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Analysis of the impact of renewable energy use on GDP and employment in Angola: An error correction model approach

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This paper explores the impact of renewable energy on Angola's GDP and employment. The study used the Autoregressive Distributed Lag (ARDL) and error correction models with data on renewable energy use, gross domestic product, unemployment rate, industry employment, vulnerable employment, labor force participation rate and gross fixed capital formation. This note contributes to the existing literature by investigating the effects of renewable energy use on vulnerable employment in a single developing country like Angola. All the data gained stationarity at first differentiation. Our analysis revealed that renewable energy use shares a causal long-run relationship with the gross domestic product, unemployment rate, vulnerable employment, and labor force participation rate. The short-term analysis exhibits a causal one-way relationship ranging from renewable energy use to vulnerable employment, labor force participation rate, and gross fixed capital formation. Our findings suggest that renewable energy use will harm vulnerable employment and labor force participation rate but improve gross fixed capital formation in the short run. However, there is no significant relationship ranging from renewable energy use to industries' employment, GDP, and unemployment in the short term. Overcoming the mixed effects of using renewable energy on employment recommends investing in research and development of the renewable energy sector, which could add to the drop in unemployment and the quality of jobs. The country's leaders could draw inspiration from countries like the People's Republic of China, Brazil, and India. Infrastructure development, skills training, and technical support should be the primary emphasis of policy initiatives. In its sustainable development policy, the government must consider that investing in the agriculture sector might add to the country, whether for renewable energy production, agricultural productivity, or jobs creation. The country would benefit from accelerating industrialization while promoting renewable energy use and on-site processing of raw materials.

Key words: Renewable energy, economic growth, employment, Angola, Autoregressive Distributed Lag (ARDL).

INTRODUCTION

Energy plays a crucial role in Angola's economic growth and development, one of the fastest growing and largest economies in sub-Sahara Africa, given that its energy demand has increased. This study aims to determine the

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impact of renewable energy on Angola's economic growth, keeping in mind the need for adequate and sustainable energy to meet the growing annual electricity demand of Angola of 13%, with hydropower power supplying more than two-thirds of Angola's mix (Enerdata, 2023). Therefore, this study contributes to the impact of renewable energy on Angola's employment and GDP and offers policy alternatives regarding renewable energy deployment in Angola to ensure robust economic growth and development. Today, the country's national development plan seeks to increase solar deployment capacity of 100 MW, wind energy of 100 MW, 370 MW of mini and medium hydropower, and 500 MW of biomass in 2025 (International Energy Agency, 2019). Furthermore, the country's economic development has witnessed a recession that mirrored its energy consumption levels from plummeting since 2015. Biomass represents nearly half of its energy mix, but its share is reducing (Alemzero et al., 2021; Enerdata, 2023).

Additionally, Angola plans to reach approximately 60% electricity access from its current 44% access rate by 2025 and increases its installed capacity to 9.9 GW. Since Angola's energy sector faces aging infrastructure and grid constraints to handle variable renewable energy generation, the government predicts investing a total of 23.5 billion US dollars in the energy sector, with a breakdown of 12 billion US dollars in a generation, 4 billion US dollars in transmission and 7.5 billion US dollars in distribution infrastructure (Enerdata, 2023). According to the Africa Energy Outlook’s report (International Energy Agency, 2019), Angola is strategizing to reduce greenhouse gas by up to 35% unconditionally to 50% conditionally by 2030 as a business-as-usual approach (BAU).

Even if the shift from burning fossil fuels for energy production to renewable energy sources lowers the total amount of carbon (as CO_2 gases) released into the atmosphere (Adams and Acheampong, 2019; Anwar et al., 2021; Azam et al., 2021), it raises some concerns. Scientists have tried to answer whether renewable energy would be up to that of non-renewable or even better. The results agree with the bewildering effects of using renewable energy on a country's economic growth according to countries (Tuna and Tuna, 2019; Musah et al., 2020; Sharma et al., 2021a; 2021b). It is therefore legitimate to be concerned about the consequences of renewable energy use on the economy of Angola.

According to Alabi et al. (2017), renewable energy consumption experiences outstanding performance in economic development in Angola. This conclusion was reached by applying FMOLS to data on CO_2 emissions, renewable energy consumption, non-renewable energy consumption, and GDP covering the period 1971 to 2011. However, Keshavarzian and Tabatabaienasab (2021) revealed that renewable energy consumption and economic growth do not influence each other in Angola. The analysis was realized using Bootstrap panel causality on GDP, renewable energy, and non-renewable energy from 1980 to 2018. These studies, which were not explicitly focused on Angola, came to different conclusions, pointing to the importance of conducting analyses with more recent data to learn the effects of renewable energies on growth. Also, the previous findings may no longer remain credible because of the variation in the data.

As the Angolan government plans to reduce poverty by 2030 while reducing carbon emissions, the debate is whether renewable energy could promote growth in Angola.

In 2020, the renewable energy sector employed at least 11.5 million people worldwide, including 4.4 million in China, 1.2 million in Brazil, and 755600 in the United States (IRENA, 2020). Photovoltaic solar industries (P.V.), biopower, hydroelectricity, and wind turbines are the most prominent job providers (renewable energy jobs), whether in the agricultural sector or the production of energy, according to IRENA (2018). From this point of view, renewable energies should consolidate growth. These effects may be due to those countries' energy policies promoting a wide adoption of renewable energies, which is not necessarily the case in Angola.

This paper questions the implications of renewable energy use on vulnerable employment, unemployment rate, industry employment, GDP, and capital in Angola with an ARDL model. This is to consolidate sustainability policies in the country. To the best of our knowledge, there is no study about the impact of renewable energy use on vulnerable employment in Angola. Our paper will address this issue, adding to the vast literature about renewable energy. This could help the authorities when formulating poverty reduction and employment policies. The remainder of the paper is as follows. Section two is the literature, explaining the various studies about renewable energy and growth. Section three describes the study data and the methodology. The results are presented in Section four, while Section five outlines the conclusions and policy implications reached from the findings.

LITERATURE REVIEW

Sustainable economic growth is the main target of economic policy in many countries worldwide (Salari et al., 2021). Policymakers have understood that sound economic policy must be effective over time by ensuring populations’ well-being. This has led researchers to conduct investigations according to their economic regions’ realities (Xie et al., 2020; Asif et al., 2021; Dimnwobi et al., 2022). Although it has given rise to various conclusions, the impact of renewable energies on growth has been studied according to its relationship with variables such as GDP, employment, and unemployment. This part of the study will present the recent studies on renewable energy and economic development.

Table 1 outlines some previous studies on the impact of renewable energy on economic growth. The results were classified into positive, negative, and no effects of renewable energy.

The results of the few existing studies about the impact of renewable energy use on economic growth in Africa are mixed. For example, Awodumi and Adewuyi (2020) found that increasing the use of renewable energy contributes to economic growth in Gabon, Egypt but reduces growth in Nigeria. They used data covering 1980-2015 and applied the NARDL method. They recommend exploring avenues to invest in and promote carbon reduction technologies in the production process. Using DCCEMG and data from 1998 to 2018, Musah et al. (2020) demonstrated that renewable energy does not influence gross domestic product in West Africa and encouraged green technology, energy innovation, wind and solar energy, and reduction of fossil energy. Nevertheless, with the NARDL approach and data covering 1990-2015, Namahoro et al. (2021) reported positive and negative impacts of renewable energy on the gross domestic product in Rwanda. Investments in renewable energy consumption and agriculture as prior sectors of development were recommended. Globally, renewable energy's impact on growth is divided into terms of hypotheses: growth, conservative, feedback, and neutrality hypothesis (Somoye et al., 2022). The growth hypothesis refers to the existence of causality ranging from renewable energy use to economic growth; the conservation hypothesis stipulates a unidirectional causality of growth towards the use of renewable energy; the feedback hypothesis reports the existence of causation between the two variables, and the neutrality hypothesis indicates the presence of a relationship between economic growth and the use of renewable energy.

The studies that support the positive impact of renewable energy use on the economic sector include Azam et al. (2021), Salari et al. (2021), Doytch and Narayan (2021), Namahoro et al. (2021), Azretbergenova et al. (2021), Rahman and Velayutham (2020), Awodumi and Adewuyi (2020), Chen et al. (2020) and Bhattacharya et al. (2017). These authors found that using renewable energy contributes to developing economic growth. Salari et al. (2021) used GDP per capita, total energy consumption, non-renewable energy consumption, renewable energy consumption, industrial energy consumption, and residential energy consumption to compare the impact of renewable and non-renewable energy consumption on the economy of the United States. Their result exhibits a growth hypothesis between renewable energy use and economic growth. Likewise, Azretbergenova et al. (2021) investigated the relationship between renewable energy and employment in European Union Countries. They used data on employment, renewable energy, GDP per capita, and fixed capital formation to finding that renewable energy positively impacts employment.

The negative impact of renewable energy on the economic sector got found by Muazu et al. (2022), Somoye et al. (2022), Namahoro et al. (2021), Awodumi and Adewuyi (2020), Chen et al. (2020), Magazzino (2017) and Bhattacharya et al. (2017). Using a non-linear ARDL approach and data on GDP, renewable energy consumption, gross fixed capital formation, and labor force participation rate from 1990 to 2019, Somoye et al. (2022) show that a positive shock of renewable energy hurts GDP in Nigeria because of the nature and source of the used renewable energy. The authors recommend policies minimizing renewable energy's adverse effect on economic growth while diversifying renewable energy sources. The study of Muazu et al. (2022) established a negative relationship between renewable energy and economic growth in some African countries using threshold regression and data on renewable energy, GDP, capital, and labor. However, they encourage investment in renewable energy and research and development so that renewable energy can support those countries' growth. In West African countries, Maji et al. (2019) assert that renewable energy retards economic growth. They recommend cleaner technology to optimize the benefits of wood biomass while minimizing its adverse effects and increasing the share of solar, wind, and geothermal in the mix of renewable energy.

This conclusion was found with the application of panel dynamic DOLS on a sample of 15 West African countries covering the 1995-2014 period and on data on GDP, renewable energy consumption, labor, and capital.

The findings of Ivanovski et al. (2021), Musah et al. (2020), Toumi and Toumi (2019), Bulut and Muratoglu (2018), Narayan and Doytch (2017), and Alper and Oguz (2016) align with the argument that renewable energy use does not affect growth. Ummalla and Samal (2019) assessed the impact of natural gas and renewable energy consumption on CO_2 emissions and economic growth in China and India. Using the ARDL model and data from 1995 to 2016 on per capita renewable energy consumption, GDP per capita, CO_2 emissions per capita, and natural gas consumption per capita, they found short-run bidirectional causality between renewable energy consumption and economic growth in India but no causality between these two variables in China. Their finding suggests that the feedback hypothesis is established among renewable energy and growth in China. They, therefore, invite Indian policymakers to change the energy structure by increasing the share of clean energy. Based on the use of the NARDL and data on renewable energy, carbon dioxide emissions, and real GDP covering the period 1990-2014, the study outcome of Toumi and Toumi (2019) support that there is no causal relationship between renewable energy and economic growth in the Kingdom of Saudi Arabia. They propose more taxation of non-renewable energy to subsidy clean

Table 1. Summary of some previous studies.

Authors	Period	Method	Country	Result
The negative effect of renewable energy on growth				
Muazu et al. (2022)	1990-2018	threshold regression	54 African countries	A negative effect of renewable energy consumption on economic growth exists
Somoye et al. (2022)	1990Q1–2019Q4	NARDL	Nigeria	An increase in renewable energy decreases economic growth
Namahoro et al. (2021)	1990-2015	NARDL	Rwanda	Renewable energy negatively affects growth in a specific region of Rwanda
Awodumi and Adewuyi (2020)	1980-2015	NARDL	Africa	Renewable energy retards growth in Nigeria
Chen et al. (2020)	1995-2015	threshold model	103 countries	The impact of renewable energy on economic growth is negative if its use does not reach a certain threshold
Magazzino (2017)	1990-2007	Granger	Italy	Renewable energy reduces GDP
Bhattacharya et al. (2017)	1991-2012	GMM, FMOLS	85 countries worldwide	Renewable energy has a significant negative impact on economic output in some countries
Baz et al. (2021)	1990-2017	NARDL	Pakistan	Renewable energy use hurts economic growth
No effect of renewable energy on growth				
İnal et al. (2022)	1990-2014	Bootstrap, ARDL, causality	African oil producer	Neutrality hypothesis
Ivanovski et al. (2021)	1990-2015	LLDVE	OCDE countries	Renewable energy has no significant impact on growth
Musah et al. (2020)	1998-2018	DCCEMG	West Africa	Renewable energy had no vital influence on the GDP
Toumi and Toumi (2018)	1990-2014	NARDL	Saudi Arabia	Neutrality
Bulut and Muratoglu (2018)	1990-2015	Cointegration	Turkey	Neutrality
Narayan and Doytch(2017)	1971-2011	GMM	89 countries worldwide	Renewable energy supports the neutrality hypothesis with GDP in certain countries
Alper and Oguz (2016)	1990-2019	ARDL	European countries	Renewable energy supports the neutrality hypothesis
Dogan (2015)	1990-2012	ARDL, VECM	Turkey	Neutrality
Aneja et al.(2017)	1990–2012	Pedroni Panel cointegration	BRICS countries	No strong relationship ranging from renewable energy to economic growth
The positive effect of renewable energy on growth				
Cheuka and Choga (2022)	1990-2019	Panel ARDL	SADC	Renewable energy generation positively impacts growth over the long term
Azam et al. (,2021)	1990-2015	FMOLS, Granger	Newly industrialized countries	Renewable electricity consumption increases the GDP
Salari et al. (2021)	2000-2016	GMM	The U.S	Renewable energy supports the growth hypothesis
Doytch and Narayan (2021)	1984-2019	Regression	107 countries	Renewable energy enhances growth in high-growth sectors
Namahoro et al. (2021)	1990-2015	NARDL	Rwanda	Renewable energy positively affects growth in certain regions
Azretbergenova et al. (2021)	2006-2019	ARDL	European Union	Renewable energy generation has a positive effect on employment in the long-term
Rahman and Velayutham (2020)	1990-2014	PMOLS, DOLS	South Asia	Renewable energy increases the GDP
Awodumi and Adewuyi (2020)	1980-2015	NARDL	Africa	Renewable energy promotes growth in Gabon and Egypt
Chen et al.(2020)	1995-2015	Threshold model	103 countries	The impact of renewable energy on economic growth is positive when its use exceeds a certain threshold
Bhattacharya et al. (2017)	1991-2012	GMM, FMOLS	85 countries	Renewable energy has a significant positive impact on economic output in some countries

Source: Author

energy and recommend policy in accordance with the SDGs in Saudi Arabia. Alper and Oguz (2016) used ARDL model to investigate the relationship among economic growth, renewable energy consumption, capital and labor for new European Union member countries for the period of 1990–

2009.Their result supports that the neutrality hypothesis between economic growth and renewable energy consumption in Cyprus, Estonia, Hungary, Poland and Slovenia, conservation hypothesis in Czech Republic and growth hypothesis in Bulgaria, Estonia, Poland, and Slovenia. They explained the mixed effect by the fact that some countries have less renewable energy in their energy portfolio than other developed European Union member countries.

Most studies linking renewable energy and employment reported that renewable energy leads to more job creation and decreases unemployment, leading to economic growth (Sari and Akkaya, 2016; Proença and Fortes, 2020). Mu et al. (2018) reported that per 1 TW h expansion of solar PV and wind power would create up to 45.1 and 15.8 thousand, respectively, direct and indirect jobs in China. They used the CGE model and data on renewable energy, agriculture, mining, coal, cooking, and refined petroleum sectors. However, they declared that to have more impact, the renewable energy sector needs more investments. According to Lehr et al. (2016), solar and wind energy generate several jobs in the building sectors in Tunisia. They suggest more local renewable energy production because when the imported renewable energy is extremely lower than 10%, employment may rise to more than 0.6% of the overall employment.

Nasirov et al. (2021) compared the impact of renewable energy (solar PV, wind, hydro) and coal and gas on employment in Chile by using the SWITCH-Chile model, a complex linear programming tool developed at the University of California. The result shows that renewable energy may generate more employment per unit of energy than coal and natural gas, however, they advise that better education, public awareness, reduction of market barriers, and renewable energy subsidies are determinants. Renner (2017) estimates the potential employment generated by renewable energy are among others sales, installation, and reparation of solars lanterns and accessories, manufacturing of improved cook stoves, distribution of fuels, construction of biomass plants and biogas digesters, manufacturing or assembly turbines and other equipment, construction of dam, penstocks and watermills. In 2021, renewable energy jobs were up to 12.7 million, including 4.3 million jobs in solar photovoltaic, 1.3 million jobs in wind power, 2.4 million direct jobs in hydropower, and 2.4 million jobs in bioenergy (IRENA and ILO, 2022).

Those results support the conclusions of the reports of the International Renewable Energy Agency (IRENA, 2013, 2014, 2018, 2020; Ferroukhi et al., 2019) and Arvanitopoulos and Agnolucci (2020). However, very few studies detail the impact of renewable energy use on vulnerable employment.

From the studies mentioned earlier, diverse econometric methodologies were employed to analyze the impact of renewable energy use on economic development. These methods include Granger causality, cointegration, FMOLS, DOLS, threshold regression, ARDL, NARDL, GMM, DCCEMG, and LLDVE. Most research focused on panel data analysis or only a few African countries, neglecting the study of developing countries like Angola. Also, research on renewable energy use has been little interested in the impact of renewable energy use on vulnerable employment or industry employment. Again, more studies focus on the impact of renewable on one or two variables related to economic growth. This paper fills the gap by using the ARDL method to examine the impact of renewable energy use on GDP, unemployment rate, industry employment, vulnerable employment, gross fixed capital formation, and labor force participation rate. ARDL has the advantage of remaining robust to small sample sizes and being applicable regardless of whether variables are stationary at level or first difference (Mirza and Kanwal, 2017).

MATERIALS AND METHODS

Materials

In the study, annual data was used on renewable energy (RE), gross domestic product (GDP), vulnerable employment (VE), unemployment rate (UEMP), employment in industries (IND), labor force participation rate (LFPR), and gross fixed capital formation (GFCF). Except for GDP data, which is extracted from the International Energy Agency, all other data are from the World Data Bank. Data on gross fixed capital formation covers the period 2000 – 2020, and the other studied data covers the period 1991 – 2020.Table 2 outlines a brief description of our data.

The data of GDP, IND, RE, UEMP, VE, and LFPR are spread over 30 years, while GFCF covers 21 years. Only GFCF is not normal (Probability is significant at 5%). In Figure 1, the curve showing the evolution of renewable energy consumption has a downward trend between 1990 and 2015, then an upward trend between 2015 and 2020. This reflects the decline in the share of renewable energy from 1990 to 2015. Initially, Angolan energy was mainly hydroelectric, but the growth in energy demand has led to more fossil fuel use, reducing the share of renewable energy. But, the government policy to reduce carbon emissions make increased gradually the share of renewable energy after 2015. An increase in vulnerable jobs after 2005, a downward trend of jobs in industries, and a relatively low unemployment rate revealing precariousness and social inequalities reinforcement in Angola were observed. GDP increased between 1994 and 2015, and then commenced to decrease. The civil war mainly affected the labor force, leading to a shrinking workforce. The labor force participation rate began to increase after 2005.

Methods

Data on RE, GDP, VE, and IND are on their logarithm form. We first determined the optimal lag of the variables and employed stationarity tests (Dickey and Fuller, 1979; Phillips and Perron, 1988). The unit root test shows that all the variables gained stationarity at first differentiation. The autoregressive distributive lag model was then executed. Some diagnostics tests were finally applied to assess our models.

The Autoregressive distributive lag (ARDL) cointegration is a test method proposed by Charemza and Deadman (1994), gradually improved by Pesaran and Shin (1997) and Pesaran et al. (2001)

Table 2. Data summary.

Variable	GDP	IND	RE	UEMP	VE	LFPR	GFCF
Mean	3198.32	8.16	62.26	5.15	65.52	78.08	26.96
Median	3216.93	8.46	62.02	3.87	64.45	78.06	27.48
Maximum	4272.46	9.10	76.82	9.43	73.71	78.66	42.79
Minimum	1927.50	6.80	47.82	3.63	59.77	77.66	16.76
Std. Dev	760.61	0.65	10.15	0.74	0.50	0.29	5.21
Skewness	-0.08	-0.69	-0.11	0.74	0.54	0.44	0.83
Kurtosis	1.57	2.43	1.43	1.93	1.93	2.32	5.63
Jarque-Bera	2.57	2.79	3.15	4.17	2.66	1.54	8.43
Probability	0.28	0.25	0.21	0.12	0.26	0.46	0.01***
Observations	30	30	30	30	30	30	21

Source: Author

and acknowledged as one of the most flexible methods when the study variables are integrated order zero or one, tolerating different lags in different variables and providing unbiased estimates and valid t-statistics independently of the endogeneity of some regressors (Harris and Sollis, 2003; Jalil and Ma, 2008). The ARDL cointegration approach or ARDL bound tests is based on the F-statistic value under the null hypothesis of no cointegration among the tested variables (Sun et al., 2017). If F-statistic exceeds the upper bound of the critical value, the null hypothesis is rejected. If F-statistic falls below the lower band of the critical value, the null hypothesis is accepted. If F-statistic falls inside the critical value band, then the outcome becomes inconclusive (Tang, 2016). When the ARDL bounds test confirms the existence of cointegration, long and short-run models are estimated and ARDL-ECM is performed, where ECM designed the Error Correction Model.

Contrariwise, the ardl model cannot apply to variables of integration order exceeding 2 (Jalil and Ma, 2008; Nkoro and Uko, 2016; Deka and Dube, 2021).

Bivariate models are used to investigate the impact of renewable energy use on each of the other variables. The ARDL model applied to renewable energy use, economic growth, unemployment rate, employment in industries, vulnerable employment, labor force participation rate, and gross fixed capital formation is specified as follows:

Model 1: Renewable Energy and Gross Domestic Product

$$\Delta LNGDP = \mu + \sum \beta_i \Delta LNGDP_{t-i} + \sum \beta_j \Delta LNRE_{t-j} + \alpha_1 LNGDP_{t-1} + \alpha_2 LNRE_{t-1} + \epsilon_{1,t} \quad (1)$$

Model 2: Renewable Energy and Vulnerable Employment

$$\Delta LNVE = \mu + \sum \beta_i \Delta LNVE_{t-i} + \sum \beta_j \Delta LNRE_{t-j} + \alpha_1 LNVE_{t-1} + \alpha_2 LNRE_{t-1} + \epsilon_{1,t} \quad (2)$$

Model 3: Renewable Energy and Unemployment Rate

$$\Delta UEMP = \mu + \sum \beta_i \Delta UEMP_{t-i} + \sum \beta_j \Delta LNRE_{t-j} + \alpha_1 UEMP_{t-1} + \alpha_2 LNRE_{t-1} + \epsilon_{1,t} \quad (3)$$

Model 4: Renewable Energy and Employment in Industries

$$\Delta LNIND = \mu + \sum \beta_i \Delta LNIND_{t-i} + \sum \beta_j \Delta LNRE_{t-j} + \alpha_1 LNIND_{t-1} + \alpha_2 LNRE_{t-1} + \epsilon_{1,t} \quad (4)$$

Model 5: Renewable Energy and Labor Force Participation Rate

$$\Delta LFPR = \mu + \sum \beta_i \Delta LFPR_{t-i} + \sum \beta_j \Delta LNRE_{t-j} + \alpha_1 LFPR_{t-1} + \alpha_2 LNRE_{t-1} + \epsilon_{1,t} \quad (5)$$

Model 6: Renewable Energy and Gross Fixed Capital Formation

$$\Delta GFCF = \mu + \sum \beta_i \Delta GFCF_{t-i} + \sum \beta_j \Delta LNRE_{t-j} + \alpha_1 GFCF_{t-1} + \alpha_2 LNRE_{t-1} + \epsilon_{1,t} \quad (6)$$

Since ARDL bounds tests show long-run relationship for models including LNGDP, LNVE, UEMP, and LFPR (Table 5), then the Error correction models studying those long-run elasticities relationship are described as follow:

Model 7: Renewable Energy and Gross Domestic Product

$$\Delta LNGDP = \mu + \sum \beta_i \Delta LNGDP_{t-i} + \sum \beta_j \Delta LNRE_{t-j} + \alpha_1 ETC_{t-1} + \epsilon_{1,t} \quad (7)$$

Model 8: Renewable Energy and Vulnerable Employment

$$\Delta LNVE = \mu + \sum \beta_i \Delta LNVE_{t-i} + \sum \beta_j \Delta LNRE_{t-j} + \alpha_1 ETC_{t-1} + \epsilon_{1,t} \quad (8)$$

Model 9: Renewable Energy and Unemployment Rate

$$\Delta UEMP = \mu + \sum \beta_i \Delta UEMP_{t-i} + \sum \beta_j \Delta LNRE_{t-j} + \alpha_1 ETC_{t-1} + \epsilon_{1,t} \quad (9)$$

Model 10: Renewable Energy and Labor Force Participation Rate

$$\Delta LFPR = \mu + \beta i \Delta LFPR t-i + \beta j \Delta LNRE t-j + \alpha 1ETC t-1 + \epsilon 1, \quad (10)$$

ETC represents the error correction term. A negative and significant value of ECT represents the existence of long-run causal relationship.

RESULTS

In this part, the authors provide the short-term and long-term analysis results and the diagnostics of the applied models.

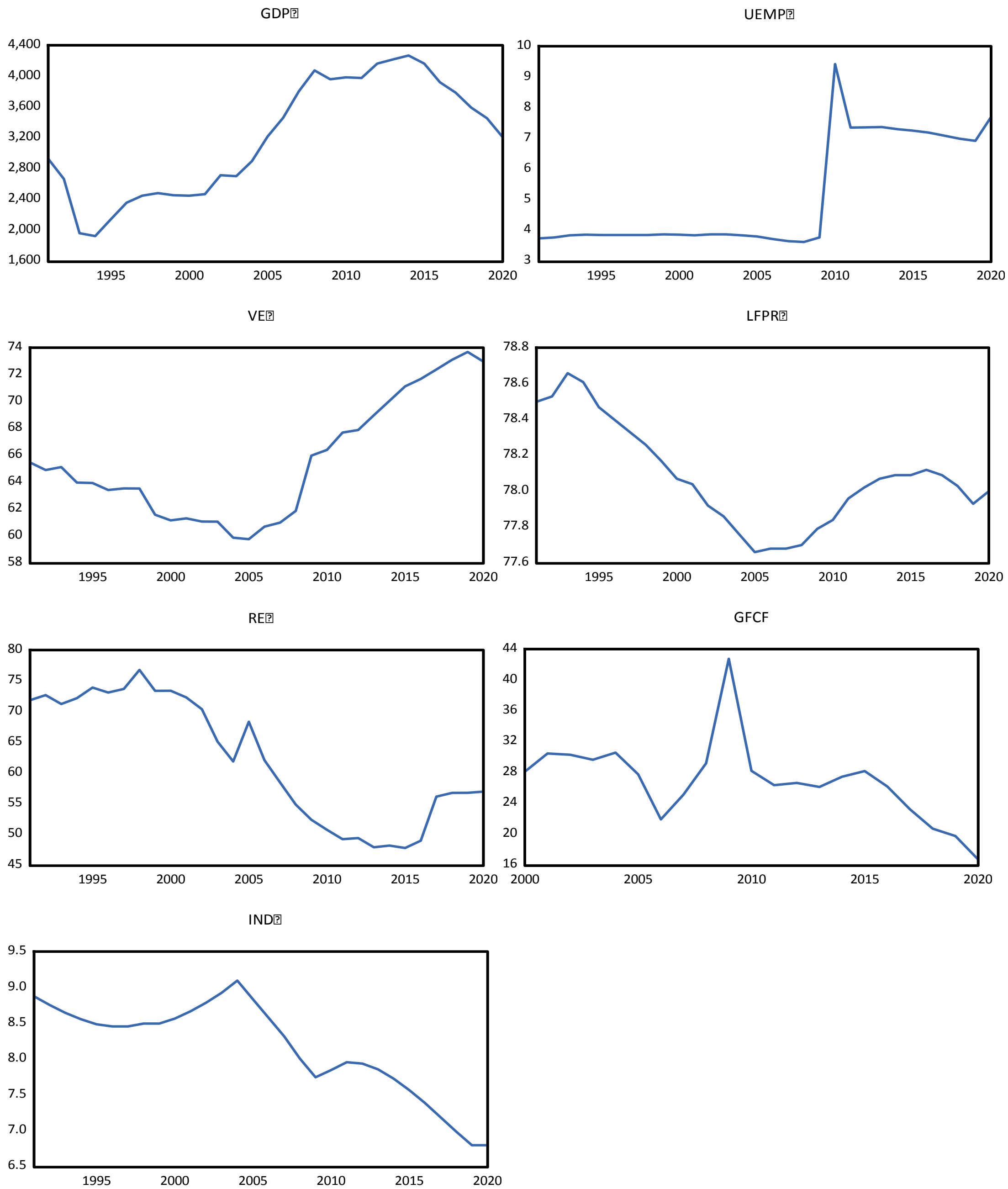

Figure 1. Data evolution.
Source: Author.

Stationarity tests

The first step of analyzing time series data is checking its stationarity. We performed Augmented Dickey-Fuller, and Phillip Perron tests to investigate the unit root tests of variables. The following equation describes the equation used for stationarity analysis.

$$\Delta y_t = \alpha_0 + \theta y_{t-1} + \gamma_1 \Delta y_{t-1} + \gamma_2 \Delta y_{t-2} + \cdots + \gamma_p \Delta y_{t-p} + \eta_1 trend + \varepsilon_t \quad (11)$$

Table 3 shows the performed stationarity tests under Augmented Dickey-Fuller and Phillip-Perron. Estimates indicate that none of the variables are stationary at level, but all the variables gained stationarity at first difference. Thus, our variables are integrated of order one. ARDL models suit variables of order zero or one when studying their relationships. The ARDL bounds test will specify whether the studied variables share a long-run relationship.

Table 3. Unit root test.

Level	Variable	ADF	P-value	P.P	P-value
At level	LNRE	-0.9780	0.7476	-1.0686	0.7143
	LNGDP	-1.5186	0.5097	-1.0375	0.7261
	LNIND	-0.9834	0.2835	-1.8809	0.0582
	UEMP	0.4597	0.8074	0.6630	0.8536
	GFCF	-0.8047	0.3547	-0.9489	0.2940
	LFPR	-3.3952	0.0205**	-1.5352	0.5020
At first difference	ΔLNRE	-4.5850	0.001***	-4.6252	0.001***
	Δ LNGDP	-3.1644	0.033**	-2.8790	0.034**
	Δ LNIND	-2.1237	0.035**	-2.1237	0.035**
	ΔUEMP	-7.0178	0.000***	-7.2324	0.000***
	ΔGFCF	-5.0907	0.000***	-5.9648	0.000***
	ΔLFPR	-2.2916	0.0237**	-2.6064	0.011**

Source: Author

Table 4 presents the optimal lags of the equations (1-6). The choice for the optimal lags is essential since it avoids models' overfitting. Models 1 to 6 have respectively as optimal lags 2; 1; 1; 2; 1 and 1.

ARDL approach

The error correction term (ECT) of Model 7, Model 8, Model 9, and Model 10 are negative and significant at a 1% level, indicating long-run relationship ranging from renewable energy use to economic growth, from renewable energy use to vulnerable employment, from renewable energy to unemployment rate and from renewable energy use to labor force participation rate.

However, the error correction terms of models containing ΔLNIND and ΔGFCF are either positive (0.01) or insignificant at the 5% level, and their F-statistic (3.71 and 1.84) do not exceed the upper bound (4.16) at the 5% significance level. We conclude that renewable energy use and industry employment do not share a long-run relationship as well as renewable energy use and gross fixed capital formation. When LNGDP or UEMP is the dependent variable, the error correction is (-0.54) or (-0.60), indicating that the rate of adjustment to equilibrium will be fast (as the speeds rate 54 and 60% exceeds 50%). Nevertheless, when LNVE or LNFPR is the dependent variable, the speed rate is 8 or 0.7% lower than 50%, revealing that the adjustment to equilibrium will be really slow.

Short-run results

Here, we provide the different results of the short-run analysis in separate tables (Tables 6 to 11). Tables 6 to 11 present the results of models [1-6] for short-run causality.

No significant causal relationship was found between renewable energy use and economic development. This finding aligns with Narayan and Doytch (2017) and Musah et al. (2020), who reported that renewable energy use does not influence economic growth. Differently, Magazzino (2017) and Anwar et al. (2021) found that renewable energy use decreased economic growth, and Azam et al. (2021) stipulated that renewable energy increased economic growth. Our finding puts in evidence the underutilization of renewable energy in Angola's economic activities and insists that by maintaining this proportion of renewable energy consumption, economic development will not depend on renewable energy consumption. Economic policies must be shaped so that renewable energy valiantly replaces fossil fuels. Indeed, the potential of renewable energy is not sufficiently exploited; solar energy is used only for domestic needs, namely for electrification. Renewable energies have not got fully integrated as alternative sources to non-renewable energies. Lags in GDP have mixed effects on GDP, indicating that investments may often not be profit-making. A 1% increase in lag 1 in LNGDP increases the current LNGDP by 1.18 units while a 1% increase in lag 2 in LNGDP reduces the current LNGDP by 72.29%.

Table 7 indicates that renewable energy use negatively affects vulnerable employment. A 1% increase in renewable energy use weakens vulnerable employment by 7.26%. This result highlights the difficulties faced by the authorities in improving the vulnerable employment sector. It was noted that the use of renewable energies is harmful to employment policy. Thus, a transition to renewable energy will only further expose disadvantaged people because they are typically in vulnerable jobs. Therefore, it is logical that people are wary of using renewable energy. Lag 1 in VE supports VE. This result

Table 4. Optimal lag selection.

Model	Lag	Lags selection criteria		
		AIC	**SBIC**	**LR**
	0	-3.0935	-2.9967	-
	1	-6.5716	-62813	8.0746
Model 1	2s	-6.7785*	-6.2946*	10.8051*
	3	-6.5775	-5.9000	2.0270
	4	-6.6839	-5.8129	7.0405
	0	-3.6680	-3.5712	-
	1s	-8.7805*	-8.4902*	124.665*
Model 2	2	-8.7198	-8.2360	5.1877
	3	-8.5418	-7.8643	2.4628
	4	-8.3700	-7.4990	2..3100
	0	2.5521	2.6489	-
	1s	0.0546*	0.2357*	67.0317*
Model 3	2	0.1367	0.6206	2.4443
	3	0.4096	1.0870	0.6621
	4	0.5933	1.4642	21078
	0	-3.2783	-3.1815	-
	1	-3.2783	-7.8985	120.02
Model 4	2s	-8.8493*	-8.3654*	20.331*
	3	-8.6600	-7.9826	2.2497
	4	-8.6104	-7.7394	4.3840
	0	-0.9745	-0.8777	-
	1s	-6.5789*	-6.2885*	135.98*
Model 5	2	-6.3652	-5.8813	1.9750
	3	-6.3343	-5.6568	5.2576
	4	-6.3827	-5.5117	6.0537
	0	4.7223	4.8204	-
	1s	3.5067	3.8008*	23.6074*
Model 6	2	3.6514	4.1415	3.9107
	3	3.9220	4.6081	2
	4	3.0712*	3.9534	0.0940

shows the selected lag.
Source: Author

shows that vulnerable jobs will reinforce job insecurity, contributing more to poverty and intermittent unemployment, hence the necessity of policies improving the employment sector.

Renewable energy use has no significant direct impact on the overall unemployment rate in Angola. This finding aligns with those of Bulut and Muratoglu (2018) and Dogan (2015) but contrasts with the study outcome of Sari and Akkaya (2016) and Proença and Fortes (2020), who indicated that renewable energy, contributes to employment. Lag 1 in UEMP positively affects UEMP.

Table 5. Long- run relationship.

Models	F-statistics	ECT	Cointegration
ΔLNGDP	3.90	-0.54 (0.00***)	Yes
ΔLNVE	6.47	-0.08 (0.00***)	Yes
ΔUEMP	4.44	-0.60 (0.00***)	Yes
ΔLNIND	3.71	0.01 (0.00***)	No
ΔLFPR	7.56	-0.007 (0.00***)	Yes
ΔGFCF	1.84	-0.45 (0.13)	No
	Lower bound	**Upper bound**	
5%	3.62	4.16	
2.5%	4.18	4.79	
1%	4.98	5.58	

Source: Author

These findings indicate that unemployment increases social inequality and poverty, hence the need to raise policies against unemployment issues.

Renewable energy does not affect employment in industries in Angola. The Lag in LNIND positively affects LNIND, revealing that industrial growth may contribute to industry employment, and reinforce economic growth. More precisely, a 1 unit increase in the lag 1 of LNIND increases current LNIND by 1.01 units.

Table 10 ascertains that renewable energy use reduces the labor force participation rate. A one percent increase in renewable energy use leads to a decrease in the labor force participation rate by 66%, reinforcing the overall unemployment and threatening the country's growth. This result differs from the findings of Sari and Akkaya (2016), Bulut and Muratoglu (2018), and Bibi and Li (2022). However, our findings align with Maji (2015) in Nigeria and Namahoro et al. (2021) in Rwanda. Lag 1 of LFPR positively influences LFPR. A 1 unit increase in lag 1 of LFPR increases LFPR by 1.05 unit.

Table 11 outlines the positive effect of renewable energy use on Gross fixed capital formation (GFCF). This impact is significant at 10% and indicates that a 1-unit increase in renewable energy use increases gross fixed capital formation by 2.88 units. This result is consistent with the findings of Awodumi and Adewuyi (2020), Chen et al. (Chen et al. 2020), and Bhattacharya et al. (2017). The lag 1 of GFCF has a positive effect on GFCF. A 1 percent increase in lag 1 of GFCF increases GFCF by 56%.

Residual diagnostic test results

Table 11 summarizes the diagnostics test results of the models. Breusch-Godfrey was used for the serial correlation test, Jarque Bera for the normality test,

Table 6. Renewable energy use and GDP.

Variable	LNGDP (dependent variable)					
	Lag 0		Lag 1		Lag 2	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
LNGDP			1.1827	0.00***	-0.7229	0.00***
LNRE	-0.3289	0.3028	-0.4025	0.1634		

Source: Author

Table 7. Renewable energy and vulnerable employment.

Variable	LNVE (dependent variable)			
	Lag 0		Lag 1	
	Coef.	t-stat	Coef.	t-stat
LNVE			0.9234	0.00***
LNRE	-0.0726	0.00***		

Source: Author

Table 8. Renewable energy use and unemployment rate.

Variable	UEMP (dependent variable)			
	Lag 0		Lag 1	
	Coef.	t-stat	Coef.	t-stat
UEMP			0.3905	0.0327**
LNRE	0.6952	0.8634	-6.4394	0.1602

Source: Author

Table 9. Renewable energy use and employment in industries.

Variables	LNIND (dependent variable)			
	Lag 0		Lag 1	
	Coef.	t-stat	Coef.	t-stat
LNIND			1.0139	0.00***
LNRE	0.0275	0.2797		

Source: Author.

Table 10. Renewable energy use and labor force participation rate.

Variable	LFPR (dependent variable)			
	Lag 0		Lag1	
	Coef.	t-stat	Coef.	t-stat
LFPR			1.0508	0.00***
LNRE	-0.6636	0.0301**	0.3634	0.1798

Source: Author

Breusch-Pagan-Godfrey for the heteroskedasticity test, and CUSUM graph for the stability test. Table 12 indicates that in the models, the residuals have no serial correlation and are homogenous at a 1% significance level. However, when the unemployment rate is the dependent variable, the model suffers from normality

Table 11. Renewable energy use and gross fixed capital formation.

Variable	GFCF (dependent variable)			
	Lag 0		Lag 1	
	Coef.	t-stat	Coef.	t-stat
GFCF			0.56	0.02**
LNRE	2.88	0.08*		

Source: Author

Table 12. Residual diagnostic test results.

	Breusch–Godfrey: Serial correlation L.M. test		Jarque-Bera normality test		Heteroskedasticity test: Breusch–Pagan–Godfrey	
Models	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
∆LNGDP	0.112	0.895	73.86	0.27	1.848	0.154
∆LNVE	0.545	0.587	68.17	0.17	1.431	0.257
∆UEMP	0.709	0.503	112.86	0.02**	4.713	0.09*
∆LNIND	8.505	0.121	1.46	0.48	3.232	0.151
∆LFPR	0.650	0.531	7.72	0.13	0.368	0.777
∆GFCF	0.028	0.972	18.68	0.11	0.358	0.704

Source: Author

issues.

The CUSUM graph lies within the 5% significance bounds indicating that all our models are stable. Thus, Figure 2 shows that the results of the models are robust.

CONCLUSIONS AND POLICY IMPLICATIONS

This paper investigates the impact of renewable energy consumption on Angola's economic development. For this, we employed data covering the period 2001 – 2020 for gross fixed capital formation and data from 1990 to 2020 for renewable energy use, unemployment rate, and vulnerable employment, employment in industries, gross domestic product, and labor force participation rate. The effects of renewable energy use was analyzed on the unemployment rate, vulnerable employment, employment in industries, gross domestic product, the labor force participation rate, and gross fixed capital formation. Unit root tests indicate that all the study data are stationary at first difference. Bivariate autoregressive distributive lag (ARDL) and error correction model (ECM) framework were used to conduct the analysis. The residual diagnostics tests confirmed the robustness of results.

This paper highlighted the need to establish economic policies considering the transition to renewable energy use and the employment issue in Angola. The results exhibit the presence of short and long-term elasticities relationships.

The long-run relationship directing from renewable energy use to gross domestic product, unemployment rate, vulnerable employment, and labor force participation rate asserts that using renewable energy may have mixed effects on Angola's economic development. These findings call on the authorities to strengthen economic policies and optimize renewable energy use. Thus, investing in research and development is necessary to find a pathway to minimize the adverse effects of renewable energy use. The risk that the use of renewable energies may cause unemployment can be minimized by improving citizens' skills. This may make it possible to take advantage of renewable energy jobs such as the sale, installation, and maintenance of solar panels and equipment and facilitate the electrification of remote areas.

However educational training for skills development can take time, discouraging citizens in a hurry to lift themselves out of poverty. Skill development in rural areas should be taught in local languages, with respect and frankness to avoid quarrels within the population. The deployment of renewable energies could come up against the refusal of the rural citizen who prefers firewood and charcoal which they can have almost for free in forests. It would therefore be difficult to convince them to spend money on alternative energy sources.

The short-run analysis reveals that using renewable energies reduces the labor force participation rate and weakens vulnerable jobs but contributes to gross fixed capital formation. Therefore, renewable energies facilitate the disappearance of vulnerable jobs, further exposing citizens. These results indicate that renewable energy is not enough to improve the quality of jobs. In this regard,

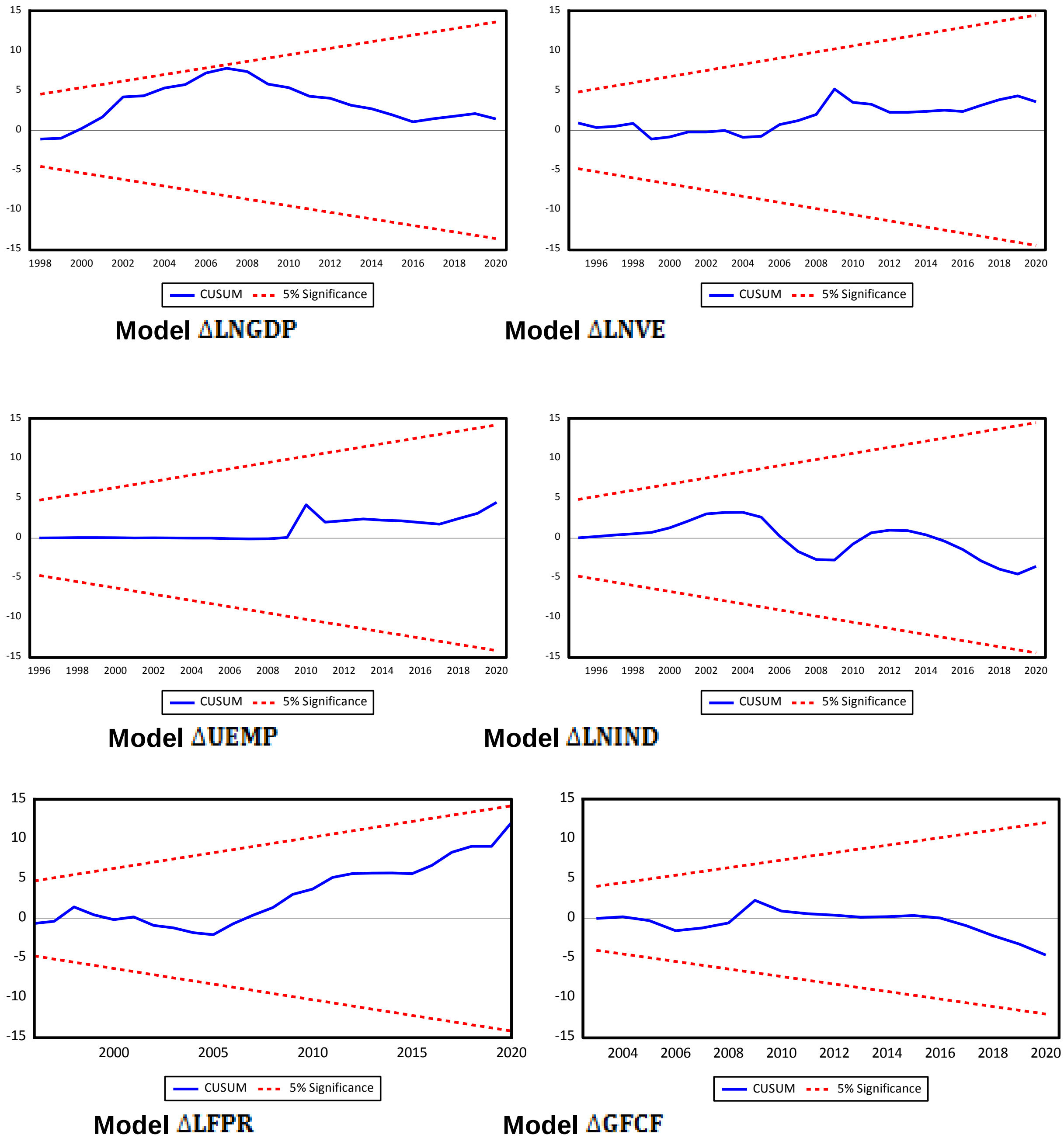

Figure 2. Different models.
Source: Author

Angola's Government must improve its policy relating to the employment sector and devote itself to job creation. The renewable energy sector is an untapped reservoir of jobs in Angola. The country’s authorities could draw inspiration for job creation policies from the renewable energy sector of countries such as the People's Republic of China, India, and Brazil. These countries devote a large part of their budget to research and development, and education. To the default for Angola to be able to strictly imitate them (lack of funds, researchers, laboratories), the country should be active in clean energy technology development. The fact that the country has no specific policy for population growth calls on the Angolan authorities to consider the consequences of that growth, namely economic need unemployment, energy needs, and environmental protection. The authors recommended implementing policies favoring infrastructure development, skills training, and technical support. Solar and wind energy remain the most easily deployable renewable energies and renewable energy jobs providers in Angola, facilitating the electrification of remote areas. This aligns with the authorities' vision. However, renewable energy integration requires the subsidization of materials and equipment and qualified personnel for maintenance.

Also, our results found that renewable energy use does not significantly impact industry employment, indicating that renewable energy does not have a vital influence on industry employment in Angola. The non-significant positive effect implies that renewable energy use is not generalized in the industrial sector. To solve this, we suggest incentivizing industries to use renewable energy more. Authorities can encourage industries to use renewable energy by taxing fossil fuels and subsidizing renewable energy to reduce potential losses. Also, the impact of renewable energy use on industry employment should be considered in the discussion of policies about sustainable development.

The lag in GFCF positively impacts GFCF, lags in GDP have mixed effects on GDP, and lag in LNIND has a positive impact on LNIND, meaning that some investments may not be profit-making while industrial growth is determinant to reduce unemployment. One of these reasons is that Angola is a country in reconstruction, whose several economic sectors (agriculture, fishing, livestock, commerce, hotels, tourism, and industries) need reforms. However, it is important to set up funds supporting entrepreneurship and the gradual transition to renewable energy. Development policy requires huge human and financial investments. The immediate action from the country's leaders should be investing in sustainable policies supporting agriculture and animal husbandry, the main economic activities in rural areas where the poverty rate is high. The country would benefit from accelerating industrialization while encouraging clean energy. For this, it will be preferable to process raw materials inside the country. This may reduce social inequalities, reinforce the employment sector and promote growth. Also, convenient investments in agriculture could help in producing biofuels.

Vulnerable employment and unemployment reinforce respectively vulnerable employment and unemployment. This finding explains the importance of reducing unemployment and vulnerable jobs. Unemployment is often caused by the refusal for certain jobs deemed poorly paid or not decent. It is therefore imperative to create a craze for such jobs, by valuing wages. Importing high-quality materials and equipment and making them accessible to workers may help to reduce vulnerable jobs.

The mixed effects of using renewable energy in the economic sector led us to think that renewable energy will not spur economic development. The renewable energy transition will be realized at the expense of economic development.

However, funding for research to develop the renewable energy sector could lessen the negative impact of renewable energy and thus boost the economic sector. Also, we suggest that decision-makers formulate energy and economic policies per the country's development programs, taking inspiration from China, Brazil, and India. The country possesses large agricultural land areas where cassava and sugar cane grow. In its sustainable development policy, the government must consider that the development of the agriculture sector could bring more to the country, whether for the development of renewable energies, agricultural productivity, or job creation.

Future studies should focus on minimizing the negative impact of renewable energy on Angola's economy. It will also be interesting to conduct further studies about optimizing renewable energy production in Angola. The authors think such studies could reinforce the low-carbon policy. It is important to specify that the major limitation of this paper is the unavailability of data. This placed a limit on the choice of time horizon as we would have preferred to extend the study time horizon.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Adams S, Acheampong AO (2019). Reducing carbon emissions: The role of renewable energy and democracy. Journal of Cleaner Production 240:118245.

Alabi O, Ackah I, Lartey A (2017). Re-visiting the renewable energy–economic growth nexus: Empirical evidence from African OPEC countries. International Journal of Energy Sector Management 11:387-403.

Alemzero DA, Sun H, Mohsin M, Iqbal N, Nadeem M, Vo XV (2021). Assessing energy security in Africa based on multi-dimensional approach of principal composite analysis. Environmental Science and Pollution Research 28:2158-2171.

Alper A, Oguz O (2016). The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. Renewable and Sustainable Energy Reviews 60:953-959.

Anwar A, Siddique M, Eyup Dogan, Sharif A (2021). The moderating role of renewable and non-renewable energy in environment-income nexus for ASEAN countries: Evidence from Method of Moments Quantile Regression. Renew Energy 164:956-967.

Arvanitopoulos T, Agnolucci P (2020). The long-term effect of renewable electricity on employment in the United Kingdom. Renewable and Sustainable Energy Reviews 134:110322.

Asif M, Bashir S, Khan S (2021). Impact of non-renewable and renewable energy consumption on economic growth: evidence from income and regional groups of countries. Environmental Science and Pollution Research 28:38764-38773.

Awodumi OB, Adewuyi AO (2020). The role of non-renewable energy consumption in economic growth and carbon emission: Evidence from oil-producing economies in Africa. Energy Strategy Reviews 27:100434.

Azam A, Rafiq M, Shafique M, Zhang H, Ateeq M, Yuan J (2021). Analyzing the relationship between economic growth and electricity consumption from renewable and non-renewable sources: Fresh evidence from newly industrialized countries. Sustainable Energy Technologies and Assessments 44:100991.

Azretbergenova G, Syzdykov B, Niyazov T, Gulzhan T, Yskak N (2021). The relationship between renewable energy production and employment in European union countries: panel data analysis. International Journal of Energy Economics and Policy 11:20-26.

Bhattacharya M, Churchill SA, Paramati SR (2017). The dynamic impact of renewable energy and institutions on economic output and CO2 emissions across regions. Renew Energy 111:157-167.

Bibi A, Li XM (2022). The asymmetric dilemma of renewable energy, financial development, and economic growth: fresh evidence from Pakistan. Environmental Science and Pollution Research 29:31797-31806.

Bulut U, Muratoglu G (2018). Renewable energy in Turkey: Great potential, low but increasing utilization, and an empirical analysis on renewable energy-growth nexus. Energy Policy 123:240-250.

Chen C, Pinar M, Stengos T (2020). Renewable energy consumption and economic growth nexus: Evidence from a threshold model. Energy Policy 139:111295.

Deka A, Dube S (2021). Analyzing the causal relationship between exchange rate, renewable energy and inflation of Mexico (1990–2019) with ARDL bounds test approach. Renew Energy Focus 37:78-83.

Dickey DA, Fuller WA (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. Journal of the American Statistical Association, pp. 427-431.

Dimnwobi SK, Madichie CV, Ekesiobi C, Asongu SA (2022). Financial development and renewable energy consumption in Nigeria. Renew Energy 192:668-677.

Dogan E (2015). The relationship between economic growth and electricity consumption from renewable and non-renewable sources: A study of Turkey. Renewable and Sustainable Energy Reviews 52:534-546.

Doytch N, Narayan S (2021). Does transitioning towards renewable energy accelerate economic growth? An analysis of sectoral growth for a dynamic panel of countries. Energy 235:121290.

Enerdata (2023). Angola Energy Report. The Ministry of Mineral Resources, Oil, and Gas (MIREMPET) and the Ministry of Energy and Water (MINEA).

Ferroukhi R, Renner M, García-Baños C, Khalid A (2019). Renewable Energy and Jobs: Annual Review. International Renewable Energy Agency (IRENA), Abu Dhabi, United Arab Emirates.

Harris R, Sollis R (2003). Applied Time Series Modelling and Forecasting. J. Wiley, Chichester, West Sussex, England; Hoboken, NJ.

İnal V, Addi HM, Çakmak EE, Torusdağ M, Çalışkan M (2022). The nexus between renewable energy, CO_2 emissions, and economic growth: Empirical evidence from African oil-producing countries. Energy Report 8:1634-1643.

International Energy Agency (2019). Africa Energy Outlook 2019 - Angola (World Energy Outlook Special Report). International Energy Agency (IEA), France.

IRENA (2020). Renewable Energy and Jobs – Annual Review 2020. International Renewable Energy Agency, Abu Dhabi.

IRENA (2018). Renewable Energy and Jobs - Annual Review 2018. International Renewable Energy Agency, Abu Dhabi.

IRENA (2013). Renewable Energy and Jobs. International Renewable Energy Agency, Abu Dhabi.

IRENA (2014). Renewable Energy and Jobs: Annual Review. International Renewable Energy Agency, Abu Dhabi.

IRENA, ILO (2022). Renewable energy and Jobs: Annual review 2022. International Renewable Energy Agency, Abu Dhabi and International Labour Organization, Geneva.

Ivanovski K, Hailemariam A, Smyth R (2021). The effect of renewable and non-renewable energy consumption on economic growth: Non-parametric evidence. Journal of Cleaner Production 286:124956.

Jalil A, Ma Y (2008). Financial development and economic growth: Time series evidence from Pakistan and China. Journal of Economic Cooperation and Development 29:29-68.

Keshavarzian M, Tabatabaienasab Z (2021). Application of Bootstrap Panel Granger Causality Test in Determining the Relationship between Renewable and Non-Renewable Energy Consumption and Economic Growth: a Case Study of OPEC Countries. Technology and Economics of Smart Grids and Sustainable Energy 6:10.

Lehr U, Mönnig A, Missaoui R, Marrouki S, Salem GB (2016). Employment from Renewable Energy and Energy Efficiency in Tunisia – New Insights, New Results. Energy Procedia 93:223-228.

Magazzino C (2017). Renewable Energy Consumption-Economic Growth Nexus in Italy. International Journal of Energy Economics and Policy 7:10.

Maji IK (2015). Does clean energy contribute to economic growth? Evidence from Nigeria. Energy Rep 1:145-150.

Maji IK, Sulaiman C, Abdul-Rahim AS (2019). Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. Energy Report 5:384-392.

Mirza FM, Kanwal A (2017). Energy consumption, carbon emissions and economic growth in Pakistan: Dynamic causality analysis. Renewable and Sustainable Energy Reviews 72:1233-1240.

Mu Y, Cai W, Evans S, Wang C, Roland-Holst D (2018). Employment impacts of renewable energy policies in China: A decomposition analysis based on a CGE modeling framework. Applied Energy 210:256-267.

Muazu A, Yu Q, Liu Q (2022). Does renewable energy consumption promote economic growth? An empirical analysis of panel threshold based on 54 African countries. International Journal of Energy Sector Management 17(1):106-127.

Musah M, Kong Y, Mensah IA, et al (2020). The link between carbon emissions, renewable energy consumption, and economic growth: A heterogeneous panel evidence from West Africa. Environmental Science and Pollution Research 27:28867-28889.

Namahoro JP, Wu Q, Xiao H, Zhou N (2021). The asymmetric nexus of renewable energy consumption and economic growth: New evidence from Rwanda. Renew Energy 174:336-346.

Narayan S, Doytch N (2017). An investigation of renewable and non-renewable energy consumption and economic growth nexus using industrial and residential energy consumption. Energy Economics 68:160-176.

Nasirov S, Girard A, Peña C, Salazar F, Simon F (2021). Expansion of renewable energy in Chile: Analysis of the effects on employment. Energy 226:120410.

Nkoro E, Uko AK (2016). Autoregressive Distributed Lag (ARDL) cointegration technique: Application and interpretation. Journal of Statistical and Econometric Methods 5:63-91.

Pesaran MH, Shin Y (1997). An Autoregressive Distributed-Lag Modelling Approach to Cointegration Analysis. In: Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium. Cambridge University Press, New York, pp. 371-413.

Pesaran MH, Shin Y, Smith RJ (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Economics 16:289-326.

Phillips PCB, Perron P (1988). Testing for a unit root in time series regression. Biometrika 75:335-346.

Proença S, Fortes P (2020). The social face of renewables: Econometric analysis of the relationship between renewables and employment. Energy Report 6:581-586.

Rahman MM, Velayutham E (2020). Renewable and non-renewable energy consumption-economic growth nexus: New evidence from South Asia. Renew Energy 147:399-408.

Renner M (2017). Rural renewable energy investments and their impact on employment. International Labour Organization.

Salari M, Kelly I, Doytch N, Javid RJ (2021). Economic growth and renewable and non-renewable energy consumption: Evidence from the U.S. states. Renew Energy 178:50-65.

Sari A, Akkaya M (2016). Contribution of Renewable Energy Potential to Sustainable Employment. Procedia - Social and Behavioral Sciences 229:316-325.

Sharma A, Dharwal M, Kumari T (2021a). Renewable energy for sustainable development: A comparative study of India and China. Materials Today: Proceedings. S2214785321060843.

Sharma GD, Tiwari AK, Erkut B, Mundi HS (2021b). Exploring the nexus between non-renewable and renewable energy consumptions and economic development: Evidence from panel estimations. Renewable and Sustainable Energy Reviews 146:111152.

Somoye OA, Ozdeser H, Seraj M (2022). The impact of renewable energy consumption on economic growth in Nigeria: fresh evidence from a non-linear ARDL approach. Environmental Science and Pollution Research 29:62611-62625.

Sun C, Zhang F, Xu M (2017). Investigation of pollution haven hypothesis for China: An ARDL approach with breakpoint unit root tests. Journal of Cleaner Production 161:153-164.

Tang TC (2016). ARDL Cointegration Tests for Beginner. Department of Economics, Faculty of Economics and Administration, Malaysia.

Toumi S, Toumi H (2019). Asymmetric causality among renewable energy consumption, CO2 emissions, and economic growth in KSA: evidence from a non-linear ARDL model. Environmental Science and Pollution Research 26:16145-16156.

Tuna G, Tuna VE (2019). The asymmetric causal relationship between renewable and non-renewable energy consumption and economic growth in the ASEAN-5 countries. Resources Policy 62:114-124.

Ummalla M, Samal A (2019). The impact of natural gas and renewable energy consumption on CO2 emissions and economic growth in two major emerging market economies. Environmental Science and Pollution Research 26:20893-20907.

Xie F, Liu Y, Guan F, Wang N (2020). How to coordinate the relationship between renewable energy consumption and green economic development: from the perspective of technological advancement. Environmental Sciences Europe 32:71.