**Asian Journal of Empirical Research**
Volume 12, Issue 2 (2022): 82-88.

http://www.aessweb.com/journals/5004

# TESTING THE ENVIRONMENTAL KUZNETS CURVE HYPOTHESIS IN CEMAC COUNTRIES

**Philemon Nsi Ella**[a,c †]
**Jean Felix Mabiala**[a,c]
**Louis Bertrand Ogoula Ikinda**[b,c]

[a] *University of Omar Bongo, Libreville, Gabon.*
[b] *Economic Department, Em Gabon, Gabon.*
[c] *Center for Research Studies in International Development and Management of Organizations (CERDIMO), Gabon.*

† ✉ *pnsiella@gmail.com (Corresponding author)*

## Article History
**Received:** 25 March 2022
**Revised:** 12 May 2022
**Accepted:** 27 May 2022
**Published:** 15 June 2022

## Keywords
Environmental kuznets curve
CEMAC countries
Fixed effects.

## ABSTRACT
The objective of this study is to test the hypothesis of the environmental Kuznet curve (EKC) for 6 CEMAC countries covering the period 1960-2014. We wanted to know if the evolution of per capita income affects environmental quality in the income-emissions relationship (environment). To achieve this objective, we used the method of fixed effects. The results of this study reveal that there is no empirical support for the presence of an environmental Kuznets curve hypothesis. On the other hand, there is rather an inverted "N"-shaped relationship between gross domestic product per capita and CO2 emissions. Moreover, the use of the FMOLS method gives robust results. For this purpose, the minimum turning point which corresponds to per capita income from which CO2 emissions increase is 89.84 dollars and the maximum point corresponding to per capita income from which CO2 emissions decreases is 116.21 dollars. Therefore, CEMAC countries must undertake income policies with the aim of reaching at least the threshold of 1116.21 dollars per capita in order to reverse the evolution of CO2 emissions.

**Contribution/Originality:** This paper contributes to the literature on environmental economics by verifying the existence of the Environmental Kuznets Curve in CEMAC countries. In addition, we have determined the per capita income thresholds from which the evolution of CO2 emissions changes in concavity using estimation techniques such as FMOLS and fixed effects.

DOI: 10.55493/5004.v12i2.4518
ISSN(P): 2306-983X/ ISSN(E): 2224-4425

**How to cite:** Philemon Nsi Ella --- Jean Felix Mabiala --- Louis Bertrand Ogoula Ikinda (2022) Testing The Environmental Kuznets Curve Hypothesis in Cemac Countries. *Asian Journal of Empirical Research*, 12(2), 82-88. 10.55493/5004.v12i2.4518



## 1. INTRODUCTION

Prior to the 1970s, valued development in terms of production goals and economic progress was the priority of all world rulers and environmental preservation was not seen as a primary concern. Today, the latter, associated with development, is becoming an important sociopolitical issue both in the countries of the South and in the countries of the North.

As early as the 1970s, the question of the depletion and scarcity of natural resources was raised (Meadows, Meadows, Randers, & Behrens, 1972) so that the economists of the Club of Rome proposed to limit economic growth to avoid future harmful effects on the environment. This point of view was empirically verified and it appeared that the intensity of use of natural resources and income describe an inverted "U"-shaped relationship called the "intensity-of-use hypothesis", (Auty, 1985).

One of the characteristics of developing countries is the use of old technologies and dependence on natural resources, the exploitation of which gradually increases emissions of the gases responsible for global warming. The countries of the Economic and Monetary Community of Central African States (CEMAC) are not spared by this trend.

In 2012, these were among the top 50 emitters of carbon dioxide ($CO_2$) in the world (World Bank, 2017). Their cumulative emissions increased from 21 million tonnes in 2000 to 56 million tonnes in 2013. A similar trend was observed for two other greenhouse gases (GHGs), namely nitrous oxide ($N_2O$) and methane ($CH_4$).

Globally, anthropogenic GHG emissions increased on average at the rate of 1.3% per year between 1970 and 2000, and 2.2% between 2000 and 2010 (IPCC, 2014). These increases in GHG emissions are partly explained by the various anthropogenic activities. Man, in his frantic quest to satisfy his generic needs and sometimes to leave a legacy to his offspring, damages the immediate environment in which he lives.

Climate change, primarily $CO_2$ emissions, induced by greenhouse gases (GHGs), poses unprecedented threats to human growth and survival, including severe weather events, elimination of animal and plant species and food shortages (Rjoub, Adebayo, Awosusi, Panait, & Popescu, 2021).

The consequences of global warming on human activities and on the quality of life are known: increased levels of drought and flooding, melting glaciers, worsening extreme weather events, rising sea levels, etc. The objective of the Kyoto Protocol (The Kyoto Protocol was an international treaty which extended the 1992 United Nations Framework Convention on Climate Change that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that global warming is occurring and that human-made $CO_2$ emissions are driving it) through the Paris Agreement, specifically aims to mitigate the harmful effects of climate change by reducing global $CO_2$ emissions, with the objective of reducing the global temperature by 3° Current Celsius to 1.5° by 2100 (UNFCCC, 2015). The success of these efforts will depend on a strong degree of commitment from GHG-producing nations to achieve an acceptable level of emissions. It then becomes important to understand the factors that can influence GHG emissions.

Taking these relational facts into account, Kuznets (1955) predicts that as per capita income increases, income inequality first increases and then decreases after reaching a certain threshold. In other words, the distribution of income is more unequal at the start of growth then it becomes more equal as growth continues. The EKC hypothesis, consistent with the original argumentation, states that environmental degradation first increases with growth and then decreases. In other words, in a country, at the start of growth, this will lead to environmental degradation, but as the level of per capita income increases, this environmental degradation will eventually decrease and the country will end up with a clean environment when it becomes prosperous.

For Arrow et al. (1996) and Stern, Hagerman, Steinberg, and Mason (1996) the verification of the EKC hypothesis is partly or largely due to the effects of international trade based essentially on the theory of comparative advantages. Indeed, each country is supposed to specialize in the production of goods and services intensive in the factors of production which it has in abundance. In this case, developed countries specialize in capital and human capital intensive activities. Developing countries specialize in activities that are intensive in natural resources and unskilled labor. These specializations would be the main explanation for the EKC hypothesis. The reduction of pollutant emissions in developed economies according to these authors could be linked to the transfer of polluting activities to poor countries.

The EKC has been criticized by Dinda (2004) since according to this curve emissions are a share of GDP, and therefore it assumes that there is a one-way causal relationship from GDP to emissions or the reverse may exist. However, this curve does not highlight the other factors influencing the level of emissions other than economic growth. For this, the Kaya identity offers a breakdown of $CO_2$ emissions according to different economic, demographic, industrial and political parameters.

For the defenders of this hypothesis, it is a question of demonstrating that economic growth is ultimately the best way for a nation to ultimately be both "fair" and "cleaner". An idea taken up by Beckerman (1992). He asserts that "in the end, the best and probably the only way to achieve a decent environment in most countries is for them to become rich". If these theoretical predictions seem clear, the conclusions of the empirical literature on the EKC are far from unanimous. Indeed, many contributions have attempted to give empirical content to the EKC with quite varied results. Although some authors have detected a CEK in their work (Apergis & Ozturk, 2015; Jebli, Youssef, & Ozturk, 2016) others have on the other hand detected an increasing monotonic relationship between economic growth and various forms of pollutants (Kais & Mbarek, 2017; Uddin et al., 2017) reflecting a lack of decoupling between economic growth and environmental quality. Another category detects more complex relationships between economic growth and the environment. Indeed, Fujii and Managi (2016) in their study of 39 OECD countries detect an "N" curve for $CH_4$, $N_2O$, $NH_3$. Usenobong and Chukwu (2012) detect an inverted "N" relationship between economic growth and $CO_2$ emissions in Nigeria. From the above, it is apparent that the empirical literature on the environmental Kuznets curve is inconclusive and ambiguous.

This means that contributions on this subject are necessary because they will allow us to push the limits of this literature. Since the CEMAC zone is part of the Congo Basin, which is the world's second lung, vital for the planet and humanity after the Amazon, it has enormous potential in natural resources. With regard to the problem of the destruction of the ozone layer, the loss of biodiversity and global warming due to increasing anthropogenic activities, (several questions are raised): is the environmental Kuznets curve verified in the countries of the Congo Basin or CEMAC? What implications in terms of sustainable development?

This work has a total of five sections. In addition to the general introduction presented in section one, section two highlights the literature review. The methodology of the study is the work of section 3. Section four presents the results and section five concludes.

## 2. THEORETICAL FOUNDATION AND EMPIRAL EVIDENCE OF THE ENVIRONMENTAL CURVE OF KUZNETS

This section will present the Environmental Kuznets Curve through the theoretical anchoring and the empirical evidence of it.

### *2.1. The Theoretical Foundations of the EKC*

In these studies on development and inequalities, Kuznets (1955) showed that there is a causal link between income inequalities and the level of development: the Kuznets curve. At the beginning, income inequalities are low but increase with the level of development. Only from a certain threshold they begin to decrease, although the development reaches high levels.

However, Grossman and Kruger (1991) applied this logic in the field of the environment: Environmental Kuznets Curve (EKC). They come to the conclusion that the level of environmental degradation increases with economic growth, but from a certain limit, it begins to be out of step with growth while growth continues. By representing on a graph the evolution of economic income (on the abscissa) and social inequalities (on the ordinate), Kuznets suggested that we would then see a so-called "inverted U" curve appear: the period of increase in inequalities does not would only be a “primary” phase of development, itself prior to a rebalancing of the distribution of income in society (once a certain development threshold, or “inflection point”, has been reached).

According to Dinda (2004) the debate around the EKC hypothesis stems from the growth controversy and related environmental policies. Beckerman (1992) put forward the hypothesis that a high level of per capita income would accentuate the deterioration of the quality of the environment. For Bhagwati (1993) economic growth can be a prerequisite for improving the quality of the environment. This allowed Panayotou (1993) to assert that economic growth can be a powerful channel for improving the quality of the environment in developing countries. This hypothesis has been the subject of several controversies. These controversies are classified into three categories into which economies can be classified based on the nature of the relationship between per capita income and per capita pollutant emissions:

- The 1st case corresponds to pre-industrial economies, still primary. The relationship between GDP and pollutant emissions has a positive linear form, and environmental degradation increases with output.
- The 2nd case corresponds to countries in transition, from a primary economy to an industrial economy. This situation is characterized by the acceleration of the consumption of natural resources, especially energy. The consequences are economic and environmental. Environmental degradation, especially pollutant emissions, is peaking. Income levels improve, lifting people out of poverty.
- 3rd case: the relationship between GDP and pollutant emissions has a negative linear form. Environmental degradation goes down with the product. Economies reinforce the use of less and less polluting technologies and develop less polluting activities, services.
- The main explanation for the shape of the EKC is that when a population achieves a sufficiently high standard of living, it places greater importance on environmental amenities (Baldwin, 1995; Selden & Song, 1994).

Indeed, after having crossed a particular per capita income threshold, the willingness of populations to pay to obtain a quality environment increases in a greater proportion than that of income (Roca, 2003). This generally results in more and more donations to environmental protection organizations, the demand and consumption of less polluting products. At this level, the income elasticity of demand for environmental quality is greater than unity; a quality environment and its preservation become luxury goods. The EKC hypothesis is derived from an economic model in which there is no feedback of environmental quality on economic growth. The degradation of the quality of the environment is recognized to have perverse effects on the quality of life but not directly on the possibilities of production (Stern et al., 1996). In the absence of this feedback, growth can be a solution to access a better quality of life in developing countries when the EKC hypothesis is satisfied.

### *2.2. Empirical Evidence of the Environmental Kuznets Curve (EKC)*

Research by Jian, Fan, He, Xiong, and Shen (2019) and Pata (2018) show a positive link between economic growth and environmental degradation in China and Turkey. For the case of Brazil, Su, Umar, Kirikkaleli, and Adebayo (2021) found an inverted U-shaped interaction between CO2 emissions and economic growth on data from 1990 to 2018. For OECD countries, Ahmad et al. (2021) showed that there is a positive relationship between CO2 emissions and economic growth.

Using quantile regression on a sample of newly industrialized countries over the period from 1990 to 2018, Akadiri and Adebayo (2021) find the existence of a positive relationship between economic growth and CO2 emissions. The use of the causality test on 13 Asian economies allowed Gao and Zhang (2021) to find unidirectional causality between CO2 emissions and economic growth. Using the ARDL, Ali, Audi, ŞENTÜRK, and Roussel (2021) detected a positive relationship between economic growth and CO2 emissions in Pakistan covering the period 1971-2014. For East African countries, Namahoro, Wu, Xiao, and Zhou (2021) studied the asymmetric association between CO2 emissions and economic growth in seven East African countries. The empirical analysis revealed that economic growth has a positive relationship with CO2 emissions at the regional level; however, nationally the association was unstable. On the other hand, the EKC hypothesis is not generally verified for CO2, the latter being considered as a pollutant with a more global and planetary impact.

## 3. METHODOLOGY

### *3.1. Data*

The data used for this study are annual and extend from 1960 to 2014 and cover the six CEMAC countries (Cameroon, Central African Republic, Congo, Gabon, Equatorial Guinea and Chad). They are obtained from the World Bank database.

The endogenous variable here is CO2 emissions (metric tons per capita). The calculation is made here by dividing the carbon dioxide emissions in metric tons (1000 kilograms) by the total number of inhabitants. As for the exogenous variables, we distinguish:

- Population density (Popdens): According to Dinda (2004) as demographic pressure increases, the quality of the environment deteriorates.
- Gross domestic product per capita: GDP per capita captures the impact of the level of development on the environment. Theoretically, the EKC hypothesis postulates that environmental degradation is accelerated in developing countries, while the opposite effect is observed when these countries reach a certain level of income.
- The economic growth rate (G): For a given level of an economy, a high (low) growth rate can lead to a better (poor) quality of the environment, or vice versa.
- Energy consumption (ENG): Many studies have shown the positive role of energy in the development process through the growth hypothesis. Energy is considered as a simple input in neoclassical growth models (Tsani, 2010).

### *3.2. Econometric Specification*

Most empirical studies analyzing the growth-environment relationship use panel data embedded in a reduced-form, quadratic or cubic model (Dinda, 2004; Nkengfack, Djoudji, & Fotio, 2020). Regarding the specification of the econometric model, we start from the basic equation where the environmental variable is explained by the product including its quadratic and cubic forms, but also control variables. Our econometric model is given as:

$$ln(CO2)_{it} = \beta_0 + \beta_1 ln(GDPC)_{it} + \beta_2 ln(GDPC)^2_{it} + \beta_3 ln(GDPC)^3_{it} + \beta_4 ln(Eng)_{it} + \beta_5 ln(G)_{it} + \beta_6 ln(Denspop)_{it} + U_i + V_t + \varepsilon_{it} \quad (1)$$

Where the variable CO2 represents carbon dioxide emissions per capita. The variables GDPC, $GDPC^2$ and $GDPC^3$ are income per capita and its respective quadratic and cubic forms. ENG represents energy consumption per capita, G denotes the rate of economic growth and the variable (Popdens) measures population density; the latter is a proxy variable for demographic pressure. $\varepsilon_{it}$, $U_i$ and $V_t$ denote respectively the error term, the specific unobserved effects of countries i and the unobserved temporal effect for each country. The coefficients β are parameters to be estimated.

In the case of the existence of the EKC in the CEMAC zone, the expected sign of the coefficient β1 is positive, that of the coefficient β2 is negative while β3 must be zero. It is however possible to have signs different from those indicated, in this case the relationship between per capita income and CO2 emissions does not have the shape of an inverted "U". It can be monotonous and positive or negative, it can have a "U" shape, an "N" or an inverted "N" shaped. The coefficient β4 and β6 are expected to be positive to indicate the positive impact of energy consumption and demographic pressure on CO2 emissions. Finally β5 can be positive or negative.

## 4. RESULTS

This section will be divided into two parts. The presentation of the results of the preliminary tests will be the subject of the first part. The second part will provided the econometric and economic interpretation of the estimation of the quality of life equation in the three models.

### *4.1. Presentation of Preliminary Test Results*

Unlike the dynamic panel, the Hausman specification test is of capital importance in the static panel because it makes it possible to specify whether the econometric model is a fixed-effect model or a random-effect model. The result of the Hausman test shows that our econometric model is a fixed effect model. It should be noted in passing that the null hypothesis of this test postulates the presence of random effects.

The results of the Hausman specification test show that our equation is a fixed-effect model because the probability of the Chi-square test is below the 1% threshold. The direct consequence of this result is that the OLS estimator (the within estimator) performs better than the Generalized Least Squares estimator. (The Between estimator). Thus, the main estimation method of our model is the fixed effect (FE). The results of the Hausman specification test are reported in the following Table 1.

**Table 1**. Presentation of Hausman test.

| **Test:** H0 : difference in coefficients not systematic |
| --- |
| Chi2 (6) = (b-B)' [v_b-v_B)^(-1)] (b-B) = 254.300<br>Prob > $chi2 = 0.000$ |

### *4.2. Presentation of the Stationary Test*

We made use of Hadri's stationary test, the results of which are contained in Table 2 and the null hypothesis of Hadri's stationary test postulates the absence of a unit root (the series is stationary).

The results of Hadri's stationarity test indicate that all variables are non-stationary at level (or stationary in first difference). Because, their order of integration is equal to 1. Economically, the presence of the unit root (the series is non-stationarity) means that the evolution of these variables is affected by temporal factors. Since the variables are integrated in the same order, we will proceed to the cointegration test.

**Table 2.** Hadri stationary test.

| | Hadri Stationarity Test | | Integration order |
|---|---|---|---|
| | P-value at level | P-value at first difference | |
| Lco2 | 0.000 | 0.383 | I(1) |
| LGDPC | 0.000 | 0.405 | I(1) |
| $LGDPC^2$ | 0.000 | 0.402 | I(1) |
| $LGDPC^3$ | 0.000 | 0.286 | I(1) |
| LENG | 0.000 | 0.365 | I(1) |
| LG | 0.000 | 0.573 | I(1) |
| LPOPDENS | 0.000 | 0.188 | I(1) |

The analysis of Kao's cointegration test Kao (1999) shows that the series are cointegrated because the p-value is less than 5% (0.0039) as shown in the Table 3:

**Table 3.** Presentation of cointegration model.

| | t-Statistic | Prob. |
|---|---|---|
| ADF | -2.663 | 0.003 |
| Residual variance | 0.007 | |
| HAC variance | 0.002 | |

In the presence of panel cointegration, several parameter estimation methods are recommended, such as FMOLS (Fully Modified Ordinary Least Square), DOLS (Dynamic Ordinary Least Square) and PMG/ARDL (Pooled Mean Group). Methods for estimating cointegration relationships such as Fully Modified Ordinary Least Square (FMOLS) or Dynamic Ordinary Least Squares (DOLS) for panel data require that all variables be integrated to order one. Given that all our variables are integrated to order 1, we opted in the context of this study to use the completely Fully Modified Ordinary Least Square (FMOLS) to test the robustness of our results.

**Table 4.** Presentation of the CO2 model.

| Estimation Method | FE | FMOLS |
|---|---|---|
| LGDPC | -18.240***<br>(-4.68) | -24.829***<br>(-3.44) |
| $LGDPC^2$ | 5.612***<br>(4.72) | 7.664***<br>(3.50) |
| $LGDPC^3$ | -0.559***<br>(-4.71) | -0.771***<br>(-3.53) |
| LENG | 1.049***<br>(23.24) | 1.081***<br>(13.44) |
| LG | -0.005<br>(0.27) | 0.014<br>(0.44) |
| LPOPDENS | 0.183***<br>(3.52) | 0.334**<br>(2.25) |
| Cons. | 22.370***<br>(5.31) | |
| $R^2$ Within | 0.8798 | |
| $R^2$ Ajusté | | 0.9377 |
| Prob (Chi2) | 0.0000 | 0.0000 |
| Number of observations | 342 | 336 |

**Note:** *** and ** indicate significance at 10% and 5% respectively. Values in parentheses represent Student statistics.

### *4.3. Presentation of the Results of the Environmental Quality Model*

The table gives the results from the estimation of our econometric model using the fixed effects (FE) method. To test the robustness (sensitivity) of our results, we used the Fully Modified Ordinary Least Square (FMOLS) method for the previous reasons (non-stationary panel and presence of a cointegrating relationship).

The Table 4 above shows that in the CEMAC zone that 87.98% of fluctuations in CO2 emissions are explained by GDP, energy consumption, growth rate and population density, and that the signs obtained coefficients are respectively $\beta_1 < 0$, $\beta_2 > 0$, $\beta_3 < 0$, $\beta_4 > 0$, $\beta_5 < 0$, $\beta_6 > 0$.

Since $\beta 1 < 0$, $\beta 2 > 0$ and $\beta 3 < 0$, then the relationship between per capita income and pollution (CO2) takes the form of an inverted "N". Per capita CO2 emissions first fall when per capita income rises to one threshold, then rises to another threshold before falling again.

However, the absence of EKC in the CEMAC zone is not a surprise, especially when the environmental variable considered is CO2 as pointed out by Holtz-Eakin and Selden (1995) the relationship is rather monotonous and positive as in Shafik (1994) or "N" shaped as indicated by Dinda (2004). Empirical evidence for an inverted "N" shaped relationship between GDP and CO2 is scarce to our knowledge. This form assumes that there are two turning points, a minimum turning point which corresponds to per capita income from which $CO_2$ emissions increase and the maximum point corresponding to per capita income from which $CO_2$ decreases.The general formula for calculating these turning points is:

$$. X^* = \exp\left(\frac{-\beta 2 \pm \sqrt{\beta 2^2 - 3\beta 1 \beta 2}}{3\beta 3}\right); \; x^*_{mini} = e^{(7.61)} = 89.84 \text{ et } X^*_{max} = e^{(14.3)} = 116.21$$

At the CEMAC level, the coefficients β1= -18.2405, β2 =5.6123 and β3 = -0.5595, the minimum turning point which corresponds to the per capita income from which $CO_2$ emissions increase is 89.84 dollars and the point maximum corresponding to the per capita income from which the $CO_2$ decreases is 116.21 dollars.

At the end of this analysis, we can establish a summary table of the result of the estimation of the EKC in the CEMAC zone. The Table 5 gives the CEMAC group in its first column, the second column gives the form of the GDP and $CO_2$ relationship, the third column reports the observations.

**Table 5.** Presentation of environmental curve Shape.

| Group | Curve shape of EKC | Observations |
|---|---|---|
| CEMAC | Inverted « N » shape | Energy (+), economic growth rate (-), industrial sector (+) and population density (+) |

It appears from this table that the Environmental Kuznets curve is not verified in the CEMAC zone. On the other hand, it is of the inverted "N" shape. The coefficients β4 and β6 have positive expected signs to indicate the positive impact of energy consumption and demographic pressure on $CO_2$ emissions.The coefficient β5 being negative, the impact of the growth rate can provide information on the environmental characteristics of the sources of economic growth.

Indeed, we performed the robustness test which consisted in modifying the estimation technique, and finally we found that the results are identical to those of the first method (FE). In other words, in the Fixed effect model (FE) and (FMOLS), the signs obtained from the coefficients are the same.

## 5. CONCLUSION

The objective of this study was to verify the existence of the environmental Kuznets curve in the CEMAC zone during the period 1970-2014. Using the fixed effects method, we found that the environmental Kuznets curve does not exist in the CEMAC countries. In contrast, we instead found an inverted "N" relationship between gross domestic product per capita and $CO_2$ emissions. Moreover, the use of the Fully Modified Ordynary Least Squares method shows that our results are robust. In addition, at the CEMAC level, there is a maximum turning point ($116.21) corresponding to the per capita income from which $CO_2$ drops and the minimum turning point ($89.84) which corresponds to the per capita income at from which $CO_2$ emissions increase. This zone is located on the descending part of the Environmental Kuznets curve. In view of the environmental situation of the planet, the question of the sustainability of development does not yet seem to be considered a priority in developing countries such as those of CEMAC. The priorities remain oriented towards the diversification of the economy, the fight against poverty and social inequalities. Nevertheless, CEMAC countries must undertake income policies with the aim of reaching at least the threshold of 1116.21 dollars per capita in order to reverse the evolution of $CO_2$ emissions.

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