TESTING THE ENVIRONMENTAL KUZNETS' CURVE HYPOTHESIS: EXPERIENCE FROM TANZANIA

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Abstract

The recent environmental concerns have compelled researchers to find out the relationship between economic growth and environmental degradation. There have been concerns that countries grow economically at the expense of the environment while others argue that greater levels of economic growth facilitate the application of environmental friendly technologies and better abatement technologies. This study investigated the existence of the Environmental Kuznets Curve (EKC) in Tanzania. This is a hypothesized relationship between economic growth and environmental degradation. The specific objectives of the study were first, to analyse the economic growth related determinants of the per capita Carbon Dioxide (CO_2) emissions and second to analyse the long term relationship between per capita Carbon Dioxide (CO_2) emissions and economic growth. The study made use of time series data for 10 years from 2008 to 2017. The variables estimated were per capita Carbon Dioxide (CO_2) as the dependent variable while The Income per capita (GDP), Income per capita squared (GDP^2), Energy Consumption (EC), and Foreign Direct Investment (FDI) were used as independent variables. In estimating this relationship, the study made use of the Autoregressive Conditional Heteroscedasticity (ARCH) model. The results from the study show that the EKC exists for the case of the tested variables in Tanzania. Lastly the study recommends that the country can still utilize environmental resources for more development but this should be coupled with efforts to use environmental friendly technologies so that the country can attain a quick U turn in the environmental degradation-economic growth relationship.

Keywords: Environmental Kuznets Curve; Environmental pollution; Economic growth; Econometric model

1.1 Background of the Study

As countries are struggling to fight against poverty through attaining sustainable economic growth, there has been a steady increase in the exploitation of natural resources coupled with a tremendous degradation of the natural environment. However, studies have shown that, there is an inverted "U" shape relationship between economic growth and the level of environmental degradation(Mosheim, 2013; Siniscalco, 1993). In Literature, this relationship has been referred to as the Environmental Kuznets Curve (EKC),(Stern, 2004; Mosheim, 2013; Onchang & Hawker, 2018). This concept was derived from the original Kuznets Curve hypothesis named after Simoom Kuznets, (1955). This hypothesis maintained that income inequality grows with economic development but after a certain level of economic development it portrays an inverse relationship with economic growth. The EKC hypothesis was firstly applied in the early 1990s with Grossman and Krueger's (1991) path breaking study of the potential impacts of the North American Free Trade Agreement (NAFTA) and the concept's popularization through the 1992 World Bank Development Report, (Stern 2004).

The EKC hypothesis postulates that, as countries start attaining economic growth, environmental degradation also tends to increase. However, after attaining a certain level of economic growth, a

further increase in economic growth leads to decrease in environmental degradation,(Mosheim, (2013); Ming, Lee, & Cheng, (2008). The studies have explained that as countries gain more and more economic growth, they tend to invest in cleaner technologies and put more efforts in recovering the degraded environment,(Fraser, 2018).Earlier studies expounded this position even more forcefully claiming that ''there is clear evidence that, although economic growth usually leads to environmental degradation in the early stages of the process, in the end the best and probably the only way to attain a decent environment in most countries is to become rich,''(Stern, 2004).However there remains a big controversy and inconclusive arguments about the EKC hypothesis. It is argued that the hypothesis is valid only for some environmental factors. For some none renewable environmental factors such as land, it may not apply,(Dinda, 2004).

Studies have mostly used panel data in testing the EKC hypothesis making the use of both fixed and random effects, (Mosheim, (2013); Ming et al., (2008); Fraser, (2018). In some cases some studies have also employed the time series data making the use of time series models such as ARIMA model, OLS estimator, ARCH regression, VAR model, and Granger causality, GMM and others, (Nuno Carlos Leitão, 2018).

To estimate the relationship postulated by the EKC, some studies have used the Per capita Carbon dioxide (CO2) emission as a dependent variable in testing this relationship, (Nuno Carlos Leitão, 2018). Other studies have used other common pollutants which are in the group of Chlorofluorocarbons (CFCs)(Dinda, (2004); Fraser, 2018). The literatures also show that GDP, GDP squared, Foreign Direct Investment (FDI), Trade openness, Globalisation and Energy consumption have been frequently used as independent variables representing economic growth, (Andreoni & Levinson, 2001).

A number of studies have been done to estimate the validity of the EKC in Tanzania, (Muhammad, & Solarin, (2016); Dominick, (2014); Bhattarai & Hammig, (2001).However, all of these studies incorporated Tanzania only among a set of comparative countries. This shows that applications devoted to Tanzania and use single country-specific time series data seem not to have been carried out. Dinda, (2004) argues that a more fruitful approach to the analysis of the relationship between economic growth and environmental impact would be the examination of historical experience of individual countries, using econometric and also qualitative historical analysis. This is because there is a different level of per capita emissions due to different laws enforcement and probably employment of outdated industrial technologies in some countries.

This study tried to cover the gap by analyzing the relationship between economic growth and the environmental impact focusing on Tanzania as an individual country. The study has also made the use of time series data for Tanzania to capture the country specific historical relationships. This study was therefore geared towards addressing two specific objectives which were firstly to analyse the economic growth related determinants of per capita Co2 emissions and secondly to analyse the long term relationship between per capita Co2 emissions and economic growth. This study contributes to the existing literature as it makes efforts to explore the relationship between economic growth and Co2 emissions by incorporating the income per capita (GDP), per capita Carbon Dioxide (Co2) emissions, Energy Consumption (EC), and Foreign Direct Investment (FDI)in a C02 emissions function for the case of Tanzania.

2.1   Research Methodology

2.1.1   Data Used in the Study

The study has made the use of time series data which were obtained from the World Bank World Development Indicators. The time period covered by the study was a period of 10 years from 2008 to 2017. This study period was limited by the availability of data for the variables intended for the study. Out of the world development indicators the researcher sorted the relevant variables for the study which included: - The income per capita (GDP), per capita Carbon Dioxide (CO2) emissions, Energy Consumption (EC), and Foreign Direct Investment (FDI).

2.1.2   Econometric Model Specification
In this study, we used per capita Carbon Dioxide (CO2) as the dependent variable while The income per capita (GDP), The income per capita squared (GDP^2), Energy Consumption (EC), and Foreign Direct Investment (FDI) were used as independent variables. Therefore, for the purpose of estimating the relationship between economic growth and the level of environmental pollution the mathematical relationship was specified as shown in equation i.
$$CO2 = f(GDP, GDP^2, EC, FDI)\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\text{ i}$$

Equation one (i) simply implies that, the CO2 emission which is a proxy of environmental pollution depends on economic growth which is represented by income per capita (GDP), income per capita squared (GDP^2), Energy Consumption (EC), and Foreign Direct Investment (FDI).

The econometric form of equation one (i) can then be expressed in a logarithmic form as seen in the subsequent equation two (ii).

$$LogCO2 = \alpha_0 + \alpha_1 LogGDP + \alpha_2 LogGDP^2 + \alpha_3 LogEC + \alpha_4 LogFDI + \varepsilon\dots\dots\dots\text{ii}$$

The logarithmic form has been applied since we assume that our variables are not normally distributed or in other words can have outliers. The solution to this is to apply the log form so as to remove the influence of such outliers.

2.1.3   Variables Descriptions and Measurements

The variables used in the study as expressed in equation i and ii were described and there expected signs according to literature were as seen in table 1.

Table 1: Variable Description and Measurements

Variable	Description	Expected Signs
CO2	Carbon dioxide emissions per capita	-
GDP	GDP per capita (Current US$)	Positive
GDP^2	Squared GDP per capita	Negative
EC	Electricity Consumption per capita	Positive
FDI	FDI net inflows (Current UD$)	Positive

Source: Author, 2019

The dependent variable CO2 is measured by CO2metric tons emissions per capita. This variable has no expected sign since it is the dependent variable. The GDP is measured by the GDP per capita GDP in current US$ and it is expected to show a positive correlation with the dependent variable. This represents the early stages of economic growth when economies are striving to grow at the expense of the environment, (Groot, Withagen, & Minliang, 2018).The GDP^2 is measured by the square of the GDP per capita. This is expected to be negatively correlated to the dependent variable since as maintained in the EKC hypothesis, at higher levels of development, developed countries start using environmental friendly technologies and devote more resources to conserve the environment, (Nuno Carlos Leitão, 2018). EC is measured by electricity consumption per capita. This variable is expected have a positive correlation with CO2 emissions. Lastly FDI is measured by the FDI net inflows. The variable is expected to have a positive correlation with CO2 emissions.

2.1.4 Data Analysis

Data analysis for this study was carried out using the Autoregressive Conditional Heteroscedasticity (ARCH) model. The ARCH model is concerned with a relationship within the heteroscedasticity, often termed serial correlation of the heteroscedasticity. It often becomes apparent when there is volatility of a particular variable, producing a pattern which is determined by some factor, (Al-najjar, 2016). The ARCH model assumes that the error term is normally distributed with zero mean and conditional variance depending on the squared error term lagged one time period,(Gujarati, 2003).Since heteroscedasticity is a common characteristic of time series data, it can be argued that the ARCH model was proper for this study. Before the main analysis was carried out, regression diagnostic tests such as the multicollinearity test and the unit root test were undertaken to prove the suitability of our study variables.

3.1   Empirical Results and Discussion

3.1.1   Correlation between the Variables Used in the Study

The variables which were used in the study were correlated to find out the degree of correlation between them. The main aim was to prove that there is no multicollinearity between any pair of the variables. The correlation results in table 2 shows that there is no serious correlation between any pair of variables. The rule of thumb is that any correlation exceeding 80% reveals a serious multicollinearity, (Gujarati, 2003). Since in the table there is no such a percentage of correlation then we conclude that our variables had no serious multicollinearity.

Table 2: Correlation between the Variables Used in the Study

	LogCO2	LogGDP	LogGDP^2	LogEC	LogFDI
LogCO2	1.00				
LogGDP	0.21	1.00			
LogGDP^2	0.13	0.42	1.00		
LogEC	0.34	0.35	0.12	1.00	
LogFDI	0.08	0.56	0.05	0.27	1.00

Source: Author, 2019

3.1.2   Unit Root Test

The unit root test was conducted to test whether of the study variables were stationary. This was done using the Augmented Dickey Fuller (ADF). The results shown in table 3 shows that all the study variables were stationary in ADF at level and at First differences.

Table 3: Unit Root Test: Augmented Dickey Fuller (ADF)

	ADF at level		ADF at first Difference	
Variables	**Statistic**	**P - value**	**Statistic**	**P - Value**
LogCO2	1.15	0.03	1.67	0.02
LogGDP	2.16	0.06	2.50	0.05
LogGDP^2	1.23	0.08	1.63	0.01
LogEC	2.10	0.02	1.89	0.03
LogFDI	1.80	0.04	2.21	0.01

Source: Author, 2019

3.1.3   The ARCH Regression Results

After proving the validity of the study data the ARCH regression analysis was lastly conducted to estimate the economic growth related determinants of Co2 emissions as required by the first objective of the study. The results for this analysis were as shown in table 4. From the table, all the explanatory variables used were statistically significant. The log GDP was statistically significant at 1%, the LogEC and Log FDI were significant at 5% while the LogGDP^2 was statistically significant at 10%.

Table 4: The ARCH Regression Results

Variables	Coefficient	T student	P - Value
LogCO2	**Dependent Variable**		
LogGDP	0.15***	7.45	0.00
LogGDP^2	-0.07*	6.78	0.09
LogEC	0.24**	45.25	0.01
LogFDI	-0.59**	7.35	0.03
Constant	-1.82**	12.20	0.01
Observations	10		
Prob > chi2	0.00		
Log likelihood	63.28		
Wald chi2 (4)	3627.82		

Note: * = Significance at 1%; ** = Significance at 5%; * = Significance at 10%**

Source: Author, 2019

It can further be observed from the variable coefficients that the Log GDP was positively correlated to the dependent variable (LogCO2). This implies that an increase in the GDP at this stage of economic growth increases the emissions of CO2. These findings are consistent with studies by Nuno Carlos Leitão, (2018) and Onchang et al., (2018). In the Tanzania context the results are consistent with Dominick, (2014).

From the other explanatory variables it can also be seen that the LogEC was positively affecting the CO2 emissions per capita which is consisted with our priory expectations. Lastly the LogFDI was negatively affecting the dependent variable indicating that as the inflows of FDI as a percentage of GDP increase the per capita emissions of CO2 decrease. This was also consistent with our expectations guided by the literature.

To arrive at the second objective which was to estimate the long term relationship between the level of emissions and economic growth, it was observed from the same regression results that the variable $LogGDP^2$ which is the square of the income percapita had a negative correlation with the dependent variable. Some studies have also came up with the same results in Tanzania and countries closely related to Tanzania,(Fraser, 2018; Stern, 2004) This implies that at higher levels of economic growth in the long run the per capita emissions of CO2 will be reduced. However, it should be noted that this variable despite having this directional relationship with the dependent variable, its level of significance was weak (10%).

The positive relationship between GDP and Co2 emissions and the negative relationship between GDP^2 and Co2 emissions is a proof of the existence of the EKC for the case of Tanzania. However, despite our appealing results which prove the existence of the EKC in Tanzania, there are several studies which have disapproved the existence of this hypothesis especially in the context of developing countries like Tanzania, (Andreoni & Levinson, (2001); Agras & Chapman, (1999); Torras & Boyce, (1998)). However these do not directly disapprove our results since they were not done in the Tanzanian context.

4.1 Conclusion and Recommendations

4.1.1 Conclusion

From the study findings we can conclude that in the context of Tanzania as an individual country the EKC hypothesis has been proven. The EKC exists in the case of CO2 emissions tested against the selected economic growth indicators. This is to say, it is expected that at early stages of economic development, environmental pollution will be growing as the country will be striving to grow at the expense of the environment. Interestingly it is also good to know that at higher stages of economic development the environmental pollution will decrease with increase in economic development. This is an indicator that if the country will take pollution reduction and good abatement technologies in the future, this will make a U turn in the pollution – economic growth relationship.

4.1.2   Policy Recommendations

As a country, Tanzania needs to keep taking advantage of the available natural resources for its development. However, a great precaution must be taken on how these resources are used. For renewable resources, it is easy to think of the EKC hypothesis and hope for improvement in the future. However, for non renewable resources a great precaution should be undertaken when depleting them in order to attain economic development.

Studies have not yet confirmed the threshold of environmental pollution in the country. The relevant authorities (The National Environmental Management Council (NEMC) and others) should make sure that even at early stages of development the environmental pollution is avoided as much as possible.

To attain a quick U turn in the pollution – economic growth relationship, the third part or external costs of economic growth should be imputed in the cost functions of the polluting agents. This is to say, polluters should bear the costs of environmental pollution by being involved in adopting clean technologies and bearing the costs of pollution abatement.

5.1   Areas for Further Research

This study has tested the existence of the EKC using only one pollutant which was CO_2. There are other pollutants such as, Nitrous oxide, Sulfur, and Chlorofluorocarbons (CFCs) which could probably display a different relationship if tested against economic growth. Future studies should consider this.

There are also a number of time series models such as the Granger Causality, ARIMA model, GARCH model, VAR model, GMM and others which could also be used in testing the hypothesis. These models can also be considered in future studies.

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