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Testing the contribution of renewable energy to the added value of Agriculture in Algeria: for the period 1990-2022

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Abstract:

This study examines the impact of renewable energy consumption on the added value of the agricultural sector in Algeria from 1990 to 2022, utilizing the ARDL and cointegration approach. The results reveal a cointegration between the variables; however, the positive and insignificant error correction coefficient indicates a lack of short-term adjustment, suggesting a long-term imbalance. The study highlights the significance of sustainable energy practices in improving agricultural productivity.

Key words: Renewable Energy, Agricultural Sector, co-Integration, Limit Error Coefficient, ARDL model.

JEL Classification Codes : Q20, O13, C22.

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Introduction:

What Paul Ehrllch said 1974 about the constant dependence on oil consumption (Heinberg, 2005, p. 191), is a suicidal act if we do not think about alternative energy to replace petroleum. During the global economic crises, the world and the Energy countries that are dependent on mature energy resources, especially the climate changes that are taking place in the world and causing the destruction of several economic facilities, and prompting the world to seek new sources to transition out of the profession and accredited path The experience experienced by some countries of the world has proven its success and purity as clean, non-polluting and longer-lasting energies.

Algeria has incorporated renewable energy plans into its Energy, Economic, and Policy Program, advancing green energy initiatives. These efforts are aimed at enhancing economic performance across various sectors, including agriculture, which is crucial for national food security and economic stability.

The main problematic:

To what extent does renewable energy contribute to the added value of the agriculture sector in Algeria?

1. Renewable energy in Algeria:

1.1. The idea of renewable energy:

Renewable energy comes from naturally replenished sources, unlike non-renewable energy, which needs human extraction.. (Qadi & al, 2010, p. 133).

1.1.1. Renewable energy according to IEA:

Renewable energy is harnessed from sources that follow natural, spontaneous processes, such as solar and wind energy, which are naturally replenished at a rate faster than their consumption. (Ranul & Madahi, 2012, pp. 140-141).

1.1.2. Definition of renewable energy according to the IPCC Intergovernmental Panel on climate change:

Renewable energy encompasses all energy derived from the sun, geophysical, or biological processes that are naturally replenished, such as biomass, solar power, water movement, and tidal energy in the oceans. Various mechanisms exist to convert these sources into primary forms of energy, such as heat and electricity. (Hamdi, 2004, p. 93).

1.1.3. Definition of renewable energy according to the United Nations Environmental Protection Program UNEP:

The UNEP defines renewable energy as energy that does not originate from a finite or limited source in nature, as it is periodically replenished at a rate faster than its consumption. It appears in the following five forms: biomass, sunlight, wind, and hydroelectric power. (Ali, 1980).

1.2. Characteristics of sustainable energy:

1.2.1. Renewable energy distinctly differs from conventional energy.

- Alternative energy sources are essential to human life, playing a vital role in meeting energy demands. They offer long-term sustainability and are primarily powered by the sun and its energy.

- Despite their long-term sustainability, alternative energy sources are not continuously available and do not exist as ready reserves available around the clock.

- The energy intensity of alternative sources is relatively low, necessitating the use of large-scale equipment and devices to harness them effectively.

- These energy sources exist in various forms, requiring specialized technology for each. For example, solar energy comes from electromagnetic waves emitted by the sun, manifesting on Earth as both light and heat, while wind energy is derived from air movement, representing mechanical energy. (el-Fershi, 2005, p. 18).

1.3. The status of renewable energy in Algeria:

A key challenge to broader renewable energy adoption is its high cost, driven by the need for various tools due to its lower energy density. Algeria, committed to sustainable development, aims to focus on renewable energy as a primary step in meeting 21st-century goals. (Boudghene Stambouli & al, 2012)

1.3.1. Solar energy:

Due to Algeria's geographical location, it possesses some of the most promising solar fields and mineral resources globally. Solar radiation across the national territory averages around 2,000 hours per year, reaching up to 3,911 hours in the high plateaus and desert regions. Daily energy availability from solar radiation per square meter is approximately 5 kW per hour across most of the country. This translates to about 1,700 kWh per square meter annually in the northern regions and 2,263 kWh per square meter in the southern regions, where values can exceed 3,000 kWh per square meter. This substantial amount of energy has the potential to meet 60% of Western Europe's energy needs, four times the global consumption, and 5,000 times Algeria's national electricity consumption. (Sonelgaz, 2010, p. 82).

1.3.2. breeze energy:

Algeria has significant wind energy potential, with average wind speeds exceeding 7 m/s at 10 meters altitude in coastal areas, potentially generating about 673 million watt-hours annually. (Saheb-Koussa & al, 2013, pp. 232-238)

1.3.3. Geothermal energy:

Algeria has over 200 geothermal heat sources located in the northeastern and northwestern regions of the country. The temperature at these sources exceeds 0.40 and can rise to 0.98 in the heated baths, reaching up to 0.118 BPA. More than 12 m³/s of hot water is extracted from these sources, with temperatures ranging between 22 and 98 degrees Celsius. This geothermal potential provides the opportunity to establish power generation stations. (Saheb-Koussa & al, 2009, pp. 2347-2351)

1.3.4. Water power:

Algeria receives a substantial amount of rainfall annually, estimated at about 65 billion m³. However, only a small portion, approximately 5%, is currently utilized. In contrast, some European countries exploit around 70% of their groundwater resources. Currently, Algeria's total water exploitation is estimated at 25 billion m³, with two-thirds of this amount coming from surface water and the remaining third from groundwater. (Benelmir & & Hamouda, 2014, pp. 710-719)

1.3.5. Biomass energy:

Algeria's potential in this area remains relatively low compared to other types of renewable energy, primarily due to the limited forest area, which constitutes only 10% of the country's total land. Additionally, energy sources derived from urban and agricultural waste are estimated at only about 5 million tons equivalent. (Boukhechba & al, 2015)

2. The concept of agricultural development, methods of achieving it and its reality in Algeria:

2.1. Definition of agricultural economic development and its determinants:

2.1.1. Definition of agricultural economic development:

Agricultural development is deeply connected to economic development. It involves a range of policies and practices designed to transform the agricultural sector, optimize the use of agricultural resources, boost production, and enhance productivity. The primary objectives are to increase national income growth and improve living standards. Additionally, agricultural development encompasses the management and preservation of natural resources, as well as the implementation of technological and institutional changes to address and sustain human needs for future generations. (Timmer & Peter, 1988)

2.1.2. Determinants of agricultural economic development:

The factors influencing agricultural economic development include various issues that affect the advancement of the agricultural sector. These challenges can impede progress and have adverse effects on both agriculture and the wider economy. Key issues include: (Lafusha, 1998, p. 11).

2.1.2.1. Economic problems:

These issues are commonly faced by many developing countries and include low productivity across various branches of the agricultural sector. This low productivity is often due to the use of outdated or inefficient technology and the poor allocation of manpower across different agricultural activities.

2.1.2.2. Political and social problems:

Political and social instability significantly hinders economic development, especially in less developed societies. Customs and traditions can obstruct progress, while limited knowledge and outdated production methods reduce productivity, impeding the achievement of development goals.

2.1.2.3. Technical and scientific problems:

Embracing modern production methods, such as mechanizing the agricultural sector and applying contemporary scientific techniques, will greatly advance development and help achieve the sector's goals.

2.1.2.4. Organizational problems:

Some of the most pressing regulatory challenges faced by developing countries include:

- The underdeveloped state of marketing systems.

- The absence of modern storage facilities.

- The relatively low level of investment directed toward the agricultural sector compared to other sectors.

- The uneven distribution of agricultural investment across different activities within the agricultural sector.

2.2. Ways to achieve agricultural development: (PingaliL & Prabhu, 2012, pp. 12302-12308)

There are two ways to achieve agricultural development, to mention a few:

2.2.1. Horizontal agricultural development:

The goal is to expand agricultural areas by reclaiming and cultivating arable lands. Subsequently, the state will undertake necessary infrastructure developments to encourage private sector investment in this area.

2.2.2. Stagnant agricultural development:

This can be accomplished by integrating modern methods into agricultural practices, such as mechanizing farming operations, utilizing improved seed varieties and high-yield breeds, and adopting advanced irrigation techniques. Furthermore, employing agricultural scientific research and intensification programs plays a crucial role in boosting productivity.

3. Evaluating the impact of renewable energy consumption on the added value of the agriculture sector in Algeria from 1990 to 2022

The study examines the relationship between renewable energy and the added value in Algeria's agriculture and industry sectors using the ARDL model. The methodology involves the following stages:

3.1. Description of the variables being examined:

The study explores how renewable energy impacts the added value of Algeria's agriculture sector. Renewable energy is measured as a percentage of total energy consumption, and the agriculture sector's added value is given in fixed local currency prices. To standardize the measurements, the decimal logarithm is used. The necessary variables for the analysis include:

LEA: The logarithm represents the proportion of renewable energy relative to total energy consumption.

LAVA: The logarithm represents the added value generated by the agriculture sector.

3.2 Self-regression model of distributed angular gaps:

The ARDL model is denoted as ARDL(ρ , q1, q2, …), where \(p \) represents the lags for the dependent variable and \(q1, q2, \ldots \) are the lags for the independent variables.

$$AVA_t = \alpha + \sum_{t=1}^{\rho} \gamma_t AVA_{t-1} + \sum_{j=1}^{k} \sum_{i=0}^{q} \beta_{ij} EA_{J,t-i} + \varepsilon_t$$

owing to the different units of measurement for the variables under study, the decimal logarithm will be applied to both sides of the equation. The equation then becomes:

$$LAVA_t = \alpha + \sum_{t=1}^{\rho} \gamma_t LAVA_{t-1} + \sum_{j=1}^{k} \sum_{i=0}^{q} \beta_{ij} LEA_{J,t-i} + \varepsilon_t$$

3.3. Determining the degrees of time dilation:

Before performing the unit root test, it is crucial to determine the optimal time lag periods. The optimal approach involves selecting the minimum values for the following parameters:

-Akaike Criterion : $AIC(P) = Ln\left|\sum_e\right| + \frac{2k^2p}{n}$

-Shwartz Criterion : $SC(P) = Ln\left|\sum_e\right| + \frac{k^2p.Ln(n)}{n}$

Overview of the findings:

Table 1: "Identifying the Optimal Lag Lengths for Time Series Analysis"

Number of slowdowns		0	1	2	3	4	5	Optimal decelerationperiod
LEA	*Akaike*	-0.435062*	-0.254869	-0.174946	-0.196824	-0.015331	-0.406107	00
	Schwarz	00.398890*	-0.182525	-0.066429	-0.052135	-0.165531	-0.189073	
LAVA	*Akaike*	-1.708898	-4.235754	-4.185683	-4.064665	-3.884918	-3.796826	01
	Schwarz	-1.67225	-4.163409	-4.077166	-3919976	-3.704057	3.579792	

Source: prepared by researchers output of EViews

Table No. 01 indicates that the optimal lag lengths are zero for renewable energy and one for agriculture's value-added, yielding the lowest AIC and SC values.

3.4. Evaluating the stability of the time series for the examined variables.

Tests to do this, but the study relied on the Augmented Dickey-Fuller (ADF) test.

Premise:

Null hypothesis $H_0 : \phi = 1$: the chain contains unit walls, and therefore the chain is unstable.

Using the Eviews program we get the following results:

3.4.1. Lea renewable energy ratio logarithm series stability test:

Table 2: Lea ADF renewable energy ratio logarithm series stability test

Lag Length: 0 (Automatic − based on SIC, maxlag = 4)					
			t-Sta	Prob.*	
ADF test statistic			-2.472702	0.1407	
TCV :	1% leve		-3.959148		
	5% leve		-3.081002		
	10% leve		-2.681330		

Source: prepared by researchers output of EViews

Table 02 shows that the Dickey-Fuller test value of 2.472702 for the added value is less than the critical value of 3.081002 at the 5% significance level. This means we fail to reject the null hypothesis, indicating the presence of a unit root and inherent instability in the logarithmic series of renewable energy (LEA).

To achieve stationarity for the logarithmic series of renewable energy (LEA), we apply first-order differencing and then re-test the series for stability. The results are as follows:

Table 3: Assessment of the stability of the logarithmic series for renewable energy (LEA) using the first-order ADF test.

$Null\ Hypothesis$: $LAVA\ has\ a\ unit\ root$ $Lag\ Length$: $0\ (Automatic\ -\ based\ on\ SIC, maxlag = 4)$				
			t-Stat	Pro.*
ADFtest statistic			-5.182333	0.0013
TCV	1% leve		-4.004425	
	5% leve		-3.098896	
	10% leve		-2.690439	

Source: prepared by researchers output of EViews

Table 03 indicates that after first-order differencing, the Dickey-Fuller value exceeds the 5% critical value, confirming that the logarithmic series of the renewable energy ratio is now stationary. This is further supported by a p-value below 0.05.

3.4.2. Stability testing of the value-added logarithm series for the agriculture sector ADF/LAVA:

Table 4: the stability test of the value-added logarithm series for the agriculture sector lava / ADF

$Null\ Hypothesis$: $LAVA\ has\ a\ unit\ root$ $Lag\ Length$: $0\ (Automatic\ -\ based\ on\ SIC, maxlag = 4)$				
			t-Stat	Pro.*
ADF test statistic			0.016778	0.9461
TCV:	1% leve		3.959148-	
	5% leve		3.081002-	
	10% leve		2.681330-	

Source: prepared by researchers output of EViews

Table No. 04 shows that the Dickey-Fuller value of 0.016778 is higher than the 5% critical value, indicating stationarity of the logarithmic series of renewable energy. This is supported by a p-value above 0.05, leading to acceptance of the alternative hypothesis.

3.4.3. Stability test of the residuals series Resid:

Table 5: Stability analysis of the residuals series employing first-order differencing and the ADF test

Null Hypothesis: LAVA has a unit root Lag Length: 0 (Automatic − based on SIC, maxlag = 4)				
			t-Stat	Pro.*
ADF test statistic			-4.266687	0.0104
TVC::	1% leve		-4.297073	
	5% leve		-3.212696	
	10% leve		-2.747676	

Source: prepared by researchers output of EViews

Table No. 05 shows that the Dickey-Fuller value, after first differencing, exceeds the 5% critical value, indicating that the residuals series is stationary. This is further validated by a p-value less than 0.05.

3.5. Threshold testing for co-integration:

Bounds testing assesses co-integration: if the F-statistic exceeds the upper critical value, co-integration is indicated; if below the lower critical value, it is not.

Bounds formula:

$$\Delta AVA_t = \alpha + \sum_{i=1}^{\rho-1} \gamma_i \Delta LAVA_{t-i} + \sum_{j=1}^{k}\sum_{i=0}^{q-1} \beta_{ij} \Delta LEA_{J,t-i} + \rho LAVA_{t-1} + \sum_{j=1}^{k} \delta_j LEA_{j,t-1} + \varepsilon_t$$

Test hypothesis: $\begin{cases} H_0 : \rho = \delta_j = 0 \\ H_1 : \rho \neq \delta_j \neq 0 \end{cases}$

Table 6: boundary test results

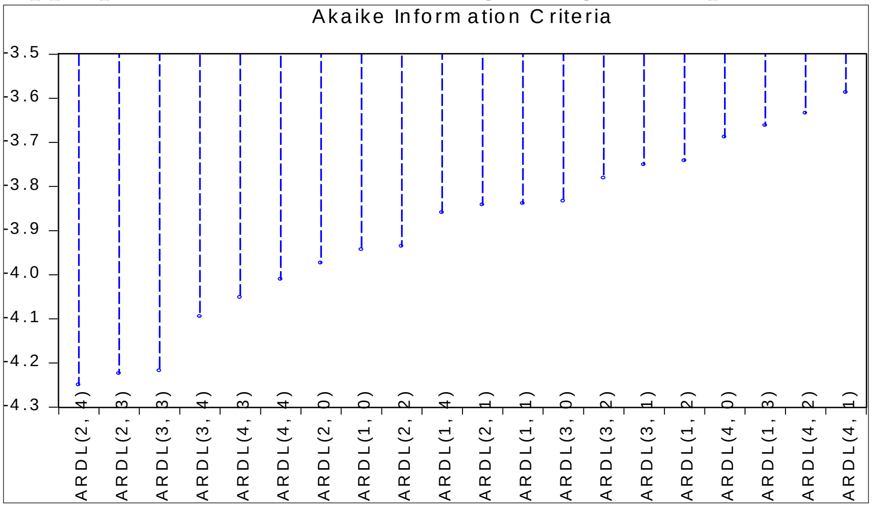
C.F.V	CV	Moral leve		
		%1	5%	10%
6.691015	I(0)I The minimum	6.84	4.94	4.04
	I(1)The upperlimit	7.84	5.73	4.78

Source: prepared by researchers output of EViews

Table No. 06 shows that the Fisher F value exceeds the upper critical limits, confirming a long-term co-integration relationship between renewable energy share and agricultural value added at the 1%, 5%, and 10% levels.

3.6. Estimating a long-term relationship: the co-integration regression model:

Figure 1: the appropriate model for estimating a long-term equilibrium relationship



Source: prepared by researchers output of EViews

Using the AIC criterion, as shown in the figure above, the ARDL(4.1) model was chosen to estimate the long-term equilibrium relationship.

3.7. Model estimation:

$$\boldsymbol{LAVA} = 0.470004594748 * \boldsymbol{LAVA}(-1) + 0.605871136135 * \boldsymbol{LAVA}(-2) - .0569013786346 * \boldsymbol{LEA} + 0.0144319955402 * \boldsymbol{LEA}(-1) - 0.0464927615621 * \boldsymbol{LEA}(-2) - 0.0633933837295 * \boldsymbol{LEA}(-3) + 0.0324059130113 * \boldsymbol{LEA}(-4) - 1.00641574471$$

From the estimated model, we note that the added value resulting from the agriculture sector(LAVA) is affected by the added value resulting from the agriculture sector(LAVA) two years late(-2), plus four years late for the ratio of renewable energy consumed to total energy(LEA) (-4).

3.7.1. Economic interpretation:

-A 1% increase in last year's LAVA value-added raises this year's by 0.47%, holding other variables constant.

- A 1% increase in the logarithm of LAVA value-added from two years ago boosts the current year's value by 0.60%, with other variables constant.

- A 1% increase in the logarithm of current renewable energy consumption reduces the logarithm of current value-added by 0.05%, with other variables constant.

- A 1% increase in the logarithm of renewable energy consumption from the previous year raises the current year's value-added by 0.01%, with other variables constant.

- A 1% increase in the logarithm of renewable energy consumption from two years ago decreases the current year's value-added by 0.04%, with other variables constant.

- A 1% increase in the logarithm of renewable energy consumption from three years ago decreases the current year's value-added by 0.06%, with other variables constant.

- A 1% increase in the logarithm of renewable energy consumption from four years ago increases the current year's value-added by 0.03%, with other variables constant.

- There is a positive correlation between the current year's agricultural value-added and the previous year's agricultural value-added.

- There is a positive relationship between the current year's agricultural value-added and the value-added from two years prior.

- There is a negative relationship between the current year's agricultural value-added and the proportion of renewable energy consumed as a fraction of total energy for the current year.

- There is a positive relationship between the current year's agricultural value-added and the percentage of renewable energy consumed from total energy in the previous year.

- There is a negative relationship between the current year's agricultural value-added and renewable energy consumption two years ago.

- There is a negative relationship between the current year's agricultural value-added and renewable energy consumption three years ago.

- There is a positive relationship between the current year's agricultural value-added and renewable energy consumption from four years ago.

- There is a negative relationship between the current year's agricultural value-added and the constant.

3.8. Assessment of the ECM:

After bounds testing for co-integration, estimating the Error Correction Model (ECM) is crucial to assess the adjustment speed coefficient. This coefficient reveals the presence of a co-integration relationship if it:

- Has a negative sign, indicating that the system is returning to long-term equilibrium.

- Is statistically significant: This confirms that the adjustment process is occurring at a meaningful rate.

- Is less than 1 in magnitude: This ensures that the adjustment towards equilibrium is not instantaneous but gradual, which is a typical characteristic of co-integrated variables.

$$\Delta AVA_t = \alpha + \sum_{i=1}^{\rho-1} \gamma_i \Delta LAVA_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{q-1} \beta_{ij} \Delta LEA_{J,t-i} - \varphi ECT_{t-1} + \varepsilon_t$$

After bounds testing for co-integration, estimating the Error Correction Model (ECM) is essential. The adjustment speed coefficient confirms co-integration if it:

Table 7: Error correction findings act

ARDL Cointegrating And Long Run Form Dependent Variable : LAVA Selected Model : ARDL(1, 4) Sampl: 1990 2022 32included observations :				
CointegratingForm				
Variabl	Coeffici	Std. Error	t-Stat	Pro
D(LAVA(-1))	-0.605871	0.350786	-1.727183	0.1592
D(LEA)	-0.056901	0.052972	-1.074183	0.3432
D(LEA(-1))	0.046493	0.036499	1.273818	0.2717
D(LEA(-2))	0.063393	0.035623	1.779585	0.1498
D(LEA(-3))	-0.032406	0.035202	-0.920562	0.4094
CointEq(-1)	0.075876	0.107693	0.704553	0.5199
Cointeq = LAVA - (1.5809*LEA + 13.2640)				
Long Run Coefficients				
Variabl	Coefficient	Std. Error	t-Stat	Pro.
LEA	1.580869	1.888974	0.836893	0.4497
C	13.264001	1.915114	6.925960	0.0023

Source: prepared by researchers output of EViews

Table No. 07 reveals that the error correction coefficient is positive and statistically insignificant, indicating that there is no short-term adjustment towards long-term equilibrium in the relationship.

Conclusion:

This research paper explores the connection between renewable energy consumption (as a percentage of total energy) and the value added by the agricultural sector in Algeria. Utilizing the ARDL methodology, the study identifies a long-term equilibrium between these variables. Key findings include:

Positive error correction factor, indicating no short-term adjustment.

Co-integration exists between renewable energy and agriculture value-added.

The ARDL model (4,1) identifies both direct and inverse relationships between the agriculture sector's value-added and renewable energy consumption, varying by lag periods.

Renewable energy's impact on agriculture is nuanced, with both positive and negative effects depending on time lags.

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