Pollution emission and institutions nexus in Africa

Mignamissi, Dieudonné

University of Yaounde II

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This paper tests the pollution emissions and institutions quality nexus in Africa, through political regime and governance indicators. We apply the system GMM estimator on a dynamic panel of 50 African countries over the period 1990-2014. The key finding suggests that a reinforcement of legislation through the improvement of institutional quality has a negative and significant effect on pollution emissions. Moreover, the findings validate the Environmental Kuznets Curve hypothesis in Africa. The results call for some policy recommendations in environmental regulation for African economies, including strengthening of institutional quality, adoption of specialized investment promotion agencies on the attractiveness of green FDI, implementation of incentive mechanisms in favour of companies that have adopted greening program of their activities.

1. Introduction

The agreement reached at the climate change conference held in Paris (COP 21) at the end of 2015 is historically unprecedented. It stresses the urgency for the countries of the world to set up actions to protect the environment. For example, it explicitly foresees limiting the increase in temperature below 2 degrees Celsius and even tending towards 1.5 degree. It is a flexible agreement, because it accounts for the needs and capacities of each country, with a periodic review of ambitions. More specifically, the agreement recommends progressive and gradual reduction of greenhouse gas (GHG) emissions across the world. Moreover, this agreement also shows that no real development plan can be conceived without integrating environmental concerns, reinforcing the problem of sustainable development, that is to say the need to reconcile economic development with environmental protection.

In Africa, the situation is paradoxical. This continent contributes little to global pollution but suffers more than other continents from the multiple effects of environmental degradation. These effects are the results of the relocations of most polluting industries from industrialized countries to African countries, bringing about increase in water and air pollution. This article aims at testing the link between pollutant emissions and institutional quality in Africa, through the political regime and governance.

According to data from the World Bank (WDI, 2018), the trend in global pollutant emissions has increased globally since 1960. They increased from 9 396 705.835 to 33 516 380 kilotonnes from 1960 to 2010, an increase of 256.68%. However, there is a disparity between regions. With regards to Africa specifically, two trends emerged. In North Africa, there has been a steady upward trend since the 1960s, which is considered as the least polluting, with 1.23 Metric ton per capita. From 1970 to 2000, the levels of polluting emissions range from 2.10 to 3.54 Metric ton per capita, representing an overall growth of 187.80%. In sub-Saharan Africa, the average pollutant emissions do not exceed 1 Metric ton per capita. Indeed, after a steady increase from 0.65 to 1.02 Metric ton per capita between the 1960s and the 1980s, pollutant emissions then fell to stabilize at 0.83 Metric ton per capita in the 1990s and 2000s.

A correlation analysis of pollutant emissions and openness in Africa leads to the identification of two groups of countries: (*i*) the first, composed of 10 countries, depicting a negative link between pollutant emissions and openness. These are countries in which liberal trade policies have not necessarily attracted polluting industries from the rest of the world, due to an acceptable institutional quality (Botswana and South Africa), political instability (Democratic Republic of Congo, Congo and Angola), or a low endowment of natural resources (Madagascar, The Gambia, *etc*.); (*ii*) the second group with 36 countries shows the positive correlation between pollutant emissions and economic openness. The lowest correlations in this group are found in Equatorial Guinea (0.04), Côte-d'Ivoire (0.05) and Comoros (0.08); the highest are in Tunisia (0.90), Morocco (0.88) and the Seychelles (0.87). These results tend to suggest that the level of pollutant emissions can be a consequence of economic development, openness policy and institutions quality in most African countries.

The fundamental contribution of this paper is in three levels: (*i*) it tests the hypothesis of the existence of an Environmental Kuznets Curve (EKC) in Africa; (*ii*) it captures the effects of economic liberalization through economic openness and foreign direct investment (FDI) inflows on the level of polluting emissions; (*iii*) it estimates the effect of the political regime and governance on the dynamics of polluting emissions in Africa.

At the end of the empirical analysis, we arrived at two main results: a reinforcement of legislation through the improvement of institutional quality has a negative and significant effect on pollution emissions. Moreover, the findings validate the Environmental Kuznets Curve hypothesis in Africa, unlike the pollution haven hypothesis.

Following this first section, which constitutes the introduction, the rest of the paper is organized into four additional sections. Section 2 highlights a selective literature review. Section 3 addesses the empirical strategy. Section 4 analyzes the main findings. Section 5 highlights the robustness checks. Section 6 concludes with some recommendations.

2. Selective literature review

One of the fundamental debates on environmental pollution pits two rival schools of thought. For the post-keynesians, notably Oates and Baumol (1975), the consequences of free trade then result in a vicious circle favoring pollution. On the basis of a two-country model, of which one poor (P) applying a «weak » regulation and another rich (R), which applies a «strong » regulation, they show that the polluting industries are moving to the poor country: this refers to the environmental dumping hypothesis. On the other hand, according to the Heckscher-Ohlin-Samuelson model, corporate relocation depends on the availability of production factors, but not on institutional laxity. For example, firms that specialize in products requiring a high level of capital (or labor) will settle in countries that are strongly endowed with this factor. Thus one can have an opposite effect to that envisaged by Oates and Baumol (1975).

Empirically, two main hypotheses are generally discussed, namely the Environmental Kuznets Curve hypothesis (Grossman and Krueger, 1995) and the pollution haven hypothesis (Suri and Chapman, 1998). The Environmental Kuznets Curve (EKC) hypothesis was tested for the first time by Grossman and Krueger (1995), who succeed in demonstrating that initially environmental quality deteriorates with increasing income. From a certain level of wealth, economic growth would be accompanied by an improvement in environmental quality, that is to say that society has the means and the will to reduce the level of pollution. Recent work on the existence of an EKC has led to controversial results. While some works validate its existence (Oh and Yun, 2014; Keene and Deller, 2015; Halicioglu and Ketenci, 2016), others find an ambiguous result (Aldy, 2005; Gassebner *et al*., 2011; Smulders *et al*., 2014). According to Abid (2017), empirical work on the Kuznets environmental curve establishes three types of results, namely favorable results, controversial results and nonsignificant results. For a complete critical theoretical and empirical literature review, refer to Stern (2004).

As for the pollution haven hypothesis, it highlights the effect of the difference of the legislations on environmental degradation (Cole, 2004). Indeed, international trade is responsible, all things being equal, for environmental damages caused by relocations (Suri and Chapman, 1998) to countries with soft laws. This effect results from a pollution transfer from the industrialized countries to the developing countries. Recent works attempt to confirm this result with more robust and sophisticated empirical tools (Stern, 2004). Work on environmental degradation is also related to the population effect and institutional quality (Cole, 2007; Goel *et al*., 2013; Asumadu Sarkodie and Adams, 2018) factors that are retained in this article as determinants.

The role of institutions in the development of modern economies is undeniable. Institutions define the development framework by modeling the behavior of individuals in the society, who are required to consider them as rules of the game (North, 1990), whether formal or informal (Acemoglu et al., 2005). Otherwise, institutions are questioned through the prism of their measurement and performance in several areas of the economy (Rodrik et al., 2005).

Work on the role of institutions have on environment has led to various results. More generally, institutions play an important role in environmental performance (Nguyet Phan and Baird, 2015; Daddi et al., 2016; Andersson, 2018). The results established by Bernauer and Koubi

(2009) show that the political institutions measured by the degree of democracy and the political system have an impact on environmental protection. Interesting results are also determined by isolating the effects of corruption and the informal economy (Goel et al., 2013), and the effects of regulatory quality (Gani, 2013).

3. Empirical strategy

3.1. The model

This paper adapts an extension of the basic model of Grossman and Krueger (1995), which examines the relationship between the level of development and pollution indicators. In its canonical form, the model establishes an empirical and non-linear logarithmic relationship between a pollution indicator and GDP per capita and is specified as follows (Stern, 2004):

$$Log(Poll) = \gamma_0 + \gamma_1 Log(y) + \gamma_2 (Logy)^2 + \varepsilon \quad (1)$$

$Poll$ is the indicator of environmental degradation (per capita), y is the real per capita income and ε is a random nuisance term. Beyond the squared (y^2) term that captures the nonlinear relation between $Poll$ and y (EKC hypothesis), Grossman and Krueger (1995) include a cubic term (y^3) for the purpose of testing N-shape EKC (Stern, 2004) or the "recoupling"effect, capturing the resumption (overlapping effect) of pollution with the increase in per capita income after a certain threshold. However, the cubic term is not taken into account because of the potential weak inverted U-relationship. This basic model can be improved through the inclusion of several variables depending on the objective, for example the use of resources that generate the production of waste (Stern, 2004). But the focus of this article is on the role of institutions. We capture institutions by two groups of variables, namely the political regime (PR) and the six governance indicators (Gov) of the World Bank (Gov_1, …, Gov_6). By adding these variables to the basic model, we obtain the following augmented form:

$$Log(Poll) = \gamma_0 + \gamma_1 Log(y) + \gamma_2 (Logy)^2 + \gamma_3 PR + \gamma_4 Gov_1 + \cdots + \gamma_9 Gov_6 + \varepsilon \quad (2)$$

Adopting a panel data specification, the estimated model is given as follows:

$$Log(Poll_{it}) = \gamma_0 + \gamma_1 Log(y_{it}) + \gamma_2 (Logy_{it})^2 + \gamma_3 PR_{it} + \gamma_4 Gov_{1_{it}} + \cdots + \gamma_9 Gov_{6_{it}} + \varepsilon_{it} \quad (3)$$

3.2. Variables and data

This article uses three types of variables (environmental, economic and institutional). The dependent variable is the log of Carbon dioxide emissions (CO2). The emissions related to CO2 are those stemming from the burning of fossil fuels and the manufacturing of cement. They include carbon dioxide produced during consumption of solid, liquid, gas fuels and gas flaring, respectively.

The GDP per capita is the economic variable of our model. According to the World Bank (WDI, 2018), GDP per capita is gross domestic product divided by midyear population. GDP is calculated as the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. The calculation supposes no deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2010 US dollars.

Institutional variables are considered as variables of interest in this paper. They are relative to the political regime (Polity2) and the six indicators of Kaufmann *et al*. (2010) of governance, namely Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption. The variable Polity2 ranges from -10 (autocratic regime) to +10 (democratic regime), and the governance indicators are between -2.5 (very bad quality) and +2.5 (very good quality). We expect a negative sign for the coefficients associated with institutions.

The data come from three main sources: World Development Indicators (WDI) for environmental and macroeconomic variables, Polity IV of the Center for Systemic Peace (CSP) for the democratic regime and the Worldwide Governance Indicators (WGI) for governance indicators. The sample covers 50 (this number vary during the estimates depending on data availability in some countries) African countries over the period 1990-2014.

3.3. Estimation technique and diagnostic tests

Three main empirical critiques related to heteroskedasticity, simultaneity, omitted variables bias, and cointegration are addressed to the EKC hypothesis (Stern, 2004). However, most studies failed to prove the existence of heteroscedasticity (Cole *et al*., 1997; Holtz-Eakin and Selden, 1995). Moreover, the question of cointegration is not a matter of urgency since we use panel data. This paper uses the GMM estimator through a dynamic panel specification to capture the lagged effect of the emission on its current level and to efficiently correct for the endogeneity bias. Indeed, one can suspect a bi-directional link between the level of emissions and the level of GDP per capita. In this context, we could suspect an endogeneity bias in the model (Stern, 2004; Cole, 2004; Lin and Liscow, 2013), which justifies our specification as a dynamic panel model. Indeed, in a dynamic panel model, the countries unobservable specific effects are correlated with the lagged dependent variable, which provides inconsistent estimators. Using the lagged values of the first difference of the endogenous variable as instruments, Arellano and Bond (1991) developed a consistent estimator, called the difference GMM estimator. However, Arellano and Bover (1995) and Blundell and Bond (1998) demonstrated that when the dependent variable is persistent over time, lagged values are very poor instruments. Using additional conditions of moment, they proposed a more robust alternative estimator called system GMM estimator.

Preliminary results from unit root tests (available on demand) open a way to the use of classical estimation methods, such as ordinary least squares on stacked or cross-section data, linear panel (fixed effects versus random effects). However, these methods remain silent with regard to accounting for the endogeneity bias that remains highly probable in the data generation process. For this reason, we choose the system GMM estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998).

4. Main findings

Overall, the pollution level of the previous year has a positive and highly significant memory effect. *Certeris paribus*, on average the increase of one point in the previous level of emission increases the current level, ranging from 0.76 to 0.82 points. This result implies a vicious circle of pollution that is difficult to break (Table 1).

The findings validate the existence of an EKC in Africa. In other words, the level of pollution tends to increase with the per capita wealth up to a certain threshold (inverted U-shape curve). The relationship remains robust except in the specification with the political regime (Polity2). Our results confim those obtained by Cole (2004) in OECD countries, Canas *et al*. (2003) in 16 industrialised countries, Orubu and Omotor (2011) in 47 African countries, Ahmed and Long (2012) in Pakistan, Borhan *et al*. (2012) in Malaysia, Esteve and Tamarit (2012) in Spain, Shahbaz *et al*. (2013) in Romania, Kais and Sami (2016) in 58 countries, Saboori *et al*. (2016) in Malaysia, Zaman and Moemen (2017) in 90 countries, Sarkodie (2018) in 17 African countries. Some studies have produced contrary results, in particular those of Focacci (2005) in Brazil, India and China, Jobert *et al*. (2012) in 55 countries, Kohler (2013) in South Africa, Heidari *et al*. (2015) in 5 ASEAN countries, Wang *et al*. (2016) in China, Ahmad *et al*. (2016) in India, Antonakakis *et al*. (2017) in 106 countries, Hu *et al.* (2018) in 25 developing countries.

The findings related to institutional variables are mixed. If the level of polluting emissions is insensitive to the political regime, this is not the case for governance. Governance indicators remain globally significant and negatively associated (except VA) with CO_2 emissions when they are individually integrated into the model. The results suggest that improving governance strengthens legislation, which would tend to limit the level of pollutant emissions. Otherwise, good governance strengthens institutions that support economic development and environmental protection. In order to capture an overall result, we generated a governance indicators (GOV), calculated as an arithmetic average of the six selected indicators.

Table 1: Relationship between institutions and pollution in Africa

	Dependant variable : CO2 emissions (metric tons per capita, in log)									
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Lagged dep. var.	0.792***	0.820***	0.780***	0.782***	0.779***	0.778***	0.779***	0.774***	0.783***	0.767***
	(0.0003)	(0.0161)	(0.0222)	(0.0224)	(0.0221)	(0.0221)	(0.0223)	(0.0222)	(0.0223)	(0.0225)
ln(GDPPC)	0.881***	0.589	2.557***	2.653***	1.908**	2.625***	2.579***	2.256***	2.442***	2.0692**
	(0.0555)	(0.425)	(0.782)	(0.791)	(0.791)	(0.781)	(0.787)	(0.788)	(0.780)	(0.8364)
ln(GDPPC)_square	-0.015***	0.000531	-0.110**	-0.116**	-0.0683	-0.115**	-0.111**	-0.0923*	-0.103**	-0.0776
	(0.0030)	(0.0270)	(0.0482)	(0.0487)	(0.0490)	(0.0481)	(0.0484)	(0.0486)	(0.0480)	(0.0518)
Polity2		-0.00179								
		(0.00465)								
CC			-0.227***							-0.3106**
			(0.0738)							(0.1310)
GE				-0.173**						0.2135*
				(0.0733)						(0.1252)
PSAV/T					-0.106**					-0.0137
					(0.0419)					(0.0521)
RQ						-0.299***				-0.2739***
						(0.0725)				(0.0975)
RL							-0.237***			-0.1305
							(0.0836)			(0.1425)
VA								0.0259		0.2429***
								(0.0644)		(0.0859)
GOV									-0.256***	
									(0.0853)	
Constant	-5.124	-3.924**	-12.34***	-12.66***	-9.775***	-12.59***	-12.46***	-10.93***	-11.92***	-10.55***
	(0.2500)	(1.633)	(3.079)	(3.118)	(3.089)	(3.069)	(3.099)	(3.098)	(3.068)	(3.2807)
Turning point	**$11 328.64**	**--**	**$11 179.78**	**$11 111.11**	**$11 464.84**	**$11 191.41**	**$11 254.75**	**$11 177.60**	**$11 250.00**	**$11 330.79**
Observations	1,119	836	732	730	731	731	731	731	732	730
# of countries	49	40	48	48	48	48	48	48	48	48
AR1 (Prob z)	0.0282	0.0453	0.0560	0.0555	0.0556	0.0516	0.0581	0.0606	0.0555	0.0483
AR2 (Prob z)	0.1268	0.3546	0.1569	0.1525	0.1700	0.1511	0.1607	0.1663	0.1589	0.1459
Hansen Prob	0.3569	0.3664	0.3124	0.3898	0.40.25	0.3632	0.3987	0.2989	0.3458	0.3759

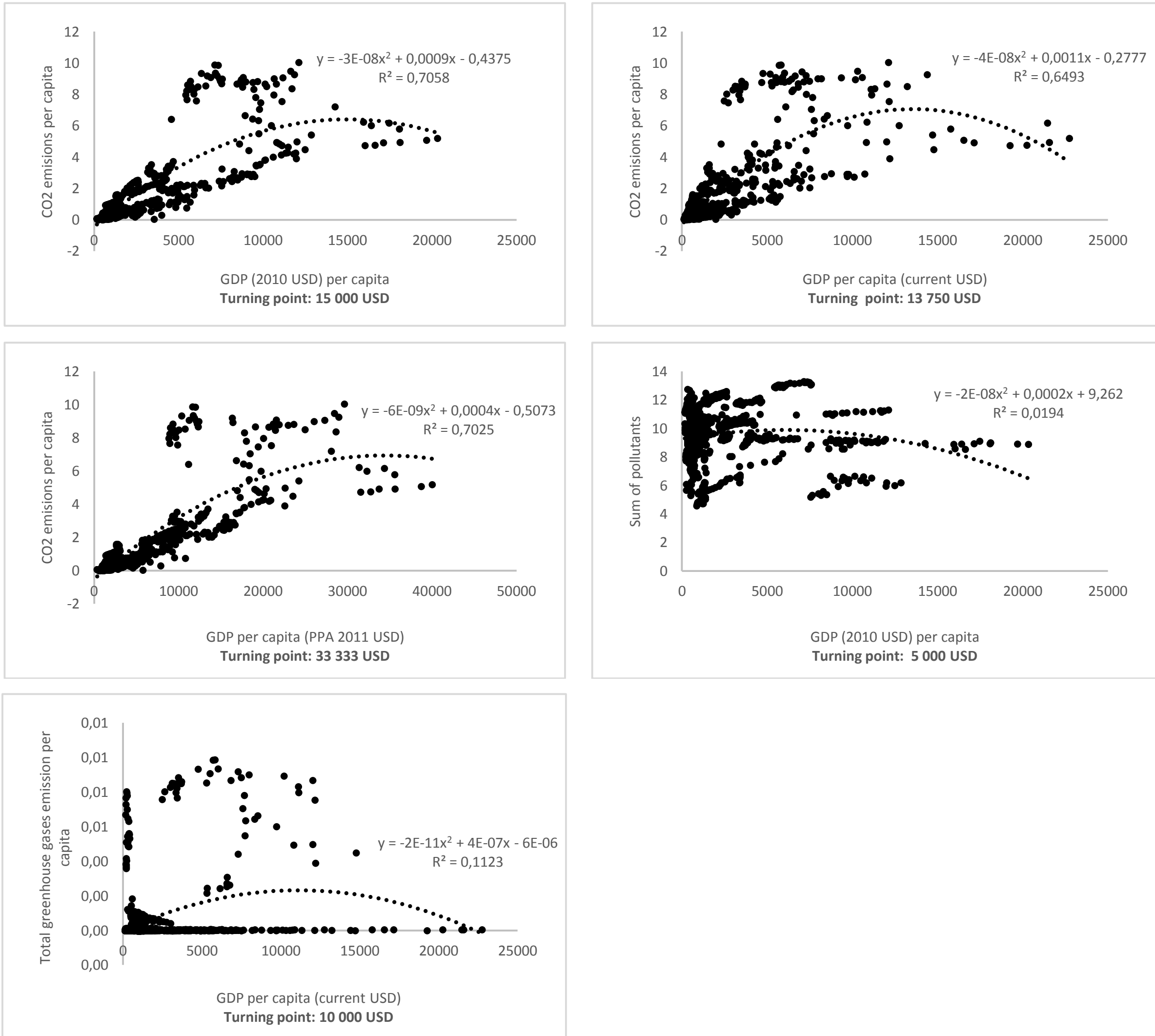
Robust standard errors are in parenthesis
*** p<0,01, ** p<0,05, * p<0,1

Note 1: VA: Voice and Accountability, PSAV/T: Political Stability and Absence of Violence / Terrorism, GE: Government Effectiveness, RQ: Regulatory Quality, RL: Rule of Law, CC: Control of Corruption
Note 2: In order to have the values directly using the formula $-\gamma_1/2\gamma_2$ from equation (3), the turning points were calculated from a level specification.

Source: Author.

The results show that CO_2 emissions decrease with improvement in global governance. This general result confirms that obtained by Goel *et al*. (2013). Capturing the institutions by corruption and the shadow economy and considering them as endogeneous, Goel *et al*. (2013) showed that government effectiveness index is negatively and significantly associated with CO_2 emissions. In addition, Cole (2007) confirmed that polluting emissions are negatively associated with the level of corruption. In other words, good quality institutions would tend to reduce the level of polluting emissions. Similarly, in a study conducted in South Africa, Asumadu Sarkodie and Adams (2018) demonstrated that the depressive character of good political institutions on pollution is observed in the long run.

Graph 1: GDP per capita and CO2 emissions per capita in Africa.



Source: Author.

From the econometric analysis, the turning point of per capita GDP beyond which environmental policies begin to exert a depressive effect on pollution is estimated at about 11,000 US dollars per capita. These thresholds are obtained from a multivariate relationship between the emissions of CO_2 per capita (in level) and the GDP per capita (in level), each specification being controlled by an institutional dimension. According to a bivariate analysis, the relationship confirms the existence of an environmental Kuznets curve, despite the difference in the thresholds (see Graph 1), regardless of the indicator of per capita income (current, actual, PPP) or pollutant (CO_2 per capita, sum of pollutants, total greenhouse gases emission per capita) used. However, the threshold appears to be reduced when we sum up many pollution indicators (CO_2, methane and nitrous oxide) or we use the total greenhouse gases. This result reflects that considering several pollutants is more perceptible than the isolated effect of CO_2.

5. Robustness

To ensure the validity of our results, we test their robustness. We adopt three approaches. Firstly, we use competing estimators for the system GMM estimator. Secondly, we check whether the results are overall sensitive to the other pollution indicators. Thirdly, we address some sub-regional membership specificities.

5.1. Robustness checks with competing estimators

The main estimation technique used in this paper is the system GMM estimator. However, as far as the endogeneity hypothesis could not be clearly proven, several other alternatives were used.

Table 2: Robustness checks with competing estimators.

	Dependent variable : CO2 emissions (metric tons per capita)							
VARIABLES	Pooled Least Squares (PLS)	Static panel Fixed Effect	Static panel Random Effects	IV Fixed Effects	IV Random Effects	Diff GMM One step	Diff GMM Two step	Syst GMM Two step
Lagged	-	-	-	-	-	0.688***	0.686***	0.799***
						(0.0420)	(0.0243)	(0.0484)
ln(GDPPC)	1.890***	1.033***	1.140***	1.083***	1.170***	1.648***	1.772***	0.705***
	(0.241)	(0.275)	(0.266)	(0.275)	(0.266)	(0.333)	(0.141)	(0.199)
ln(GDPPC)_square	-0.0478***	0.00645	0.00192	0.00373	0.000290	-0.0908***	-0.1000***	-0.0312***
	(0.0162)	(0.0179)	(0.0174)	(0.0178)	(0.0174)	(0.0217)	(0.00995)	(0.0112)
CC	0.139*	-0.0561	-0.0351	-0.0650	-0.0451	-0.0983	-0.0824***	-0.0762***
	(0.0747)	(0.0513)	(0.0508)	(0.0511)	(0.0507)	(0.0616)	(0.0110)	(0.0122)
GE	0.660***	-0.0595	-0.0299	-0.0538	-0.0248	-0.00524	-0.0296*	-0.0182
	(0.103)	(0.0524)	(0.0518)	(0.0522)	(0.0517)	(0.0602)	(0.0177)	(0.0146)
PSAV/T	0.0402	-0.0191	-0.0181	-0.0185	-0.0181	0.0325	0.0356***	-0.0294***
	(0.0386)	(0.0215)	(0.0215)	(0.0215)	(0.0214)	(0.0243)	(0.00714)	(0.00648)
RQ	-0.346***	0.00650	-0.00704	0.00866	-0.00450	-0.0451	-0.0297**	0.0298**
	(0.0831)	(0.0454)	(0.0451)	(0.0452)	(0.0449)	(0.0511)	(0.0119)	(0.0149)
RL	-0.0707	0.0128	0.0170	-0.00937	-0.00351	0.0351	0.0511**	0.0539**
	(0.111)	(0.0613)	(0.0611)	(0.0616)	(0.0614)	(0.0647)	(0.0232)	(0.0264)
VA	-0.155***	0.0413	0.0343	0.0405	0.0356	0.0187	-0.00230	0.0358*
	(0.0529)	(0.0381)	(0.0376)	(0.0379)	(0.0375)	(0.0444)	(0.0177)	(0.0195)
Constant	-11.72***	-8.707***	-9.204***	-8.932***	-9.352***	-7.358***	-7.739***	-3.565***
	(0.886)	(1.058)	(1.019)	(1.057)	(1.019)	(1.302)	(0.509)	(0.896)
Observations	730	730	730	728	728	552	552	730
R-squared	0.855	0.530						
# of countries	48	48	48	47	47	47	47	48
AR1 Prob						0.0644	0.8548	0.6964
AR2 Prob						0.1481	0.7778	0.6270

Hansen Prob		0.2556	0.3635	0.4552

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author.

These are: (*i*) pooled least squares (PLS), under the assumption that countries would be considered as homogeneous; (*ii*) static panel estimation (fixed effects and random effects), under the assumption that the lagged endogenous memory effect is negligible, in addition to that of the perfect homogeneity of the explanatory variables; (*iii*) instrumental variable (fixed effects and random effects) estimator, for controlling the specific endogeneity bias associated with the GDP per capita; (*iv*) difference GMM estimator, if the additional moment conditions required by the system GMM are irrelevant. The results (see Table 2) validate the existence of an EKC for PLS and for additional specifications of GMM. Once more, emissions remain insensitive to the political regime with all specifications. Some governance indicators remain negatively correlated with CO_2 emissions in PLS and for additional specifications of GMM.

5.2. Robustness checks with pollution indicators

In this approach, we capture the specific effect related to other pollution variables in log and in level. They are methane[1] (metric tons per capita in log), nitrous oxide[2] - N_2O (in log), and total greenhouse gas – GHG per capita (in level and in log). We use the system GMM estimator.

Table 3: Robustness checks with pollution indicators.

	Dependent variables : Methane, Nitrous oxide, GHG per capita (in level) and GHG per capita (in log)			
VARIABLES	Methane	Nitrous oxide	GHG per capita (in level)	GHG per capita (in log)
Lagged	0.893***	0.795***	1.056***	0.238***
	(0.00560)	(0.0143)	(0.000132)	(0.00537)
ln(GDPPC)	-0.246***	0.685**	0.00714***	1.018***
	(0.0387)	(0.273)	(1.01e-05)	(0.270)
ln(GDPPC)_square	0.0171***	-0.0546***	-0.000504***	-0.0401**
	(0.00241)	(0.0183)	(6.64e-07)	(0.0172)
CC	-0.165***	-0.132***	0.000777***	0.0868***
	(0.0133)	(0.0206)	(8.15e-07)	(0.0287)
GE	0.0577***	0.0135	-0.000197***	-0.0700
	(0.0144)	(0.0263)	(1.01e-06)	(0.0654)
PSAV/T	-0.0398***	-0.0746***	0.000610***	-0.114***
	(0.00848)	(0.0116)	(6.14e-07)	(0.0290)
RQ	-0.0276***	-0.154***	6.18e-05***	-0.143***
	(0.00570)	(0.0221)	(3.03e-07)	(0.0154)
RL	-0.0379*	0.0588*	-0.000338***	-0.0246
	(0.0205)	(0.0310)	(1.11e-06)	(0.0273)
VA	0.0297***	-0.0367**	-0.000295***	-0.511***
	(0.00888)	(0.0172)	(2.18e-06)	(0.0189)
Constant	1.696***	-0.619	-0.0245***	-1.893*
	(0.175)	(0.977)	(3.66e-05)	(1.071)
Observations	638	638	685	613
# of countries	48	48	48	46
AR1 Prob	0.0010	0.0006	0.1024	0.0476
AR2 Prob	0.4080	0.9267	0.7220	0.0148
Hansen Prob	0.5320	0.4950	0.5156	0.5987

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[1] Methane emissions result from human activities such as agriculture and industrial production.
[2] Nitrous oxide result from the burning of agricultural biomass, industrial activities and livestock management.

Source: Author

The results (see Table 3) validate the existence of an EKC for nitrous oxide, and total GHG[3] (per capita and in log), but not for methane. In all these specifications, the more sensitive governance indicators to pollution are control of corruption, political stability and absence of violence, regulatory quality and rule of law.

5.3. Robustness checks to sub-regional membership

The third strategy of this robustness test focuses on subregional estimates, that is, the base model is specified for each subregion. The OLS estimator validates the existence of an EKC in Northern Africa and Southern Africa (Table 4). The political regime highlights a controversial result depending on sub regions and variables considered.

Table 4: Robustness checks with subregional dummies

Dependent variable : CO_2 metric ton per capital (in log)										
	North Africa		West Africa		Central Africa		Southern Africa		Eastern Africa	
ln(GDPPC)	72.52***	40.06**	10.03	-25.31	-29.06***	-26.92***	14.22	22.88*	-169.3	-113.6
	(13.50)	(19.47)	(12.66)	(16.19)	(5.822)	(6.796)	(8.679)	(11.87)	(307.0)	(251.6)
ln(GDPPC)_square	-8.533***	-4.572*	-1.225	4.031*	4.066***	3.727***	-2.143*	-3.120*	27.97	18.50
	(1.673)	(2.444)	(1.826)	(2.374)	(0.788)	(0.922)	(1.210)	(1.657)	(45.71)	(37.96)
ln(GDPPC)_cube	0.338***	0.177*	0.0559	-0.203*	-0.178***	-0.160***	0.116**	0.149*	-1.517	-0.984
	(0.0688)	(0.102)	(0.0874)	(0.115)	(0.0347)	(0.0411)	(0.0554)	(0.0758)	(2.263)	(1.906)
Polity2	-0.026***	0.00318	-0.0145	-0.0200	-0.054***	-0.055***	0.0544***	0.0481***	-0.0220	-0.00598
	(0.00887)	(0.0116)	(0.0112)	(0.0161)	(0.0138)	(0.0162)	(0.0104)	(0.0105)	(0.0191)	(0.0273)
Gov. Index	-0.402***		-0.126*		0.0713		-1.12***		-0.314	
	(0.0896)		(0.0688)		(0.163)		(0.0760)		(0.252)	
CC		-0.109		0.239		0.523		-0.541**		0.102
		(0.132)		(0.148)		(0.401)		(0.207)		(0.155)
GE		-0.226		0.276		0.888**		0.859***		0.259
		(0.143)		(0.185)		(0.409)		(0.285)		(0.282)
PS		-0.0327		0.298***		-0.0147		-0.131		-0.159
		(0.0992)		(0.0869)		(0.199)		(0.117)		(0.123)
RQ		-0.111		-0.64***		-0.344		0.218		0.201
		(0.104)		(0.155)		(0.335)		(0.193)		(0.303)
RL		0.334***		-0.322		-0.656		-0.937***		0.208
		(0.0861)		(0.217)		(0.490)		(0.161)		(0.338)
VA		-0.31***		-0.161		-0.0125		-0.0800		-0.55***
		(0.0995)		(0.184)		(0.348)		(0.208)		(0.170)
Constant	-206.3***	-118.0**	-30.34	48.27	62.65***	58.46***	-35.82*	-60.20**	333.2	225.2
	(36.10)	(51.53)	(29.13)	(36.60)	(13.93)	(16.28)	(20.34)	(27.91)	(686.1)	(555.1)
Observations	67	67	180	179	112	112	84	84	56	56
R-squared	0.976	0.983	0.713	0.760	0.957	0.961	0.975	0.989	0.700	0.895

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author

In addition, the effect of the average index of governance is significant in Northern Africa, Western Africa and Southern Africa respectively. More precisely, (*i*) in Central Africa, only the political regime appear to reduce polluting emissions; (*ii*) in West Africa, it is RQ; (*iii*) in

[3] The main greenhouse gases (GHGs) naturally present in the atmosphere are water vapor (H_2O), methane, carbon dioxide and nitrous oxide. The other GHG components are Dichlorodifluoromethane (CCl_2F_2), Chlorodifluoromethane ($CHClF_2$), Tetrafluoromethane (CF_4), and Sulfur Hexafluoride (SF_6). They contribute to trapping the returned energy, increasing the average temperature of the Earth. Each GHG has a different effect on global warming. For example, over a 100-year period, one kilogram of methane has an impact on the greenhouse effect 25 times stronger than a kilogram of CO2.

northern and East Africa, it is voice acountability; (*iv*) in southern Africa, the rule of law and the control of corruption are hingering pollution significantly; These results show that some institutional dimensions play an important role in environmental protection in Africa.

6. Concluding remarks

This article tested the nexus between pollution and institutional quality, through political regime and governance indicators in Africa. We applied the system GMM estimator and many other competing estimators for robustness to a panel of 50 African countries over the period 1990-2014. The study establishes the following key findings:

- The EKC hypothesis is verified in Africa. In other words, the relationship between the level of emissions per capita and income per capita is non-linear in Africa. The level of development is accompanied by environmental degradation up to a certain threshold;
- The institutional variables have mixed results. On the one hand, the findings suggest that the level of pollutant emissions is insensitive to the political regime in Africa. On the other hand, a significant reduction in polluting emissions is associated with an improvement in the quality of governance;
- Overall, robustness tests validate the existence of an EKC and the depressive effect of good institutional quality on polluting emissions. The result suggests that the level of pollutant emissions in Africa does not necessarily depend on trade openness and FDI inflows, but on the existence of weak institutional quality.

These results call for some policy recommendations in environmental regulation for African economies, including strengthening of institutional quality, adoption of specialized investment promotion agencies on the attractiveness of green FDI, implementation of incentive mechanisms in favour of companies that have adopted greening program on their activities. Lastly, in relation to the nature of the pollution indicators selected, the choice of a predominantly renewable energy mix should be promoted, and the transport system reformed.

References

Abid M. (2017), Does economic, financial and institutional developments matter for environmental quality? A comparative analysis of EU and MEA countries, *Journal of Environmental Management* 188, 183-194.

Acemoglu, D., Johnson, S., & Robinson, J. (2005). "Institutions as a Fundamental Cause of long-run growth". In Philippe Aghion, and Steven Durlauf (ed.), *Handbook of Economic Growth* 1, pp. 385-472.

Ahmad, A., Y. Zhao, M. Shahbaz, S. Bano, Z. Zhanga, S. Wang, Y. Liu (2016) "Carbon emissions, energy consumption and economic growth: An aggregate and disaggregate analysis of the Indian economy", *Energy Policy* 96, 131–143.

Ahmed, K. and W. Long (2012) "Environmental Kuznets curve and Pakistan: An Empirical Analysis", *Procedia Economics and Finance* 1, 4–13.

Aldy, J. E. (2005) "An Environmental Kuznets Curve Analysis of U.S. State-Level Carbon Dioxide Emissions", *The Journal of Environment Development,* 14 (1), 48–72.

Andersson F. N.G. (2018), International trade and carbon emissions: The role of Chinese institutional and policy reforms, *Journal of Environmental Management* 205, 29-39.

Antonakakis, N., I. Chatziantoniou and G. Filis (2017) ''Energy consumption, CO2 emissions, and economic growth: An ethical dilemma". *Renew. Sust. Energ. Rev*. 68, 808–824.

Arellano, M. and O. Bover (1995) "Another look at the instrumental variables estimation of error components models", *Journal of Econometrics,* 68, 9–51.

Arellano, M. and S. Bond (1991) "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations", *Review of Economic Studies*, 58, 277–297.

Asiedu, E. (2004) "Policy Reform and Foreign Direct Investment in Africa: Absolute Progress but relative Decline", *Development Policy Review*, 22(1), 54–79.

Asumadu Sarkodie S. and S. Adams (2018) "Renewable energy, nuclear energy, and environmental pollution: Accounting for political institutional quality in South Africa", *Science of The Total Environment*, 643, 1: 1590–1601.

Bernauer T. and V. Koubi (2009), Effects of political institutions on air quality, *Ecological Economics* 68, 1355 – 1365.

Blundell, R. and S. Bond (1998) "Initial conditions and moment restrictions in dynamic panel data models", *Journal of Econometrics,* 87, 11–143.

Borhan, H., E.M. Ahmed and M. Hitam (2012) "The Impact of CO2 on Economic Growth in Asean 8", *Procedia-Social Behavioral Sciences* 35: 389-397.

Canas, A., P. Ferrao, and P. Conceicao (2003) "A new environmental Kuznets curve? Relationship between direct material input and income per capita: evidence from industrialised countries", *Ecological Economics* 46, 217–229.

Clark, B., A. K. Jorgenson and D. Auerbach (2012) "Up in Smoke: The Human Ecology and Political Ecoomy of Coal Consumption", *Organization Environment,* 25 (4), 452–469.

Cole, M. A. (2007) "Corruption, income and the environment: An empirical analysis", *Ecological Economics*, 62(3-4), 637–647.

Cole, M. A., A. J. Rayner and J. M. Bates (1997) "The environmental Kuznets curve: An empirical analysis", *Environment and Development Economics*, 2(4), 401–416.

Cole, M.A. (2004) "Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages", *Ecological Economics* 48 (1), 71–81.

Cynthia Lin, C.-Y. and Z. D. Liscow (2013) "Endogeneity in the Environmental Kuznets Curve: An Instrumental Variables Approach", *Am. J. Agr. Econ*., 95 (2), 268–274.

Daddi T., F. Testa, M. Frey, and F. Iraldo (2016), Exploring the link between institutional pressures and environmental management systems effectiveness: An empiric al study, *Journal of Environmental Management*, 1-10.

Dinda S. (2004) “Environmental Kuznets Curve Hypothesis: A Survey Ecological Economics”, *Ecological Economics*, 49, 431–455.

Esteve, V. and C. Tamarit (2012) “Threshold cointegration and nonlinear adjustment between CO2 and income: The Environmental Kuznets Curve in Spain, 1857-2007”, *Energy Economics* 34, 2148–2156.

Fairbrother, M. (2013) “Rich People, Poor People, and Environmental Concern: Evidence across Nations and Time”, *Eur Sociol Rev.,* 29 (5), 910–922.

Focacci, A. (2005) “Empirical analysis of the environmental and energy policies in some developing countries using widely employed macroeconomic indicators: the cases of Brazil, China and India”, *Energy Policy* 33, 543–554.

Gani A., (2013),"The effect of trade and institutions on pollution in the Arab countries", *Journal of International Trade Law and Policy*, 12 (2) pp. 154 – 168.

Gassebner, M., M. J. Lamla and J.-E. Sturm (2011) “Determinants of pollution: what do we really know?”, *Oxf Econ Pap.,* 63 (3), 568–595.

Goel R. K., R. Herrala, U. Mazhar (2013), Institutional quality and environmental pollution: MENA countries versus the rest of the world, *Economic Systems* 37, 508–521.

Goel, R. K., R. Herrala, and U. Mazhar (2013) “Institutional quality and environmental pollution: MENA countries versus the rest of the world”, *Economic Systems*, 37(4), 508–521.

Grossman, G. M. and A.B. Krueger (1995) “Economic Growth and the Environment”, *Quarterly Journal of Economics*, 110 (2), 353–377.

Halicioglu, F. and N. Ketenci (2016) “The impact of international trade on environmental quality: The case of transition countries”, *Energy*, 109, 1130–1138.

Heidari, H., S. Turan Katircioğlu and L. Saeidpour (2015) « Economic growth, CO2 emissions, and energy consumption in the five ASEAN countries”, Int. *J. Electr. Power Energy Syst*. 64, 785 –791.

Holian, M. J. (2014) “The Effect of Social and Economic Development on Air Pollution in Indian Cities”, *Environment and Urbanization Asia,* 5 (1), 1–15.

Holtz-Eakin, D. and T. M. Selden (1995) “Stoking the fires. CO2 emissions and economic growth”, *Journal of Public Economics*, 57, 85–101.

Hu H., N. Xie, D. Fang and X. Zhang (2018) “The role of renewable energy consumption and commercial services trade in carbon dioxide reduction: Evidence from 25 developing countries”, *Appl. Energy* 211, 1229 –1244.

Jobert, T., F. Karanfil and A. Tykhonenko (2012) “The Environmental Kuznets Curve reconsidered from the perspective of heterogeneity: insights for climate change and energy policy”, *GREDEG Working Paper Series*: GREDEG WP No. 2012–15.

Kais, S. and H. Sami (2016) “An econometric study of the impact of economic growth and energy use on carbon emissions: Panel data evidence from fifty eight countries”, *Renew. Sust. Energ. Rev.* 59, 1101 –1110.

Kaufmann, D., A. Kraay and M. Mastruzzi (2010) "The Worldwide Governance Indicators: A Summary of Methodology, Data and Analytical Issues", *World Bank Policy Research Working Paper* No.5430, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1682130.

Keene, A. and S.C. Deller (2015) "Evidence of the Environmental Kuznets' Curve among US Counties and the Impact of Social Capital", *International Regional Science Review,* 38 (4), 358–387.

Kohler, M. (2013) "CO2 Emissions, Energy Consumption, Income and Foreign Trade: A South African Perspective", *Economic Research Southern Africa (ERSA) working paper* 356.

Mani, M. and D. Wheeler (1998) "In Search of Pollution Havens? Dirty Industry in the World Economy, 1960 to 1995", *The Journal of Environment Development,* 7 (3), 215–247.

Neumayer, E. (2002) "Do Democracies Exhibit Stronger International Environmental Commitment? A Cross-country Analysis", *Journal of Peace Research,* 39 (2), 139–164.

Nguyet Phan T., and K. Baird (2015), The comprehensiveness of environmental management systems: The infl uence of institutiona l pressures and the impact on environmental performance, *Journal of Environmental Management* 160, 45-56.

North, D. (1990). *Institutions, Institutional Change and Economic Performance*. New York: Cambridge University Press.

Oates, W. E. W. Baumol (1975) "The Instruments for Environmental Policy", in *Economic Analysis of Environmental Problems*, ed. Edwin S. Mills, NBER, ISBN: 0-87014-267-4, 95–132.

Oh, J. and C. Yun (2014) "Environmental Kuznets curve revisited with special reference to Eastern Europe and Central Asia", *International Area Studies Review,* 17 (4), 359–374.

Orubu, C.O. and D.G. Omotor (2011) "Environmental quality and economic growth: Searching for environmental Kuznets curves for air and water pollutants in Africa", *Energy Policy* 39(7), 4178–4188.

Rodrik, D., Subramanian, A., and Trebbi, F. (2004). "Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development". *Journal of Economic Growth*, pp. 131-165.

Roodman, D. (2009) "How to do xtabond2: An introduction to difference and system GMM in Stata", *The Stata Journal*, 9 (1), 86–136.

Saboori, B., J. Sulaiman and S. Mohd (2016) "Environmental Kuznets curve and energy consumption in Malaysia: A cointegration approach", *Energy Sources*, *Part B: Economics, Planning and Policy* 11 (9), 861–867.

Sarkodie, A. S. (2018) "The invisible hand and EKC hypothesis: what are the drivers of environmental degradation and pollution in Africa?", *Environ. Sci. Pollut. Res*. 25, 21993 – 22022.

Sarzynski, A. (2012) "Bigger Is Not Always Better: A Comparative Analysis of Cities and their Air Pollution Impact", *Urban Stud*, 49 (14), 3121-3138.

Shahbaz, M., M. Mutascu and P. Azim (2013) "Environmental Kuznets curve in Romania and the role of energy consumption", *Renewable and Sustainable Energy Reviews* 18, 165–173.

Smulders, S., M. Toman and C. Withagen (2014) "Growth theory and 'green growth", *Oxf Rev Econ Policy,* 30 (3), 423–446.

Stern, D. I. (2004), "The Rise and Fall of the Environmental Kuznets Curve", *World Development* 32(8), 1419–1439.

Suri, V. and D. Chapman (1998) "Economic growth, trade and energy: implications for the environmental Kuznets curve", *Ecological Economics*, 25(2), 195–208.

Wang, S.S., D. Q. Zhou, P. Zhou and Q. W. Wang (2016), "The relationship between economic growth, energy consumption, and CO2 emissions: Empirical evidence from China", *Sci. Total Environ*. 542, 360–371 (Part A).

Zaman, K., M. A-el. Moemen (2017), "Energy consumption, carbon dioxide emissions and economic development: Evaluating alternative and plausible environmental hypothesis for sustainable growth", *Renewable and Sustainable Energy Reviews* 74, 1119 –1130.

Appendices

Table A1: List of countries.

South Africa	Congo, D. R.	Guinea	Mauritania	Seychelles
Algeria	Congo	Equatoriale Guinea	Mozambique	Sierra Leone
Angola	Côte d'Ivoire	Guinea-Bissau	Namibia	Somalia
Benin	Djibouti	Kenya	Niger	Soudan
Botswana	Egypt	Lesotho	Nigaria	Tanzania
Burkina Faso	Erythrea	Liberia	Uganda	Chad
Burundi	Ethiopia	Libya	Central African Republic	Togo
Cabo Verde	Gabon	Madagascar	Rwanda	Tunisia
Cameroon	Gambia	Malawi	Sao Tomé-et-Principe	Zambia
Comores	Ghana	Mali	Senegal	Zimbabwe

Table A2: Summary statistics.

VARIABLES	N	Mean	Standard deviation	Minimum	Maximum
CO2_mt_pc	1,243	1.032	1.992	0.0107	10.04
ln_CO2_ mt_pc	1,243	-1.164	1.485	-4.534	2.307
CO2_kt	1,246	18,460	62,616	33.00	503,112
CO2_kt_pc	1,247	0.00103	0.00199	0	0.0100
ln_CO2_kt	1,246	7.649	1.907	3.497	13.13
met_kt_eq_CO2	1,150	16,234	22,183	17.81	189,678
ln_met_kt_eq_CO2	1,150	8.658	1.827	2.880	12.15
nit_ox_thousands_mt_eq_CO2	1,150	9,602	16,898	6.202	172,723
ln_ nit_ox_thousands_tm_eq_CO2	1,150	7.833	2.062	1.825	12.06
Sum_Poll	1,250	42,169	81,417	82.64	590,903
ln_Sum_Poll	1,250	9.362	1.812	4.415	13.29
Sum_Poll_pc	1,247	0.00300	0.00474	3.02e-05	0.0750
Tot_ghg	1,128	12,518	61,074	-34.87	503,112
Tot_ghg_pc	1,175	0.000467	0.00165	-4.88e-05	0.00987
ln_Tot_ghg	1,032	4.779	2.436	-4.605	13.13
gdppc_2010	1,166	2,000	2,884	161.8	20,334
ln_ gdppc_2010	1,166	6.965	1.042	5.087	9.920
gdppc_curr	1,201	1,584	2,627	102.6	22,742
ln_ gdppc_curr	1,201	6.630	1.114	4.631	10.03
gdppc_ppp_2011	1,166	4,246	5,670	354.3	40,016
ln_ gdppc_ppp_2011	1,166	7.808	0.966	5.870	10.60
Polity2	938	0.200	5.205	-9	10
CC	773	-0.655	0.595	-1.869	1.217
GE	771	-0.768	0.606	-2.446	1.020
PS	772	-0.537	0.922	-3.315	1.282
RQ	772	-0.729	0.622	-2.645	0.804
RL	772	-0.732	0.633	-2.606	1.044
VA	772	-0.645	0.707	-2.226	0.970
GOUV	773	-0.677	0.601	-2.449	0.880

Source: Author.