TRADE AND GROWTH IMPACTS ON AIR POLLUTION IN THE AGGREGATED SUB-SAHARAN AFRICA AND SELECTED AFRICAN COUNTRIES

F. Aka Bédia[1]

Abstract

This paper examines the impacts of trade intensity as measured by the share of exports plus imports in GDP and economic growth proxies by the GDP per capita on air pollution as measured by CO_2 *emissions. We focus first on Sub-Saharan Africa as a whole during the period 1961-2003 to see how trade intensity and GDP per capita growth have impacted* CO_2 *emissions in that zone, and secondly on each individual country of the SSA zone. We use an Autoregressive distributed lag (ARDL) model to analyze both the short and long-run impacts of these variables on the environment. Our results indicate that for the aggregate SSA in the short-run a 1% increase in economic growth leads to 1.04% increase in* CO_2 *emission thus a degradation of air quality, while a 1% increase in trade intensity account for 0.15% decrease in pollution. Most importantly in the long-run, a 1% increase in GDP per capita contributes to 1.8% increase in air pollution while a 1% increase in trade intensity leads to 0.57% decrease in* CO_2 *emission thus beneficial to the environment. For individual countries, the results allow to classify them into three groups. For the first group composed of Congo Democratic Republic, Congo Republic, Nigeria and South Africa), in the long-run economic expansion does have a negative impact on environment, whereas trade is beneficial to environment. For the second group of countries including Central African Republic, Gabon, Ghana, Niger, Senegal and Togo, in the long-run equation economic expansion does have a positive impact on environment, while trade is not beneficial to environment. Concerning the third group of countries including Benin, Burkina Faso, Burundi, Cote d'Ivoire, Kenya, Madagascar, Malawi, Mauritania, Rwanda and Zambia, in the long-run economic expansion does have a negative impact on environment, and trade is not beneficial to environment.*

JEL Classification: C2, F18, O13

Keywords: Pollution, Environmental Kuznets Curve, Growth, Trade intensity, ECM.

1. INTRODUCTION

Environmental questions have regain interest and more attention during recent years due to climatic problems associated with the increased accumulation of pollution and to the deterioration in the quality of the environment due to human activity. The study of the relationship between pollution and income has mainly focused on investigating the environmental Kuznets curve (EKC) (see Stern, 2004). This so call environmental Kuznets

[1] Department of Economics and Laboratory of Analysis, Modelling and Economic Prospective (Lampe), Centre de Recherche pour le Développement (CRD), University of Bouaké, Côte d'Ivoire; Email: akbdia@yahoo.fr

curve originated from Kuznets (1955) who hypothesized in 1954 that income inequality first rises in early years of economic growth and then falls in the curse of economic development[2]. Grossman and Krueger's (1991) are those who set up the actual EKC concept. They point out that the level of environmental degradation and per capita income follows the same inverted U-shaped relationship as does income inequality and per capita income in the original Kuznets curve.

This inverted U-shape curve shows that pollution intensity rises with per capita income at the early stages of economic development and falls as per capita income rises beyond some threshold level that could be determined. In effect from the estimated coefficients of the following equation[3] $\ln E_t = \alpha + \beta_1 \ln Y_t + \beta_2 \ln Y_t^2 + \zeta_t$, the threshold point could be computed as the exponential of the ratio β_1 over 2 β_2. A negative value for the coefficient β_2 confirms the inverted U-shape of the curve.

Empirically the growth-pollution literature studying the relationship between per capita income and pollution per capita (see List, Millimet and Stengos, 2003 and Azomahou, Lasney and Van 2006) for individual countries and groups of countries has found that: (i) at the early stages of economic development pollution intensity rises with per capita income; (ii) but pollution intensity falls as per capita income rises beyond some threshold level (see Grossman and Krueger, 1995 and List and Gallet, 1999, among others).

Methodologically previous studies of the relationships between pollution and income have used cross-sectional or panel data for a sample of developing and developed countries, or single countries. In contrast in this paper we use an Autoregressive distributed lag (ARDL) model to analyze both the short and long-run relationships between the variables for the Sub-Saharan Africa as a whole, as it is well known that environment is a global phenomenon because pollution in one country necessarily influences neighboring others' atmosphere and even beyond.

Although several pollutants have been considered in the study of the EKC (see Managi, 2006) in this paper we use CO_2 as in Douglas and Selden, 1992. In effect the debate concerning the reduction of carbon dioxide (CO_2) emissions is still active both in developed nations and developing countries. In Sub-Saharan Africa countries where environmental quality is not yet a major preoccupation several capital cities are polluted by the emissions of this gas from imported used vehicles and polluting industries. We could forecast that these emissions will increase in the future as these countries will industrialize by outsourcing old industries from the northern countries.

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[2] Simon Kuznets delivered the presidential address; entitled "Economic Growth and Income Inequality" at the sixty-seventh annual meeting of the American Economic Association in December 1954". He suggested that as per capita income increases, income inequality also increases at first but then, after some turning point, starts declining. Kuznets believed that the distribution of income becomes more unequal at early stages of income growth but that the distribution eventually moves back toward greater equality as economic growth continues.

[3] Where E, denotes per capita pollution, Y, denotes per capita income, Y^2 indicates square income per capita, ζ_t, is an error term.

Our empirical findings indicate that for the aggregated Sub-Saharan Africa area, in the short-run a 1% increase in economic growth leads to 1.04% increase in CO_2 emission, while a 1% increase in trade intensity account for 0.15% decrease in pollution. Most importantly in the long-run, in which we should crucially be interested, a 1% increase in the income per capita contributes to 1.8% increase in pollution while a 1% increase in trade intensity leads to 0.57% decrease in CO_2 emission and thus favorable to air quality.

Considering the selected individual countries it is possible to classify them into three groups. For the first group composed of Congo Democratic Republic, Congo Republic, Nigeria and South Africa), in the long-run economic expansion does have a negative impact on environment, whereas trade is beneficial to environment. For the second group of countries including Central African Republic, Gabon, Ghana, Niger, Senegal and Togo, in the long-run equation economic expansion does have a positive impact on environment, whereas trade is not beneficial to environment. Concerning the third group of countries including Benin, Burkina Faso, Burundi, Cote d'Ivoire, Kenya, Madagascar, Malawi, Mauritania, Rwanda and Zambia, in the long-run economic expansion does have a negative impact on environment, and trade is not beneficial to environment.

The remaining of the paper is organized as follows. Section 2 presents the model and the econometric methodology. Section 3 presents estimations results and final remarks are provided in Section 4.

2. THE MODEL SPECIFICATION

We adopt a simple model aiming to estimate the following relationship[4]:

$$E_t = F(Y_t, T_t) + \zeta_t \tag{1}$$

where *E*, denotes per capita emissions of carbon dioxide (CO_2), *Y*, denotes per capita *GDP*, *T* indicates trade intensity as measured by the share of exports and imports in *GDP*, ζ_t, is a stochastic error term, and *t* is a year index. Expressing Eq. 1 in a natural logarithm form we have the following long run equation:

$$\ln E_t = \alpha + \gamma_1 \ln Y_t + \gamma_2 \ln T_t + \zeta_t \tag{2}$$

[4] This equation is disaggregated for individual countries as follows : $E_{i,t} = F(Y_{i,t}, T_{i,t}) + \zeta_{i,t}$

The assumptions concerning the preceding Eq. 2 are that while the *GDP* per capita is supposed to positively impact the emissions of CO_2 i.e. negatively the environment, the trade intensity variable will negatively impact pollution, thus positively the environment.

The estimations will be performed for each individual country and for the aggregated SSA using an unrestricted general to specific Hendry type error correction model (ECM) where the long run relationship is embedded within the dynamic specification, including the lagged dependent and independent variables as follows:

$$\Delta \ln E_t = \alpha + \gamma_1 \Delta \ln Y_t + \gamma_2 \Delta \ln T_t + \gamma_3 \left(\ln E_{t-1} - \alpha_1 \ln Y_{t-1} - \alpha_2 \ln T_{t-1} \right) + u_t \qquad (3)$$

This model is re-parameterized in the estimable form:

$$\Delta \ln E_t = \alpha + \gamma_1 \Delta \ln Y_t + \gamma_2 \Delta \mathrm{T}_t + \gamma_3 \ln E_{t-1} + \gamma_4 \ln Y_{t-1} + \gamma_5 \ln T_{t-1} + u_t \qquad (4)$$

3. DATA AND RESULTS

We estimate the model using data from World Development Indicators (WDI 2006) and covering the period 1960-2005. Figure 1 shows the series for the aggregate Sub-Saharan Africa in natural logarithm (Top panel) and in first difference (Bottom panel). Figures for the twenty selected individual countries are reported in appendix 1 (Countries have been selected in relation with data constraint).

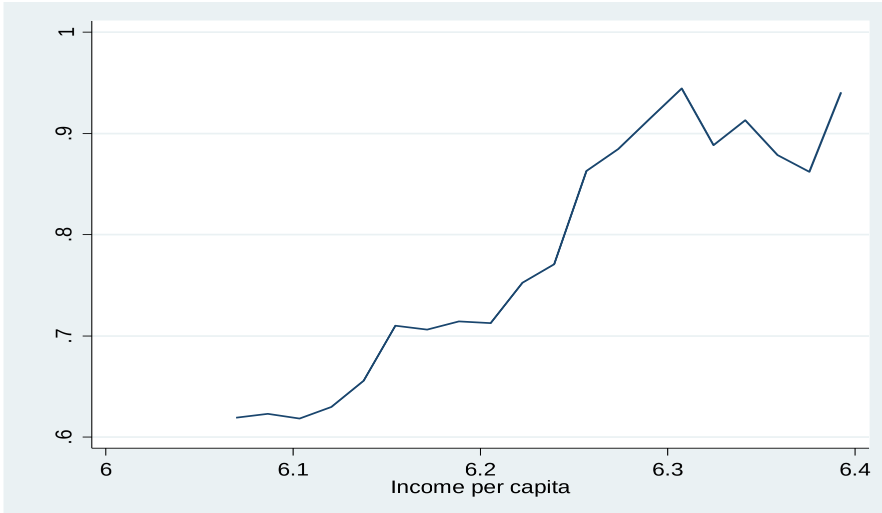
The variable *LCO2_SSA* indicates pollution measured as CO_2 emission (metric ton per capita), *LGDPpc_SSA* indicates Gross domestic product per capita and *LTradIntens_SSA* indicates trade intensity as measured by the share of exports plus imports in GDP.

Figure 1: Evolution of Pollution, Trade and Growth (Aggregated SSA)

From Figure 1 we could distinguish four sub-periods in the relationships between the tree variables. The first one spans from 1960 to 1970 where trade intensity and GDPPC are above the pollution. From 1970 to 1980 pollution overcomes trade but not GDPPC. Finally from 1980 to 1995, pollution (CO_2 emissions) overcomes both GDP per capita and trade. Finally since 1996, trade and income per capita are above pollution. This indicates that the SSA data could replicate the EK curve.

Figure 3 depicts the environment Kuznets curve expressing the relationships between income growth and the deterioration of environment for sub-Saharan Africa. Curves for individual countries are reported in appendix 2.

Figure 3: Environmental Kuznets Curve (Sub-Saharan Africa)



The curve for Sub-Saharan Africa seems to mimic the first stage of an inverted U-shape curve consistent with the assumption of the theory showing that pollution intensity rises with per capita income at the early stages of economic development, in which these countries are, and falls as per capita income rises beyond some threshold level that could be determined. For individual countries the curves are diversified and show various pattern of the EKC (see Appendix 2).

In effect, for the aggregate Sub-Saharan Africa, from the estimated coefficients of the following Eq. 5:

$$\ln E_t = -69.10 + 20.6134 \ln Y_t - 1.5348 \ln Y_t^2 \tag{5}$$

we computed the ratio $-\left(\beta_1 / 2\beta_2\right)$. The negative value of $\beta_2 = -1.53$ confirms here the inverted U-shape of the EK curve. Therefore the predicted turning point of the curve in the aggregated Sub-Saharan Africa mean income level could be approximated by $\kappa = \exp\left(-\left(\beta_1 / 2\beta_2\right)\right) = 824.93$. Most of the Sub-Saharan African countries individually taken are bellow this mean income per capita value and therefore at the first stage of the EKC.

Five of individual countries (see Table 1), namely Benin, Central African Republic, Madagascar, Malawi, and Rwanda have a positive value of β_2, meaning that these countries don't follow the inverted U-shape of the EK curve. All remaining fifty countries do have a negative value of β_2 confirming the inverted U-shape of their EK curve.

The final estimated dynamic ECM Eq. 4 (for individual countries and the SSA) is reported in Table 2 along with the diagnostic tests and the long-run elasticity of the variables and their t-ratio regarding which all variables are significant. Figure 3 depicts the estimates and residuals. The dynamic ECM equation is reported as follows:

$$\Delta \ln E_t = -2.547 + 1.043\Delta \ln Y_t - 0.1552\Delta \ln T_t - 0.2179 \ln E_{t-1} + 0.3889 \ln Y_{t-1} - 0.1279 \ln T_{t-1} \quad (6)$$

This equation indicates that in the short run, a 1% increase in the *GDP* per capita enhance CO_2 emissions by 1.043%, while a 1% increase in the trade intensity leads to 0.15% decrease in pollution. The coefficient (-0.2179) in Eq. 6 indicates the speed of the adjustment of the system to the long-run. The long run equation derived from the dynamic ECM is the following:

$$\ln E_t = 1.8 \ln Y_t - 0.57 \ln T_t \quad (7)$$

In this long-run equation the *GDP* per capita has a positive sign expressing thus the fact that economic expansion does have a negative impact on environment; whereas the *trade intensity* has a negative sign indicating that trade is beneficial to environment in the aggregated Sub-Saharan Africa area. For individual countries, the relationships between growth, trade and pollution are diversified.

Table 1: Turning Point of the Inverted U-shape of the EK Curve

	Country	Estimated EKC Equation	Turning Point
1	Benin	$\ln E_t = 566.4 - 204.9 \ln Y_t + 18.44 \ln Y_t^2$	258,75
2	Burkina Faso	$\ln E_t = -247.3 + 88.4 \ln Y_t - 7.974 \ln Y_t^2$	255,45
3	Burundi	$\ln E_t = -36.77 + 12.75 \ln Y_t - 1.22 \ln Y_t^2$	185,94
4	Central African Rep.	$\ln E_t = 12.49 - 5.098 \ln Y_t + 0.4253 \ln Y_t^2$	400,78
5	Congo, Dem. Rep.	$\ln E_t = -21.14 + 6.3 \ln Y_t - 0.5164 \ln Y_t^2$	445,82
6	Congo, Rep.	$\ln E_t = -36.35 + 9.513 \ln Y_t - 0.6325 \ln Y_t^2$	1844,86
7	Cote d'Ivoire	$\ln E_t = -48.54 + 13.2 \ln Y_t - 0.9055 \ln Y_t^2$	1463,80
8	Gabon	$\ln E_t = -147.7 + 33.42 \ln Y_t - 1.862 \ln Y_t^2$	7896,87
9	Ghana	$\ln E_t = -65.49 + 23.46 \ln Y_t - 2.145 \ln Y_t^2$	237,11
10	Kenya	$\ln E_t = -34.57 + 11.56 \ln Y_t - 1.002 \ln Y_t^2$	320,05
11	Madagascar	$\ln E_t = 65.34 - 23.95 \ln Y_t + 2.119 \ln Y_t^2$	284,65
12	Malawi	$\ln E_t = 209.8 - 86.63 \ln Y_t + 8.834 \ln Y_t^2$	134,72
13	Mauritania	$\ln E_t = -953.2 + 318.6 \ln Y_t - 26.64 \ln Y_t^2$	395,33
14	Niger	$\ln E_t = -93.82 + 35.59 \ln Y_t - 3.455 \ln Y_t^2$	172,52
15	Nigeria	$\ln E_t = -24.35 + 4.998 \ln Y_t - 0.1716 \ln Y_t^2$	2111558,93*
16	Rwanda	$\ln E_t = 199.2 - 77.5 \ln Y_t + 7.398 \ln Y_t^2$	188,27
17	Senegal	$\ln E_t = -1.266e + 004 + 4119 \ln Y_t - 334.9 \ln Y_t^2$	468,53
18	South Africa	$\ln E_t = -75.03 + 18.47 \ln Y_t - 1.105 \ln Y_t^2$	4261,88
19	Togo	$\ln E_t = -195 + 68.68 \ln Y_t - 6.102 \ln Y_t^2$	278,01
20	Zambia	$\ln E_t = -58.9 + 16.45 \ln Y_t - 1.127 \ln Y_t^2$	1477,54

	Aggregate SS Africa	$\ln E_t = -69.10 + 20.6134 \ln Y_t - 1.5348 \ln Y_t^2$	824.93

Note: The value for turning point of Nigeria seems outlier.

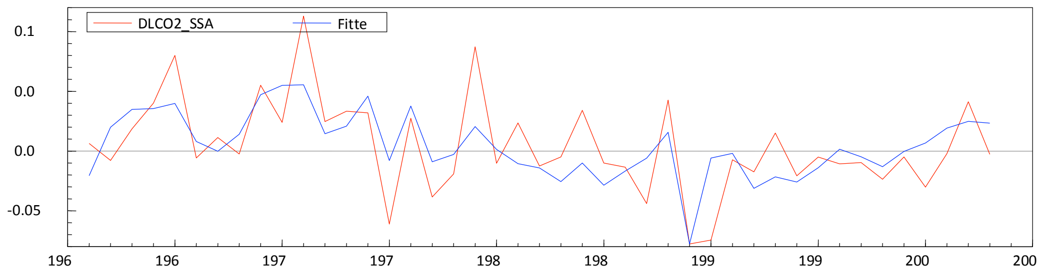
Table 2: Model Estimation, OLS 1961 to 2003 (Dependent variable: DLCO2_SSA)[5]

	Coefficients	**Std. Error**	**t-value**
Constant	-2.54730	1.123	-2.27
DLGDPpc	1.04251	0.2705	3.85
DLTradIntens_SSA	-0.155187	0.1323	-1.17
LCO2_SSA_1	-0.217913	0.1072	-2.03
LGDPpc_SSA_1	0.388865	0.1706	2.28
LTradIntens_SSA_1	-0.127946	0.08877	-1.44
DUM89	-0.0749316	0.0329	-2.28
sigma	0.030251	RSS	0.0329444211
R^2	0.475991	F(6,36) =	5.45 [0.000]**
log-likelihood	93.2295	DW	2.01
no. of observations	43	no. of parameters	7

Note: LGDPpc_SSA_1 indicates the log of GDPpc_SSA one period lag. DUM89 is a dummy variable.

Figure 5: Estimates and Residuals

[5] Estimations are performed using PcGive 10 (Hendry and Doornik 2001).



DLCO2_SSA
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0.1
0.0
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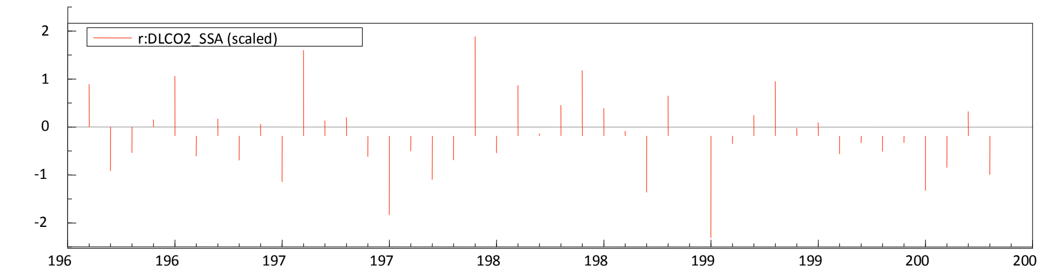
-0.05
196
196
197
197
198
198
199
199
200
200



r:DLCO2_SSA (scaled)
2
1
0
-1
-2
196
196
197
197
198
198
199
199
200
200

Table 3: Estimated Dynamic and Long-run Equations

	Country	**Estimated Dynamic** ECM **Equations**	**Long-run Equations**
1	Benin	$\Delta \ln E_t = -3.6 + 0.47\Delta \ln Y_t + 0.53\Delta \ln T_t - 0.11\ln E_{t-1} + 0.51\ln Y_{t-1} + 0.14\ln T_{t-1}$	$\ln E_t = 4.54\ln Y_t + 1.27\ln T_t$
2	Burkina Faso	$\Delta \ln E_t = -4.69 - 0.79\Delta \ln Y_t - 0.14\Delta \ln T_t - 0.28\ln E_{t-1} + 0.58\ln Y_{t-1} + 0.24\ln T_{t-1}$	$\ln E_t = 2{,}07\ln Y_t + 0.86\ln T_t$
3	Burundi	$\Delta \ln E_t = -1.61 - 0.65\Delta \ln Y_t - 0.11\Delta \ln T_t - 0.16\ln E_{t-1} + 0.22\ln Y_{t-1} + 0.001\ln T_{t-1}$	$\ln E_t = 1.31\ln Y_t + 0.007\ln T_t$
4	Central African Rep.	$\Delta \ln E_t = 0.51 - 0.08\Delta \ln Y_t - 0.06\Delta \ln T_t - 0.29\ln E_{t-1} - 0.30\ln Y_{t-1} + 0.10\ln T_{t-1}$	$\ln E_t = -1.01\ln Y_t + 0.33\ln T_t$
5	Congo, Dem. Rep.	$\Delta \ln E_t = -4.36 + 0.32\Delta \ln Y_t - 0.03\Delta \ln T_t - 0.57\ln E_{t-1} + 0.59\ln Y_{t-1} - 0.05\ln T_{t-1}$	$\ln E_t = 1.02\ln Y_t - 0.09\ln T_t$
6	Congo, Rep.	$\Delta \ln E_t = -1.46 + 1.83\Delta \ln Y_t + 0.24\Delta \ln T_t - 0.38\ln E_{t-1} + 0.53\ln Y_{t-1} - 0.54\ln T_{t-1}$	$\ln E_t = 1.4\ln Y_t - 1.44\ln T_t$
7	Cote d'Ivoire	$\Delta \ln E_t = -4.77 - 0.43\Delta \ln Y_t + 0.16\Delta \ln T_t - 0.43\ln E_{t-1} + 0.52\ln Y_{t-1} + 0.24\ln T_{t-1}$	$\ln E_t = 1.8\ln Y_t + 0.53\ln T_t$
8	Gabon	$\Delta \ln E_t = -3.7 + 0.07\Delta \ln Y_t + 0.37\Delta \ln T_t - 0.14\ln E_{t-1} - 0.13\ln Y_{t-1} + 1.1\ln T_{t-1}$	$\ln E_t = -0.9\ln Y_t + 7.86\ln T_t$
9	Ghana	$\Delta \ln E_t = -0.2 + 0.24\Delta \ln Y_t - 0.01\Delta \ln T_t - 0.25\ln E_{t-1} - 0.1\ln Y_{t-1} + 0.04\ln T_{t-1}$	$\ln E_t = -0.22\ln Y_t + 0.17\ln T_t$
10	Kenya	$\Delta \ln E_t = -1.4 + 1.04\Delta \ln Y_t + 0.25\Delta \ln T_t - 0.23\ln E_{t-1} + 0.1\ln Y_{t-1} + 0.2\ln T_{t-1}$	$\ln E_t = 0.21\ln Y_t + 0.86\ln T_t$
11	Madagascar	$\Delta \ln E_t = -4.39 + 0.41\Delta \ln Y_t + 0.38\Delta \ln T_t - 0.37\ln E_{t-1} + 0.34\ln Y_{t-1} + 0.44\ln T_{t-1}$	$\ln E_t = 0.93\ln Y_t + 1.21\ln T_t$
12	Malawi	$\Delta \ln E_t = -2.04 + 1.1\Delta \ln Y_t + 0.43\Delta \ln T_t - 0.13\ln E_{t-1} + 0.25\ln Y_{t-1} + 0.12\ln T_{t-1}$	$\ln E_t = 1.88\ln Y_t + 0.891\ln T_t$
13	Mauritania	$\Delta \ln E_t = -0.75 + 0.27\Delta \ln Y_t - 0.4\Delta \ln T_t - 0.16\ln E_{t-1} + 0.01\ln Y_{t-1} + 0.15\ln T_{t-1}$	$\ln E_t = 0.05\ln Y_t + 0.931\ln T_t$
14	Niger	$\Delta \ln E_t = -0.5 - 0.7\Delta \ln Y_t + 0.1\Delta \ln T_t - 0.25\ln E_{t-1} - 0.14\ln Y_{t-1} + 0.18\ln T_{t-1}$	$\ln E_t = -0.56\ln Y_t + 0.70\ln T_t$

15	Nigeria	$\Delta \ln E_t = -4.16 + 1.6\Delta \ln Y_t - 0.13\Delta \ln T_t - 0.16 \ln E_{t-1} + 0.8 \ln Y_{t-1} - 0.18 \ln T_{t-1}$	$\ln E_t = 5.01 \ln Y_t - 1.1 \ln T_t$

Table 3: Estimated Dynamic and Long-run Equations (Contd.)

	Country	**Estimated Dynamic** ECM **Equations**	**Long-run Equations**
16	Rwanda	$\Delta \ln E_t = -6.18 + 0.34\Delta \ln Y_t + 0.07\Delta \ln T_t - 0.15\ln E_{t-1} + 0.8\ln Y_{t-1} + 0.5\ln T_{t-1}$	$\ln E_t = 5.1\ln Y_t + 3.01\ln T_t$
17	Senegal	$\Delta \ln E_t = -392.6 + 40.54\Delta \ln Y_t - 16.51\Delta \ln T_t + 1.44\ln E_{t-1} + 73.02\ln Y_{t-1} - 14.75\ln T_{t-1}$	$\ln E_t = -50.6\ln Y_t + 10.21\ln T_t$
18	South Africa	$\Delta \ln E_t = -0.95 + 0.48\Delta \ln Y_t - 0.02\ln T_t - 0.14\ln E_{t-1} + 0.16\ln Y_{t-1} - 0.007\ln T_{t-1}$	$\ln E_t = 1.13\ln Y_t - 0.05\ln T_t$
19	Togo	$\Delta \ln E_t = -0.13 - 1.5\Delta \ln Y_t + 0.22\Delta \ln T_t - 0.31\ln E_{t-1} - 0.40\ln Y_{t-1} + 0.41\ln T_{t-1}$	$\ln E_t = -1.27\ln Y_t + 1.34\ln T_t$
20	Zambia	$\Delta \ln E_t = -4.41 + 0.05\Delta \ln Y_t - 0.16\Delta \ln T_t - 0.25\ln E_{t-1} + 0.63\ln Y_{t-1} + 0.09\ln T_{t-1}$	$\ln E_t = 2.53\ln Y_t + 0.38\ln T_t$
	Aggregate SS Africa	$\Delta \ln E_t = -2.55 + 1.04\Delta \ln Y_t - 0.16\Delta \ln T_t - 0.22\ln E_{t-1} + 0.40\ln Y_{t-1} - 0.13\ln T_{t-1}$	$\ln E_t = 1.8\ln Y_t - 0.57\ln T_t$

Note: *E* indicates metric tons Per capita CO2 Emissions; *Y* indicates GDP per capita; and *T* indicate Trade intensity

In effect considering individual countries, it is possible to classify them into three groups. For the first group composed of Congo Democratic Republic, Congo Republic, Nigeria and South Africa, in the long-run equation the *GDP* per capita has a positive sign expressing thus the fact that economic expansion does have a negative impact on environment; whereas the *trade intensity* has a negative sign indicating that trade is beneficial to environment in these countries.

For the second group of countries including Central African Republic, Gabon, Ghana, Niger, Senegal and Togo, in the long-run equation the *GDP* per capita has a negative sign expressing thus the fact that economic expansion does have a positive impact on environment; whereas the *trade intensity* has a positive sign indicating that trade is not beneficial to environment in these countries.

Concerning the third group of countries including Benin, Burkina Faso, Burundi, Cote d'Ivoire, Kenya, Madagascar, Malawi, Mauritania, Rwanda and Zambia, in the long-run equation the *GDP* per capita has a positive sign expressing thus the fact that economic expansion does have a negative impact on environment; and the *trade intensity* has also a positive sign indicating that trade is not beneficial to environment in these countries.

4 FINAL REMARKS

This paper has examined the impact of economic expansion as measured by the GDP per capita growth and the trade intensity proxies by the share of imports plus exports in the GDP on pollution as measured by CO_2 emissions in the aggregate SSA and selected individual African countries over the period 1961-2003. These relationships are analyzed using an autoregressive distributed lag ECM approach. We find diverse impacts of economic expansion and trade intensity on pollution. In the short run an increase in GDP per capita enhances CO_2 emissions while trade intensity negatively impacts pollution. For the aggregate SSA, in the long run the effect of economic expansion on pollution is positive. On the other hand the impact of trade intensity on CO_2 emissions is negative. Concerning individual countries the results are much diversified.

These findings suggest that economic expansion in Sub-Saharan Africa does have a significant and negative impact on environment as predicted by the theory of the environment Kuznets curve. But more importantly, the intensity of trade, which is an aspect of the increasing globalization phenomenon of Sub-Saharan Africa economies, does have a significant and beneficial impact on the environment in this zone. While international trade favors, the growth of GDP per capita degrades environment. These results should be considered country by country as each country depicts its own curve.

The beneficial aspects of the trade intensity on the reduction of pollution should be considered by policymakers concerned with new growth strategies in the Sub-Saharan Africa, as a clean source of economic growth. In the same time, the economic expansion by other sources generating pollutants should tend to be regulated by rules limiting atmospheric emissions as its impacts on the environment in this zone are negative. Further investigations should extend this paper to individual Sub-Saharan African countries, and use an alternative multivariate VAR approach which could allow to analyze the interactions between the three variables, as pollution and trade could have an impact on the growth process and reciprocally.

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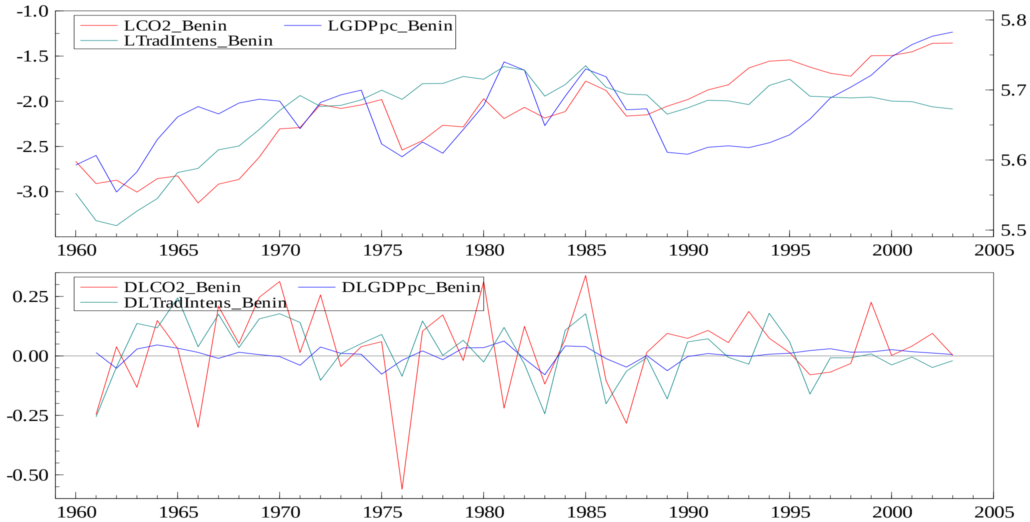
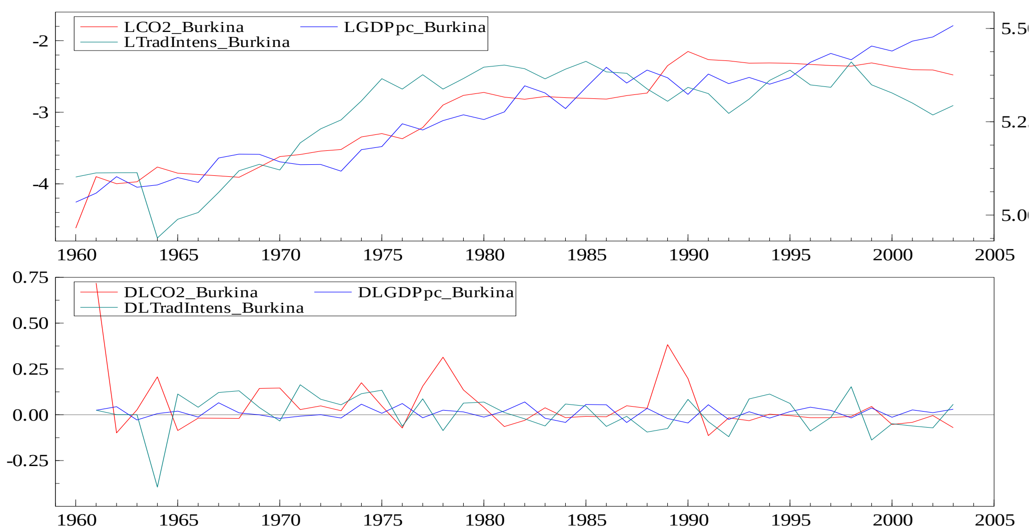
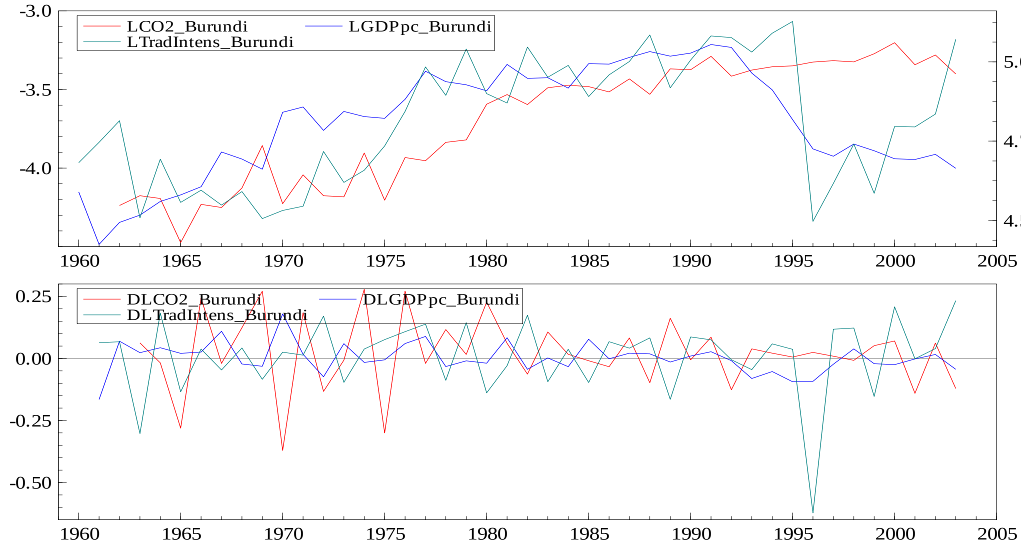
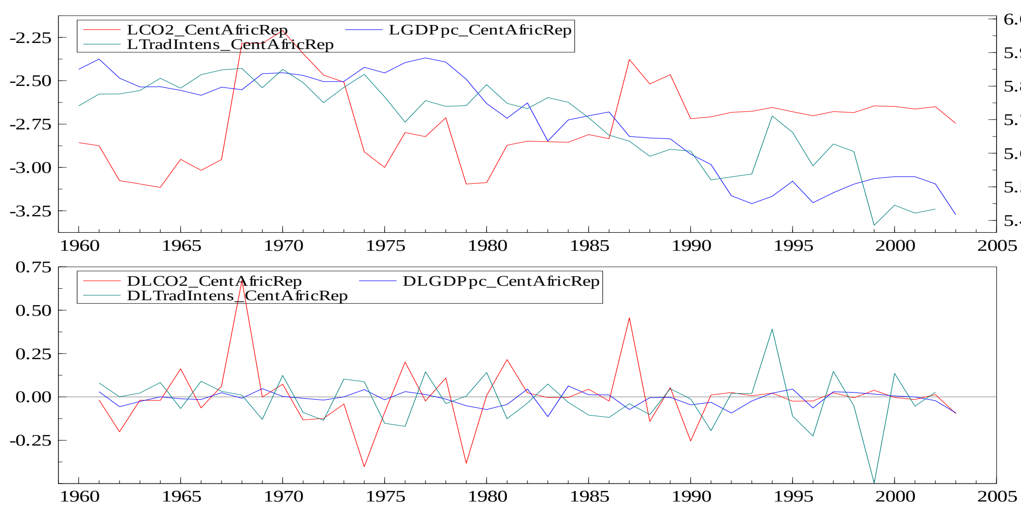
Appendix 1a: Evolution of Pollution, Trade and Growth (Individual Countries)

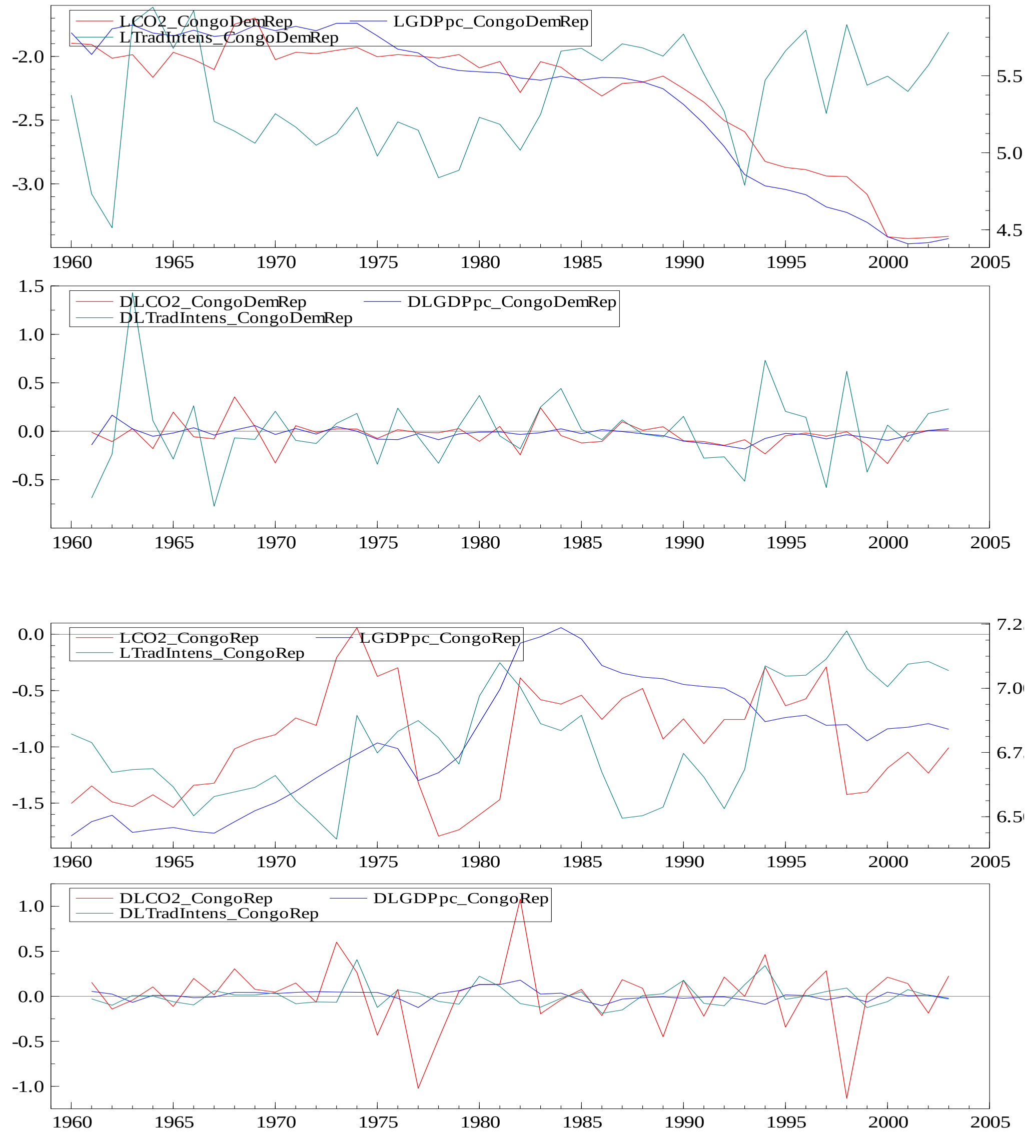






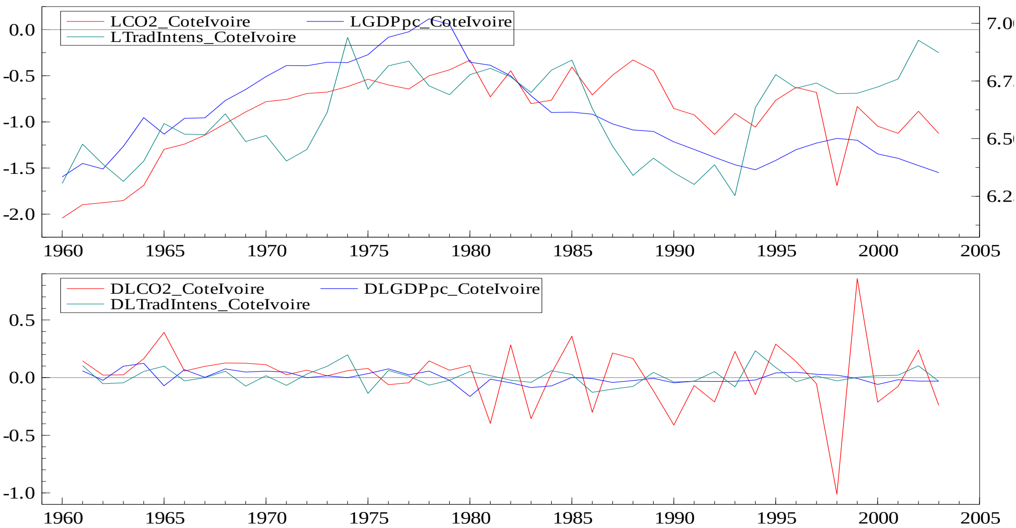
Appendix 1a: Evolution of Pollution, Trade and Growth (Individual Countries) (Contd.)





Appendix 1a: Evolution of Pollution, Trade and Growth (Individual Countries)

(Contd.)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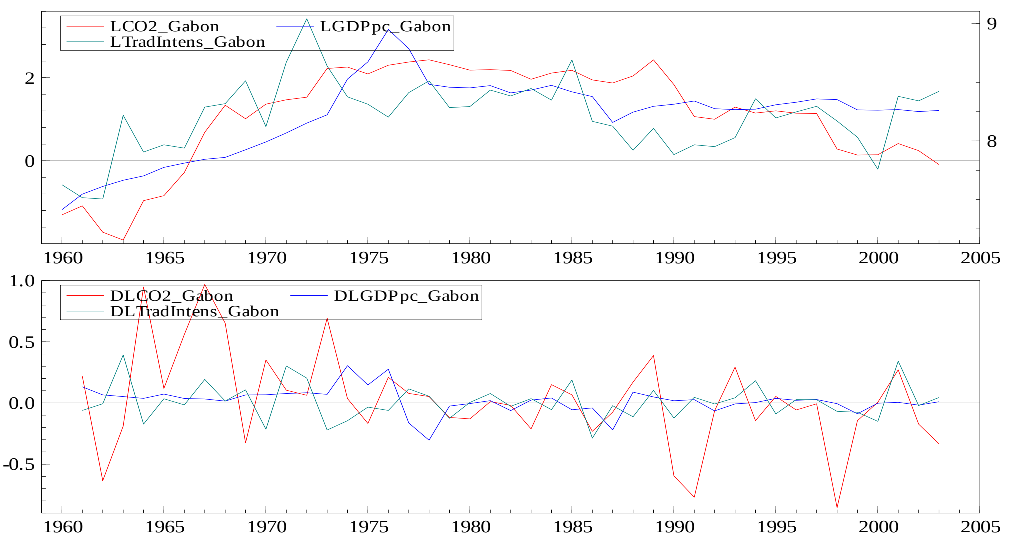
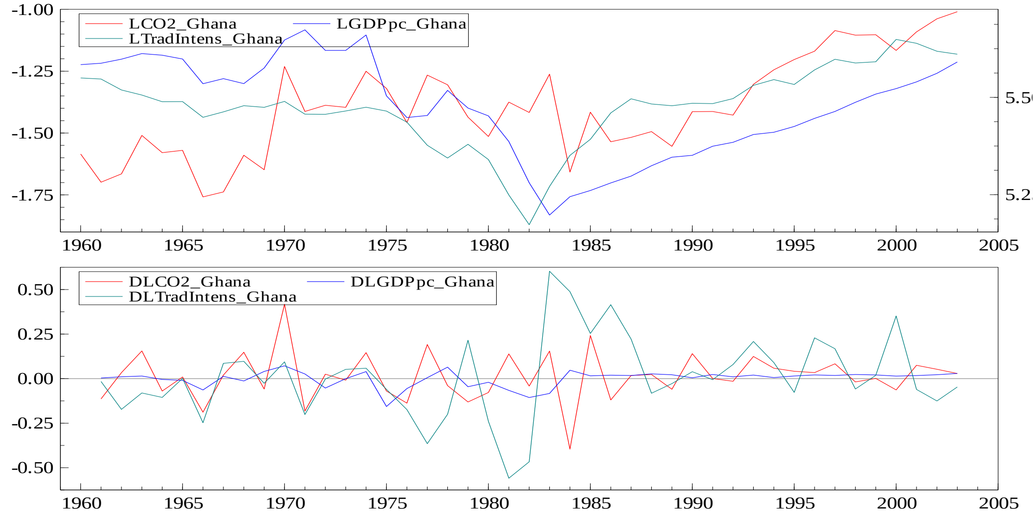
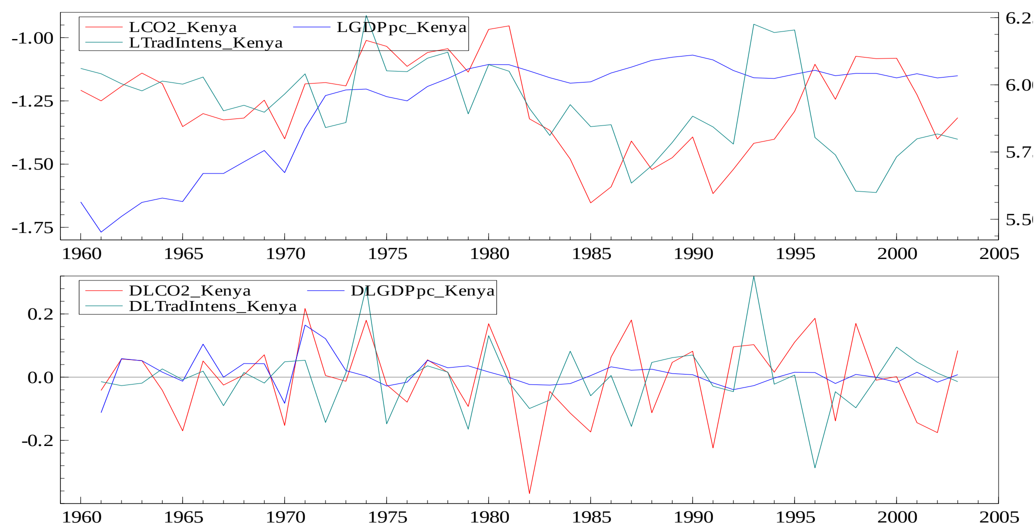
LGDPpc_CoteIvoire
LTradIntens_CoteIvoire
DLCO2_CoteIvoire
DLGDPpc_CoteIvoire
DLTradIntens_CoteIvoire
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005

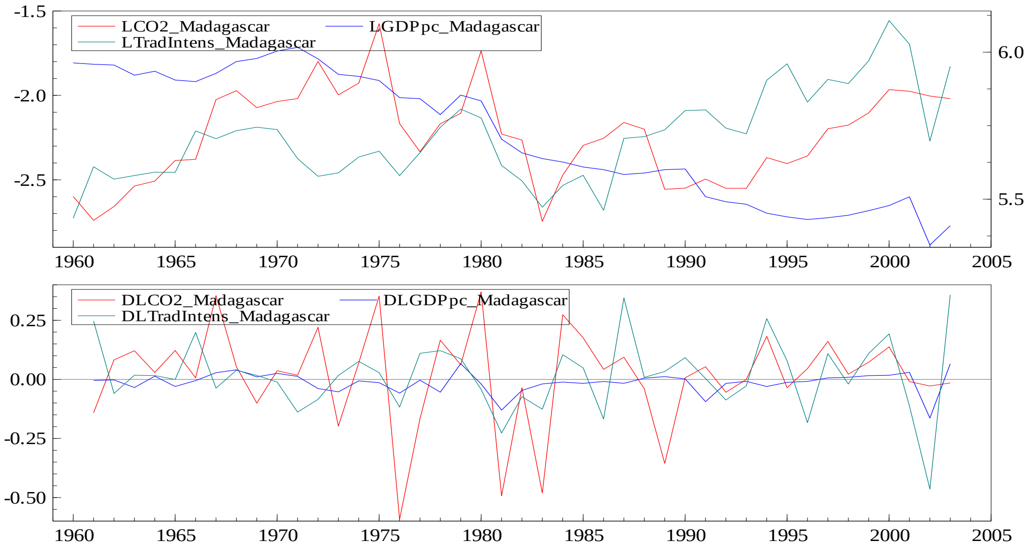

LCO2_Gabon
LGDPpc_Gabon
LTradIntens_Gabon
DLCO2_Gabon
DLGDPpc_Gabon
DLTradIntens_Gabon
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005

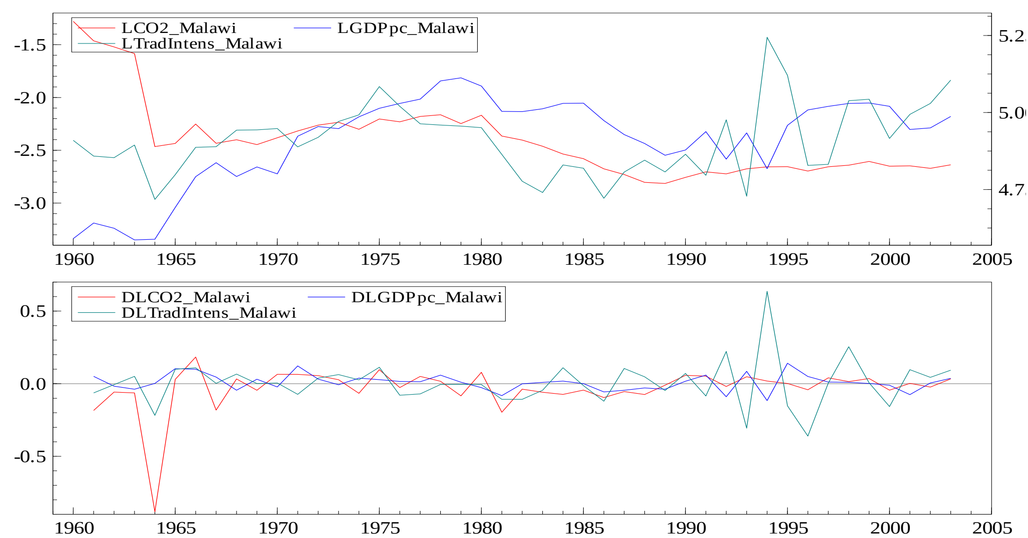


Appendix 1a: Evolution of Pollution, Trade and Growth (Individual Countries)

(Contd.)

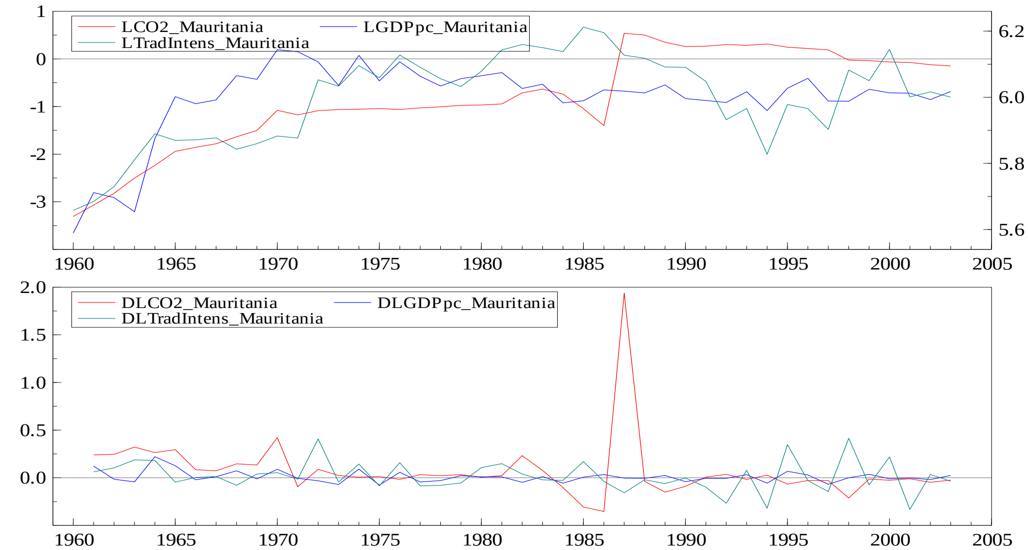






Appendix 1a: Evolution of Pollution, Trade and Growth (Individual Countries)

(Contd.)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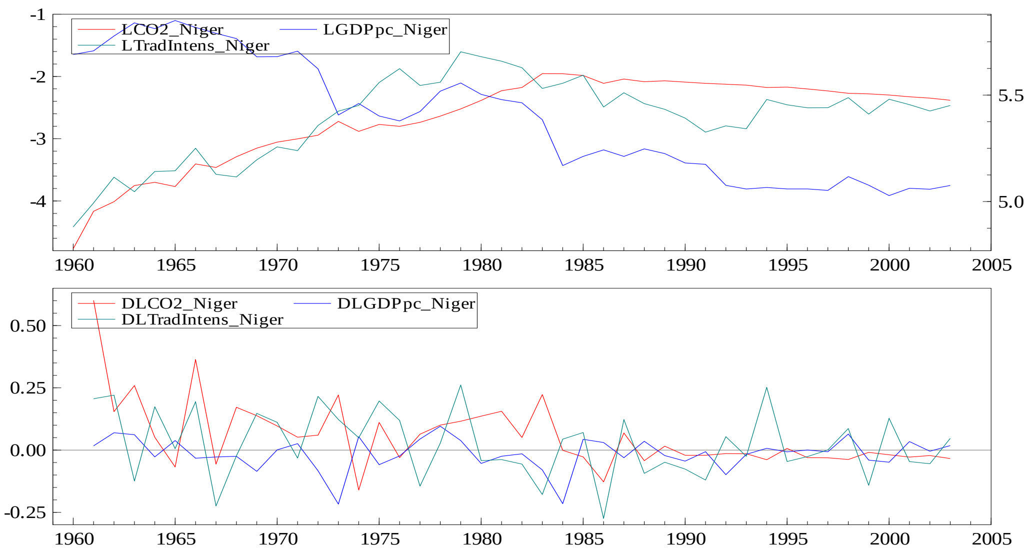
LTradIntens_Mauritania
DLCO2_Mauritania
DLGDPpc_Mauritania
DLTradIntens_Mauritania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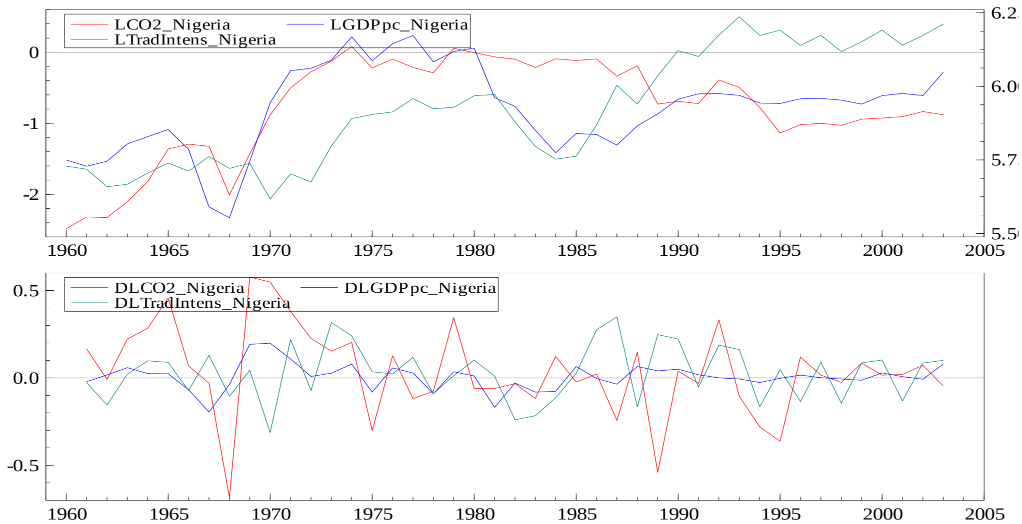
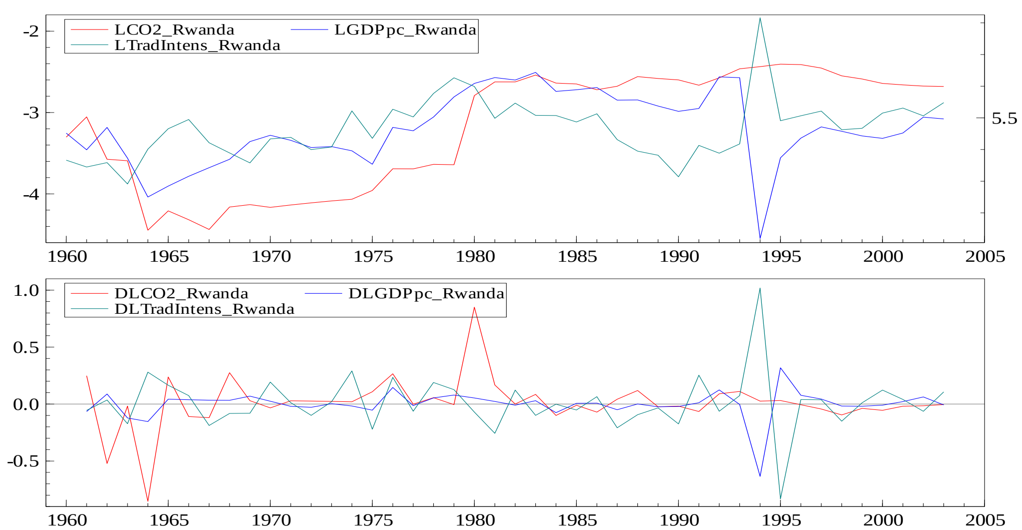
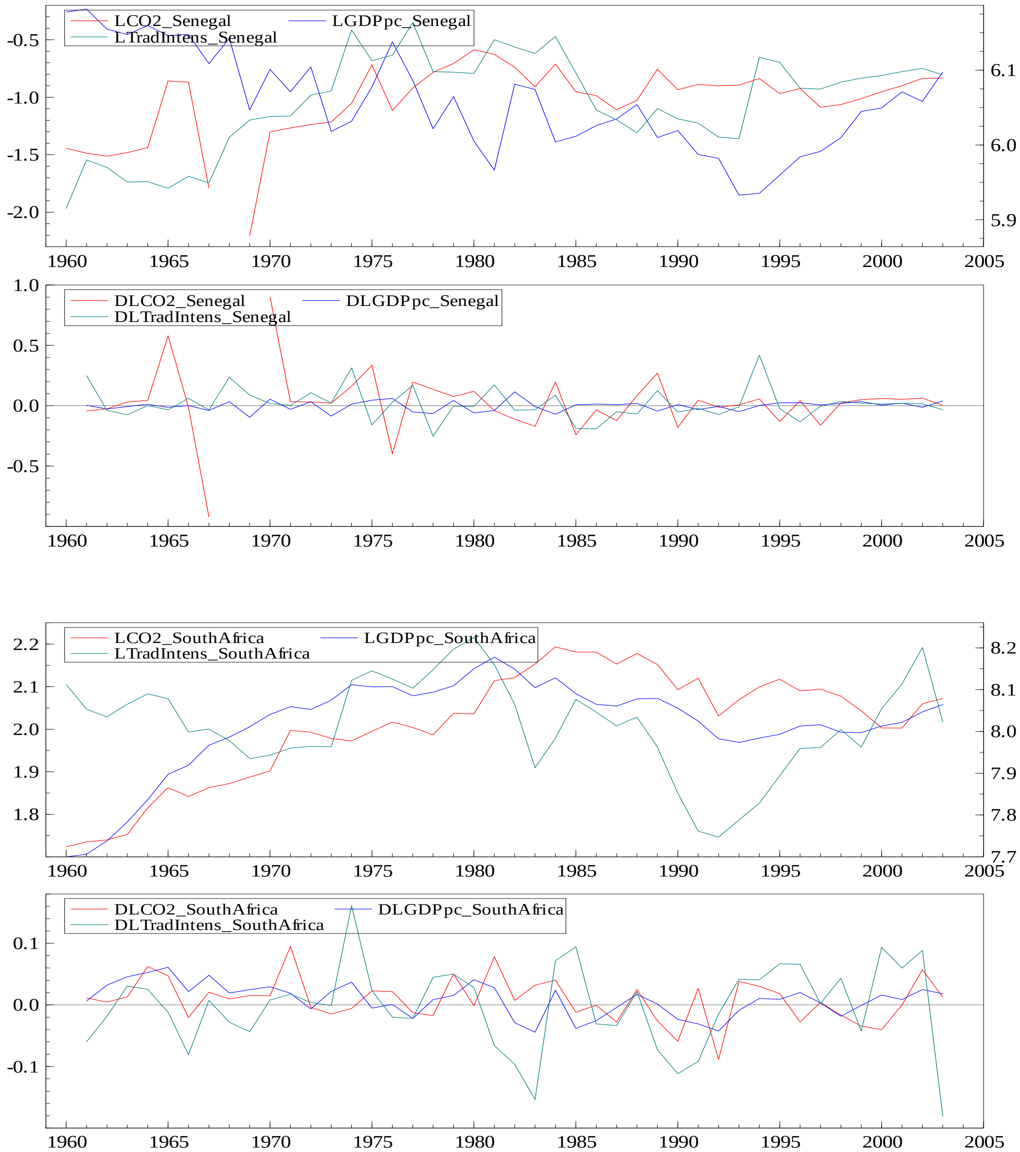
LGDPpc_Niger
LTradIntens_Niger
DLCO2_Niger
DLGDPpc_Niger
DLTradIntens_Niger



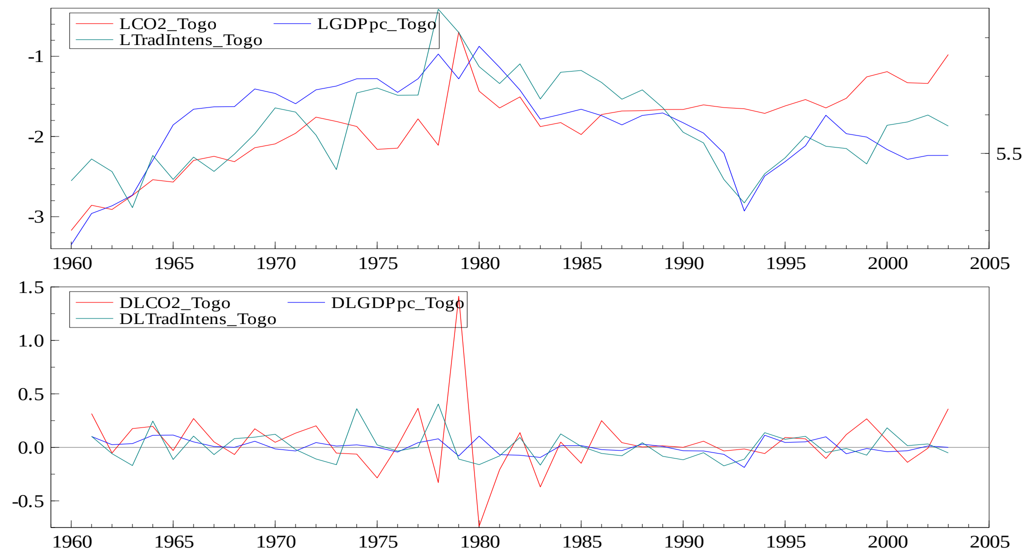
Appendix 1a: Evolution of Pollution, Trade and Growth (Individual Countries) (Contd.)





Appendix 1a: Evolution of Pollution, Trade and Growth (Individual Countries)

(Contd.)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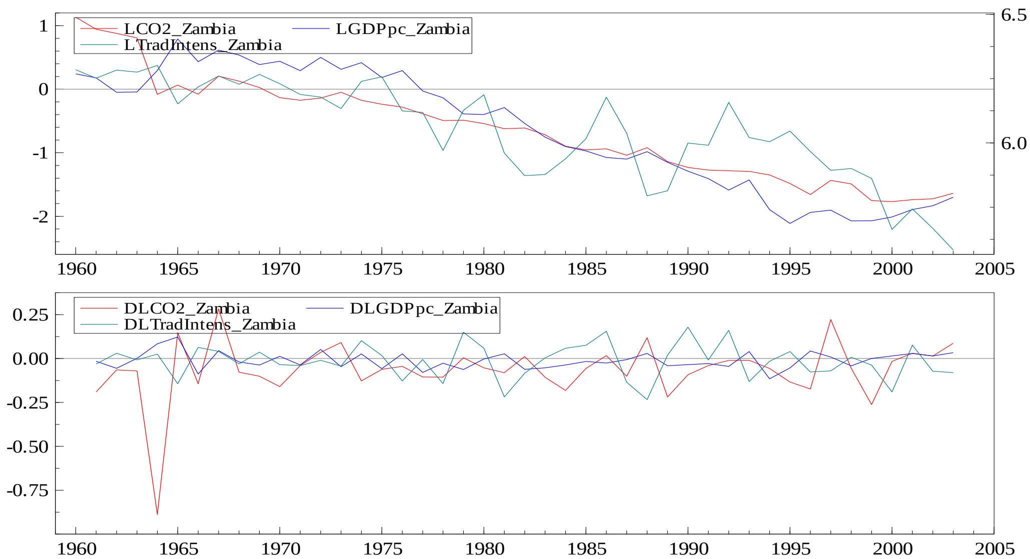
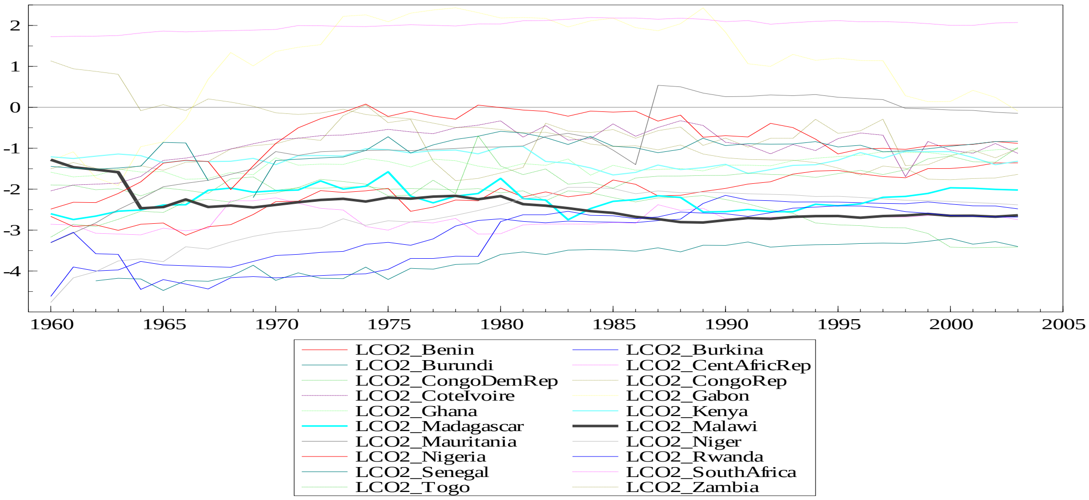
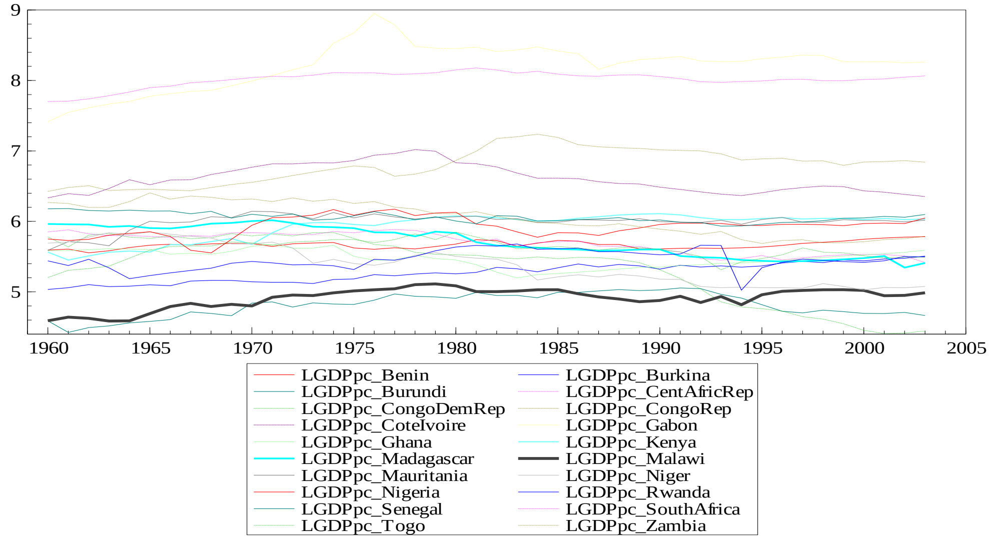
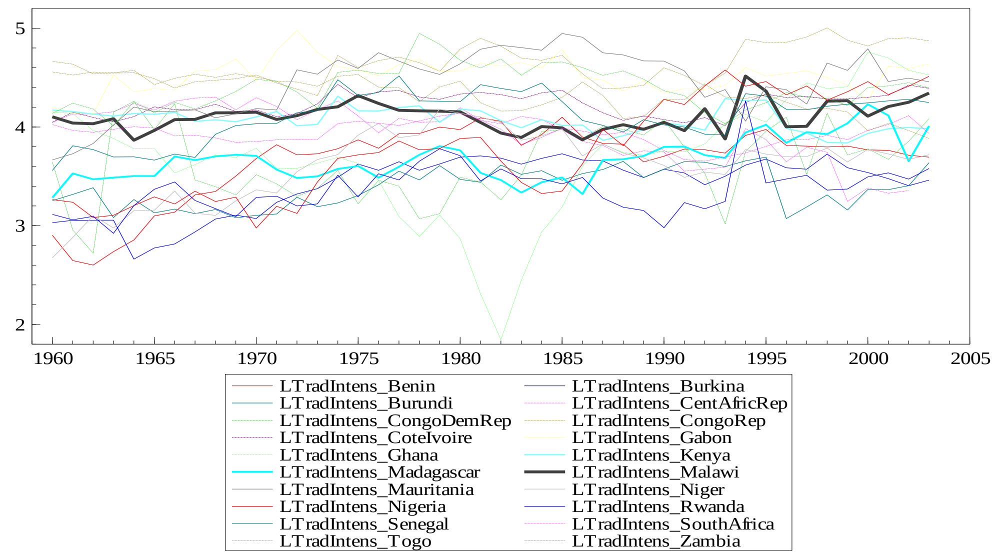
LGDPpc_Togo
LTradIntens_Togo
DLCO2_Togo
DLGDPpc_Togo
DLTradIntens_Togo


LCO2_Zambia
LGDPpc_Zambia
LTradIntens_Zambia
DLCO2_Zambia
DLGDPpc_Zambia
DLTradIntens_Zambia

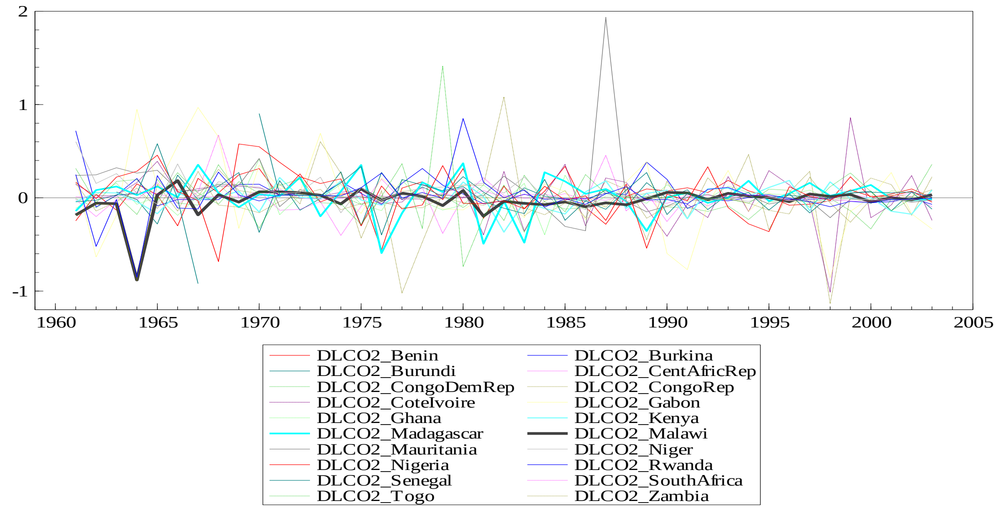
Appendix 1b: Joint Evolution of the Pollution (Log Level)

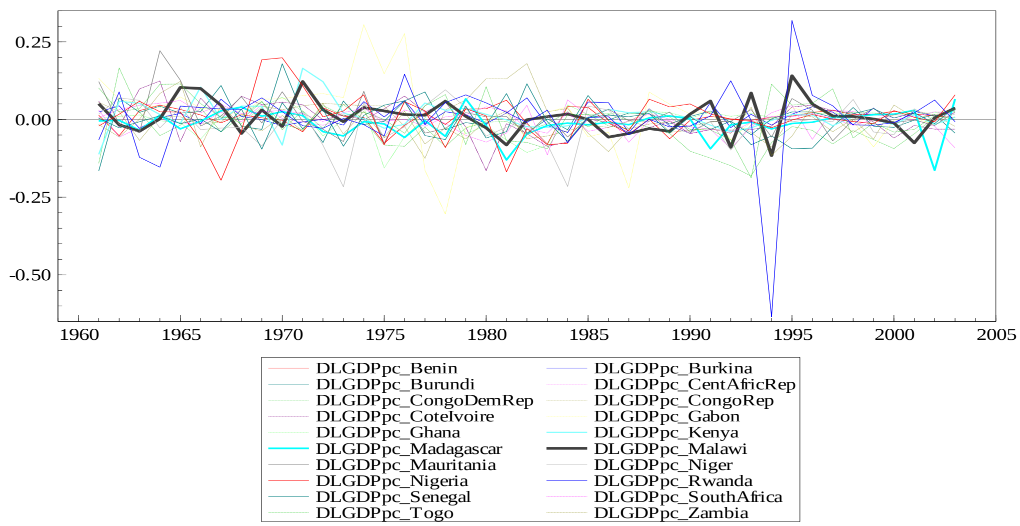


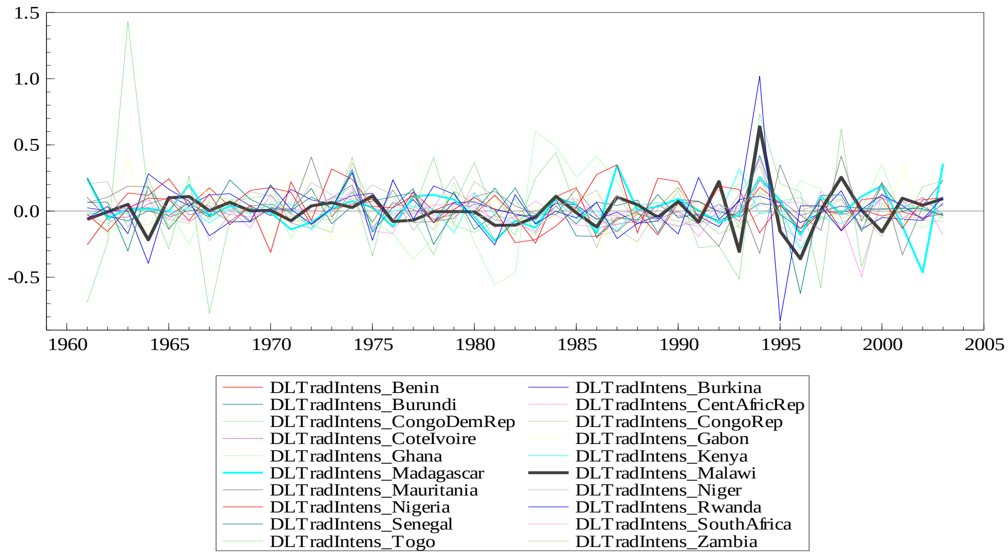



5
4
3
2
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
LTradIntens_Benin
LTradIntens_Burkina
LTradIntens_Burundi
LTradIntens_CentAfricRep
LTradIntens_CongoDemRep
LTradIntens_CongoRep
LTradIntens_CoteIvoire
LTradIntens_Gabon
LTradIntens_Ghana
LTradIntens_Kenya
LTradIntens_Madagascar
LTradIntens_Malawi
LTradIntens_Mauritania
LTradIntens_Niger
LTradIntens_Nigeria
LTradIntens_Rwanda
LTradIntens_Senegal
LTradIntens_SouthAfrica
LTradIntens_Togo
LTradIntens_Zambia

Appendix 1c: Joint Evolution of the Pollution (Growth Rate)

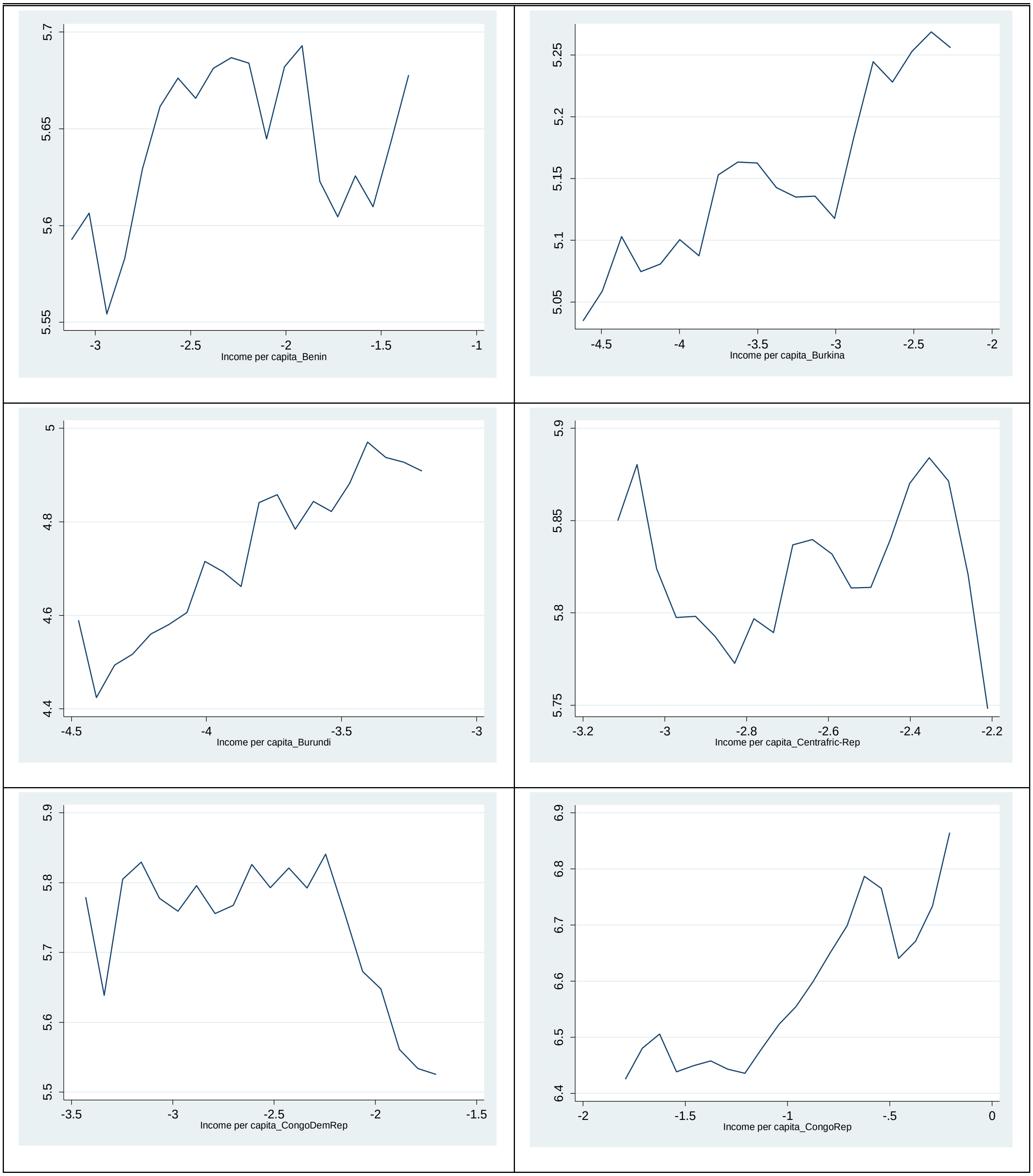






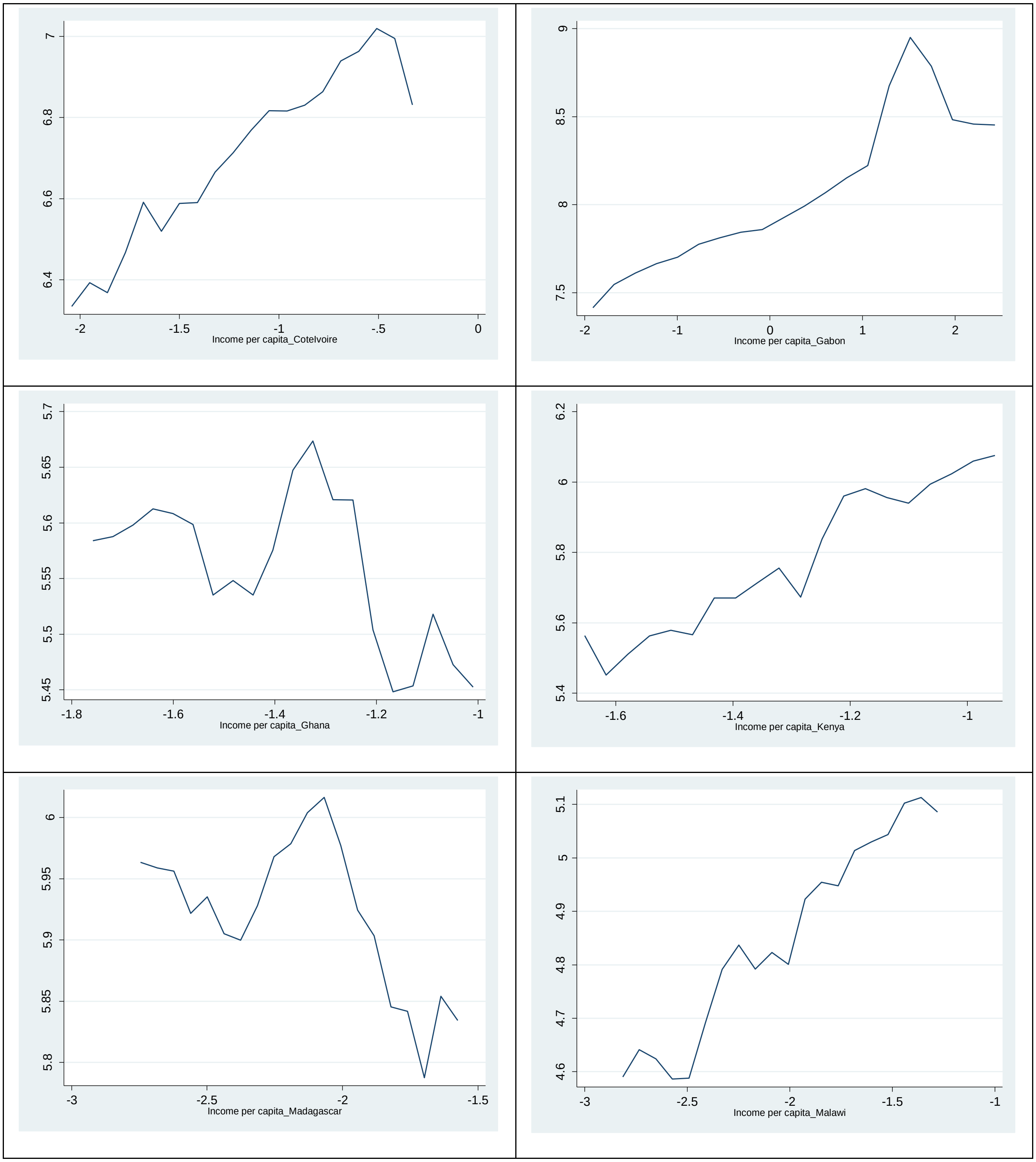
1.5
1.0
0.5
0.0
-0.5
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
DLTradIntens_Benin
DLTradIntens_Burkina
DLTradIntens_Burundi
DLTradIntens_CentAfricRep
DLTradIntens_CongoDemRep
DLTradIntens_CongoRep
DLTradIntens_CoteIvoire
DLTradIntens_Gabon
DLTradIntens_Ghana
DLTradIntens_Kenya
DLTradIntens_Madagascar
DLTradIntens_Malawi
DLTradIntens_Mauritania
DLTradIntens_Niger
DLTradIntens_Nigeria
DLTradIntens_Rwanda
DLTradIntens_Senegal
DLTradIntens_SouthAfrica
DLTradIntens_Togo
DLTradIntens_Zambia

Appendix 2: Environmental Kuznets Curve (Selected Sub-Saharan Africa Countries)

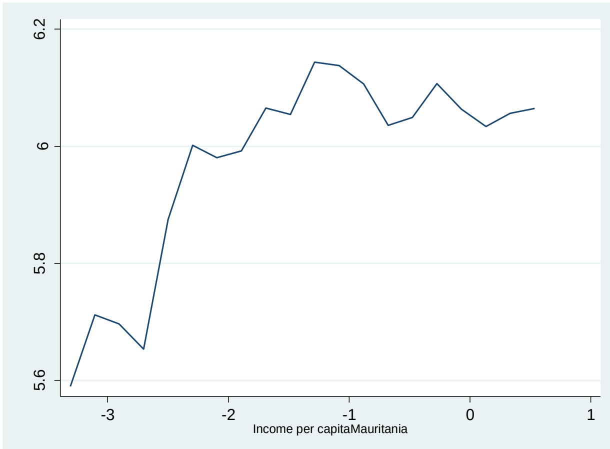


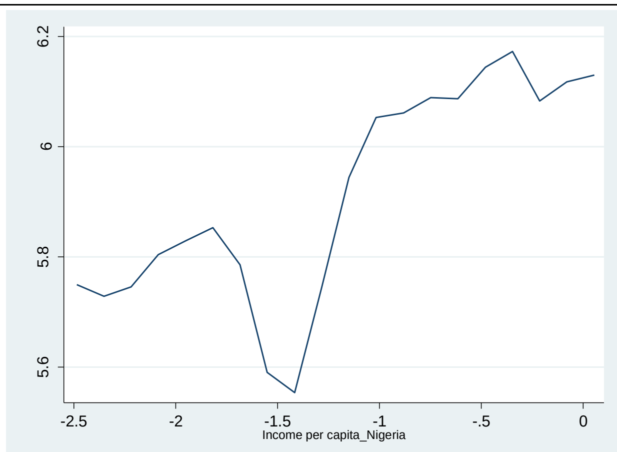
Appendix 2: Environmental Kuznets Curve (Selected Sub-Saharan Africa Countries)

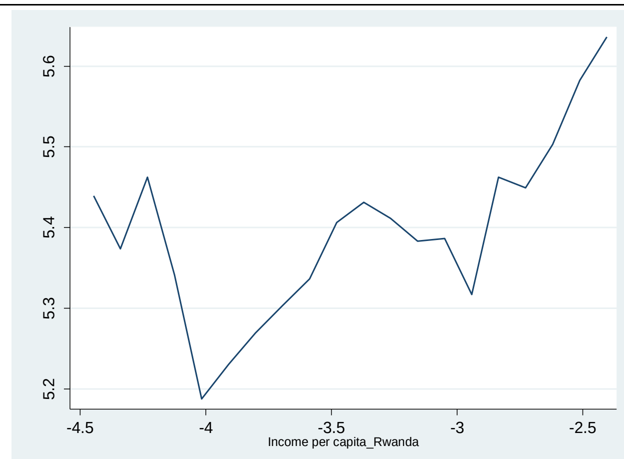
(Contd.)

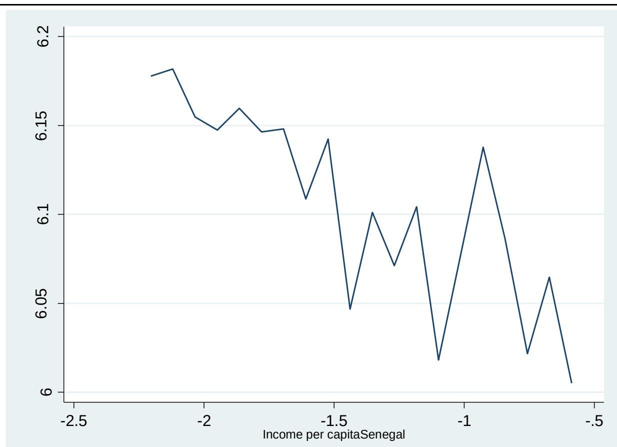


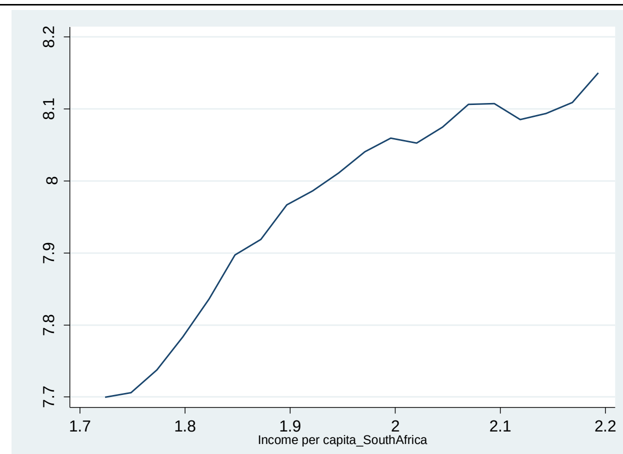
Appendix 2: Environmental Kuznets Curve (Selected Sub-Saharan Africa Countries) (Contd.)











Appendix 2: Environmental Kuznets Curve (Selected Sub-Saharan Africa Countries) (Contd.)