Energy 119 (2017) 453–471

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Biomass energy consumption, economic growth and carbon emissions: Fresh evidence from West Africa using a simultaneous equation model

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ARTICLE INFO

Article history:
Received 8 March 2016
Received in revised form
7 September 2016
Accepted 15 December 2016

Keywords:
Biomass consumption
Economic growth
Carbon emissions
West Africa
Simultaneous equation model

ABSTRACT

This study investigated the relationship among biomass energy consumption, economic growth and carbon emissions in West Africa during 1980–2010. This nexus was explored by integrating the pollution production function and energy demand function with an augmented endogenous growth model. Moreover, this paper employed a simultaneous equation model estimated with three stage least squares (3SLS). Analysis was conducted for individual West African countries and panel of the countries.

The overall results show that a complete significant interactive relationship (feedback effects) exists among GDP, biomass consumption and carbon emission in five West Africa countries (Nigeria, Burkina Faso, The Gambia, Mali and Togo). There are partial significant links among the variables in the remaining West African countries. A complete significant nexus among the variables was also discovered for panel of the countries. Based on the results, some policy implications were drawn for West African countries. There is need to reduce the prevailing high energy intensity of output in West Africa through the adoption of energy-efficient technologies. It is also imperative to find clean energy alternatives (or complementary) to biomass use so as to reduce the resulting high carbon emissions which may hinder the attainment of high and sustainable growth in the nearest future.

1. Introduction

1.1. Research issues and motivation of the study

The world economies rely so much on various energy sources, especially petroleum products and biomass as a catalyst for economic growth (Apergis and Payne [1]). Correspondingly, the associated emissions and climate change have generated huge environmental concerns among policymakers and other stakeholders in the energy sector. Hence, the quest for clean energy and energy-efficient appliances has continued to be a priority for stakeholders in sustainable development. This has necessitated conduct of researches to analyse output-energy-emission links and development of optimisation framework for reducing cost and emission level (Ali [2] and Abdelaziz et al. [3]).

Capital, labour and energy are critical requirement in facilitating growth. These inputs should be combined in the production process in a way that is friendly to the environment to produce sustainable growth. Energy consumption, as much as it contributes to growth, can generate carbon emissions that are hazardous to the environment and human existence. In the same vein, economic growth can facilitate investment in cleaner environment, as much as it requires increased energy use, while clean environment is healthy for higher productivity, just has poor environment can retard growth.

In recent years, the increased carbon emissions arising from intensified energy consumption to facilitate rapid growth of economic activities has been a major policy issue in Sub-Saharan Africa, particularly West Africa. The process of producing national output among West African economies appears to be associated with very high carbon emissions. For instance, average income per capita increased marginally from about $580 in 1980 to about $584 in 2010 among 11 West African countries, representing an increase of 0.70%. However, average carbon emission in this sub-region rose from about 7608 metric tons to about 10,217 metric tons,

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http://dx.doi.org/10.1016/j.energy.2016.12.059
0360-5442/

List of abbreviations

IEA	International Energy Agency
EKC	Environmental Kuznets Curve
OECD	Organization for Economic Co-operation and Development
GDP	Gross Domestic Product
MENA	Middle East and North Africa
SAARC	South Asian Association for Regional Cooperation (Bangladesh, India, Nepal, Pakistan and Sri Lanka)
BRICS	Brazil, Russia, India, China, South Africa
ECOWAS	Economic Community of West African States
CO2	Carbon emission
GHG	Greenhouse Gas
FMOLS	Fully Modified Ordinary Least Square
VECM	Vector Error Correction Model
3SLS/2SLS	Three Stage Least Square/Two Stage Least Square
Sys-GMM	System Generalised Moment Method
ARDL	Autoregressive Distributed Lag
ADF	Augmented Dickey-Fuller
PP	Phillip Perron
OLS	Ordinary Least Square
ECM	Error Correction Model
USA	United States of America
VAR	Vector Autoregressive
PMG	Pooled Mean Group
CCEPMG	Common Correlated Effect Mean Group
SSA	Sub-Saharan Africa

representing an increase of about 34.29% over the same period. Nevertheless, consumption of renewable energy is projected to grow rapidly in the World economies including those in West Africa (US Energy Information Administration-USEIA [4]). Specifically, average biomass energy consumption among West African economies rose by about 128% over the period 1980–2010 (Global Material Flow [5]). Against the above background, the links among energy (biomass) use, carbon emissions, and economic growth in West Africa needs to be examined to inform policies for sustainable growth and development.

The contributions of this paper to the existing body of knowledge in the area of renewable energy (biomass) and sustainable growth are articulated in the following. First, the review of literature in this study shows the dearth of studies in this area especially those covering the entire issue (biomass-output-pollution nexus) addressed in this paper. Majority of the previous studies examined the links between renewable energy and output, while only very few of them (Menyah & Wolde-Rufael [6]; Apergis & Payne [1]; and Sebri and Ben-Salha [7]) extended analysis to cover their effects on CO2 emissions. The need for a complete analysis is based on the idea that there could be positive links between biomass energy and output, but such links may have adverse effect on the environment, which may necessitate introduction of either energy conservation policy or promotion of other renewable energy (clean energy) use. Further, only eight (8) of the total studies reviewed (about 50) focused specifically on biomass as a renewable energy for growth. Besides, while seven (7) of these studies focused on the link between biomass consumption and economic growth (Ozturk and Bilgili [8]; Bildirici [9]; Bildirici [10]; Bildirici and Ozaksoy [11]; Payne, [12]; Yildirim et al. [13] and Ohler and Fetters [14]), the remaining one (1) is on the relationship between biomass consumption and carbon emissions (Bilgili [15]). Thus, none of the existing studies on biomass consumption covers economic growth and carbon emissions in a single combined framework like this present paper.

Second, despite heavy reliance on biomass for energy use in West Africa compared to other African sub-regions and developing economies in general (IEA [16]), no study exists specifically for the sub-region.[1] It should be stressed that only one very recent study on biomass consumption and economic growth (Ozturk and Bilgili [8]) focused on Sub-Saharan Africa (SSA) countries, where the authors also stressed the lack of study on SSA. However, the study does not cover carbon emission effect of the link between biomass use and economic growth, which is a major part of this study so as to broaden policy lessons that could be drawn for sustainable development.

Third, this study also addressed the need for better understanding of the links among energy (biomass) consumption, economic growth and carbon emission by developing an analytical framework that integrate the endogenous growth model with both energy demand function and pollution production function that is consistent with the energy demand theory and Environmental Kuznets Curve –EKC hypothesis (Grossman and Krueger [17]) and Kaya identity (OECD-EIA [18]). Thus, explicit and policy oriented economic research should derive from solid economic theory (Beaudreau [19]).

Fourth, this study deviates from the single equation and multivariate granger causality approaches adopted in the previous studies by using simultaneous equation techniques that are suitable to handle the integrated analytical framework discussed above. Besides, simultaneous equation techniques are capable of solving some technical and econometric issues (such as endogeneity problem and residual contemporaneous correlation issue) associated with the use of single equation and various multivariate granger causality methods in estimating the link between carbon emission and output as well as energy augmented EKC equation (Itkonen [20]).

1.2. Stylized facts about Co2 emissions, biomass consumption and GDP per capita in West Africa

In most developing economies such as those of West Africa, small scale businesses and informal sectors constitute a greater amount of economic activities, many of which depend so much on primary sources of energy, especially from biomass (wood and waste) which are combustibles. Thus, the use of biomass for various purposes is predominant in the West African sub-region.

As revealed in Table 1, the high dependence on biomass use is evident among West African countries. For instance, 98% of the population in Mali and Sierra Leone relied on traditional use of biomass for cooking in 2012. In summary, seven out of the eleven selected West African countries have over 90% of their population relying on traditional biomass in the same year, while between 78% and 85% of the population in two of the remaining selected countries (Ghana and Cote d'Ivoire) appear to rely on traditional biomass, and over 50% of the population in the rest of the countries (Nigeria and Senegal) consume the energy product. A comparative

[1] In 2009, the relative importance of various energy sources in Sub-Sahara Africa can be seen as follows solid biofuels (61%), other renewables (0.2%), coal and peat (19.7%), oil (14.1%), natural gas (2.7%), nuclear (0.6%) and hydro (1.4%)-Ozturk & Bilgili (2015).