Exploring the economic and demographic determinants of CO_2 emissions in Africa

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1. Introduction

In the absence of a credible global climate policy, the rise in CO2 emissions especially in developing economies due to increasing economic activities remains a threat to human survival. Among the developing world, Africa has experienced an increasing demographic and economic development over the last few decades. The process of economic development in Africa is however associated with a shift from traditional agricultural based economies to agricultural intensification, industrialization and expansion of the service sector. Since production activities, distribution and consumption of goods and services depends heavily on the use of energy, the pursuit for rapid economic growth in Africa therefore has wide-ranging implications on energy use and CO2 emissions. The restructuring of African economies towards increasing industrial activities, value addition and export orientation could also impact on emissions embodied in trade especially when developing economies are considered in the existing literature to be large net exporters of embodied carbon.

On the other hand, changes in demographic trends such as urbanization and population may also affect economic development, energy use and CO2 emissions with consequential effects on sustainable development. Urbanization is a major demographic trend in the world, particularly in Asia and Africa (Montgomery 2008) with potentially major consequences for development and the environment (Hardoy, Mitlin et al. 2013). In the developing world, Africa has experienced the highest urban growth during the last two decades at 3.5% per year and in the short time horizon, it is estimated that some African cities will account for up to 85% of the population (AfDB 2012). As indicated by (Jones 1989) urbanization is a major feature of economic development and involves structural changes throughout the economy with important implications for energy use. Urbanization leads to large scale movements of the labor force into urban areas resulting in the concentration of economic activities in urban areas. This phenomenon drives economics of scale in production, fuel switching with respect to the shift from less energy intensive agricultural production to more energy intensive manufacturing as well as a change from traditional wood burning to fossil fuel energy sources. The increase in the demand for infrastructure, effects on mobility and transport in terms of increase in motorized traffic and the increase in the use of household appliances all increases energy use with significance effects on CO2 emissions.

Even though the nexus between economic/demographic variables and CO2 emissions has been extensively investigated in both developed and developing countries with mixed conclusions, none of the studies so far explicitly look into this issue with a specific reference to Africa. This paper attempts to fills this gap by using panel data techniques that allow cross-section dependence and the estimation of heterogeneous slope coefficients which varies across panels to model the economic and demographic determinants of CO2 emissions in Africa. By means of multi-region-input-output (MRIO) approach, we also calculate the embodied carbon in goods domestically produced and imported across various sectors which help us to determine country specific production and consumption-based emissions and embodied carbon in imports and exports.

2. Methods

Conventional panel estimators such as fixed/random effects, GMM etc. assume cross-sectional independent errors. However, the presence of some form of cross-sectional correlation of errors in panel data applications which is likely to be the rule rather than an exception could lead to misleading inferences and even inconsistent estimators (Andrews 2005; Phillips and Sul 2007; Sarafidis and Robertson 2009; Chudik and Pesaran 2013). As indicated by Andrews (2005), observed or unobserved common shocks such as macroeconomic, technological, political and environmental shocks among others are potential characteristics of cross-section economic data with typically varied impact across different units. Thus we exploit recently developed heterogeneous coefficient estimators such as the mean group (MG) estimator of Pesaran and Smith (1995), Pesaran (2006) Common Correlated Effects Mean Group (CCEMG) estimator, and the Augmented Mean Group (AMG) estimator of Eberhardt and Teal (2010) and Eberhardt and Bond (2009) in this paper. These estimators allow for heterogeneity in the estimation of the slope coefficients without assuming that the impacts of economic and demographic variables on CO_2 emission are homogeneous across countries. Also, due to differences among countries in terms of economic structure, energy sources and environmental constraints, homogenous impact of covariates is rather a strong assumption that is unlikely to hold across a large group of countries.

The data set used includes an unbalanced panel of 41 African countries for which data on all variables are available over the period 1980 to 2009. We group these countries into low, middle and high income countries using the World Bank classification. The estimation is conducted using the full sample of countries as well as the low and middle income groups of countries. Economic variables used in the empirical analysis to predict CO2 emissions (ton) include, real income (per capita GDP, PPP 2005 constant US$), industrialization (industry, value added as a % of GDP) while energy efficiency (GDP in PPP

constant 2005 $ per energy use in kg of oil equivalent) is used to proxy technical progress. The main demographic variables include urbanization (measured as a percentage of the population living in urban areas) and the percentage of population within the age bracket 15-64 (which mainly forms the economically active segment of the population) and those above 64. Other variables included as controls are service (value added as a % of GDP) and net inflows of foreign direct investment i.e. FDI (% of GDP) to capture trade openness and technology spillover effects from foreign countries. All variables are log-transformed and are obtained from the World Bank (2013) Development Indicators online database.

In the MRIO calculations, we follow the approach by Peters (2008) and Böhringer, Carbone et al. (2011) using the GTAP 8 database to calculate emissions embodied in trade (i.e. production, export and import) and the composition (direct, intermediates from domestic and imported sources) of embodied carbon in good in energy intensive sectors.

3. Results and conclusions

The estimated coefficients from the full sample of countries (41) indicates that increasing income levels, urbanization rate and the percentage of population between 15-64 years have a significant and positive impact on CO emissions in all models (i.e. MG, CCEMG and AMG). While the estimated coefficients on technical progress was negative and statistically significant at all conventional significance level in all models, industrialization, increases in services, FDI and percentage of population above 64 years were all found to be insignificant. In the case of the low income countries (21), we find technical progress, income, and urbanization to be the only significant determinants of CO2 emissions with technical progress decreasing CO2 emissions while income and urbanization exert positive impacts. Similar results were found in the case of middle income countries (19) but the results of the CCEMG and AMG show a negative industrialization coefficient although only the coefficient in the CCEMG model was significant at the 10% significance level. An interesting insight from the MRIO calculations is that, most African countries except Egypt, Mozambique, South Africa and Zimbabwe are net importers of embodied carbon contrary to the widely held view and studies that show that developing countries are huge net exporters of emissions. This is relevant especially in an era where trade measures are being discussed to regulate emissions in and from developing countries.

The recent economic growth and the rapid spate of demographic changes in a number of African countries with consequential effects on environment has been a topical issue in recent years. Nevertheless, much less is known about the impact of urbanization, industrialization and economic activities on CO_2 emissions in Africa. This paper provides new insights and shows that income and urbanization increases CO_2 emissions in Africa while industrialization appears to reduce emissions in only middle income African countries. However, economic policies aimed at increasing energy efficiency through economies of scale and technological improvements significantly reduce CO2 emissions in Africa. Thus, energy efficiency which is often advocated as a way to partially mitigate concerns regarding climate change, energy security and oil price hikes could also be used to significantly mitigate CO2 emissions. The understanding of the economic-demographic-CO2 nexus is particularly relevant for the design of effective urbanization policy interventions since economic policies that fail to capture demographic dynamics will most likely make sustainable development policies more difficult to be realized.

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