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THE IMPACT OF ENVIRONMENTAL DEGRADATION ON TECHNOLOGICAL INNOVATION IN THE CONGO BASIN

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ABSTRACT

Environmental issues have gradually become the primary concern of all countries in the world, and have developed all kinds of environmental controls and policy standards, at the same time, the concept of green consumption and environmental protection are increasingly popular, in this paper, Based on the panel data gotten from WDI 2020,we examined the effects of Environmental degradation on Technological innovations in the Congo basin using the Pooled Mean Group (PMG) method of estimation, we find out that, environmental degradation positively contributes to technological innovation. This therefore highlights the urgency for the government of the respective countries of the Congo basin to strengthen environmental policies so as to benefit from environmentally friendly technologies.

Keywords: environmental degradation, technological innovation, PMG model, Congo basin, CO2 emissions.

INTRODUCTION

Economic activity promotes wealth creation but has an impact on technological innovation. The production systems currently used in many countries generate vast quantities of waste and contamination, causing degradation to natural resources. But there is evidence that technological innovations may bring social benefits, while producing negative effects on the environment.

The growth in technology transfer across the world especially in the 21st century has greatly impacted various sectors of the economy across countries around the world. For example, the rise in technology has brought about growth in cross-border trade, investment, and so on. Technological progress is the engine of growth in any country. However, to sustain this growth,

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appropriate research and development (R&D) needs to be considered, which can be facilitated by channeling resources (financial and otherwise) and infrastructural development to enhance technological diffusion. This leads to some pertinent questions for Africa especially with little resources being available for R&D. for instance, the average public expenditure for R&D as a percentage of total public expenditure in African countries is less than 1% (World Development Indicators, 2010).

According to endogenous growth theory, research and development (R&D) expenditures can boost economic productivity and natural resource rents (NRR) utilization, however, the involvement of Technological Innovation in environmental sustainability, is uncertain Aghion and Howitt (1992).The past two decades witnessed a heightened concern over environmental degradation. Of the various options open to society to reduce the environmental burden, technology is widely considered as the most attractive option. Whether technology alone will be sufficient to achieve an environmentally sustainable future is unclear. This will depend on public and private support for environmentally beneficial technologies and the extent to which further growth in world population and economic output will compromise per capita emissions reductions and a more efficient use of natural resources. However, there has been tremendous pressure on the environmental resources to produce more food for growing population that in turns cause to deplete natural resources raising air and water pollution, deforestation, soil erosion, overgrazing and damage to marine and coastal ecosystem. Since CO2 is the principal greenhouse gas responsible for the environmental degradation and climate change; its regulation thus becomes a very important intergovernmental question (Talukdar & Meisner, 2001). Such a study will lead to the proposal of a plan of convergence of the CO2 emissions for countries of the Congo Basin.

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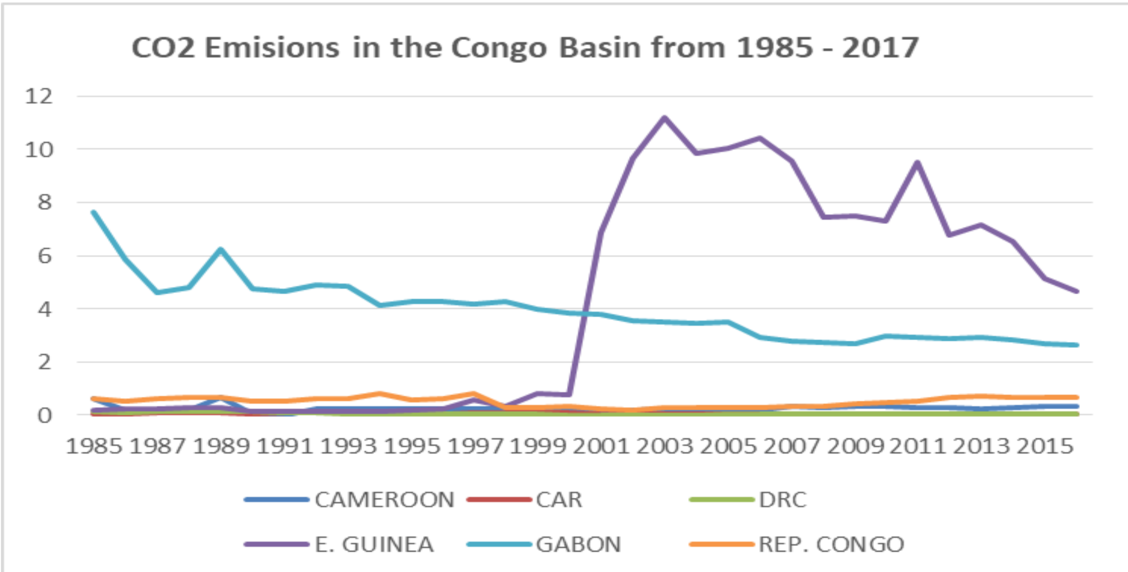
Figure 1: The evolution of CO2 emissions in metric tons per capita in the congo basin from 1985 to 2016



Source : Author from WDI 2020

Technological Innovation and some Stylized Facts

The production frontier can be enhanced by the efficient diffuse on of technologies (Ekekwe, 2010; Osabuohien, 2010). Technological development involves the process of adopting new innovations in order to enhance productivity. It is the ability of technology having a wider impact on the economic society through its application by the larger population. Furthermore, technological progress is the acceptance of an innovation and the usage of same to enhance human activities in the society. The process of acceptance and usage of technology in the society largely depends on the involvement of the society in adequate R&D, which aids dissemination of innovations to the needed segment of the society.

The innovation of appropriate technology is the distinguishing factor between the growth capacities of various countries. The African region is not an exception, which has been known to be amongst the slow growth regions of the world, with rising number of poor populaces. According to UNCTAD 2010, the poverty rate for Africa in the period 1996was the highest (48.5%), compared to other regions such as the Asian and Oceania region of 38.9% poverty rate; the Latin America and the Caribbean region had 0.9% poverty rate and the transition economies (like Brazil) was 6.5% while the developed Europe region poverty rate of 1%. In 2005, the

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poverty rate reduced; Africa barely witnessing a reduction to 42.5%, the Asia and Oceania region reduced to 26.1%, the Latin America and the Caribbean was 8.1%, and the transition economies and the developed European region was 5.1% and 0.2%, respectively.

Adequate technological innovation can give rise to new economic activities, thereby enhancing the economic development. It also enhances industry in their production process and thereby reduces poverty incidence (United Nations, 2010). Extant literature has asserted that the difference in the growth of various countries around the world cannot be separated from the existence of adequate research and development which can be translated into appropriate technology. As noted by Mukoyama (2003), apart from innovation spurred by R&D translating into technology development, technological innovation or diffusion is as well sensitive with regards to the subject matter. Therefore, the technological development process is as crucial as

The aim of this work is to analyze the effects of technological innovation on environmental pollution in the Congo basin by using an econometric model. We take into account dynamic effects, the time series properties of the data and the presence of heterogeneity in the sample. We specify a model in which CO2 emissions are related with technological innovations among other variables. The study involves the six countries of the Congo basin region and the results might show important disparities between these countries.

LITERATURE REVIEW

Generally, Environmental control has two opposite effects on technological innovation. When environmental costs are high, environmental protection hinder technological innovation of enterprises, and when enterprises actively seek ways to improve the level of pollution treatment, environmental regulations promote technological innovation of enterprises.

The government's regulation of pollution behaviour in the production and operation of enterprises through environmental regulations will have certain effects on the economic behavior of regulated enterprises. In order to meet the environmental standards set by the government, regulated enterprises will take certain measures on their own initiative, such as strengthening investment in environmental protection. The implementation of such measures will additionally increase the environmental costs of the enterprise, resulting in two types of costs: explicit and hidden. The former includes direct costs and indirect costs. Direct costs are the passive expenditures of enterprises, such as pollution taxes paid and fines paid in violation of environmental regulations. Indirect costs are the active expenditures of enterprises, such as the cost of purchasing environmentally-friendly production equipment to reduce pollution, and the costs of transferring pollution-intensive industries to weakly regulated areas. The latter refers to

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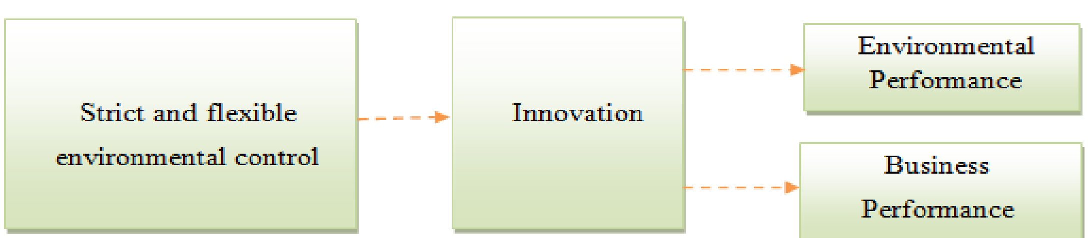
the decline of corporate image and the generation of opportunity costs due to moral hazard due to pollution discharge and negative pollution control. It can be seen that with the strengthening of environmental pressures, these costs of companies responding in a negative way will increase. Higher environmental costs have squeezed the company's productive costs and technological innovation investment, which has a negative effect on the daily production activities and technological research and development behavior of the enterprise, thereby inhibiting the company's technological innovation and improvement in production efficiency.

Environmental control such as technological standards, environmental taxes, or tradable emissions permits force firms to allocate some inputs (labour, capital) to pollution reduction, which is unproductive from a business perspective. Technological standards restrict the choice of technologies or inputs in the production process. Taxes and tradable permits charge firms for their emissions pollution, a by-product of the production process that was free before. These fees necessarily divert capital away from productive investments.

This traditional paradigm was challenged by a number of analysts, notably Professor Michael Porter (Porter 1991) and his co-author Claas van der Linde (Porter and van der Linde 1995). Based on case studies, the authors suggest that pollution is often a waste of resources and that a reduction in pollution may lead to an improvement in the productivity with which resources are used. More stringent but properly designed environmental regulations (in particular, market-based instrument such as taxes or cap-and-trade emissions allowances) can "trigger innovation [broadly defined] that may partially or more than fully offset the costs of complying with them" in some instances (Porter and van der Linde 1995, 98).

Figure 2summarizes the main causal links involved in the Porter's theory. As Porter and van der Linde first described this relationship, if properly designed, environmental regulations can lead to "innovation offsets" that will not only improve environmental performance, but also Partially and sometimes more than fully offset the additional cost of regulation.

Figure 2: graphical representation of the Porter Theory



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Porter and van der Linde go on to explain that there are at least five reasons that properly crafted regulations may lead to these outcomes:

- First, environmental regulations signal companies about likely resource inefficiencies and potential technological improvements.
- Second, regulation focused on information gathering can achieve major benefits by raising corporate awareness.
- Third, regulation reduces the uncertainty that investments to address the environment will be valuable.
- Fourth, regulation creates pressure that motivates innovation and progress.
- Fifth, regulation levels the transitional playing field.

The Porter Hypothesis (PH) has met with great success in political debate, especially in the United States, because it contradicts the idea that environmental protection is always detrimental to economic growth. The PH has been invoked to persuade the business community to accept environmental regulations, as it may benefit from them in addition to other stakeholders. In a nutshell, well-designed environmental regulations might lead to a Pareto improvement or “win–win” situation in some cases, by not only protecting the environment, but also enhancing profits and competitiveness through the improvement of the products or their production process or through enhancement of product quality.

Also,Julian Simon and Gunter Steinmann growth theory (1977), states that the greater the population, the greater the level of technological growth yielding the greater the per capita income. An idea derived from Boserup (Simon 1977), which Simon refers to as the *Population Push model*, and distinguishes between current knowledge and knowledge being applied for production. Underlying the population push model of technological development is the added idea that technology can and does develop independent of population growth (learning-by-doing) and therefore technology builds upon itself, reconciling the pull and push models of technological progress. So even in the case of a static population, there will be some level of technological advancement, albeit slower than in situations of growing population. It is just necessity remains the mother to, and is the primary force behind, invention. This technological progress function is added to the Douglas-Cobb production function to produce a model containing endogenous technological progress based on population growth and learning by-doing. One other aspect of note in his model is that labour supply and population are used synonymously as he dismisses the impact of age-structure and dependency ratio on economic growth as minimal to the effect of the savings rate. He uses Japan and the US as an example of the disparity between savings rate and the effect it has on output (Simon 1977).The results of the

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model yield modest per capita economic growth at equilibrium and Simon determines that maximized long term economic growth (always in per capita terms unless otherwise noted) requires population growth and rate of savings with a low discount rate. At a higher discount rate there was still increased consumption. This population growth rate, he makes clear, is higher than the rate that produces the highest adoption of technology (Simon 1986). Any growth that occurs too fast will have diminishing return or create a circumstance where is stagnating. As well, modest negative population growth will have the effect of limiting growth but large negative out flows in population will stagnate growth outright. The level of total technology (available and in use) never decreases since this is, in his estimation, illogical. (Simon 1986).

The current scholars' research conclusions on the impact of environmental pollution on technological innovation are inconsistent. The most representative viewpoints are as follows: The first viewpoint is that strengthening environmental regulation will inhibit technological innovation.

Gray used the American manufacturing industry as a sample from 1958 to 1978. It was empirically found that the increase in pollution control costs has reduced the total factor productivity (TFP) of the manufacturing sector, of which 30% was caused by environmental controls.

Jaffe et al. proposed that environmental control will produce a "crowding effect". In order to meet the relevant environmental requirements, enterprises must invest a lot of material, money, human and technical resources in pollution control or pollution reduction, thereby crowding out investment in production and operation, which is not conducive to the improvement of production technology.

Kneller et al. Used the British manufacturing industry from 2000 to 2006 as a research sample to conduct an empirical test on this "crowding effect" of environmental regulation.

The second view is that strengthening environmental regulation is conducive to promoting technological innovation. This view is based on the "Porter Hypothesis", believes moderate environmental regulation can stimulate technological innovation, improve production efficiency, and offset the costs that environmental regulation may bring. In the long run, the industry's technological innovation capability and international competitiveness can be improved.

Miao Miao et al. empirically analyze the relationship between environmental regulations, financing constraints and corporate technological innovation. The results show that the local government's efforts to strengthen environmental regulations can significantly enhance the

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innovation ability of enterprises, which is specifically reflected by the increase in Research and development (R & D) investment.

Zhao Hong (2007) found that environmental regulation has a significant positive effect on the R&D expenditure and the number of patent applications lagging behind 3 periods. For every 1% increase in the intensity of environmental regulation, R&D expenditure increases by 0.19%, indicating that environmental regulation has a significant impact on technological innovation in the medium and long term. To some extent, the "Porter hypothesis" has been partially confirmed in China.

The third view is that the impact of environmental controls on technological innovation is uncertain. For example, some scholars found that the impact of environmental control on technological innovation is different in different industries or regions, Li Ping et al (2013). Some scholars found that the relationship between the two shows a "U"-type dynamic trend, that is, before the intensity of environmental control reaches the inflection point, the "innovation compensation" effect has not yet been realized; after the inflection point value, it will significantly promote technological innovation Zhang Cheng et al (2011). Some scholars have found in evidence that there is an inverted "U"-type characteristic of the relationship between the two effects Li Jing et al (2013).

METHODOLOGY

To achieve the objective of this work, descriptive and empirical analyses were engaged based on technological innovation variables. The related variable engaged in the study as proxy for technological innovation include: industry value added. This variable is used to understand the effect of technological innovation on the promotion of economic progress in the Congo Basin. The role of technological innovation in the economic progress (real per capita GDP-RPGDP and Output per worker) in the Congo Basin is hinged on the mathematical Solow (1957) growth model to illustrate the growth processes in a country, where growth is a function of the combined influence of labour and capital. The Solow growth model is mathematically expressed as thus;

$$Y = (AL^{\alpha}K^{1-\alpha}) \quad \text{....... (1)}$$

Where Y is a measure of growth-economic progress and L represents labour inputs, K capital inputs and A is a parameter that reflects the level of Technology or total factor productivity. Hence, the empirical model is proposed to examine the relationship between technological innovation and economic progress, as a result we therefore say that, Technological Innovation depends also on the measures of Environmental Quality (CO2 emissions). This implies

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$$\boldsymbol{Tchinno = f(CO2, K, U)} \ldots\ldots\ldots (2)$$

In its explicit form equation (2) can therefore be written as follows:

$$\boldsymbol{Tchinno_{it} = \beta_{0i} + \beta_1 CO2_{it} + \beta_2 K_{it} + \varepsilon_{it}} \ldots\ldots\ldots (3)$$

Where:

$\boldsymbol{Tchinno}$representsTechnological innovation captured by Industry value added (INDVA), **CO2** represents Carbon dioxide emissions used to capture the quality of the environment, $\boldsymbol{K}$is other control variables include; Gross Domestic Product per capita (GDP), Trade Openness (TradeOpen)**,** In the last decades it has been observed a gradual displacement of dirty industries from developed countries to the underdeveloped economies. This phenomenon called Pollution Heaven Hypothesis (PHH) occurs because of less stringent environmental regulation in low- and middle-income economies, which allows them to have a competitive advantage by being able to set lower prices for the goods produces, since no cost like the environment cost is taken into consideration, $\boldsymbol{\beta_{0i}}$is the Intercept of the model while$\boldsymbol{\beta_{1\ldots,\ldots t}}$represents the Coefficients of the independent variables, expected to reflect the sign and magnitude of influence of the individual independent variables on the respective indicators of the model and$\boldsymbol{it}$is the Individual country and the period identifier (i.e. i =6, t=34, 1985-2019).

Following the empirical literature (Abosedra et al., 2009; Narayan and Smyth, 2009; and Sebri and Abid, 2012), it is plausible to form the long-run relationship between Technological innovationandCO2in linear form, with a view of testing the long-run, short-run and causality relationships between these variables in the Congo Basin as clarified in equation 4 above. Pesaran et al. (1999) suggest that for a cross-section and a dynamic panel, panel regression and an error correction model can be combined by applying an Auto Regressive Distributive Lag (*ARDLp q,*) as follows:

$$\boldsymbol{Tchinno_{i,t} = \varphi^i\left[Tchinno_{i,t-1}\left\{\beta_0^i + \beta_1^i CO2_{i,t-1} + \beta_2^i K_{i,t-1}\right\}\right] + \sum_{j=1}^{p-1} \gamma_j^i Tchinno_{i,t-j} + \sum_{j=0}^{q-1} \delta_j^i \Delta CO2_{i,t-j} + \sum_{j=0}^{q-1} \delta_j^i \Delta K_{i,t-j} + \mu_i + \varepsilon_{it}} \ldots\ldots \textit{(4)}$$

Where $\boldsymbol{Tchinno}$represent Technological innovation,δ and γ respectively represents the short-term coefficient of the lagged independent and dependent variable, β represents the long-term coefficient, p and q represents respectively the lagged dependent and independent variable, φ is the coefficient of the speed of adjustment towards the long-term equilibrium, $\varepsilon_{it}$the error term.

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Estimation Technique

Numerous studies have used Engle and Granger (1987) and Johansen and Juselius (1991) and Johansen (1991) techniques to test the co-integration between economic variables. These techniques oblige that all regressors in the system must be stationary with the same order of integration. Pesaran et al. (2001) has developed a model to introduce a delegate co-integration technique known as ARDL bound testing approach which has many advantages over the previous co-integration techniques (Pesaran et al., 2001; Ghatak and Siddiki, 2001; Jayaraman and Choong, 2009; Ozturk and Acaravci, 2011; Bekhet and Al-Smadi, 2015):

RESULTS AND DISCUSSION

Table 1: Descriptive statistics

Variable	Observations	Mean	Std. Dev	Min	Max
CO2	210	1.376163	2.459503	0	11.20397
GDP	210	1.013948	13.26376	-36.55682	140.3708
TradeOPEN	210	64.25775	39.92406	0	156.8618
ForeignDI	210	5.668898	15.52444	-8.70307	161.8238
GrossFCF	210	19.69876	13.55962	0	79.46179
FinalCE	210	61.54432	31.39822	0	102.1948
MineralR	210	1.117962	3.523287	0	19.50502
PopGrowth	210	2.909139	.7896997	.2594899	6.018169
ControlofCorrupt	210	-.6874792	.6297539	-1.826361	0
GovernmentEff	210	-.7022354	.6745474	-1.884151	0

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Political Stability	210	-.500717	.8285725	-2.844653	.6365217
RegulatoryQuality	210	-.6339553	.6326758	-2.297536	.175352

Source: Author from STATA 15

According to the descriptive statistics, (table 1) the environmental control variable(CO2) averagely contributes 1.376163% to the Technological Innovations and having a maximum effect of 11.20397% whereas other variables like Gross Domestic Product (GDP) averagely contributes **1.013948**% to the environmental degradation and having a maximum effect of 140.3708% and Foreign Direct Investment (FDI) averagely contributes 5.668898% to environmental degradation in the six countries of our study with a maximum value of 161.8238%

Before estimating the PMG we determine the integration of our different variables because to use a PMG no variable of the model must be integrated of order 2 or I(2). But before we proceed with the PMG test, we will first of all carryout the Im-Pesaran-Shin Unit root test as shown in Table 2

Table 2: Im-Pesaran-Shin Unit root test

Variables	Im-Pesaran-Shin								Decision
	LEVEL				DIFFERENCE				
	Constant		Constant + Trend		Constant		Constant + Trend		
	Stat	P. Value	Stat	P. Value	Stat	P. Value	Stat	P. Value	
INDVA	-1.0193	0.1540	-0.5458	0.2926	-7.0846	0.0000	-5.4495	0.0000	I(1)
CO2	-1.9399	0.0262	-3.2706	0.0005	-11.6543	0.0000	-10.7569	0.0000	I(0)

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GDP	1.4899	0.9319	1.6046	0.9457	-7.4107	0.0000	-6.3117	0.0000	I(1)
TradeOpen	-0.0957	0.4619	0.2652	0.6046	-8.4441	0.0000	-7.2573	0.0000	I(0)
ForiegnDI	-0.7220	0.2351	-1.4476	0.0739	-11.1861	0.0000	-10.0398	0.0000	I(1)
GrossFCE	-1.9023	0.0286	-3.3498	0.0004	-9.7099	0.0000	-8.4953	0.0000	I(0)
FinalCE	-2.5873	0.0048	-2.6559	0.0040	-11.6437	0.0000	-11.1760	0.0000	I(0)
MineralR	-2.1430	0.0161	-0.2585	0.3980	-6.5582	0.0000	-4.7458	0.0000	I(0)
PopGrowth	-11.6522	0.0000	-12.6725	0.0000	-11.7521	0.0000	-11.2609	0.0000	I(0)
ControlofC	-1.9366	0.0264	-0.0067	0.4973	-7.9230	0.0000	-6.4866	0.0000	I(0)
Gov'tment	-0.4894	0.3123	2.0077	0.9777	-8.7490	0.0000	-7.7080	0.0000	I(1)
PoliticalSty	0.2532	0.6000	3.2687	0.9995	-8.2405	0.0000	-7.2016	0.0000	I(1)
ReguQty	-0.9404	0.1735	0.5885	0.7219	-9.9022	0.0000	-8.8112	0.0000	I(1)
Note: *I(1) and I(0) signifies stationary at first difference and at level respectively*									

Source: Author from STATA 15

From our results above (Table 2), we realized that most of the variables are stationary at level except for Industrial Value Added, Gross Domestic Product and Foreign Direct Investment, Government Effectiveness, Political Stability and Regulatory Quality which are stationary at first difference.

3.2- Panel Cointegration tests

Table 3: Kao Cointegration Test results

	Statistics	P. Value
Modified Dickey-Fuller t	**-2.0209**	**0.0216**
Dickey-Fuller t	**-1.3164**	**0.0940**
Augmented Dickey-Fuller t	**-1.2903**	**0.0985**

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Unadjusted modified Dickey-Fuller t	**-2.1046**	**0.0177**
Unadjusted Dickey-Fuller t	**-1.3503**	**0.0885**

Source: Author from STATA 15

Table 3 represents the result of Koa cointegration test. (see appendix 1, Pedroni cointegration test) These tests or results significantly reject the null hypothesis of the absence of cointegration at various levels of significance**.** Therefore, it can be confirmed that the variables in our equation move together especially in the long run. This is to say; after allowing for country specific effects, there is a relationship between the variables used in the study and that Environmental Control affect Technological Innovations in the Congo basin Countries. Our next step will therefore be to estimate the magnitude of such variables on Technological Innovations by using the panel ARDL technique

Table 4:Pooled Mean Group (PMG) estimation results for CO2 Emissions on Technological Innovation, Short run estimates.

Model 1, dependent variable: Techninno. (PMG estimation)						
Countries / Variables	Cameroon	CAR	DRC	Eq. Guinea	Gabon	Rep. Congo
CO2	**4.780077*** (3.759989)**	-18.69884 (35.75024)	30.52431 (115.8533)	**-1.348529** (.6408373)**	**1.537365*** (1.536271**)	-4.256522 (5.246987)
GrossDP	**-.694994** (.3435836)**	**-.3664576*** (.1127876)**	**.8731095* (.6734653)**	-.1401479 (.1321653)	-.109665 (.2509072)	**6304174*** (.2195705)**
FinalCE	.0043735 (.09263)	.0889766 (.1702589)	**-.2011027** (.1587797)**	**-.2788992*** (.0843528)**	**-.2448938* (.1309173)**	-.0912095 (.08746)

GDP2	**-.0557589** (.0270486)**	-.0008131 (.006373)	.0228199 (.0403159)	.0018551 (.0011974)	-.0097641 (.0197928)	**-.0329827 (.0212823)**
TradeOpen	**.1366901* (.1032386)**	-.0193842 (.0998737)	.0437729 (.1269642)	**-.0728598* (.04126)**	**.0875582* (.1223384)**	-.029224 (.0550683)
MineralR	31.44722 (40.88536)	20.49024 (18.68285)	.6904277 (.5987482)	**78.76728* (43.09529)**	-75.93512 (50.30976)	-2.089409 (3.977519)
PoliticalStability	**5.407788* (2.936987)**	**13.16227*** (2.111724)**	6.599107 (7.075074)	-1.524431 (4.358845)	-2.219029 (6.113322)	**6.554836* (3.852546)**
Government EffecTiveness	-4.09528 (7.065611)	-6.573762 (5.032088)	-13.16522 (10.62288)	-10.06342 (10.37827)	-9.163775 (6.132232)	-.7497007 (12.062)
Regulatory Quality	-3.820985 (7.286622)	-9.834757 (6.938542)	.8427864 (9.913582)	11.15872 (8.552636)	**15.14005** (6.277755)**	-3.594099 (10.85547)
_cons	.3349412 (.7356978)	1.810081 (.6939766)	1.100156 (1.492312)	-2.131014 (1.359786)	1.551577 (1.557355)	1.149031 (1.00464)
ECT	**-.57512*** (.1248822)**	**-.9786795*** (.1180077)**	**-.641449*** (.1849068)**	**-.6131344*** (.143815)**	**-1.043981*** (.1603674)**	**- .6736564*** (.156189)**

Note: ***, **, * represent 1%, 5% and 10% respectively, (.) represent the standard error; CAR and DRC representCentral Africa Republic and Democratic Republic of Congo respectively.

Table 5:Pooled Mean Group (PMG) estimation results for CO2 Emissions onTechnological Innovation, Long run estimates.

D.Techninno	Coef.	Std. Err	z	P>|z|	[95% Conf. Interval]	
ECT						
CO2	.6089942	.320175	1.90	**0.057**	-.0185372	1.236526

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GDP	.7263516	.1015484	7.15	**0.000**	.5273205	.9253828
FCE	.416789	.1195764	3.49	**0.000**	.1824236	.6511545
GDP2	-.0072341	.0013222	-5.47	**0.000**	-.0098256	-.0046426
PoliticalStability	-2.745559	1.285313	-2.14	**0.033**	-5.264726	-.2263912
GovernmentEffectiveness	11.40912	4.067509	2.80	**0.005**	3.436952	19.38129
RegulatoryQuality	-8.039773	3.7866	-2.12	**0.034**	-15.46137	-.6181733
ControlofCorruption	-.5612192	2.798626	-0.20	0.841	-6.046425	4.923987

Source: Author from STATA 15

Econometric and economic interpretations

The objective of this paper is to evaluate the impact of Environmental Degradation on Technological Innovation in the Countries of the Congo basin. This objective is examined using the results in table 4 and 5which enables us to study the impact of the various variables retained in our study on Technological Innovation according to their levels significance. Our model is comprised of nine variables. The results gotten using the PMG method shows that in the short run the variable, Environmental Degradation (CO_2) is significant in three of the six countries of our study. Other variables such as Gross Domestic Product (GDP) is equally significant in four of the six countries of our study, Final Consumption Expenditure (FinalCE) and Trade Openness (TradeOpen) are significant in three countries in the Congo basin.

In the long run (table 5) these variables greatly affects Technological innovation at various levels of significance except for control of corruption which is not significant. The significant of these variables means that these variables explain the dependent variable Technological innovation both in the short and long run. Since we considered industry value added as a proxy for Technological innovation, this means that these variables are considered as playing a greater role on Technological innovation in the area of our study.

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More precisely, the Carbon dioxide emissions (CO_2) which is used as a proxy for the quality of the environment is positively significant in Cameroon, Gabon and negatively significant in Equatorial Guinea in the short run. This positive relationship signifies that both CO_2 and technological innovation move in the same direction, hence a unit increase in CO_2 will lead to a considerable increase in Technological innovation in these countries of the Congo basin. This may be due to the fact that, when there is an increase in environmental degradation, people will develop innovative technologies that will help to reduce environmental pollution. In the long run we also have the same relationship between technological innovation and CO_2, hence, CO_2 with a coefficient = .6089942and a p-value = 0.057 indicates that it is positively significant at the 10% threshold level. This positive relationship signifies that both CO_2 and Technological innovation move in the same direction, thus a 1% increase in CO_2 will lead to 60.9% increase in Technological innovation in the Congo basin. This result is in line with the Boserupian theory where she suggested that population growth and resulting increase in population density induce technological changes, Désiré A. et al (2020) equally found a direct positive effect between technologies and CO_2 emissions in sub-Saharan Africa.

Again, GDP in the short run significantly affect Technological innovation in four of the six countries of our study, Cameroon, CAR, DRC and Republic of Congo. With a negative significant impact on Technological innovation in Cameroon and CAR and a positive effect in DRC and the Republic of Congo. This result is explained by the fact that GDP occupies a significant weight in the country's economy since it is the overall output of goods and services in a given period of time and the result is in line or compatible with the work of Akin (2014). While in the long run with a p-value of 0.000 and a coefficient of .7263516 it simply implies that GDP is positively significant at the 1% threshold level. This positive relationship signifies that both GDP and Technological innovation move in the same direction in the long run and therefore an increase in GDP by 1 unit will lead to an increase in Technological innovation by 72.64% in the Congo basin.

We equally realized that trade openness (TradeOpen) on its part is statistically significant in three of the six countries in our study, Cameroon and Equatorial Guinea and Gabon in the short run. In Cameroon and Gabon, Trade Open is positively significant at 10% significant level which implies that a unit increase in international trade would result to a significant improvement in technological innovation. This result indicates that trade liberalization does not necessarily lead into the migration of polluting industries from developed countries to the developing countries which are less intransigent in terms of environmental protection, but can lead to the transfer of technology between countries.

Finally, we realized that, the quality of the institutions also plays an important role in the advancement of technological innovation. This is explained by the fact that in the short run, political stability significant contribute to technological innovation in three out of the six countries of our study, (Cameroon, CAR and the Republic of Congo) while regulatory quality also has a significant contribution to technological innovation in Gabon. The outcome from the regressions shows that in the short run, the variables are positively significantly on technological innovation at various levels of significance during the time frame under consideration. In the long run the quality of institution (Political stability, Government effectiveness and Regulatory control) equally explains the technological innovation at different significant level in the Congo Basin. This is in line with the works of Edinaldo et al where they examined the relationship between innovations and institutional quality and realised that, the control of corruption, market-friendly policies, protection of property rights and more effective judiciary system boost an economic rate of innovation. Also Romer (1990), Aghion and Howit (1992), Grossman and Helpman (2001) equally show that institution impact innovation.

Robustness checks

To verify the robustness of our results, the Fixed Effects (FE) estimation, the Random Effect (RE) and the Driscoll-Kraay standard error of estimation will be applied. Indeed, several works have shown that the FE method is very important in explaining the problems that undermine environmental degradation. Thus, it would be wise to take it into account in our study to verify whether environmental degradation affects technological innovation and equally to check if our results remain robust after the Implementation of the FE estimation, RE estimation and the Driscoll-Kraay standard error of estimation (Table 6).

Table 6: Estimate for CO2 Emissionson Technological Innovation FE, RE and DRISCOLL-KRAAY regression

MODEL / VARIABLES	DRISCOLL-KRAAY Dependent variable Techninno		FIXED EFFECT (FE) Dependent variable Techninno		RANDOM EFFECT (RE) Dependent variable Techninno	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
CO2	**-.5537575*****	.1736571	**-.458209***	.2646256	**-.5537575*****	.1881547

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GrossDP	**.7716173*** **	.1190846	**.7853101*** **	.0663049	**.7716173*** **	.0657344
TradeOpen	**.0461261*** **	.0152637	**.0600765*** **	.019608	**.0461261*** **	.0123996
ForeignDI	**-.1544379*** **	.0264035	**-.1284707*** **	.0347578	**-.1544379*** **	.0323756
FinalCE	**.1165097** **	.0527434	**.1067235** **	.0607534	**.1165097** **	.0588944
GDP2	**-.0055676*** **	.0009006	**-.0055494*** **	.0005685	**-.0055676*** **	.0005629
GovernmentEffvenness	1.773986	1.7982	2.635569	2.967186	1.773986	2.653535
RegulatoryQuality	-2.667373	1.933373	-3.331905	3.141832	-2.667373	2.846719
_cons	-1.160013	1.152287	**-2.14358***	1.128017	-1.160013	.8935477
Prob > F = 0.0000 R-squared = 0.4900			Prob >F = 0.0000 F(8,196) = 24.73		Prob > chi2 = 0.0000 Wald chi2(8) = 193.12	

Source: author using STATA

Results Interpretations

The three regression methods above (FE), (RE) and the Driscoll-Kraay standard error of estimation produce very similar result for each variable although at different significant levels and equally vary slightly in terms of their magnitudes. Here we realized that using the fixed effects estimation, Carbon dioxide emissions(CO_2) is significant at 10% threshold, with a negative impact on Technological innovations, implying that there is an indirect relationship between CO_2 and Technological innovations in the Congo basin. Also, foreign direct investment (ForeignDI) and the square of gross domestic product (GDP2) are significant at 1% level with negative impact on Technological innovations. This indicates that a unit increase in each of these variables will cause a drop in Technological innovations in the Congo Basin. But other variables such as gross domestic product (GDP), trade openness (TradeOpen) are significant at 1% significant level, with a direct relationship with Technological innovations. This indicates that a unit increase in each of these variables will lead to an increase in Technological innovations in the Congo Basin.

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However, using the Driscoll-Kraay standard errors estimation that are more robust to cross sectional and temporal dependence, we equally finds almost similar result for each variable to that of the fixed effects estimations but with different significant levels and their magnitudes. More precisely, looking at (CO2) variable which is our proxy for the quality of the environment, foreign direct investment (ForeignDI) and the square of GDP (GDP2) are all negatively significant at 1% threshold, showing an indirect relationship between these variables and technological innovations. It therefore implies that a rise in CO2, ForeignDI and GDP2 by one unit will lead to a decrease in technological innovations in the Congo Basin. While gross domestic product (GrossDP), Trade openness (TradeOpen) and Final consumption expenditures (FinalCE) shows a direct relationship between these variables and technological innovations at different significant threshold. With this positive significant, it simply implies that a 1% increase in these variables will lead to an improvement in technological innovations in the Congo Basin.

Finally, The Random effect method equally shows a similar result as that of the fixed effect and the Driscoll-Kraay estimation methods of the same variables but at different significant threshold. Here the CO2 emissions and technological innovations move in opposite direction. .It therefore implies that a rise in CO2 in the Congo Basin region will lead to a reduction in technological innovations. However, other variables such as Gross domestic product, trade openness and final consumption expenditure positively affect technological innovation at different significant level, implying that a rise by one unit in these variables, will lead to an improvement in technological innovation in the Congo Basin region.

Conclusion

According to the theoretical analysis, environmental control may effect technological innovation positively or negatively. This article uses data gotten from WDI 2020 statistical data for empirical research, uses industry value added to measure technological innovation level, and carbon dioxide emissions as explanatory variables to perform regression. The empirical results from the PMG estimates all show the positive impact of environmental control on the level of technological innovation.

To verify the robustness of our results, we used other alternative estimation namely the fixed effects (FE) estimation and the Driscoll-Kraay standard error estimation method to see whether our result remain robust. However, we got very similar result for each variable although at different significant levels and equally vary slightly in terms of their magnitudes. These variables are therefore considered as the factors affecting technological innovation in the Congo Basin.

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Hence, when formulating environmental protection policies, the government should not only consider controlling environmental pollution, but also consider whether the environmental policies introduced can encourage enterprises to carry out technological innovation and enhance. For example, the government should increase the fines for environmental pollution, increase environmental protection subsidies, give full play to the positive role of environmental protection laws and systems in increasing environmental protection investment behavior of enterprises, establish appropriate reward and punishment measures, actively reward green output, and combine incentives and punishments to stimulate enterprises technological innovation and enhances competitiveness, thereby increasing economic performance, and promoting the comprehensive and coordinated development of enterprises.

Enterprises should also actively cooperate with relevant environmental rules issued by the government, make reasonable use of national incentive policies, increase investment in green technology innovation, improve environmental issues, reduce unnecessary waste of resources, achieve optimal allocation of resources, and increase labor production efficiency and improve innovation.

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