[*AN ANALYSIS OF DRIVING FACTORS OF CO_2 EMISSIONS BY FINAL ENERGY CONSUMPTION IN AFRICA*]

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Overview

A low-carbon economy is key to mitigating climate change. To reduce greenhouse gas emissions from anthropogenic activity, many governments of developed countries have implemented national carbon-neutral strategies. However, it is not always affordable for most developing countries to invest in low-carbon technologies or carbon alternatives. Considering that 40% of African households still live below the poverty line and generally lack access to electricity and clean cooking energy, for example, it would be utterly unreasonable to ask them to take on the financial costs of addressing climate change. For this reason, African countries are often left out of conversations about managing high CO_2 emissions.

Nevertheless, Africa now boasts some of the world's fastest-growing economies, and with increases in GDP and population across the continent, energy consumption is also on the rise, which results in greater CO_2 emissions. As the climate crisis grows in severity, it is vital that African countries find sustainable ways to support their growing demand for energy while on its path of rapid development. African countries should not simply follow the same path that developed countries went on in terms of energy usage. In order to avoid repeating past errors, now, it is necessary that African countries understand what factors are currently driving total CO_2 emissions so that they can implement the necessary policies to attain net-zero emissions by 2050.

In this context, it is important to not only investigate how different sectors of final energy consumption impact total CO_2 emissions, as well as the extent to which various energy sources individually contribute in order to develop the proper energy policies by understanding the current driving factors of CO_2 emissions. In particular, understanding the relationship between total final energy consumption, including biofuels and waste, and total CO_2 emissions will be crucial to improving Africa's energy ecosystem since traditional biomass remains the leading source of energy consumption on the continent. However, there are few studies have tackled this issue.

To identify the main drivers of total CO_2 emissions in Africa, we analyzed country-level panel data on total CO_2 emissions and sectoral total final energy consumption by energy source for 38 African countries from 1990 to 2019 using IEA data. Of the 54 African countries, we performed our study using available data from 38 that account for 95% of total CO_2 emissions, 94% of total final energy consumption, and 98% of GDP on the African continent as of 2019.

The main research questions explored in this paper are as follows:

(1) What are the current driving factors in total CO2 emissions by total final energy consumption by energy source and sector in Africa?
(2) For each energy source (i.e. biofuels and waste, fossil fuels, and electricity), which sectors are contributing the most to total CO2 emissions?

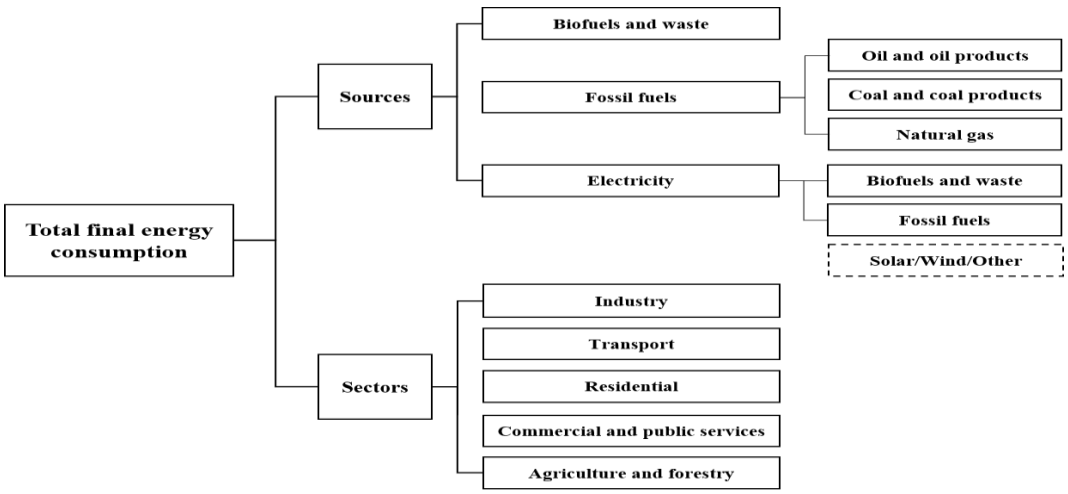

Figure 1. Total final energy consumption by energy sources and sectors.

Methods

This paper examines the main driving factors of the change in total CO_2 emissions by total final energy consumption (TFEC) using a two-way fixed effects panel regression model.

$$lnCO2_{it} = \beta_0 + \sum^s \beta_k lnC_{it}^{es} + \gamma lnX_{it} + \mu_i + v_t + \varepsilon_{it} \quad (1)$$

In Model (1), the dependent variable is total CO_2 emissions; the subscript i denotes a $country$; and the subscript t denotes a $year$. The notation ln represents a natural log transformation. As the independent variables, C_{it} denotes TFEC for $country\ i$ in $year\ t$; and the superscript e denotes energy source (i.e. biofuels and waste, fossil fuels, or electricity); the superscript s denotes sectoral TFEC (i.e. industry, transport, residential, commercial and public services, and agriculture and forestry). We have three main models – one for each energy source – and each model includes five independent variables by sectors. X_{it} denotes control variables for $country\ i$ in $year\ t$; μ_i denotes a country fixed effect; v_t denotes a year fixed effect; and ε_{it} denotes the error term clustered at the country level. The time-varying country-level control variables are GDP per capita, population, and net ODA. We applied a natural log transformation in all variables to solve the heteroskedasticity problem.

Additionally, we use interaction terms to measure periodic, economic, and regional impacts on the study.

$$lnCO2_{it} = \beta_0 + \sum^s \beta_k lnC_{it}^{es} + \sum^s \alpha_k lnC_{it}^{es} \cdot After_t + \gamma lnX_{it} + \mu_i + v_t + \varepsilon_{it} \quad (2)$$

$$lnCO2_{it} = \beta_0 + \sum^s \beta_k lnC_{it}^{es} + \sum^s \alpha_k lnC_{it}^{es} \cdot GDP_i + \gamma lnX_{it} + \mu_i + v_t + \varepsilon_{it} \quad (3)$$

$$lnCO2_{it} = \beta_0 + \sum^s \beta_k lnC_{it}^{es} + \sum^s \alpha_k lnC_{it}^{es} \cdot SSA_i + \gamma lnX_{it} + \mu_i + v_t + \varepsilon_{it} \quad (4)$$

In Model (2), $After_t$ is 1 if $year_t$ is later than 2004 (i.e. the latter half of the 30-year range); otherwise it is 0.

In Model (3), GDP_i is 1 if $country_i$ is one of the top 19 countries by GDP; otherwise it is 0.

In Model (4), SSA_i is 1 if $country_i$ is located south of the Sahara Desert; otherwise it is 0.

Results

Our results indicate that out of total biofuels and waste energy consumption, the residential sector is the major driver of total CO_2 emissions. Next, in terms of fossil fuel consumption, the transport and industrial sectors are the main drivers of total CO_2 emissions. For electricity consumption, the commercial and public service sector is the primary driver of total CO_2 emissions. Though biofuels and waste remain the largest energy source, the relative use of fossil fuels increased over the period studied.

It is also worth noting that the residential sector's contribution to total CO_2 emissions in biofuels and waste consumption decreased from 2005 to 2019 compared to its contribution from 1990 to 2004, while its relative contribution to fossil fuel consumption increased over the same period. Also, the impact of the residential sector on total CO_2 emissions within biofuels and waste consumption is relatively large among the bottom 19 countries out of 38 with the lowest GDPs as well as among the Sub-Saharan African countries in comparison to North Africa.

This indicates that low-income countries still use unsustainable and dangerous energy sources in the household. In fossil fuel and electricity consumption, SSA countries have a relatively higher impact in the industrial sector on total CO_2 emissions compared to North Africa.

Conclusions

Our results highlight that in order for African countries to develop low-carbon economies for coping with climate change, these countries should shift from traditional biomass energy to clean and modern alternative biomass energy and renewable energy rather than fossil fuels. In addition, these countries have to invest in renewable energy and energy-efficient technology to avoid becoming major CO_2 emitters. Lastly, our findings suggest that fossil fuel consumption and investment need to be reduced significantly to meet international targets for addressing climate change.

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