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Is there a Kuznets curve for Sub-Saharan Africa?

A dissertation submitted as part of the requirement for the BSc Applied Geography

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12.05.2017

Acknowledgements

I am tremendously fortunate for my supervisor, Professor Adrian Newton, for his efforts in addressing my concerns and worries throughout the entire process of my independent research project.

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Abstract

Not only is the Kuznets curve a widely debated issue, the reason behind such theory is relevant to both the past and future. As a result of globalisation, industries are growing, relocating and diversifying which is having distinct impacts upon the environment. Sub Saharan Africa (SSA) has yet to follow in the footsteps of other industrialised nations, so it is crucial to see whether the region is a contender for the famous theory. This study involved using regression techniques, in terms of the quadratic curvilinear method to investigate an apparent Kuznets curve between 20 countries within Sub Saharan Africa. These methods were tested between three development variables; GDP, GDP per capita and infant mortality rate, and two environmental indicators; CO_2 emissions and Forest Area. The results indicate that there is a Kuznets curve for Sub Saharan Africa in terms of GDP and CO_2, but other indicators e.g. GDP per capita and CO_2 have only shown linear trends. As for infant mortality rate there is no significant relationship, and produced the opposite of what was hypothesised.

1.0 Introduction

There is clear evidence that many economies are growing, some at faster rates than others. Although these nations benefit from increased employment and financial stability, negative externalities are explicit. Despite rising income, human welfare is impacted by environmental degradation – production and consumption require large inputs of energy and material, and generate larger quantities of waste by increasing the extraction of natural resources, accumulating waste and concentrating pollutants, overwhelming the carrying capacity of the biosphere. Furthermore, it is also argued that the depletion of the resources base will eventually put economic activity itself at risk (Panayotou 1994).

The Environmental Kuznets Curve (EKC) concept is a recent development in environmental economics, particularly since Grossman and Krueger's (1993) path-breaking study of the environmental impacts of the North American Free Trade Agreement. The theory dates back to the 1970s when several scientists began to question how natural resource availability could be compatible with sustained economic growth (Omotor 2015). The EKC hypothesis has the main maxim that there is the existence of an inverted U-shaped curve between environmental pollution and economic development (Stanton 2012), which Figure 1 demonstrates.

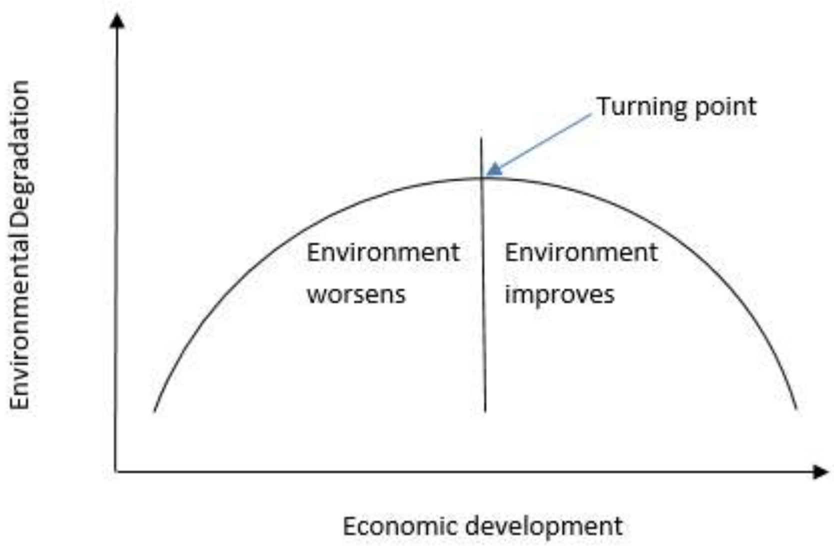

Figure 1. The Environmental Kuznets curve (personal collection)

As Beckerman (1992) famously wrote,

> “The strong correlation between incomes, and the extent to which environmental protection measures are adopted, demonstrates that in the longer run, the surest way to improve your environment is to become rich.”

The transition from a manufacturing economy to a service-dominated nation generates a network of wealth through increasing demand for less materially intensive goods, as well as the enforcement and regulation of environmental protection measures (Ajide and Oyinlola, 2010).

In the quest for every nation to actualise some economic successes, there has been obvious threat to the environment. Each year witnesses several hectares of productive dry land turn into worthless desert, likewise more than 11 million hectares of forests are destroyed yearly (United Nations 1987). In Europe, acid precipitation eliminates forests and lakes as well as damaging the artistic and architectural heritage of nations.

Stern (2004) concluded that the EKC has no theoretical evidence, only statistical. Therefore there is little evidence for a common inverted U-shaped pathway in which countries are following (Newton and Cantarello 2014). However, researchers are still testing the theory. Azam and Khan (2016) found that with critical analysis, contrasting levels of development signify different relationships between economic development and environmental degradation.

According to Omotor (2015), if an EKC is indeed a generalized phenomenon, this will be an indication, ceteris paribus, that environmental degradation will automatically fall in the long run as incomes rise. Nevertheless, if the EKC proposition does not hold, this would be an indication that policy intervention would be necessary to curb pollution and make sustainable development a reality.

Within Africa however, empirical studies have shown diverse yet limited results. Baliamoune-Lutz (2012) Osabuohien et al. (2014) have validated the hypothesis while Orubu et al. (2009) and Orubu and Omotor (2011) failed to confirm the existence of EKC.

Due to the specific activities, government ruling and the path that the region is taking, there is widespread perception that the region of Sub-Saharan Africa is structurally different from the rest of the world. Sunday (2016) believes that lessons from East Asia or Latin America do not apply to them, as their situation is so dissimilar. This is one of the reasons why the validity of the EKC hypothesis must be confirmed in this isolated region, as each nation can work, build and learn from one another especially when addressing the impact from variant pollutants.

1.1 The global problem

Both Arrow et al (1995) and Stern et al (1996) argued that if there was an EKC type relationship it might be a result of the effects of trade on the distribution of polluting industries. The Hecksher-Ohlin trade theory suggests that, under free trade, developing countries would specialize in the production of goods that are intensive i.e. labour and natural resources (World Trade Organisation 2010). This is especially the case in that Sub Saharan Africa is endowed with many finite resources. The developed countries would specialise in human capital and manufactured capital-intensive activities. Part of the reduction in environmental degradation levels in the developed countries and increases in environmental degradation in middle-income countries may reflect this specialization (Hettige et al. 1992, Lucas et al. 1992, Suri and Chapman 1998). Environmental regulation in developed countries might further encourage polluting activities to gravitate towards the developing countries (Lucas et al., 1992).

In low-income countries, Torras and Boyce (1998) reported that institutional factors affect the EKC relationship, such as wider literacy, greater political liberties and civil rights that in turn positively affect environmental quality. Likewise, Panayotou (1997) suggests that environmental policy could enable a ‘harmonisation between economic growth and environmental quality’. He puts forward the idea that the quality of policies and institutions can help flatten the EKC and reduce the environmental consequence of economic growth.

1.2 Limitation of current literature

As for the variables considered when testing the Kuznets curve, it is important to assess whether they all lead to the same long run effect as shown by the inverted

U-shaped curve. Researchers are far from agreement as to whether the Kuznets curve provides the same concept for available data, leading to the debate of whether indicators such as infant mortality rate, deforestation rates or CO_2 emissions produce a convincing theory. Stern (1998) argues that the evidence for the inverted U-shaped relationship is only apparent when testing specific environmental measures. However, this is open to contest since a number of conflicting studies by Grossman and Krueger (1993) were published. According to their study, suspended particulates decline monotonically with income.

Moreover, many of the previous studies used a single environmental variable, particularly carbon dioxide emissions, as a proxy for environmental quality (Sunday 2016). But not all environmental pollutants follow the same EKC process; the impact of FDI and economic growth on each environmental variable in a particular country may vary. Having identified certain common features in the relevant literature including a profusion of research being done on a particular country in conjunction with the singular use of a particular variable, for example CO_2 emissions (Holtz-Eakin and Selden 1995, Grunewald et al. 2009, Beck and Joshi 2015, Zerbo 2015), this paper will examine the literature closely in order to demonstrate the relationships between varied social development and environmental indicators. Despite many studies being conducted on single countries, few have examined Sub Saharan African economies as a whole.

Dasgupta et al. (2002) provide the evidence that environmental improvement is possible in developing countries and that environmental exhaustion will be lower in countries that are achieving, or have achieved steady economic growth. By providing data that showed a decline in pollutants in developing countries overtime, this means the particular theory can be applied to SSA countries as well as alternative industrialising economies.

Amongst the wide literature, infant mortality rate as a variable for economic development is scarcely used. However it is proven that non-income factors, such as income inequality, literacy rate, political rights and civil unrest, urbanisation and the population level of a country have impacts on the level of environmental quality (Oparinde 2010), yet none particularly focused on the infant mortality rate as a development variable. Those that have explored this tend to test income against mortality rate (Flegg 1982, Pritchett and Summers 1996).

On the whole, it could be argued that the empirical evidence has been largely mixed, with the determining turning points being significant merely for singular pollutants. Withal, the bulk of studies confirm the existence of the theory, plus different income turning points in relation to various pollutants. Many studies focus on sulphur dioxide as a means for environmental degradation and to a lesser extent on deforestation rates, all whilst neglecting infant mortality rate and carbon emissions. It is therefore crucial to evaluate the importance of carbon in developing countries (Orubu et al. 2009).

Thanks to advances in remote sensing, a study by Cuaresma et al. (2016) investigates this relationship using a Cross-Border Deforestation Index (CBDI) in which their resulting estimated Kuznets curve for deforestation includes many of the countries used in this study. Overall, it was found that there is only weak evidence concerning the upward-sloping effect of income on forest cover. Now, however, an IIED study finds that several Chinese companies in Gabon and Mozambique have moved upstream, acquiring forest-land concessions and setting up local factories to directly engage in timber harvesting. More direct access to forests allows Chinese investments to play a bigger role in forest management in Africa (Xiaoxue Weng et al. 2014).

1.3 Research questions

In conclusion, results are mixed and still open is the window of debate on its validity. The creation of the EKC has therefore raised some questions in which has provided an order of investigation;

- Do all aspects of environmental quality deteriorate with economic development?
- How do we define economic development?
- Do contrasting variables have the same effect on environmental quality?

The main objective of the current research is to explore and analyse the economic growth effect on the environment, and to test the empirical validity of other factors in conjunction by using specific measures of environmental indictors and economic development indicators. These are Forest area and Carbon dioxide emissions (CO_2), and GDP, GDP per capita and Infant mortality rate. In addition, it is necessary to investigate if Sub Saharan Africa's economic growth effect on these environmental factors will follow Kuznets' hypothesis.

The effort in this study represents an empirical contribution to the existing knowledge and debate on the Environmental Kuznets Curve hypothesis. The lack of present day confirmations of the curve existing for the region as a whole provides the basis to the study. Accordingly, the objective is to contribute to filling this research gap on the subject matter in Sub-Saharan Africa on account of collecting and developing environmental and economic data for a variety of SSA economies plus undertaking empirical studies that will assist in allocating efficient environmental or even socio-economic policies.

2.0 Methodology

2.1 Data

The data span of the present study is 1990-2013, using world development indicators from the World Bank as our data regarding CO_2 emissions, forest area, real GDP, GDP per capita and infant mortality rate. Unfortunately, data for many countries was limited due to conflict or the lack of resources required to collect such facts.

In order to establish the stability of the EKC model, this research introduced other variables relevant in explaining the extent of economic development and environmental degradation. To test for the environmental Kuznets curve as a whole region, a number of measures were implemented in order to discover the relationships between development and environmental degradation. The infant mortality rate is deemed fit in the model as countries that have a lower number of child deaths below the age of 1, per thousand, will indicate the level of substantial healthcare linking to development, and also the decreased rate of pollution. It is often found that natural gas pollution is likely to increase the rate of infant mortality (Cesur et al. 2013), therefore including the rate of infant mortality would be an acceptable variable. The trend would follow the same curve, but in respect would act the opposite way. Due to lower infant mortality numbers indicating a higher developed economy, the curve would start off with looking at the most developed countries first instead of further along the curve. GDP per capita also plays a significant role in determining the level of environmental degradation. A higher average income connotes higher pollution levels due to intense pressures that will be placed on the available natural resources. As a result, a higher percentage of the population will be able to afford utilities and products that require the use of fossil fuels. Moreover, the demand will escalate generating the potential rise in imports. Forest area will take a different approach due to the graph representing a downward trend when forest area decreases, instead of the typical rise to reach the peak of an inverted U-shape curve when there is increased environmental degradation. Rather than incorporating deforestation rates, the study focuses on forest area. The theory will still work effectively due to the effects of economic growth in turn leading to declining forest area rates therefore this will produce a U-shaped curve.

Instead of focusing on one country, 20 Sub-Saharan African countries were sampled to assess whether the EKC is present in one particular region (see Appendix A). By examining a range of countries within a specified location, it is easier to establish at what rate they are changing compared to one other or if there are links in the data. However, previous studies have chosen to focus on one specific country due to individual uncertainties which could affect the overall relationship results (Nasr et al. 2014). Though by looking at each country within a scatter plot in which this study does, one is able to spot the outliers in order to determine if they are significant enough to be removed so as to not affect the whole dataset.

The assumption of the EKC is that though the level of emissions per capita may differ over countries at any particular income level and so the income elasticity is the same in all countries at a given income level.

The basic EKC equation is written as $EE_{it} = (\alpha + \beta_i F_i) + \delta Y\text{it} + \phi(Y_{it})^2 + k_t + \varepsilon_{it}$ (Alstine and Neumayer 2010). Here, E denotes the environmental indicator, Y denotes per capita income. F denotes country specific effects, k refers to year specific dummies or a linear trend and I and t refer to country and year (Alstine and Neumayer 2010a).

The correlation test was conducted in ensuring that our model is void of multicollinearity problem – a situation where a perfect linear relationship exists among two or more of our explanatory variables. Two major tests of correlation were conducted, namely the Pearson's coefficient and Spearman's rank.

To test for a nonlinear relationship, the quadratic model was fit to the data to produce the EKC, thus using a quadratic regression. As a polynomial term turns a linear regression model into a curve, the inverted U-shape of the Kuznets's theory is evidence enough that in order to find if there is a U-shape amongst the data, this method would be suitable. This feature is also evident in research methods testing the EKC such as Bartoszczuk et al. (2002) and Barro and J. (2008). The first null hypothesis is that a quadratic equation does not fit the data significantly better than a linear equation. There is also a null hypothesis for each equation stating that it does not fit the data significantly better than a horizontal line. In other words, that there is no relationship between the X and Y variables. Some studies, including the original Grossman and Krueger (1991) paper, used a cubic EKC in levels and found an N-shape EKC. This might just be a polynomial approximation to a logarithmic curve. To analyse this particular data set, the quadratic (squared) function is used as it produced a higher r^2 value for all sets thus a greater ability to predict. As the quadratic model can be used to model a series that "takes off" or a series that dampens (IBM 2017) it is deemed fit to interpret the theory of the EKC. There is also reason to fit a quadratic or higher model if there is reason to believe that the relationship between the variables is inherently polynomial in nature, a test that has been popular in current literature. These regressions will be tested for the data of 1990 and 2013 to compare the EKCs from when the region was relatively inactive in terms of growth to recent times when they have had the opportunity to reap the benefits of globalisation.

Furthermore, the forest area and CO_2 percentage change of the years 1990 and 2013 is tested using a paired t-test, specifically indicating the whole change in the 13 years. By using this method it can be seen if there is a significant change between the first sets of data and the last, thus if there was any change at all between the means of the countries after development.

Like many statistical procedures, the paired sample *t*-test has two competing hypotheses, the null hypothesis and the alternative hypothesis. The null hypothesis assumes that the true mean difference between the paired samples is zero, in which this paper will be following.

2.2 Strengths and Weaknesses of the chosen approach

The polynomial regression does a better job at fitting the chosen data than a test for a monotonic relationship. The fitted model is also more reliable with a larger sample size. Second, errors in a regression model are assumed to be uncorrelated; if this assumption does not hold, and it often fails to in the case of time series data, standard errors will not be valid and resulting test statistics may be useless (Franklin and Ruth 2012).

Although spearman's rank and Pearson's co-efficient test for monotonic relationships, a value of $r^2 = 0$ does not indicate that there is no relationship between the variables. A perfect quadratic equation can still exist if $r^2=0$.

One problem with interpreting correlation coefficients solely in terms of statistical significance is that it tells you whether there is a non-random association between two variables, but it interprets nothing about how strong this relationship really is. The advantage of thinking about r^2, in the quadratic function, is that it makes the true strength of the correlation more obvious.

Even where EKCs exist, with median GDP per capita far below mean GDP per capita the environmental implications can be unpleasant for many low-income countries for many years to come (Cole and Neumayer 2005). Second, GDP per capita is typically considered to be a unit root non-stationary process (Bradford et al. 2005) and methods for panel data are usually used. However according to Wagner (2008) regressors involving nonlinear transformations of unit root process behave differently from the linear unit root cases usually considered due to the stochastic behaviour is fundamentally changed by such transformations. Despite considering potential unit root behaviour, several papers fail to acknowledge implications of nonlinear transformations (Perman and Stern 2003). Non-stationary panels remain an area of active research, indeed developing and deploying adequate methods for nonlinear transformations of integrated regressors in whose findings may further challenge past EKC analyses (Alstine and Neumayer 2010b).

In relation to relevance of the data, to use CO_2 levels from the World Bank, the author had to dedicate the data set to 1990-2013. As for the other variables chosen, these have expanded to the 2015 dates but as a result of the importance of the CO_2 variable, two years had to be removed from the desired dataset. Furthermore the chosen econometric evidence captures historical and contemporary evidence but it is not deterministic. The data and time limits used, especially in the case of a developing country, cannot develop a clear trend into the future, but with the aid of the Kuznets's curve this is done for us. The trends shown will clearly depict whether the region is following the curve as of 1990 and 2013.

The availability of environmental quality data is one of the major limitations of the robustness of EKC studies. Not only is it hard enough for poorer countries to obtain this data and have the appropriate facilities in order to pursue it, the data is something that is not easy to be measured accurately (Dinda 2004).

Finally, in this study, outliers are removed within certain circumstances if the data set is affected so greatly by one country. Removing data points can introduce other types of bias into the results, as well as potentially losing critical information. Nevertheless, by comparing the original data to the differing results without such outliers, the bias and loss of information is kept at a minimum. This also allows for any potential disadvantages with the theory. Any outliers will be removed and the conflicting results will be compared with the original.

Each research method will be addressed in a particular manner in order to finalise an answer.

2.3 Do all aspects of environmental quality deteriorate with economic development?

To address this particular research question both forest area and CO_2 are presented against variables of economic development, in which a U-shaped relationship between the two variables is believed to be apparent, imitating the theory of the EKC. Further to this, the quadratic regression will indicate how strong the relationship will be and so can be used for comparison between the variables.

2.4 How do we define economic development?

The second research objective is to investigate how economic development is defined, and whether all types of increasing development can have the same effect upon the environment. This includes GDP, GDP per capita and infant mortality rate, one of the very variables not shown in abundance in the literature.

There are many indicators used in order to define economic development, but many overlap and can have different results in terms of the economy and the people.

2.5 Is there an apparent Kuznets curve for Sub Saharan Africa?

The Kuznets curve for the 20 countries will be displayed on a scatter graph, using a quadratic function to fit a curve to the results. This will be tested for each variable against one another from the subset of economic development and environmental degradation variables. As a result, one will be able to identify where one specific country is upon the curve, indicating at what level they are degrading the environment and whether this is in relation to their development stage.

2.6 Potential challenges regarding the research methods

In this study, the author will use a series of data analysis including Pearson's co-efficient, Spearman's rank, paired t-tests and a quadratic regression in order to test the relationship between economic development and environmental degradation amongst 20 Sub-Saharan African countries. This will also provide evidence for any drastic changes in mean environmental degradation rates. In doing so the main challenge is that Sub Saharan Africa, having faced difficulties such as war and corruption, may not take the same path in which other studies have concluded an EKC. Being faced already with the challenge of the World Bank not providing adequate data in the desired time period, lack of resources and doubtful investment means that Africa is still in the early stages of economic development. Especially for individual states, the completion of an entire EKC is could be difficult. Therefore by looking at the region as a whole and comparing it to data 23 years earlier, it is thought that there would be key differences derived from some increased trade and development that these parts have seen since the interest of developing economies.

3.0 Results

The results of this study include presentation and description of the major statistical tests used in relation to the studies research questions.

3.1 Curves

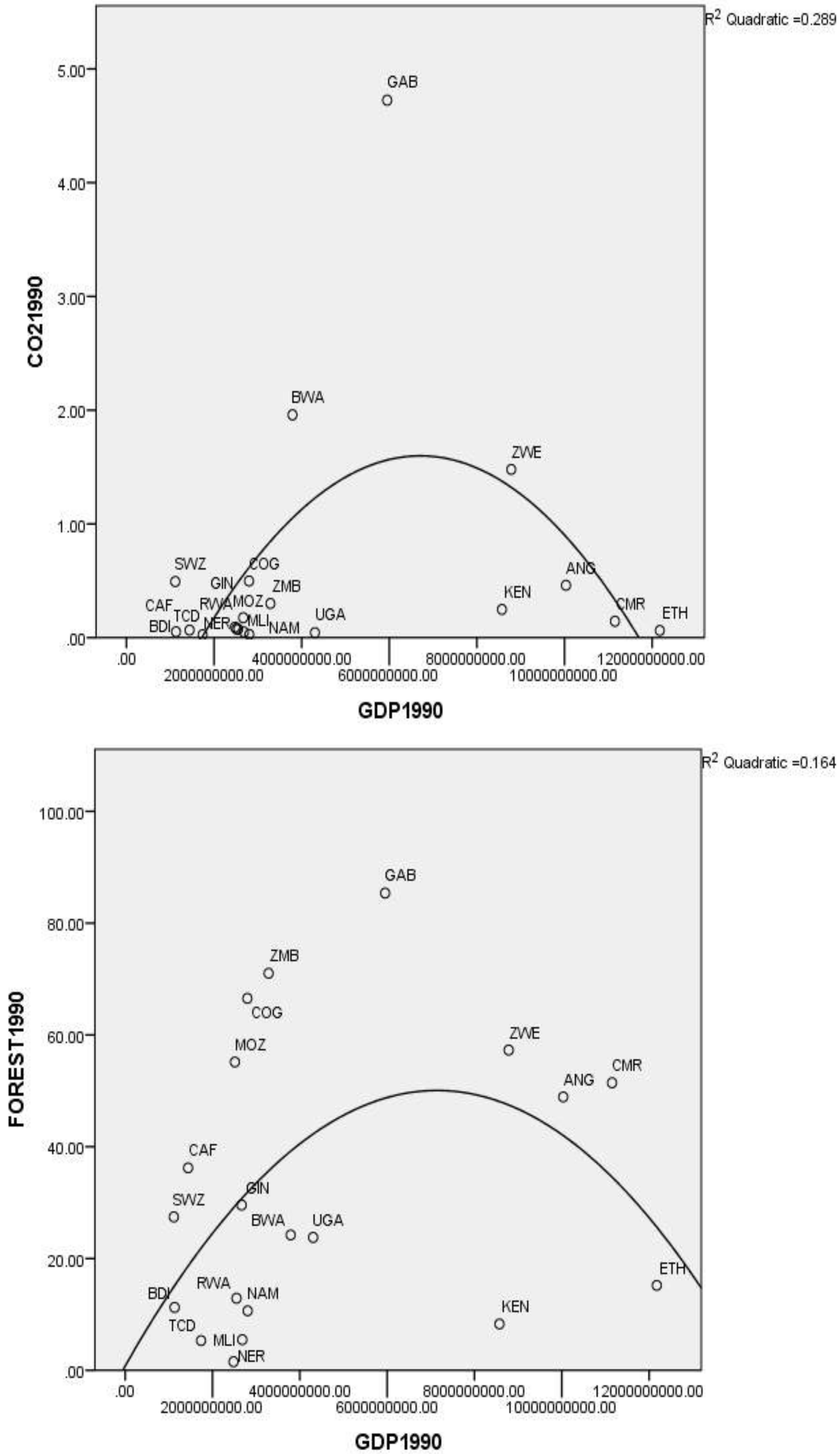

Figure 2. Curvilinear regression scatter plot results using the quadratic function for the GDP variable in 1990

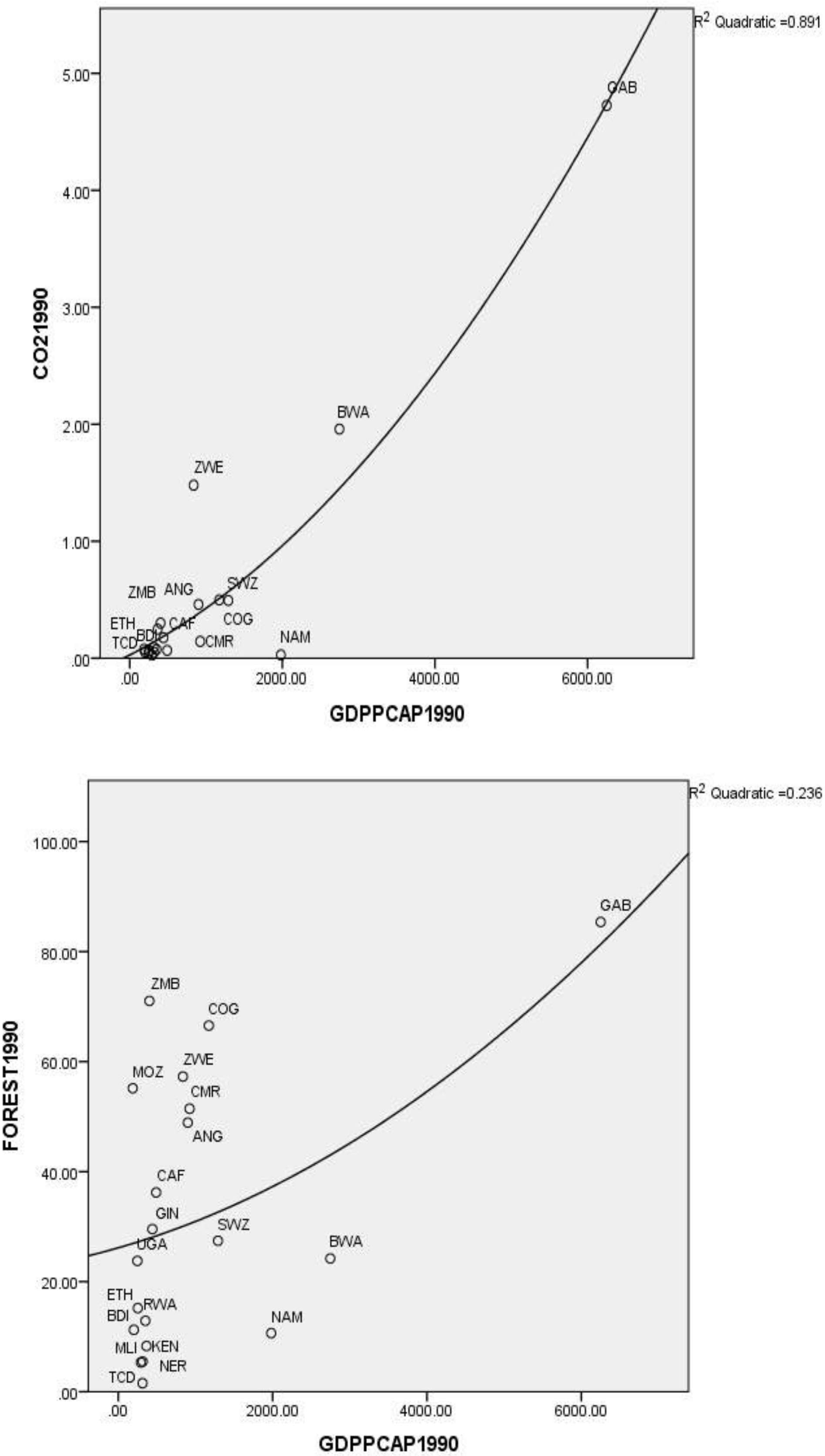

Figure 3. Curvilinear regression scatter plot results using the quadratic function for the GDP per capita variable in 1990

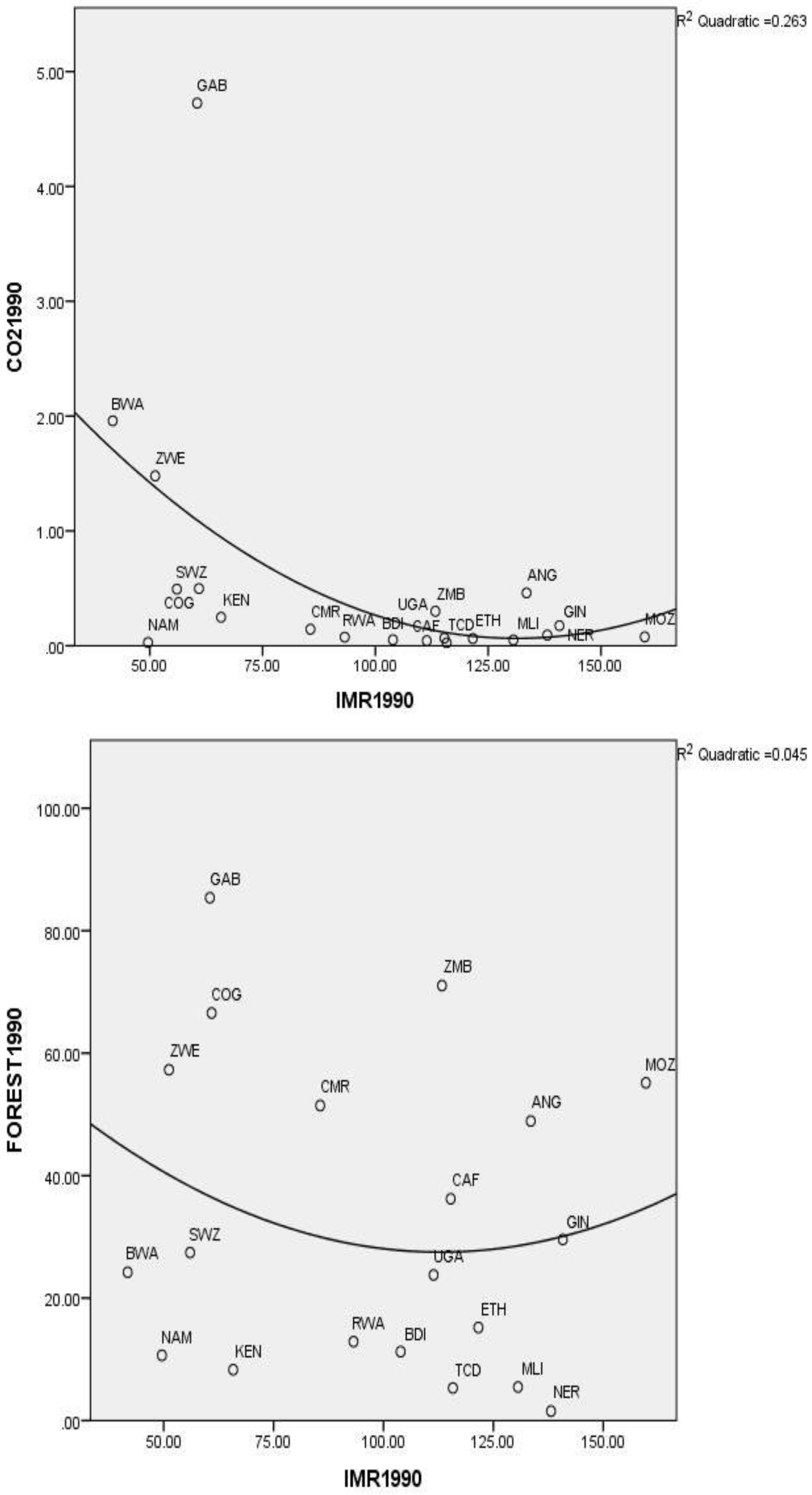

Figure 4. Curvilinear regression scatter plot results using the quadratic function for the Infant Mortality Rate variable in 1990

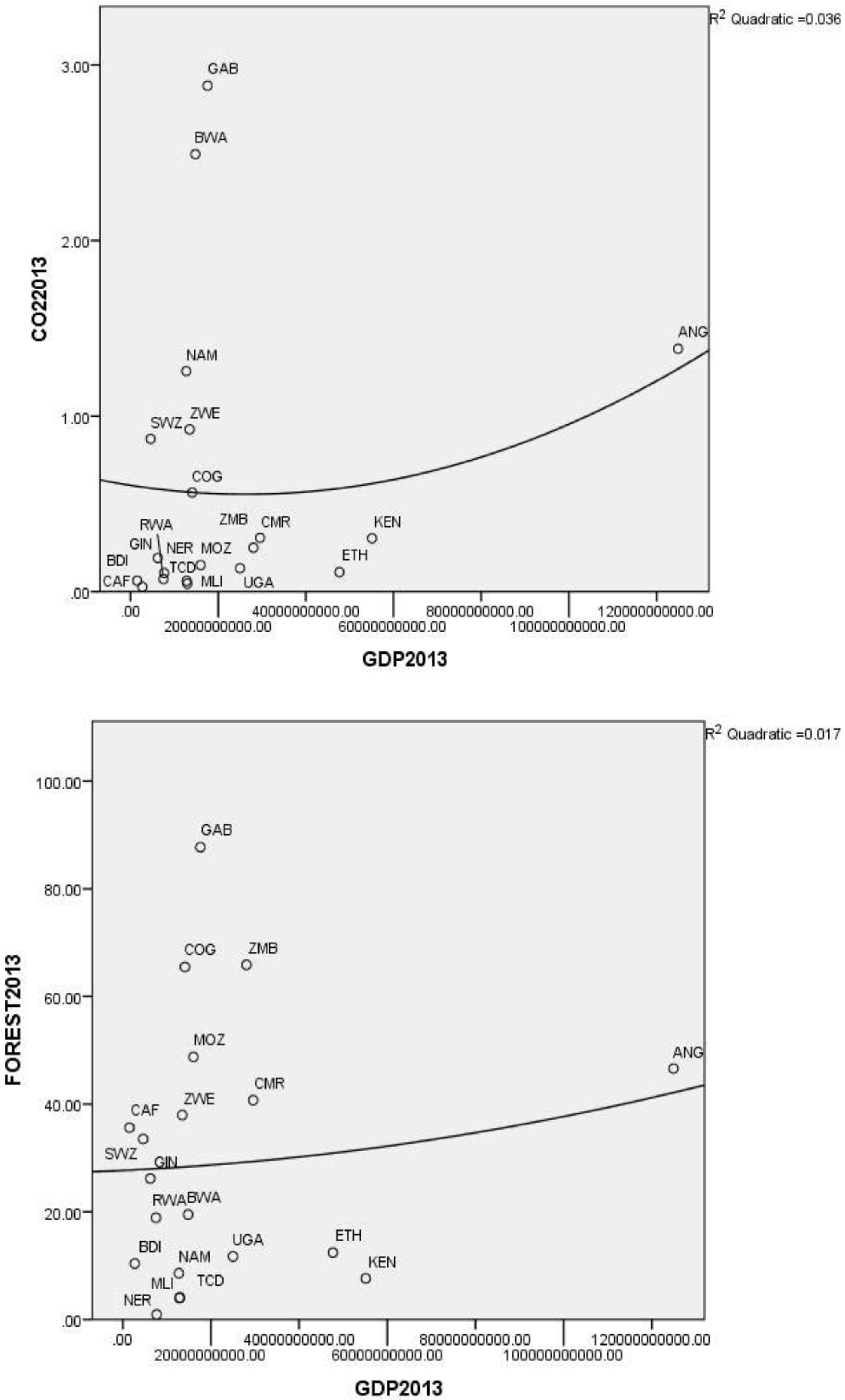

Figure 5. Curvilinear regression scatter plot results using the quadratic function for the GDP variable in 2013

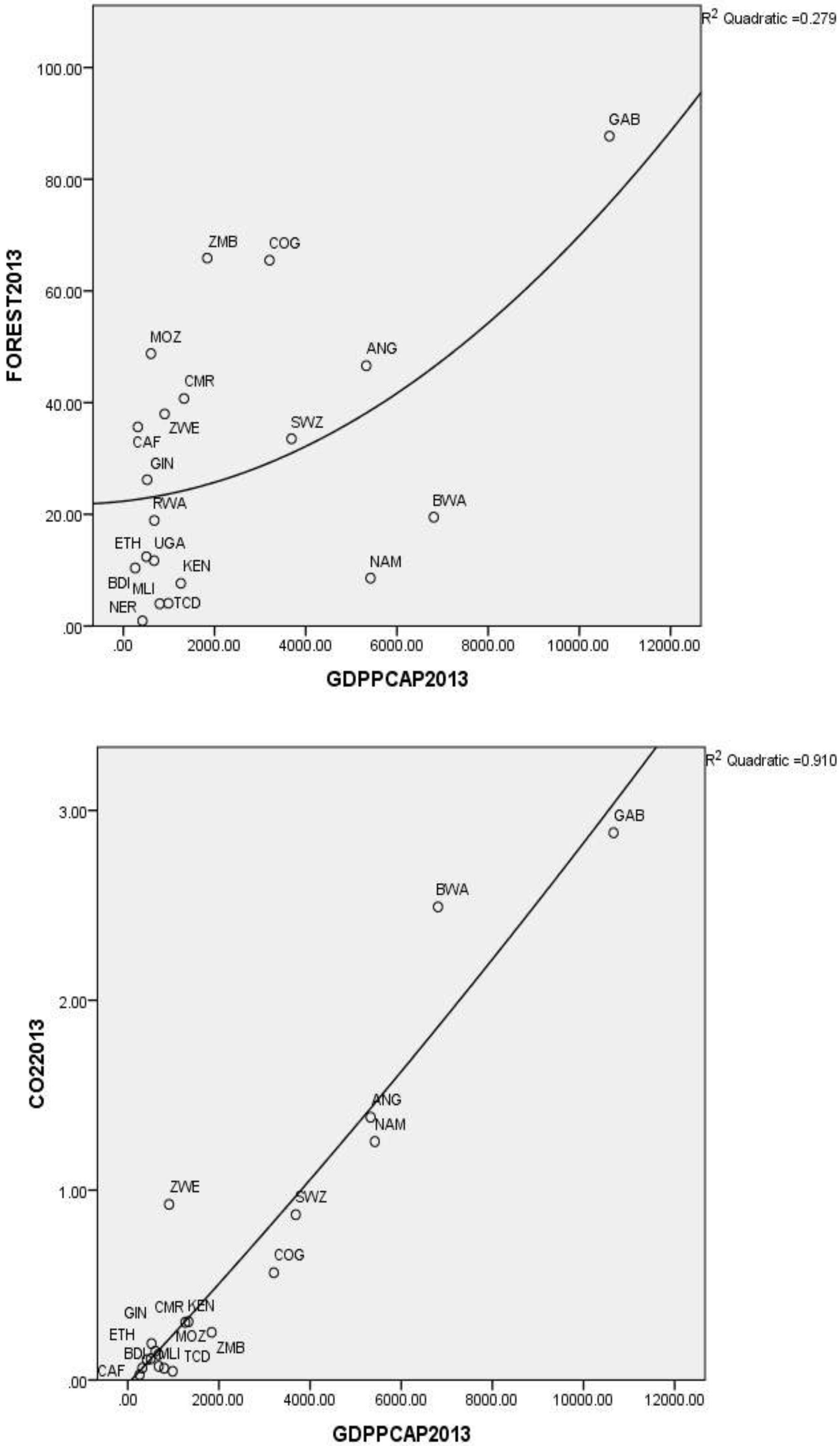

Figure 6. Curvilinear regression scatter plot results using the quadratic function for the GDP per capita variable in 2013

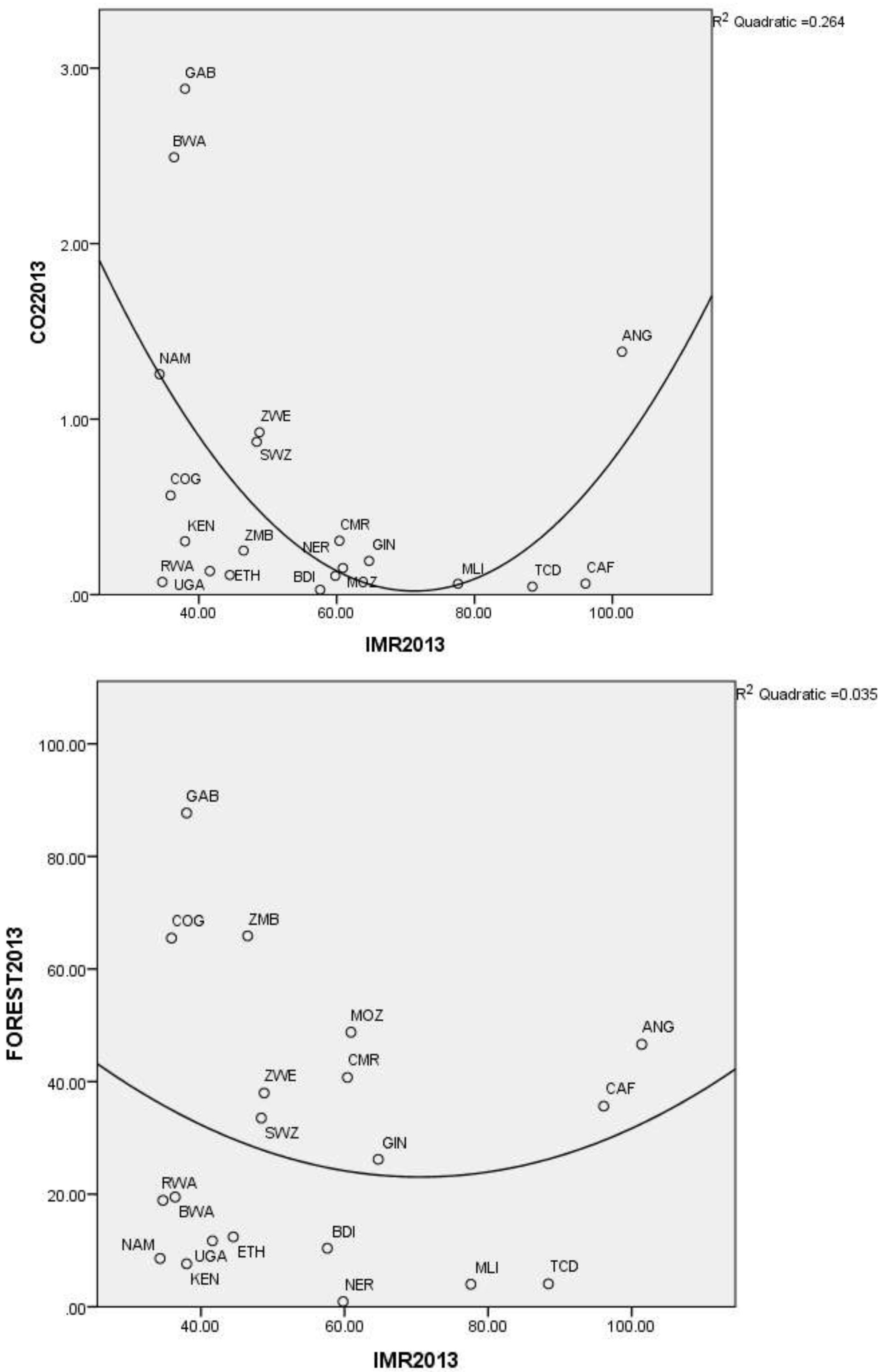

Figure 7. Curvilinear regression scatter plot results using the quadratic function for the Infant Mortality variable in 2013

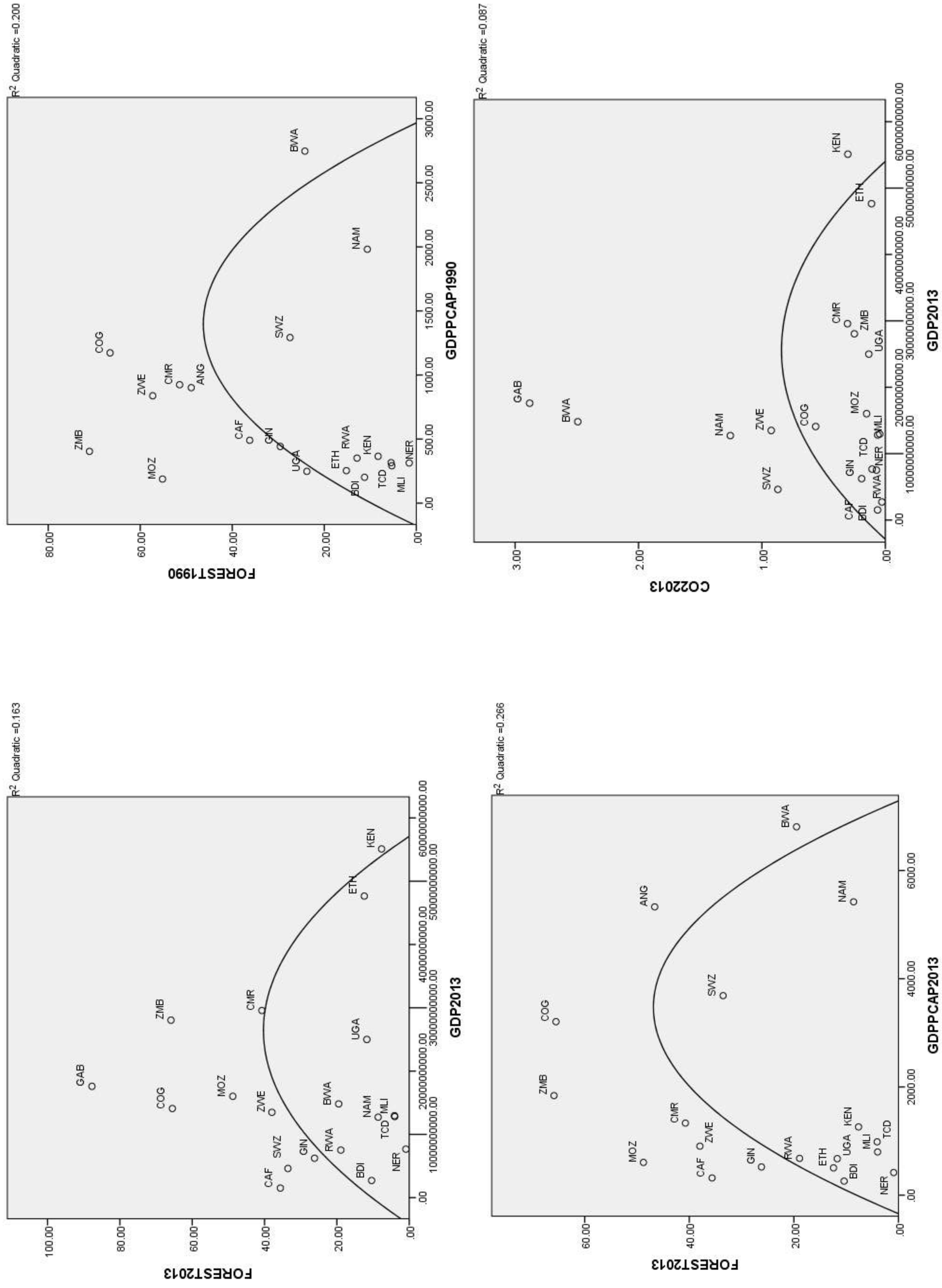

Figure 8. Outliers of the curvilinear results of Sub Saharan Africa excluding Angola from GDP 2013 against both CO2 2013 and Forest Area 2013, and excluding Gabon from GDP per capita against Forest Area in both 1990 and 2013.

The quadratic regression results for each economic and environmental variable against one another are shown from Figures 2 to 8. This is done in the years 1990 and 2013, where one can see significant shifts in the hypothesised Kuznets curve.

Plots indicating evidence of a curvilinear relationship were between GDP and CO_2, and, GDP and Forest both in the year of 1990 and 2013. Here, the countries are relatively similar in respect of the position along the curve in which they lie, for example Gabon is at the peak of the curve whilst Ethiopia, Angola and Zimbabwe are all in the downward stages, thus with rising GDP comes the drop in CO_2 and Forest area. Even though they did follow the hypothesised curve, the *r* values were relatively low (CO_2; r^2=0.289, Forest; r^2=0.169), meaning that for CO_2 only 29% of the points were accounted for, and the remaining 71% of the variability is still unaccounted. Advancing 23 years, 2013 sees the same relationships shift to a more linear state with the regression having a weak relationship (CO_2; r^2= 0.036, Forest; 2013 r^2 = 0.017). These particular curves represent Angola as the major outlier in which Figure 8 shows the quadratic curvilinear graphs without this data. Figure 5 shows Angola as having a significantly greater GDP than the other countries, so high in fact it distorts the curve completely to a more linear relationship. Compared to the original, GDP within Figure 8 now has more of an inverted U-shape fitted curve, both for CO_2 and Forest area. However, these graphs differ in accountability, leaving more variability to be unaccounted for compared to the original curves (CO_2; r^2=0.087, Forest; r^2= 0.163).

GDP per capita presents a linear, mostly monotonic relationship, especially in the case of CO_2. Here, we have the highest r^2values of all the curves (1990; r^2=0.891, 2013; r^2=0.910), only leaving 11% and 9% unaccounted for. As a result, CO_2 can be described as increasing monotonically with GDP per capita. Between GDP per capita and Forest, in both years, Gabon is the outlier in which Figure 8 shows that there is a clear inverted U-shape relationship without such country.

Compared to the previous however, (1990; r^2= 0.087) without Gabon means that the r^2 has decreased significantly to 0.891 from 0.07, an 82% difference in accountability. Similar to the results with GDP and how Gabon distorts the curve to a more linear state, the same is apparent for Gabon within the GDP per capita and

Forest area curve. Swaziland and Angola are the countries especially to create a more distinct curve in 2013, and from their initial position tend to have followed the curve whilst increasing their GDP per capita and increasing rate of forest area.

Infant mortality rate takes the opposite of the Kuznets's hypothesis and produces a U-shaped curve. CO_2 in 1990 represents an r^2 of 0.263 and in 2013 increases slightly to 0.264. The difference in time periods can see the outlier's increase from solely Gabon; to, one could argue, Gabon, Botswana and Angola. As for forest area, this is very insignificant. There is no obvious relationship (1990; r^2= 0.045 and 2013*;* r^2= 0.035*).*

3.2 Correlations

Table 1. Pearson Correlation and Spearman's Rank results with their co-efficient for each relationship

1990	CO_2 (Pearson Correlation)	CO_2 (Spearman's Rank)	Forest (Pearson Correlation)	Forest (Spearman's Rank)
GDP	0.154	0.301	0.22	0.311
GDPPCAP	0.931**	0.642**	0.479	0.43
IMR	-0.474	-0.388	-0.162	-0.173
2013				
GDP	0.164	0.418	0.128	0.289
GDPPCAP	0.953**	0.826**	0.511*	0.382
IMR	-0.274	-0.387	-0.09	-0.026

* .Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

	p-value			
2013	CO_2 (Pearson Correlation)	CO_2 (Spearman's Rank)	Forest (Pearson Correlation)	Forest (Spearman's Rank)
GDP	0.489	0.067	0.33	0.058
GDPPCAP	0	0	0.021	0.97
IMR	0.035	0.091	0.496	0.466
1990				
GDP	0.516	0.198	0.351	0.182
GDPPCAP	0	0.002	0.33	0.58
IMR	0.35	0.91	0.486	0.446

A Pearson correlation coefficient and spearman's rank correlations co-efficient were computed to assess the relationship between variables in development and environmental degradation in 1990 and 2013. The results that stood out the most in 1990 were between GDP per capita and CO_2, and in 2013 between GDP per capita, and CO_2 and GDP a long with Forest area for the Pearson's correlation. All were significant at the 0.01 level excluding Forest area, which was significant to the 0.05 level. Infant mortality rate outputs showed negative correlations for the relationship between each environmental variable, but failed to reach near to the perfect negative correlation mark. The least supportive relationship between the variables was between infant mortality rate and forest, both for Pearson's and spearman's rank, which showed nearly no correlation. Ultimately, there is mostly a linear, monotonic relationship between GDP per capita.

3.3 Percentage Difference

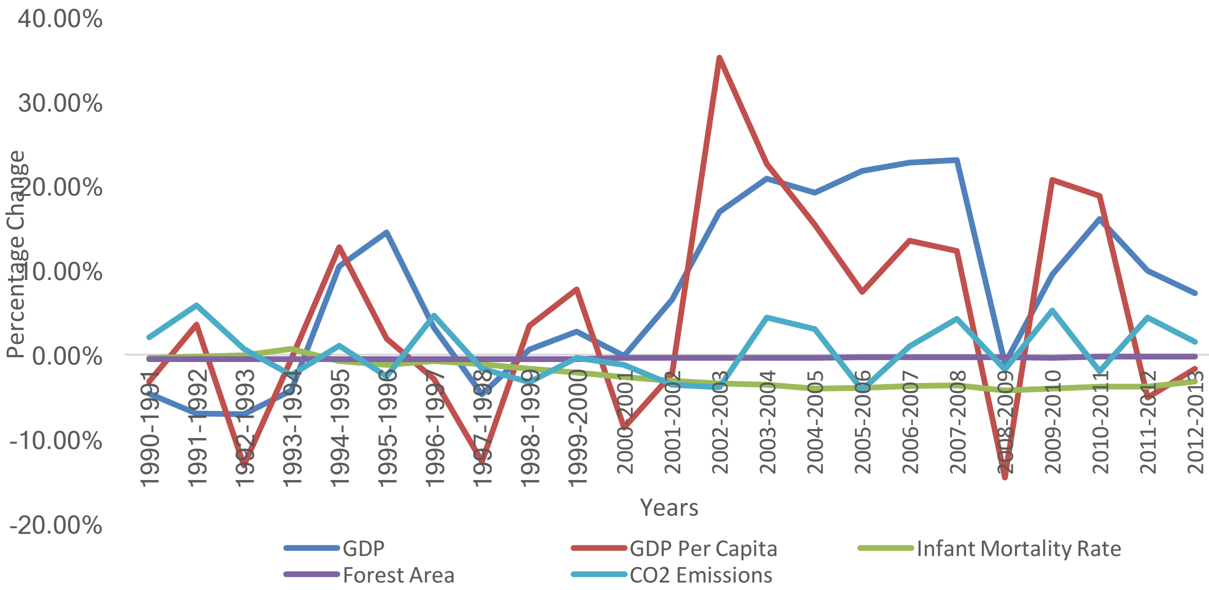

Figure 9. The percentage difference in each variable (GDP, GDP per capita, Infant Mortality Rate and CO_2 Emissions) between each year ranging from 1990-2013.

Over the period 1990-2013, Sub Saharan Africa on average increased their GDP and GDP per capita. The period did not see a steady economic % growth rate, instead GDP and GDP per capita were both fluctuating significantly throughout the 23 years such as in 2000-2002 where GDP growth rates fell 10.90%. However, they grew 57.77% in the two consecutive years. GDP per capita mirrors much of the GDP % growth but overall since 1990, the average income per person has nearly tripled. As for Forest area this has decreased very steadily. From 2005 to 2013, the percentage change through the years started to expand, with the largest difference being in 2010-2011 with a change of -0.27% from -0.34% in the years prior. Infant mortality rate has been on the decline since 1990 with the exception of growth by 0.66% between 1993 and 1994. Since 2000, where the largest increase in % GDP per capita growth was seen, infant mortality rate has not been fluctuating, instead decreasing steadily each year. However, from 2008, along with the plummet in GDP and GDP per capita, infant mortality rate has only increased on average within the region.

3.4 Paired Samples T-test

Table 2. Paired samples t-test p-results for the change between 2009 and 2013

1990-2013	Sig. (2-tailed)
GDP	0.005
GDPPCAP	0.001
IMR	0
CO_2	0.665
FOREST	0.031

A paired-samples t-test was conducted to compare the results for each variable between 1990 and 2013. There is a clear difference in between GDP and GDP per capita between both years above all. From these results we can compare the other variables in accordance. There is evidence to suggest that Sub-Saharan Africa experienced statistically significantly greater GDP per capita ($p = 0.001$) from when in 1990 (mean = 998.56 units, SD = 1402.12) compared to 2013 (mean = 2310.24 units, SD = 2773.50). The 95% confidence interval for the difference is (-2048.63, -574.67). Apart from this, GDP ($p = .005$) and IMR ($p > .001$) were the only alternative results to reject the null hypothesis. Therefore the null hypothesis of the values being equal after development is rejected for such variables. As for CO_2 and Forest Area, these produced outcomes on the other end of the scale.

Although reflecting high correlations (CO_2*; r = .856,* Forest*; r = .973*), the variables were shown to support the null hypothesis (CO_2*; p = 0.665,* Forest*; p= 0.031*).

4.0 Discussion

This study set out to assess the impact of development, i.e. GDP, GDP per capita and Infant mortality rates, on the rate of the environment in which investigated solely CO_2 and forest area. In an effort to investigate this impact, the author performed a quadratic regression in order to produce a curvilinear regression which will have tested the theory of the Kuznets's curve. In addition, a linear regression was performed a long with a t-test to compare data sets after development. Sub-Saharan Africa is undergoing changes in its forest resources, as well as economic development, and the process of change needs to be studies in the context of dynamics of the country's economy, society and environment. For this section, the discussion will be achieved through investigating the key results, outlining the limitations of the study and recommending methods for further research.

4.1 Inverted U-shape for GDP and CO_2 (1990)

According to Stern et al. (1996) and Panayotou (1993), at high levels of economic growth structural changes toward information intensive industries, as well as a greater social conscience and environmental regulation, lead to a gradual decline of environmental degradation. This is also apparent in the results between GDP and CO_2 in 1990 shows by Figure 2, where this relationship follows the Kuznets's curve theory in which depicts a bubble of low income countries at the beginning of the curve. The relationship between these two variables has been very effective particularly in the literature, and a number of studies have confirmed the hypothesis especially amidst CO_2 suspended particles and economic growth (Holtz-Eakin and Selden 1995, Cole et al. 1997, Heerink et al. 2001, Luo et al. 2014). Such tests suggest that economic growth increases the growth of CO_2 emissions in five provinces (Peng et al. 2016).

Although many studies have particularly focused on SO_2, CO_2 has strong econometric evidence to support the hypothesis for CO_2 and GDP. Grossman and

Krueger also found that emission levels of sulphur dioxide and dark matter suspended in the air increase with per capita GDP at low levels of national income, but decrease with per capita GDP at higher levels of income, confirming the inverted U-shape relationship. Furthermore, the evidence from this study, as well as others, supports the statement by Grossman and Krueger (1993)

> ʻʼ During the initial stage of the developmental process, when the typical economy is dominated by agriculture and allied activities, pollution intensity will be generally low. But as the economy moves into heavy industry, pollution will tend to increase. Furthermore, as the economy shifts into high technology and services, pollution intensity will tend to fallʼʼ.

Most Sub-Saharan African countries are still at the intermediate stage of development, where industrial production and transportation is energy-intensive. According to Schwela (2002) indoor pollution from cooking fuels is relatively high in African countries whereas in the developed countries, the use of coal as a source of fuel is rapidly giving way to cleaner forms of energy such as natural gas, solar energy, and wind-driven systems; hence, pollution from particulate matter in these countries is relatively lower. As incomes rise due to economic growth in African countries, air pollution from this source should decline, as households switch from cooking with firewood to gas, drive newer cars, and as production technologies become cleaner.

However the curve has shifted during the 23 years between 1990 and 2013 to a more linear state. Many of the countries have experienced an increase in GDP and an increase in CO_2 since 1990 (Angola, Botswana, Cameroon, Chad, Congo, Ethiopia, Guinea, Kenya, Mali, Mozambique, Namibia, Swaziland and Uganda), suggesting they are in the early stages of the Kuznets curve. However, without seeing the countries' individual curves, it is more difficult to know if the theory is proven; the relationship may have not been completely monotonic. Previous studies have seen the curve not being able to attain a reasonable turning point, suggesting that Africa could be turning on the EKC at lower levels of income (Baliamoune-Lutz 2012). Furthermore, this also can be a result of African countries not yet receiving the perceived turning point in GDP per capita (Lee et al. 2010). GDP per capita presents a linear trend according to the results obtained by the Pearson's co-efficient and Spearman's rank tests. Martinez-Zarzoso and

Maruotti (2013) note that CO_2 emissions and income is country specific and changes over time, confirmed by the results found in this paper.

This paper shows that the relationship between CO_2 emissions and income is country-specific and changes over time. Our results point to the existence of several nonlinear relationships for most countries and an almost linear relationship for one group. In line with the findings in Vollebergh et al. (2009) our findings indicate that the homogeneity assumption might lead to results that are sensitive to the inclusion or exclusion of particular countries.

What's more, the next country down the line will also displace its environmental impact in turn. The most polluting industries have moved to China in recent years, and as China develops and labour costs rise they will move again, particularly to Africa where labour is cheap and where environmental regulations are lacking due to poor environmental laws and strategies.

4.2 Forest Area disproving the hypothesis

According to the EKC, economic growth is a possible way to slow down deforestation. Slowing down deforestation through economic growth can change the path of forest transition (Culas 2012). However, the question remains: will those deforesting countries achieve enough per capita income for turning points? And will Africa take the same route as other countries who have proved the theory correct?

As made clear in the methodology, the theory regarding forest area and growth will mimic the Kuznets theory in the hypothesis that as a country grows economically, forest area will start high or at a particular staring point, depending on the countries available forest cover, to experience a decline in area and finally an increase due to an expansion in awareness and conservation. This is turn will not produce the famous inverted U-shaped curve, but instead a perfect U. Studies estimate an N-shaped EKC for deforestation (Bhattarai and Hammig 2001), but a corollary is that a plot of forest area, as opposed to deforestation rates, would resemble a U shape. For the purposes of this article, it is assumed that both forms of curve can be regarded as indicating Kuznetsian relationships (Mather et al. 1999).

In terms of the results from the curvilinear regression and correlations, forest area did not produce a Kuznets curve for any of its relationships with the economic growth variables. It is reasonable to postulate that an increase in population, accompanied by an increase in growth of GDP per capita or GDP, would be the significant driving force in the change in forest area. However, studies have failed to use empirical evidence to confirm this relationship (Mather and Needle 2000). Moreover, the results we understand in this particular study are strengthened by Wang (2003), in which their results do not support the applicability of the environmental Kuznets curve to forest cover being taken as an environmental indicator of environmental quality.

Stronger evidence of rejection of the environmental Kuznets curve for forests is identified by Shafik and Bandyopadhyay (1992), who find that "per capita income appears to have very little bearing on the rate of deforestation," while Cropper and Griffiths (1994) conclude that economic growth will clearly not solve the problem of deforestation as any turning point is at such high levels of income per capita.

These unexpected findings could suggest that national policies for forest conservation may be influenced by policies in neighboring countries, which can result in a pattern of political spatial dependence. Although some nations may lack in GDP per capita, IMR or GDP, this may not stop authorities from prioritising in the land they have, especially if the forest in special or is home to species of scientific interest. Although the relationship has seen continents such as Europe and the Americas follow in the Kuznets path, the new age may see Africa as the outlier. In the case of deforestation, these may be climatic or geomorphological variables (Choumert et al. 2012). And fourth, phenomena in neighboring countries are likely to influence deforestation patterns in a given country. For example, more stringent forest protection policies in a country may cause more deforestation in an adjacent country are discussed by Cuaresma et al. (2016).

Not only has the awareness for the drastic changes in the environment increased in more economically developed countries, but also in the newly industrialised economies like China. Environmental change has been ignored by booming industries in the past, but with relocation of business to Africa especially, companies and governments are not letting the past define the future. Economies now are acting in more efficient ways than ever before, not using the past economic booms such as the industrial revolution as an example to act. Technology has improved and people showing cognizance due to the changing environmental conditions around them.

4.3 A U-shaped curve for Infant mortality rate

Results here however suggest that as a country decreases the number of infant deaths per 1000, per year, both forest area and CO_2 will increase, before decreasing to a turning point. Infant mortality and CO_2 in 1990 have a clear trend that confirms the theory, mimicking the beginning of a potential Kuznets curve. However, 2013 see's Angola as an outlier. Although averaging a decrease in infant mortality rate at a similar rate as the other countries in the study, CO_2 emissions elevate to the same level as the more developed nations. Again, investment from overseas is leading to sharp expansions in polluting industries – even development including the construction of roads, schools and hospitals, and rapid urbanisation distorts the reliability of the curve in this scenario. The results shown in Figures 4 and 7 doubtlessly confirm the theory of Simpson et al. (2014), in which they argue infant mortality is merely a proxy for the societal and economic conditions of nations, with these disparities in development accounting for a large portion of the global disparity in carbon footprints.

Infant mortality has been concluded by Jiang (2011) to decrease with growth. Although such a variable of economic development can be acquainted for, there are factors including inflation, trade, remittance and rural population growth and socioeconomic characteristics of the household that can potentially impact the number of infant deaths (Iftikhar et al. 2016).

4.4 Outliers

However, 2013 follows an opposing relationship whereby at low levels of GDP countries have both low CO_2 rates as well as high. The result of development then shifts from the curve to a more linear regression. Gabon and Botswana especially excel in the higher CO_2 rates in this particular phenomenon and one resulting factor is trade openness, brought on by globalisation, in dealing with the pollution level (Zerbo 2015). Compared to the other countries studied, Gabon and Botswana have a significantly higher economic success rate than the other countries studied. Furthermore, Gabon is the fifth largest oil producer in Africa, experiencing strong economic growth over the past decade driven by oil and manganese production. The oil sector has accounted for 80% of exports, weighing up to 45% of GDP (The World Bank 2017). Botswana however, is supported by natural resources, in particular diamonds (The World Bank 2016). Continued investment by China in these parts of Sub Saharan Africa means that there is relocating pollution levels from globalised industries. Along with this phenomenon there is the issue of corruption and tax havens that may be increasing GDP, but the average person is staying below the poverty line. Unexpectedly, this can have an effect on what was once theorised by Kuznets.

In any case, data on outliers suggest the direction of worthwhile further research. Since plausible explanation can be given for many of the outliers, their analysis may increase confidence in the basic results. The large number of observations in our study to a substantial extent compensate for the unreliable nature of many income distribution data. As a result of that large number, even the most influential outliers do not appear to have a major impact on the results, which increases confidence in the validity of the conclusions.

GDP and its relationship in 2013 from a true Kuznets curve fit produce a more linear regression. Here, Angola is the particular case in which skews the data curve in making the traditional Kuznets curve flatten. There is a clear difference between the countries that adhere to the theory and Angola in terms of GDP. During the 23 years, Angola's GDP has more than doubled due to the high prices of crude oil which accounts for 97% of their exports (The World Bank 2017). Without Angola in the picture, the Kuznets theory is proven. Therefore, it can be said that Angola is an ‘’exception that proves the rule.’’

Likewise with GDP and Forest, there is one particular outlier between GDP per capita and Forest area, and in this case it’s Gabon. This is the same for both years, which represents the clear income difference per capita between countries. Gabon does not adhere to the theory in this case.

It is clear that countries that do not adhere to the Kuznets theory are within a different line of development from the alternative countries.

4.5 Limitations of the study

Despite the notable findings, this study has some limitations. Most importantly, the sample size was too small. Access to data was limited and only annual time series data on individual countries were available. The quadratic regressor results, along with the curvilinear graphs may have provided different results if the data set is expanded to reflect quarterly or monthly series, or if the countries were split into low, middle and high income economies. Of course, the number of countries chosen only showed a limited amount of high-income countries, with many of the outliers having been within this category.

Fare et al. (2001) refer that due to the non-availability of actual data on environmental quality, this is the major restriction of all EKC studies. Environmental quality is something that is not measured accurately. Therefore, a guide of environmental quality, which could be a better measurement, should be developed and used to examine the EKC hypothesis. More broadly, forest cover is, by and large, a quantity statistic. It does not inform about the quality of the forest. Furthermore, it is merely one of many indicators of the state of the natural environment, so it cannot be used as a wholesale surrogate for assessing the complex interactions between economic growth and the natural environment.

Moreover the turning point on the environmental Kuznets curve is associated with the dynamics of individual environmental elements that change with income. Stern (2004) draws his attention to the mean - median problem. He underlines that early EKC studies showed that a number of indicators: 2 SO emissions, x NO, and deforestation, peak at income levels around the current world mean per capita income. A hasty glimpse at the available econometric estimates might have lead one to believe that, given likely future levels of mean income per capita, environmental degradation should turn down from the present onward. GDP is an appropriate measure of how well the economy is doing in terms of imports and exports, which divided by the population equates to the GDP per capita. However, the corrupt governments of Africa, in particular the countries this study has chosen, GDP per capita may not be as suited giving that the ideal share of the GDP is not allocated equally. Income is not yet, normally distributed but very skewed, with much larger numbers of people below mean income per capita than above it. Hence, this shows a median rather than mean income that is the relevant variable.

This observation is important for other EKC analysis too due to the historical transitions which can only clearly be identified when one has a complete time series which includes the transition event. In most cases, the data sets used in EKC models have been incomplete time series and unbalanced and have required pooled cross-sectional techniques. The results of this study indicate that it is misleading to interpret EKC results in terms of a stages of income growth process that all countries must pass through.

Furthermore to assess the curve quadratic regression may not have been the most appropriate factor here. Due to several outliers, the quadratic function is easily distorted and can be changed significantly as seen in Figure 4. Results for a cubic specification indicate that heterogeneity should be accounted for in the model specification and a flattening of the income–pollution relationship is not well approximated by a quadratic function (Carson 2009).

Previous studies focusing solely on one particular country have not had to account for the different stages of development that 20 countries are in. The comparison between 1990 and 2013 may be hard to account for considering this. Since income and development levels differ among these economies, the realisation (non-realization) of EKC in Africa cannot be used to affirm the existence (non-existence) of EKC in individual Africa economies. In addition, Perman and Stern (2003) argued that there is a doubt on the general applicability of EKC because even when co-integration relationship was established between variables in the region, many of the relationships for individual countries were not concave.

5.0 Conclusion

The objective of this paper was to investigate an apparent Kuznets's curve theory within Sub Saharan Africa and to examine closely whether each environmental variable had the same relationship with alternative economic development variables. And that, in view of raising the attention of researchers, practitioners and policy makers on the underlying causes that lead to the validation of the EKC for CO_2 and deforestation in the academic literature, despite critical reviews of EKCs. The author has therefore applied quadratic regression and a subset of correlations to create EKCs between GDP, GDP per capita, infant mortality rate and CO_2 and Forest area for 20 countries across Sub Saharan Africa.

From the results, we can acknowledge that Sub Saharan Africa does produce a Kuznets's curve, but only in relation to GDP and CO_2. This adds to the numerous findings and Stern's (1998) theory of a Kuznets curve only being apparent for specific variables. In this case, Sub Saharan Africa is not unique. Conversely, forest area investigated along any of the economic variables did not support the hypothesis. This was also the case with exploring any distinction between infant mortality rate and environmental degradation. It is clear there are many definitions for economic growth, but the Kuznets theory does not provide an adequate representation for either here, only showing the theory being proven for one set of variables. However, the monotonic relationship presented by GDP per capita could be a result of the region not reaching a turning point as of 2013. It is therefore necessary to closely examine these patterns in the years to come, due to expected growth, which may have this particular outcome.

In addition it could be proposed to focus on EKC studies using panel techniques and investigate the study-to-study variation focusing on econometric tests performed, such as tests for endogeneity and multicollinearity. Future research can also investigate the factors to represent forest quality in the place of forest area.

Sub Saharan Africa is set to endure an extensive time period of increased CO_2 caused by the shift from primary to secondary sectors of the industry. However there is reason to believe that these developing countries can take many actions to improve their environmental conditions and that those actions can have enormously positive responses for social welfare. In order to propose an appropriate economic policy for each country, it was necessary to study the nature of the relationship between these factors in order for government officials and organisations to focus on how each adverse economic development variable could affect the environment, thus enhance appropriate strategies.

The main conclusion that should be drawn from this study is that EKC hypothesis shouldn't be taken for granted and that further investigation needs to be done. Parametric methodologies which were used have some drawbacks and can misleads us. It is therefore necessary the EKC hypothesis to be examined further especially for Sub Saharan Africa.

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Appendix

Appendix A – Evaluative Supplement

This project was undertaken on the basis of being relative to the current global issues regarding the environment and growing economies. By looking into this through the Kuznets curve, it sheds light on how such theory is appointed. By being proven correct for such variables, the theory is important for the future of development and ways to alleviate the stress on the environment through governmental policies.

The strengths of this project were largely the visual aspect in calculating whether there were curves for the region of Sub-Saharan Africa. The theory is aided by these curves and provides essential, easy to gauge information for the reader from such a complicated set of data and variants. Secondly the project encompasses not only one country, but 20. Sub Saharan Africa is one of the most important regions in the world in terms of economic prospects. Investment from China is one of the examples of this, and the hope for continued growth. However, an aspect that is continuously ignored in the developing world is the effects on their environment. With the Kuznets theory being proven in this study, populations from these nations can become more aware of the environment in which they live in. The region is also dependent on the quality of their livestock and surrounding environment, as their primary form of income is based on the farming sector. With untouched, abundant amounts of natural resources it is important for history to not repeat itself especially at the present time when the environment is already suffering from the past effects. This is why the theory is so important, and can tell us where these countries lie at this particular time. Although we cannot predict the future it is crucial to act on what we already know, and work to prevent future disasters. Sustainable development should be the message from the project, in which Sub Saharan Africa is taking an alternative route and making the most of their natural, renewable resources.

The t-test and % difference were included to give the reader a sound understanding of how well these countries are developing and to what extent their growth is stable. A statistical test of this is useful when comparing it to the curves.

The limitations of the project could be the quality of data obtained from the World Bank and the little primary data collected. All evidence was backed up from secondary resources, but this is the only option in order to study these particular countries. The quality of data is affected by the reliability, completeness and update status. The reliability is based on the World Bank. Clearly stated, the World Bank works to help developing countries improve the capacity, efficiency and effectiveness of national statistical systems, implying the relatively poor accuracy of the current data obtained from these systems from the member countries. The data comprises some of the least developed nations in terms of governmental systems and corruption. Countries initially chosen were ruled out due to the lack of available data due to war, inability to collect such data or lack of resources e.g. Somalia. Moreover, the data obtained was at such a large respect that several countries such as Gabon, Botswana and Angola could skew the averages to a much higher number than intended, not accounting for the ones that are growing at a much slower rate, or those who cannot help but have a larger area of forest. Lastly, some theory behind the variables chosen would not have followed the typical inverted U-shape, but instead a U shape such as forest area. Even though this is clearly stated and hypothesised, it is easier for all graphs to essentially follow the same trend.

The presence of many statistical evaluations and tests being done surrounding the EKC for many different regions or countries provides the uncertainty for which data analysis to initially use. Through much research on the topic, the author decided to use the first set of tests that were used by Stern (2003) in his heavily cited work.

I have gained a more in depth understanding at the region in particular and how its development indicators are linked to environmental degradation. With further reading on the topic it is also interesting to know how these countries are developing through particular dominating trades. Furthermore it is important to know which countries are taking a more sustainable approach to development in relation to what environmental policies are they implementing and to combat which problem relating to their speedy development. Not only on the topic chosen, but overall the project has tested the time development and writing skills of the researcher. These challenges included having to learn and research particular statistical procedures not yet taught in the course. Interlinking world processes are having an effect upon the region and by undertaking a research project on this particular topic it is not only relevant but critical to the understanding of how to deal with the negative implications on the environment of yet to develop countries. By using SPSS and excel on a frequent basis, the author has also developed skills, which have never been taught within schooling. A lot of the statistics used were self-taught using primarily the internet from sites such as IBM.

For future works it would be useful to separate countries into their level of development, however this is difficult with Sub Saharan Africa in particular due the presence of only outliers. There is no clear line in which countries can fit into to determine their level of development. Furthermore it would also be beneficial to explore unit root tests with this particular data set and countries as although in the study it has been negatively connoted due to past studies, there is still room to imply new data into the system. There is also a lack of development factors in research, hence the use of infant mortality rate here. It is suggested that other factors such as consumer spending or access to services should be further studied. The research questions used were also broad; in the future research questions and aims could be more focused especially when splitting the region up into their levels of development. When addressing these, it would be useful is the author would take extra time to research new methods of data analysis not yet used within examining the Kuznets curve.

Appendix B - Countries and Abbreviations

Name of Country	Abbreviation
Angola	ANG
Botswana	BWA
Burundi	BDI
Cameroon	CMR
Central African Republic	CAF
Chad	TCD
Congo. Rep.	COG
Ethiopia	ETH
Gabon	GAB
Guinea	GIN
Kenya	KEN
Mali	MLI
Mozambique	MOZ
Namibia	NAM
Niger	NER
Rwanda	RWA
Swaziland	SWZ
Uganda	UGA
Zambia	ZMB
Zimbabwe	ZWE

Appendix C – Variables, Definitions and Abbreviations

Term	Abbreviation	Definition
Gross Domestic Product	GDP (current US$)	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products
Gross Domestic Product Per Capita	GDPPCAP (current US$)	GDP per capita is gross domestic product divided by midyear population
Infant Mortality Rate	IMR (per 1000 births)	Infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year.
Forest Area	Forest (% of land area)	Forest area is land under natural or planted stands of trees of at least 5 meters in situ, whether productive or not, and excludes tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) and trees in urban parks and gardens.
Carbon Dioxide Emissions	CO2 Emissions (metric tonnes per capita)	Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.

Appendix D – SPSS Outputs

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	GDP1990 - GDP2013	-18151953340.00000	25552016350.00000	5713604552.00000	-30110665110.00000	-6193241579.00000	-3.177	19	.005

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	FOREST1990 & FOREST2013	20	.973	.000

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	CO21990 & CO22013	20	.856	.000

Appendix E – Interim Interview Agreed Comments

Independent Research Project Interim Interview : Agreed Comments Form

Student Name: Maddison Paget-Gover	Programme: Applied Geography
Date: 11/05/2016	IRP Title: The effects of the increased industrialisation in Sub-Saharan African Economies
Supervisor Name: Proffessor Adnan Newton	

- Maddison has communicated a good grasp of her subject area and a clear understanding of the research process.
- Her priority now is to read more deeply into the subject, and then to use this to help refine her research plans. These need fleshing out in a bit more detail.

Two copies of this form are needed – student to retain one copy the other is to be handed in to the student admin office C114.

Student Signature:	Supervisor Signature:
M. Paget	[signature]

Appendix F – Learning Contract

BU Bournemouth University

LEARNING CONTRACT: INDEPENDENT RESEARCH PROJECT

Student Name: Maddison Paget-Gower

Degree Programme: Applied Geography BSc

Proposed Project Title: The Effects of the increased Industrialisation on Sub Saharan African Economies -

Supervisor: Professor Adrian Newton

Research Proposal Attached ☑ YES ☐ NO **and includes:**

YES	NO	
☑	☑	**Risk Assessment for fieldwork and evidence of COSSH assessment for all laboratory procedures (online risk assessment completed)**
☐	☑	**Completed booking forms for all field equipment**
☐	☑	**Letters of permission where appropriate providing evidence of access to such things as field sites and/or museum archives**
☑	☐	**Completed Ethics Checklist**

Copies of all relevant forms may be found on myBU - SciTech tab - Projects - Project Forms

INTERIM INTERVIEW – Progress evaluation

The nature of this review should be clearly defined and agreed. Please complete the box below with the agreed details including the agreed submission date which is normally the first week of November in Level 6/H. Submission is via a formal tutorial with the supervisor.

Assessment Due:

FINAL ASSESSMENT – RESEARCH PAPER/REPORT

This assessment is normally governed by the guidance provided in the Independent Research Project Guide. Any variance in terms of format and word limit should be agreed and specified in the box below. Submission date cannot however be changed unless evidence of mitigating circumstances are provided in accordance with the standard BU Guidelines.

PTO

As the student undertaking the above project I agree to:

- E-mail my supervisor on a fortnightly basis with a progress report
- Meet with my supervisor at least once a month to discuss progress and I understand that it is my responsibility to organise these meetings
- Comply with the terms of this learning contract and the guidance set out in the Guide to Independent Research Projects
- I understand that this is an *independent* project and that I am solely responsible for its completion
- I agree to comply with all laboratory and fieldwork protocols established by the Faculty.

As the supervisor of this project I agree to:

- Meet with the student undertaking this project on at least a monthly basis and to respond to the progress e-mails as appropriate
- To meet formally with the student during the first week in November to undertake the interim interview
- To provide guidance and support to the student undertaking this project bearing in mind that it is an *independent* research project. This is inclusive of commenting on drafts of the final report in a timely fashion.

Both of the undersigned parties agree to be bound by this learning contract:	
Student Signature:	[signature]
PRINT NAME:	MADDISON PAGET-GOWER
Date:	11.05.2016

Supervisor Signature:	[signature]
PRINT NAME:	ADRIAN NEWTON
Date:	11.05.2016

When completed, this form should be handed in to SciTech Admin (C114) and a copy retained by the student to be included in an appendix to the final IRP document.