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"Atmospheric Pollution and Economic Growth in Cameroon"

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Abstract

This paper investigates the effects of economic growth, electricity consumption and urbanization on CO_2 emissions in Cameroon applying the newly developed ARDL to time series data from 1971 to 2011. In addition, we used a Vector Error Correction Model (VECM) in order to examine the long and short runs causality between CO_2 emissions and others variables. The results obtained suggest that CO_2 emissions are positively related to economic growth, electricity consumption and urbanization. Besides, the results suggest that there exist two forms of long run unidirectional causality when CO_2 emissions and electricity consumption are dependent variables. We also found that in the short run, there is bidirectional causality between CO_2 emissions and electricity consumption. Although Cameroon is not a major contributor to global carbon emissions, it should participate in the global effort of mitigation.

Keywords: CO_2 emissions, Economic growth, electricity consumption, urbanization, ARDL, VECM

JEL Codes: H5, H6

1. Introduction

Since some decades, environmental degradation is considered as a serious problem for the national and international communities, and therefore, it's on top of the economic policy agenda of both developed and developing countries.

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Many factors are responsible for this degradation. Meadows and al (1972)[4] warned against the environmental consequences of industrialisation, urbanisation and the overconsumption of environmental goods. According to them, the adverse consequences of these activities would lead to an ecological disaster.

The United Nation's Development Programme (UNDP) attributes these degradations to technological change that allowed humans to exploit natural resources that were not always renewable or whose renewal rates were lower than their exploitation rates (UNDP, 2009). According to World Trade Organisation (WTO), the high demographic growth and the increase in world consumption have exacerbated environmental degradation (WTO, 1998).

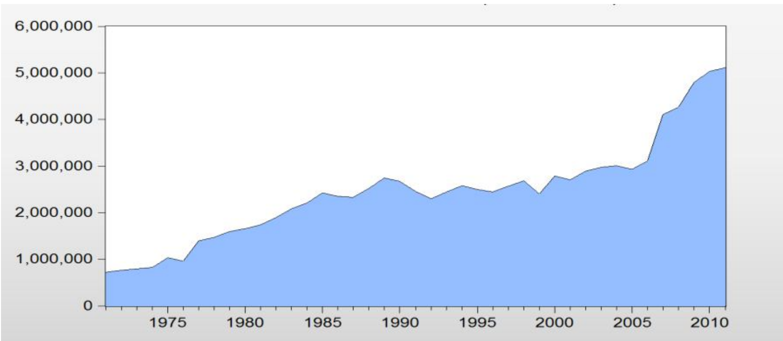
These actions have increased environmental damages, notably global warming, due to the emission of Greenhouse Gases (GHG), especially CO_2. In fact, Stern (2007) estimated that CO_2 emissions increased from 280 parts per million (ppm)[5] before the industrial revolution to 430 ppm nowadays and will reach the critical level of 550 ppm by 2100, with the consequences of increasing temperatures by 2 to 3°C, increasing the sea level, loss of aquatic biodiversity, acid rains leading to agricultural loss and large scale famine.

However, environmental problems are not the same everywhere and thus can require country specific solutions. In Cameroon, the main GHGs that cause climate warming are: CO_2 which represents about 54% of total emissions in 1994, Methane (CH_4) with 24.36%, Nitrous (N_2O) oxide with 18.05%, meanwhile carbon monoxide (CO) represents only 3.3%. Other GHG considered by the study, notably Nitrogen Protoxides (NO_x) and non-methane volatile organic compounds (NMVOC) are responsible only for less than 1% of GHG emissions in Cameroon (MINEP, 2005). It is therefore quickly noticed that CO_2 is the main GHG emitted in Cameroon.

[4]This report entitled, "The Limit of Growth", predicted that our economic society would collapse during the first halve of the 21st century if nothing was done to correct the causes of our future predicament that is, demographic growth, energy growth and technological growth (Meadows et al., 1972).

[5]Parts per million (ppm) is a unit of measure often used by scientists to indicate the number of GHG molecules per molecule of dry air. This indicator is used to express pollution concentrations.

Graph 1: Evolution of CO_2 Emissions in Cameroon (Millions of Tonnes)



Source: Authors' computation from annual data of IEA.

Graph 1 presents global trend of CO_2 emissions in Cameroon from 1971 to 2011. It is observed that CO_2 emissions have permanently increased since 1971, passing from 0.7 million tonnes in 1971 to 5.1 million tonnes in 2011. MINEP (2005) attributes these emissions to energy use, industrial development and land use. However, the International Energy Agency (IEA) attributes CO_2 emissions in Cameroon to fossil fuel consumption, electricity production and other industry energy own use (IEA, 2013).

The economic performances of Cameroon have been unstable over the period from 1986 to 1994. However, since the devaluation in 1994, the national economy has found positive economic growth path, with a positive annual growth rate of Gross Domestic Product (GDP) estimated to 3.4% per year from 1994 to 2011 (Computed from World Development Indicators 2012). As other developing countries, Cameroon faces many challenges. The underemployment rate is around 75.8%, and the Human Development Index is very low[6]. These difficulties are coupled to demographic dynamics. The United Nations (UN) estimated the total population of Cameroon at 22.2 millions inhabitant, and following annual growth rate of 2.6%, it will reach 48.6 millions in 2050 (UN, 2012). Population growth is accompanied with sudden urbanization, 53% of the total population lives in cities in 2013, and the ratio was estimated at 39% in 1990. The overgrowing population and the necessity to maintain economic growth therefore require investing in key sectors as energy.

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[6] UNDP (2011) establishes the HDI of Cameroon to 0.482 placing it at the 150th position out of 187 countries.

The paper is organized as follows: section 2 presents a literature review, section 3 presents the empirical strategy used in this research, while section 4 discusses the empirical results and presents some recommendations. The last section concludes the paper.

2. Literature Review

In 1955, the American economist Simon Kuznets found an inverted U shape relationship between per capita income and social inequalities, translating the fact that in the short run, the low level of incomes widens inequalities which evolve and reduce as per capita income increases. During the early 90s, this concept was transposed to the debate on growth and environmental quality. Instead of viewing economic growth as a threat to the environment and proposing to stop it, the EKC hypothesis supposes a sort of compatibility between the protection of the environment and future economic growth.

The first strand of studies aimed at verifying the EKC hypothesis. First papers to test the validity of EKC are those of Grossman and Krueger (1991) on the environmental impacts of NAFTA, Shafik and Bandyopadhyay (1992) in the 1992 world development report of the World Bank and that of Panayotou (1993) of the International Labour Organisation (ILO). These authors use different indicators of environmental degradation (CO_2, SO_2, NO_x, CO, municipal wastes, suspended particles, etc.) and obtain an inverted U curve for most of the pollutants with turning points between 3000$ and 5000$ per capita.

Grossman and Krueger (1995), Holtz-Eakin and Selden (1995), Cole and al. (1997), Hooi and Smyth (2009), Saboori and Souleymani (2011) have tested the ECK for different regions and for different indicators. However, their results were mixed. See Dinda (2004) and Nourry (2007) for a comprehensive and critical survey of studies that tested the EKC hypothesis. The principal shortcomings of studies based on the ECK are that they implicitly suppose a unidirectional causality running from economic growth to environmental degradation.

The other strand of literature is devoted to the causal relations among economic growth and energy consumption.

Payne (2010), Ozturk (2010); and Mohd and al. (2012) have summarized different types of economic growth-energy relationship based on the literature, and each of these possibilities has important implications for energy policy (Akpan, 2011). These relations are listed as follows:

- Bidirectional causality between economic growth and energy consumption (feedback hypothesis): according to this hypothesis, any restriction (increase) in economic growth (energy use) will lead to a reduction in energy use (economic growth).
- Unidirectional causality running from economic growth to energy consumption (conservation hypothesis). A positive sign indicates that the increase in economic growth will result to increase in energy use. This result implies that energy conservation policies could be carried out with little or no adverse effect on economic growth.
- Unidirectional causality running from energy consumption to economic growth (growth hypothesis). Growth hypothesis indicates that any restrictions (increase) on energy use may adversely (positively) affect economic growth. Any conservation policy will cause reductions in economic growth.
- No causal relationship between economic growth and energy use (neutrality hypothesis). This hypothesis implies that energy use and economic growth are not correlated. Thus, policies aimed at expanding or conserving energy network would not affect economic growth.

However, other authors examine the causality between economic growth and carbon emissions, including additional variables as energy consumption. The hypothesis is that environmental performance and energy consumption may be jointly determined. Given that economic growth is closely related to energy consumption, high economic growth rates require more energy consumption. This further, may lead to more pollution.

Halicioglu (2009) examine the causality between CO_2 emissions, Energy consumption, income and foreign trade in Turkey. The study supports a bi-directional Granger causality between CO2 emissions and growth and CO2 emissions and energy consumption. Odhiambo (2011) found a unidirectional causality running from economic growth to CO_2 emissions in South Africa. More, he found that energy consumption granger causes both carbon emissions and economic growth.

Akpan and al (2012) applies a multivariate vector error Model (VECM) to examine the interrelations between electricity consumption, economic growth and economic growth in Nigeria and found a unidirectional causality running from economic growth to carbon emissions, and no causal relation between electricity consumption and economic growth.

Furthermore, other studies examine the relationship between carbon emissions and demographic factors such as population density, urbanization. Shi (2003) and Cole and Neumayer (2004) found a positive link between CO_2 emissions and a set of other explanatory variables including population, urbanization rate and energy intensity. Dhakal (2009) indicates that around 40 percent contribution in CO_2 emissions is due to an 18 percent increase in population.

Halicioglu (2009) for Turkey and Shahbaz and al. (2010) for Portugal investigate the relationship between CO_2 emissions, energy consumption, economic growth and trade openness for Pakistan. Their results support the EKC hypothesis. Furthermore, they find a one-way causal relationship running from income to CO2 emissions. Energy consumption increases CO_2 emissions both in the short and long run, whereas, trade openness tends to reduce CO_2 emissions in the long run.

According to Intergovernmental Panel on Climate Change, Less Developed Countries are most vulnerable to effect of climate change. Although they are listed neither in the Appendix A, nor in the Appendix B of the Kyoto Protocol control of CO_2 emissions, it reveals interesting to investigate the relationship between macro-socioeconomics and environmental variables in these countries in order to propose appropriate sustainable policies. This study fits into the economic literature and aims at examining the relationship between CO_2 emissions, economic growth, electricity consumption (used as a proxy of energy use) and urbanization in Cameroon.

3. Methodology

3.1. Empirical Model and Description of Data

The proposed model is specified as follows:

$$CO = f(gdpc, elec, urb) \quad (1)$$

Where CO stands for carbon emissions per capita, gdpc is Gross Domestic Product per capita and captures economic growth, elec stands for electricity consumption per capita and urb is the ratio of urban population to the total population.

The previous equation can be rewritten in its log-linear form as follows:

$$lnCO_t = \alpha_0 + \alpha_1 ln\, gdpc_t + \alpha_2 lnelec_t + \alpha_3 lnurb_t + \varepsilon_t \quad (2)$$

Where ε_t is the residual or the error term and α_0 is the constant term. According to a variety of studies, the expected sign of each parameter has been formulated. Thus, α_1, α_2 and α_3 are expected to be positive. This will allow us to estimate elasticities between such variables and carbon footprint in Cameroun.

3.2. Cointegration Test

There exist different tests for cointegration in the economic literature. Some include Engle and Granger (1987), Johansen test (1988), Johansen and Juselius test (1990) and recently the Auto Regressive Distributed Lags (ARDL) approach to cointegration developed by Peseran and al. (1999; 2001). This study adopts the ARDL in order to fill the shortcomings of the other techniques.

In fact, the ARDL is more flexible and could be implemented when all the series I (0), I (1) or I (1) and I (0)[7], contrary to Engle and Granger (1987), Johansen test (1988) which requires that all the variables should be integrated at the same order. Also, this method is more efficient for studies with a low sample size. Finally, it takes into account the problem of the endogeneity of variables and remains applicable when some variables of the model are endogenous.

[7] However, the main limitation of this method is that it cannot be applied when the order of integration is greater than 1 (Ouattara, 2004).

Basically, ARDL cointegration test is based on the following unrestricted error correction models:

$$\Delta lnco_t = \pi_0 + \pi_1 lnco_{t-1} + \pi_2 lngdpc_{t-1} + \pi_3 lnelec_{t-1} + \pi_4 lnurb_{t-1} + \sum_{i=1}^{a} \pi_{5i} \Delta lnco_{t-i} + \sum_{i=0}^{b} \pi_{6i} \Delta lngdpc_{t-i} + \sum_{i=0}^{c} \pi_{7i} \Delta lnelec_{t-1} + \sum_{i=0}^{d} \pi_{8i} \Delta lnurb_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta lngdpc_t = \alpha_0 + \alpha_1 lngdpc_{t-1} + \alpha_2 lnco_{t-1} + \alpha_3 lnelec_{t-1} + \alpha_4 lnurb_{t-1} + \sum_{i=1}^{a} \alpha_{5i} \Delta lngdpc_{t-i} + \sum_{i=0}^{b} \alpha_{6i} \Delta lnco_{t-i} + \sum_{i=0}^{c} \alpha_{7i} \Delta lnelec_{t-1} + \sum_{i=0}^{d} \alpha_{8i} \Delta lnurb_{t-i} + \varepsilon_t \quad (4)$$

$$\Delta lnelec_t = \beta_0 + \beta_1 lnelec_{t-1} + \beta_2 lngdpc_{t-1} + \beta_3 lnco_{t-1} + \beta_4 lnurb_{t-1} + \sum_{i=1}^{a} \beta_{5i} \Delta lnelec_{t-i} + \sum_{i=0}^{b} \beta_{6i} \Delta lngdpc_{t-i} + \sum_{i=0}^{c} \beta_{7i} \Delta lnco_{t-1} + \sum_{i=0}^{d} \beta_{8i} \Delta lnurb_{t-i} + \varepsilon_t \quad (5)$$

$$\Delta lnurb_t = \sigma_0 + \sigma_1 lnurb_{t-1} + \sigma_2 lngdpc_{t-1} + \sigma_3 lnelec_{t-1} + \sigma_4 lnco_{t-1} + \sum_{i=1}^{a} \sigma_{5i} \Delta lnurb_{t-i} + \sum_{i=0}^{b} \sigma_{6i} \Delta lngdpc_{t-i} + \sum_{i=0}^{c} \sigma_{7i} \Delta lnelec_{t-1} + \sum_{i=0}^{d} \sigma_{8i} \Delta lnco_{t-i} + \varepsilon_t \quad (6)$$

Where π_0 α_0 β_0 σ_0 are the drift terms for each equation, Δ is the first difference operator, $\sum$ is the summation sign. Variables in the level form terms capture the long run effect while those in first difference capture the short run effects.

The cointegration test is carried out in two steps: the first consists of determining the optimal ARDL using Akaike and Schwarz criteria by estimating equations 3 to 6 through the Ordinary Least Squares (OLS) technique.

The second step consists of testing for co integration based on the following hypothesis[8]:

$$\begin{cases} H_0 : \pi_1 = \pi_2 = \pi_3 = \pi_4 = 0 \quad \text{against} \\ H_1 : \pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq 0 \end{cases}$$

Cointegration hypothesis is accepted or rejected by comparing the calculated F-statistic or Wald statistic to the upper and lower critical values proposed by Pesaran et al (1999, 2001).

8 This hypothesis remain appropriate for equations 4, 5 and 6.

The lower bound or critical value assumes that all the variables of the model are I (0) while the upper critical bounds assume that all the variables of the model are I (1). We should respect one of the following decision rules:

- Reject if the calculated F-statistics is lower than the lower bound;
- The test is inconclusive if the calculated F-statistics lies between the critical values of Pesaran;
- Accept the cointegration hypothesis if the calculated F-statistic is greater than the upper bound.

If the cointegration hypothesis is accepted, then the following Error Correction Model (ECM) which captures short term variations can be estimated:

Where *ect* is the error correction term and η its coefficient. The error correction term indicates the adjustment speed between the long and the short run, and should be negative and significant in order to confirm cointegration between the variables.

3.3. Granger Causality Test

Following Odhiambo (2008, 2011) and Akapan and al (2012), we adopt the Vector Error Correction Model (ECM) of each equation to test the short run causality between CO_2 Emissions, Economic Growth, electricity consumption and population in Cameroon. In contrast to the conventional Granger causality method, this approach allows for the inclusion of the lagged error-correction term (ECT) derived from the cointegration equation and allows the test of short and long run causality simultaneously.

The proposed VECM is formulated as follows:

$$\Delta lnco_t = \pi_0 + \sum_{i=1}^{a} \pi_{1i} \Delta lnco_{t-i} + \sum_{i=0}^{b} \pi_{2i} \Delta lngdpc_{t-i} + \sum_{i=0}^{c} \pi_{3i} \Delta lnelec_{t-1} + \sum_{i=0}^{d} \pi_{4i} \Delta lnurb_{t-i} + \eta ect_{t-1} + \varepsilon_t ....(7)$$

$$\Delta lngdpc_t = \alpha_0 + \sum_{i=1}^{a} \alpha_{1i} \Delta lngdpc_{t-i} + \sum_{i=0}^{b} \alpha_{2i} \Delta lnco_{t-i} + \sum_{i=0}^{c} \alpha_{3i} \Delta lnelec_{t-1} + \sum_{i=0}^{d} \alpha_{4i} \Delta lnurb_{t-i} + \eta ect_{t-1} + \varepsilon_t .(8)$$

$$\Delta lnelec_t = \beta_0 + \sum_{i=1}^{a} \beta_{1i} \Delta lnelec_{t-i} + \sum_{i=0}^{b} \beta_{2i} \Delta lngdpc_{t-i} + \sum_{i=0}^{c} \beta_{3i} \Delta lnco_{t-1} + \sum_{i=0}^{d} \beta_{4i} \Delta lnurb_{t-i} + \eta ect_{t-1} + \varepsilon_t .(9)$$

$$\Delta lnurb_t = \sigma_0 + \sum_{i=1}^{a} \sigma_{1i} \Delta lnurb_{t-i} + \sum_{i=0}^{b} \sigma_{2i} \Delta lngdpc_{t-i} + \sum_{i=0}^{c} \sigma_{3i} \Delta lnelec_{t-1} + \sum_{i=0}^{d} \sigma_{4i} \Delta lnco_{t-i} + \eta ect_{t-1} + \varepsilon_t . (10)$$

Where ect is the error correction, other variables remain unchanged.

Long run causality is based on the significance of the lagged error correction term. The direction of the causality, in this case, can only be determined by the F-statistic and the lagged error-correction term. If it coefficient is negative and significant, then the cointegration hypothesis is accepted. While the t statistic on the coefficient of the lagged error-correction term represents the long-run causal relationship, the t-statistic on the explanatory variables represents the short-run causal effect (see Odhiambo, 2008 and 2011; Narayan and Smyth, 2006). For example, bi-directional causality between income and CO_2 emissions will be accepted if π_{2i} and α_{2i} in equations 7 and 8 are statistically different from zero. Unidirectional causality from income to CO_2 is accepted if α_{2i} in equation 8 is statistically different from zero[9].

4. Results and Discussions

4.1. Unit Root Test

According to Ouattara (2004), because Pesaran and al. (2001) critical bounds are based on the assumption that such variables should be stationary at I(0) or I(1), if a variable is integrated at I(2), then the computation of F-statistics for cointegration becomes inconclusive. The unit root test has the objective of verifying that none of the variables is integrated of order greater than 1. The Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests were used and the results indicate that urbanization is stationary at the level form, while carbon emission per capita and electricity consumption are integrated at their level form. However, GDP per capita is integrated at different level. Results are presented in table 1 below:

[9] This hypothesis will be extended to each equation from 7 to 10 and for each variable.

Table 1: Unit Root Estimation

Variable	ADF		PP	
	Level	**First difference**	**Level**	**First difference**
Lnco	-1.998123	-7.218325***	-1.998123	-7.158656***
Lngdpc	-2.978984**	-	-2.085318	-4.131562**
Lnelec	-0.794709	-5.436134***	-0.989516	-5.436134***
Lnurb	-4.315279***	-	-18.41328***	-

Source: Authors' calculations.

***, ** depicts significance at 1% and 5% respectively.

4.2. Cointegration Test Results

The bound test confirms only one cointegration relation, notably when CO_2 emissions per capita are the dependent variable. Other equations were not cointegrated, except the electricity model (equation 5) which reveals inconclusive results. These results are reported in table 3 below:

Table 2: Results of Cointegration Test

Estimated model	**Optimal lag**		**Value of F-statistics**		**Decision**	
$F_{co}(co/gdpc, elec, urb)$	1		4.423662***		Cointegration	
$F_{gdpc}(gdpc/co, elec, urb)$	1		0.9195502		No cointegration	
$F_{elec}(elec/gdpc, co, urb)$	1		2.228702		Inconclusive	
$F_{urb}(urb/gdpc, elec, co)$	1		1.223771		No cointegration	
Critical values of Pesaran	**10%**		**5%**		**1%**	
	I(0)	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
	2.20	3.09	2.56	3.46	3.29	4.37

Source: Authors' calculations.
*** depict significance at 1%.

4.3. Empirical Results of Equation 2

Confirmation of the cointegration among CO_2 and the independent variables suggests to safely proceeding to the estimation of the long run effect of these variables on CO_2 emission. The Ordinary Least Squares (OLS) technique was applied and the results are shown in table 3.

The diagnostic test, in particular Breusch-Godfrey, ARCH and Jacque-Bera tests respectively show the absence of autocorrelation and heteroscedasticity. Also, the estimated model passes the diagnostic test of normality. As such, the use of OLS is appropriate.

Table 3: Long Run Estimation

Variables	Dependent variable: lnco		
	Coefficient	Standard error	T-statistic
Lngdpc	0.738553***	0.110464	6.685609
Lnelec	0.210554*	0.119239	1.765820
Lnurb	0.434413***	0.085922	5.055886
Constant	-9.154246***	0.622862	-14.69701
Diagnostic tests			
R^2 = 0.829588 Adj. R^2 = 0.815771 F-statistic = 60.040338 Prob.(F-statistic) = 0.0000		Jacque-Bera= 0.7041 Breusch-Godfrey = 0.1341 ARCH = 0.15	

Source: Authors' calculations.

***, * depict significance at 1% and 10% respectively.

The Adjusted R^2 indicates that around 81% of per capita CO_2 emissions in Cameroon are explained by the explanatory variables. The F-statistic indicates that the proposed model is globally significant at 1%. Furthermore, we note that **lngdpc** and **lnurb** are significant at 1% while **lnelec** is significant at 5%. These variables are therefore pertinent in explaining the degradation of the quality of air in Cameroon.

Economic growth, electricity consumption and urbanization coefficients have expected positive sign. These results are in line with other authors. For example Sharma (2010) found that economic growth positively affects carbon emissions in a panel of low income countries. Hoi and Smyth (2009) for a panel of five ASEAN and Saboori and al (2011) for Iran also found that per capita income positively affect carbon emissions in the first stage of economic growth, but an inverse relation is observed when these countries reaches certain income level.

However and all thing being equal, 1% increase in per capita income will lead to only 0.73% increase in CO_2 emissions per capita in Cameroon.

This low elasticity could be explained by the fact that Cameroonian economy is led by the tertiary sector which is not generally considered as pollution intensive (around 46.6% of GDP proceed from this sector).

The results also indicate that 1% increase in electricity consumption and urbanization will increase carbon emissions per capita by 0.21% and 0.43% respectively. These results are consistent with various studies that use electricity consumption (as proxy of energy consumption) and urbanization (as proxy of population) as determinant of environmental pollution (see Beauchemin and Bocquier, 2008; Duh and al. 2008, Hooi and Smyth, 2009; Halicioglu, 2009; Akpan and al, 2011).

4.4. Result of the Causality Test

Following Odhiambo (2008; 2011) and Akpan and al (2012), the Granger causality test between CO_2 Emissions, Economic Growth, electricity consumption and urbanization is based on a VECM. The results are presented in table 4 below.

Table 4: Granger Causality Test Based on VECM

Dependent variables	Independent variables or sources of causality				
	Δlnco	Δlngdpc	Δlnelec	Δlnurb	ect(-1)
Δlnco	-	0.6885*** [0.2344]	- 0.2117 [0.1653]	0.1498 [0.9275]	- 0.4720*** [0.1277]
Δlngdpc	0.2872*** [0.0977]	-	0.2509 [0.1006]	0.9594 [0.5769]	0.18689** [0.0919]
Δlnelec	- 0.2114 [0.1651]	0.6007** [0.2410]	-	- 0.4679 [0.9238]	- 0.2751* [0.1431]
Δlnurb	0.0049 [0.03078]	0.07632 [0.0458]	- 0.0155 [0.03070]	-	- 0.0157 [0.0273]
Causality decision: co ⟷ gdpc; gdpc ⟶ elec.					

Source: Authors' calculations.

***, **, * indicate statistical significance at 1%, 5% and 10% respectively and values in brackets represent standard error of each short run variable.

From the results presented above, it is evident that in the long run, income, electricity consumption and urbanization Granger cause carbon emissions.

This is supported by the coefficient of the error correction term which is negative and significant. Although the cointegration test for energy equation was inconclusive, we can conclude that there is a unidirectional long run causality running from carbon emissions, income and urbanization to electricity consumption per capita. This because, following Kremers et al. (1992) the significance of the lagged error-correction term is a more efficient way of establishing cointegration. Despite the fact that the lagged error correction term of economic growth equation is significant, there is no long run causality because its coefficient is not correctly signed.

At the short run, there is bidirectional Granger causality between economic growth and carbon, this result is supported by their corresponding t-statistic. Again, there is short run causality running from economic growth to electricity consumption per capita without feedback. This is explained by the fact as more as income increases; citizens are willing to improve their standard of living. In 2009, around 40% of Cameroonians has access to electricity. We should note that Electricity consumption has a positive but insignificant effect on economic growth in the short run. According to Carolina et al (2011), if Cameroon could improve its economic infrastructure to the level of Africa's middle-income countries, it could raise its per capita economic growth rate by about 3.3 percentage points. This illustrate that infrastructure development doesn't benefit to economic growth in Cameroun

4.5. Economic Policy Recommendations

Based on the previous results, economic growth, electricity consumption and urbanization positively affect carbon emissions in Cameroon, but their impacts have been marginal till today. Given that climate change is a global phenomenon, it's imperative that Cameroon participate in the global abatement strategy. In this sense, some policy recommendations should be implement in order to

First, it is necessary to create a national observatory for collecting and monitoring of critical environmental indicators (such as GHG, deforestation and other pollutants).

Second, there is a need for technology transfer to help developing countries (as Cameroon) to achieve sustainability emerges. To reduce pollution levels many developing countries expect technology transfers in the form of foreign direct investment from developed countries. Theoretically, these technologies will boost economic growth at smaller environmental damages.

Finally, it would be important to make operational the environmental police by reinforcing the technical capacities of administrations in charge of elaborating programmes for the promotion of sustainable environmental management.

However, this study presents shortcomings. In fact, only per capita CO_2 emission is used as environmental indicator. This indicator doesn't reflect global environmental situation in Cameroon. .Thus, results obtained may not reflect the entire environmental situation in Cameroon. According to this view, it would pertinent to conduct a study in which economic growth and its determinants are confronted to various environmental indicators such sulphur dioxide, deforestation; or a newly developed indictor such as Environmental Sustainable Index (ESI).

5. Conclusion

This study aimed at examining the determinants of carbon emissions in Cameroon, and the interrelation that may exist between these variables. These interrelations were tested using the Auto Regressive Distributed Lag (ARDL) to cointegration developed by Pesaran et al. In addition, short run and long run causality where tested using a Vector Error Correction Model (VECM). From the long run results for equation 2, we found positives and significant coefficients for economic growth (lndgpc), for electricity power consumption per capita (lnelec) and for urbanization (lnurb). These results indicate that any increase in these variables will increase carbon emissions in Cameroun. The results also confirm the existence of two unidirectional causal relations when carbon emissions and electricity consumption (equations 3 and 5 respectively) are the dependent variables, while there are two short run causality relations: bidirectional causality between carbon emissions and economic growth, and a unidirectional causal relation running from economic growth to electricity power consumption.

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