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The influence of energy governance on climate resilience :Case of Tunisia exposed to natural risks: An econometric study for the period.(2024-1993)

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Abstract

This econometric study, conducted with EViews 12 software, examines the impact of energy governance on climate resilience in Tunisia for the period 1993–2024, a country exposed to increasing natural hazards. Using time series, we analyze the long- and short-term effect of several variables, such as energy governance (EG), environmental regulations (ER), green infrastructure investments (IGI), and climate change awareness and education (ICAE). The results show that, in the long term, energy governance and environmental regulations have a significant negative impact on climate resilience, while stakeholder engagement (SE), renewable energy consumption (REC), and climate change education (ICAE) enhance resilience. Short-term estimates reveal similar effects, highlighting the urgency of reforming energy and environmental policies to improve climate resilience in Tunisia.

Keywords: energy governance, climate resilience, natural risks, Tunisia, green infrastructure investments, climate change awareness, renewable energy consumption, environmental regulations, econometric study, EViews 12.

Introduction

Tunisia, located in the heart of the Mediterranean, faces a multitude of environmental challenges exacerbated by climate change. The country's vulnerability to natural hazards, such as droughts, floods and heat waves, represents a significant threat to its sustainable development and the security of its populations. In this context, energy governance is emerging as a key factor in strengthening the country's climate resilience.

Energy governance, defined by the policies, institutions and practices that govern the use of energy resources, plays a crucial role in how a country adapts to the effects of climate change. Effective management of energy resources can not only improve access to energy, but also promote sustainable energy solutions and reduce dependence on fossil fuels, thereby contributing to greater resilience to environmental risks.

This study aims to explore the impact of energy governance on climate resilience in Tunisia, based on an econometric analysis of data from 1993 to 2024. We will highlight nine independent variables, including renewable energy consumption, energy efficiency, and investments in green infrastructure, which influence the country's adaptive capacity to natural disasters. The dependent variable, climate resilience, will be measured by indicators such as adaptive capacity and the effectiveness of climate impact mitigation measures. By examining the relationships between these variables, this study aims to provide informed recommendations for policy makers in Tunisia, highlighting the importance of strengthened energy governance to improve climate resilience. In sum, this research aims to contribute to the literature on the interactions between energy governance and climate resilience, while offering practical perspectives for sustainable development adapted to future environmental challenges.

1. Limitations of the study:

Temporal limitations: The study was applied for the period 1993-2024.

2. Study modalities:

As part of this study on the influence of energy governance on climate resilience in Tunisia, it is important to clearly define the key terms and concepts that will be used throughout the research. Here is a list of these terms, accompanied by their definitions:

1. Energy governance: Set of policies, regulations, institutions and practices that govern the production, distribution and consumption of energy. It aims to ensure sustainable and efficient use of energy resources. (Abid, M., & Abid, Y. (2023)).

2. Climate resilience: Capacity of a system, community or economy to adapt and recover from the impacts of climate change and extreme events (such as natural disasters), while maintaining its essential functions. (Akintola, S. O., & Olabisi, O. J. (2022)).

3. Renewable energy: Energy sources that are naturally replenished and can be used without the risk of short-term depletion. This includes solar, wind, hydro, geothermal, and biomass. (Allouche, A. (2021)).

4. Energy efficiency: Optimized use of energy to perform the same task or obtain the same service, thus resulting in a reduction in energy consumption. (Bauluz, C. E., & Di Nardo, A. (2022)).

5. Green infrastructure: Systems and structures that integrate natural processes to manage environmental resources and provide ecosystem services, such as stormwater management, temperature regulation, and biodiversity. (Ben Yaïche, H. (2021)).

6. Climate change awareness: The process of educating and informing populations about the challenges and effects of climate change, as well as possible actions to mitigate these impacts. (Bouguettaia, A., & Ramdani, H. (2023)).

7. Environmental regulations: Laws and standards put in place to protect the environment and regulate activities that may have an impact on it, including energy-related policies. (Bruneau, C. (2021)).

8. Stakeholder engagement: Degree of participation and involvement of different actors (government, businesses, NGOs, citizens) in decision-making processes and initiatives related to energy governance. (Chahed, J., & Chabchoub, M. (2023)).

9. Access to energy: The ability of a population to obtain reliable, affordable and sustainable energy to meet their daily needs. (Chahrour, R. (2021)).

10. Energy Cost: Price paid by consumers for energy, influenced by factors such as supply and demand, government policies, and production costs. (El-Baz, M., & Boughanmi, H. (2022)).

3. Population and Sample Studied:

Data were collected on the study variables for the period (1993-2024) and to conduct a descriptive analysis of these variables, as the sample size reached 31 observations for each of the study variables. Therefore, this element was assigned to the examination of data related to the study variables by presenting the descriptive analysis of the data as follows: The following was adopted: EViews 12.

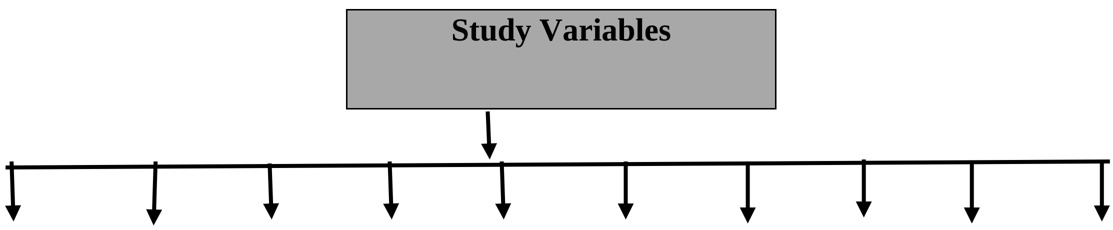
To carry out this study on the influence of energy governance on climate resilience in Tunisia, a rigorous methodological approach will be adopted, encompassing the following steps:

4. Definition of Variables

The variables will be clearly defined and operationalized:

- **Dependent variable:**
- ✓ Climate resilience (CS): Measured by quantitative indicators such as the mortality rate related to natural disasters, the effectiveness of emergency responses, and the adaptive capacity of infrastructure.
- **Independent variables:**
- ✓ Energy governance (EG): Governance indices, quality of energy policies.
- ✓ Renewable energy consumption (REC): Percentage of total energy coming from renewable sources.
- ✓ Investments in green infrastructure (IGI): Amounts invested in sustainable infrastructure.
- ✓ Energy efficiency (EE): National index measuring the efficient use of energy.
- ✓ Climate change awareness and education (CCAE): Indicators of education programs on climate risks.
- ✓ Environmental regulations (ER): Quality and implementation of regulations.
- ✓ Stakeholder engagement (SE): Measured by surveys on the involvement of actors.
- ✓ Access to energy (AE): Percentage of the population with access to reliable energy.
- ✓ Cost of energy (CE): Average price of energy on the market.

Figure 1: Study variables



Energy cost = X9 (EC)	Access to energy = X8 (AE)	Stakeholder Engagement X7 = (SE)	Environmental regulations = X6 (ER)	Climate change awareness = and education: X5 (ICAE)	Energy efficiency = X4 (EE)	Investments in green infrastructure = X3 (IGI)	Renewable energy consumption = X2 (REC)	Energy governance = X1 (EG)	Climate resilience (CS) =Y

CS=f (EG.REC.IGI.EE.ICAE.ER.SE.AE.EC)

5. Results of the estimators of the descriptive analysis of the variables

Table 1 : Results of the estimators of the descriptive analysis of the variables

Variable	ER	IGI	SE	EC	EG	ICAE	EE	REC	CS	AE
Mean	0.394479	1.192577	1.468981	0.271176	0.925967	0.781019	3.128405	1.705393	9.161296	3.376612
Median	0.509329	1.306127	1.629455	0.673841	0.924584	0.000000	4.176258	2.010048	9.176469	4.265536
Maximum	0.940685	1.798651	1.856729	1.040234	1.041945	1.961229	4.517122	2.066751	9.438848	4.945806
Minimum	-.250635	-.308295	0.439450	-.589115	0.757647	0.000000	0.000000	-.553694	8.447313	0.000000
Standard Deviation	0.549282	0.563869	0.392892	1.050652	0.073757	0.911380	1.874181	0.720971	0.195215	1.853182
Skewness	-1.31394	-.145360	-.245988	-.406435	-.412885	0.320210	-.031232	-.314550	-.425890	-.223520
Kurtosis	4.410506	3.685654	3.351433	8.317743	2.893518	1.172383	2.196870	6.999336	7.010088	2.682034
Jarque-Bera Test	1.86001	1.623364	1.444596	1.58948	0.924312	1.000430	1.531703	1.89768	1.28460	1.118810
Probability	0.002658	0.022111	0.014665	0.000000	0.629924	0.082067	0.038164	0.000000	0.000000	0.017259
Total	12.62332	38.16245	47.00739	8.677619	29.63095	24.99262	100.1090	54.57256	293.1615	108.0516
Sum of Squared Deviations	9.353030	9.856407	4.785290	34.21994	0.168642	25.74903	108.8891	16.11377	1.181377	106.4628
Number of Observations	32	32	32	32	32	32	32	32	32	32

Source : Prepared by the researcher based on the results of the EViews 12 program

The arithmetic mean of Climate Resilience Y= (CS) in Iraq during the study period was 9.161296, and its highest value was recorded at 9.438848, and the lowest value was estimated at 8.447313. We notice small differences in the values, and we note from the value of the standard deviation Std.Dev that the value is somewhat high. As for the indicator variable (AE) and the indicator variable (EE), this indicates a lack of homogeneity of the variables to follow a normal distribution, as the significance value (probability) was greater than 0.05 for the value of the JarqueBera test.

6. Stability analysis of time series:

To study the stability of time series of variables, we use two tests: the Extended Dickey-Fuller (ADF) test and the Philippe-Perron PP test, with the addition of the logarithm for better stability of the model as follows:

Table 2 : Unit Root Test (PP)

***At the level**

Variable	CS	ER	IGI	SE	EC	EG	ICAE	EE	REC	AE
With constant										
t-statistic	-4.6791	-1.7098	-3.2816	-3.8843	-2.0343	-2.5364	-2.0636	-1.7046	-6.4871	-1.8802
Probability	0.0007	0.4166	0.0246	0.0058	0.2714	0.1170	0.2599	0.4191	0.0000	0.3368
Significance Level	***	n0	**	***	n0	n0	n0	n0	***	n0
With constant and trend										
t-statistic	-4.5087	-2.1518	-1.0809	-1.3107	-2.7871	-1.7029	-2.0982	-1.0541	-3.7655	-1.1575
Probability	0.0059	0.4983	0.9163	0.8664	0.2122	0.7258	0.5266	0.9209	0.0325	0.9019
Significance Level	***	n0	n0	n0	n0	n0	n0	n0	**	n0
Without constant or trend										
t-statistic	1.0270	-1.2566	-0.2254	0.6645	-1.9709	0.2006	-1.5086	-0.0300	-0.0629	0.0115
Probability	0.9161	0.1876	0.5969	0.8543	0.0480	0.7378	0.1210	0.6651	0.6540	0.6788
Significance Level	n0	n0	n0	n0	**	n0	n0	n0	n0	n0

Source : Prepared by the researcher based on the results of the EViews 12 program

***At the first difference**

Variable	d(CS)	d(ER)	d(IGI)	d(SE)	d(EC)	d(EG)	d(ICAE)	d(EE)	d(REC)	d(AE)
With constant										
t-statistic	-8.4747	-5.5862	-4.8562	-5.0141	-6.1090	-3.8420	-4.8633	-4.8458	-2.1779	-5.2216
Probability	0.0000	0.0001	0.0005	0.0003	0.0000	0.0066	0.0005	0.0005	0.0000	0.0002
Significance Level	***	***	***	***	***	***	***	***	***	***
With constant and trend										
t-statistic	-8.1786	-5.5648	-6.2444	-6.7649	-5.9697	-4.0592	-4.8910	-5.0567	-3.5287	-5.6592
Probability	0.0000	0.0005	0.0001	0.0000	0.0002	0.0173	0.0024	0.0016	0.0543	0.0004
Significance Level	***	***	***	***	***	**	***	***	*	***
Without constant or trend										
t-statistic	-8.5129	-5.6667	-4.7753	-4.8089	-6.0798	-3.9293	-4.9626	-4.7615	-1.8466	-5.1262
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0625	0.0000
Significance Level	***	***	***	***	***	***	***	***	*	***

Source : Prepared by the researcher based on the results of the EViews 12 program

***At the level**

Variable	With Constant (t-statistic)	Probability (p-value)	With Constant and Trend (t-statistic)
CS	-2.7970	0.0715	-2.7424
ER	-1.7098	0.4166	-2.0411
IGI	-3.1457	0.0334	-1.3565
SE	-3.5174	0.0142	-1.4878
EC	-2.0143	0.2795	-2.7035
EG	-2.8605	0.0621	-2.5747
ICAE	-1.9357	0.3124	-1.8254

EE	-1.7046	0.4191	-1.0541
REC	-6.4871	0.0000	-11.7956
AE	-1.8802	0.3368	-1.1571

Source : Prepared by the researcher based on the results of the EViews 12 program

Table 3 : Unit Root Test (ADF) in First Difference

Variable	With Constant (t-statistic)	Probability (p-value)	With Constant and Trend (t-statistic)
d(CS)	-8.1807	0.0000	-2.1477
d(ER)	-5.5531	0.0001	-5.4927
d(IGI)	-4.8630	0.0005	-6.1970
d(SE)	-5.0181	0.0003	-6.4242
d(EC)	-5.6815	0.0001	-5.5787
d(EG)	-3.8289	0.0068	-4.1025
d(ICAE)	-4.8950	0.0004	-4.9184
d(EE)	-4.8458	0.0005	-5.0844
d(REC)	-3.1796	0.0317	-3.0427
d(AE)	-5.2216	0.0002	-5.5841

Source : Prepared by the researcher based on the results of the EViews 12 program

is significant at the (1%) level (***) •

is significant at the (5%) level (**) •

is significant at the (10%) level (*) •

• (n0) is not significant

We adopt unit root tests for time series of variables in the model. The use of PP ADF (Philippe-Péron) tests and their results are shown in the table, where it is seen that the level (CS) of some series is stable, and others are only stable when the difference on them occurs at the first System: The option of applying the ARDL model to autoregressive distributed time intervals guides us, so this test It does not require integration of the variables studied to the same degree, and this is what distinguishes it. As Pesaran thinks, we can apply the limit test according to the ARDL methodology without considering the characteristics of the time series, whether these variables are stable in their first-order differences (I1), stable in their levels (0I) or a combination of both. These variables are not stable to quadratic differences; This is the only condition for applying this test.

7. Modeling of relationships

After analyzing the indicator variables used in the standard study and determining the degree of integration of the time series, which all settled at the first difference, the results of the estimation of the cointegration model according to the ARDL methodology will be presented below, where the model is estimated as follows:

CS=f (EG.REC.IGI.EE.ICAE.ER.SE.AE.EC)

7.1.Estimation of an unconstrained error model and selection of optimal lag periods for the model variables

Through the study, we attempted to modify the modified automatic deceleration periods resulting from the estimation of the ARDL-ECM error correction model using the ordinary least squares (OLS) method. The results are presented in the following table:

Table 4: Test of representative lag periods for the selected and estimated models

Model	Lags Used	Optimal Lags	(p,q1)
p_1	q_1	AIC	
Model	4	1	(1.1.1.1.1.1.1.1.1.)

Source : Prepared by the researcher based on the results of the EViews 12 program

After determining the time lags for all models, as shown in the table, which were chosen according to the AIC criterion, and to ensure the existence of a long-term relationship, we use the bounds test as well as the best-fit quality of the estimated model after subjecting it to diagnostic tests.

7.2.Limits testing

To detect the existence of a long-term relationship between variables, the bounded test must be used, comparing the F value calculated for the coefficients of the lagged independent variables with the value of the critical F statistic, according to the limits set by Pesaran. et al. The test is carried out on the basis of the null hypothesis, according to which there is no long-term equilibrium relationship between the variables.

7.3. Results of limit tests for models

Table 5: Results of limit tests for the models

Result	f. stat	K	10%	5%	2.5%	1%	Critical values	Model
Significance less than 1% means a .long-term relationship	7.440291	1	3.2	3.67	4.08	4.66	upper limits	**Model equation**

Source : Prepared by the researcher based on the results of the EViews 12 program

After determining the results of the bounds test for the models as shown in a table, the Fisher f-statistic value for the models was estimated to be 7.440291, which exceeds the upper limits of significance (1%) set by Peasaran, up to the (10%), which leads to rejecting the null hypothesis. The claim that there is no long-run relationship moves from the explanatory variables to the dependent variables and accepts the alternative hypothesis, which states that there is a long-run relationship. This can be done by choosing cointegration for the long-run equilibrium relationship for all models.

8. Results of model estimation

After ensuring the existence of a long-term equilibrium relationship between the variables of the model that we have included in this study, the results of cointegration and short-term relationship as well as the form of the long-term relationship are estimated below:

Through the results presented in the short-term ARDL estimation table, which appears in the upper part of the table, while the lower part shows the estimation of the long-term relationship through the estimated model, an interpretation of it in the long term and in the short term will be as follows:

8.1. Model estimation

ARDL Model Results for CS Variable Evolution

Data date: 03/12/24

Sampling range: 1993-2023

Number of comments after amendments: 31

Maximum number of dependent variable lags: 3 (automatic selection)

Model selection method: Acapic criterion (AIC)

Dynamic variables (lag 1, auto): EG REC IGI EE ICAE ER SE AE EC

Static variables: C

Number of models evaluated: 1536

(1 ,1 ,1 ,1 ,1 ,1 ,1 ,1 ,1 ,1) Selected form: ARDL

Note : The final sample of the equation is larger than the selection sample

Table 6: Model estimates:

Variable	Coefficient	Standard Error	t-statistic	p-value
CS (-1)	0.484005	0.178023	2.718785	0.0200
EG	-4.440120	0.720836	-6.159682	0.0001
EG (-1)	-1.828619	0.582456	-3.139498	0.0094
REC	2.881472	0.414739	6.947671	0.0000
REC (-1)	-2.450102	0.465604	-5.262205	0.0003
IGI	1.756945	0.382783	4.589929	0.0008
IGI (-1)	-2.151729	0.245015	-8.782030	0.0000
EE	-0.779311	0.112443	-6.930739	0.0000
EE (-1)	-0.292327	0.048650	-6.008771	0.0001
ICAE	-0.100154	0.047994	-2.086803	0.0610
ICAE (-1)	0.295559	0.028400	10.40702	0.0000
ER	-0.804715	0.181575	-4.431873	0.0010
ER (-1)	0.694475	0.104834	6.624526	0.0000
SE	0.020032	0.392760	0.051002	0.9602
SE (-1)	0.994199	0.268651	3.700706	0.0035
AE	-0.057352	0.019786	-2.898552	0.0145
AE (-1)	0.794507	0.100309	7.920568	0.0000
EC	0.716149	0.114602	6.249023	0.0001
EC (-1)	0.323752	0.063283	5.115957	0.0003
Constant (C)	9.093600	0.925086	9.830006	0.0000

Source : Prepared by the researcher based on the results of the EViews 12 program

The correlation square (R-square): indicates the degree of variance of the dependent variable climate resilience (CS) that can be explained by the independent variables of the model, since its value was 0.993601, which means that 99.36% of the variance of climate resilience is explained by these variables. The adjusted R-square, which takes into account the number of samples and the number of variables, was 0.982549, which indicates a strong and adjusted interpretation of the variance. As for the regression error (S.E. of regression), its value was 0.019522, which reflects the average error in the typical predictions of the model. Furthermore, the value of F-statistic was estimated to be 89.89918, with a probability value (Prob (F-statistic)) close to zero, indicating the presence of a strong statistical relationship and

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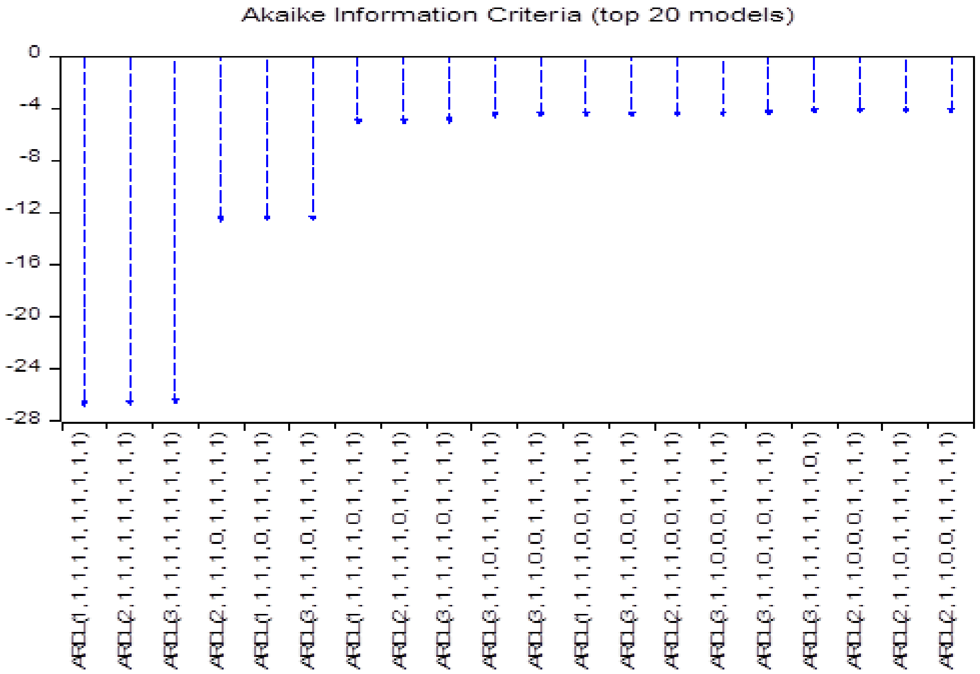
the null hypothesis was strongly rejected, indicating a strong association between the independent variables and the dependent variable in the model.

8.1.Top 20 models

The following figure also shows the appropriate model

Figure 2 : Akaike Information Benchmarks (Top 20 Models)



Source : Prepared by the researcher based on the results of the EViews 12 program

8.2. Model quality detection

In the framework of the estimation by the ordinary least squares method, which requires that the errors of the model follow a normal distribution, otherwise they are biased and that they are independent and have the least variance, it is assumed that the model estimated according to the ARDL methodology meets the assumptions of this method by performing a set of diagnostic tests, which are three test:

1-Normality test for the normal distribution of random errors

2- Test the lack of autocorrelation between the errors

3 - Homoscedasticity test

The results were as follows:

The table summarizes the results of detecting the estimated quality of the model

Table 7: Detection results of the estimated quality of the model

Tests	JB	BG LM	ARCH
Results of the study model tests	χ^2 = 0.578832 (0.748701)	F = 0.264929 (0.7702)	F = 1.759097 (0.1963)

Source : Prepared by the researcher based on the results of the EViews 12 program

After determining the quality results of the estimated models in the table, the following appears:

The Jarque-Berra statistic was greater than 0.05 for the entire study model, which means that the residuals follow a normal distribution.

The P-value statistic for the BG LM test indicates that the f-value statistic is greater than 0.05, and from there, we accept the null hypothesis: that there is no serial autocorrelation of the residuals for the model.

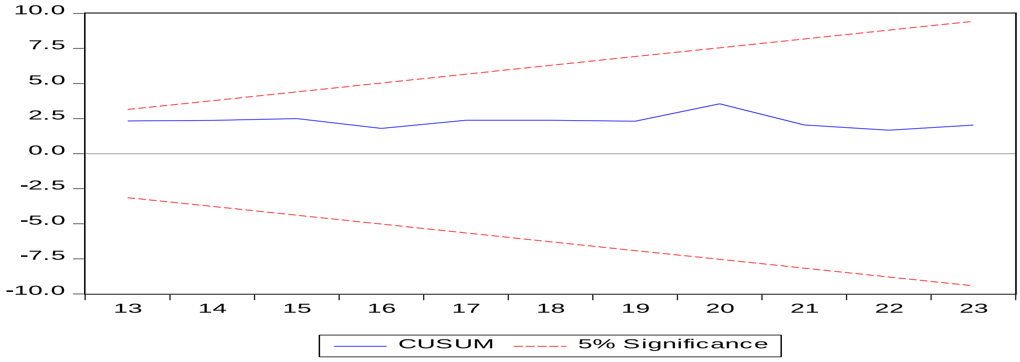
-The ARCH test shows that the probability value of the F-statistic is greater than the critical value at the 0.05 significance level, so we accept the null hypothesis, that is, that the variance is constant for the entire model.

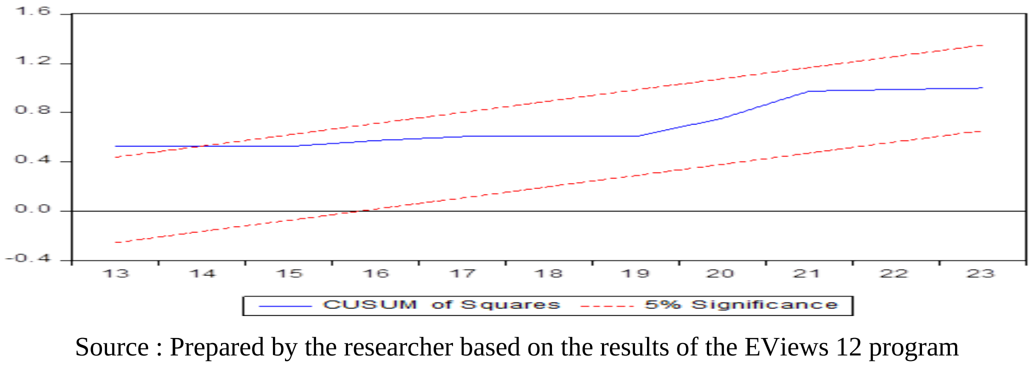
The results of the diagnostic tests show the quality of the model in standard terms, so the cointegration model will be estimated in both terms.

8.2.Testing the structural stability of the model coefficients

To ensure that the data used are free from any structural changes, Peearan conducted two tests to test the structural stability of the model coefficients in the short and long run. The first test represents the cumulative group selection of recursive residuals (CUSUM). , while the second test is the cumulative group test of squares of recursive residuals (CUSUM of squares), where the structural stability of the estimated coefficients of the ARDL model is obtained if the test plot for both the CUSUM of squares and the CUSUM. falls within the critical limits at the 5% significance level, so we reject the null hypothesis: the parameters are unstable and we accept the alternative hypothesis of their stability during the study period.

Figure 3 : The recursive cumulative group test for residuals and squared residuals for the model "





Source : Prepared by the researcher based on the results of the EViews 12 program

From the graphs presented above, we found that the cumulative set of recursive residuals (CUSUM of Squared) is located in the critical region of the model, which confirms the stability of the model at the significance level (5%). the cumulative set of squares of the recursive residuals (CUSUM of Squared), and from here, we can say that there is consistency and stability between the long-term results and the short-term results of the estimated model.

8.3.Test for autocorrelation between errors

In this test we will rely on the Darbin-Watson (DW) statistics, since we have from the estimation table the value of the statistic equal to (2.09), which means that it is in the region of no autocorrelation between the errors.

- ❖ **Jarque-Béra's essay**

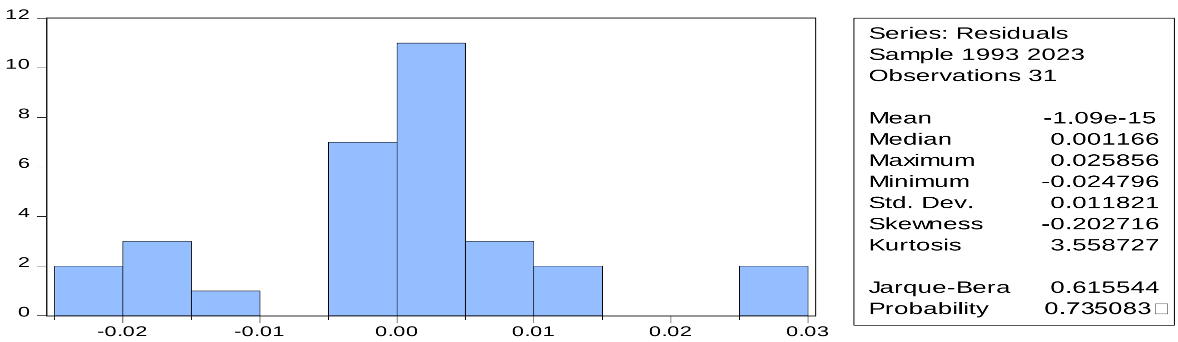
This test is based on the following two hypotheses:

H0: follows a normal distribution

H1: It does not follow a normal distribution

8.4. Testing the normal distribution of the estimated residuals

Figure 4: The normal distribution of the estimated residuals

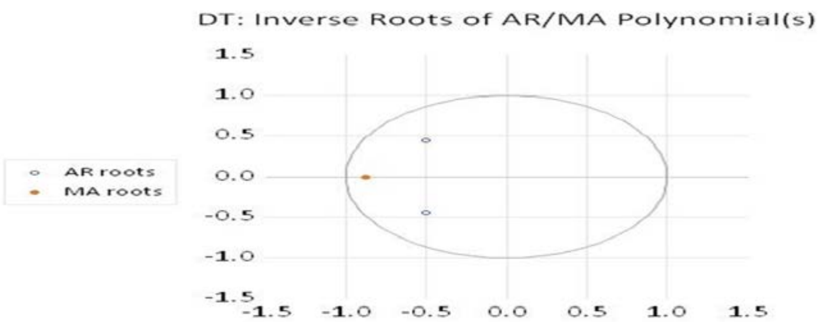


Source : Prepared by the researcher based on the results of the EViews 12 program

From the above figure, it is clear that the residuals follow a normal distribution, as the J-B statistic, which has a value of 0.615, is completely below the critical value of the distribution. $X_2^2(0.05)$، in addition to the fact that the corresponding probability is greater than 0.05, which amounts to rejecting the null hypothesis.

8.4. The polynomial root characteristic of the study model

Figure 5: The polynomial root



Source : Prepared by the researcher based on the results of the EViews 12 program

From the above figure, we notice that the root of the characteristic polynomial of the model lies inside the unary circle, which indicates the stability of the model process.

9. ARDL Long-Term Model and Bounds Tests

ARDL Model Results: Long-Term and Bounds Tests

Selected Model: ARDL (1, 1, 1, 1, 1, 1, 1, 1, 1, 1)

Status: Constrained Constant and No Trend

Table 8: Conditional Regression for Error Correction

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Constant (C)	9.093600	0.925086	9.830006	0.0000
(CS) (-1)*	-0.515995	0.178023	-2.898477	0.0000
(ER) (-1)	-0.110241	0.133850	-0.823614	0.0277
(IGI) (-1)	-0.394784	0.374609	-1.053856	0.0145
(SE) (-1)	1.014230	0.482160	2.103514	0.0092
(EC) (-1)	1.039901	0.167285	6.216328	0.0001
(EG) (-1)	-6.268739	1.255568	-4.992750	0.0004
(ICAE) (-1)	0.195406	0.042776	4.568075	0.0008
(EE) (-1)	-1.071639	0.157024	-6.824676	0.0000
(REC) (-1)	0.431370	0.194386	2.219142	0.0484
(AE) (-1)	0.737155	0.092323	7.984492	0.0000
D(ER)	-0.804715	0.181575	-4.431873	0.0010
D(IGI)	1.756945	0.382783	4.589929	0.0008
D(SE)	0.020032	0.392760	0.051002	0.9602
D(EC)	0.716149	0.114602	6.249023	0.0001
D(EG)	-4.440120	0.720836	-6.159682	0.0001
D(ICAE)	-0.100154	0.047994	-2.086803	0.0610
D(EE)	-0.779311	0.112443	-6.930739	0.0000
D(REC)	2.881472	0.414739	6.947671	0.0000
D(AE)	-0.057352	0.019786	-2.898552	0.0145

Source : Prepared by the researcher based on the results of the EViews 12 program

Note: The probability value is not compatible with the t-Bounds distribution.

Table 9: Level equation

Variable	Coefficient	Standard Error	t-Statistic	p-Value
(ER)	-0.213647	0.307140	-0.695602	0.0011
(IGI)	-0.765093	0.483741	-1.581618	0.0420
(SE)	1.965583	1.287582	1.526569	0.0051
(EC)	2.015333	0.958785	2.101965	0.0094
(EG)	-12.14885	6.316632	-1.923311	0.0007
(ICAE)	0.378697	0.096857	3.909863	0.0024
(EE)	-2.076841	0.967636	-2.146304	0.0050
(REC)	0.835998	0.183191	4.563541	0.0008
(AE)	1.428609	0.624051	2.289249	0.0428

Constant (C)	17.62344	4.532788	3.887992	0.0025

Source : Prepared by the researcher based on the results of the EViews 12 program

8.4. Level equation

EC=CS−(−0.2136·ER−0.7651·IGI+1.9656·SE+2.0153·EC−12.1488·EG+0.3787·ICAE−2.0768·EE+0.8360·REC+1.4286·AE+17.6234I)

= CS - (-0.2136 \cdot ER - 0.7651 \cdot IGI + 1.9656 \cdot SE + 2.0153 \cdot EC - 12.1488 \cdot EG + 0.3787 \cdot ICAE - 2.0768 \cdot EE + 0.8360 \cdot REC + 1.4286 \cdot AE + 17.6234) EC

(CS)t = (-0.2136*(ER)t -0.7651*(IGI)t + 1.9656*(SE)t + 2.0153*(EC)t -12.1488*(EG)t+ 0.3787*(ICAE)t -2.0768*(EE)t + 0.8360*(REC)t + 1.4286*(AE)t + 17.6234+ε_t)

It can be seen from the table above that the value of γ was negative (-0.515995) and significant with an estimated value of (0.0000), which is less than 0.05. This indicates that the long-term model corrects the errors of the short-term model within about two years.

9. Results

- **Analysis of the Long-Term Estimation Results**

The following is clear from the bottom of the table:

1- The Environmental Regulations (ER) variable had a negative impact on the dependent variable Climate Resilience (CS) in the long term and has a very acceptable significance at 0.11% (0.0011), which is less than (5%), as an increase of (1%) leads to a decrease in CS by 0.21%

2- The Green Infrastructure Investments (IGI) variable had a negative impact on the dependent variable Stakeholder Engagement (SE) in the long term and has an acceptable significance at 0.51% (0.0051), which is less than 10%, as it leads to an increase of (1%) to a decrease in renewable energy CS by (0.76%)

3- The Stakeholder Engagement (SE) variable had a positive impact on the dependent variable Climate Resilience (CS) in the long term and has a very acceptable significance at 0.15% (0.0051), or less than 5%, because it results in an increase of (1%) to an increase in CS renewable energies of (1.96%). 4- The variable Energy Cost (EC) had a positive impact on the dependent variable Climate Resilience (CS) in the long term and has a very acceptable significance at 0.94% (0.0094), or less than 5%, because an increase of (1%) leads to an increase in CS of (2.01%)

5- The variable Energy Governance (EG) had a negative impact on the dependent variable Climate Resilience (CS) in the long term and has a very acceptable significance at 0.07% (0.0007), or less than 1%, an increase (1%) leads to a decrease in CS of (12.14%)

6- The variable Climate Change Awareness and Education (ICAE) had a positive impact on the dependent variable Climate Resilience (CS) in the long term and has a very acceptable significance at 0.24% (0.0024), or less than 1%, because it leads to a increase (1%) to an increase in CS of (0.37%)

7- The variable Energy Efficiency (EE) had a negative impact on the dependent variable, Climate Change (CS) in the long term, and it has a very acceptable significance at 0.5% (0.0050), or less than 1%, because an increase (1%) leads to a decrease in CS (2.07%)

8- The variable Renewable Consumption (REC) has a positive impact on the variable Climate Resilience (CS) in the long term and has an acceptable significance at 0.08% (0.0008), or less than 1%, because an increase (1%) leads to an increase in CS of (0.83%)

9- The variable Access to Energy (AE) had a positive impact on the dependent variable Climate Resilience (CS) in the long term and has a very acceptable significance at 4.28% (0.0428), or less than 5%, because this leads to an increase of (1%) to an increase in CS of (1.42%)

Analysis of the results of the short-term estimations

As for the figures in the upper part of the table, it is clear that:

1- The variable Environmental Regulations (ER) had a negative impact on the dependent variable Climate Resilience (CS) in the short term and has a very acceptable significance at 2.77% (0.0277), or less than 5%, an increase (1%) leads to a decrease in CS (0.11%)

2- The variable Investments in Green Infrastructure (IGI) negatively affected the dependent variable Climate Resilience (CS) in the short term and has an acceptable significance at 1.45% (0.0145), or less than 10%, as it leads to an increase of (1%) To a decrease in CS of (0.39%)

3- The variable Stakeholder Engagement (SE) had a positive impact on the dependent variable Climate Resilience (CS) in the short term and has a very acceptable significance at 0.92% (0.0092), or less than 5%, as this leads to an increase of (1%) To an increase in CS of (1.01%)

4- The variable Energy Cost (EC) had a positive impact on the dependent variable Climate Resilience (CS) in the short term and has a very acceptable significance at 0.01% (0.0001), or less than 5%, as this leads to an increase of (1%)) to an increase in CS of (1.4%)

5- The variable Energy Governance (EG) had a negative impact on the dependent variable Climate Resilience (CS) in the short term and has a very acceptable significance at 0.04% (0.0004), or less than 1%, as an increase (1%) leads to a decrease in CS (6.26%)

6- The variable Climate Change Awareness and Education (ICAE) had a positive impact on the dependent variable Climate Resilience (CS) in the short term and has a very acceptable significance at 0.04% (0.0004), or less than 1%, as an increase (1%) leads to a decrease in CS (6.26%)

7- The variable Climate Change Awareness and Education (CACE) had a positive impact on the dependent variable Climate Resilience (CS) in the short term and has a very acceptable significance at 0.04% (0.0004), or less than 1%, as an increase (1%) leads to a decrease in CS (6.26%) acceptable at 0.08% (0.0008), or less than 1%, as this leads to an increase (1%) to an increase in CS of (0.19%)

7- The variable Energy Efficiency (EE) had a negative impact on the dependent variable Climate Resilience (CS) in the short term and has a very acceptable significance at 0.0% (0.0000), or less than 1%, where an increase of 1 (1%) leads to a decrease in CS (1.07%)

8- The variable Climate Resilience (REC) has a positive impact on the dependent variable Climate Resilience (CS) in the short term and has an acceptable significance at 0.48% (0.0484), or less than 5%, as it leads to an increase of (1%) to an increase in CS of (0.43%)

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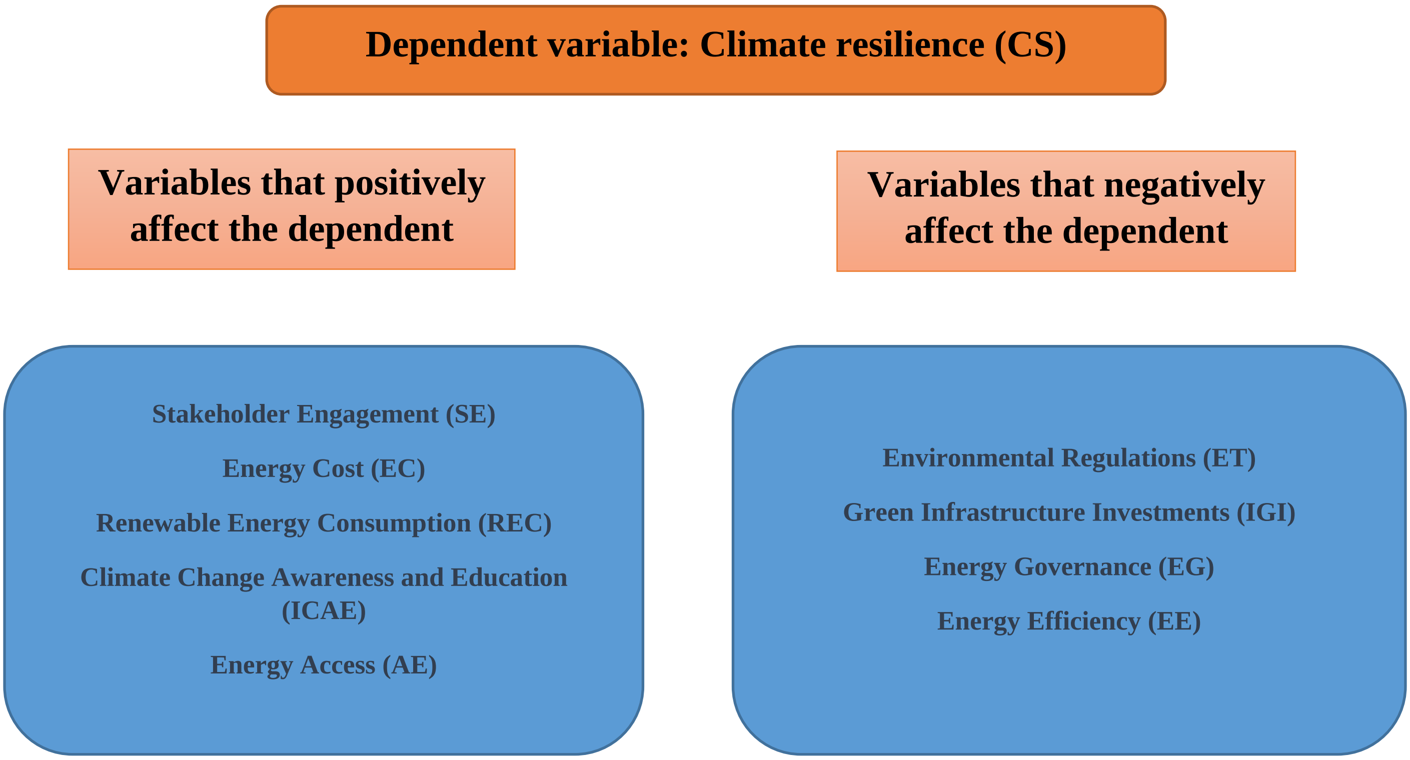
9- The variable Access to Energy (AE) had a positive impact on the dependent variable Climate Resilience (CS) in the short term and has a very acceptable significance at 0.00% (0.0000), which is less than 1%, as it leads from an increase of (1%) to an increase in CS of (0.73%).

Figure 6: Analysis of the results of the long and short term estimation in Tunisia



10. Recommendations based on the results of the analysis:

1. Reassessment of environmental regulations (ER):

Given the negative impact of environmental regulations on climate resilience (CS), it is recommended to review these laws to ensure that they support climate resilience rather than hinder it. A balance must be struck between protecting the environment and supporting climate resilience projects.

2. Strengthening green infrastructure investments (IGI):

Investments in green infrastructure have shown a negative impact, therefore there is a need to improve the management and planning of these investments. This will ensure that they effectively contribute to improving climate resilience, with a focus on innovation in the use of resources and sustainable construction technologies.

3. Strengthening stakeholder participation (SE):

The analysis shows that stakeholder participation plays a positive role in supporting climate resilience. It is therefore essential to broaden the participation of different stakeholders, such as local communities, governments and private companies, to strengthen collaboration and sustainable partnerships in the face of climate change.

4. Reducing the cost of energy (EC):

Given the positive impact of reducing the cost of energy on climate resilience, it is recommended to put in place policies aimed at reducing the costs of energy production and distribution, particularly renewable energy, in order to support sustainable projects and strengthen resilience to climate challenges.

5. Improving governance in the energy sector (EG):

There is a need to improve governance in the energy sector to ensure the effectiveness of decisions and strategies put in place to strengthen climate resilience. This includes improved transparency, increased accountability and strong legal mechanisms to encourage innovation in the energy sector.

6. Strengthening Climate Change Awareness and Education (ICAE):

Given the positive impact of climate change awareness and education, it is recommended to expand education and awareness programs targeting local communities and educational institutions. This would help foster a deeper understanding of climate change impacts and effective adaptation measures.

7. Improving Energy Efficiency (EE):

Although energy efficiency has shown a negative impact, it is advisable to develop technologies and programs that balance energy efficiency and climate resilience goals, with an emphasis on innovation in energy management to minimize negative climate impacts.

8. Promoting Renewable Energy Consumption (REC):

The positive impact of renewable energy consumption on climate resilience suggests the need to support renewable energy projects and expand their use in different sectors. It is also recommended to provide economic incentives to encourage investments in this area.

9. Increasing Access to Energy (EA):

Given the positive impact of increased access to energy on climate resilience, it is recommended to develop energy infrastructure to ensure equitable access to sustainable energy sources for all, thereby strengthening the capacity to cope with climate change and improve living conditions.

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