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Abstract

There have been increased attention on how man's activities affect the environment negatively especially in developed countries. However, there are countless number of activities such as charcoal production and electricity generation from oil in developing countries that have potential carbon related social cost. In this study, the Arrellano Bond dynamic panel generalised method of moments is applied to estimate the relationship between social cost of carbon emissions and electricity generation from oil sources, GDP, charcoal consumption, energy resource depletion and population in oil producing African countries. The findings suggest the predictors have either positive or negative effect on the social cost of carbon emissions. The study recommends in order combat global warming, there should be efficient and modernised charcoal production and electricity production from non-fossil sources.

Key words: charcoal production, electricity generation from oil sources, economic growth, energy resource depletion, energy, carbon emissions, Africa

1. Introduction

Food is a very important source of energy to the body and barbeque tastes great. However, several input to food preparation, such as charcoal, which is mostly used in rural areas and for barbeque have negative effect on the environment. According to Johnson (2009), in the base case, the charcoal grilling footprint of 998 kg CO_2e is almost three times as large as that for LPG grilling, 349 kg CO_2e. In Africa, about 70% of the final energy consumed comes from biomass. According to Byer (1987), the commonest form of biomass in Africa is firewood and charcoal. On the positive side, charcoal production is a major source of income in rural areas (Kammen and Lew, 2005). This implies that the production, packaging and transportation form important economic cycle in developing countries that sustain the livelihood of many households. In addition, with the unavailability of liquefied natural gas and perennial shortage in most developing countries, charcoal has become the prime fuel for cooking. Again, unlike other forms of biomass such as fuel, residue and dung, charcoal can be stored without the fear for insects (Kammen and Lew, 2005).

Despite these advantages, Kammen and Lew (2005) suggest that production and charcoal consumption can have dire consequences on the environment than other alternatives such as fuelwood and biomass residues. This is because, charcoal is a by-product of fuelwood obtained through the process of carbonization and a large portion of the wood is lost during the production phase, charcoal consumers use more wood than the average fuelwood user. This consequences arises from inefficiencies associated with the production, transportation and transportation. Okello et al (2002) stress that charcoal production efficiency is about 10 to 25%. Despite this negative environmental impact, the consumption of charcoal seems to be increasing. This great the intertwined problem of net carbon emission, deforestation, and erosion. For instance, Mwampamba (2007) finds that charcoal consumption is a real threat to the long term survival forests in Tanzania.

The OECD/IEA (2005) estimates that about 1.3 million people die every year because of exposure to indoor air pollution from biomass. Also, valuable time and effort is devoted to fuel collection instead of education or income generation. This also causes environmental damage in form of land degradation. In addition, unsustainable charcoal production leads to deforestation. Using the social cost of carbon emissions calculation o Nordhaus (2010), this study seeks to ascertain the social impact of charcoal production, the quantity of oil use in power generation, energy resource depletion and GDP per capita in oil producing African countries.

Charcoal is a source of energy derived by heating fuel wood materials like logs and twigs in a kiln or similar structure with limited access to air and is common among the rural dwellers. It is a traditional source of energy, which has remained the major source of fuel for over half of the world's population (FAO, 2001). Even though Africa produces about 10% of global energy, it uses only 3% (AfDB, 2010). In addition, Africa is home to modern sources of renewable energy such as solar, hydro and wind. Despite this potential energy wealth, the quality and quantity of energy supply in most of SSA is very poor. About 80% of the population relies on traditional biomass fuel for cooking, the largest share in the world (OECD/IEA 2010). The production and consumption however comes with it, health and environmental consequences. For instance, Pennise et al (2001), in charcoal production, 51% of the wood is converted to charcoal, 27% to CO_2 and 13% as products of incomplete combustion or by-products. Andreae (1991) estimates that biomass burning including charcoal production accounts for 2 -45% of global emissions.

Whilst previous attempts have been made to study the environmental consequences of charcoal production or consumption, this study attempts to quantify the social cost of charcoal production.

The novelty of this study is in three folds. First, the predictors of charcoal consumption is studied. This will help to ascertain the effect of electricity consumption, price, income, rural population growth, urban population growth and final household expenditure on charcoal consumption. Since poverty is considered the most significant parameter that drives extensive traditional use of fuel wood and residues (UNDP, 2002), it is important to ascertain the social cost of GDP per capita in oil producing African countries. Further, the effect of using oil for electricity generation on the environment is also ascertained. Finally, the impact of other variables such as GDP, urbanization and energy use on carbon emissions is also studied. The importance of this study is to derive elasticities that can help policy makers design to combat energy-related emissions and help to craft appropriate policies on afforestation and emissions reduction in Africa.

2. Method

According to Nordhaus (2010), the social cost of carbon emissions is $8 per ton. Using this figure, the total emissions of each country is multiplied by $8 to get the total social cost in US dollars. The predictors of the study include quantity of charcoal production in tonnes, GDP per capita, quantity of oil used in power generation, energy resource depletion and population. GDP per capita is measured in US dollars. The study spans from 1971 to 2012. All data are obtained from the International Energy Agency.

TABLES

TABLE 1.0

SUMMARY STATISTICS

Variables	Obs	Mean	Median	Max	Min	Std	Skew
SC	388	1.225693	1.149693	3.307616	-0.494850	0.909002	0.294804
Y	388	10.15941	10.08870	11.45663	8.508029	0.553675	-0.097730
CP	388	5.238547	5.437719	6.585473	2.723456	0.931103	-1.013259
P	388	7.177801	7.256312	8.191398	5.778652	0.590381	-0.707883
D	388	8.953625	8.984987	10.67490	4.919219	0.882487	-0.979188
0	388	8.481919	8.688405	10.47051	6.000000	0.953216	-0.352271

Notes: This table summarizes descriptive statistics (sample mean, median, maximum, minimum, standard deviation, skewness) of the social cost of carbon emissions (SC), GDP (Y), electricity production from oil sources (O), charcoal production (CP), energy resources depletion (D) and population (P). The sample period runs from 1971 to 2012 for 12 countries (Algeria, Angola, Cameroon, Congo, Democratic Republic of Congo, Côte d'Ivoire, Egypt, Gabon, Ghana, Nigeria, South Africa, Sudan and Tunisia). All variables are in logs. The countries under consideration are Algeria, Angola, Cameroon, Congo, Cote D'ivoire, Democratic Republic of Congo, Egypt, Gabon, Ghana, Nigeria, South Africa and Tunisia. These countries were selected based on data availability (data on Equatorial Guinea, Libya, Sudan were not complete).

The purpose of the study is to examine the social cost of charcoal production, urbanization, and oil dependent electricity production and energy resource depletion in oil producing African countries. Following the work of Omri et al (2014), the Arrellano Bond dynamic GMM is applied. The advantage is of the dynamic panel GMM is that the inclusion of instrumental variables overcome the problem of endogeneity (Omri et al, 2014).

$$SC_{\iota,t} = f(Y_{\iota,t}, CP_{\iota,t}, D_{\iota,t}, P_{\iota,t}, O_{\iota,t}) \qquad 1$$

Where $SC_{\iota,t}$ represents social cost, $Y_{\iota,t}$ is income per capita, $CP_{\iota,t}$ is charcoal production, $D_{\iota,t}$ is energy resource depletion, $P_{\iota,t}$ is population and $O_{\iota,t}$ is electricity generation from crude oil sources. Whilst increased in income has been found to be a sign of economic development, Bhattacharyya and Ghoshal (2010) find higher rate of carbon emissions to be associated with higher economic growth and increased population. This is because, both economic growth and population growth thrives on the consumption of energy, which has been found to be a major cause of carbon emissions (Zhang and Cheng, 2009). Further, Pennise et al (2001) find that charcoal production is an important source of carbon emissions. We also believe that energy resource depletion, may lead to a shift in energy consumption and will therefore have a relationship with carbon emissions.

Equation 1 can be expressed as a linear function between social cost and the predictors.

$$SC_{\iota,t} = \beta_o + \delta Y_{\iota,t} + \alpha CP_{\iota,t} + \phi D_{\iota,t} + \varphi P_{\iota,t} + \rho O_{\iota,t} + \mu_{\iota,t} \qquad 2$$

In order to estimate the social cost of income per capita, charcoal production, energy resource depletion, electricity production from oil sources and population, the Arrellano Bond dynamic panel model is employed. Instrumental variables are used to check the problem of endogeneity among the predictors (Fang, 2011). The first lag of the each predictor is used as an instrumental variable. In the case of the lag dependent variable, the second lag is used.

4. Results

We begin our analysis by conducting the I'm, Pesaran and Shin (2003). The essence of the unit root is to ascertain where the variables are stationary. After checking the form of the empirical

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
C	**0.020**	**-16.165**	**-4.648**	**-3.491**	**-1.081**	**-5.663**	**0.799**
	(0.008)	(1.212)	(1.463)	(1.416)	(1.031)	(1.801)	(0.209)
SC(-1)	**1.001**						**0.956**
	(0.004)						(0.012)
Y		**1.709**					**0.090**
		(0.121)					(0.021)
D			**0.652**				0.004
			(0.162)				(0.008)
0				**0.556**			0.004
				(0.156)			(0.005)
CP					**0.442**		0.009
					(0.0.198)		(0.007)
P						**0.961**	**-0.022**
						(0.261)	(0.012)
DW	1.967	0.13	0.04	0.05	0.04	0.03	2.07
R^2	0.99	0.84	0.28	0.38	0.23	0.42	0.99

function, two models are estimated. These are one-way random effect model, Arrellano Bond (1991) dynamic panel general method of moments with all the predictors and the GMM that seeks to estimate the effect of individual predictors (including the lagged dependent variable) on the dependent variable. The Arrellano Bond test indicates the model has superior attributes. The predictors are instrumented with their lag variables. Number 1 to 6 reports the findings of the effects of individual variables whilst number 7 reports the findings of the model that contains all the variables.

The output of the I'm, Pesaran and Shin (2003) unit root test with individual variable effects except the Levin, Lin and Chu which assumes common effects. The null hypothesis assumes the presence of unit root in the variable. However if the null is rejected, it means the variable is stationary. The variables are stationary after first difference.

TABLE 2.0

ESTIMATION RESULTS – DYNAMIC PANEL GMM

The sample period runs from 1971 to 2012 for 12 countries (Algeria, Angola, Cameroon, Congo, Democratic Republic of Congo, Côte d'Ivoire, Egypt, Gabon, Ghana, Nigeria, South Africa, Sudan and Tunisia). All variables are in logs.

4. Discussion

Table 2 summarises the output of the dynamic generalised method of moments. Specifications (1) to (6) report the effect of individual predictors on the social cost of carbon emissions. In specification (7), the collective effect of all predictors is reported. The study finds that higher income have significant and positive relationship with the social cost of carbon emissions. This implies that economic growth increases the social cost of carbon emissions. Specifically, any 1% increase in GDP increases the social cost of carbon emissions by 1.709% in the individual models and 0.090% in the collective model. This is not surprising since most of these countries rely on carbon-intensive sectors such as manufacturing, mining, oil drilling, and agriculture to power their growth. This results support Raupach et al (2007) who find that the economic growth of developing countries is a cause to increased emissions. With regards to charcoal production, the study finds a significant relationship with social cost of carbon emissions in the individual speciation but insignificant in the collective model. This implies that charcoal production affect carbon emissions when acting alone but when it acts together with other predictors, it does not have any relationship with carbon emissions. Specifically, 1% increase in charcoal production increases the social cost of carbon emissions by 0.442%. There are three main ways charcoal production can affect carbon emissions. First, charcoal is prepared with wood. Cutting down trees the carbon dioxide absorptive capacity of the environment. Second, emissions from inefficient charcoal production leads to carbon emissions since it involves the burning of the wood (Lynch et al., 2004). Finally, since most of the charcoal produced is consumed in the urban and peri-urban areas, the transportation of the charcoal also add to emissions.

Further, electricity generation from crude oil sources have direct relationship with the social cost of carbon emissions but only significant in the individual models. Bhattacharyya (2011) reports that the burning of crude oil is one of the major causes of carbon emissions. This finding therefore supports Bhattacharyya's assertion. Specifically, 1% increase in electricity generated from oil sources leads to 0.556% increase in social cost of carbon emissions. Moreover, energy resource depletion has positive relationship with the social cost of carbon emissions. This is because, since renewable energy is obtained from infinite sources such as the sun, wind and water bodies, it is the non-renewable forms of energy such as coal, oil and natural gas deplete. These energy sources have been found to be major contributors of greenhouses gases (Machado et al., 2001). Therefore, any 1% increase in energy resource depletion increases the social cost of carbon emissions by 0.652%. The study reveals that population has an inverse relationship with the social cost of carbon emissions. However, population has a direct relationship with social cost in the individual estimation. Finally, the social cost of carbon emission of the previous year has a positive relationship with current emissions.

5. Conclusion

The purpose of the study is to examine the effect of charcoal production, electricity production from oil sources, energy resource depletion, GDP and population on the social cost of carbon emissions in oil producing African countries. This study has become necessary since global warming has become a threat to the survival of mankind. The dynamic panel generalised method of moments is used which has the ability to overcome the problem of endogeneity. The study finds that apart from population, all other factors have positive relationship with the social cost of carbon emissions.

The study recommends efficiency and modernization of charcoal production to reduce its impacts on the environment. In addition, renewable energy consumption should be encouraged to minimise energy resource depletion. Finally, alternative sources of power generation such as hydro and natural should be identified and used to minimise the impact of burning of crude oil on the environment.

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