

ENVIRONMENTAL DEGRADATION EFFECT OF AGRICULTURAL AND INDUSTRIAL GROWTH IN GHANA

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Abstract Empirical examination into the existence of the Environmental Kuznets Curve (EKC) have focused principally on aggregate economic growth and environmental degradation with little knowledge on its potential existence in the individual sectors of the economy particularly the extreme cases of agricultural and industrial sectors. Such evidence could usefully shape policy instruments aimed at ensuring environmental sustainability amidst the quest to promote growth in these sectors. The paper therefore examines the effect of agricultural growth, industrial growth on environmental degradation in Ghana. Relying on data from the World Development Indicators for the period 1971-2008 and employing the Johansen cointegration technique, a long run EKC hypothesis is confirmed in the agricultural sector as well as the industrial sector.

Keywords: Environmental Kuznets Curve, Agricultural Growth, Industrial Growth, Ghana

INTRODUCTION

The increasing amount of carbon dioxide emissions over the past two decades (Boopen & Vinesh, 2011) has raised important developmental concerns by policy makers. These emissions have been attributed mainly to human activities that are directly linked with economic growth (activities) and development (Boopen & Vinesh, 2011). The Intergovernmental Panel on Climate Change (IPCC) 2007 report shows that emissions of Green House Gases (GHG) are fast increasing, with an average increase of 1.6% over the last three decades. These emissions are expected to increase if there is no policy intervention (Hossain, 2012). However, the Environmental Kuznets Curve (EKC) hypothesis proposed by Grossman & Krueger (1991) suggests that, since such emissions stem mainly from societal development, environmental degradation (emissions) will eventually fall as the economy grows. The EKC hypothesis based on Kuznets' (1955) economic growth and income inequality argument, posits that at low level of income (i.e. economic growth), a country's environmental degradation is high but as income increases, environmental degradation falls. The result of this important and complex (Abouie-Mehrizi *et al.* 2012) relationship implies an inverted U shaped curve

or bell shaped curve between income and environmental degradation.

The EKC hypothesis, since its origin, has been used to examine the relationship between income and environmental degradation. Empirical investigations into this relationship have been grouped under three main strands by Sharma (2011), Saboori & Soleymani (2011), Saboori *et al.* (2012), and Hossain (2012). The first strand focuses on studies that test the existence of the EKC hypothesis, while some studies confirm the EKC hypothesis, others do not. Studies that confirm EKC include Grossman & Krueger (1995), Hettige *et al.* (1992), Cropper & Griffiths (1994), Saboori & Soleymani (2012), Saboori *et al.* (2012), and Hossain (2012). Studies like Shafik (1994) and Holtz-Eakin & Selden (1995) do not support EKC. Other studies under this strand, also examine the growth-environment nexus in a bivariate framework example Dinda & Coondoo (2002, 2006), Akbostanci *et al.* (2009) and Lee & Lee (2009). However, this strand is believed to suffer from omitted variables bias (Sharma, 2011; Saboori & Soleymani, 2011) and also since a number of these studies used cross-country panel "they could not examine the impact of environmental policies, historic experiences, development of trade relationship and other exogenous factors through time" (Saboori & Soleymani, 2011; p. 45).

The next strand of the literature focuses on energy-growth nexus. These studies in effect propose that energy is a needed input for growth and they include the pioneering work of Kraft & Kraft (1978), Wolde-Rufael (2006), Ozturk & Acaravci (2010), Adom (2011), Kwakwa (2012), Souhila & Kourbali (2012), Apergis & Danuletiu (2012) and Kalyoncu *et al.* (2013) with some obtaining unidirectional causality from energy to growth, unidirectional causality from growth to energy, bidirectional causality between energy and growth and no causal relationship at all. Finally, the third strand of the literature combines the first and the second strands by examining the relationship between energy consumption, economic growth and carbon emission through a multivariate framework. Some of these studies focused on granger causality without estimating the signs (see Soytaş & Sari, 2009; Ang, 2009; Tiwari, 2011) and this may be a weakness since they do not seek to examine what variables causes environmental degradation (Sharma, 2011).

It is worthy to note that a number of these studies that test for the existence of the EKC hypothesis have largely centered on developed country with little known about the situation in developing countries, particularly African economies (Boopen & Vinesh, 2011). Moreover a careful look at the literature shows that while testing for the EKC hypothesis, focus has been placed on the relationship between aggregate income and the environmental degradation with dearth of knowledge on its existence in other sectors of the economy particularly the extreme cases of agricultural and industrial sectors. Knowing the environmental effect of each sectoral growth is eminent for policy makers in coming up with measures to deal with the problem of environmental degradation. Following the above gaps in the literature, a study in Africa that focuses on the effect of growth of the agricultural and industrial sectors on environmental degradation is necessary to unravel whether such an inverted U-shaped relation exists in both the agricultural and industrial sectors. It is against this background that this study is carried out in an attempt to test the EKC hypothesis by examining the relationship between agrarian growth and industrial growth and environmental degradation using data from Ghana. The country is an interesting case study since economic performance over the years has received considerable boost from the agricultural and industrial sectors' growth while carbon emission keeps on rising.

After independence in 1957, Ghana embarked upon rapid industrialisation through heavy government ownership, government control of foreign trade, and a large government bureaucracy to promote growth. The strategy of rapid industrialisation was not successful and caused the economy to deteriorate. As a remedy to the poor economic conditions, the Government adopted the Economic Recovery Programme (ERP)/ Structural Adjustment Programme (SAP) in 1983

initiated by the IMF and the World Bank and as a result, the economy responded positively (see Asante & Addo, 1997). Since then, the performances of both the agricultural and industrial sectors have been impressive. For instance, from 1995 to 2001, the agricultural sector saw an annual average growth rate of 18.15% jumping to an annual average growth of 22.18% from 2002 to 2007. The industrial sector has seen a similar stride in its performance over the years as it grew from an annual average growth rate of 15.10% from 1997 to 2001 to 21.47% from 2002 to 2008 (World Development Indicator (WDI), 2012). With all these growth taking place in the two sectors, environmental degradation in terms of carbon emission metric tons per capita has been increasing generally from 0.21 in 1960 to 0.23 in 1980, to 0.32 in 2000 and currently, it stands at 0.36 (WDI, 2012).

Empirical findings on the environmental effect of the growth in the agricultural and industrial sectors from this study would contribute to the literature on the EKC hypothesis in two ways. Firstly, unlike many existing studies, the current study does not look at the effect of aggregate growth on environmental degradation rather, it seeks to find out if the EKC hypothesis holds in the different sectors of the economy. Also, the study provides evidence from Ghana where little is known about in the literature on EKC hypothesis. Again, the paper also offers evidence for policy makers to promote growth without sacrificing the quality of the environmental.

The rest of the paper is organised as follows. Section 2 deals with the data type and source and the method employed in the analysis. Section 3 discusses the empirical results and section 4 concludes the study and offer policy recommendations.

METHODOLOGY

Data Source and Scope of Study

Annual time series data covering the period from 1971 to 2008 was used for this study and they were sourced entirely from the World Development Indicators (WDI, 2012). The choice of sample period was based mainly on data availability.

Model Estimation

According to Saboori & Soleymani (2011), a general formulation of the EKC hypothesis is specified as:

$$ENV = f(Y, Y^2, Z) \quad (1)$$

where *ENV*, an environmental degradation indicator is said to be a function of income, *Y*, the square of income (Y^2) and *Z* is any other explanatory variable like intensity of energy consumption that influence environmental degradation which is added to serve as a control variable. However,

given that the study seeks to investigate whether the hypothesis holds when the economy is disaggregated into the agricultural and industrial sectors, the income variable is divided into agricultural and industrial growth. As a result, the above model is modified to what is below:

$$ENV = f(IND, IND^2, AGR, AGR^2, EIN) \quad (2)$$

where *ENV* is still the environmental degradation indicator, *IND* is the industrial growth, *AGR* is agricultural growth and *EIN* is energy intensity usage. The logarithm version of equation (2) gives:

$$ENV = \beta_0 + \beta_1 IND + \beta_2 IND^2 + \beta_3 AGR + \beta_4 AGR^2 + \beta_5 EIN + u \quad (3)$$

where $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ and β_5 are the coefficients of the variables while *u* is the error term. All variables in equation (3) are expressed in logs.

Description of Variables and Expected Signs

Environmental degradation *ENV* is measured by the log of carbon emissions produced from consumption of solid, liquid, and gas fuels and gas flaring. It is the dependent variable. The industrial growth, *IND* is measured by the log of industrial value added while the agricultural growth *AGR* is measured by the log of agricultural value added. Energy intensity usage, *EIN* is measured by the log of the ratio of gross domestic product to energy consumption. Following the hypothesis of EKC, and previous studies mentioned earlier, the coefficient of *IND*, β_1 and that of *AGR*, β_3 are expected to be positive to capture the fact that initially, carbon emissions increase with income. On the other hand, if the inverted U-shape curve between income and environment degradation holds in both sectors then the coefficient of *IND*² which is β_2 and *AGR*², β_4 would be negative. From other studies such as Sharma (2011), Hossain (2012) and Saboori *et al.* (2012), *EIN* is expected to have positive effect on *ENV*.

Econometrics Techniques

The use of non-stationary variables in estimation normally renders meaningless results and since most time series variables are not stationary at levels, the stationarity test needs to be done to avoid any spurious regression. Variables are stationary when their means and variances value do not vary over time (Gujarati & Sangeetha, 2007). A non-stationary variable is differenced until stationarity is attained. The number of times a non-stationary variable is differenced

for it to become stationary determines the order at which it is said to be integrated. For instance, those variables that attain stationarity at first differenced is said to be integrated on the order 1 denoted as *I(1)* and those that become stationary at second differenced are integrated of the order two, *I(2)*. Because a long run relationship is expected to be present among the variables, a cointegration test is further carried out. A confirmation of such relationship will necessitate the estimation of an error-correction model (ECM) which is given as below:

$$\begin{aligned} \Delta ENV = & \beta_0 \sum_{i=1}^p \beta_1 \Delta ENV_{t-i} + \sum_{i=0}^p \beta_2 \Delta AGR_{t-i} \\ & + \sum_{i=0}^p \beta_3 \Delta AGR^2_{t-i} + \sum_{i=0}^p \beta_4 \Delta IND_{t-i} \\ & + \sum_{i=0}^p \beta_5 \Delta IND^2_{t-i} + \sum_{i=0}^p \beta_6 \Delta EIN_{t-i} + \xi_t \end{aligned} \quad (4)$$

The Δ in the above equation is the first differences of a variable β_0 is the intercept while $\beta_1, \beta_2, \beta_3 \dots \beta_6$ are the estimated coefficients of the respective variables at *i* number of lags included in the estimation. ECM_{t-1} is the lagged error term whose coefficient λ indicates the speed of adjustment of the variables toward the long run equilibrium following a disequilibrium in the short run. The coefficient of the lagged ECM is expected to be negative and statistically significant to confirm the long run relationship between the dependent variable and the independent variables.

FINDINGS AND INTERPRETATION OF RESULTS

Stationarity Test Results

The results for the Augmented Dickey-Fuller stationarity test presented in Table 1 show that at levels none of the variables was stationary at any statistical level of significance. However, the variables became stationary at first difference. Thus *ENV, IND, IND*², *AGR, AGR*² and *EIN* are all integrated of the order one, *I(1)* at 1% level of significance.

Cointegration Results

After getting the variables to be stationary at first difference, the cointegration test was conducted to ascertain the existence of long run relationship between *ENV* and the explanatory variables. The Johansen cointegration test in Table 2 reveals that cointegration was present implying a long run relationship between *ENV* and its explanatory variables.

Table 1: Augmented Dickey-Fuller Unit Root Test in Levels and at First Difference

| Variable | t-statistic | Critical Value 1% | Critical Value 5% | P-Value |
|----------|-------------|-------------------|-------------------|---------|
| ENV | 0.057946 | -3.626784 | -2.945842 | 0.9578 |
| AGR | -0.020839 | -3.621023 | -2.943427 | 0.9505 |
| AGR2 | 0.100853 | -3.626784 | -2.945842 | 0.9616 |
| IND | -0.448397 | -3.626784 | -2.945842 | 0.8898 |
| IND2 | -0.317257 | -3.626784 | -2.945842 | 0.9174 |
| EIN | -1.060007 | -2.650145 | -1.953381 | 0.2540 |
| DENV | -9.399145 | -3.626784 | -2.945842 | 0.0000 |
| DAGR | -4.788122 | -3.626784 | -2.945842 | 0.0004 |
| DAGR2 | -4.733398 | -3.626784 | -2.945842 | 0.0005 |
| DIND | -4.249542 | -3.626784 | -2.945842 | 0.0019 |
| DIND2 | -4.250615 | -3.626784 | -2.945842 | 0.0019 |
| DEIN | -4.800544 | -3.626784 | -2.945842 | 0.0005 |

*MacKinnon (1996) one-sided p-values.

Table 2: Johansen Cointegration Test Result

| Hypothesized No. of Conitegration | Eigen value | Max-Eigen Statistic | 0.05 Critical Value | Prob** |
|-----------------------------------|-------------|---------------------|---------------------|--------|
| None * | 0.96074 | 110.0769 | 40.07757 | 0.0000 |
| At most 1 * | 0.767466 | 49.59638 | 33.87687 | 0.0003 |
| At most 2 | 0.476918 | 22.03259 | 27.58434 | 0.2187 |
| At most 3 | 0.41415 | 18.17952 | 21.13162 | 0.1233 |
| At most 4 | 0.305452 | 12.39281 | 14.2646 | 0.0968 |
| At most 5 | 0.000136 | 0.004625 | 3.841466 | 0.9449 |

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

3.3 LONG RUN ESTIMATION RESULTS FROM COINTEGRATION

The long run estimation from the normalised cointegrating vector is finally presented in Table 3. The long run results show that industrial growth (*IND*) and Agricultural growth (*AGR*) positively affect environmental degradation at one percent level of significance. Also the square of industrial growth (*IND*²) and agricultural growth (*AGR*²) all negatively affect environment degradation. This is an indication that an inverted U-shape relationship exist between agricultural growth and environmental degradation as well as industrial growth and environmental degradation. Thus in the long run,

growth in Ghana's agricultural and industrial sectors support the EKC hypothesis confirming Boopen & Vinesh (2011) that the EKC is a long run phenomenon. The results here suggest that an agrarian economy and not industrialised one alone may experience the EKC hypothesis as the introductory statement of Panayotou's (1997) work might suggest. Consequently, the general explanation to the EKC hypothesis is applicable to both sectors although the explanation seems to be more concerned about industrialised economies. For instance, Panayotou (1997) asserts Grossman & Krueger (1995) account that poor countries (low industrialised economies) experience high level of environmental pollution because individuals here prefer jobs and income to cleaner environment but individuals in high richer countries (high

industrialised economies) seek for cleaner environment, can easily justify the “Industrial Environment Kuznets Curve”.

Table 3: The Long Run Estimation ENV from the Normalised Cointegrating Vector

| Variable | Coefficient | Standard error | T ratio |
|------------------|-------------|----------------|---------|
| IND | 1.240*** | 0.0922 | 13.449 |
| IND ² | -0.004*** | 0.0005 | -8.000 |
| AGR | 118.825*** | 10.2576 | 11.584 |
| AGR ² | -2.814*** | 0.2416 | -11.646 |
| EIN | 0.146*** | 0.0209 | 6.9856 |

***Significant at 1% level Log likelihood 60.20388

However, Bhattarai *et al.* (2004; p. 11) links agriculture to the EKC when they hypothesized that:

“initially agricultural intensification happens at the cost of deforestation. However, as the economy develops the pressure for deforestation decreases because of the contribution of agricultural intensification on agricultural productivity. Further, people start realising the environmental services provided by the forestland thereby stopping the deforestation.”

Furthermore, Coderoni & Esposti (2011) have noted a two-way and bidirectional impact of agriculture on the environment which may help advance the “Agricultural Environmental Kuznets Curve”. They point out that on the one hand, agricultural activities lead to pollution of water bodies, deforestation, loss of biodiversity, alteration of habitat and emission of Green House Gases while on the other hand, agriculture also provide a sink for Green House Gases, prevents and controls floods and helps in conserving biodiversity.

Table 4: Estimates of Over-Parameterised Error Correction Models

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|------------------------|-------------|------------|-------------|--------|
| DAGR | 9.840035 | 8.742308 | 1.125565 | 0.2895 |
| DAGR ² | -0.230877 | 0.202173 | -1.141979 | 0.2829 |
| DIND | -11.30615 | 4.146432 | -2.726717 | 0.0233 |
| DIND ² | 0.273794 | 0.099406 | 2.754302 | 0.0223 |
| DEIN | 0.01002 | 0.007079 | 1.415528 | 0.1906 |
| C | 0.073948 | 0.02509 | 2.947378 | 0.0163 |
| ECM(-1) | -0.448059 | 0.242842 | -1.845062 | 0.0981 |
| DENV(-1) | -0.557289 | 0.347615 | -1.603178 | 0.1434 |
| DENV(-2) | -0.091533 | 0.30385 | -0.301245 | 0.7701 |
| DENV(-3) | -0.294601 | 0.315076 | -0.935016 | 0.3742 |
| DAGR (-1) | 3.629016 | 9.07236 | 0.400008 | 0.6985 |
| DAGR (-2) | 7.843526 | 8.321876 | 0.942519 | 0.3705 |
| DAGR (-3) | -10.31368 | 17.51279 | -0.588923 | 0.5704 |
| DAGR ² (-1) | -0.089591 | 0.211196 | -0.424208 | 0.6814 |
| DAGR ² (-2) | -0.182566 | 0.194134 | -0.94041 | 0.3716 |
| DAGR ² (-3) | 0.231786 | 0.408006 | 0.568095 | 0.5839 |
| DIND (-1) | -11.46218 | 5.854664 | -1.957786 | 0.0819 |
| DIND (-2) | 8.446707 | 6.339715 | 1.332348 | 0.2155 |
| DIND (-3) | -11.12471 | 5.111247 | -2.176515 | 0.0575 |
| DIND ² (-1) | 0.275759 | 0.141766 | 1.945163 | 0.0836 |
| DIND ² (-2) | -0.20103 | 0.153624 | -1.30858 | 0.2231 |
| DIND ² (-3) | 0.270491 | 0.12459 | 2.171048 | 0.058 |
| DEIN(-1) | 0.003505 | 0.01142 | 0.306944 | 0.7659 |
| DEIN(-2) | -0.01771 | 0.015781 | -1.122239 | 0.2908 |
| DEIN(-3) | -0.012649 | 0.010721 | -1.179866 | 0.2683 |

R² = 0.90 Adj. R² = 0.64 DW test = 2.09 F-test = 3.46 (p < 5%)

Table 5: Short Run Results from Error Correction Model

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|--------------------------|-------------|------------|-------------|--------|
| <i>DIND</i> | -9.042882 | 2.936705 | -3.079261 | 0.0047 |
| <i>DIND</i> ² | 0.220823 | 0.072534 | 3.0444 | 0.0052 |
| <i>DAGR</i> | 10.38078 | 5.625766 | 1.845221 | 0.076 |
| <i>DAGR</i> ² | -0.242537 | 0.131407 | -1.84569 | 0.0759 |
| <i>DEIN</i> | 0.001716 | 0.00423 | 0.405546 | 0.6883 |
| <i>C</i> | 0.037202 | 0.016742 | 2.22209 | 0.0348 |
| <i>ECM(-1)</i> | -0.40728 | 0.173635 | -2.34561 | 0.0266 |
| <i>DEIN(-1)</i> | 0.00735 | 0.003944 | 1.863536 | 0.0733 |
| <i>DENV(-1)</i> | -0.24256 | 0.151145 | -1.604817 | 0.1202 |

$$R^2 = 0.61 \quad \text{Adj. } R^2 = 0.49 \quad \text{DW test} = 2.24 \quad \text{F-test} = 5.26 \quad (p < 1\%)$$

Energy intensity usage is also found to positively affect environmental degradation meaning environmental degradation increases with high level of energy use. The finding here is similar to studies like Sharma (2011), Saboori and Soleymani (2011), Hossain (2012) and Saboori *et al.* (2012).

The Short Run Results from Error Correction Model

The short run results derived from the estimation of the error correction model are presented in Table 5. The error correction model results started by taking an over-parameterised estimation, which involved an estimation of the first differences of the variables together with their lags (see Table 4). An optimal lag length of three was used for the estimation based on the appropriate information criterion-Akaike information criterion. However, since interpreting results from Table 4 is not clear, an empirically parsimonious model was derived by eliminating those variables that were not significant to finally arrive at the results in Table 5.

It can be observed that the final model from Table 5 has about 61% of the changes in the dependent variable explained by the independent variables. This is seen by the R^2 value of 0.61. Also, the overall fitness of the model (F-test value of 5.26) is also significant at 1%. The model reveals that the coefficient of the *ECM(-1)* is correctly signed and significant at five percent confirming the long run relationship between environmental degradation and the other variables. The *ECM(-1)* coefficient of -0.41 indicates that the speed of adjustment to equilibrium in the long run whenever there is a shock in the short run is 41% which is quite moderate.

In the short run, the inverted U-shaped curve is confirmed in the agricultural sector as indicated by the positive and significant coefficient of *DAGR* and a negative significant coefficient of *DAGR*². Interestingly there is no such relationship between the industrial growth and environmental degradation which

perhaps confirms the long run phenomenon issue of the EKC raised by Boopen & Vinesh (2011). From the results there is a negative relationship between *DIND* and environmental degradation but a positive one between *DIND*² and environmental degradation. Meanwhile intensity of energy usage positively affects environmental degradation just like its long run effect.

Diagnostic Tests

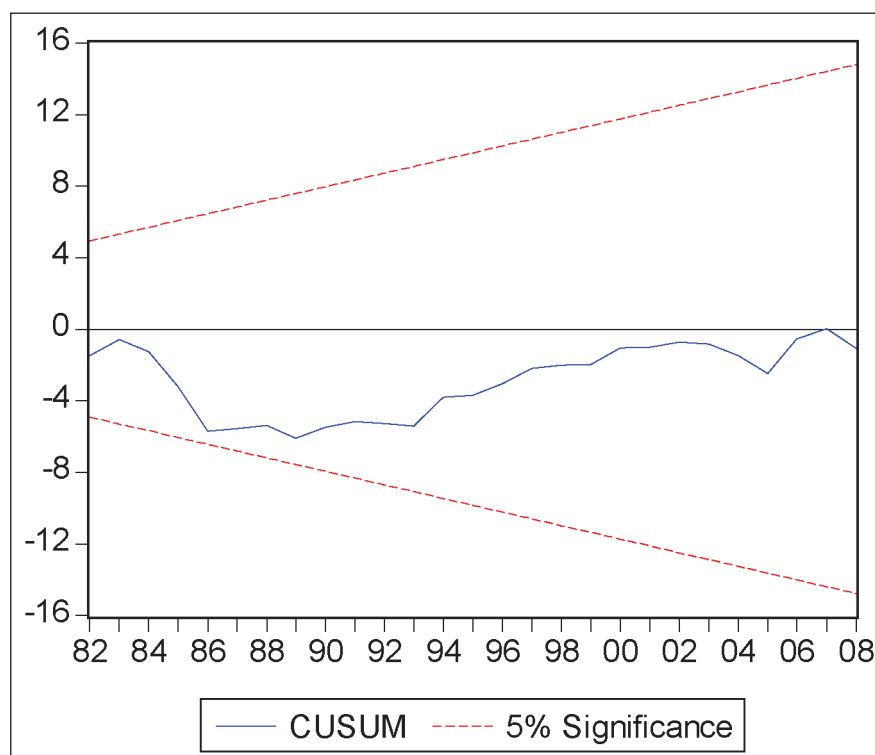
The adequacy of the specified model was also examined with various diagnostic tests including test for serial correlation (ARCH LM Test), heteroscedasticity (White Heteroscedasticity Test) and stability test (Ramsey RESET test). From Table 6 the results indicate that the model had the desired econometric properties. Thus it did not suffer from Heteroscedasticity, serial correlation or instability. The stability of the estimated parameter is confirmed by the Cumulative Sum (CUSUM) in Fig. 1.

Table 6: Diagnostic Tests Results

| Diagnostic Test | F-statistic | Probability |
|-------------------------------|-------------|-------------|
| White Heteroskedasticity Test | 0.476482 | 0.930207 |
| ARCH LM Test | 0.035617 | 0.851465 |
| Ramsey RESET test | 0.658620 | 0.424415 |

CONCLUSION AND RECOMMENDATIONS

This paper has attempted to investigate the effect of agricultural growth and industrial growth on environmental degradation in Ghana. Relying on WDI data between for the period, 1971-2008, the Johansen cointegrating test showed a long run relationship among variables namely agricultural growth, square of agricultural growth, industrial growth, square of industrial growth and environmental degradation. The long run estimation from the cointegrating equation

Fig. 1: Plot of cumulative sum of recursive residuals

showed positive and significant coefficients for both agricultural and industrial growth but significant negative coefficients for the square of industrial and agricultural growth. This confirms the EKC hypothesis in the agricultural sector as well as the industrial sector. A positive coefficient of intensity of energy use was also found. The results in the short run are similar to those of the long run except that the EKC hypothesis was not supported by growth in the industrial sector. The speed of the adjustment given by the lagged error correction term had the correct sign of -0.41 at 5 percent level of significance indicating that there would be about 41 percent speed of adjustment towards the long run equilibrium when there is any imbalance in the short run.

The recommendations based on the above findings are as follows. Firstly growth in the industrial and agricultural sectors can be promoted to help reduce the environmental degradation (cumulative emissions of carbon dioxide) in Ghana as this has been found to reduce emission in the long run. Secondly efficient use of energy is needed to reduce environmental degradation and lastly further studies can be carried out in other countries to ascertain the relationship between agricultural growth, industrial growth and environmental degradation.

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