CO2 emission and Economic growth in sub-Sahara countries: Is there a Kuznets curve?

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Abstract

The purpose of this study is to find whether there is an environmental Kuznets curve between economic growth and CO2 emission in sub-Sahara countries for the period of 2010 to 2017. The study uses GMM (Generalized Method of Moments) model to determine the relation between CO22 emission and economic growth. The data use in the model was secondary data collected from World Bank data. The variables use to measure economic growth is national gross domestic product and agricultural value added. The results show for both variables that there is no inverted U-shaped environmental Kuznets curve between CO2 emission and economic growth in sub-Saharan countries. An Inverted N shaped curve was found. More action must be taken in the growth and development procedure of Sub-Saharan countries in order to protect the environment through adaptation or mitigation strategies.

Keywords: CO2 Emission, Economic growth, Environmental Kuznets Curve, GMM, Sub-Saharan Africa,

Résumé

Le but de cette étude est de déterminer s'il existe une courbe environnementale de Kuznets entre la croissance économique et les émissions de CO2 dans les pays d'Afrique subsaharienne pour la période allant de 2010 à 2017. L'étude utilise un modèle GMM (Méthode des Moments Généralisés) pour déterminer la relation entre les émissions de CO2 et la croissance économique. Les données utilisées dans le modèle sont des données secondaires recueillies à partir des données de la Banque mondiale. Les variables utilisées pour mesurer la croissance économique sont le produit intérieur brut national et la valeur ajoutée agricole. Les résultats montrent, pour les deux variables, qu'il n'existe pas de courbe de Kuznets environnementale en U inversée entre les émissions de CO2 et la croissance économique dans les pays d'Afrique subsaharienne. Une courbe en forme de N inversé a été trouvée. Des mesures supplémentaires doivent être prises dans les procédures de croissance et de développement des pays d'Afrique subsaharienne afin de protéger l'environnement via les stratégies d'adaptation ou d'atténuation.

Mots-clés: Émissions de CO2, Croissance Économique, Courbe Environnementale de Kuznets, , GMM, Afrique Sub-Saharienne

This paper was presented at the Conference on Climate Change and Food Security in West Africa co-organized by Université Cheikh Anta Diop de Dakar (UCAD) and Center for Development Research (ZEF), University of Bonn, on 17-18 November 2019 in Dakar, Senegal.

Introduction

Global warming is a natural reality with severe impacts on mankind welfare (Wallace, Held, Thompson, & Trenberth, 2O14).To cope with its negative effects a lot of means are required particularly financial resources to implement projects which can help to adapt and mitigate climate change (Stern, 2OO7).Hence, Economic growth and development are relevant in achieving environment protection even if there were for long, a traditional view that economic growth and environmental quality are conflicting purpose because it seems that economic activities release greenhouse gases which contribute to environment degradation. Beside, some authors like (Beckerman, 1992) have come with more explanation showing that it's only a high level of economic growth or development which can ensure good environment quality. He then claim that, "there is clear evidence that, although economic growth usually leads to environmental degradation in the early stages of the process, in the end the best and probably the only way to attain a decent environment in most countries is to become rich».

Economic growth, comprehended as an increase in the production capacity of a country achievement is always followed by having external effects on the environment irrespective of the source of growth; either industrialization, land cultivation, transports; it is followed by emission of greenhouse gases which pollute environment (Smith & Martino, 2007). The environment, on the other hand, offers a wide variety of benefits to people. Therefore, the creation of environmental pollution to achieve economic growth has created a situation in the long term which acts against individuals wellbeing (Ward, 2006).Carbon dioxide (CO2) emissions, which we consider to be indicative of environmental pollution in our study finds its source in both natural resources and human activities. While economic growth takes place, pollution of the environment also rises. Consequently, many researchers find it relevant to examine the relationship between environmental pollution and economic growth. The results of these studies are most of the time linked to the Environmental Kuznets Curve (EKC); which is considered to be an inverted U-shaped relationship between per capita income and environmental degradation. It was the findings of (Grossman & Krueger, 1991) and (Shafik & Bandyopadhyay, 1992) in the early 1990's through cross-country analysis.

The economy of Sub-Sahara countries has shown enormous growth during the last decade (Commission Economique pour l'Afrique, 2017).Consequently, the energy consumption especially in industrial sector has added pollution to the environment, in addition to pollution coming from agricultural sector which mainly contribute to sub-saharan economic growth. Nevertheless, it is noticed that the agricultural sector is facing great challenges such as lack of irrigation system, pesticides, extension services, Infrastructures and financement of research to adapt and cope with climate change effect which makes more vulnerable farmers. As for industrial sector, according to (Goujon & Kafando, 2012) even if industrial sector is less developed the total proportion of industries to GDP is about 25.1%. Middle Industry proportion is about 21.0% while manufacture is 8.4 %. Regarding all this, it is relevant to examine whether it exists an environmental Kuznets curve between economic growth and co2 emission in sub-Saharan Africa in order to be able to know the required policy to be implemented to ensure sustainable development. To that end this question raises: Economics Growth and CO2 emission in sub-Saharan countries: Is there a Kuznets curve?

The general objective of this paper is to find the existence of an inverted U shape curve between CO2 emission and economic growth for sub-Saharan countries. Specifically it consists of 1-Determining the existence of Kuznets curve between CO2 emission and economic growth (GDP per LCU) for sub-Saharan countries. 2-Find how agricultural value added impacts environment in a Kuznets curve framework. Numerous studies have been conducted word widely to find the existence of environmental Kuznets curve for both developed and developing countries ((Adu & Denkyirah, 2O18), (Aldy, 2005), (Khalid & Wei, 2012)). Many of them just try to know whether there is a Kuznets curve between economic growth and co2 emission. This paper in addition is investigating the relation which can exist between agricultural value added and environment degradation since the agriculture sector mainly contribute to economic development in sub-Sahara Africa, and also release a huge amount of CO2 up 14% of the total CO2 emitted globally of all sectors. The remainder of the paper is organized as follow: The first section will present the literature Review while the second section will expose the Methodology use in the study and the third section will present the Results which will be followed by conclusion.

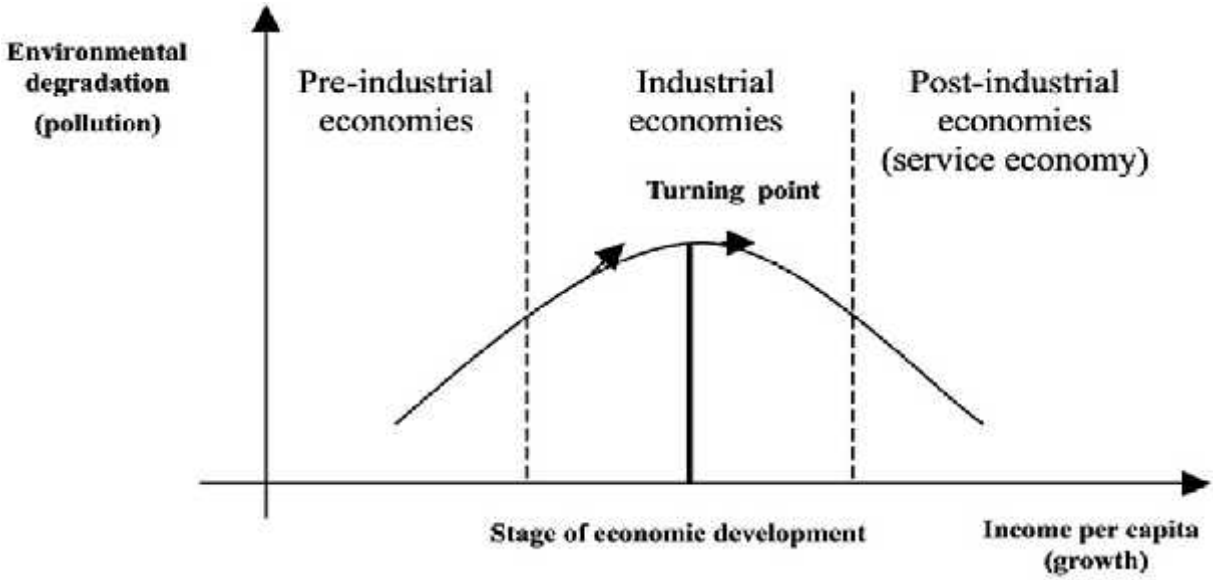
1. Literature Review

This section will consist of presenting the theoretical review and empirical review around the environmental Kuznets curve. The environmental Kuznets curve is an inverted U-shape relationship between economic growth and environmental degradation. There are others greenhouse gases which can be used to measure environment degradation like CH4, and N2O but in this study CO2 was considered for environmental degradation measurement. Various econometric approaches are used to test such hypothesis like ARDL, VECM, GMM and fixed or random effect findings in the empirical review.

1.1-Environmental Kuznets Curve: What does the theory said?

The Environmental Kuznets Curve (EKC) hypothesis has gain the attention of lot of researchers provoking a large body of theoretical and empirical literature. An inverted U-shape relationship between economic growth and environmental degradation is described by the EKC meaning that, environmental degradation increases with economic growth, reaches its maximum level and decreases when the economy reaches the given critical high level of income. The following figure will illustrate the explanation made above

Figure 1: Environmental Kuznets Curve



Source: Panatoyou (1993)

The EKC concept was introduced in the early 1990s by Grossman and Krueger (1991). The main idea is that as the economic growth is increasing, it is also necessary that environmental quality is maintained or improved (World Commission on Environment and Development, 1987).In fact, as revenue increases, the demand for improvements in environmental quality will rise. Some authors like Beckerman (1992) has given more explanation to this point of view claiming that, "there is clear evidence that, although economic growth usually leads to environmental degradation in the early stages of the process, in the end the best and probably the only way to attain a decent environment in most countries is to become rich». Thus, the traditional view that economic growth and environmental quality are conflicting purpose depends on the scale effect. Indeed, According to (Panatoyou, 1993), the argument of Environmental Kuznets curve is that "at higher levels of development, structural changes towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulations, better technology, and higher environmental expenditures, result in leveling off and gradual declining of environmental degradation".

1.2-Empirical Background on Co2 Emission and economic growth in a Kuznets curve framework

Many studies have been done world widely to determine the existence of environmental Kuznets curve between co2 emission and economic growth. Both for developed countries and developing countries. Some of them confirm the existence of the environmental Kuznets curve while others did not. (Alsan, Destek, & Ilyas, 2017) examined the validity of inverted U-shaped Environmental Kuznets Curve by investigating the relationship between economic growth and environmental pollution for the period from 1966 to 2013 in the USA. Their study uses bootstrap rolling window estimation method to detect the possible changes in causal relations and also obtain the parameters for sub-sample periods. The results show the existence of inverted U-shaped Environmental Kuznets Curve in the

USA. (Lacheheb, Rahim, & Sirag, 2015)**,** study examines the existence of environmental Kuznets curve (EKC) hypothesis between economic growth and carbon dioxide (CO2) emission in Algeria for the period 1971-2009 using autoregressive distributed lag co-integration framework. Data were retrieved from World Bank Development Indicators. Findings reveal that EKC hypothesis does not exist. (AraBegum, KaziSohag, Abdullah, & Jaafar, 2015), investigates the dynamic impacts of GDP growth, energy consumption and population growth on CO2 emissions using econometric approaches for Malaysia. Empirical results from ARDL bounds testing approach show that over the period of 1970–1980, per capita CO2 emissions decreased with increasing per capita GDP (economic growth); however from1980 to 2009, per capita CO2 emissions increased sharply with a further increase of per capita GDP. This is also supported by the dynamic ordinary least squared (DOLS) and the Sasabuchi–Lind–Mehlum U (SLM U test) tests. Consequently, the hypothesis of the EKC is not valid in Malaysia during the study period.

(Khalid & Wei, 2012) Investigated the EKC between carbon emission and other four variables (energy consumption, economic growth, trade openness and population) using auto regressive distributed lag (ARDL) methodology for Pakistan from the period of 1971 to 2008. The results do not support EKC in a short-run, whereas the long-run inverted U-shaped hypothesis was confirmed between carbon emission and growth, energy consumption, trade openness and population density. (Saboori n, Sulaiman, & Mohd, 2012) attempt to establish a long-run as well as causal relationship between economic growth and carbon dioxide (CO2) emissions for Malaysia. For the period (1980 to 2009), the Environmental Kuznets Curve (EKC) hypothesis was tested utilizing the Auto-Regressive Distributed Lag (ARDL) methodology. The findings suggest the existence of a long-run relationship between per capita CO2 emissions and real per capita Gross Domestic Product (GDP).An inverted-U shape relationship between CO2 emissions and GDP was found in both short and long-run. (Aldy, 2005) make additional contributions to the EKC literature by using a novel data set self-constructed of state-level. The results based on standard EKC specifications illustrate that per capita CO2 emissions may follow an inverted U-pattern with respect to per capita income for the United States during the 1960 to 1999 period.

2-Methodology

This section consists of presenting the model used for analysis while justifying its choice and then data sources accompanied with variables descriptive statistic. The GMM is used in the study to avoid all the bias which can appear and related to autocorrelation of errors or endogeinity between CO2 emission and economic growth: The data use in the study are secondary data from world bank on sub-Sahara countries spanning the period of 2010 to 2017.The analytical model will be first presented followed by data sources and then descriptive statistics.

2.1-The Model

This study follows ((Baek & Krueger, 2O13), (Grossman & Krueger, 1995), (Bandyopadhyay & Shafik, 1992), (Dinda, 2OO4)) approach for analyzing the impact of

economic growth on environment degradation in sub-Sahara countries using GMM model. The GMM is usually practiced in the setting of semi-parametric models in which the parameter of interest is finite dimensional. We use the lagged differences of variables and the constant for the variables as instruments to control multi-collinearity because the lagged dependent variable creates an endogeneity problem, the other dynamic estimators such as Mean Group and Pooled Mean Group, Maximum likelihood may not give robust and consistent results. For exemple, time invariant unobserved effects, which are included in the error term, will be correlated with the lagged dependent variable causing a dynamic panel bias. Hence, Arellano Bond's (1991) GMM technique is suitable for dynamic panels. A GMM estimator is also efficient when T (time) is short and N (countries) is large. To control for the validity of the instrumental variables for the GMM model the Sargan test will be conducted. Indeed, it is a Chi-square test which determines whether the residuals are correlated with the instrumental variables. We conclude that the instruments are valid and thus there is no indication of instrument mis-specification when we cannot reject the null hypothesis of the Sargan test (Arellano & Bond, 1991).

2.2-Empirical evidence for EKC

Various studies have found the empirical evidence for the existence of an EKC. The data used in these studies are panel data. Therefore, we use the following reduced form model derived from ((Baek & Krueger, 2O13), (Grossman & Krueger, 1995), (Bandyopadhyay & Shafik, 1992), Dinda, 2OO4)) to test the various possible relationships between CO2 emission and economic growth:

$$y_{it} = \alpha_i + \theta_t + \beta_1 x_{it} + \beta_2 x_{it}^2 + \beta_3 x_{it}^3 + \beta_4 x_{it} + \varepsilon_{it} \quad (1)$$

Where: y is CO2 emission, x is GDP per lcu. Here, the subscript i and t stands for the countries and the time periods, respectively. α is constant and β_k is the coefficient of the polynomials of income variable. The country specific terms capture all fixed factors inherent to each country, which are not considered in the model. The parameter θ_t denotes a time-varying intercept. x is a vector of variables which can contribute to environmental degration. This study considers trade of gdp and manufacturing.

$$y_{it} = \alpha_i + \theta_t + \beta_1 x_{it} + \beta_2 x_{it}^2 + \beta_3 x_{it}^3 + \beta_4 x_{it} + \Phi y_{(it-1)} + \varepsilon_{it} \quad (2)$$

The second equation is the GMM equation, which is essentially a dynamic panel equation that accommodates additionally dynamic effects of the dependent variable,

The econometric model we construct above allow us to test several forms of hypothesis between environment and economic growth (DINDA, 2004):

I. $\beta_1 = \beta_2 = \beta_3 = 0$
(3)

A flat pattern or no relationship between

And

ii. $\beta_1 > 0 \quad \beta_2 = \beta_3 = 0$ (4)

A monotonic increasing relationship or a linear relationship between

And

iii. $\beta_1 < 0 \quad \beta_2 = \beta_3 = 0$ (5)

A monotonic decreasing relationship between

And

iv. $\beta_1 > 0 \quad \beta_2 < 0 \quad \beta_3 = 0$ (6)

An inverted-U-shaped relationship, i.e., EKC.

v. $\beta_1 < 0 \quad \beta_2 > 0 \quad \beta_3 = 0$ (7)

U-shaped relationship.

vi. $\beta_1 > 0 \quad \beta_2 < 0 \quad \beta_3 > 0$
(8)

A cubic polynomial or N-shaped curve.

vii. $\beta_1 < 0 \quad \beta_2 > 0 \quad \beta_3 < 0$ (9)

An inverted N-shaped curve.

3. Data source

The data uses in this study are secondary data from the World Bank data for 45 sub-Saharan countries from 2010 to 2017.The dependent variable is CO_2 emission kg per purchasing power parity per gdp (CO_2ppgdp); while the explanatory variables are gdp per capita in local currency (gdpcap); agricultural value added ofgdp (Vaagric); trade per gdp (tradeofgdp); manufacturing per gdp (manufact).The descriptive statistics of these variables are given in the following section.

3.1. Descriptive Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
CO_2ppgdp	1096	0.202	0.191	0.007	1.355
Vaagric	1030	26.465	16.899	0.891	93.977
gdpcap	1188	406861	974056.6	54.111	39.4649
tradeofgdp	1.140	76.341	46.505	11. 087	531.737
manufact	963	11.233	46.505	11. 087	531.737

Source: Author computation from Stata 14 base on World Bank Data(2010 to 2017)

Note: CO_2ppgdp means co_2 emission per gdp; Vaagric is agricultural value added ofgdp; gdpcap is gdp per capital in lcu; tradeofgdp is trade per gdp; manufact is manufacturing per gdp

3.2. -Findings

Results from the GMM regressions

Regarding the results we can firstly say that the instruments are valid since the sargan test is significant. Furthermore we can notice that there is no U shaped Environmental Kuznets curve between co2 emission and economic growth for sub-Saharan countries. Indeed, while examining first the coefficients of co2 emission and agricultural value added, we have β_1 =-0.002687 β_2 = 0.000883 β_3=-8.03e^{-7}which does not respect an inverted U shaped curve conditions according to (Dinda,2OO4) hypothesis but rather respects an inverted N shaped curve condition where β_1 <0 β_2 >0 β_3<0.This means that despite the fact that agricultural value added contributes enough to economic growth in sub-Saharan countries, the level growth cannot reduce environment degradation: There still enough riches to create to improve environment quality.

The same result is observed while examining the existence of an inverted U shaped curve between CO2 emission and gross domestic product. The coefficients are as followed with the following signs β_1 =-2.44e^{-8} β_2 = 1.08e^{-14} β_3=-1.07e^{-21}.The non-existence of inverted U shaped relation goes in line with (Lacheheb, Rahim, & Sirag, 2015) and (AraBegum, KaziSohag, Abdullah, & Jaafar, 2015) who also found the non-existence of inverted U shaped curve respectively in Algeria and Malaysia. These results also confirm the existence of an inverted N shaped curve between co2 emission and gross domestic product in sub-Saharan countries which explain the view of Beckerman (1992) for whom ‘‘developing countries are too poor to green’’. As for controlling variables like trade per gdp and manufacturing per gdp the regression result is showing that they have positive impact on co2 emission meaning that as countries trade level increases and manufacturing increase the degradation level also increases.

3.3. Dynamic panel-data estimation, two-step system GMM for co2 emission and agricultural value added

Table1: Dynamic panel-data estimation, two-step system GMM for co2 emission and dgp per cap (lcu)

Variables	GMM Estimation	
Dep. Variable: co_2pppgdp	Coef.	P>|t|
co_2pppgdp_1	.952	0.000
gdpcap	-2.44e-08	0.000
gdpcap2	1.08e-14	0.000
gdpca	-1.07e-21	0.000
Tradeofgdp	.001	0.000
Manufact	.023	0.000
cons	.009	0.000
Arellano-Bond test for AR(1) in first differences	z = -3.25	Pr > z = 0.001
Sargan test	chi2(4) = 10.32	Prob > chi2 = 0.35

Source: Author Estimate from Stata 14 base on World Bank Data (2010 to 2017)

Table2: Dynamic panel-data estimation, two-step system GMM for co2 emission and agricultural value added

Variables	GMM System	
Dep. Variable: co2pppgdp	Coef.	P>|t|
co2pppgdp_1	.9518679	0.000
vaagric	-.002687	0.000
vaagric2	.0000883	0.000
vaagric3	-8.03e-07	0.000
Tradeofgdp	0.034	0.000
Manufact	0.0112	0.000
_cons	.0237787	0.000
Arellano-Bond test for AR(1) in first differences	z = -3.28	Pr > z = 0.001
Arellano-Bond test for AR(2) in first differences	z = -1.40	Pr > z = 0.161

Source: Author Estimate from Stata 14 base on World Bank Data (2010 to 2017)

Conclusion

The purpose of this study is to find whether it exists an environmental U shaped relation, first between co2 emission and gross domestic product and then between co2

emission and agricultural value added since the agricultural sector mainly participated to the economic growth of sub-Saharan countries up to 40% of GDP and also heavily emit greenhouse gases such co2.It emits up to 14% of the total greenhouse gases (smith et al 2007).The world bank data for 45 sub- Saharan countries was used for the period of 1990 to 2017.The Generalized Method of Moments was used following ((Baek & Krueger, 2O13), (Grossman & Krueger, 1995), (Bandyopadhyay & Shafik, 1992)) framework and the results for both estimations(relation between CO2 emission and GDP or CO2 emission and agricultural value added) was showing the non -existence of an inverted U shaped environmental Kuznets curve for sub-Saharan countries. The existing relation found is the existence of an inverted N shaped curve between CO2 emission and agricultural value added and gross domestic product.

Sub-Saharan countries must consequently make additional effort to clean the environment and adapt to climate change effects in their development process. More finance must be granted for research and development or Projects implementation in order to encourage environmental protection programs since cleaning the environment is very costly. Besides preventing the environment for global warming is a must since minkand cannot leave aside his environment. There are some limitations to our study. First the study just considers CO2 as greenhouse gaze for environmental degradation measurement further studies may consider others greenhouse gases while drawing the Environmental Kuznets curve. Secondly the relation between environmental degradation and economic growth can be analyzed using semi parametric tools or spatial analysis tools. These tools can help knowing how co2 emitted in the region can affect the emission of others or the how the growth level of one country can affect the emission level of other countries.

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