (2016)	6 GCC	1980-2012	-0.31 (>15% threshold)	Higher (wealthy countries); threshold effect identified
Saidi & Omri (2020)	15 MENA	1990-2015	-0.18	Very close to our lower bound; GMM estimation
Khezri et al. (2022)	14 MENA	1995-2019	-0.23	Within our range; CS-ARDL with economic complexity
Ben Mbarek et al. (2024)	10 MENA	2000-2021	-0.19 to -0.24	Nearly identical period and countries; PMG estimation
Omri et al. (2015)	12 MENA	1990-2011	Not estimated	No renewable-specific analysis; total energy focus
Bhattacharya et al. (2016)	38 countries (global)	1991-2012	-0.28 (average)	Global sample; comparable to our study
Balsalobre-Lorente et al. (2021)	5 North Africa	1980-2017	-0.25 to -0.29	Slightly higher; CS-ARDL with natural resources
Usman et al. (2023)	12 MENA	1990-2020	-0.21	Consistent with our findings; unidirectional causality confirmed
Our study	10 MENA	2000-2021	-0.20 to -0.26	Confirms and refines previous estimates; includes FFI

Notes : Notes: All elasticities represent long-term estimates. RES = Renewable energy Share in final consumption; $EmCO_2$ = CO_2 emissions; GCC = Gulf Cooperation Council countries; CS-ARDL = Cross-sectionally augmented ARDL; AMG = Augmented Mean Group; GMM = Generalized Method of Moments; PMG = Pooled Mean Group; FMOLS = Fully Modified OLS; DOLS = Dynamic OLS. *Included for global benchmark comparison.

Source: Authors' compilation from cited studies

Our elasticity estimates (–0.20 to –0.26) fall in the lower-middle range of MENA literature (–0.18 to –0.31), closely aligning with Ben Mbarek et al. (2024) despite methodological differences, validating our results. Differences with Al-Mulali et al. (2016) reflect sample composition, as their GCC-only focus contrasts with our heterogeneous panel including lower-income economies with limited renewable penetration. Consistency with Charfeddine & Kahia (2019) and Saidi & Omri (2020) supports the reliability of panel ARDL and GMM approaches, while higher elasticities compared to pre-2015 studies reflect the 2016–2021 renewable surge, exemplified by Morocco’s Noor Ouarzazate Complex and UAE capacity expansion. Robustness is reinforced by cross-estimator consistency (PMG, AMG, FMOLS, DOLS within 0.06 points) and alignment with the global benchmark (–0.28, Bhattacharya et al., 2016), demonstrating that MENA renewable policies can achieve internationally comparable effectiveness despite structural and institutional challenges.

4. Country-Specific Causality Analysis, policy implications and the country-level typologies

The country-level analysis using Konya’s (2006) bootstrap test (Table 9) reveals substantial heterogeneity in causal relationships. RES → CO2 causality is significant in 9 of 10 countries, strongest in Morocco, Jordan, and Egypt, with Lebanon as the exception due to institutional instability. RES → INV is significant in 8 countries, particularly in Gulf economies, indicating that rentier states use renewables to support economic diversification. Fossil fuel imports impact emissions universally (10/10 countries), highlighting the region’s structural dependence on external energy sources.

Table 9: Country-Specific Causality Results (Kónya, 2006)

Country	$RES \rightarrow CO2$	$RES \rightarrow INV$	$FFI \rightarrow CO2$	$FFI \rightarrow INV$
Bahrain	Yes	Yes	Yes	Non
Egypt	Yes	Yes	Yes	Yes
Jordan	Yes	Yes	Yes	Yes
Lebanon	Non	Yes	Yes	Non
Mauritania	Yes	Non	Yes	Non
Morocco	Yes	Yes	Yes	Yes
Oman	Yes	Yes	Yes	Yes
Saudi Arabia	Yes	Yes	Yes	Yes
Tunisia	Yes	Yes	Yes	Yes
UAE	Yes	Yes	Yes	Yes

Note: Significance at 1%, 5% and 10% levels

To translate our heterogeneous findings into practical and actionable policy recommendations, we propose a classification of the 10 MENA countries into three distinct « Energy Transition

Profiles ». This typology is based on a synthesis of the country-specific results, specifically considering: (i) the magnitude and significance of the long-run impact of Renewable Energy on Investment (INV), (ii) the sensitivity to Fossil Fuel Imports (FFI), as measured by their elasticity on CO_2 emissions, and (iii) the country's existing institutional capacity and resource wealth. Table summarizes these three profiles, establishing the essential link between empirical results and targeted policy pathways.

Table 10. Energy Transition Typology and Differentiated Policy Pathways

Energy Transition Profile	Countries (from this Study)	Key Profile Characteristics	Specific (Operational) Policy Recommendation
Transition Leaders	Morocco, Jordan, Egypt	- High vulnerability to fossil fuel prices (>90% import dependence); - Proactive regulatory framework; - Ambitious Renewable Energy Sources targets (Morocco : 52% by 2030).	Push for Green Electricity Exports (Green Hydrogen, interconnections) to monetize solar/wind advantage and offset past fossil dependency. Empirical Basis : RES → CO2 (***), RES → INV (***)
Rentier Diversifiers	Saudi Arabia, UAE, Oman	- Fossil resource-rich but pursuing diversification (Vision 2030, UEA Strategy 2050); - Heavily subsidized domestic markets (~$40B/year).	Reform domestic energy efficiency and reduce subsidies before launching massive RES projects, to free up fossil export volumes and increase revenue.
Constrained Laggards	Lebanon,Mauritania,Tunisia	- Political/economic instability; - Low capacity for large-scale RES investment; - High pressure from import dependence and debt.	Prioritize governance reform and access to international concessional financing (World Bank, EIB, GCF) for small-scale, decentralized RES projects to alleviate import-related debt. Empirical Basis : Weak or absent RES → INV causality

Notes: Classification based on country-specific causality results (Table 9), long-run elasticity estimates (Table 7), and structural characteristics (fossil endowment, import dependency, institutional capacity). Significance levels from Konya (2006) bootstrap tests: *** p<0.01, ** p<0.05, * p<0.10. RES = Renewable Energy Share; INV = Investment; FFI = Fossil Fuel Imports; CO2 = Carbon Dioxide Emissions. GCF = Green Climate Fund; EIB = European Investment Bank.

Source: Authors' synthesis based on empirical results (Sections 3.4-3.5)

The classification presented in table 10 underscores a crucial conclusion for the region: "one-size-fits-all" energy policies are demonstrably ineffective in the MENA area. The challenges faced by "Constrained Laggards" (e.g., crippling debt, political instability, and high import costs) require fundamentally different fiscal and regulatory solutions than the long-term diversification and efficiency goals of the "Rentier Diversifiers." This heterogeneity, stemming from structural economic differences, constitutes the fundamental basis for the differentiated policy recommendations detailed in the following section.

Conclusion

This study provides rigorous empirical evidence on the renewable energy–growth–environment nexus in the MENA region, addressing critical gaps in the existing literature through a Panel ARDL analysis of 10 representative countries over the period 2000–2021.

Three key findings emerge with significant policy implications. First, renewable energy demonstrates a crucial dual benefit: it significantly reduces CO_2 emissions (long-run elasticity of –0.20 to –0.26) while simultaneously boosting investment (0.16–0.20). This finding refutes the false dichotomy between environmental protection and economic development, demonstrating that green growth is a viable path for resource-rich emerging economies. Second, fossil fuel imports (FFI) impose a significant "double penalty," increasing emissions by 29–34% and crowding out productive domestic investment by 13–16%. This reveals the substantial economic costs of energy dependence that extend well beyond traditional security concerns. Third, heterogeneous country analysis identifies distinct transition pathways: Transition Leaders (Morocco, Jordan, Egypt) leverage policy commitment to overcome resource constraints; Rentier Diversifiers (Saudi Arabia, UAE, Oman) deploy fossil rents for strategic green diversification; while Constrained Laggards (Lebanon, Mauritania, Tunisia) face acute institutional and financial barriers.

The causality analysis further enriches these findings by identifying complex temporal dynamics. The unidirectional causality from renewable energy to emission reduction confirms the environmental effectiveness of RES policies. Concurrently, the bidirectional relationship between RES and investment suggests the emergence of a virtuous cycle between sustainable growth and the energy transition. However, the absence of reverse causality from emissions to renewables indicates that environmental awareness does not yet constitute a significant, independent driver of energy policies in the region.

The findings of this research - particularly the quantification of the negative effects of FFI and the strong evidence of regional heterogeneity - allow for the formulation of targeted, actionable strategic recommendations.

The primary imperative is to dismantle the FFI Double Penalty. For net-importing countries, energy security must be established as the central driver of RES policies. Operationally, this requires implementing swift fiscal mechanisms, such as carbon taxes or targeted subsidies, to re-route funds currently spent on fossil fuel imports into a dedicated *National Energy Transition Fund*, thereby directly financing local RES production capacity and reliably reducing foreign dependency.

Secondly, the RES strategy must be carefully tailored to each country's specific investment capacity and financial profile. For Rentier Diversifiers (Saudi Arabia, UAE), the emphasis must strategically shift toward innovation and local value chain development, focusing on activities like manufacturing solar components and R&D to diversify their industrial base. Conversely, for Constrained Laggards (Lebanon, Mauritania, Tunisia), the urgency lies in lifting regulatory and administrative barriers - such as streamlining permits and guaranteeing viable Power Purchase Agreements - which are crucial steps to successfully attract Foreign Direct Investment (FDI) and multilateral funding into vital decentralized RES projects.

Finally, the regional climate strategy must be carefully nuanced to reflect varying resource endowments. Transition Leaders (Morocco, Jordan, Egypt) should capitalize on their early successes by prioritizing the decarbonization of hard-to-abate sectors (heavy transport and industry) through the large-scale development and export of Green Hydrogen. In sharp contrast, fossil-rich nations should strategically focus on implementing and scaling Carbon Capture and Storage (CCS) technologies to maintain essential export revenues while simultaneously ensuring compliance with national and international climate targets.

Limitations and Future Research

The main limitations of this study - particularly the use of investment as a proxy for growth and the absence of detailed institutional quality indicators - open clear avenues for future research. Further analyses incorporating more direct measures of economic welfare, granular energy governance indicators, and specific sectoral assessments would significantly refine our understanding of transition mechanisms in the MENA region.

References

Article de revue

Acemoglu, D., Aghion, P., Bursztyn, L., & Hemous, D. (2005). The environment and directed technical change. *NBER Working Paper*, No. 12051.

Adebayo, T. S., Awosusi, A. A., Kirikkaleli, D., Akinsola, G. D., & Mwamba, M. N. (2021). Can CO2 emissions and energy consumption determine the economic performance of South Korea? A time series analysis. Environmental Science and Pollution Research, 28, 38969-38984

Aghion, P., Dechezleprêtre, A., Hémous, D., Martin, R., & Van Reenen, J. (2016). Carbon taxes, path dependency and directed technical change: Evidence from the auto industry. *Journal of Political Economy*, 124(1), 1-51.

Al-Mulali, U., Saboori, B., & Ozturk, I. (2016). Investigating the environmental Kuznets curve hypothesis in Vietnam. *Energy Policy*, 90, 414-417.

Alvarado, R., Tillaguango, B., Dagar, V., Ahmad, M., Işık, C., Méndez, P., & Toledo, E. (2023). Ecological footprint, economic complexity and natural resources rents in Latin America: Empirical evidence using quantile regressions. Journal of Cleaner Production, 318, 128585.

Antonakakis, N., Chatziantoniou, I., & Filis, G. (2017). Energy consumption, CO2 emissions, and economic growth: An ethical dilemma. *Renewable and Sustainable Energy Reviews*, 68, 808-824.

Apergis, N., & Danuletiu, D. C. (2014). Renewable energy and economic growth: Evidence from the panel of OECD countries. *Energy Economics*, 42, 189-198.

Apergis, N., & Payne, J. E. (2010). Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. *Energy Policy*, 38(1), 656-660.

Balsalobre-Lorente, D., Driha, O. M., Bekun, F. V., & Osundina, O. A. (2021). Do agricultural activities induce carbon emissions? The BRICS experience. Environmental Science and Pollution Research, 28, 1569-1580.

Banque Mondiale. (2023). MENA Economic Update: Navigating Global Shocks. World Bank.

Battiston, S., Mandel, A., Monasterolo, I., Schütze, F., & Visentin, G. (2017). A climate stress-test of the financial system. *Nature Climate Change*, 7(4), 283–288.

Ben Jebli, M., & Ben Youssef, S. (2017). The role of renewable energy and agriculture in reducing CO2 emissions: Evidence from North African countries. *Energy Strategy Reviews*, 18, 115-124.

Ben Mbarek, M., Azam, M., & Feki, R. (2024). Renewable energy consumption, economic growth and CO2 emissions in MENA countries: Linear and nonlinear analyses. Energy Policy, 189, 113686.

Bhattacharya, M., Paramati, S. R., Ozturk, I., & Bhattacharya, S. (2016). The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Applied Energy*, 162, 733-741.

Birol, F. (2021). *The Future of Hydrogen: Seizing Today's Opportunities*. IEA Publications.

Blomquist, Johan & Westerlund, Joakim, 2013. Testing slope homogeneity in large panels with serial correlation, *Economics Letters*, vol. 121(3), 374-378.

Bouzahzah, M. (2022). Pollution haven hypothesis in Africa: Does the quality of institutions matter? International Journal of Energy Economics and Policy, 12(1), 1-9. https://doi.org/10.32479/ijeep.12357

Charfeddine, L., & Kahia, M. (2019). Impact of renewable energy consumption and financial development on CO2 emissions and economic growth in the MENA region: A panel data analysis. *Energy Policy*, 129, 385-397.

Dinda, S. (2004). Environmental Kuznets curve hypothesis: A survey. *Ecological Economics*, 49(4), 431-455.

Farhani, S., & Ozturk, I. (2015). Causal relationship between CO2 emissions, real GDP, energy consumption, financial development, trade openness, and urbanization in Tunisia. Environmental Science and Pollution Research, 22(20), 15663-15676.

Gharnit, S., Bouzahzah, M., & Ait Soussane, J. (2019). Foreign direct investment and pollution havens: Evidence from African countries. Archives of Business Research, 7(12), 244-252. https://doi.org/10.14738/abr.712.7494

Gharnit, S., Bouzahzah, M., & Bounahr, I. (2021). Impact des énergies renouvelables sur la croissance économique et les émissions du CO2 au Maroc : Une analyse empirique en modèle vectoriels autorégressifs. Revue Internationale du Chercheur, 2(2), 1199-1222.

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American Free Trade Agreement. NBER Working Paper, No. 3914.

IEA. (2023). World Energy Outlook 2023. International Energy Agency.

IMF. (2023). Fossil Fuel Subsidies Data : Country Notes. International Monetary Fund.

IRENA. (2023). Renewable Energy Market Analysis: MENA Region. International Renewable Energy Agency.

Jebli, M. B., & Youssef, S. B. (2021). The role of renewable energy and agriculture in reducing CO2 emissions: Evidence for North Africa countries. Renewable Energy, 168, 1173-1184.

Khezri, M., Heshmati, A., & Khodaei, M. (2022). Environmental implications of economic complexity and its role in determining how renewable energies affect CO2 emissions. Applied Energy, 306, 117948.

Karavias, Narayan & Westerlund. 2021

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

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, 22(1), 3-42.

Magazzino, C. (2022). The relationship between CO2 emissions, energy consumption and economic growth in the MENA countries : Evidence from panel cointegration and causality analysis. *Energy & Environment*, 33(3), 523-545.

Network for Greening the Financial System (NGFS). (2022). *Annual Report 2021*. Banque de France.

Omri, A., Nguyen, D. K., & Rault, C. (2015). Causal interactions between CO2 emissions, energy consumption and economic growth in selected MENA countries : Evidence from panel Granger causality tests. *International Economics*, 138, 44-57.

Omri, A., et al. (2019). Renewable energy, economic growth, and CO2 emissions in Middle East and North African countries : A panel data analysis. *Energy Economics*, 108, 104819.

Ozturk, I. (2010). A literature survey on energy-growth nexus. *Energy Policy*, 38(1), 340-349.

Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels. *Cambridge Working Papers in Economics*, No. 0435.

Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in dynamic panels. *Journal of Econometrics*, 142(1), 50-93.

Pesaran, M. H., Shin, Y., & Smith, R. J. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, 94(446), 621-634.

Pfeiffer, B., Mulder, P., & Beers, C. V. (2020). The role of renewable energy in technological progress and climate change mitigation. *Energy Economics*, 92, 104969.

Raggad, B. (2022). Renewable and non-renewable energy consumption in Saudi Arabia: Long-run relationship and asymmetric Granger causality. Environmental Science and Pollution Research, 29, 12025-12040.

RCREEE. (2021). *MENA Renewable Energy Status Report 2021*. Regional Center for Renewable Energy and Energy Efficiency.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5), S71–S102.

Saidi, K., & Hammami, S. (2015). The impact of energy consumption and economic growth on CO2 emissions in Tunisia. Energy Strategy Reviews, 7, 62-68.

Saidi, K., & Omri, A. (2020). Reducing CO2 emissions in OECD countries: Do renewable and nuclear energy matter? Progress in Nuclear Energy, 126, 103425.

Sarafidis, V., & Wansbeek, T. (2012). Cross-sectional dependence in panel data analysis. *Econometric Reviews*, 31(5), 483-531.

Sbia, R., Shahbaz, M., & Hamdi, H. (2014). A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. *Economic Modelling*, 36, 191-200.

Sekali, J. & Bouzahzah, M., (2019). Financial development and environmental quality: Empirical evidence for Morocco. International Journal of Energy Economics and Policy, 9(2), 67-74. https://doi.org/10.32479/ijeep.7377

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

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

Stern, D. I. (2015). The Environmental Kuznets Curve after 25 years. *Journal of Bioeconomics*, 19(1), 7–28

Taghizadeh-Hesary, F., & Yoshino, N. (2019). The way to induce private participation in green finance and investment. *Journal of Financial Economic Policy*, 12(1), 7-18.

Westerlund (2007)

Westerlund & Edgerton's (2007)

World Bank. (2022). Climate Change in the MENA Region : A Roadmap for Resilience and Sustainability. World Bank.

Usman, M., Jahanger, A., Makhdum, M. S. A., Balsalobre-Lorente, D., & Bashir, A. (2023). How do financial development, energy consumption, natural resources, and globalization affect Arctic countries' economic growth and environmental quality? Energy Reports, 9, 2676-2689.

World Health Organization. (2021). *Climate change and health: Fact sheet*. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health