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Do West African Economic and Monetary Union member countries have a unique Environmental Kuznets Curve (EKC)?

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ABSTRACT

WAMU (West African Monetary Union) established in 1963 becomes WAEMU (West African Economic and Monetary Union) since 1994 with the aim of coordinating the member countries' actions in all the economy sectors. The environment attracts attention today and the search for well-being, required reconciling economic growth and better environment quality. In the WAEMU economic dynamics, we wonder if it can be extended to an economic, monetary and environmental Union. A crucial step in this is to know whether the member countries have the same relationship between growth and pollution. The reference in this field is the Environmental Kuznets Curve (EKC). It describes an inverted U-shaped relationship between growth and pollution. With annual data from 1970 to 2010 on CO_2 emissions per capita and GDP per capita , we estimated the cubic form of the EKC model proposed by Grossman and Krueger (1991) as part of a panel and then by country. Energy consumption, the economic growth rate, the industry share in GDP and population density, were used as control variables. A strong assumption of the EKC theory is the supposed lack feedback of pollution on GDP. By releasing this hypothesis and taking into account the endogeneity problem, the estimation results by the instrumental variables method show that there are two groups of countries in the WAEMU area. A group for which the GDP - CO_2 relationship is neutral consists of relatively low-income countries: Burkina Faso, Mali, Niger and Togo. In other countries, the EKC is satisfied, but the turning points determined are inaccessible. We conclude in this case that these countries are on the ascending part of the Environmental Kuznets Curve. The GDP - CO_2 relationship is positive. Ultimately, it appears that the CO_2 - GDP relationship is not uniform in the WAEMU area.

Keywords: Gross Domestic Product, Growth, Carbon Dioxide Emission, West African Economic and Monetary Union (WAEMU), Environmental Kuznets Curve

INTRODUCTION

The 20th century was the century of profound and remarkable progress in human civilization. It is marked by strong progress in science and technology. The main consequences of this are firstly, the increasing exploitation of natural resources and economic development, and secondly, the growing negative impacts on the environment. Indeed, the entire world and particularly the African continent have extensive amounts of natural resources. These resources have long been untapped and they are also the source of conflicts. On the African continent, the natural resources exploitation began since the colonial years; it has increased after the independence and continues to grow driven by the extraction means modernization. The misuse of natural resources contributes to wealth creation but it creates the environmental quality degradation too. The environment attracts attention today and there is an urgent need to deal with sustainability which can be seen as the pursuit of human-ecosystem equilibrium. The organizing principle for sustainability is the sustainable development which integrates immediate and longer term objectives on the one hand and local and global actions on the other hand for better quality of life for generations. It combines interdependent social, economic and environmental issues of human progress. So the pursuit of people well-being today requires reconciling economic growth and better environment quality. This requirement makes the evaluation of the relationship between growth and pollution, a crucial step.

In economic literature, several studies have focused on income and pollution relationship analysis. The reference in this area is the environmental Kuznets curve hypothesis (EKC). It describes an inverted "U" shaped relationship between income and pollution. The environment issues have special attention since the warming of the planet and other environmental problems have become increasingly crucial. Especially, as Kijima et al. (2010) said, it is urgent for the authorities in charge of environmental policies to understand and predict changes in environmental quality over time. Thus it is necessary to develop models to identify this relationship. Unlike the radical and pessimistic view developed since the 1970s that economic growth has adverse effects on the environment quality, the viewpoint that the relationship may have an inverted "U" shaped was also developed. This hypothesis suggests that there may be a break in the positive relationship between the degradation of environmental quality and income from an income threshold level called the turning point.

The inverted "U" shaped relationship between income and income inequality, which was implemented first by Kuznets (1955), has been reinterpreted in the environmental economics literature in the 1990s as the environmental Kuznets Curve (EKC). Indeed, Kuznets (1955) predicts that as far as per capita income increases, income inequalities increase first and then decrease after having reached a certain threshold.

The EKC hypothesis, consistent with the original argument states that the environmental degradation first increases with the growth and then decline. In other words, in a country it will result in environmental degradation but gradually as the level of per capita income increases, this environmental degradation may fall and the country will result in a clean environment when it becomes developed.

The West African Economic and Monetary Union (WAEMU) developing member countries seem to have recovered from the early 21st century by way of economic growth and promising prospects. According to the IMF and the BCEAO (the WAEMU Central Bank) the growth rate is between 3 % and 5% since 2000. These results come essentially from the

Union objectives reorientation in 1994. Indeed, it was only a monetary union at its inception in 1963. Due to the succession of crises in the 1980s, the main macroeconomic and financial indicators have known a rapid deterioration, plunging the member countries in a deep economic crisis. It appeared that monetary stability is not alone sufficient to ensure sustainable growth. It must be accompanied by some other mechanisms to ensure Union cohesion and revive the foundations for sustainable growth. In January 1994, WAMU becomes WAEMU with the main objective to implement common policies in regional planning, transport and telecommunications, agriculture, energy, environment etc.

In this structural dynamic we wonder if WAEMU can be extended to an economic, monetary and environmental Union. A crucial step in this is to know whether the member countries of the Union have the same relationship between growth and pollution. The environment quality is generally measured by pollutant emissions, deforestation, water quality, soil quality etc. In this study, we estimate the relationship between real GDP and CO_2 emissions per capita by testing the EKC hypothesis in a panel way and in a country by country way. Our aim is to examine and compare the GDP-CO_2 emissions relationship in WAEMU. We achieve this aim through using the EKC model proposed by Grossman & Krueger (1991). We look first for the appropriate EKC model specification, panel or not. Secondly, we take into account the endogeneity problem and use the instrumental variables approach to estimate the appropriate specification EKC model for WAEMU.

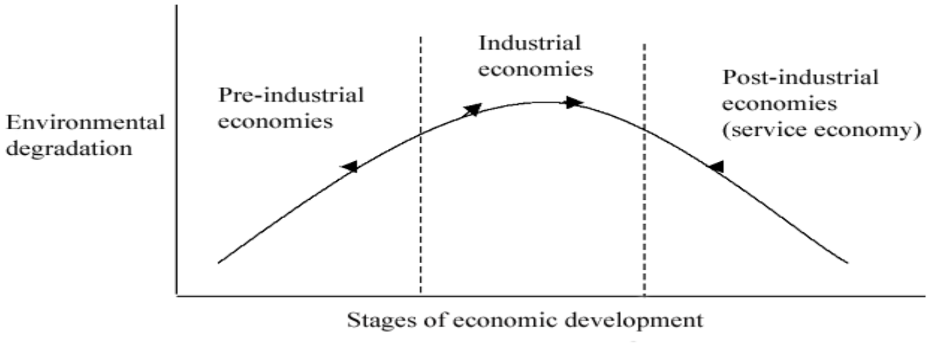
The rest of the paper is organized as follow. In section 2 we make a literature review. Section 3 describes the EKC model proposed by Grossman & Krueger (1991). In section 4, we discuss the results and we give some concluding remarks in section 5.

LITERATURE REVIEW

The debate

The debate around the EKC hypothesis originates from the controversy over growth and corresponding policies as said Dinda (2004). The researchers initially hypothesized that a high per capita income level would increase the degradation of environmental quality. Then one hypothesized that, high levels of income can reduce environmental degradation (Beckerman 1992). Thus, according to Bhagawati (1993), economic growth can be a precondition for improving environment quality. Similarly, Panayotou (1993) asserted that economic growth can be a powerful channel for improving the environment quality in developing countries. However the latter case was subject of controversy.

The EKC may be graphically illustrated as indicated in the following Figure 1:



Source: Panayotou (2003)

Figure 1: The different phases of the EKC

This graphic determines three vertical bands in which economies can be classified according to the nature of the relationship between GDP and pollutant emissions. The left band corresponds to pre-industrial economies, still primary. The GDP and pollutant emissions relationship has a positive linear form, in fact, showing that the environmental degradation increases with the product. The central band corresponds to countries in transition situation, from a primary economy to an industrial one. This situation is characterized by the acceleration of natural resources consumption, especially energy. The consequences are economic and environmental. The environmental degradation like pollutants emissions peaked. The income level improves, thus lowering the poverty level. However, the demand for a better environment quality becomes stronger. These relatively wealthier economies turn towards cleaner natural resources extraction technologies and cleaner production processes, which invert the curve. In the last tape, the GDP-pollutant relationship becomes negative. The environmental degradation decrease with the product. The economies reinforce the use of less polluting technologies and developed less polluting activities, mainly services.

The main explanation for the EKC is the notion that when a population reaches a sufficiently high standard living, it gives greater importance to environmental equipment (Pezzey 1989; Selden & Song, 1994). Indeed, after crossing a particular per capita income threshold, people's willingness to pay to obtain a better environment quality is increasing in greater proportion than income (Roca, 2003). This is usually expressed through increasing donations to environmental protection organizations and greater demand and consumption of cleaner products. At this level the revenue elasticity of demand for environment quality is greater than one. Environment quality and its preservation become luxury goods.
The EKC hypothesis comes from a business model in which there is no environment quality feedback on economic growth. The deteriorating quality of the environment is recognized to have adverse effects on the quality of life but not directly on the production possibilities (Stern et al. 1996). In the absence of this feedback, the growth can be a solution to access a better quality of life in developing countries where the EKC hypothesis is satisfied.

According to Lopez (1994), economic growth comes from production factors accumulation. One consequence is the increasing demand for clean production factors by firms. In parallel the demand for a better environment quality by the population and the willingness to pay for it increases. The benefits and drawbacks associated with obtaining a high quality environment, therefore, give a conceptual overview of the EKC. This allows us to better understand the views of some researchers. Munasinghe (1999) argues that the environmental Kuznets curve is the set of intersection points of the marginal cost curves and marginal profit. For Andreoni & Levinson (2001), the EKC can be derived from the technological link between a good consumption and the reduction of its by-products or unwanted pollutants. When pollution is not taxed, companies use it as an input until its marginal product is zero. The growth-environment relationship appears as a dynamic process. The capital stock is divided in two parts: the first is used directly in the production process with pollution and environmental degradation; the second part is intended to improve the environment quality (Dinda, 2002). So for Dessus & Bussolo (1998), Jaeger (1998) Selden & Song (1994), spending on pollution in the production process is crucial. However, they are not decisive in the EKC for dangerous physical wastes, which are neither easy to reduce nor easy to transfer. For a more comprehensive overview of the elements that can explain the inverted "U" shaped relationship between growth and environment, see Dinda (2004). However, several studies have verified the EKC since Grossman & Krueger (1991). The literature on the EKC is characterized by a lack of consensus and controversy.

Several critics of the EKC hypothesis were published for example by Ansuategi et al. (1998), Arrow et al. (1995), Ekins (1997), Pearson (1994), Stern et al. (1996) and Stern (1998). The main criticism, mostly held by Arrow et al. (1995), is the endogeneity problem. The no feedback hypothesis of environment quality on economic growth in the EKC model presented in "The World Development Report (1992)" is generally questioned. This idea assumes that environmental degradation can slow growth process. For them, economic activity is inevitably disruptive in some cases. Indeed, the needs satisfaction requires energy flows and other natural resources. Their abuse is the source of growth but results in adverse effects on the environment too. The question here is whether a bad environment is an actual brake on growth, and, generally, the answer is yes. According to Lieb (2003), per capita income influences pollution, but pollution also affects the per capita income. Labor productivity may decline because some pollutants can cause health problems and decreased concentration and learning abilities, (Van Ewijk & Wijnbergen 1995). For McConnell (1997), pollution reduced harvests, forest yields and yields in the fisheries sector. There would be a two-way causal relationship between income and pollution. Reducing pollution (reduction in pollutant emissions) potentially hampers income growth by limiting production activities and inputs strongly emitters of harmful products to the environment quality. However, it appeared that the emissions level of certain pollutants decreased in developed countries. Empirical studies generally show that the EKC hypothesis is verified in these countries for the pollutants other than the CO_2 emissions. This could be related to a change of the type of pollutant emitted, rather than the overall decrease in pollution.

For Arrow et al. (1995) and Stern et al. (1996), the EKC hypothesis is partly or largely due to the effects of international trade primarily based on the theory of comparative advantage. Indeed, each country is expected to specialize in goods and services production in intensive factors which each has in abundance. In this case, developed countries specialize in capital intensive activities and human capital; developing countries specialize in intensive activities in the natural resources and unskilled labor. These specializations are the main explanation for the EKC hypothesis. The pollutant emissions reduction in developed economies by these authors could be related to the transfer of polluting activities to poor countries.

Some empirical EKC estimation results

In the literature, two patterns emerge in the results depending on the quality of environmental variable considered in the model. The pollutants called local ones, such as sulfur dioxide (SO_2), nitrogen oxide (NOx), carbon monoxide (CO), etc. would display with the income an inverted "U" shaped relationship. The EKC generally exists for these pollutants. Indeed, the impacts of these pollutants can be more easily internalized in a local or regional economy. These local pollutants influence the air quality, the water and therefore the health of people in a given area. However, the EKC hypothesis is not usually checked for CO_2, since it is considered as a pollutant having a global impact. It is the main pollutant that influences climate change.

The debate about the relationship between income and the quality of the environment is animated in a long time. Before the 1970s, there was the belief that the use of natural resources is growing at almost the same pace as the economy, (Dinda, 2004). By the 1970s, the issue of depletion and scarcity of natural resources has arisen (Meadows et al., 1972), so economists of Rome’s Club proposed to limit economic growth to avoid future harmful effects on the environment. This view has been empirically verified and it was found that the intensity of natural resources use and income describe an inverted "U" shaped relationship called "intensity-of-use hypothesis" (Auty, 1985). Since 1990, the researchers tested the inverted "U" shaped relationship between income and environment quality, checked beforehand between income and inequality income by Kuznets in 1950s and then in the 1970s between the natural resources intensity and income by economists of Rome's Club.

Grossman & Krueger (1991) are the first to have tested the EKC hypothesis. These authors tested the environmental impacts of the Free Trade Agreement North American (NAFTA) as part of a panel. Environmental variables considered are sulfur dioxide (SO_2), suspended particles in the air (SPM). The EKC hypothesis is verified and the turning point (the per capita income level at which emissions peak) for SO_2 is between \$ 4,000 and \$ 5,000. However, this turning point is far lower with suspended particles.

Shafik & Bandyopadhyay (1992) focused on testing the EKC hypothesis for ten indicators. They identified several forms of relationship of these indicators with income. Only the variable concentration of pollutants in the air described with income an inverted "U" shaped relationship. The turning point is determined between \$ 3,000 and \$ 4,000. Other indicators describe a neutral relationship (deforestation), a positive linear relationship (the quality of rivers) and a negative linear relationship (lack of drinking water and lack of urban sanitation). However, in the case of CO_2 emissions, the results are ambiguous.

Selden & Song (1994) tested the EKC for four variables emissions, SO_2, NOx, SPM and CO. This study showed that the EKC hypothesis is held for all the environmental variables in developed countries. However, the turning points are widely different for each type of pollutant. Indeed, the income level at which the breaking of the positive relationship between growth and pollution has been established is \$ 8700 for SO_2, \$ 11,200 for NOx, \$ 10,300 for PMS and \$ 5600 for carbon monoxide (CO).

For their part, List & Gallet (1999) showed that between 1929 and 1994 the path of sulfur dioxide (SO_2) and nitrous oxide (NOx) per capita, compared to per capita income has an inverted "U" shaped in United States. Several other studies have found similar results. This is the case of Cole (2000b), Hill & Magnani (2000), Millimet et al. (2000). However, Cole et al. (1997) analyzed the relationship between income and various environmental indicators, including the SPM, SO_2, NO_2, methane emissions.... They found that EKC is held for some pollutants. These pollutants have an impact locally determined. However, for environmental indicators that have a wider or indirect impact on human health, the relationship with income is positive or the turning point is very high. From these findings, it is implicit that CO_2 is the main greenhouse gas with effects widely spread in time and space, which would not satisfy the EKC; if so, the turning point would be high.

The EKC results for CO_2 in the literature are not unanimous. Some elements may explain this. The results are usually influenced by the period of study, the level of development of the economies studied, econometric techniques, and the sample's homogeneity degree, taking into account control variables or the EKC model form (quadratic or cubic). Indeed, Shafik (1994) found that the relationship between GDP and CO_2 is positive between 1960 and 1990 for a panel of 149 countries. The break in the positive relationship of CO_2 emissions to GDP, thus satisfying the EKC, does not occur; unlike in Holtz-Eakin & Selden (1995) for a 131 countries panel between 1951 and 1986 the turning point is very high (\$

35,428). Their result is similar to those of Cole et al. (1997) on CO_2 emissions. The EKC hypothesis is held but the turning point is very high. This puts in doubt the change of CO_2 emissions trajectory.

Some studies have found feasible turning points. Schmalnesee et al. (1998), in a panel of 141 countries between 1951 and 1986 have established the turning point between \$ 10,000 and \$ 17,000. For Galeotti & Lanza (1999a, 1999b), the turning point is rather between \$ 15,000 and \$ 22,000. Panayotou et al. (1999), with a sample of 150 countries between 1960 and 1992 found that the turning point is between \$ 11 500 and \$ 17 000. The income-CO_2 emissions elasticity is low (often negative) when the per capita income is low, but it increases with income up to a threshold level (the turning point between \$ 10,000 and \$ 22,000), and drop. This can be explained by the structural change in economies.

Another category of studies has shown the effect of sample size and composition, mainly the turning point level. Indeed, studies which have considered a representative sample (cosmopolitan) found generally a monotonous relationship between different types of pollutants and income, in other words the EKC is not verified. However, there is an EKC with more uniform or homogeneous samples. This is the case of studies concerning OECD countries; structurally related savings (see Dijkgraaf & Vollebergh (1998), Selden & Song (1994), and Cole et al. (1997)). On the other hand, a sample with big income gaps, determines a higher turning point than a sample with very close income levels gaps (see List and Gallet (1999), Stern and Common (2001), Lefohn et al. (1999)). However, Hill & Magnani (2002), with a panel of 156 countries showed that there is an EKC.

Some studies have focused on the introduction of control variables in the EKC model. These variables are assumed to influence the product and / or pollution. These additional variables generally relate to political environment (Torras & Boyce, 1998), the production structure (Panayotou, 1997), trade (Suri & Chapman, 1998) and the energy variable (Jobert & Karanfil, 2010).

ANALYSIS

The model

The EKC hypothesis model as proposed by Grossman & Krueger (1991) is empirically tested by estimating equation (1) defined below:

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

Where y represents the environmental variable, x is the per capita income and z is any other variable which can influence the environment degradation. The index i denotes the country and the index t indicates time. α is a constant and β_k are the coefficients of the k explanatory variables. Equation (1) can test all possible forms of the relationship between income and pollution. Seven different forms of this relationship can be obtained based on the values taken by the β_k coefficients, as shown in the following figure.

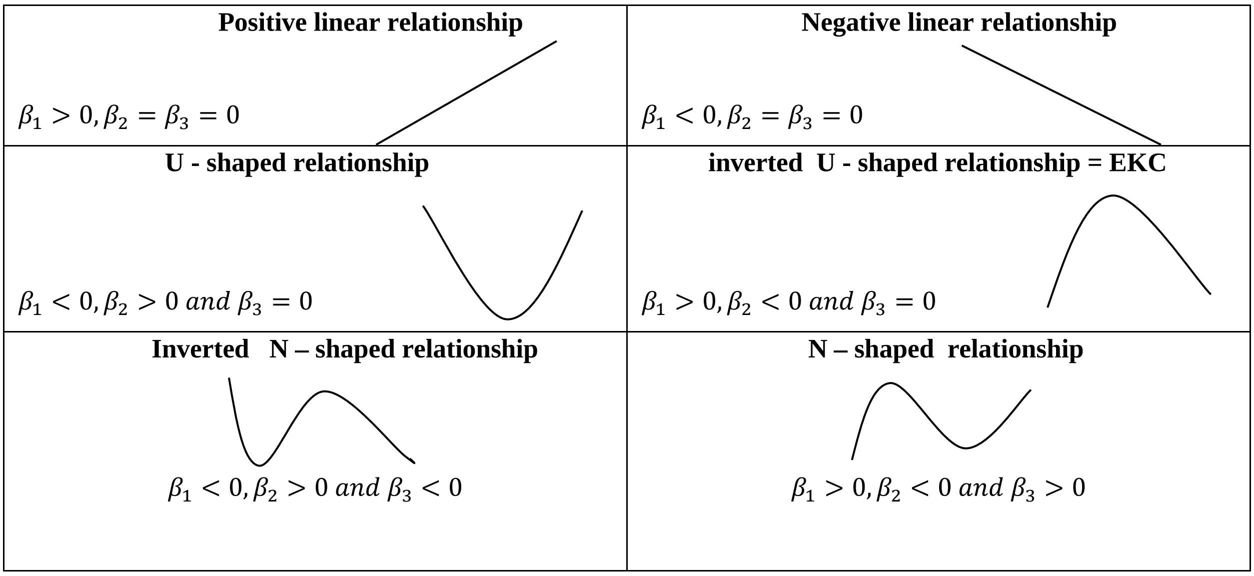


Figure 2: various forms of the relationship gdp-pollutant

Our goal is to determine the trajectory of CO_2 emissions in the WAEMU area. We can improve the basic specification model by including control variables which may directly or indirectly influence the CO_2 emissions on the one hand and taking into account the structural differences between countries, on the other hand.

As Jobert et al. (2010) we include the energy (En) in the model. It can directly contribute to development but to harmful products too. Many studies have shown the positive role of energy through the growth scenario process. Energy is considered as a simple input in the neoclassical growth models (Tsani, 2010). According to Belloumi (2009), the energy is considered as the primary source of added value because the other production factors such as labor and capital cannot well function without energy. A positive energy influence could indicate fossil fuels consumption, which emit more pollutants. In contrast, a negative influence would indicate a transition to energy sources that emitting fewer pollutants.

In the current WAEMU area's economic dynamism, we include in our model the economic growth rate (g), as Nguyen (1999) done. According to Nguyen (1999), the economy's impact on the environment is recognized but this of economic growth is not as obvious. For an economy's given level, a strong (weak) growth rate may lead to a better (poor) environment quality, or vice versa. According to experts, most of the world future economic growth will come from developing countries as well as most of the future population growth. That's why we include in the model the population density (dens). According to Nguyen (1999), a fast population growth rate in southern countries can be a threat to natural resources because their economies are mainly based on these resources exploitation. The environmental quality may decline and greatly reduced absorption capacity. According to Dinda (2004), as population pressure increases, environment quality is deteriorating.

One of the main EKC explanations is the structural change in the economy. Arrow et al. (1995) gives a simplified EKC's view, it is a representation of the natural process of economic development from a low-waste polluting agricultural economy to an industrial one and then to a low-waste services economy. In general, the ascending part of the EKC corresponds to the passage from a primary economy to an industrial one. The down part is the transition from an energy-intensive industrial economy to a services economy which is intensive in technology. We include in our model this aspect of the EKC by the industry share in GDP (ind). A positive sign of the industry share coefficient could indicate that the WAEMU area is on the ascending part of the EKC and a negative sign place the area on the descending part.

To estimate the relationship between GDP and CO_2 emissions in WAEMU area in a panel way and in a by country way, we specified the EKC models as follow:

$$\text{Ln}(CO2)_{it} = \alpha_i + \beta_1 \ln(GDP)_{it} + \beta_2 \ln(\text{GDP})^2{}_{it} + \beta_3 \ln(GDP)^3{}_{it} + \beta_4 \ln(En)_{it} + \beta_5 \ln(g)_{it} + \beta_6 \ln(ind)_{it} + \beta_7 \ln(dens)_{it} + \varepsilon_{it} \quad (2)$$

$$\text{Ln}(CO2)_{t} = \alpha + \beta_1 \ln(GDP)_{t} + \beta_2 \ln(\text{GDP})^2{}_{t} + \beta_3 \ln(GDP)^3{}_{t} + \beta_4 \ln(En)_{t} + \beta_5 \ln(g)_{t} + \beta_6 \ln(ind)_{t} + \beta_7 \ln(dens)_{t} + \varepsilon_{t} \quad (3)$$

Where:

ln (CO_2) denotes the natural logarithms of CO_2 emissions

ln (GDP) denotes the natural logarithms of real gross domestic product

ln (En) denotes the natural logarithms of energy consumption

ln (g) denotes the natural logarithms of economic growth

ln (ind) denotes the natural logarithms of the industry sector share in GDP

ln (dens) denotes the natural logarithms of the population density

The method

The data used for this study are annual and run from 1970 to 2010. They are obtained from the BCEAO database (Central Bank of West African States) for energy consumption. GDP per capita, economic growth rates, industry share in GDP and population density are obtained from the database of the World Bank (World Development Indicators (WDI, 2012)). These data refer to seven members of WAEMU: Benin, Burkina Faso, Ivory Coast, Mali, Niger, Senegal and Togo. Guinea-Bissau is not taken into account; data are not available between 1970 and 2010. The gross domestic product per head (GDP) is expressed in dollars (US constant 2005). The total energy consumption (En), is expressed in kiloton's of oil equivalent (ktoe) per capita, the CO_2 emissions is expressed in metric tons per capita, population density (dens) in the number of people per km2 and the industrial sector share in gdp (ind) is expressed as a percentage of total GDP. The data (GDP, En, CO_2 and dens) are taken into logarithm to the econometric treatment. In this case the coefficients are interpreted as elasticities.

In the standard procedure for estimating the EKC, the GDP - pollution relationship is determined by the coefficients β_k (k= 1, 2 & 3) of our model. We also evaluate the effect of other variables. To determine whether the WAEMU countries have a unique GDP - CO_2 relationship, our approach is organized like that:

1 – Estimation of model (3); this will allow us to determine if there are different groups of countries with similar CO_2 emissions trajectories;

2 – Estimation of model (2); is model (2) the appropriate specification?

3 – Releasing the retroaction's assumption and model's (2) or (3) estimation by the instrumental variables method or GMM method and endogenous test.

FINDINGS

Preliminary tests are necessary to ensure the quality of the estimates. On one side, ADF and PP unit-root tests have shown that the series are integrated in the same order 1. On the other side, Johansen cointegration tests indicate that there are long term relationships between the series in the Union. The results of these tests are available on request (to save space).

By country estimation

The results of the model (3) estimation country by country are shown in table 1. They justify the use of the control variables. Indeed, the energy variable is significantly positive in three countries. The growth rate and the industry sector share in GDP are significant in two countries and the population density is significant in four countries but the influence signs are ambiguous for these variables.

The β_1 β_2 and β_3 coefficients interpretation determines the shape of the GDP - CO_2 relationship. We can distinguish two groups of countries within the WAEMU area. The countries for which there is no relationship between GDP and CO_2 emissions, because the β_k (k=1, 2, 3) coefficients are not significant, are Burkina Faso and Togo. Benin, Ivory Coast, Mali, Niger and Senegal form the group of countries where the GDP – CO_2 relationship exists. However, the relationship is not unique. Indeed, the relationship has an inverted "U" shaped in Benin but a "U" shaped in the others countries.

	Benin	Burkina Faso	Ivory Coast	Mali	Niger	Senegal	Togo
α	53.48	168.42***	1833.89*	251.79***	228.34***	2468.52***	-219.49***
	(0.38)	*(0.00)*	*(0.08)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*
Pib	3.16**	-1.20	-14.25*	-1.49***	-1.57***	-20.28***	3.39
	(0.01)	*(0.74)*	*(0.06)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.64)*
Pib^2	-1.01***	-0.009	0.02*	0.01***	0.008***	0.04***	-0.008
	(0.00)	*(0.74)*	*(0.07)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.67)*
Pib^3	0.03	0.007	-0.008	0.09**	-0.07	-0.007	0.001
	(0.33)	*(0.88)*	*(0.75)*	*(0.03)*	*(0.24)*	*(0.68)*	*(0.81)*
En	-	-	0.53***	-	0.28***	0.25**	-
			(0.00)		*(0.00)*	*(0.03)*	
g	-	0.05*	-0.06*	-	-	-	-
		(0.08)	*(0.08)*				
Ind	-	0.10*	-	-	-	-0.53***	-
		(0.06)				*(0.00)*	
Dens	-0.29***	-	0.26**	-	-0.19***	0.45***	-
	(0.00)		*(0.03)*		*(0.00)*	*(0.00)*	
TP	**7275331.95$US**	**nd**	**nd**	**nd**	**nd**	**nd**	**nd**
R^2	0.89	0.84	0.67	0.41	0.58	0.45	0.16
F	87.11***	45.76***	17.85***	10.62***	12.27***	7.63***	1.08
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.39)*

Notes: TP = Turning point and nd = not determined.
(***), (**) and (*) indicate statistical significance at 1%, 5% and 10% level respectively. The p-values are given in brackets.

Table 1: EKC results country by country

Panel estimation

The model's (2) estimation results in a panel way are shown in table 2.

	MCO		within		MCG	
$\boldsymbol{\alpha}$	154, 16***	*(0.00)*	175, 31***	*(0.00)*	174, 53***	*(0.00)*
$\boldsymbol{pib}$	-0, 23	*(0.14)*	-0, 99***	*(0.00)*	-0, 87***	*(0.00)*
$\boldsymbol{pib^2}$	-0, 0004	*(0.53)*	0, 001**	*(0.01)*	0, 0007*	*(0.09)*
$\boldsymbol{pib^3}$	0, 001	*(0.93)*	-0, 11***	*(0.00)*	-0, 08**	*(0.01)*
$\boldsymbol{En}$	0, 20***	*(0.00)*	0, 42***	*(0.00)*	0, 39***	*(0.00)*
$\boldsymbol{g}$	0, 01	*(0.48)*	0, 04*	*(0.07)*	0, 05**	*(0.02)*
$\boldsymbol{Ind}$	0, 14***	*(0.00)*	0, 26***	*(0.00)*	0, 24***	*(0.00)*
$\boldsymbol{Dens}$.	-0, 12***	*(0.00)*	-0, 06***	*(0.00)*	-0, 08***	*(0.00)*
TP	**nd**		**nd**		**nd**	
$\boldsymbol{R^2}$	0, 91		0, 85		0, 85	
$\boldsymbol{F-stat}$ ^{a}	26, 09***	*(0.00)*	253, 51***	*(0.00)*	1671, 17***	*(0.00)*

Notes: TP = Turning point and nd = not determined.
(***), (**) and (*) indicate statistical significance at 1%, 5% and 10% level respectively. The p-value are given in brackets.

Table 2: Panel results

It appears that all the coefficients are significant. The coefficients β_1 and β_3 are less than zero and the coefficient β_2 is positive. This indicates that the GDP and CO_2 emissions, in WAEMU area, describe an inverted "N" shape relationship. As per capita income increases, first CO_2 emissions fall, then rise and finally fall again. This form assumes that there are two turning points, a minimum turning point that corresponds to the per capita income from which the CO_2 emissions increase and the maximum point corresponding to per capita income from which the CO_2 emissions decline. The formula for calculating these turning points is:

$$x^* = \exp[(-\beta_2 \mp \sqrt{\beta_2^2 - 3\beta_1\beta_3})/3\beta_3]$$

The coefficients do not allow the calculation of the turning points. Indeed, β_2 is too low compared to β_1 and β_3 so that the turning points are undetermined. Under such conditions, we take reservations with the results.

In a panel way we assume that the countries are homogeneous. If this assumption is not true, it is possible that there is a bias related to the heterogeneity of countries. In this case, it would be reasonable to consider that the slope coefficients vary from one country to another and retain the results in Table 1. We make a Fisher test to determine the best specification. Consider that the results of Tables 1 and panel ones are those of the unconstrained and constrained models respectively. Some constraints deal with the estimated coefficients in panel results, they are assumed to be constant for all WAEMU countries. Here the null hypothesis is the homogeneity of parameters against the alternative hypothesis of heterogeneity. The calculated statistic (Fc) is compared to the tabulated statistic at 1% level ($F_{0.01}$). $F_c > F_{0.01}$, the null hypothesis of homogeneity of the EKC model parameters in the WAEMU is rejected. The slope coefficients vary from one country to another. It appears that the appropriate EKC specification model in WAEMU is the model (3).

Taking into account the endogeneity problem in estimating the EKC model

The endogeneity problem was much ignored in the literature of the EKC. However, it can affect the quality of estimates. To solve this problem, we do like Lin & Liscow (2013) and many others researchers, using an instrumental variables approach (IV). The instruments used here are the logarithm of the explanatory variables shifted by one period, two periods and / or three periods. These instruments do not act directly on CO_2 emissions. According to Baum et al. (2003), a good instrument is one that is correlated with the regressors and uncorrelated with the residuals. We re-estimate the EKC model (3) by the instrumental variables approach in the WAEMU area, allowing controlling the endogeneity problem. To check the robustness of our results, we make the Durbin-Wu-Hausman test which confirms the presence of an endogeneity problem and justify the use of the IV method. We make Sargan test and Pagan & Hall test respectively for checking the validity of the instruments and the absence of heteroskedasticity. The results are reported in Table 3.

	Benin	Burkina Faso	Ivory Coast	Mali	Niger	Senegal	Togo
α	63.88***	-51.21	320.17***	297.02***	195.10***	230.52***	85.13***
	(0.00)	*(0.86)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*
Pib	13.60**	-6.36	9.69**	-1.60	-1.27	15.26***	-1.70
	(0.02)	*(0.44)*	*(0.04)*	*(0.15)*	*(0.28)*	*(0.00)*	*(0.84)*
Pib²	-1.15**	0.06	-0.17**	0.02	0.007	-0.12***	0.026
	(0.01)	*(0.39)*	*(0.04)*	*(0.10)*	*(0.63)*	*(0.00)*	*(0.67)*
Pib3	0.005***	-0.002	0.001**	-0.001	-0.004	0.002***	0.008
	(0.00)	*(0.27)*	*(0.04)*	*(0.24)*	*(0.93)*	*(0.00)*	*(0.64)*
En	-	1.41*	0.66***	-	0.32***	0.25*	0.09**
		(0.09)	*(0.00)*		*(0.00)*	*(0.06)*	*(0.03)*
g	-	0.15**	-	-	-	-	-
		(0.04)					
Ind	-	0.33*	-	-	-	-0.64***	-
		(0.05)				*(0.00)*	
Dens	0.33***	-	0.34*	-	-0.19***	0.52***	-
	(0.00)		*(0.05)*		*(0.00)*	*(0.00)*	
TP	**6.57x10^{18} $US**	**-**	**2.38x10^{12} $US**	**-**	**-**	**4.09x10^{27} $US**	**-**
R^2	0.85	0.70	0.87	0.42	0.65	0.74	0.33
F	19.65***	12.64***	35.94***	4.84***	8.79***	37.94***	31.23***
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*
Sargan test	10.67	3.07	7.87	6.22	10.47	9.35	9.69
	(0.13)	*(0.80)*	*(0.21)*	*(0.58)*	*(0.21)*	*(0.43)*	*(0.32)*
D-W-H test	7.49*	10.31**	7.21*	9.82**	7.03*	8.13**	6.08*
	(0.05)	*(0.01)*	*(0.07)*	*(0.03)*	*(0.08)*	*(0.04)*	*(0.08)*
Pagan Hall test	23.94	2.58	8.46	9.48	3.31	8.12	21.21
	(0.12)	*(0.99)*	*(0.85)*	*(0.66)*	*(0.85)*	*(0.88)*	*(0.17)*

Notes: TP = turning point and nd=not determined
(***), (**) and (*) indicate statistical significance at 1%, 5% and 10% level respectively. The p-values are given in brackets.

Table 3: EKC model results taking into account the endogeneity problem

The results are obtained by relaxing the hypothesis of no endogeneity of real GDP. This avoids a simultaneity bias. The causal link between GDP and the environment can be bidirectional. The second part of result's table shows that the estimated performances are quite good; the determination coefficient (R^2) is generally satisfactory as the Fisher statistic that is significant at the 1% level in all cases. The validity of the instruments is measured by the Sargan test. This test's null hypothesis is H_0: the instruments are valid. Their choice may not be relevant; in practice according to Goaied & Sassi (2010), the researcher must proceed with instruments changes in the model until obtaining satisfactory results.

According to the results in Table 3, we cannot reject the null hypothesis of instrument's validity. The p-value of the Sargan statistic is greater than 5% in all cases. Durbin-Wu-Hausman test (D-W-H) is equivalent to Hausman specification test. Here it ensures that OLS estimator is convergent (the null hypothesis H_0). In this case the IV estimator that solves the endogeneity problem is not justified. The p-values of the D-W-H test are generally below 10%, the null hypothesis is rejected with an error risk of 10%. The presence of the endogeneity problem is confirmed. The EKC estimation in the WAEMU zone by instrumental variables approach is justified. However, the IV method produces consistent estimators, if errors are homoskedastic. Otherwise, the GMM approach is more appropriate according to Baum et al. (2003). Pagan & Hall (1983) proposed a test where the null hypothesis is that residuals are homoskedastic. The results of this test in Table 3 fail to reject the null hypothesis. Ultimately, the IV estimator provides consistent estimators of EKC in the WAEMU area.

The estimation results country by country with the consideration of endogeneity problem define two types of GDP - CO_2 relationship within the Union. The relationship is neutral in Burkina Faso, Mali, Niger and Togo; the coefficients β_1, β_2 and β_3 are not significantly non-zero in these countries. However, the EKC is met in Benin, Ivory Coast and Senegal. The coefficients β_1 and β_3 are significantly positive and the coefficient β_2 is significantly negative in these countries. The latter three countries have the highest per capita incomes and CO_2 emissions in the WAEMU area. They are about respectively US $ 1,144.97, US $ 2,190.22 and US $ 1,520.24 for Benin, Ivory Coast and Senegal, compared to US $ 1161.46 for the area and 0.21, 0.50 and 0.44 average CO_2 emissions compared to 0.22 metric tons per capita for the area. Taking into account the endogeneity problem has yielded coefficients β_1, β_2 and β_3 statistically significant with the expected signs for the EKC in Benin, Ivory Coast and Senegal. However the turning points are too high to be reached, they are therefore unattainable, as in Bella et al. (2010). They have shown in their study that the results of the EKC estimation in non-OECD countries between 1971 and 2006 showed significant coefficients with expected signs, but the turning points were not accessible.

The control variables, which do not have a significant effect, have been excluded. However, they generally have a positive effect on CO_2 emissions when they are significant except for the population density in Niger and the industry share in GDP in Senegal. As Bella et al. (2010) , given the fact that the turning points can't be achieved, the positive β_1 coefficients of GDP per capita and overall positive effects of the control variables, we can assume that the relationship between GDP and CO_2 emissions is monotone and positive in these three countries of WAEMU area. The relationship is neutral in the other countries.

	EKC (standard)	EKC (taking into account endogeneity problem)	Observations (control variables)
WAEMU	Inverted « N » shape relationship TP= undetermined		Energy (+), growth rate (+), industry share (+) and population density (-)
Benin	EKC TP=7,27x10^6 \$US TP= undetermined	EKC TP = 6,57x 10^{18} \$US TP= undetermined	Population density (-)
Burkina Faso	Neutral	Neutral	Growth rate (+) and industry share (+)
Ivory Cost	Monotone and negative	EKC TP=2,38x 10^{12} \$US TP= undetermined	Energy (+), growth rate (-) and population density (+)
Mali	Monotone and negative	Neutral	nothing
Niger	Monotone and negative	Neutral	Energy (+), population density (-)
Senegal	Monotone and negative	EKC TP=4,09x 10^{27} \$US TP= undetermined	Energy (+), industry share (-) and population density (+)
Togo	Neutral	Neutral	nothing

Notes: the signs (+) and (-) indicate a positive effect and a negative effect respectively. TP = turning point

Table 4: Summary results

CONCLUSION

This paper examined the possible way for WAEMU countries to coordinate their environmental policies as they done in some other sectors. We examine and compare for that the relationship between GDP and CO_2 emissions in WAEMU. To achieve our aim, we use the Environmental Kuznets Curve (EKC) model proposed by Grossman & Krueger (1991) and introduce control variables to catch the main elements that can influence the production activities and pollution emissions. We detect heterogeneity and endogeneity problems in WAEMU; for that we retain a by country EKC model specification and the Instrumental Variable (IV) estimation approach.

In sum, we see (1) that the control variables globally have a positive influence on CO_2 emissions. (2) The GDP-CO_2 relationship is neutral in Burkina Faso, Mali, Niger and Togo. (3) For Benin, Ivory Cost and Senegal the conditions for EKC are empirically obtained but the turning points are undetermined. In this case it is assumed that the relationship is monotone and positive. These findings confirm largely the results found in the empirical EKC literature; the inverted "U" shaped relationship is not obtained in developing countries and rarely for CO_2 emissions. (4) The endogeneity problem's omission influences the results.

Ultimately, it appears that the CO_2 - GDP relationship is not uniform in the WAEMU. The actual implementation of common environmental policies would not be optimal in the area. Therefore we suggest a strategy by objectives instead of a common environmental policy.

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