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A Long-Run Relationship Investigation of Energy Consumption and Air Pollution in Togo

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Abstract

The world is facing the challenge of global warming and climate change issues. Energy use is crucial to human survival and development. Improvements in lifestyles have historically been associated with increases in energy consumption and the access to appropriate energy services has been seen as a necessary precondition for development. This research dealt with the oil and electricity consumption evaluated the impact of energy consumption on air pollution. It is generally focused on the impact of implementing energy planning policies and measures on sector energy demand and pollutants emissions, particularly CO2. Based on panel data techniques using Eviews, the research investigated a long-run relationship between energy consumption and air pollution as CO2 emission through Togolese annual data for the period 1992-2012.This work that is dealt with the oil and electricity consumption evaluated the impact of energy consumption on air pollution. Results overwhelming showed that CO2 emission and energy consumption moved together in the long-run. Findings appeared that first, energy consumption is granger caused the Co2 emission and Co2 emission is granger caused the energy consumption. Findings also suggested that in long-run, energy consumption would impact on the air pollution.

Keywords: Energy consumption, oil consumption, electricity consumption, air pollution, CO2emission.

Introduction

Improvements in lifestyles have historically been associated with increases in energy consumption and the access to appropriate energy services has been seen as a necessary precondition for development. While the development or post-industrialization nations have seen some decoupling of energy and gross domestic product (GDP) growth in recent years at high levels of per capita energy use; nature has endowed sub-Saharan Africa with an array of natural energy resources such as wind, coal, water, oil, wood and solar, a large number of these resources have remained unexploited for decades. Consequently, many African countries faced serious energy deficits due to poor investment in energy infrastructure. The inadequate provision of energy services in Sub-Saharan Africa has been cited by the United Nations Economic Commission for Africa (UNECA, 2010) as a limiting factor to economic growth and poverty alleviation efforts. Predominantly, the rural population and the urban poor are the ones who do not have access to modern energy services; a situation which has resulted in majority of the population to live on less than $1 a day (GNESD, 2012).

Theoretical Background

Energy use is crucial to human survival and development. While the development or post-industrialization nations have seen some decoupling of energy and gross domestic product (GDP) growth in recent years at high levels of per capita energy use; nature has endowed sub-Saharan Africa with an array of natural energy resources such as wind, coal, water, oil, wood and solar, a large number of these resources have remained unexploited for decades.

Research objectives

This work dealt with the oil and electricity consumption evaluated the impact of energy consumption on air pollution. The explanatory investigation is to analyze the long-run relationship investigation of energy consumption and air pollution in Togo.

To that investigation, we propose the following research questions:

- Is there no a long run relationship between **Energy consumption and air pollution?**
- **Does energy consumption granger cause the Co2 emission?**
- Does **Co2 emission granger cause the energy consumption?**

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1.3 Hypotheses

In order to reach the objectives of this research and assisting in answering the research problems, the subsequent hypotheses are therefore formulated:

- Ho1 **:** there is no a long run relationship between Energy consumption and air pollution
- **H02: Energy consumption does not Granger cause Co2 emission**
- H03 : **Co2 emission does not Granger cause Energy consumption**

Literature review

Energy consumption and economic growth seemed evidence from developing countries. But the economic growth-pollution debate still argued that:

- Economic growth would lead to a worsening pollution problem; tighter environmental regulation will reduce economic growth;
- Trade liberalization would exacerbate environmental degradation, especially in developing countries with weak environmental protection;
- Tighter environmental protection in the developed countries would lead to a loss of competitiveness compared with that of countries with lower standards, especially in polluting industries and;
- Tighter environmental protection in the developed countries would lead to relocation of investment to developing countries with lax regulation, especially in polluting industries.

In Togo context, due to recent industrialization, urbanization and agricultural motorization, recent trends reveal that energy consumption is increased rapidly (IEA 2012). Air pollution is increased and the degradation of environmental quality would arise from human activities in Togo and it is a "big problem" because despite government attempts to diversify the economy, it is still heavily dependent on agriculture and related activities. Then, engaging roughly 68% of the population and the climate change influenced the production. Thus, it is very vital for the government to lay down policies and regulate the energy consumption or CO2 emission with the final aim of achieving sustainable development. That is today, environmental issues in Togo have such an impact on business and industrial decisions that they have become part and parcel of economics. The preservation of the environment, the conservation of natural resources, and concern with health hazards has obvious consequences on the economy. Environmentalist and conservationist have sensitized the general public and made it aware that many resources of "mother earth" are finite, and that should not undo in one generation the work of nature over millions of years. More and more peoples feel that we have duty to future generations to preserve what remains of our natural environment and of wildlife, so they talk more and more about development sustainability or environment protection.

Like in all Africa countries, in Togo energy and environment management are important new topic. A long time ago the Togolese economy was largely market based and depended heavily on the agricultural sector. Almost 70% of the Togolese people are engaged in some form of agricultural activity. Despite government attempts to diversify the economy, it is still heavily dependent on agriculture and related activities, engaging roughly 68% of the population. Growth was negative in 2000-03 because of the difficulty of meeting the conditions of international donors, continued low prices of key exports, foreign divestment and political instability. Political turmoil has continued to damage the economy since 1993, with a rising risk premium associated with doing business in the country, foreign investment shriveling, transportation costs increasing, French businesses fleeing, and criminal elements that traffic in weapons gaining ground. The government will continue to survive financially off of the sale of phosphate, which represents 90% of foreign exchange earnings.

Energy consumption and economics growth

Fossil Fuels, total is the amount of energy consumed from the use of crude oil and natural gas liquids, coal and coal products.

Energy use is crucial to human survival and development. Improvements in lifestyles have historically been associated with increases in energy consumption and the access to appropriate energy services has always been seen as a necessary precondition for development. The significance of energy for development appears to be the greatest in those countries that have the lowest aggregate levels of energy consumption and where energy use is inefficient.

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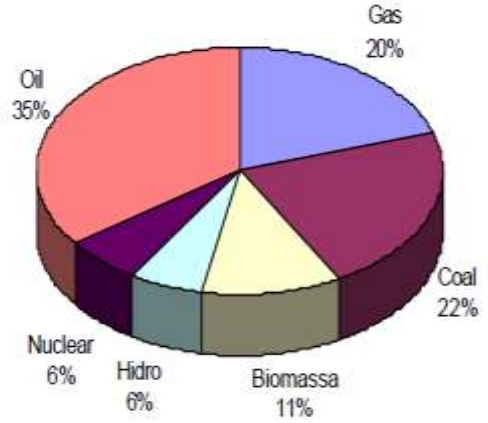
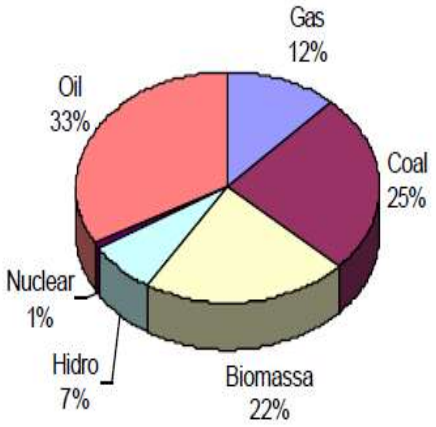
Profile of the World's primary Energy consumption (1998)	**Profile of primary Energy consumption in developing countries (1998)**
	
Population 5.90 billion % of fossil fuel: 77% Energy: 10,562 x 106 toe 1.79 toe/capita Growth of energy consumption (1979-2009): 2.2% /year	Population 4.56 billion (77.73% of world population) % of fossil fuels: 70% Energy: 3,861

Figure 1: Profile of primary and world energy consumption

So empirical research showed that there is a strong relationship between energy consumption and economic growth. For example, a unidirectional granger causality running from energy consumption to GDP entails that the country's economy is energy dependent and therefore, energy consumption is a prerequisite for economic growth (Jumbe, 2004). In other words, inadequate provision of energy may limit economic growth or may result in poor economic performance. However, when causality runs from economic growth to energy consumption, this indicates that an economy is less energy dependent and thus energy conservation policies, such as phasing out energy subsidies may not adversely affect economic growth (Mehara, 2006). On the other hand, if there is no causality between energy consumption and economic growth (also known as the neutral hypothesis), this implies that policies to enhance energy consumption will not increase economic growth.

Despite the burgeoning volume of literature on the causal relationship between energy consumption and economic growth, no attempt has being made to quantify the direction of causality between energy consumption and economic growth for any regional economic community in Africa. The few causality studies that have been conducted are based on individual countries and use time series data. Results from these studies have been mixed, mainly because of the different econometric methods used. Jumbe (2004) examined the causality relationship between GDP and per capita consumption of electricity for Malawi and found a bidirectional relationship. Wolde-Rufael (2006) investigated the long-run relationship between energy use per capita and per capita real GDP for 19 African countries and found mixed results, ranging from negative causality to bidirectional causality. As already indicated, previous causality studies have been done at country level and use time series data. Panel estimation techniques are less applied in the study for the causal relationship between energy consumption and GDP (Ciarreta and Zarraga, 2008). Lee (2005) applies panel estimation techniques on 18 developing countries, which includes two sub-Saharan African countries (Kenya and Ghana) and finds evidence of causality running from energy consumption to GDP. Mehra (2007) applies a similar technique for 11 oil exporting countries and finds evidence of a unidirectional strong causality running from energy consumption to per capita GDP. Recently, Ciarreta and Zarraga (2008) apply the

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heterogeneous panel cointegration test and panel system GMM to estimate the causal relationship between economic growth and electricity consumption for 12 countries. They find no evidence of a short-run causal relationship, but establish a long-run relationship running from electricity consumption to GDP.

With regard to energy provision, many African countries have recognized the importance of regional energy cooperation and integration to address the energy deficit. For example, the Common Market for Africa composed of several countries was formed with the objective of promoting regional integration through trade development.

The link between Energy Consumption and Co2 emissions

Much of the current energy supply and use, based, as it is, on limited resources of fossil fuels, is deemed to be environmentally unsustainable. There is no energy production or conversion technology without risk or without waste. Somewhere along all energy chain from resource extraction to the provision of energy services pollutants are produced, emitted or disposed of, often with severe health and environmental impacts. Even if a technology does not emit harmful substances at the point of use, emissions and wastes may be associated with its manufacture or other parts of its life cycle. Combustion of fossil fuels is chiefly responsible for urban air pollution, regional acidification and the risk of human-induced climate change. Thus, achieving sustainable economic development on a global scale will require the judicious use of resources, technology, appropriate economic incentives and strategic policy planning at the local and national levels. It will also require regular monitoring of the impacts of selected policies and strategies to see if they are furthering sustainable development or if they should be adjusted. It is important to be able to measure a country's state of development and to monitor its progress or lack of progress towards sustainability. First, policymakers need to know their country's current status concerning energy and economic sustainability, what needs to be improved and how these improvements can be achieved. Second, it is important for policymakers to understand the implications of selected energy, environmental and economic programs, policies and plans, and their impacts on the shaping of development and on the feasibility of making this development sustainable. Third, inevitably there will be trade-offs. In short, there is an imminent need for informed and balanced choices to be made on policy, investment and corrective action. When choosing energy fuels and associated technologies for the production, delivery and use of energy services, it is essential to take into account economic, social and environmental consequences. Policymakers need methods for measuring and assessing the current and future effects of energy use on human health, human society, air, soil and water. They need to determine whether current energy use is sustainable and, if not, how to change it so that it is. This is the purpose of the energy indicators presented in this report, which address important issues within three of the major dimensions of sustainable development: economic, social and environmental.

The vast majority of the energy we consume to heat and light our homes and power our vehicles comes from fossil fuels, such as coal, natural gas and oil. When these fuels are burned, CO2 is emitted as a waste product. After coal, oil and natural gas are the most "carbon intensive" of the fossil fuels, since it generates the highest amount of CO2 per unit of energy produced. This is especially important for Togo where energy uses is essential fossil fuels component.

The relationship between economic growth and its impact on the environment is ably demonstrated by the Kuznets Curve. The Kuznets Curve states that there is an inverted U-shaped relationship between economic growth and the environment. Negative environmental externalities increase steadily proportionately to economic growth up to a turning point during the initial stages of economic development (see Chart below). Once the turning point is reached, the economy then begins to place more emphasis on the importance of the environment, by devoting resources to negate further negative effects on the environment. As a consequence, environmental pollution and degradation begin to decline since the country has the capacity to invest in environmental friendly technology. Similar results were found by Grossman and Kruger (1995).

Research methodology

The Pearson correlation coefficient, multiple regression and granger causality test are used in this research methodology.

Pearson correlation coefficient and multiple regression analysis

Correlation is a general method of analysis useful when studying possible association between two continuous or ordinal scale variables. Several measures of correlation exist. The appropriate type for a particular situation depends on the distribution and measurement scale of the data. Three measures of correlation are commonly applied in biostatistics and these will be discussed below. Eviews is used to

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calculate r_p . The sampling distribution for Pearson's r_p is not normal. In order to attain confidence limits for r_p based on a standard normal distribution, we transform r_p using Fisher's Z transformation to get a Fisher's Z transformation is defined as :

$$z_p = \frac{1}{2}\log_e\left(\frac{1+r_p}{1-r_p}\right) \sim N\left(\zeta_p, sd = \frac{1}{\sqrt{n-3}}\right)$$

where

$$\zeta_p = \frac{1}{2}\log_e\left(\frac{1+\rho_p}{1-\rho_p}\right)$$

We will use this to get the usual confidence interval, so, an approximate 100(1 - α) % confidence interval for ζ_p is given by $[z_{p,\,\alpha/2}\ ,\ z_{p,\,1-\alpha/2}\ ]$, where

$$z_{p,\,\alpha/2} = z_p - \left(t_{n-3,1-\alpha/2} \Big/ \sqrt{n-3}\right), z_{p,1-\alpha/2} = z_p + \left(t_{n-3,1-\alpha/2} \Big/ \sqrt{n-3}\right)$$

But really what we want is an approximate 100(1 - a)% confidence interval for ρ_p is given by $[r_{p,\,\alpha/2}\ ,\ r_{\,p,\,1-\alpha/2}\ ]$, where

$$r_{p,\alpha/2} = \frac{\exp(2z_{p,\alpha/2})-1}{\exp(2z_{p,\alpha/2})+1}, r_{p,1-\alpha/2} = \frac{\exp(2z_{p,1-\alpha/2})-1}{\exp(2z_{p,1-\alpha/2})+1}$$

Granger Causality Test

In multivariate time series analysis, causality test is done to check which variable causes (precedes) another variable. Given two variables X and Y, X is said to Granger cause Y if lagged values of X predicts Y well. If lagged values of X predict Y and at the same time lagged values of Y predict X, then there is a bi-directional causality between X and Y. According to Granger (1988), the existence of cointegration between X and Y must be checked before running causality test.

If cointegrating relationship is found, then there must exist causality in at least one direction.

Testing of hypotheses

Data used in this analysis are annual time series on CO2 emission and energy consumption in Togo for the period of 1992 to 2012. CO2 data is obtained from the IMF, World Economic Outlook 2012. The Pearson correlation coefficient, multiple regression and granger causality test are used in this research methodology.

Dependent variable: Carbon dioxide emission CO2

Independent variables: Electricity consumption (EC), Oil consumption (OC)

Multiple regression analysis

Ho1: There is no a long run relationship between Energy consumption and air pollution

The correlation coefficient R square equal to 0.781991 it meant that there is a strong correlation between the dependent variable Co2 emission and the independent variables (Oil consumption OC and Electricity consumption EC).

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Table1: Multiple regression relationships between Oil consumption, Electricity consumption (EC) and Co2 emission.

Dependent Variable: LOG(CO2)				
Method: Least Squares				
Date: 07/10/13 Time: 11:13				
Sample(adjusted): 1992 2012				
Included observations: 21 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.150018	1.352499	-0.110821	0.0601
EC	0.034760	0.005479	-0.461448	0.0410
DLOG(OC)	1.203354	0.311196	3.327593	0.0425
R-squared	0.781991	Mean dependent var		0.338830
Adjusted R-squared	0.702488	S.D. dependent var		0.088411
S.E. of regression	0.055742	Akaike info criterion		-2.674971
Sum squared resid	0.012429	Schwarz criterion		-2.744384
Log likelihood	10.02491	F-statistic		8.578249
Durbin-Watson stat	0.524742	Prob(F-statistic)		0.042862

Estimation Command:
==========
LS LOG(CO2) C EC DLOG(OC)
Estimation Equation:
==========
LOG(CO2) = C(1) + C(2)*EC + C(3)*DLOG(OC)
Substituted Coefficients:
==========
LOG(CO2) = 0.150018 +0.034760*EC + 1.203354*DLOG(OC)
The three variables are correlated.
The regression model indicated in this table 2 showed a long run relationship is existed between these three variables. Then when Oil consumption, Electricity consumption (EC) increased simultaneously by 1%, the Co2 emission will be growth respectively by 1.31.203354 for Oil consumption (OC) and 0.034760 for , Electricity consumption (EC).

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Pearson correlation coefficient

Table 2: Correlation Matrix

	Co2 emission	EC	OC
Co2 emission	1	0.52860932122	0.61171834341
EC	0.52860932122	1	0.01123352211
OC	0.61171834341	0.01123352211	1

This analysis showed that all three variables **Electricity consumption EC, Oil consumption OC and Co2 emission** are correlated.

Granger causality test

H02: Energy consumption does not Granger cause Co2 emission

H03 : Co2 emission does not Granger cause Energy consumption

To test for the direction of causality between trade and economic growth, Granger causality test would be used to reinforce the null hypothesis 2 and 3 test.

The results of granger causality test used VAR in levels are presented in Table 3. This indicated that the null hypothesis 2 (H02) that "**Energy consumption does not granger cause Co2 emission"** is rejected. The hypothesis (H03) that ''**Co2 emission** does not granger causes **Energy consumption''** is also rejected. These results provided evidence of bi-directional causality between **Energy consumption** and **Co2 emission**. **Energy consumption** and **Co2 emission** in Togo complemented each other. The results were consistent with other empirical studies. Bi-directional causality between **Energy consumption (Electricity consumption EC and Oil consumption OC)** and **Co2 emission** in Togo was not surprising because of the main oil consumption were the main contributor to air pollution and Co2 emission.

Table 3: Granger causality test used VAR in levels

H0	Wald test/χ2	Conclusion
Energy consumption does not Granger cause Co2 emission	**28.856 (0.000)**	**Reject the hypothesis. There is causality from Energy consumption to Co2 emission**
Co2 emission does not Granger cause Energy consumption	**23.829 (0.022)**	**Reject the null hypothesis. There is causality from Co2 emission to Energy consumption**

Note: Probabilities are in parentheses

Hence, these results were not surprising. These results provided evidence in support of **Energy consumption (Electricity consumption EC and Oil consumption OC)** hypothesis and as well as the existence of reverse causality.

Conclusion

The purpose of this study was test correlation between CO2 emission, EC electricity consumption and OC oil consumption**.** From the test result, findings concluded that there would be a causal relationship between variables at the long-run relationship between them. Many works have shown that there would be a causal relationship between energy consumption and air pollution. Energy consumption seemed to have no impact on the air pollution. A simple analysis showed that pollution was not only function of energy growth or economic growth; it was depent also from place, time, and population.

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With regard to the big countries like China, United State and Canada, Togo did not take part in the pollutant raw. We could understand this situation because like all "developing countries" faced serious energy deficits due to poor investment in energy infrastructure. And electricity price were very expensive. Many people still used coal and biomass energy (rural localities') we just left the agriculture for industrialization and we new experiment an economic growth with research of energy efficiency.
Based on the analysis and the rational presentation, Togo should not have any obligation to reduce its carbon emissions for quite some time. But to avoid suffering from climate change Togolese government must think about sustainable environment with using renewable energies. With the good air quality Togo could base its development on tourism policies toward energy security and climate change complementary.

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