THE ROLE OF EDUCATION IN THE RELATIONSHIP BETWEEN RENEWABLE ENERGY AND ECONOMIC GROWTH IN CAMEROON.

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Abstract- **The objective of this study is to analyze the role played by education in the relationship between renewable energy consumption and economic growth in Cameroon. Using the ARDL method for the period 1990 to 2020, the results reveal that there is no significant long-term relationship, although it is positive, between renewable energy consumption and economic growth. However, in the short term, renewable energy consumption increases economic growth by 20%, with education playing a role. It would therefore be important to rehabilitate renewable energy platforms and ensure monitoring and evaluation. Additionally, Cameroon should invest more in education to strengthen the positive effect of renewable energy consumption on economic growth.**

***Keywords*: Renewable energy, education, economic growth, ARDL.**

1. INTRODUCTION

Five emerging perspectives in the literature regarding the relationship between renewable energy consumption and economic growth are: (1) the hypothesis of positive growth stimulated by renewable energy consumption, (2) the hypothesis of negative growth stimulated by renewable energy consumption, (3) the feedback effect, (4) the neutrality hypothesis, and (5) the non-linearity hypothesis. The mixed viewpoints in the theoretical and empirical literature on the relationship between renewable energy consumption and economic growth indicate that the subject is far from conclusive.

This study focuses on the hypothesis of non-linearity in the relationship between renewable energy consumption and economic growth, taking into account education as a mechanism for transmitting the effects of renewable energy consumption on economic growth. Furthermore, education is defined both theoretically and empirically as a key factor in economic growth.

Given the importance of renewable energy sources for Cameroon and the lack of consensus on the effects of renewable energy consumption on economic growth, the question arises: What is the effect of renewable energy consumption on economic growth in Cameroon? What role is played by education?

2. BRIEF LITERATURE REVIEW

Empirically, Marinas et al. (2019), using an ARDL model for the period 1990 to 2014, found no short-term relationship between renewable energy consumption and economic growth in Bulgaria and Romania. However, Kunofiwa and Tsaurai (2020) examined the role played by education in the relationship between renewable energy consumption and economic growth in the BRICS countries for the period 1994 to 2015.

3. METHODOLOGY

3. 1. Model and variables

i. The empirical model: Justification and model specification.

Many studies have explored the relationship between renewable energy and economic growth using three different types of data: time series, panel analyses, and country-level analyses. Given the dynamics of growth, the endogeneity relationship between the variables of interest (economic growth, energy, and education), and the differences in stationarity order among these variables, the ARDL model is the method to which the literature converges in light of these characteristics.

ii. Model specification to be estimated.

Given our research problem, the reference model that takes into account the variables of interest will be:

$$\mathrm{TXCROISS_t} = \beta_0 + \beta_1 \mathrm{LER_t} + \beta_2 \mathrm{LED_t} + \varepsilon_t \quad (4)$$

$With\ TXCROISS_t$ The growth rate of GDP at time t; LER_t the logarithm of renewable energy consumption at time t et LED_t the logarithm of education level at time t.

Then, this model (4) would be converted into an ARDL version in equation (5) below:

$$\Delta \mathrm{TXCROISS_t} = \beta_0 + \beta_1 \mathrm{LER_t} + \beta_2 \mathrm{LED_t} + \sum_{i=1}^{p} \theta_i \Delta \mathrm{TXCROISS_{t-i}} + \sum_{j=1}^{q} \gamma_j \Delta \mathrm{LER_{t-j}} + \sum_{l=1}^{r} \delta_i \Delta \mathrm{TXCROISS_{t-l}} + \omega_t \quad (5)$$

Where Δ represents the first difference, t is the time period-year, et ω_t are the error terms in the different models. The bounds test follows the joint F-statistic with its asymptotic distribution under the null hypothesis of no cointegration.

3.2. Data and Sources

The data for all these variables are sourced from the World Bank's World Development Indicators. They form a time series that covers the period 1990-2020 (30 years). The choice of this period is solely based on data availability, and all the data are in annual frequency.

- TXCROISS: represents the annual growth rate of GDP.
- LER: represents the logarithm of the share of renewable energy consumption in total energy consumption.
- LED: represents the logarithm of the secondary school enrollment rate.

3.3. Empirical Strategy

- Breakpoint test for time series

The interest of this breakpoint test lies in the selection of the appropriate stationarity test for the series.

- Stationarity test

In order to avoid potential limitations and shortcomings of a single testing method (Lin & Zhu, 2017), the analysis will employ the Fisher-ADF, Phillips-Perron (PP), and KPSS tests for series that exhibit stability over the period, and the Zivot and Andrews test for series that have experienced a structural break. The commonly accepted significance level is 5%.

- Optimal lag.

The model associated with the lag-augmented cointegration test is the following ARDL cointegration specification:

$$\Delta Y_t = \delta_1 Y_{t-1} + \delta_2 Y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \sum_{j=0}^{q-1} \beta_j \Delta X_{t-j} + \pi_0 + \pi_t + e_t \quad (6)$$

$$\Delta Y_t = \pi_0 + \pi_t + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \sum_{j=0}^{q-1} \beta_j \Delta X_{t-j} + \gamma \varepsilon_{t-1} + e_t \quad (7)$$

Where γ is the error correction term, adjustment coefficient, or error correction force. We conclude the existence of a cointegration relationship between X_t and Y_t, if and only if $0 \prec \hat{\gamma} \prec 1$ and reject $H_0 : \gamma = 0$.

There are two steps to follow in applying the Pesaran cointegration test, namely: determining the optimal lag order first (AIC, SIC), and then using the Fisher test to verify the assumptions:

$H_0 : \alpha_1 = \alpha_2 = 0$ existence of a cointegration relationship.

$H_1 : \alpha_1 \neq \alpha_2 \neq 0$ absence of a cointegration relationship.

4. STATISTICAL AND ECONOMETRIC RESULTS.

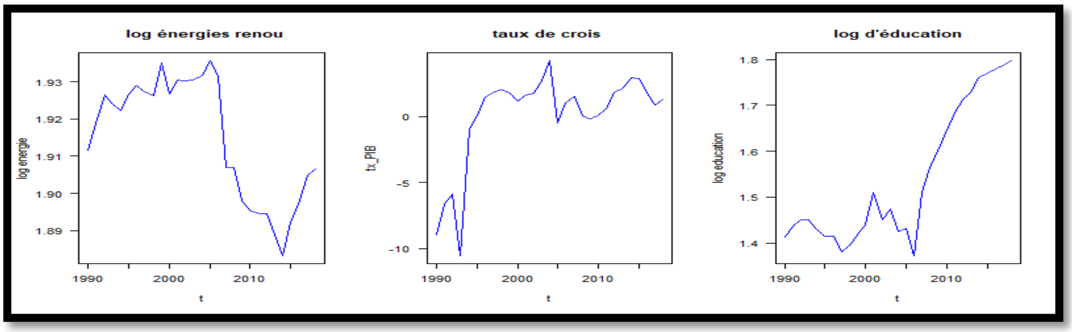
The analysis will involve conducting descriptive statistics, including graphical analysis of the variables and descriptive statistics. Then, the various pre-estimation tests of the ARDL model will be implemented, followed by presenting the econometric results from the post-estimation tests of the effects of renewable energy consumption on economic growth in Cameroon, taking into account the role played by the level of education.

4.1. Statistical results

4.1.1. Graphical analysis of the variables

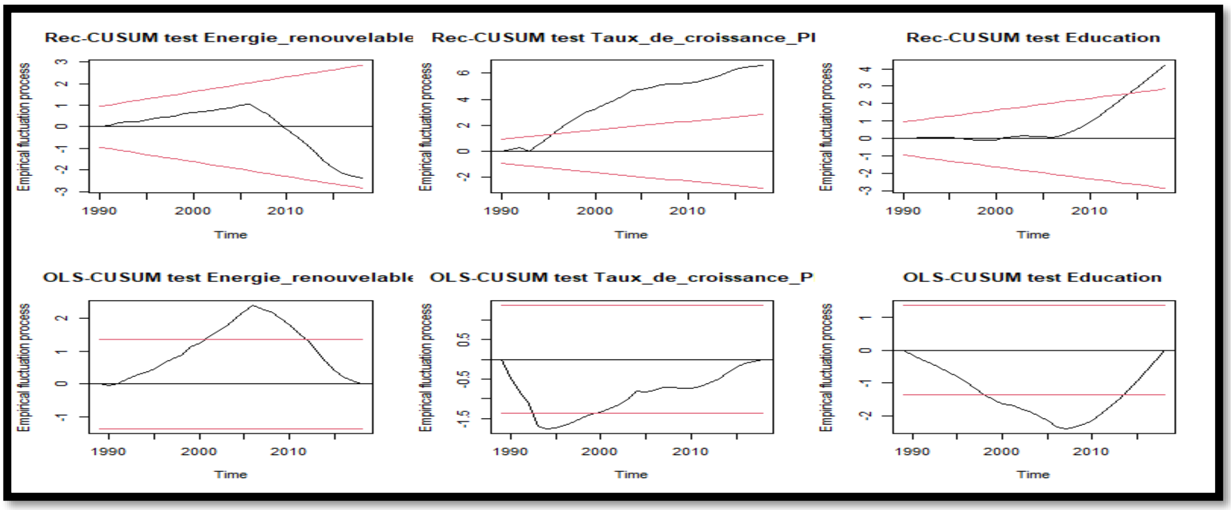
- Evolution of the series

Figure 1: Graphical representation of the time series.



- Study of the existence of breakpoints.

Figure 2: Breakpoint test of the time series.



4.1.2. Analysis of the structure of the variables

Table 1 below shows that the time series data consists of 29 observations.

Table 1: Descriptive statistics.

	TXCROISS	LED	LER
Mean	0,064	1,540	1,915
Median	1,275	1,451	1,922
Maximum	4,205	1,797	1,936
Minimum	-10,541	1,372	1,883
Standard deviation	3,532	0,148	0,016
Skewness	-1,851	0,640	- 0,419
Kurtosis	5,476	1,779	1,690
Jarque-Bera	23,978	3,779	2,921
Probability	0,000	0,151	0,232
Observations	29	29	29

4.2. Empirical results of the effects of energy consumption on economic growth.

4.2.1. Preliminary tests on the series

- Study of the stationarity of the time series

The analysis of the existence of a breakpoint in the series revealed the presence of a breakpoint in the GDP growth rate series. The appropriate stationarity test is the Zivot and Andrews test. The test results show that with a 5% risk of error, the series TXCROISS over the period 1990-2018 is stationary. Indeed, the test statistic is strictly greater than the critical value (-7,61 < -4,8), which leads to rejecting the hypothesis of a unit root (see Appendix 1).

Furthermore, the series of renewable energy consumption and education level did not experience any significant breakpoint during the period. Therefore, the ADF test and the Phillips-Perron (PP) and KPSS tests were used to confirm the stationarity of each series at a significance level of 5%. The following table presents the results:

Table 2: Stationarity tests for the series.

time series	ADF TEST	PP Test	KPSS Tet		Conclusion at a significance level of 5%.
	P-value	**P-value**	**Val. Obs**	**Point crit.**	
LER	0,32	0,48	0,65	0,463	Not stationary
D(LER)	0,00	0,01	0,18	0,463	Stationary
LED	0,10	0,54	0,89	0,463	Not stationary
D(LED)	0	0,01	0,40	0,463	Stationary

Note: Val. Obs. is the observed value or the critical value from McKinnon. Point crit refers to the critical value.

The analysis of the above table 2 reveals at a 5% significance level that only the first-order differenced series are stationary. In other words, the LER and LED series are integrated of order 1, while the TXCROISS series is stationary at the level. Therefore, it will be interesting to first analyze the long-term relationship between the variables.

- Long-term relationship analysis: Pesaran et al.'s cointegration test

According to the AIC criterion based on Figure 3 (in the appendix), the specified model is an ARDL (5, 5, 4) as it is the most optimal among the other 19 models, minimizing the AIC. Therefore, this is the model that yields statistically significant results.

4.2.2. Estimation of the ARDL model for the relationship between economic growth, energy, and education

Given that the most optimal model is the ARDL (5, 5, 4), the estimation of this model is presented in the following table:

Table 3: Résultats d'estimation des coefficients du modèle ARDL

Dep. Var. : TXCROISS	Coefficient	Std. Error	t-value	Prob.*
TXCROISS(-1)	0,468	0,215	2,182	0,065
TXCROISS(-2)	0,324	0,125	2,597	0,036
TXCROISS(-3)	-0,017	0,106	-0,157	0,88
TXCROISS(-4)	-0,281	0,129	-2,169	0,067
TXCROISS(-5)	0,118	0,128	0,922	0,387
LER	0,954	0,808	-1,622	0,015
LER(-1)	0,21	0,526	1,247	0,253
LER(-2)	0,132	0,316	-1,072	0,32
LER(-3)	0,974	0,7	2,416	0,046
LER(-4)	0,601	0,191	-2,271	0,057
LER(-5)	0,863	0,354	-2,366	0,05
LED	0,243	0,893	0,95	0,374
LED(-1)	-0,757	0,57	-2,313	0,054
LED(-2)	0,322	0,37	1,102	0,307
LED(-3)	0,405	0,25	2,974	0,021
LED(-4)	-0,172	0,765	-4,289	0,004
C	1,486	0,858	0,777	0,463
Observations	29			
R2	0,819832			
F-statistic	1,99079			
Prob (F-statistic)	0,00544			

❖ Diagnostic tests of the model

- Residual White Noise Test

Based on the results from Table 4 (see appendix), the order of autocorrelation is determined by the number of terms that fall outside the corridor.

- Test of error autocorrelation

The results of this test are as follows:

Table 4 : Test d'absence d'autocorrélation des erreurs (Breusch-Godfrey)

F-statistic	8,531741	Prob. F(5,2)	0,1082
Obs*R2	22,92518	Prob. Chi-Square(5)	0,0603

The table 4 above shows that the test probability is greater than 5% (critical threshold), indicating that the residuals are not autocorrelated.

- Heteroscedasticity test

To check whether the residuals are heteroscedastic or homoscedastic, we can use the ARCH test.

Table 5: Heteroscedasticity test (ARCH) of the residuals

F-statistic	0.766831	Prob. F(5,13)	0.5898
Obs*R2	4.327449	Prob. Chi-Square(5)	0.5033

According to the table above, the residuals are not heteroscedastic because the probability of the F-statistic is greater than 5%. Therefore, the variance of the residuals in the estimated model is constant.

- Test of Normality of Residuals

The application of this test provided us with the results shown in Figure 4 (see appendix). These results confirm that the residuals are normally distributed, as the Jarque-Bera probability is higher than 5%.

- Model stability test

Overall, the results of the various diagnostic tests have confirmed the validity of the estimated ARDL (5,5,4) model.

- Cointegration Bounds Test

By analyzing the table below, the existence of a cointegration relationship allows for estimating the long-term effects between renewable energy consumption and economic growth when education is included, but it does not imply a long-term relationship between these variables.

Table 6 : Results of Pesaran et al. (2001) cointegration test are as follows:

F-limit test		Null hypothesis: No long-term relationship		
Test statistic	Value	Level of significance	I(0)	I(1)
F-statistic	10.98920	10%	2,63	3,35

k	2	5%	3,1	3,87
		2,5%	3,55	4,38
		1%	4,13	5
Actual sample size (n) = 29				

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- Short-term dynamics, adjustment coefficient, and long-term coefficients

Table 8 below shows that the adjustment coefficient or error correction term **(CointEq(-1))** is statistically significant. It is negative, between zero and one in absolute value, and significantly different from zero at the 5% level. This confirms the presence of an error correction mechanism. The error correction model is therefore validated. This implies that 65% of the imbalance between the desired and actual level of GDP growth per capita in Cameroon can be adjusted, indicating a good speed of adjustment in the relationship process following a shock in the previous year. In the short term, an increase in the lagged difference of renewable energy consumption is associated with a 20% increase in economic growth.

Table 7: Short-term dynamics and adjustment coefficient

Variable : TXCROISS	**Coefficient**	**std. error**	**t_statistic**	**Prob.**
D(TXCROISS(-1))	-0,008	0,09	-0,086	0,933
D(TXCROISS(-2))	0,261	0,085	3,07	0,012
D(TXCROISS(-3))	0,238	0,082	2,896	0,016
D(LER)	0,818	0,757	-0,943	0,368
D(LER(-1))	0,485	0,526	0,168	0,87
D(LER(-2))	0,232	0,581	-0,773	0,457
D(LER(-3))	**0,198**	**0,666**	**3,414**	**0,007**
D(LED)	0,689	0,278	1,744	0,112
D(LED(-1))	-0,804	0,831	-1,289	0,227
D(LED(-2))	0,958	0,858	0,14	0,892
D(LED(-3))	0,295	0,147	5,107	0,001
CointEq(-1)*	-0,645	0,085	-7,559	0

Furthermore, the estimated effect of the third difference in education on economic growth is statistically significant. This results in a 30% increase in economic growth if the level of education increases by 1%. The above evidence of the positive effect of energy consumption on short-term economic growth is supported by Fondja (2013), Dhungel (2017), and Parajuli (2020).

Table 8: Coefficient of the long-term relationship

Variable	Coefficient	std. error	t_statistic	Prob.
LER	0,18459	0,3056	0,32351	0,753
LED	0,258527	0,14735	0,215122	0,834
C	-3,30738	2,8671	-0,312168	0,7613

CONCLUSION

The objective of this study was to analyze the effects of renewable energy consumption on economic growth in Cameroon, with a particular focus on the role of education. The estimation results reveal that in the short term, an increase in the lagged difference of renewable energy consumption is associated with a 20% increase in economic growth. Although there is no significant long-term relationship, the relationship remains positive. Similar results are observed for the relationship between education and economic growth, where a 1% increase in the third difference of education level leads to a 30% increase in economic growth. However, the effect diminishes in the long run. These key findings are robust and supported by the post-estimation tests, which ensure the interpretation of the coefficients. In order to ensure the positive effect of renewable energy consumption on economic growth, the government should facilitate the transfer of new energy technologies, improve the capacity of the standards department in the field of renewable energy, monitor the quality of imported equipment, enhance the training of trainers, provide funding for research and laboratory equipment in universities and colleges, and define the level of collaboration between the public standards service and the Energy Research Laboratory (LRE).

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Appendix

Appendix 1: Stationarity Test of the Growth Rate (TXCROISS)

summary(ur.za(Taux_de_croissance_PIB))

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################################
# Zivot-Andrews Unit Root Test #
################################

Test statistic: -7.6116
Critical values: 0.01= -5.34 0.05= -4.8 0.1= -4.58

Potential break point at position: 4
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Table 9: White Noise Test of the Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.033	0.033	0.0299	0.863
		2	-0.353	-0.354	3.6861	0.158
		3	0.072	0.114	3.8463	0.279
		4	-0.089	-0.262	4.1032	0.392
		5	-0.050	0.062	4.1861	0.523
		6	-0.027	-0.214	4.2125	0.648
		7	-0.292	-0.302	7.3994	0.389
		8	0.060	0.002	7.5442	0.479
		9	0.179	-0.119	8.8896	0.448
		10	-0.203	-0.233	10.742	0.378
		11	-0.073	-0.210	11.000	0.443
		12	0.204	-0.032	13.167	0.357

*Probabilities may not be valid for this equation specification.

Figure 3: Graphical AIC value

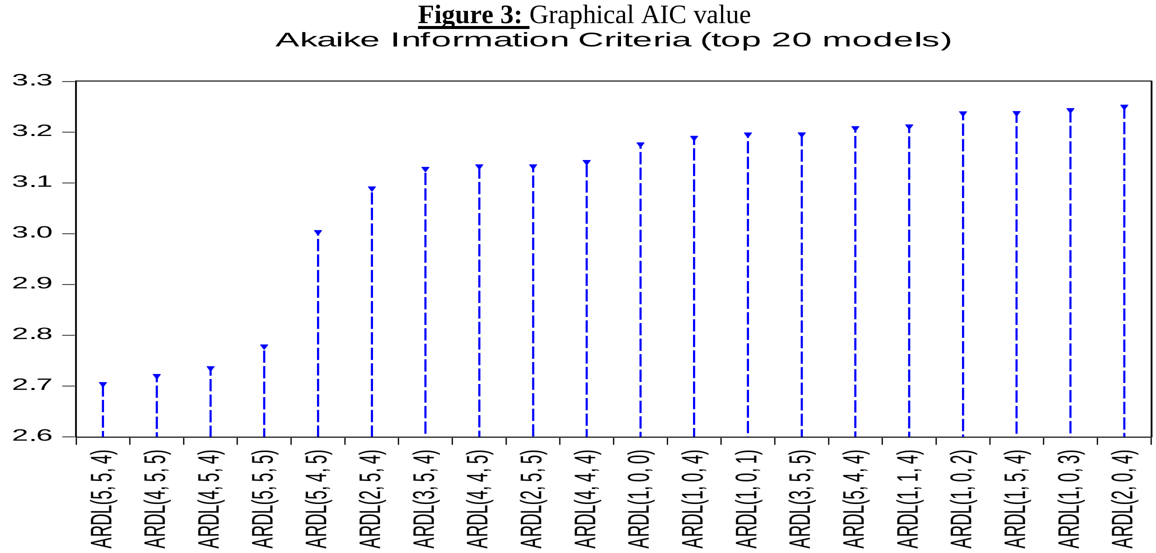


Figure 4: Histogram of the residuals distribution

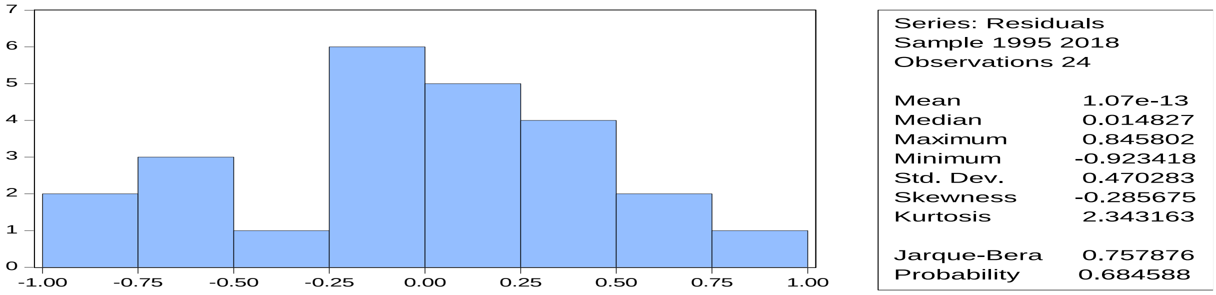
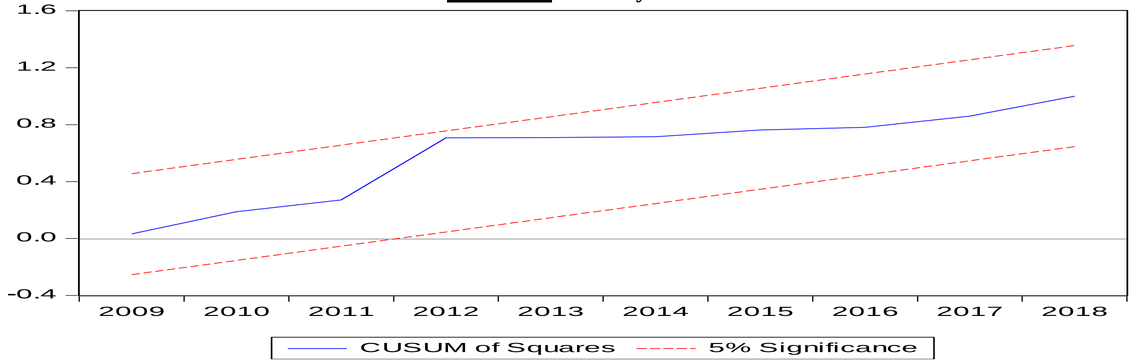


Figure 5: Stability test



Appendix 2: Model stability test