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THE IMPACT OF ENERGY CONSUMPTION AND PRODUCTIVITY GROWTH ON CARBON EMISSIONS IN GHANA

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ABSTRACT

The environment plays two vital roles for mankind. It provides food and raw materials for production and consumption and also accepts the wastes generated through man's activities and renders them harmless. This calls for sustainable environmental management. This study examines the impact of productivity growth, forest depletion, renewable energy consumption and non-renewable energy consumption on carbon emissions in Ghana. The findings suggest that productivity growth is the most important factor that reduces carbon emissions in the short-run. In the long run however, renewable energy consumption has most influence on carbon emissions. Forest depletion leads to carbon emissions in both the short and long –run. The study recommends that in order to curb carbon emissions, afforestation programmes and investment in renewable energy should be encouraged.

Keywords: Productivity growth, Carbon emissions, Renewable energy consumption, Non-renewable energy consumption, Forest depletion, Environment.

JEL: Q2, Q4, Q5, O4.

1. INTRODUCTION

The World faces the hydra-headed challenge of energy security, sustainable growth and environmental management. This is because, it has been established that energy consumption, especially non-renewable leads to more emissions which intend affect the environment (Bhattacharyya, 2011). For instance, according to the Global (2010) of World Energy, coal emits 94.6 total carbon dioxide per each unit use. This makes coal and crude dangerous to the environment despite their usefulness. In addition, due to urbanization, unsustainable farming and logging, large tracts of land which were considered as virgin forest some few decades ago are been cleared to make way for estate development and agriculture. Nepstad *et al.* (1999) finds that both logging and bush fire increase forest vulnerability to future burning and release forest carbon stocks to the atmosphere, potentially doubling net carbon emissions from regional land-use in South America. Moreover Gullison *et al.* (2007) posits that without the implementation of effective policies and measures to slow deforestation, clearing of tropical forests will likely release an additional 87 to 130 GtC by 2100. Houghton (2005) affirms this assertion by indicating that the role of deforestation and fossil fuel use on climate change may be more severe than previously estimated.

In order to reduce global warming and curb the negative effect of man's activities on the environment, the Kyoto protocol set a Green House Gases emissions target of 5.2% (lower than the 1990 level) between 2008 and 2013. Whilst industrialized countries arguably contribute more to emissions, the rate at which population and growth are increasing in developing economies makes the Kyoto protocol seem one sided. Due to this, most studies on economic impact on emissions have concentrated on the developed economies or China and India. This study wants to use Ghana as a potential case study for Africa. Ghana has consistently achieved growth rate of more that 5.5% over the past 14 years. In 2011, due to commercial oil production, KPMG (2013) estimates that the country achieved the highest growth in the world at 14.4%. Whilst this has positive impact such as reduction in unemployment, it also has carbon emission consequences. According to Lindmark (2002), there is a high increase in carbon emissions during the developing stages of a country. To buttress Lindmark (2002)'s proposition, Ghana lost about 80% of its forest cover in the last century, which was considered as one of the highest in the world. In addition, the rate of deforestation between 1990 and 2000 was 1.7% (ITTO 2005) . Ghana had 8.2 million hectares of high forestin 1990 but only 1.2 million hectares remain today. The deforestation is caused mainly by bush clearance for agriculture, logging, bushfires, and unsustainable harvesting of fuel wood, including charcoal production1. This situation has been worsened by the ever increasing demand for charcoal due to increases in oil and natural gas prices. Recently, forest reserves are exploited for charcoal and timber unlike in the past when such activities were done in off-reserve areas. At the current deforestation level of 2%, Ghana's deforestation rate is among the highest in Africa, with current levels of wood-fuel consumption far exceeding forest growth. Wood-fuel cooking is therefore giving rise to harmful gas emissions as well as a significant health risk. Fuel Wood and charcoal are major sources of fuel for the residential areas especially in the urban slums and rural areas providing more than 80% of residential energy consumption.

The burning of forests for the purpose of land clearing and the oxidation of carbon compound in the vegetation are additional sources of emissions of CO_2 through land use into the atmosphere (Parker, 2009). According to Bonsu *et al.* (2011), deforestation consequently leads to soil erosion which exposes organic carbon in the soil to rapid oxidation resulting in CO_2 release into the atmosphere whilst Houghton (2003) suggests that deforestation is the largest contributor of tropical land use emissions.

Literature on climate change is inundated with how emissions can be reduced. Whilst some studies suggest the reduction of carbon emissions through technological means, others suggest the use of economic means such as increasing fuel prices, introduction of taxes to curb the consumption of fossil fuel or subsidies to boost the consumption of renewable energy. In as much as these policies and innovations may affect carbon emissions, they may have growth consequences. Hogan and Jorgenson (1990) argue that policies that increase energy prices to reduce emissions can have negative effect on economic growth in the long run. Another option may be to reduce energy consumption but such an action can also affect growth if energy consumption Granger causes growth or has a bidirectional relation with growth. In other to test for the causality between energy consumption and emissions, Ang (2008) examines the long-run relationship between output, pollutant emissions, and energy consumption in Malaysia from 1971–1999. The results indicate a direct relationship between pollution and energy use in the long-run.

Menyah and Wolde-Rufael (2010) study the causal relationship between carbon dioxide (CO2) emissions, renewable and nuclear energy consumption and real GDP for the US for the period 1960-2007. Using a modified version of the Granger causality test, they find a unidirectional causality running from nuclear energy consumption to CO2 emissions without feedback but no causality running from renewable energy to CO2 emissions. The econometric evidence of their study seems to suggest that nuclear energy consumption can help to mitigate CO2 emissions, but so far, renewable energy consumption has not reached a level where it can make a significant contribution to emissions reduction. Apergis *et al.* (2010) examines the causal relationship between CO2 emissions, nuclear energy consumption, renewable energy consumption, and economic growth for a group of 19 developed and developing countries for the period 1984-2007 using a panel error correction model.

On Asia, Zhang *et al.* (2013) calculates energy-related carbon emissions from Beijing's production and household sectors in 1995, 2000, 2005, and 2009 based on the default carbon-emission coefficients provided by the Intergovernmental Panel on Climate Change (IPCC). Taking 1995-2000, 2000-2005, and 2005-2009 as the study periods, their study decompose the effects of changes in carbon emissions resulting from eight causal factors using the logarithmic mean Divisia index method: economic activity and population size, which reflect the change in socioeconomic activity; energy intensity and energy consumption per capita, which reflect the change in the intensity of energy use; and economic structure, the urban and rural population distribution structure, and the energy mix of the production and household sectors, which reflect structural changes. Their findings indicate that in all three study periods, the changes in economic activity, population size, and energy consumption per capita stimulated emissions, whereas the changes in energy intensity, the urban and rural population distribution structure, and the energy mix of the production and household sectors decreased emissions. On the other hand, variations the structure of the economy, decreases emissions in the first and third periods, and increased emissions in the second period. The results clearly indicate that under current practices, carbon emissions will increase as a result of rapid growth of the economy, the population, and the energy consumption per capita. They suggest that energy-related pollution can be reduced by adjusting the structure of the economy and the energy mix.

The Ministry of Energy & Petroleum of Ghana announced on July 5, 2013 that the country has accepted a proposal from a Chinese company to generate electricity from a 700MW coal-fired power plant in Ghana. Whilst the rationale behind this agreement may be to boost electricity supply and enhance Ghana's energy security, the effects of the use of existing fossil fuels on carbon emissions have not been investigated. Again, since coal is the most environmentally unfriendly type of energy (Bhattacharyya, 2011), findings from this study will guide energy policy design especially when the environment must be considered. The purpose of this study is to estimate the impact of both renewable and non-renewable energy in addition to forest depletion on carbon emissions.

2. METHOD

Structural time series models (STSM) use a Kalman filter which contains a stochastic trend and cyclical components (Harvey, 1989; Koopman *et al*., 2000). One advantage of these models is that the components are open to distinct interpretations (Lindmark, 2002). It is therefore possible to estimate variables that cannot be directly observed with a stochastic trend which may represent lifestyle, energy related regulations or changes in economic structure (Crafts *et al*., 1989).

The above discussion focused on the conceptual issue of modelling technical progress using a deterministic trend and hence the arguments for using the alternative STSM estimating technique. In order to model the stochastic trend, the STSM developed by Harvey *et al*. (1986), Harvey (1989), Harvey and Shephard (1993) and Harvey (1997) is used. The STSM decomposes time series into different components that can be interpreted directly. The basic form of the STSM is modelled as a function of time trend and a set of seasonal dummies. The advance multivariate form of the STSM is obtained by adding explanatory variables to the basic form (Harvey and Shephard, 1993). The major advantage is that it is able to estimate a stochastically changing unobservable trend (Hunt *et al*., 2003a; Hunt *et al*., 2003b).

However, there are also strong statistical arguments for using this STSM as opposed to the more generally accepted technique of unit roots and cointegration. Harvey (1997) heavily criticizes the over reliance on the cointegration methodology as being unnecessary and/or a misleading procedure due, to amongst other things, its poor statistical properties. Due to this and the superior characteristics of the STSM, this study follows Hunt *et al*. (2003a) as follows:

$$CO2_t = \theta^o_{fd} fd_t + \theta^o_{Nr} Nr_t + \theta^o_R R_t + \theta^o_{TFP} TFP_t + \mu^o_{tt} + \varepsilon_{tt} \qquad 1$$

Where $CO2_t$ is the natural log of carbon emissions, fd_t is the natural log of forest depletion, Nr_t is the natural log of non-renewable energy consumption, TFP_t is the natural log of Productivity growth , and ε_t is the error term θ^o_{fd}, θ^o_{Nr}, θ^o_R and θ^o_{TFP} are the elasticities of forest depletion, non-renewable energy consumption, renewable energy consumption and productivity growth respectively.

$$\mu^o_{tt} = \mu^o_{tt-1} + \gamma^o_{tt-1} + \eta^o_{tt} \qquad 2$$

$$\gamma_{it}^{o} = \gamma_{it-1}^{o} + \xi_{it}^{o} \qquad 3$$

Where $\varepsilon_{it} \sim NID(0, \sigma_{eo}^{2})$, $\eta_{it}^{o} \sim NID(0, \sigma_{\eta^o}^{2})$ and $\xi_{it}^{o} \sim NID(0, \sigma_{\xi^o}^{2})$. Equation (2) and (3) represent the UEDT for energy demand. μ_{it}^{o} is made up of level and slope components. This is a stochastic trend dependent on $\sigma_{\xi^o}^{2}$ and $\sigma_{\eta^o}^{2}$. Following the work of Broadstock and Hunt (2010), the first model is estimated as Autoregressive Distribution Lag version with 4 lags. Statistical insignificant variables are eliminated and normality, auxiliary residuals and diagnostic test are carried out to obtain the preferred equation. Equations (1) to (3) are estimated with the software package STAMP (Koopman *et al.*, 2000).

3. ANALYSIS AND DISCUSSION

Table-1.

CO2_1	-0.82	
CO2_2	-1.24	
CO2_3	-1.84	
CO2_4	-1.42	
Non-renewable (Nr)	-0.48	
Nr_2	-0.74	
Nr_3	-0.43	
Renewables_4	5.34	
FD	0.12	
FD_2	-0.14	
FD_4	-0.12	
TFP	-6.05	
TFP_1	1.82	
TFP_4	-2.69	
Goodness-of-fit results		
Prediction error variance (p.e.v)		0.000361
Prediction error mean deviation (m.d)		0.000218
Ratio p.e.v. / m.d in squares		1.736752
Coefficient of determination R2		0.995592
... based on differences RD2		0.887925
Durbin-Watson test is 1.72835.		

2.1. Data

Annual data from 1971 to 2011 on aggregate renewable and non-renewable energy consumption are obtained from the IEA. Forest depletion in constant US dollars is obtained from the World Bank Development indicators. The data on Total Factor Productivity used as a proxy for productivity growth is obtained from the UNIDO database.

The short run elasticity for renewable energy is 5.34. This means that in the short-run, the major cause of carbon emissions in Ghana is renewable energy consumption. Data from the IEA indicates that renewable energy in Ghana is made of Biofuels and waste and mostly consumed in the residential sector. This is usually through the use of charcoal and coal pot to for cooking and heating water. About 1.3 million households or 31% of all families in Ghana use charcoal as cooking fuel.In the capital city Accra, about 70% of households are using charcoal for cooking.

Charcoal production is the only energy subsector where the cooking appliances and most production equipment are produced locally. Charcoal is produced from inefficient kilns with a carbonization ratio of about 8 tonnes of wood to 1 tonne of charcoal. These kilns are themselves responsible for high emissions of greenhouse gasses (Pennise and Smith, 2001). This may be the reason for the high short-run elasticity of renewable energy consumption. However, in the long run, as more households move from the use of charcoal to use LPG or electric cooker, renewable energy consumption relates inversely with carbon emissions. In the long-run, the elasticity for renewable energy consumption is -1.00.

This study confirms Bhattacharyya (2011) assertion that non-renewable energy contributes to carbon emissions. The study reports a short-run elasticity of -0.48 and a long run of 0.31 for non-renewable energy consumption. The low elasticities for non-renewable energy may be due to the fact that Ghana currently does not use coal and relies on LPG as a substitute to charcoal in the residential sector. Therefore, the emissions from the non-renewable energy may be driven by gasoline and diesel. Ghana used to pride itself as one of the largest timber producers in the World. Apart from logging, non-sustainable agriculture methods, the use of wood for charcoal making and bushfires seem to contribute to the depreciation in the country's forest reserves. Whilst forest depletion leads to carbon emissions, Gitz and Ciais (2004) point to the fact that climate change also adversely impact tropical forests by reducing precipitation and making the forest drier, more susceptible to fires, and more prone to replacement by, grasslands, or savanna ecosystems. The findings indicate that short-run elasticity for forest depletion is 0.12 with long run elasticity of 0.03.

Productivity growth is the cheapest means of reducing carbon emissions (McKinsey, 2010). This is because, productivity reduces the amount of capital, energy and other factors of production in a production process but still achieve the same results. The IEA (2010) posits that increasing energy efficiency, much of which can be achieved through low-cost options, offers the greatest potential for reducing CO_2 emissions over the period to 2050. It should be the highest priority in the short term. Dincer (2000) suggests that achieving solutions to environmental problems that we face today requires long-term potential actions for sustainable development. In this regard, renewable energy resources and productivity growth appear to be the one of the most efficient and effective solutions. The higher efficiency gains through productivity can however lead to complacency or even higher energy consumption which is referred to as the rebound effect (Greening *et al.*, 2000). In the short-run, the estimated elasticity for productivity growth is -6.05 implying that the biggest impact on carbon emission reduction in Ghana in the short-run is productivity. In the long-run, the gains in carbon reduction through productivity may have been offset by other factors such as more non-renewable energy usage or forest depletion. The estimated long-run elasticity is 1.30.

Figure-1. Carbon emission trend for Ghana

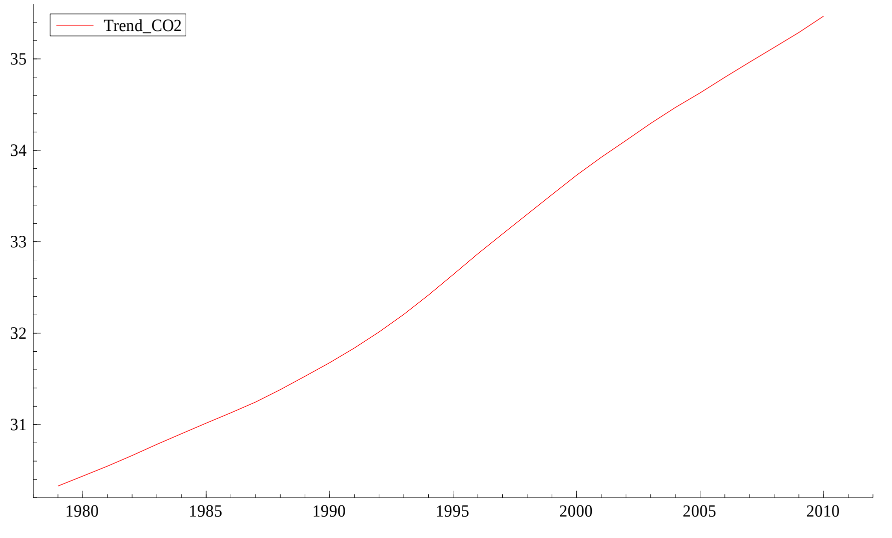

Figure 1.0 shows the carbon emission trend of Ghana from 1971 to 2010 estimated through the Structural Time Series Model. The trend slopes upward though slightly decreasing indicating that 'carbon emission behaviour' of Ghana is not sustainable and increasing. This may be due to several factors including an absence of a carbon emission policy, usage of charcoal in residential areas especially in slums and the rural areas, felling of trees for timber or farming and the high usage of 'second hand' (used) vehicles.

4. CONCLUSION

The environment plays two vital roles for mankind. It provides the food and raw materials for consumption and production. In addition, it takes the waste man generates and renders them harmless. Due to this, it is necessary to sustainably manage the environment. The purpose of this study is study estimate factors that contribute to carbon emissions in Ghana. The effects of factors such as forest depletion, renewable energy consumption, non-renewable energy consumption and productivity growth on carbon emissions from 1971 to 2010 are measured. The study is necessitated by the fact that most of the existing studies measuring the relations between energy consumption and carbon emissions usually test the causality either in a multivariate framework or in a bivariate model. The STSM is applied since it has the ability to model 'carbon emission behaviour trend'. The results indicate that in the short –run , productivity growth is the most important factor in carbon emission reductions whilst renewable energy consumption causes emissions more in the short –run than any other factor. However, in the long-run, renewable energy consumption reduces carbon emissions whereas non-renewable energy consumption, forest depletion and productivity growth all lead to carbon emissions.

The study recommends that investment in renewable energy such as solar panels, wind and other forms of clean energy to replace charcoal as a residential fuel. In addition, productivity growth and afforestation policies should be designed to reduce carbon emissions.

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