Article **ECORFAN-Bolivia Journal**
ENGINEERING December 2014 Vol.1 No.1 1-11

Relationship between renewable and non renewable electricity production and economic growth in Cameroon

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Received January 10, 2014; Accepted June 27, 2014

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The purpose of this study is to assess the long run relationship between electricity production and economic growth in Cameroon. This was done using the Johansen Cointegration test and the fully modified OLS method. Our results show that economic growth and electricity production are cointegrated thus has a long run association-ship. Furthermore the FMOLS output reveals that, electricity production from hydroelectricity plant (electricity produced from renewable source) significant and positively contribute to economic growth whereas electricity produced from oil (electricity produced from non-renewable source) negatively contribute to economic growth.

**Johansen Cointegration Test, FMOLS, Cameroon, Electricity Production, Economic Growth.**

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**Citation:** Chiatchoua C, Pegou S., Montes P., Megne M. Relationship between renewable and non renewable electricity production and economic growth in Cameroon. ECORFAN Journal-Bolivia 2014, 1-1: 1-11

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Introduction

Cameroon is a country situated in Central Africa. Its population growth has been increasing at an average yearly rate of 2.6% within the past two decades. As a result of increasing population, electricity consumption has also been increasing. The country is endowed with a gigantic hydroelectric potential, which places it second potential hydroelectric producer in Sub Saharan Africa after Democratic Republic of Congo. For the past three decades the country has been struggling to impulse sustainable economic growth, regardless of its hydroelectric potential to generate green and renewable energy, to supply industries in other to boost economic growth.

The recently construction projects of hydroelectric dams and that of thermal energy generators in Cameroon has been of great concern to businesses and to the government as well, most effectively due to the fact that for more than 20 years as from today, many companies in Cameroon have been operating under capacity due to rampant electricity outages resulting from unstable supply of electricity as a result of increasing demand, droughts and crumbling of existing installations. This has put the country into a difficult situation of social unrest as unemployment among youths has been increasing year after year. The government of Cameroon has engaged itself into heavy investment projects to build many dams with the prospect to soar electricity production, which are waiting to become fully operational.

Political debates are focused on the solution of economic growth and job creation in Cameroon, and some analyst of the civil society have been urging the government to encourage investment such that electricity supply should be increased through production. Thus arises three different views:

1) There is a bidirectional relationship between electricity consumption and economic growth.
2) Electricity consumption does not have a causal relationship with growth.
3) There is a uni-directional causal relationship between electricity consumption.

To understand this dilemma, we decided to look at the contribution of electricity production (renewable and non-renewable) to national output in Cameroon from 1975 to 2013. This leads us to ask the main question this paper is to resolve: Does electricity production influence economic growth in Cameroon? We then proceed to hypothesise on the research question by stating that: Ho: Electricity production from renewable sources positively impact on economic growth; while Electricity production from oil sources negatively impact on economic growth in Cameroon.

To be able to answer this question, we are going to use the Fully Modified Ordinarily Least Squares (FMOLS) method developed by Phillips and Hansen in 1990. We choose this method because it gives us reliable results as we are going to explain in the Data and methodology section. Before then, we are going to talk about electricity Consumption and Economics Growth in Cameroon.

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Then the Electric power transmission and distribution losses versus Electricity production from oil sources in Cameroon will be compared. After that we will end up with the Conclusion and recommendations.

An Overview of Electricity production and Economics Growth

Cameroon is blessed with numerous sources of electricity supply but most of these sources are not being used and in this cornucopia, there is the monopolization of a single source hydropower. Of all the electricity produced and sold in Cameroon, hydropower accounts for about 95%. Within the Sub-Saharan African states, Cameroon ranks second with a potential of about 55.2 GW per a producible potential of 294 TWH/year behind the Democratic Republic of Congo in hydropower production. Despite the heavy reliance on hydropower, only about 20% of Cameroonian has access to the grid network. Most of the people connected to the grid are urban residents while rural electrification in Cameroon remains on a staggering rate of less than 15% (Wirsliy, 2010).

Another principle source of energy used in Cameroon for electricity production is fuel which accounts for about 11% of the total electricity produced in the country. Cameroon is blessed with sunlight and where by the average sunlight intensity is 2,327.5 TWH. This gives the country a good potential of biomass with its 20 million hectares of tropical forest, and its natural gas reserve is estimated at 110 thousand millionm^3. Despite these numerous sources, little investments have been made to develop their uses (Egbe, 2010).

Presently, Cameroon has three hydropower production dams, namely Songloulou, Edea and Lagdo with respective installed generating capacities of 387 MW, 263MW, 72 MW. There are also three other dams devoted to reinforce the Edea and Songloulou plants. These three retaining dams are Mbakaou constructed on river Djerem, Bamendjin constructed on river Noum and Mape constructed on river Mbam. The three retaining dams constructed on the main tributaries of the river Sanaga are aimed to augment the power generated of the Edea and Songloulou power stations during the period of low water mark. Due to the high cost of production, transportation and distribution of electricity during drought period many Cameroonians are been disconnected from the grid due to price increment by the energy company AES-SONEL Cameroon (Tchouaha, 2012).

Electric power transmission and distribution losses versus Electricity production from oil sources.

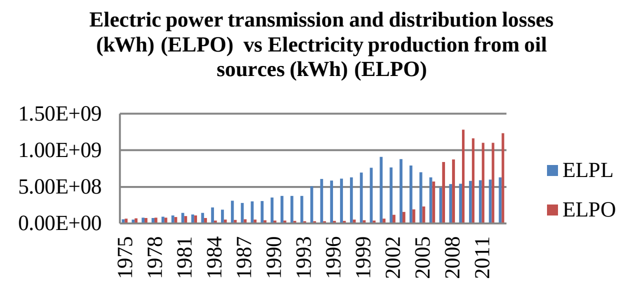

Table 1 Electric power transmission and Distribution losses vs Electricity production from oil Sources

This graph shows the frequency of electricity power transmission and distribution losses compare to that of electricity production from oil sources from 1975 to 2013. We have decided to divide this histogram into three parts that is:

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1) 1975 to 1980 (electricity power transmission and distribution losses is almost equal to electricity production from oil sources)

2) 1981 to 2006 (electricity power transmission and distribution losses is more than thrice as large electricity production from oil sources)

3) 2007 to 2013 (electricity power transmission and distribution losses is almost equal to three quarter of electricity production from oil sources)

From this graph it is evident that electric power transmission and distribution losses have been extremely greater than electricity production from oil sources in Cameroon. It is only as from 2006 that the situation was reversed; yet electricity production from oil sources has almost never account for twice of electricity losses, to overshadow these losses. This led us to say electric power transmission and distribution losses may be so important in Cameroon such that it could wipe out the effect of electricity production from oil sources.

Literature review

A majority of studies found that there exist a unidirectional causality between electricity consumption and economic growth, other studies such as Ogundipe and Apata (2013) , Bildirici and Kayikci (2012), Gurgul and Lach (2011), Hu and Lin (2013), and even Nazlioglu et al. (2014) found that there was bidirectional causality between electricity consumption and economic growth.

Another sets of studies such as Altinay and Karagöl (2005), Shiu and Lam (2004), and Atif and Siddiqi (2010) have found that there was unidirectional causality from electricity consumption to economic growth, on the opposite other studies going from Ozun and Cifter (2007), Ciarreta and Zarraga (2007), Hye and Riaz (2008), Adom (2011) to Akinwale et al. (2013) found that there was unidirectional causality from economic growth to electricity consumption. The findings of Asaduzzaman and Billah (2008) also found positive relationship between energy consumption and economic growth for Bangladesh using data spanning from 1994– 2004 and reported that higher level of energy use led to higher level of growth. The study conducted by Lean and Shahbaz (2012) claim that electricity consumption has positive impact on economic growth and bi-directional Granger causality has been identified between electricity consumption and economic growth in Pakistan. Akinlo (2009) conducted a study in Nigeria to investigate relationship between economic growth and electricity consumption during the period 1980 to 2006. The result exhibits that there is unidirectional Granger causality running from electricity consumption to real GDP and suggested use of electricity could stimulate the Nigerian economy (Masuduzzaman, 2013). Relatively few studies such as Yu and Hwang (1984) and Aktaş and Yılmaz (2008) have reached there were no causality between electricity consumption and economic growth". In a related study, Ozturk and Acaravci (2011) using an ARDL Bounds Cointegration approach investigated the relationship and the direction of causality between electricity consumption and economic growth for 11 Middle East and North Africa countries (MENA) from 1990-2006.

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The authors found no unique evidence of long-run equilibrium relationship between electricity consumption and economic growth in Iran, Morocco and Syria. However, the study found the existence of level relationship between electricity consumption and economic growth for Egypt, Israel, Oman, and Saudi Arabia. The test of causality revealed a one-way short-run Granger causality from economic growth to electricity consumption in Israel. In Egypt, Oman, and Saudi Arabia, the causality test revealed the existence of one-way both short and long-run Granger causality from electricity consumption to economic growth. Generally, the authors concluded that their results suggest that there is weak evidence on the long-run and causal relationship between electricity consumption and economic growth in MENA countries (Adom, 2011). It therefore becomes evident that the direction of causality between electricity consumption or production depends mostly on the country in which the study is undertaken. Thus the existing literature reveals that due to the application of different econometric methodologies and different sample sizes, the empirical results are very mixed and even vary for the same country and are not conclusive.

Data and Methodology

In this section we present first of all the choice of the model, the data collection process, the statistical tests and the results and interpretations.

Choice of model

The model we use in this study is a development of the well-known Cobb-Douglas model. This model has been chosen because it enables us to assess the elasticity of economic growth relative to electricity production.

We decided to look at electricity production impact on economic growth rather than consumption because very few studies have related electricity production to economic growth. Cobb-Douglas from their model of economic growth propounded that: $GDP = AK^{\alpha}L^{\beta}$ (1)

They develop this model in such a way as to explain that, in an economy there are two main factors that are substitutable (capital and labour), and they significantly influence economic growth. Their model also includes the productivity factor A, which can deter or boost economic growth, thereby playing as a counter force to one of the two main substitutable factors (capital and labour); there come the introduction of electricity production as an element of the productivity factor to fit into our model. Therefore we can extend the Cobb-Douglas model to become: $GDP = A'K^{\alpha}L^{\beta}E_r^{\delta}\, E_o^{\vartheta}$ (2)

We introduce the logarithm function in other to make equation 2 linear in the parameters, so that we can use the regression technique to determine the elasticity of economic growth on electricity production. Therefore we obtain:

$$LogGDP = \tau + \alpha logK + \beta logL + \delta logE_r + \vartheta logE_o + \varphi logE_l \quad (3)$$

Where $logA' = \tau$ *is a constant term* GDP is national output in current local currency (CFA Franc), A' is the productivity factor less electricity production component, K is Gross fixed capital formation in current local currency (CFA Franc), L is the total labour force, $E_r = ELPR$ is Electricity production from renewable sources (kWh) and $E_o = ELPO$ is Electricity production from oil sources which is the proxy for non-renewable electricity production (kWh).

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Data collected process

The data we used in this study are collected from the online world development indicator database. We used Eviews 8 econometric software to analyse the data and to perform the fully modified ordinary least squares regression technique.

Statistical test
Unit root test

Group unit root test: Summary of Series: ELPO, ELPR, GDP, K, L					
Level group Unit root test					
Method	Statistic	Prob.**	Cross-sections	Obs	**Decision**
Null: Unit root (assumes common unit root process)					
Levin, Lin & Chu t*	3.76689	0.9999	5	189	Ω
Null: Unit root (assumes individual unit root process)					
Im, Pesaran and Shin W-stat	4.95705	1.0000	5	189	Ω
ADF - Fisher Chi-square	1.21898	0.9996	5	189	Ω
PP - Fisher Chi-square	1.17044	0.9996	5	190	Ω
Ω has a unit root (not stationary), ϡ do not have a unit root (stationary)					
First difference unit root test					
Method	Statistic	Prob.**	Cross-sections	Obs	**Decision**
Null: Unit root (assumes common unit root process)					
Levin, Lin & Chu t*	-12.6989	0.0000	5	185	ϡ
Null: Unit root (assumes individual unit root process)					
Im, Pesaran and Shin W-stat	-12.0658	0.0000	5	185	ϡ
ADF - Fisher Chi-square	111.394	0.0000	5	185	ϡ
PP - Fisher Chi-square	112.086	0.0000	5	185	ϡ
Ω has a unit root (not stationary), ϡ do not have a unit root (stationary)					

Table 2 Group unit root test for the variables of the model

From table 2 we can conclude that the series are not stationary at level, so we proceed to look if they are at first difference, which turns out to be conclusive; therefore we proceed to test for the cointegration of the unit rooted variables, this is done using the Johansen cointegration test, we choose to use the panel unit root test rather that the individual unit root test because recent literature suggests that panel-based unit root tests have higher power than unit root tests based on individual time series Levin et.al (2002).

Cointegration test

It is well known that many economic time series are difference stationary. In general, a regression involving the levels of these I(1) series like in this study, will produce misleading results, with conventional Wald tests for coefficient significance spuriously showing a significant relationship between unrelated series (Phillips 1986).

Engle and Granger (1987) note that a linear combination of two or more I(1) series may be stationary, or I(0), in which case we say the series are cointegrated. Such a linear combination defines a cointegrating equation with cointegrating vector of weights characterising the long-run relationship between the variables. We will work with the standard triangular representation of a regression specification and assume the existence of a single cointegrating vector (Hansen 1992b, Phillips and Hansen 1990). Consider the $(n+1)$ dimensional time series vector process$X_t'\beta$, with cointegrating equation

$$y_t = X_t'\beta + D_{1t}'\gamma_1 + \mu \quad (4)$$

Where $D_t = (D_{1t}', D_{2t}')$ deterministic trend regressors and the stochastic regressors are governed by the system of equations:

$$X_t = \beth_{21}{,}D_{1t} + \beth_{22}{,}D_{2t} + \epsilon_{2t}\ \mathrm{ET}\Delta\epsilon_{2t}u_{2t}. \quad (5)$$

The p_1-vector of D_{1t} regressors enter into both the cointegrating equation and the regressors equations, while the p_2-vector of $D_{2t}$are deterministic trend regressors which are included in the regressors equations but excluded from the cointegrating equation (if a non-trending regressor such as the constant is present, it is assumed to be an element of D_{1t} so it is not in D_{2t}).

From table 5 at the appendix we performed the Johansen cointegration test to assess if the series are cointegrated, that is to know if the variables of interest have long run association-ship. We came out with the conclusion that given the result of the Trace test and the Max-eigenvalue test statistics values, it is evident that the null hypothesis of no cointegration of the variable is rejected at 5%, stipulating the presence of at most 2 cointegrated equations.

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To be able to come out with reliable long run estimate of the parameters given that the variables of interest are cointegrated at first difference I (1), the Fully Modified Ordinary Least Square regression is employed. The estimator employs preliminary estimates of the symmetric and one-sided long-run covariance matrices of the residuals. Let μ_{1t}be the residuals obtained after estimating $y_t = X_t'\beta + D_{1t}'\gamma_1 + \mu$ the μ_{2t}may be obtained indirectly as $\mu_{2t} = \Delta\varepsilon_{2t}$from the levels regressions $\Delta X_t = ב_{21},D_{1t} + ב_{22},D_{2t} + \mu_{2t}$.

Phillips and Hansen (1990) propose an estimator which employs a semi-parametric correction to eliminate the problems caused by the long run correlation between the cointegrating equation and stochastic regressors innovations. The resulting Fully Modified OLS (FMOLS) estimator is asymptotically unbiased and has fully efficient mixture normal asymptotic allowing for standard Wald tests using asymptotic Chi-square statistical inference.

Results and interpretation

$$LogGDP = \tau + \alpha logK + \beta logL + \delta logE_r + \vartheta logE_o (3)$$

$$LOG\ GDP = -15.65 + 0.25 * LOG(K) + 0.02 * LOG(L) + 1.73 * LOG(ELPR) - 0.013 * LOG(ELPO) \quad (6)$$

The estimated coefficients are presented in table 6. Of central importance are the coefficients $\alpha, \beta, \delta\ and\ \vartheta$ which imply that the estimated cointegrating vector for $logGDP$ and electricity production from renewable and non renewable are 1.73, and -0.013. The P-values of all these estimated parameters are highly statistically significant as they portray values equal to zero, except for the case on non-renewable electricity elasticity which is statistically significant at the threshold of 5%.

We proceed to test if effectively the elasticity coefficient is different from zero, since it is weakly significant. This is done using the Wald test as can be seen on table 10, from which we are able to reject the null hypothesis of the parameter being equalled to zero. Therefore we conclude that electricity production from non-renewable sources do contribute negatively to economic growth in Cameroon.

The Durbin-Watson statistic is 1.64 which is closed to 2, as an indication of the absence of autocorrelation of the unobserved parameter and the independent variables; but we cannot rely solely on this result in the case of FMOLS Pedroni (2000); without further investigation so we proceed, with the VIF test on table 9, to conclude that their centred values are all below 10 as an indication of the absence of multi-collinearity among the variables, which confirm the absence of serial correlation. Also the fit is very strong with a value of 98.4% to indicate that the independent variables of our model explain national output variable in Cameroon with an accuracy 98.4% as can be seen on table 6 and table 7.

From table 6 it is evident that, on average a percentage change in electricity production from renewable sources holding constant electricity production from oil sources (Electricity production from non-renewable sources) would impulse national output growth by 1.74%, while on the same token a 1% change of electricity production from oil sources holding electricity production from renewable sources constant would impede on economic growth by 0.013%. From the above we conclude that the positive signs of the elasticity of electricity production from renewable sources and the negative sign of the elasticity of electricity from non-renewable sources corroborate with what we expected as hypothesised at the introduction.

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Therefore electricity production has a positive relationship with economic growth depending upon the source of electricity production in Cameroon. Yet we want to be sure if there is causality between these variables of interest and economic growth in Cameroon, so we proceed with the granger causality test. The results are on table 8, from which we conclude that there is no causality between electricity production and economic growth in Cameroon. But there exist unidirectional causality going from GDP to electricity production from non-renewable sources. The test of causality shows that it is national output that causes electricity production from non-renewable source, meaning that the country needs to use a good portion of its output to convert into electricity of non-renewable sources, thereby playing as a counter force to economic growth.

Conclusion and recommendations

The main objective of this study is to question the contribution of electricity production on economic growth in Cameroon between 1975 and 2013. From the ongoing, it is evident that globally taken electricity production contributes significantly and favourably to economic growth in Cameroon.

Therefore it should be reminded that electricity is being produced from two main sources in Cameroon (Electricity production from oil sources and Electricity production from renewable sources). Our results show that electricity produced from oil sources impact significantly and negatively on growth in Cameroon, while electricity produced from hydroelectricity plan (Electricity production from renewable sources) significantly and positively impact on economic growth in Cameroon.

Though electricity production significantly impact on economic growth in Cameroon, we found that it does not cause economic growth. The causality goes instead from economic growth to electricity production from non-renewable sources, proving that the government of Cameroon is under using its resources by allocating a consistent portion of its national output to produce electricity from non-renewable sources, which in return contributes to deter economic growth in the country. This conclusion and remarks drive us to recommend to policy makers to reduce resources allocated to the production of electricity from oil sources and convert it into investment on solar energy which is abundant and less costly to be produced in Cameroon. It has been noticed that Electric power transmission and distribution losses for the past three decades has been accounting for an average of 14% of electricity production in Cameroon, this should be reduced. To be done, the electricity distribution and transportation department should work to reduce these losses by using well adapted cables and logistic materials for transportation purposes; and also to constantly checking the plants and machineries (such as poles and cables, transformers etc.) in such a way as to replace them as soon as before they start showing signs of complete worn out. Most importantly the electricity regulation board from its French acronym (*Agence De Régulation De L'énergie Électrique*) should make a path way in such a way that the electricity company and to a larger extend the government should invest in the extension of electrification lines into rural areas in other to connect these areas to the grid.

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At last but not the least we recommend that the cost of domestic electricity which cost about 50% more as compare to unit cost of industrial connectivity should be reduced, in other to enable the rural population and the greatest portion of the population to have access to electricity, which would definitely improve standard of living and create more jobs among youths.

Due to this we expect that since the government of Cameroon is claiming to work in other to boost economic growth in other to be two digits in the coming years such as to become an emerging economy is a near future, it has to augment its production of renewable electricity such that the percentage increase in production should be around 5%.

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ISSN- 2410-4191