社會科學論叢 2015 年 10 月
第九卷第二期 89-116 頁

# Disaggregated Growth and Environmental Quality in Developing Countries: Some Evidence from Sub-Saharan Africa

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# Disaggregated Growth and Environmental Quality in Developing Countries: Some Evidence from Sub-Saharan Africa

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## Abstract

In recent years, the debate about the costs, benefits and longer-term implications of growth policy tools has been intensified among policy makers and other stakeholders. Over the past four decades, several theoretical and empirical investigations have been conducted aimed at arriving at the exact relationship between economic growth and environmental quality. Such investigations are particularly important given that achieving growth and development that are sustainable also require due consideration of the impact of those growth policies on the environment.

Using a panel dataset from 1985-2010 on 36 Sub-Saharan African (SSA) countries, the study examines the environmental impact of economic growth with greater emphasis on disaggregated growth. Employing the System Generalized Method of Moments to explore the dynamic behaviour of the environment, it was revealed that the effects of industrial and services activities on the quality and sustainability of the environment in Sub-Saharan Africa are ambiguous, mixed and inconclusive as their effects on the environment depend

somewhat on how one measures environmental quality and/or sustainability. Agricultural activities however have an unambiguous improving effect on all the measures of environmental degradation, quality and sustainability in the region. Based on these conclusions, the paper offers some policy recommendations.

**Keywords:** CO2 Emissions, Adjusted Net Savings, Energy Use Intensity/Efficiency, Sectoral Economic Growth, System GMM, Sub-Saharan Africa

**JEL Classification:** L9; O1; O4

# I. Introduction

The debate about the costs, benefits and longer-term implications of economic growth policy tools has gained currency resulting in several theoretical and empirical investigations aimed at arriving at the exact relationship between economic growth and environmental quality. Among the key issues shaping the free economic growth debate is the question of how economic growth affects environmental quality, either in terms of direct effects on our environment, or indirectly through ill health. De Lucia (2003) opines that gaining an in-depth understanding of the environmental performance of a particular ecosystem depends on the existing policies and patterns of domestic and international policies that promote sustainable economic growth inter alia.

The Food and Agriculture Organization (FAO, 2005) estimated that about 13 million hectares of the word's forest are lost due to deforestation and Africa was found to lead the list of countries with the highest rate of deforestation (Naoto, 2006). Diarrassouba and Boubacar (2009) revealed that this worrisome situation is further aggravated by the possible negative impacts of climate change due to an increase in the mean global temperature. There is growing evidence that Africa is likely to suffer the most devastating impacts of natural calamities such as droughts and floods (Diarrassouba and Boubacar, 2009). Some studies have examined environmental quality and its assimilative capacity as a natural resource endowment (Krutilla, 1991; Carraro and Siniscalco, 1992 and Baumol and Oates, 1998). Theoretically, it is suggested that environmental endowment does not simply depend on its mere availability but crucially on how it is utilized and how it is affected in both the production and consumption processes of a nation (De Lucia, 2003). Environmental endowment is also concerned with how it influences a country's comparative cost advantage and its growth patterns over other countries. Achieving sustainable growth remains at the center of almost all economic policies and assumes a particularly dominant position in developing countries where economic growth rates are

still lower especially when compared with that of their counterparts in the developed world.

In SSA and other developing regions of the world, achieving higher economic growth is extremely paramount such that economic performance is linked to the career advancement of politicians (Todaro, 2009). Incentivized by both financial rewards and political gains, policy makers have a vested interest in and unparalleled enthusiasm for growing the economy. However, ensuring environmental sustainability in our quest to grow cannot and should not be overlooked because achieving growth and development that are sustainable also require due consideration of the impact of these policies on the environment. This indicates that the extent to which growth policies tend to affect the environment is very essential for proper environmental policies as well as environmental–friendly growth policies. It is believed that if due consideration is not given to environmental issues; a time may come when the region's growth would no longer be sustainable. For instance, Zhang (2012) revealed that, although pro-growth policies have contributed immensely to China's recent dramatic economic expansion, this rapid economic growth has also created a series of social and environmental problems. Though, there is vast economic literature linking economic growth and environmental quality/sustainability, there is no consensus regarding the exact relationship between economic growth and the environment. On one hand, economists suggest that as an economy expands, both consumption and production increase leading to a depletion of the natural resource while on the other hand, economists assert that, rising income usually induces greater public demand for cleaner environment which generates additional resource for greater environmental protection (Ratnayake and Kim, 1999; Radetzki, 1992).

It is argued that studies that focus on the aggregate are usually less useful for economic policy as they tend to lump so many issues together and thereby hiding pertinent information. Thus, examining disaggregated environmental sustainability is particularly important and insightful compared to investigations into aggregated environmental sustainability for a number of reasons. First, the use of aggregated

environmental sustainability data does not reveal the extent to which different countries rely on different environmental endowment (also see Yang, 2000). Also, the use of aggregated environmental sustainability data means that it is not possible to identify the effect of economic growth on specific environmental endowment (also see Sari *et al*., 2008). Moreover, finding or failing to find a relationship between aggregated environmental sustainability and aggregated economic growth, might hide the relationships between specific environmental endowments and disaggregated economic growth. Further, estimating the relationship between aggregated environmental sustainability and aggregated economic growth is of little or no value to policy makers when it comes to isolating the contribution that different components of the environmental endowment mix make to economic growth (Lean and Smyth, 2013). It is against this backdrop that this paper estimates the environmental effects of disaggregated economic growth. The rest of the paper is organized as follows: section 2 looks at the empirical literature, section 3 deals with the methodology and data source while the results and discussion are captured in section 4. Finally, section 5 concludes the study and also offers policy recommendations

# II. Literature Review

In the economic literature on environment, there seems to be two broad categories of studies. One category supports the view that economic growth has positive association with environmental quality whiles the other category of study found that there is a great deal of association between growth and environmental quality. Thus, studies examining the effects of economic growth, trade openness, foreign direct investments, industrialization, and urbanization on the environment have shown mixed results. In this section, we present a brief review of the factors influencing the environment but with greater emphasis on how disaggregated growth (i.e. industry, agriculture and services) tends to affect, on one hand, environmental degradation and quality (measured in this study by the level of Carbon dioxide [CO2] emissions

per capita and energy use efficiency), and on the other hand, environmental sustainability (measured in this study by Net Adjusted Savings as a percentage of Gross National Income [GNI]).

Theoretically, it is argued that promoting and achieving appreciable expansion in the economy requires the use of natural resources in economic activities indicating that tampering with the environment is a necessary and crucial requirement for economic growth and development. However, to ensure that achieving economic growth and development does not impose unfavorable effects on the environment, there is the need for sound, efficient and sustainable utilization of the environment so that economic growth could be associated with improvement in environmental quality and sustainability.

## A. Energy consumption intensity[1]

Sadorsky (2013), using both dynamic and static panel models investigated the effects of urbanization on energy demand and intensity. In the long-run, he found mixed results regarding the relationship between urbanization and energy intensity. While urbanization was not a significant determinant of energy intensity in the static model, it was found to be significant in the dynamic specifications and slightly larger than unity. Mishra et al. (2009) studied the impact of urbanization on energy intensity in a sample of Pacific Island economies. It was found that urbanization has a negative impact on energy intensity in New Caledonia, but a positive impact in Fiji, French Polynesia, Samoa and Tonga. This indicates that urbanization tends to improve energy efficiency/intensity in New Caledonia and otherwise in Fiji, French Polynesia, Samoa and Tonga. Krey et al. (2012) used integrated assessment models to analyze the impact of urbanization on residential energy use in China and India. They found that residential energy use is not very sensitive to urbanization directly

[1] Energy consumption efficiency is used interchangeably with Energy use efficiency or intensity in this paper.

but the relationship between urbanization and energy use depends upon how labour productivity affects economic growth. Poumanyvong and Kaneko (2010) used panel data to estimate the impact of income, urbanization, industrialization, and population on energy use in a sample of 99 countries covering the period 1975-2005. They found that the impact of urbanization on energy use varies by income class. In particular, urbanization decreases energy use in the low-income group, while it increases energy use in the middle- and high-income groups.

Parikh and Shukla (1995) used a pooled data set on both developed and developing countries from 1965-1987 to investigate the impact of urbanization and economic growth on energy consumption. The study found that urbanization elasticity ranges between 0.28 and 0.47 while the income elasticity ranges between 0.25 and 0.47. Naoto (2006) investigated the relationship between trade energy intensity in a panel of 32 developed countries for the period 1975-1995. The elasticities obtained ranged from –1.1 to –0.1 depending on the specification of the regression model implying that greater openness to trade in these countries had improved energy efficiency/intensity during the period 1975 and 1995. However, Hubler (2009) revealed that Foreign Direct Investment (FDI) and trade are responsible for the decline in energy intensity in China. Specifically, the study reported that imports directly improve productivity, especially if the imported goods have better characteristics than the domestically produced goods. Imports indirectly create productivity spillovers via imitation of the imported products and via improved application of methods adopted together with the imported goods. Also, if the characteristics of the imported goods are unfriendly to the environment, there is a great likelihood that, trade would tend to harm the environment. Of course, exports of agricultural and industrial goods whose production require the indiscriminate exploitation of the environment would also reduce environmental quality and sustainability. Further, Fisher-Vanden et al. (2004) suggested that foreign ownership, which facilitates technological transfer, decrease energy intensity. However, the authors were quick to admit that greater export of energy intensive products and primary products could increase industrial

energy intensity.

## B. CO2, SO2 emissions and Adjusted Net Savings

Maiti and Agarwal (2012) and Uttara et al. (2012) revealed that as a result of the expansion in the activities of motor vans and industries, urbanization tends to affect the environment through a number of avenues such as the creation of slum conditions, land insecurity, worsening of water quality, problems of waste disposal, excessive air and noise pollution.

Empirically, Xing and Kolstad (2002) explored the environmental impact of FDI in both developed and developing countries and found a weak evidence to support the claim that developing countries tend to have lax environmental regulations as a strategy to attract dirty industries from developed countries. In a related study in Ivory Coast, Mexico, and Venezuela, foreign owned plants were found to be more energy efficient and use cleaner type of energy than domestically owned firms (Eskeland and Harrison, 2003). Contrarily, He (2006) examined the FDI-environment nexus between 1994 and 2001 using panel data on 29 Chinese provinces' industrial Sulphur dioxide (SO2) emissions. Employing a system Generalized Method of Moment to study the dynamism of the environment, the author reported that an increase in FDI inflows results in a moderate deterioration of environmental quality. Also, Agarwal (2012) found evidence to prove that the importation of foreign capital or foreign technology has led to an increase in pollution intensity in China but there is no evidence to suggest that trade liberalization has led to a significant rise in environmental pollution. Cole and Elliot (2003) also found that trade increases emissions. Antweiler et al. (2001) showed that an increase in GDP tends to increase SO2 concentration, while SO2 concentration decreases as per capita GDP rises. Further, Antweiler et al. (2001) estimated that trade liberalization reduces pollution. The findings of Dasgupta et al. (2002) however contrasted that of Antweiler et al. (2001) as the former found that greater openness tends to increase environmental pollution, especially CO2 and SO2 emissions. .

Abdulai and Ramcke (2009) investigated the relationship between economic growth and environmental degradation using a panel data from both rich and poor countries for the period 1980 to 2003 and found that most pollutants tend to increase at the initial level of economic growth but eventually fall as an economy grows beyond a certain threshold, though with some uncertainties. Further, Abdulai and Ramcke (2009) revealed that trade liberalization might be beneficial to sustainable development for rich countries, but harmful to poor ones considering the adverse effect trade openness has on the environment of poor countries. Arouri et al. (2012) confirmed the findings of Abdulai and Ramcke (2009) as they observed similar trends in most of the Middle East and North African (MENA) countries. Furthermore, an earlier study by Grossman and Krueger (1993) found an 'inverted 'U' shaped relation between SO2 concentrations and per capita income which is consistent with the conclusions by Abdulai and Ramcke (2009) and Arouri et al. (2012). However, Boopen and Vinesh (2011), Saboori et al. (2012) and Akpan and Akpan (2012) found the converse to exist in Mauritius, Indonesia and Nigeria respectively. Cole and Elliot (2003) found that SO2 emission reduces as income increases due partly to the fact that increases in income enable society to acquire the requisite technology to deal with environmental nuisance.

Sharma (2011) in a related study on the drivers of carbon dioxide emissions among 69 countries found inter alia that urbanization has a negative impact on CO2 emissions in high income, middle income, and low income panels. On the other hand, Cole and Neumayer (2004) found that population increases with carbon dioxide emissions in addition to a 'U-shaped' relationship between sulfur dioxide emissions and population growth. Also, Martínez-Zarzoso and Maruotti (2011) found an inverted-U shaped relationship between urbanization and CO2 emissions. Furthermore, Wang et al. (2013) found that factors such as population growth, urbanization, Gross Domestic Product (GDP) per capita, industrialization level and service level, can cause an increase in CO2 emissions. In particular, Wang et al. (2011) found a positive relationship between the formation and development of heavy industrial

sand carbon and sulfur emissions in China.

This brief review attests to the fact that the empirical relationship between economic growth and CO2 emissions is inconclusive. Thus this study will contribute to the empirical debate from the perspective of SSA.

# III. Methodology and Data

## A. Specification of Empirical model

To examine the impact of economic growth on the environment and following from our literature review, a dynamic panel model is specified while controlling for urbanization, foreign direct investment, trade openness and population density. This specification stems from the dynamic nature of the various measures of environmental quality. For instance, CO2 emissions in some previous years usually impact on current year's emissions. Though this dynamic relationship between past and current emissions may not be necessarily direct, it cannot be totally ignored in empirical studies. The paper focuses on disaggregated growth rather than the aggregated. Hence, economic growth is disaggregated into industry, services and agriculture. The paper thus examines the impact of these components of economic growth on three environmental variables namely CO2 emissions per capita (CO2), Adjusted Net Savings (ANS) and Energy use per capita (EI). ANS is used as a measure of environmental sustainability while CO2 and EI are measures of environmental quality.

$$EQit = \alpha 1 + \alpha 2EQit\text{-}1 + \alpha 3AGRICit + \alpha 4SERit + \alpha 5INDit + \alpha 6FDIit + \alpha 7FDIit\text{-}1 + \alpha 8TOPit + \alpha 9URBit + \alpha 10POPDit + \varepsilon it \ldots\ldots \quad (1)$$

$$EQit = \alpha 1 + \alpha 2EQit\text{-}1 + \alpha 3Yit + \alpha 4FDIit + \alpha 5FDIit\text{-}1 + \alpha 6TOPit + \alpha 7URBit + \alpha 8POPDit + \varepsilon it \cdots\cdots\cdots\cdots\cdots\cdots \quad (2)$$

In equation (1) environmental quality/sustainability (EQ) is regressed on dis-

aggregated sectoral components of growth (i.e. industry, services and agriculture) while in equation (2) environmental quality/sustainability (EQ) is regressed on aggregated growth (i.e. economic growth). EQ represents environmental variables such as CO2 emissions per capita (CO2), Adjusted Net Savings (ANS) and Energy use per capita or Energy use efficiency (EI). In the ANS estimation, a positive coefficient indicates a move towards more environmental sustainability whereas in the CO2 and EI models, a positive coefficient on a variable imply an increase in such a variable tends to harm the quality of the environment. It is been argued by Abdulai and Ramcke (2009), that about a third of all energy consumed in developing countries comes from wood, crop residues, straw and dung, which are often burned in poorly designed stoves within ill-ventilated huts. In addition, energy consumption is closely linked to the depletion of natural resources.

■Table 1. Measurement of variables

| Variable | Measurement |
|---|---|
| CO2 emissions (CO2) | CO2 emissions per capita |
| Adjusted Net Savings (ANS) | Adjusted Net Savings (% of GNI) |
| Energy use efficiency (EI) | Energy use in kg of oil equivalent per capita |
| Economic growth (Y) | Real per capita GDP growth |
| Industry (IND) | Industry, value added as a % of GDP |
| Service (SERV) | Service, valued added as a % of GDP |
| Agriculture (AGRIC) | Agriculture, valued added as a % of GDP |
| Urbanization (URB) | Fraction of the population living in urban areas |
| Foreign Direct Investment (FDI) | Share of FDI (net inflows) in GDP |
| Trade openness (TOP) | (Export + Import)/GDP |
| Population density (POPD) | Annual percentage change in total population |

World Development Indicators (2011)

## B. Data

The study makes use of annual panel dataset from the World Bank's World Development Indicators (WDI) on 36 SSA countries from 1985-2010 (i.e. annual time series of 26 years across 36 countries). The WDI is the foremost World Bank collection of development indicators, compiled from officially-recognized international sources. It presents the most current and accurate global development data available. Its scope encompasses national, regional and global estimates. WDI data are presented by country, by topic, and by indicator (World Bank, 2014). Both the sample period and the inclusion of the 36 SSA countries for this study are informed by data availability on all the variables of interest. Since environmental quality has many dimensions, each of which may respond to economic variables differently, the study uses three measures (ANS, EI and CO2) of environmental quality so as to provide a comprehensive picture of how the various components of economic growth, alongside with trade openness, FDI, industrialization, urbanization impact on the environment

# IV. Estimation of empirical model

The empirical model specified in equation (1) is estimated using the two-step system Generalized Method of Moments (GMM) developed by Arrelano and Bond (1991). The GMM is appropriate for this study due to the fact that, this estimation technique tend to produce efficient estimates particularly in dynamic panel models. The results of the system GMM estimations are presented in Tables 3-4. Prior to the empirical estimation, a pre-estimation sensitivity analysis was carried out to test for the stationarity properties of the variables and the results are presented in Table 2.

## A. Pre-estimation Sensitivity Analysis: Stationarity or unit root Test

Ascertaining the stationarity properties of the included variables is important in order to avoid the occurrence of spurious regressions. The Fisher test is employed to

check the stationarity properties of the various variables chosen for this study. The results of the stationarity test are presented in Table 2. As a measure of robustness, four different statistics are computed and all the four tests strongly reject the null hypothesis that all the panels contain unit roots. The conclusion is that at least one of the panels has no unit root and thus avoiding the tendency of spurious regressions or unrelated regressions.

■Table 2. Stationarity/Unit root: Fisher Unit root test of Variables based on Augmented Dickey Fuller (ADF)

| Variable | Inverse $\chi 2$ | | Inverse Normal | | Inverse Logit t | | Modified inv. $\chi 2$ | |
|---|---|---|---|---|---|---|---|---|
| | Statistic | Prob. | Statistic | Prob. | Statistic | Prob. | Statistic | Prob. |
| CO2 per capita | 210.25 | 0.000 | -9.145 | 0.000 | -9.403 | 0.000 | 11.85 | 0.000 |
| Energy use per capita | 134.20 | 0.000 | -7.977 | 0.000 | -8.383 | 0.000 | 11.03 | 0.000 |
| Adjusted net saving | 158.45 | 0.000 | -7.470 | 0.000 | -7.617 | 0.000 | 9.681 | 0.000 |
| Economic growth | 343.73 | 0.000 | -13.92 | 0.000 | -15.76 | 0.000 | 22.64 | 0.000 |
| Industry | 207.03 | 0.000 | -8.854 | 0.000 | -9.202 | 0.000 | 11.58 | 0.000 |
| Agriculture | 233.35 | 0.000 | -10.07 | 0.000 | -10.62 | 0.000 | 13.81 | 0.000 |
| Services | 217.85 | 0.000 | -9.447 | 0.000 | -9.767 | 0.000 | 12.49 | 0.000 |
| Trade openness | 212.69 | 0.000 | -9.167 | 0.000 | -9.362 | 0.000 | 11.72 | 0.000 |
| Foreign direct investment | 287.62 | 0.000 | -11.88 | 0.000 | -12.99 | 0.000 | 17.97 | 0.000 |
| Urbanization | 211.21 | 0.000 | -8.279 | 0.000 | -8.822 | 0.000 | 11.60 | 0.000 |
| Population density | 246.32 | 0.000 | -9.858 | 0.000 | -10.76 | 0.000 | 14.52 | 0.000 |

H0: All panels contain unit root or All panels are non-stationarity

H1: At least one does not contain unit root or At least one panel is stationarity

# V. Results and Discussions

The results of the System GMM estimations of the environmental effect of the relevant disaggregated growth components are presented in Table 3. These com-

ponents are Agriculture, Industry and Services. It is worth-noting that in the CO2 emissions and Energy use efficiency regressions, a positive coefficient on a variable implies that an increase in such a variable leads to an increase in environmental deterioration or a fall in environmental quality and vice versa. However, in the ANS estimation, a positive coefficient on a variable means that an increase in such a variable improves environmental sustainability and the converse is also true. Table 3 presents the results of the System GMM Estimations for aggregated economic growth. The results from Tables 3 and 4 give a more comprehensive and insightful perspective of how economic growth and its broad sectoral components (i.e. Agriculture, Industry and Services) tend to harm or improve the environment.

*It is evident from Tables 3 and 4 that the lags of all the dependent variables are found to be significant and positive in all the estimations confirming the dynamic nature of the selected measures of environmental quality. The positive coefficients on the lags indicate that CO2 emissions in a previous year tend to harm the environment in a current year. Similarly, higher energy use efficiency in a previous year leads to a higher energy use efficiency in a current year and the converse also holds. Indeed, the higher the sustainability of the environment (as measured by ANS in some previous years, the higher the environmental sustainability in current years. Though this finding is not surprising, it is quite consequential for the region as it indicates that failing to adopt sound environmental management practices now, is a recipe for further environmental degradation in the future.*

■Table 3. System GMM Estimations: A disaggregated sectorial growth approach

| REGRESSORS | DEPENDENT VARIABLES | | | | | |
|---|---|---|---|---|---|---|
| | CO2 EMISSIONS | | ADJUSTED NET SAVING | | ENERGY USE EFFICIENCY | |
| | Coefficient | Std. Err | Coefficient | Std. Err | Coefficient | Std. Err |
| Lag of dependent variable | 0.00014*** | 0.0294 | 0.0045*** | 0.0001 | 0.0016*** | 0.0001 |
| Urbanization | 0.003*** | 0.0014 | 0.0547*** | 0.0173 | -0.0549 | 0.642 |
| Industry | -0.024*** | 0.0037 | -0.5765*** | 0.1522 | -0.0849*** | 0.0045 |
| Agriculture | -0.003*** | 0.0002 | 0.1471*** | 0.0365 | -0.3433*** | 0.0063 |
| Services | -0.003** | 0.0029 | -0.2082*** | 0.0201 | 0.3650*** | 0.0701 |
| Trade openness | 0.025*** | 0.0001 | -0.2966*** | 0.0471 | 0.0042*** | 0.0003 |
| Foreign Direct Investment | 0.003*** | 0.0004 | -0.4938*** | 0.0049 | 0.0834*** | 0.0066 |
| Foreign Direct Investment(-1) | 0.006*** | 0.0008 | -0.0144*** | 0.1030 | 0.0815*** | 0.0094 |
| Population density | -0.004** | 0.0002 | 0.0803*** | 0.0283 | 0.0425*** | 0.0019 |
| Constant | 0.002 | 0.308 | 0.0003 | .9972 | -0.0032 | 0.1421 |
| Prob.>F | 0.000 | | 0.000 | | 0.000 | |
| AR (1)[2] Test (P-value) | 0.0990 | | 0.0587 | | 0.2789 | |
| AR (2) Test (P-value) | 0.4639 | | 0.1007 | | 0.4035 | |
| Sargan Test | 20.53 | | 17.57 | | 11.85 | |

*, **, *** *correspond respectively to 10%, 5% and 1% level of significance*

The results further reveal that a rise in industrial activities in the region is observed to be accompanied by a reduction in ANS, CO2 emissions and energy use inefficiency. This is an indication that industrialization in SSA leads to a reduction in environmental sustainability (i.e. ANS); but improves energy intensity (or reduce energy use inefficiency) and leads to less significant CO2 emissions.

[2] In Tables 3 and 4 the AR (1) and AR (2) are tests for detecting the presence of first-order and second-order autocorrelation respectively. The null hypotheses are no first-order and second order autocorrelation. Thus with p-values which are greater than 5% we fail to reject both null hypotheses and conclude that there is no first order and second order autocorrelation in the models.

The result also shows that the harmful effect of industrialization on the environment is rather ambiguous as it tends to improve environmental quality through lesser CO2 emissions and higher energy use efficiency but tend to reduce the sustainability of the environment as measured by ANS.

■ Table 4. System GMM Estimations: An aggregated economic growth approach

| REGRESSORS | DEPENDENT VARIABLES | | | | | |
|---|---|---|---|---|---|---|
| | CO2 EMISSIONS | | ADJUSTED NET SAVING | | ENERGY USE EFFICIENCY | |
| | Coefficient | Std. Err | Coefficient | Std. Err | Coefficient | Std. Err |
| Lag of dependent variable | 0.0040*** | 0.0013 | 0.0054*** | 0.0008 | 0.0089*** | 0.0003 |
| Urbanization | 0.0006*** | 0.0001 | 0.1724*** | 0.0340 | -0.0372 | 0.1571 |
| Economic growth | -0.0028** | 0.0003 | -0.2334*** | 0.0277 | -0.0863 *** | 0.0031 |
| Trade openness | 0.0542*** | 0.0036 | -0.3283*** | 0.0076 | -0.0648*** | 0.0015 |
| Foreign Direct Investment | 0.0028*** | 0.0011 | -0.304*** | 0.0341 | 0.0872*** | 0.0002 |
| Foreign Direct Investment (-1) | 0.0047 | 0.0012 | -0.1724*** | 0.0068 | -0.3047*** | 0.0019 |
| Population density | -0.0014** | 0.0010 | 0.0447*** | 0.0139 | 0.0216*** | 0.0065 |
| Constant | 0.0374 | 0.1086 | 0.0082 | 0.0617 | -0.0014 | 0.0549 |
| Prob.>F | 0.000 | | 0.000 | | 0.000 | |
| AR (1) Test (P-value) | 0.0430 | | 0.0369 | | 0.2907 | |
| AR (2) Test (P-value) | 0.5929 | | 0.0999 | | 0.3398 | |
| Sargan Test | 17.27 | | 32.41 | | 14.35 | |

*, **, *** *correspond respectively to 10%, 5% and 1% level of significance*

Furthermore, agricultural activities are found not only to be significant in all specifications, but also unambiguously reduce environmental degradation (measured by CO2 emission), environmental quality (measured by energy use efficiency) as well as environmental sustainability (measured by Adjusted Net Savings). What is more, the activities of the services sector in the region tend to improve environmental quality as measured by CO2 emissions and energy use efficiency but turn out to

reduce the sustainability of the environment as measured by ANS. Thus, the exact relationship between the services sector on the environment in SSA is mixed and inconclusive as it depends crucially and largely on how one defines environmental quality and/or sustainability. The net effect of service and industrial activities on the environment depends on whether their improving effects tend to outweigh their destructive effects.

Further, economic growth (as reported in Table 4) is significant in all the specifications. This appears to suggest that while economic growth tends to have a reducing effect on the level of CO2 emissions and an improving effect on energy use efficiency, it rather reduces environmental sustainability. Stated differently, while economic growth leads to a lesser and lesser CO2 emissions (which is a move towards more environmental quality) and greater energy use efficiency in the region, economic growth rather undermines environmental sustainability. These results are generally consistent with the conclusions of Cole and Elliot (2003) found that SO2 emission reduces as income increase and Arouri et al. (2012) confirmed the EKC hypothesis in most of MENA countries. However, Boopen and Vinesh (2011), Saboori et al. (2012) and Akpan and Akpan (2012) found the contrary to exist.

On the effect of the control variables on the environment, urbanization is found to be significant and impacts positively on all measures of environmental quality employed in this paper with the exception of energy intensity. This means that as the proportion of people living in the urban areas of the sub-region increases, Adjusted Net Savings (which measures environmental sustainability) tends to improve while at the same time, increases CO2 emissions. Urbanization, however, has no systematic influence on energy use efficiency. The effect of urbanization on CO2 is consistent with the findings of Wang et al. (2013), Maiti and Agrawal (2005) and Uttara et al. (2012). Thus, it can be concluded that urbanization tends to enhance environmental sustainability as measured by ANS while at the same time it destroys the environment through CO2 emissions and reduces energy use efficiency. This may be due to the fact that most of the economic activities done in the urban areas tend to emit

more CO2 into the atmosphere and/or tend to rely heavily and massively on energy. Hence, the effect of urbanization on the environment is somewhat mixed depending on the measurement of environmental quality. The net effect of urbanization would thus depend on whether the gains generated from ANS outweigh the harmful effects generated through CO2 emissions and energy use inefficiency at least per the findings of this study.

Moreover, the estimated coefficients on FDI and its lag are significant and positive in the CO2 and energy use efficiency specifications but negative in the ANS specification. These findings are consistent with that of He (2006) and Agrawal (2012) but at variance with that of Eskeland and Harrison (2003). This implies that increases in FDI tend to have an unambiguous damaging effect on the environment regardless of the environmental quality variable in question. These stems from the fact that the bulk of the FDI inflows into the region are essentially less environment-friendly as FDI tend to reduce environmental sustainability (measured by ANS), reduce energy use efficiency and increase CO2 emissions which are measures of environmental degradation and quality respectively. The harmful effect of FDI on environmental sustainability (ANS) corroborates with the findings of He (2006) but at variance with Eskeland and Harrison (2003). Similarly, greater openness to trade is also seen to be associated with an increase in CO2 emissions, a reduction in ANS (i.e. environmental sustainability) and worsens energy intensity (i.e. environmental quality). This indicates that trade openness increases CO2 emissions, reduces energy use efficiency and reduces the sustainability of the environment. In SSA, most of the FDI inflows in countries such as Ghana, Tanzania, Mali and Zambia are in the extractive sectors that involve substantial environmental degradation in the course of mineral prospecting with little or no sound environmental management practices. Similarly, most of the exports from the sampled countries are primary commodities which involve the exploitation of the environment. In effect, trade openness and FDI broadly have the same impact on the environment, however, with the impact of the latter on the environment been slightly pronounced than the former. The relation-

ship between trade openness and CO2 established in this study is consistent with the conclusion of Antweiler et al. (2001) but contrasts that of Dasgupta et al. (2002).

Finally, rising population density in SSA is associated with an improvement in all the environmental measures employed.

# VI. Conclusions and Recommendations

The paper reveals that the effects of urbanization, industrialization, and services on the quality and sustainability of the environment in SSA are ambiguous, mixed and inconclusive as their effects on the environment depend largely on how one measures environmental quality and/or sustainability. For instance, while urbanization tends to improve environmental sustainability as measured by ANS and CO2 emissions, energy use efficiency tends to worsen as urbanization increases. Similarly, whereas a rise in services and industrial activities tends to be associated with a reduction in CO2 emissions and energy use inefficiency, ANS as a measure of environmental sustainability deteriorates over the same period. Indeed, agricultural activity is the only component of disaggregated growth which has an unambiguously improving impact on all the measures of environmental degradation, quality and sustainability in the region. This conclusion is not surprising because agricultural activities in the region do not require greater energy consumption, nor do they lead to more CO2 emission. Similarly, population density is found to unequivocally improve all the measures of environmental degradation, quality and sustainability in the region. Further, trade openness and FDI unambiguously cause deterioration in all the measures of environmental quality with the impact of the latter on the environment been slightly pronounced than the former. In the same way, economic growth was found to unequivocally reduce or minimize the level of environmental degradation or deterioration in the region.

Based on the study findings, the paper offers the following recommendations Firstly, industrial activities alongside with services, though, are found to be associat-

ed with a reduction in CO2 emissions and an improvement in energy use efficiency, they generally tend to reduce the sustainability of the environment as measured by ANS. As a result, it is recommended that policymakers should carefully and critically examine which aspects of industrial activities in SSA tend to reduce the sustainability of the environment and deal with them appropriately.

Also, agricultural activity unambiguously improves the environment regardless of the environmental variables in question as they tend to reduce CO2 emissions, improve energy use efficiency and concurrently increase ANS. It is recommended that the current agricultural practices should be continued as they have no destructive effect on the environment. However, beyond a certain threshold, involving higher capital and/or energy intensive equipment, agricultural activities might eventually lead to a fall in environmental outcomes. Thus, caution should be exercised as to how agricultural activities are carried out.

Additionally, aggregated economic growth unambiguously improves all the three environment outcomes employed in this study. This conclusion is "good news" for the region in that, though in the disaggregated analysis, environmental sustainability was found to be reduced by services, and industrial activities, the aggregated analysis assures the region that economic growth would improve the environment. This conclusion underscores and justifies this current investigation on the grounds that, following the aggregated approach, we are unable to identify which aspects of the aggregated growth is actually improving or destroying the environment.

Further, despite the fact that trade openness and FDI tend to improve the sustainability of the environment in SSA as measured by ANS, they at the same time harm the environment as measured by CO2 emissions and energy use intensity. This conclusion suggests clearly that there is an urgent need for policy makers, be it environmentalists or economists, to come out with pragmatic and clearly defined policies to halt and probably reverse the negative impact of trade and FDI on the emissions of CO2 and energy use efficiency by using energy friendly technology.

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# APPENDICES

## APPENDIX I

List of SSA countries sampled for the study

| | | | | |
|---|---|---|---|---|
| Angola | Congo, Dem. Rep. | Lesotho | Nigeria | Togo |
| Benin | Congo, Rep. | Liberia | Rwanda | Uganda |
| Botswana | Cote d'Ivoire | Madagascar | Senegal | Zambia |
| Burkina Faso | Ethiopia | Malawi | Sierra Leone | Zimbabwe |
| Burundi | Gabon | Mali | South Africa | |
| Cameroon | Gambia, The | Mauritania | Sudan | |
| Cape Verde | Ghana | Mauritius | Swaziland | |
| Central African | Kenya | Niger | Tanzania | |