

Investigation of the Relationship between Economic Growth and Carbon Dioxide (CO₂) Emissions as Economic Structure Changes: Evidence from Ghana

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Abstract Increase in human activities contribute to the economic growth of a country. However, these human activities also contribute to the environmental pollution (i.e. carbon dioxide emissions). The effect of carbon dioxide (CO₂) emissions on the environment is becoming a pressing reality. The study explores the relationship between CO₂ and economic growth in Ghana when the economic structure changes. The study also tested the existence of EKC relationship between economic growth and CO₂ in Ghana. Using linear regression model to find the linear relationship between environmental pollution and economic growth in Ghana, the study employed Ordinary Least Square (OLS) in order to minimize the sum of squared residuals. The study used the data of World Development Indicators (WDI) 2017 for the period 1970-2016. The study employed CO₂ (metric tonnes per capita) as proxy of environmental pollution and GDP per capita (current US \$) as proxy of economic growth. Findings indicate that CO₂ and GDP per capita increases at different pace and varies over time period and therefore the study could not establish existence of EKC in Ghana. However, the relationship between the variables is significant with t-value $7.784 > 2$ and P-value of $0.000 < 0.05$. This means that CO₂ emission level in Ghana is influence by GDP. The study findings also indicate that agriculture as the engine of Ghana's economy growth and development is experiencing continuous decline in terms of its contribution to GDP for the past four decades. The study therefore concluded that, there is the need for establishment of regulations, proper institutional structures to set up policy framework, enforcement agencies to monitor to ensure compliance and creation of public awareness of the dangers pose by environmental degradation.

Keywords Environmental Kuznet Curve (EKC), Carbon dioxide (CO₂) emissions, Gross Domestic Product (GDP), Economic growth, Structural change

1. Introduction

The emission of Greenhouse gases (GHG) globally in the atmosphere has dying consequences and poses serious threat to human sustainable development. The impact of global climate change affects climate patterns (i.e. increasing water stress, raising of sea level due to polar ice melting, destruction of the ecosystems) and also increase climatic episodes such as droughts, hurricanes and floods. The GHG consist of pollutants such as Carbon dioxide emission (CO₂), Nitrous oxide (N₂O), Methane (CH₄) and Fluorinated gases (F-gases). Among the four pollutants, carbon dioxide emissions is considered as the key contributor to global warming and has received a lot of international attention [4, 22]. There are two main sources of carbon dioxide [21].

The first source which is considered as the largest contributor to carbon dioxide emissions is the combustion of fossil fuel. The combustion of fossil fuels consist of natural gas, crude oil and coal burning. The second source of carbon dioxide comes from industrial processes that releases carbon dioxide into the atmosphere through chemical reaction. On this basis, one can say that carbon dioxide emissions-other variables nexus is chemical and physical.

Carbon dioxide (CO₂) emission has increased over the years all over the world due to globalization and fast economic activities [1]. The increase in human activities such as manufacturing, transport, electricity generation and consumption of goods and services contribute to the economic growth of a country. However, these human activities also contribute to the environmental pollution [30-32]. That is, increase in economic growth involves activities like an increase in the country's foreign direct investment, increase in agricultural activities, Spread of industries and above all increase in the consumption of energy. All these activities contribute one way or other to

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environmental pollution. Therefore, one can deduce that economic growth has causal relationship with the environmental pollution of a country.

The study aimed to examine the relationship between CO₂ and economic growth in Ghana when the economic structure changes. The study is also aimed to test the existence of EKC relationship between economic growth and CO₂ in Ghana.

2. Literature Review

Theoretical study

The relationship between CO₂ emissions and economic growth have been studied extensively using Environmental Kuznet Curve (EKC) which was hypothesized by [20]. Kuznets hypothesis juxtapose that initially environmental pollution increases as the country begin to develop but however at a certain point of economic development and growth, the environmental pollution level diminishes as depicted in figure 1. That is, the achievement of economic growth and development means that the country now have enough resources at their disposal to reduce and mitigate any form of environmental degradation.

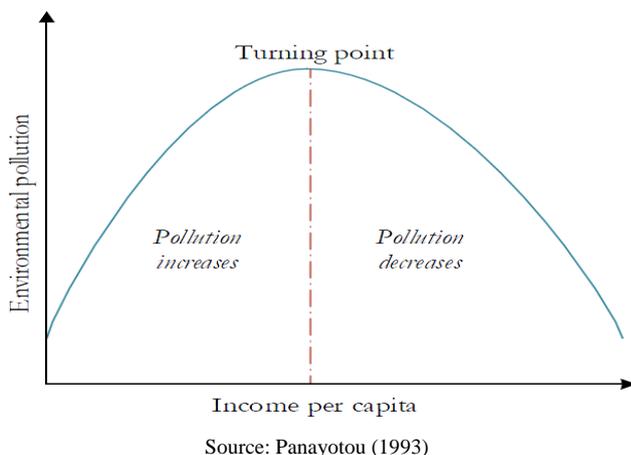


Figure 1. Environmental Kuznets Curve

The study used EKC to link economic growth to the changes of the economic structure as the country undergo developmental processes from pre-industrial economies to industrial economies and to post-industrial economies. The changes of the economic structure involve changes in terms of industry, service and agriculture sector over common time period along with economic growth changes having different content of transformation. The impact of the changes of the structure of the economy can either increase or decrease the pollution intensity. Therefore the application of EKC will provide indication of environmental degradation and economic growth level as the country go through various stages in the development process.

Environmental Kuznets Curve (EKC) model denotes the structural transformation of economy with economic growth connected to uninterrupted structural revolution and change. Structural variations replicates the modifications in the

stakes of agriculture, industry and service which mostly followed the same time pattern with the changes in growth rate but however the content of change differ from period to period. By altering the conformation of economic activity to other sectors impacts on the environmental quality which increases or decreases the pollution intensity of the country. Structural change hypothesis postulate that economic growth in Ghana changes the country's economic pillar of agriculture of low-pollution to high-polluting industry and later back to low polluting services. At the initial stage of development, a country's environmental degradation level is low. The population increase call for an increase in agriculture activities and extraction intensification.

Empirical study

A lot of empirical work has been done to prove or disprove the assertion of Environmental Kuznets Curve (EKC) and the relationship between the variables. The EKC hypothesis is considered to show the relationship between economic development and the environmental pollutant [15]. That is, EKC is postulated as having U-shape. Some studies found positive relationship [3, 7, 11, 23], neutral or no evidence of EKC [6, 12, 18] and even negative relationship [13] between CO₂ emissions and economic growth. Other researchers also found the influence of the variable (i.e. economic growth) on CO₂ to be based on time factor whether short or long run relationship.

The dynamic relationship between environmental pollution and economic growth, was undertaken by [27] to find the causal relationship between electricity consumption, economic growth and carbon emissions employing panel causality analysis that controls for cross-sectional dependence across countries. The study tested for the existence of EKC in BRICS. Findings are that EKC hypothesis can only be found in Russia. In relations to causality, the study found unidirectional causality runs from GDP to CO₂ emissions in South Africa and from CO₂ to GDP in Brazil. In the other vein, unidirectional causality runs from energy consumption to CO₂ in India. However, causality among the variables could not be established in China and Russia. However, [2] applied the fixed and random effects model in Asian countries to examine the relation between pollution and economic growth. The study findings seems to support the existence of Environmental Kuznets Curve (EKC) hypothesis. Similar study was done by [26] in 43 developing countries for the period 1980-2004. The study examines the EKC hypothesis of income against CO₂ emissions for both short and long run. The whole idea of the study is that once there is an evidence that income elasticity of the country is smaller in the long run than the short run, then the country in question has reduced carbon emissions as a results of an increase in income. Findings of their study support the EKC hypothesis that is, Middle Eastern panel income elasticity is smaller in the long run than the short run. Therefore concluded that carbon emissions level has decreased as a results of the increase in income level.

Applying, the same methodology, [8] also tested the EKC hypothesis in 36 high income countries including three MENA countries namely: Oman, Bahrain and UAE for the period 1980-2005. The empirical results of the study shows unidirectional causality from GDP to CO₂ emissions in both short and long term relationship. Analysis of individual countries suggest that Oman including other 6 non MENA countries CO₂ emissions have fallen as a results of an increase in income in the long term. [10] also extended the EKC analysis done by other researchers in Turkey by adding foreign direct investment and trade in the equation. Findings of their study validates the existence of EKC in Turkey and that FDI and trade openness have positive effect on CO₂ using annual data for the period of 1974-2010. Bidirectional causality was also found between the CO₂ emissions and FDI.

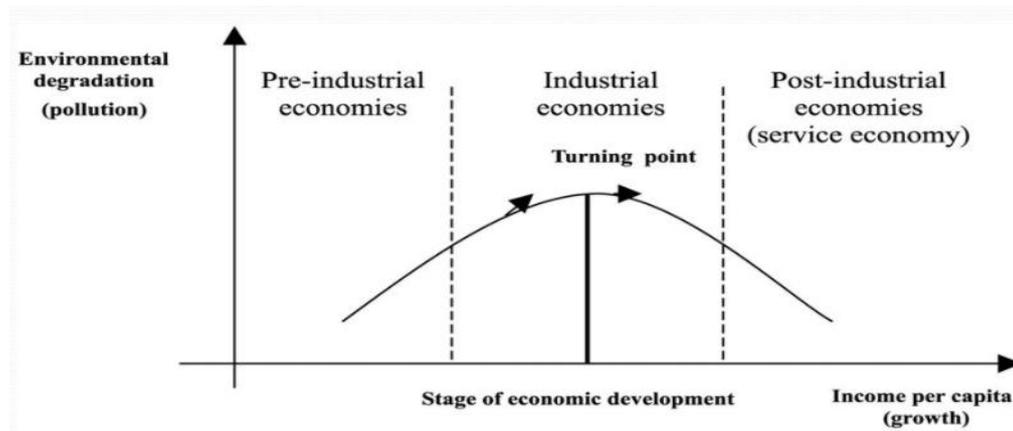
Similar study by [22] was conducted in Vietnam between the period 1976-2009 to understand the relationship between CO₂ emissions, energy consumption, FDI and economic growth. Tang and Tan applied the same methodology of using Johansen Cointegration and Granger causality. Using CO₂, energy consumption, FDI and Economic growth for the analysis, the study found long-run relationship between CO₂ emissions, energy consumption, income and FDI. The study support EKC hypothesis which assumes an inverted U-shaped relationship between CO₂ emissions and economic growth in Vietnam. The results of the study also reveal that energy consumption and income influence CO₂ emissions positively whiles the square of income however has negative impact on CO₂ emission in Vietnam. Study by [29] also support the U-shaped relationship between economic growth and surfur emissions with other parameters such as trade and population. Their study was conducted using panel data of 42 countries over the period 1950-2000. Contrary, [28] also found EKC hypothesis not to be valid in Turkey but however found long run relationship between CO₂ emissions, energy consumption and GDP.

Additionally, [14] also explored CO₂ Emissions, Energy consumption, Economic growth and FDI in Vietnam for the period 1980-2010. The study meant to test the EKC hypothesis and to examines the causality relationships among CO₂ emissions, energy consumption, economic growth and FDI using ADF- unit root Cointegration, [9] vector autoregressive model & trace an maximum eigenvalue tests in order to determine number of cointegration relationship of the variables under study and Granger Causality test using Vector Error-Correction Model (VECM) to measure cause and effect relationship of the variables. Findings are that EKC test is inconclusive since result is statistically insignificant. The study also found bidirectional relationship of FDI on both income and energy consumption in the short run and that FDI is considered as critical component for national economic growth. However, in the long run bidirectional relationship was found between CO₂ and income, energy consumption on income and FDI; and income on FDI. Only CO₂ and FDI have unidirectional.

Developmental Stages of Ghana

Every economy all over the world go through various stages in its economic development. There are three stages in economic development of a country. That is, Pre-industrial economies, Industrial economies and Post-industrial economies.

As Ghana economy undergo various stages in development, from agricultural based economy to industrial based economy requires the need to increase the energy supply of the economy which will increase the pollution level. At the same time as the country become industry-based, means production and consumption of goods and services will increase. This will increase the economic growth. On the other hand, as the economy move from the industry-based to service economy (i.e. post-industrial economy), means the need for advanced and more efficient technology. This will reduce the environment pollution level of a country since the service industry is less energy-intensive.



Source: Panayotou (1993)

Figure 2

Agriculture is considered as the main pillar of Ghana’s economy since independence in 1957. Ghana has struggled over the years to intensify the drive towards industrial-based production in order to serve as a means of providing more employment. Despite all the determinations by governments since independence, agriculture has achieved desirable point as most important contributor to Gross Domestic Product (GDP). The Agricultural Sector has contributed significantly to the Ghanaian economy, although more recently it has been overtaken by the Services Sector. However, agricultural sector continues to offer employment for nearly fifty percent (50%) of employed persons in Ghana [5]. It is projected that a slightly over half (51.5%) of households own or operate a farm in Ghana. Farming is predominantly rural, with 82.5 percent of rural households involved. As Ghana population increases from 6,652,287 in 1960 to 28,206,728 in 2016 [25] has called for an increase in food production to meet the growing demand. This has led to an application of various poor agricultural practice in order to sustain life. These bad agriculture practices also promote greenhouse gases emissions having its main anthropogenic sources from the use of agricultural land and energy consumption [19].

The country Ghana still based its economic development on agriculture particularly cocoa. Even though, economic growth of the country has seen some improvement over the years based on developing partners aid such as World Bank and International Monetary Fund (IMF). Regardless of the progressive growth rates of the last two decades, there is barely any sign of significant structural transformation in Ghana’s economic development.

3. Methodology

The study looked at the relationship between economic growth and CO₂ emission in the various structural changes in Ghana economy. The study also looked at the contribution of the various sectors of the economy to the economic growth of Ghana. Using the data of [25] for the analysis and discussions for the period 1970-2016. The study divided the time period of data analysis into phases. The study employed CO₂ (metric tonnes per capita) as proxy of environmental pollution and GDP per capita (current US \$) as proxy of economic growth.

Using linear regression model in equation (1) to find the linear relationship between environmental pollution and economic growth in Ghana, the study employed Ordinary Least Square (OLS) in order to minimize the sum of squared residuals.

$$CO_2(t) = \alpha + \beta_1 GDP_t + e_t \tag{1}$$

Additionally, data for the analysis was transformed into their natural logarithms in both sides which then gives equation (2) below. The transformation of the data in their

natural logarithms would firstly make the interpretation of results easily and secondly, the data transformed appears to satisfy the linearity assumption of the regression model.

$$\log CO_2(t) = \alpha + \beta_1 \log GDP_t + e_t \tag{2}$$

Where logCO₂ is the natural logarithm of the CO₂ used as dependent variable while logGDP is the natural logarithm of GDP as independent variable. α is a constant term and β_1 is the estimate of CO₂ – GDP elasticity, e is an error term. From the analysis equation (2) can be expressed as:

$$\log CO_2(t) = -1.514 + 0.383 \log GDP_t + e_t \tag{3}$$

4. Results and Discussion

The trend of various sector contribution to GDP

To achieve economic growth depends on agricultural, services and industrial strength of the country. However, Ghana has been directly dependent on agriculture output for foreign exchange, create employment and also to ensure that the citizens have enough to feed on. Agriculture sector alone contribute enormously in terms of tax revenue as much as 20.3% of real GDP in 2015 [16]. Table 1 below provides the trend of the various sectors contribution to GDP in Ghana. Details indicates that agriculture sector of Ghana is declining in terms of its contribution to economic growth averagely at 1.2% from as high as 65.045% in 1978 to as low as 19.598% in 2016. However, both service and industry shows an increase in trend of their impact on economic growth in Ghana. Both service and industry are increasing averagely at 0.78% and 0.75% respectively.

Table 1

Sectors	Trends in GDP contribution	Lowest Contribution (Year, % in Value Added)		Highest Contribution (Year, % in Value Added)	
		Year	Value Added	Year	Value Added
Agriculture	Decreasing	2016	19.598	1978	65.045
Service	Increasing	1977	21.882	2016	52.243
Industry	Increasing	1982	6.467	2012	28.938

Source: Authors, 2017

To put in perspective the trend of the various sectors contribution to GDP, the study categorized the time period for our analysis into phases to determine the effect of structural changes in the economy. The phases will help us to ascertain the major sector player in a particular time period and their contribution to Ghana’s GDP.

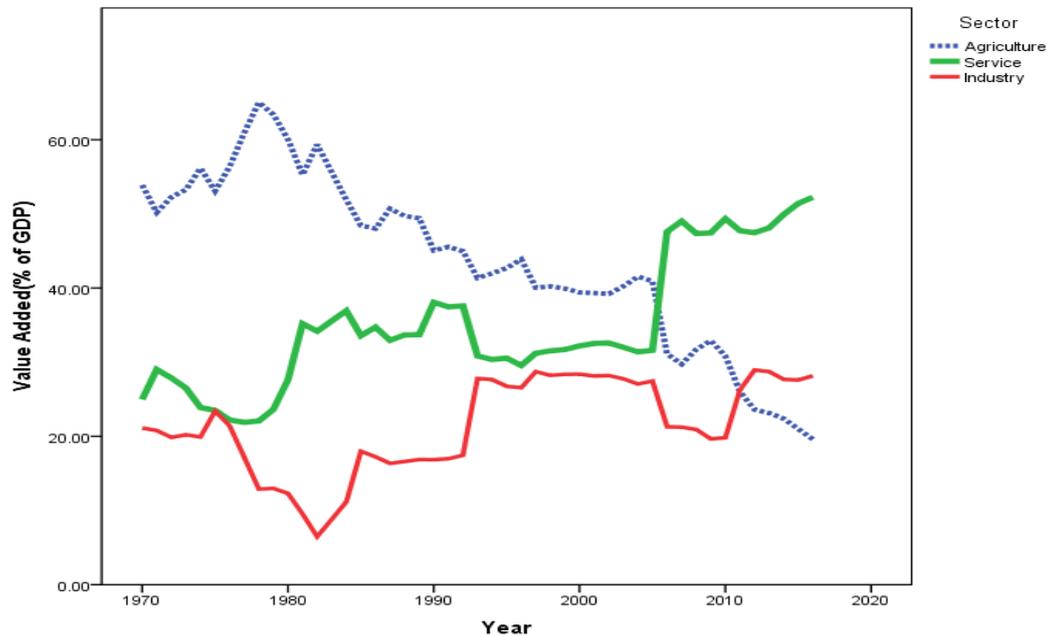


Figure 3. Trend of Sectors contribution to GDP

The study divided the phases (i.e. time period) into five categories based on the pattern of economic growth and political structure changes at certain period of time. The study discussed them as follows:

Phase 1. 1970-1979

After attainment of independence in 1957, Ghana's economy in 1970-1979 shows a decline of industrialization contribution to GDP at 3.51% averagely to GDP from 23.41% value added to GDP in 1975 to 12.89% in 1978. The service sector also saw a decline in terms of percent of value added by 1.19%. The only sector that increased its contribution was agriculture sector at an average of 2.12% to GDP.

Phase 2. 1980-1989

Service and Industry sectors saw a strident momentum in contribution to economic growth of Ghana. Both service and industry sector saw a change of 0.08% and 1.78% from 1980-1989 using the formula in equation (1) below with average of 2.33% and 3.84% respectively. However, sector like agriculture declined in terms of growth of 0.25% due to structural change in the economy from agricultural based to industrial based.

% change =

$$\frac{(\text{Current value added} - \text{Previous value added})}{\text{Previous value added}} \times 100$$

Phase 3. 1990-1999

As the economy continue to undergo further structural change from 1980-89 to 1990-1999. The various sector contribution also changes from one point of the developmental processes. The period 1990-1999 saw a decline in both agriculture and service sectors value added to Ghana's economic growth. Both declined by 0.12% and

0.22% respectively. The average performance of agriculture sector was in the decline of 0.70% while's service sector average also declined by 1.42% in phase 3 of Ghana's developmental process. In the period of 1990-1999 saw only industry sector contributing positively towards GDP of Ghana with an average percentage of 1.7 and a percentage from 1990 to 1999 of 0.1%.

Phase 4. 2000-2009

Service sector in period 2000-2009 became the only sector that contributed positively towards economic growth in Ghana with an average of 5.88% and a change of 0.56% from year 2000 to 2009. However, both agriculture and industry percentage value added to the economy for period in review declined. The average declined rate of 3.94% and 0.97% for agriculture and industry respectively.

Phase 5. 2010-2016

This period under review projects serious decline of the main sector (i.e. agriculture) which serves as a backbone of Ghana's economic growth and development. This period was faced with dramatic shift in the structural composition of the economy from agricultural based economy to both service and industry based economy. This then increases the share of services sector impact on GDP to 1.20% with a trend of change in the same period of 0.1%. The industrial sector saw a growth in value to Ghana's GDP with an average of 4.57%. As indicated, agriculture sector declined with an average of 1.87% leading to negative change of 0.36% from 2010-2016.

Trend of CO₂ per capita and GDP per capita in Ghana

The use of fossil fuels in Africa has increased steadily and therefore contribute 3.7% of global emission in 2009 [24]. However, Ghana contributes 0.13% in 2011 to the world greenhouse gases [26]. The figure 4 provides the pattern of

CO₂ emission and GDP per capita to understand how the two variables behaves when the structure of the economy changes. To get standard measure and to understand the picture of the trend well, the data of CO₂ (metric tonnes per capita) and GDP per capita (current US \$) were transformed in their natural logarithm. The trend of CO₂ and GDP per

capita as shown in figure 4 depicts that even though both variables increases but at a different stride and varies over time period indicating GDP per capita increasing steadily more than CO₂ per capita in Ghana. This may be due to the changes in Ghana economic structure from agriculture based to service based which has less impact on environment.

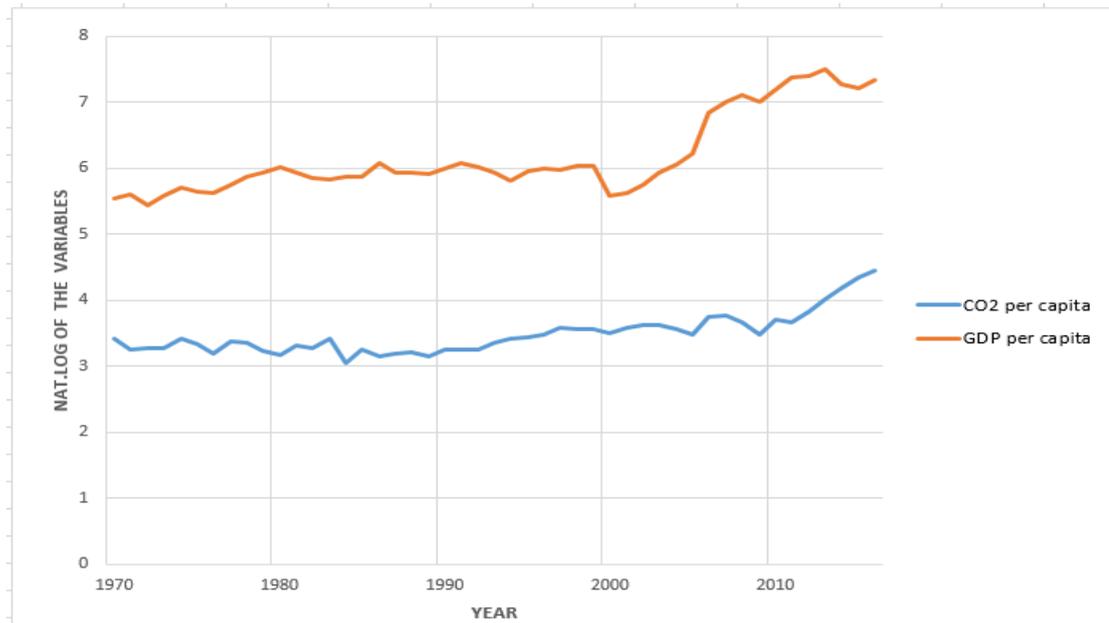


Figure 4

Table 2

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.757 ^a	.574	.564	.0876848	.574	60.583	1	45	.000	.431

a. Predictors: (Constant), LogGDP

b. Dependent Variable: LogCO₂

Table 3

ANOVA^a

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	.466	1	.466	60.583	.000 ^b
1 Residual	.346	45	.008		
Total	.812	46			

a. Dependent Variable: LogCO₂

b. Predictors: (Constant), LogGDP

Table 4

Coefficients^a

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	-1.514	.133		-11.408	.000
1 LogGDP	.383	.049	.757	7.784	.000

a. Dependent Variable: LogCO₂

5. Conclusions

It is highly believed that as the country develop economically all things been equal, the country will shift from the so call clean agricultural practices to a more polluting industrialization and then later reverse to service economy which is more cleaner. The reverse will then improve the quality of the environment due to application of advanced technology.

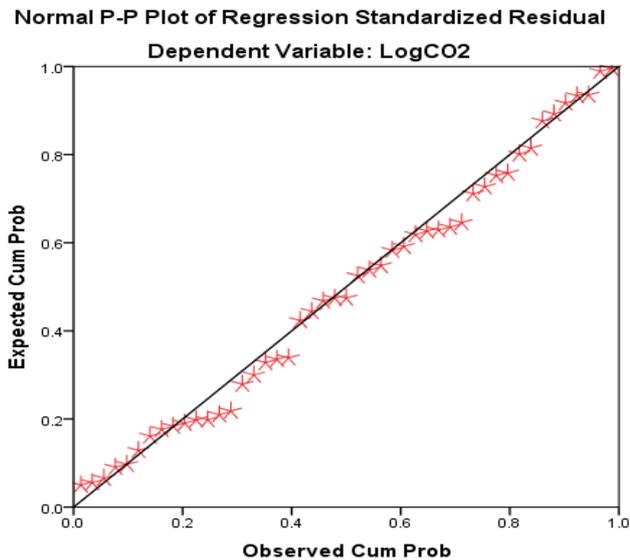


Figure 5

The study examined the relationship between CO₂ and economic growth in Ghana when the economic structure changes. The study also tested the existence of EKC relationship between economic growth and CO₂ in Ghana. The study findings indicate that the main sector of Ghana's economy which is agriculture has experienced continuous decline in terms of its contribution to GDP for the past four decades. That is, agriculture value added (i.e. % of GDP) for the period 1970-1979 was 2.12%. This positive contribution started declining on average of 2% of GDP in 1980-1989, 0.7 percent in 1990-1999, 3.94 percent in 2000-2009 and 1.87 percent in 2010-2016. It is likely that agriculture sector contribution will experience further dew drop in the years ahead due to government expurgation of expenditure on the sector. However, both service and industry sectors increased their contribution to GDP with the service sector leading followed by industry. Both contemporary and chronological pattern of Ghana's economy depicts momentous structural modifications. Therefore Ghana's economic structure has moved from its traditional agriculture based economic transformation toward service- based economy, with diminutive change in the industrial-based economy. The study could not establish whether EKC exist in Ghana since CO₂ and GDP per capita are increasing at different pace and varies in different time period. However, the relationship between the variables is significant with t-value 7.784 > 2 and P- value of 0.000 < 0.05. This means that CO₂ emission level in Ghana is influence by GDP. With the normal P-P plot of regression (in figure 5) showing strong "goodness of fits".

The R² of 57.4% shows how the regression line fits through the CO₂ and GDP graph. Therefore, 57.4% of the observations are explainable. The regression coefficient (i.e. β_1) of 0.383 shows the marginal effect of a percentage change of logGDP on logCO₂. That is, 1% change of logGDP will cause 38.3% change of logCO₂.

To conclude, there is the need for the establishment of regulations, proper institutional structures to set up policy framework, enforcement agencies to monitor to ensure compliance and creation of public awareness of the dangers pose by environmental degradation. There is also the need for further studies to look at the causes of continuous decline in agricultural sector contribution to GDP.

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