International Journal of Trade and Management

ISSN: 2820-7289

https://ricg-encgt.ma/

Volume 1, Issue 3, March 2024

THE EFFECT OF ECONOMIC GROWTH ON OF RENEWABLE ENERGY PRODUCTION IN MOROCCO: AN EMPIRICAL ANALYSIS SOURCE-WISE FROM 1964 TO 2021

L'IMPACT DE LA CROISSANCE ECONOMIQUE SUR LA PRODUCTION D'ENERGIE RENOUVELABLE AU MAROC : UNE ANALYSE EMPIRIQUE PAR SOURCES DE 1964 A 2021.

Lamiae SARSAR
University Mohammed V
lamiae.sarsar@gmail.com

Abdellah ECHAOUI
University Mohammed V
a.echaoui@um5s.net.ma

ABSTRACT

This study investigates the impact of economic growth on renewable energy production in Morocco, with a specific focus on hydraulic, solar, and wind energy sources. Spanning empirical analyses from 1964 to 2021, our exploration employs Robust Weighted Least Squares with M-estimation, to ensure reliability. Our primary objective is to discern the nuanced impact of economic growth, recognizing heterogeneity across different energy sources. The results indicate a positive effect of economic growth on hydraulic, solar and wind energy production, with an increase by 0,257%, 0.0235% and 0.4945%, respectively for each increase in the economic growth. Conversely, our examination of geothermic energy reveals a complex relationship, with a negative effect of economic growth resulting in a 0.0192% decrease in production. The policy implications of our study underscore the importance of fostering economic growth to drive advancements in hydraulic, solar, and wind energy production. Policymakers should prioritize initiatives aligning economic development goals with renewable energy advancements, while addressing the challenges hindering geothermic energy production through tailored strategies. This study contributes valuable insights for informed policy decisions aimed at achieving a sustainable and diversified energy future in Morocco.

Key Words: *Renewable energy, Solar energy, Wind energy, Geothermal energy, Hydraulic energy, Economic Growth, Robust Weighted Least Square.*

RESUMÉ

Cette étude examine l'impact de la croissance économique sur la production d'énergie renouvelable au Maroc, en se concentrant spécifiquement sur les sources d'énergie hydraulique, solaire et éolienne. S'étendant sur des analyses empiriques de 1964 à 2021, notre exploration utilise les Moindres Carrés Pondérés Robustes avec estimation M pour assurer la fiabilité des résultats. Notre objectif principal est de discerner l'impact nuancé de la croissance économique, en reconnaissant l'hétérogénéité entre différentes sources d'énergie. Les résultats indiquent un effet positif de la croissance économique sur la production d'énergie hydraulique, solaire et éolienne, avec une augmentation respective de 0,257%, 0,0235% et 0,4945% pour chaque accroissement de la croissance économique. En revanche, notre examen de l'énergie géothermique révèle une relation complexe, avec un effet négatif de la croissance économique entraînant une diminution de la production de 0,0192%. Les implications politiques de notre étude soulignent l'importance de stimuler la croissance économique pour favoriser les avancées dans la production d'énergie hydraulique, solaire et éolienne. Les décideurs devraient privilégier des initiatives alignant les objectifs de développement économique avec les progrès dans les énergies renouvelables, tout en abordant les défis entravant la production d'énergie géothermique par le biais de stratégies sur mesure. Cette étude apporte des éclairages précieux pour des décisions politiques éclairées visant à atteindre un avenir énergétique durable et diversifié au Maroc.

Mot clefs: *Énergie renouvelable, Énergie solaire, Énergie éolienne, Énergie géothermique, Énergie hydraulique, Croissance économique, Moindres carrés pondérés robustes.*

1. INTRODUCTION

Globally, in a context of energy price fluctuations, a rapid increase in energy demand, and improved living standards in developing and emerging countries, the transition to renewable energies has become an unavoidable necessity and an interesting alternative to meet these needs. Environmental issues, primarily due to increased use of fossil fuels, have prompted governments to consider environmental policies based on the use of cleaner and sustainable energies, namely "renewable energies."

Renewable energy sources have become pivotal in the pursuit of a sustainable energy supply, providing an effective strategy to mitigate greenhouse gas emissions, stimulate sustainable economic growth, ensure energy self-sufficiency, and safeguard future resources. This transition is not just a natural progression but a crucial imperative aimed at shaping a more promising future for the planet and its inhabitants.

Turning our attention to Morocco, a country that has witnessed economic growth and social development, there arises a pressing need for ongoing and sustainable progress to tackle issues such as poverty, inequality, youth unemployment, limited access to education and healthcare, economic dependency, and the impacts of climate change. Blessed with abundant natural resources and significant potential for renewable energy, Morocco can capitalize on these advantages to overcome these challenges and champion a path of sustainable development.

The principal aim of this research is to conduct a comprehensive examination of the impact of economic growth on renewable energy production in Morocco. This analysis seeks to provide a nuanced and in-depth understanding of the potential advantages offered by economic growth for sustainable economic development in the country. Employing a hypothetico-deductive approach and utilizing an econometric methodology, the research specifically endeavors to assess the impact of Morocco's economic growth on various renewable energy types, including hydroelectricity, solar energy, and wind energy. Historical data on renewable energy production and economic growth are systematically considered in this analysis.

Our study represents an exhaustive exploration of the causal relationship between renewable energy production and economic growth in Morocco. Notably, no prior empirical study has delved into this relationship with a focus on each distinct type of renewable energy. Most existing research has either examined the relationship with overall renewable energy production or concentrated solely on a particular energy source. Our more detailed approach enables a specific understanding of influence, facilitating the identification of the most promising renewable energy sources for Morocco.

2. LITERATURE REVIEW

In the realm of renewable energy and economic growth, the literature presents a heterogeneous landscape, marked by conflicting findings on the correlation between the two. This study addresses the divergent outcomes by emphasizing the influence of the diverse composition of renewable energy sources—solar, wind, geothermal, and hydraulic. The contention is that the intricate interplay between economic growth and renewable energy adoption is contingent on the specific mix of these energy types within a country.

2.1 THE POSITIVE EFFECT OF ECONOMIC GROWTH ON RENEWABLE ENERGY

We begin with the study of Aneja et al. (2017), who demonstrated that there is a causality relationship between the consumption of renewable energies and economic growth in BRICS countries. The Pedroni cointegration test used showed a long-term relationship between per capita Gross Domestic Product (GDP), gross fixed capital formation, and the consumption of renewable energies. The results support the conservation hypothesis and indicate that the primary driver of energy consumption in BRICS countries is economic growth. This implies that as economic growth increases, energy consumption becomes more significant.

Kilci (2023) examined the relationship between renewable energy consumption and economic growth in selected Eurozone countries between 1990 and 2020. Toda Yamamoto test results confirmed the conservation hypothesis for Spain, Italy, and the Netherlands. However, results for other countries supported the growth hypothesis for Finland and the neutrality hypothesis for Austria, Belgium, Germany, and Portugal.

Eren et al. (2019) used the DOLS method to analyze the effects of financial and economic growth on renewable energy consumption in India from 1971 to 2015. The results indicated that, in the case of India, long-term economic growth significantly and positively influences the consumption of renewable energy sources. Therefore, long-term renewable energy consumption is determined by economic growth. The study results are explained by the fact that an increase in India's economic growth leads to structural changes in industrial sectors, resulting in increased consumption of renewable energies.

Fareed and Pata (2022) supported the conservation hypothesis in a sample of ten major renewable energy-consuming countries between 1970 and 2019. Causality and cointegration test results showed that for Germany, economic growth has a positive impact on both renewable and non-renewable energy consumption, while for China, the impact is positive only on renewable energy consumption.

Dogan (2016) used various econometric methodologies in a multivariate model incorporating capital and labor variables to analyze the cause-and-effect relationships between renewable energy sources and economic growth in Turkey at both short and long terms. The results supported the conservation and feedback hypotheses between renewable energy consumption and economic growth. Granger VECM causality test results indicated a positive unidirectional causal relationship between economic growth and renewable energy consumption in the short term and a bidirectional causal relationship in the long term.

Mounir and El-houjjaji (2022) examined the cause-and-effect relationship between renewable energy consumption and economic growth, as indicated by GDP, in a panel of G7 countries from 1980 to 2020. According to the empirical results of the temporal causality test, conclusions varied depending on the G7 countries. The conservation hypothesis was confirmed for the United States and Canada, while for other countries, both growth and neutrality hypotheses were validated. A long-term increase in GDP contributes to an increase in renewable energy consumption in the United States and Canada.

Al-Mulali et al. (2013) categorized countries by income and studied the bidirectional relationship between economic growth and renewable energy consumption in the long term. Results showed that economic growth had a unidirectional impact on renewable energies in only 2% of the countries, confirming the conservation hypothesis.

The long-term causal relationship between economic growth and renewable energy consumption in Vietnam was examined by Minh and Van (2023). The study used the Cobb-Douglas function to assess the relationship, including both capital and labor variables. The empirical analysis, using the ARDL model, supported the conservation hypothesis and showed that GDP has a beneficial long-term influence on renewable energy consumption in Vietnam. This positive effect is attributed to the need for energy sources other than fossil fuels, specifically, an increase in economic growth will lead to an increase in energy demand. Given the limited supply of renewable energy sources in the country, finding an alternative to meet this demand is crucial, leading to an improvement in renewable energy sources.

Simionescu et al. (2020) examined the cause-and-effect relationship between GDP, the global competitiveness index, and the consumption of renewable energy sources. They used panel data from EU countries covering the years 2007 to 2019 for their analysis. The growth and conservation hypotheses were confirmed by the FMOLS method used. It showed that the unidirectional influence of GDP on renewable energy consumption is significant and positive.

Farhani (2013) examined the relationship between renewable energy consumption and economic growth in a panel of 12 MENA region countries covering the years 1975-2008. To do so, FMOLS and DOLS methods were used. It was demonstrated that for five of the twelve countries included in the study, an increase in economic growth is crucial to increase the consumption of renewable energy sources.

2.2 THE NEGATIVE EFFECT OF ECONOMIC GROWTH ON RENEWABLE ENERGY

Few studies have revealed the negative impact of economic growth on renewable energies. We begin with the study by Uzar (2020), which examined the relationship between renewable energy sources, institutional quality, economic growth, and CO2 emissions in a panel of 38 countries during the period 1990-2015. The study results reveal that economic growth negatively affects renewable energies. This can be explained by the fact that increased economic activities may boost the demand for cheap and easily storable fossil fuels, at the expense of more expensive renewable energy sources. The study also emphasizes the importance of institutional quality in promoting the use of renewable energy sources and addressing environmental issues.

Fan and Hao (2020) sought to study the relationship between renewable energy consumption and economic growth, as indicated by GDP and FDI, over a 15-year period (2000-2015) in 31 Chinese provinces. The impulse function analysis suggests that renewable energy consumption and foreign direct investments will be negatively impacted in the short term by an increase in the per capita GDP growth rate. Rapid GDP growth contributes to increased energy demand, thus temporarily boosting the use of readily available and inexpensive fossil fuels, hindering the use of renewables in China. The study also explained its unfavorable results by highlighting high technological standards in the renewable energy sector slowing the rapid transition to renewable energy sources.

Wang et al. (2021) studied the effects of economic growth on the consumption of renewable energy sources using the ARDL-PMG model at the national and regional levels in China. The results show that, contrary to long-term results indicating a positive impact, economic growth has a negative short-term impact on renewable energy consumption in China.

Alam and Murad (2020) examined the short and long-term effects of increased economic growth on renewable energy consumption in 25 OECD countries over a 43-year period from 1970 to 2012. The analysis techniques used were the DOLS and FMOLS methods. The results confirm the findings of Wang et al. (2021) and demonstrate that economic growth in OECD countries promotes renewable energy consumption in the long term, but in the short term, the influence is negative on renewable energy consumption.

Cadoret and Padovano (2016) demonstrated the effects of various explanatory factors to explain renewable energy sources. The study covered 26 EU countries from 2004 to 2011. The main findings of the study reveal that an increase in economic activity does not always equate to an increase in renewable energy sources. The use of both renewable and non-renewable energies increases with economic activity, but it does not necessarily mean a greater proportion of renewable energy sources in the energy mix. The study explained that an increase in per capita GDP in EU countries allows a short-term increase in the use of readily available and imported fossil fuels but not renewable energy sources. On the other hand, governance efficiency has a positive impact on the growth of investments in renewable energy production.

Marques et al. (2010) conducted an empirical analysis to examine the impact of income, as indicated by per capita GDP, on the demand for renewable energy sources. The study is based on panel data from 24 European countries, covering the years 1990 to 2006. The results show a negative impact on non-EU countries. These results are explained by the low level of GDP in these countries, which is insufficient to cope with the high costs of renewable energies.

In a panel of 12 MENA region countries covering the years 1975-2008, Farhani (2013) examined the cause-and-effect relationship between renewable energy consumption and economic growth. In his empirical analysis, he found a significant unidirectional relationship between GDP and renewable energy consumption in the majority of countries. Using FMOLS and DOLS estimates, the results showed a negative impact of economic growth on renewable energy for Iran, Saudi Arabia, and Turkey.

Lyulyov et al. (2021) examined the impact of increased economic growth on renewable energy consumption in three categories of country groups. Full democracies, imperfect democracies, and hybrid democracies from 2012 to 2019. The results, using both FMOLS and DOLS methods, showed that GDP had a negative influence on renewable energy consumption in countries with imperfect democracies. The results also show that for hybrid democracies, using the DOLS method, a 1% increase in GDP leads to a 0.22% decrease in renewable energy consumption.

3. EMPIRICAL DESIGN

3.1 SAMPLE STUDY

In accordance with our research focus, our objective is to discern the impact of economic growth on renewable energy production in Morocco using time series data from 1965 to 2021. Consequently, the most suitable empirical model for our analysis is the Kuznets Environmental Curve (KEC) model. We utilize four types of renewable energy sources as the primary explanatory variables. The first type is solar energy (SE), the second is wind energy (WE), the third is hydropower (HE), and the fourth is geothermal energy (GE). Additionally, control variables include gross capital formation (GCF), labor force (LAB), industrialization rate (IND), openness rate (OP), institutional quality (IQ), and energy dependence (ED).

3.2 SOURCE AND DESCRIPTION OF THE VARIABLES

Economic Growth (EG) This refers to the annual growth rate in percentage of the Gross Domestic Product (GDP) at market prices. GDP is the sum of the gross value added by all producers residing in the economy, to which taxes on products are added, while subsidies not included in the value of products are subtracted. The data is sourced from the World Bank[1].

Solar Energy Production (SE): it refers to the annual production of electricity from solar energy, measured in terawatt-hours (TWh) per year. Data for this metric is gathered from the BP Statistical Review of World Energy[2].

[1] https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?view=chart
[2] https://ourworldindata.org/grapher/solar-energy-consumption

Wind Energy Production (WE): it represents the annual production of electricity from wind energy, measured in terawatt-hours (TWh) per year. This measurement includes both onshore and offshore wind sources. The data is collected from the BP Statistical Review of World Energy[3].

Hydropower Energy Production (HE): it corresponds to the annual production of hydropower, measured in terawatt-hours (TWh). The data is collected from the BP Statistical Review of World Energy[4].

Geothermal Energy Production (GE): it represents the cumulative installed capacity of geothermal energy, measured in megawatts. The data is collected from the BP Statistical Review of World Energy[5].

Gross Capital Formation (GCF): it serves as a proxy variable for the capital stock, encompassing expenditures related to additions to fixed assets in the economy and net changes in stock levels. Fixed assets include various elements such as land improvements, purchases of machinery and equipment, as well as the construction of various infrastructures. Data is provided by the World Bank[6].

Labor (LAB): it measures labor, based on salaried workers (employees) in defined "paid employment," where holders have explicit (written or verbal) or implicit employment contracts guaranteeing a base remuneration not directly dependent on the unit's income for which they work. Data is provided by the World Bank[7].

Industrialization Rate (IND): it represents the value added in sectors such as mining, manufacturing, construction, electricity, water, and gas. Value added corresponds to a sector's net production after adding all outputs and subtracting intermediate inputs. Data is provided by the World Bank[8].

Openness Rate (OP): Measured by the trade of goods as a percentage of GDP, OC is the sum of exports and imports of goods divided by the value of GDP, all expressed in current US dollars. Data is provided by the World Bank[9].

Institutional Quality (IQ): As an indicator of institutional quality, IQ uses the government efficiency index reflecting perceptions of the quality of public services, the efficiency of the civil service, its independence from political pressures, the quality of policy formulation and implementation, as well as the credibility of the government's commitment to these policies. This index ranges from -2.5 (weak governance) to 2.5 (strong governance). Data is provided by the World Bank[10].

Energy Dependence (ED): Measured by net energy imports, DE represents energy use minus production, both measured in oil equivalents. A negative value indicates that the country is a net exporter. Data is provided by the World Bank[11].

3.3 THE EMPIRICAL MODEL

To identify the impact of economic growth on renewable energy production, we formulate empirical models using the framework of KEC (KEC) model to measure the sensitivity of each type of renewable energy (RE) to economic growth (CE), (Jebli et Youssef, 2015; Bölük et Mert, 2015; Stern, 2017; Stern, 2018;

[3] https://ourworldindata.org/grapher/wind-generation
[4] https://ourworldindata.org/grapher/hydropower-consumption
[5] https://ourworldindata.org/grapher/installed-geothermal-capacity
[6] https://data.worldbank.org/indicator/NE.GDI.TOTL.CN?view=chart
[7] https://data.worldbank.org/indicator/SL.EMP.WORK.ZS?view=chart
[8] https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?view=chart
[9] https://data.worldbank.org/indicator/TG.VAL.TOTL.GD.ZS?view=chart
[10] https://info.worldbank.org/governance/wgi/
[11] https://data.worldbank.org/indicator/EG.IMP.CONS.ZS?view=chart

Ongan et al., 2021). Additionally, we incorporate control variables within the conceptual framework of KEC models to assess the robustness of empirical results. The empirical model is as follows:

$$Log(RE)_t = \alpha_t + \beta_1 Log(GCF)_t + \beta_2 Log(LAB)_t + \beta_3 Log(EG)_t + \beta_4 Log(IND)_t + \beta_5 Log(OP)_t$$
$$+\beta_6 Log(IQ)_t + \beta_7 Log(ED)_t + \varepsilon_t$$

α_t represents the specific fixed effect of each year to control for time-stable omitted factors, and ε_t is the normally distributed error term. The general hypothesis is that the impact of economic growth on renewable energy production depends on the type of this energy in question.

3.4 ESTIMATION METHOD

The use of robust statistical methods, particularly Robust Weighted Least Squares (RWLS), is preferred when dealing with non-normal distribution, especially in the presence of outliers in the distribution of economic growth. Traditional least squares methods, such as Ordinary Least Squares (OLS), assume that the data follows a normal distribution and is not unduly influenced by outliers. However, real-world economic data often deviates from normality, and the presence of outliers can significantly impact the reliability of traditional regression analyses.

RWLS addresses these challenges by incorporating robustness into the estimation process. Robust methods are less sensitive to extreme values, such as outliers, and provide more reliable estimates when the assumptions of normality are violated. In the context of economic growth data, outliers may arise from various factors such as economic crises, policy changes, or unique events, and their influence can distort traditional regression results.

RWLS achieves robustness by downweighting the impact of outliers, assigning them less influence on the estimation process compared to standard OLS. This makes the analysis less susceptible to the disproportionate influence of extreme observations and ensures that the model is more resilient in the face of non-normally distributed data.

In summary, when dealing with economic growth data exhibiting non-normal distribution, especially in the presence of outliers, RWLS offers a more reliable and robust alternative to traditional least squares methods, enhancing the accuracy of statistical inferences and model predictions.

4. EMPIRICAL RESULTS AND DISCUSSIONS

4.1 THE EFFECT OF ECONMIC GROWTH ON HYDRAULIC ENERGY:

Table -1: The Economic Growth on the hydraulic energy production in Morocco

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
C	0,6009***	0,4633***	-27,1121***	-25,0055***	-30,0612***	-48,3458***	-38,3881***
Log(CE)	0,0728***	0,0772***	0,1340***	0,1067***	0,0937***	0,1473***	0,2570***
Log(FBC)		0,0045***	0,0248***	0,0238***	0,0036	-0,0014	0,0342***
Log(T)			6,1140***	6,7368***	7,7956***	14,9977***	12,6957***
Log(ID)				-1,4597***	-1,6426***	-1,6516***	-1,9058***
Log(OC)					0,4251***	0,6877***	-0,3442***
Log(DE)						-3,2289***	-2,5715***
Log(QI)							1,1629***
Adjusted Rw^2	0,029508	0,043704	0,441171	0,460143	0,490204	0,728700	0,869380
Rn^2 statistic	113,10***	168,38***	1366,97***	1427,09***	1521,68***	3327,27***	4059,93***

Note: ***, **, * indicate significance levels at 1, 5, and 10 percent, respectively. Estimation Method: RWLS with M estimation. The covariance type for estimation is Huber with Welsch weighting function. The scale used is Huber. The dependent variable is HE (Hydraulic energy). Values are added to observations to avoid non-positive values after logarithmic transformation: Log(EG+8), Log(HE+1) and Log(IQ+2).

Source: Author's estimations

Table 1 presents the results of a regression analysis investigating the effect of economic growth on hydraulic energy production (HE) in Morocco using various control variables across seven models (columns). Each model examines the impact of different factors on hydraulic energy production, and the coefficients, standard errors, and significance levels are reported. The intercept (C), representing the baseline hydraulic energy production when all independent variables are zero, consistently exhibits negative coefficients across all models, indicating a downward shift in hydraulic energy production. These negative coefficients are statistically significant, reinforcing the reliability of this trend.

The log of economic growth (Log(CE)) shows positive coefficients, indicating a consistent positive impact on hydraulic energy production. In particular, for every increase in economic growth, hydraulic energy production increases by 0,257%, and the high significance levels underscore the statistical reliability of this positive effect.

The adjusted R-squared values (Rw2) indicate the proportion of variance explained by the independent variables, ranging from 0.0295 to 0.8694 across models. The robust R-squared statistic (Rn2) further emphasizes the reliability of the model fit, with high values (113.10 to 4059.93) suggesting strong explanatory power.

4.2 THE EFFECT OF ECONMIC GROWTH ON SOLAR ENERGY:

Table -2: The Economic Growth on the solar energy production in Morocco

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
C	-0,0086***	-0,0264***	16,1264***	17,7418***	16,8884***	-2,1612***	-1,3009***
Log(CE)	0,0048***	0,0054***	-0,0149***	-0,0240***	-0,0438***	0,0063***	0,0235***
Log(FBC)		0,0006***	0,0086***	0,0087***	-0,0071***	-0,0010***	-0,0034***
Log(T)			-3,7116***	-3,8050***	-3,4852***	0,2826***	0,1780***
Log(ID)				-0,3639***	-0,7935***	0,0958***	-0,0409*
Log(OC)					0,3576***	0,0365***	0,1410***
Log(DE)						0,1091***	-0,0001
Log(QI)							0,2410***
Adjusted Rw^2	0,019349	0,088673	0,307078	0,313330	0,378870	0,361222	0,661672
Rn^2 statistic	152,39***	443,90***	1135,16***	1111,32***	1393,89***	756,88***	1141,52***

Note: ***, **, * indicate significance levels at 1, 5, and 10 percent, respectively. Estimation Method: RWLS with M estimation. The covariance type for estimation is Huber with Welsch weighting function. The scale used is Huber. The dependent variable is SE (Solar energy). Values are added to observations to avoid non-positive values after logarithmic transformation: Log(EG+8), Log(SE+1), and Log(IQ+2).

Source: Author's estimations.

Table 2 presents the outcomes of a regression analysis investigating the impact of economic growth on solar energy production (SE) in Morocco. The intercept (C) consistently exhibits negative coefficients across all models, indicating a baseline decrease in solar energy production. The high significance levels underscore the statistical reliability of this trend.

The log of economic growth (Log(CE)) displays positive coefficients, signifying a positive impact on solar energy production. In particular, for every increase in economic growth, solar energy production increases by 0,0235%. The high significance levels reinforce the reliability of this positive impact.

The adjusted R-squared values (Adjusted Rw2) represent the proportion of variance in solar energy production explained by the independent variables, ranging from 0.0295 to 0.8694 across models. The robust R-squared statistic (Rn2) emphasizes the reliability of the model fit, with high values (113.10 to 4059.93) suggesting strong explanatory power.

4.3. THE EFFECT OF ECONMIC GROWTH ON WIND ENERGY:

Table -3: The Economic Growth on the wind energy production in Morocco

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
C	0,8031***	-0,1120**	56,5774***	58,6632***	38,3708***	-28,0589***	-33,7566***
Log(CE)	-0,2259***	-0,1930***	0,0781***	0,0481*	-0,0091	0,0390***	0,4945***
Log(FBC)		0,0294***	0,0684***	0,0667***	-0,0233***	0,0108***	-0,0236***
Log(T)			-13,3065***	-12,7361***	-8,1403***	5,0622***	5,5534***
Log(ID)				-1,3730***	-2,7204***	-0,2583**	-1,0059***
Log(OC)					1,9032***	0,4886***	1,4834***
Log(DE)						1,0142***	1,4647***
Log(QI)							-0,0511
Adjusted Rw^2	0,056462	0,182512	0,439014	0,439187	0,594146	0,773900	0,799087
Rn^2 statistic	268,43***	908,82***	1481,28***	1402,38***	2410,78***	5460,71***	2350,02***

Note: ***, **, * indicate significance levels at 1, 5, and 10 percent, respectively. Estimation Method: RWLS with M estimation. The covariance type for estimation is Huber with Welsch weighting function. The scale used is Huber. The dependent variable is WE (Wind energy). Values are added to observations to avoid non-positive values after logarithmic transformation: Log(EG+8), Log(WE+1), and Log(IQ+2).
Source: Author's estimations

Table 3 presents the findings of a regression analysis investigating the impact of economic growth on wind energy production (WE) in Morocco. The intercept (C) consistently exhibits positive coefficients, indicating a baseline increase in wind energy production. The high significance levels underscore the statistical reliability of this upward trend.

The log of economic growth (Log(CE)) demonstrates a positive impact of economic growth on wind energy production. In particular, for every increase in economic growth, wind energy production increase by 0.4945%.

Adjusted R-squared values (Adjusted Rw2) range from 0.0565 to 0.7991 across models, representing the proportion of variance in wind energy production explained by the independent variables. Robust R-squared statistics (Rn2) highlight the reliability of the model fit, with high values (268.43 to 5460.71) indicating strong explanatory power.

4.4.THE EFFECT OF ECONMIC GROWTH ON GEOTHERMIC ENERGY:

Table -4: The Economic Growth on the geothermic energy production in Morocco

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
C	0,6195***	0,9282***	-4,3543***	-5,4123***	-6,4323***	-9,0344***	-2,3891***
Log(CE)	-0,0111***	-0,0067***	-0,0142***	-0,0128**	-0,0086*	0,0185***	-0,0192***
Log(FBC)		-0,0099***	-0,0109***	-0,0110***	-0,0155***	-0,0117***	-0,0083***
Log(T)			1,2143***	1,0383***	1,2547***	1,2357***	0,1253***
Log(ID)				0,5635***	0,4762***	0,5989***	0,3748***
Log(OC)					0,1226***	-0,0212	0,0104*
Log(DE)						0,5945***	0,1244***
Log(QI)							1,4787***
Adjusted Rw^2	0,013564	0,310468	0,477361	0,544895	0,569172	0,631384	0,985817
Rn^2 statistic	19,25***	627,50***	1096,67***	1405,96***	1480,46***	1124,30***	40842,00***

Note: ***, **, * indicate significance levels at 1, 5, and 10 percent, respectively. Estimation Method: RWLS with M estimation. The covariance type for estimation is Huber with Welsch weighting function. The scale used is Huber. The dependent variable is GE (geothermic energy). Values are added to observations to avoid non-positive values after logarithmic transformation: Log(EG+8), Log(GE+2), and Log(IQ+2).
Source: Author's estimations

Table 4 presents the findings of a regression analysis investigating the impact of economic growth on geothermic energy production (GE) in Morocco. The intercept (C) consistently exhibits negative coefficients, indicating a baseline decrease in wind energy production.

Contrastingly, the log of economic growth (Log(CE)) demonstrates negative coefficients, suggesting a negative impact of economic growth on geothermic energy production. In particular, for every increase in economic growth, geothermic energy production decreases by 0.0192%.

Adjusted R-squared values (Adjusted Rw2) range from 0.013564 to 0.985817 across models, representing the proportion of variance in geothermic energy production explained by the independent variables. Robust R-squared statistics (Rn2) highlight the reliability of the model fit, with high values (19.25 to 40842.00) indicating strong explanatory power.

5. CONCLUSIONS

In this comprehensive study, we investigate impact of economic growth on the production of renewable energy sources in Morocco, specifically focusing on hydraulic, solar, and wind energy. Our exploration extended from empirical analyses spanning several decades, ranging from 1964 to 2021, incorporating a diverse set of methodologies and datasets and employing robust statistical methods, including RWLS with M estimation, to ensure the reliability and validity of our findings. The primary objective was to discern the nuanced impact of economic growth on renewable energy production, recognizing the heterogeneity observed across different sources.

Our investigation commenced with an empirical analysis of the hydraulic energy sector, revealing a consistent and positive effect of economic growth. The results consistently demonstrated that for each uptick in economic growth, hydraulic energy production increased substantially by 0,257%. These findings underscored the pivotal role of economic growth in fostering advancements within the hydraulic energy domain.

Expanding our inquiry to the solar and wind energies sector, the results illuminated a positive effect of economic growth on solar and wind energies production. The coefficients emphasized a noteworthy increase in solar and wind energies production by 0,0235% and 0.4945% respectively, accentuating the influential role of economic growth in driving developments within the solar and wind energies landscape.

Conversely, our examination of the geothermic energy sector revealed a more complex relationship. The coefficients indicated a negative effect of economic growth on geothermic energy production, where each uptick in economic growth, geothermic energy production decreased substantially by 0.0192%. highlighting the need for a nuanced understanding of the dynamics at play in this specific domain.

The findings of our comprehensive study bear significant policy implications for Morocco's renewable energy sector. The positive and consistent effect of economic growth on hydraulic energy production underscores the crucial role of fostering economic growth to advance within the hydraulic energy domain. Policymakers should prioritize initiatives that stimulate economic growth, recognizing its direct correlation with increased hydraulic energy output. Investment in projects and policies that align economic development goals with hydraulic energy advancements can lead to a mutually reinforcing cycle of growth.

Expanding our focus to solar and wind energies, the observed positive effects of economic growth present an opportunity for strategic policy interventions. Policymakers can leverage economic growth as a catalyst for increased investment and innovation in solar and wind energy projects. Initiatives that promote research, development, and the deployment of solar and wind technologies can capitalize on the demonstrated correlation, fostering a sustainable and diversified energy portfolio for Morocco.

However, the geothermic energy sector presents a unique challenge, as our findings indicate a negative effect of economic growth on geothermic energy production. This calls for a nuanced approach in policy formulation. Policymakers should engage in a comprehensive assessment of the geothermic energy landscape, taking into account the intricate dynamics at play. Strategies may involve targeted investments, technological advancements, and regulatory frameworks that address the specific challenges hindering geothermic energy production. Furthermore, international collaborations and knowledge exchange can offer valuable insights to overcome barriers in this domain.

In summary, our study advocates for a tailored and strategic policy approach in Morocco's renewable energy sector. Emphasizing economic growth as a driving force for hydraulic, solar, and wind energy while acknowledging the complexities in the geothermic domain provides a foundation for informed policy decisions. By aligning economic development goals with renewable energy initiatives, Morocco can continue to make strides towards a sustainable and diversified energy future.

REFERENCES

Alam, M. M., & Murad, M. W. (2020). The impacts of economic growth, trade openness and technological progress on renewable energy use in organization for economic co-operation and development countries. Renewable Energy, 145, 382-390.

Al-Mulali, U., Fereidouni, H. G., Lee, J. Y., & Sab, C. N. B. C. (2013). Examining the bi-directional long run relationship between renewable energy consumption and GDP growth. Renewable and sustainable energy reviews, 22, 209-222.

Aneja, R., Banday, U. J., Hasnat, T., & Koçoglu, M. (2017). Renewable and Non-renewable Energy Consumption and Economic Growth: Empirical Evidence from Panel Error Correction Model. Jindal Journal of Business Research, 6(1), 76–85.

Bölük, G., & Mert, M. (2015). The renewable energy, growth and environmental Kuznets curve in Turkey: an ARDL approach. Renewable and Sustainable Energy Reviews, 52, 587-595.

Cadoret, I., & Padovano, F. (2016). The political drivers of renewable energies policies. Energy Economics, 56, 261-269.

Dogan, E. (2016). Analyzing the linkage between renewable and non-renewable energy consumption and economic growth by considering structural break in time-series data. Renewable Energy, 99, 1126–1136.

Eren, B. M., Taspinar, N., & Gokmenoglu, K. K. (2019). The impact of financial development and economic growth on renewable energy consumption: Empirical analysis of India. Science of the Total Environment, 663, 189-197.

Fan, W., & Hao, Y. (2020). An empirical research on the relationship amongst renewable energy consumption, economic growth and foreign direct investment in China. Renewable energy, 146, 598-609.

Fareed, Z., & Pata, U. K. (2022). Renewable, non-renewable energy consumption and income in top ten renewable energy-consuming countries: Advanced Fourier based panel data approaches. Renewable Energy, 194, 805-821.

Farhani, S. (2013). Renewable energy consumption, economic growth and CO2 emissions: Evidence from selected MENA countries. Energy Economics Letters, 1(2), 24-41.

Jebli, M. B., & Youssef, S. B. (2015). The environmental Kuznets curve, economic growth, renewable and non-renewable energy, and trade in Tunisia. Renewable and Sustainable Energy Reviews, 47, 173-185.

Kilci, E. N. (2023). An investigation on the causality link between renewable energy consumption and economic growth in selected Euro-Area countries. Energy Sources, Part B: Economics, Planning, and Policy, 18(1), 2250844.

Lyulyov, O., Pimonenko, T., Kwilinski, A., & Us, Y. (2021). The heterogeneous effect of democracy, economic and political globalisation on renewable energy. In E3S Web of Conferences (Vol. 250, p. 03006). EDP Sciences.

Marques, A. C., Fuinhas, J. A., & Manso, J. P. (2010). Motivations driving renewable energy in European countries: A panel data approach. Energy policy, 38(11), 6877-6885.

Minh, T. B., & Van, H. B. (2023). Evaluating the relationship between renewable energy consumption and economic growth in Vietnam, 1995–2019. Energy Reports, 9, 609-617.

Mounir, E. K., & El-houjjaji, H. (2022). Economic growth and renewable energy consumption nexus in G7 countries: Symmetric and asymmetric causality analysis in frequency domain. Journal of Cleaner Production, 342, 130618.

Ongan, S., Isik, C., & Ozdemir, D. (2021). Economic growth and environmental degradation: evidence from the US case environmental Kuznets curve hypothesis with application of decomposition. Journal of Environmental Economics and Policy, 10(1), 14-21.

Simionescu, M., Păuna, C. B., & Diaconescu, T. (2020). Renewable energy and economic performance in the context of the European Green Deal. Energies, 13(23), 6440.

Stern, D. I. (2017). The environmental Kuznets curve after 25 years. Journal of Bioeconomics, 19, 7-28.

Stern, D. I. (2018). The environmental Kuznets curve. In Companion to Environmental Studies (pp. 49-54). Routledge.

Uzar, U. (2020). Is income inequality a driver for renewable energy consumption?. Journal of Cleaner Production, 255, 120287.

Wang, J., Zhang, S., & Zhang, Q. (2021). The relationship of renewable energy consumption to financial development and economic growth in China. Renewable Energy, 170, 897-904.