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EMPIRICAL ANALYSIS AND FORECAST OF ELECTRICITY DEMAND IN WEST AFRICAN ECONOMIC AND MONETARY ZONE: EVIDENCE FROM PANEL ADRL MODELLING

DRAMA Bedi Guy Hervé[1]

[1]*Department of Economics, University Peleforo Gon of Korhogo, Republic of Cote d'Ivoire*
Email: dramsiben.upgck@gmail.com

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ABSTRACT

The present research work aims at analyzing on one hand, the residential demand of electricity and on the other hand forecasting it. The research involves a four-country panel from the West African Economic and Monetary Union (WAEMU) over the 1991-2016 periods. The outcomes of the ADRL modelling according to the PMG estimation show an existing long term relationship among the housing demand of electricity, the energy price, and the populations' income and its growth. Those results also show that the consumers' electricity demand is inelastic compared to the price but it is elastic in comparison to their incomes. The long term elasticity superior to the short term one shows that consumers' reactions to the change of price and revenue are observable through times. Concerning the forecasting of the residential electricity demand, the results of the evaluation from the RMSE criterion of the predictive capacity of the homogenous and heterogeneous estimators show that the homogenous estimators provide better forecasting for the residential electricity demand in the WAEMU areas.

Contribution/ Originality: This study contributes in the existing literature by analyzing the residential demand of electricity and on the other hand forecasting it. The paper's primary contribution is finding that long term elasticity superior to the short term one shows that consumers' reactions to the change of price and revenue are observable through times. In addition, the study reveals that he homogenous estimators provide better forecasting for the residential electricity demand in the WAEMU areas.

1. INTRODUCTION

Previous research works about the residential electricity go back to Houthakker *et al.* (1974). The interest in studying the residential electricity demand at that precise moment is justified by the necessity of electricity for households as it heavily contributes to the well-being of families. The particularity of electricity in households lays on a couple of major characteristics. First, it is economically impossible to stock electricity in important quantities. Secondly, in the course, electricity can only be distributed by sharing firms. Then, consumers cannot resell their acquisitions. From that standpoint, any problem related to electricity demand could be quite from the well-being economy (Houthakker, 1951). The residential demand of electricity or the electricity demand in households constitute the demand of resident particular people such as households, private persons, organizations and professionals (Thioune, 2015). Since then, analysis about electricity demand is at the chore of energetic debates all around the world and interest a great number of economists. Those latter seek generally to analyze the determining elements of electricity demand or the energetic efficiency; to find the optimal price scale in the electricity domain and to analyze the link that exists between electricity consumption and economic growth. If the consumption of electric energy represents so much interest in economic analysis, that is surely because of its great importance in the world development process since the industrial revolution at the end of the eighteenth century. In fact, the industrial revolution is characterized by a tremendous acceleration of the economic growth, the consumption rate and so on. Those facts deeply overwhelm Western Europe countries (Thioune, 2015). According to Hounkpatin (2013) the available electric energy in sufficient quantity and quality in a given country constitute a determinant factor of its economic and social development; it brings comfort and well-being in households, favors the artisanal development of Small and Medium size Business (SMB) and industries. It also favors the development of administration services along with agriculture and that all allowing a very interesting economic growth of the country in balance with its population growth. Unfortunately, it is evident enough to remark that until today, access to electricity remains a major problem in Africa, though the continent overflows with enormous potentials in natural resources. A survey from the African Development Bank (ADB) shows that around 39% of total energy consumed in sub-Saharan Africa is imported against 19% of world average (African Development Bank Group, 2006) Moreover, sub-Saharan Africa has got the world lowest electrification rate with only 26% International Energy Agency (IEA) (2006) and Wolde-Rufael (2009). Especially in West Africa, just as agricultural raw products, energetic resources are very abundant and they should have been contributing to the improvement of people's well-being. Among those resources we can quote petrol, natural gas, an excellent potential in hydraulic, solar and wind-powered energies. That is what is called mix-energetic.

The consumption of electric energy per inhabitant coming from all those resources is sometimes linked to the economic and social development level of a given country (Djezou, 2013). Though endowed with all those resources, people's access to electricity in Africa, particularly in the WAEMU area remains a current problem to be faced. For example in 2009, 175 million Africans, out of 300.7 million did not have access to electricity; that is around 25% in rural areas and 75% in urban areas (Seck, 2015). That analysis becomes even more alarming when one remarks that the population of that area grows at an exponential rate (around 103 million in 2012, 110 million in 2014, and 116 million inhabitants in 2016) (World Development Indicator, 2017) and brings about an increasing of electricity demand. That is certainly the main cause of an electricity consumption multiplied by 2.3 while the Gross Domestic Product (GDP) is multiplied by 1.6 over the 1980-2000 periods (Sokona and Thomas, 2002). Those energetic challenges faced by WAEMU countries have driven regional organizations and political authorities to lead several projects and to elaborate numbers of policies to solve those energetic issues mainly the problem of power cut and that low access to electricity. For the regional cooperation, there has been the development of some interconnections such as the West African Power Pool. There are several networks of the distribution and production of electricity but they are limited in terms of joined power and there is just a little connection between them. Then, the limits of the policies essentially based on the offer (extension of networks) in electricity sub-sectors have called the governments' attentions on the kind of needs and then on that of electricity (Sarr, 2005). The changes of the price of oil products and those of natural gas, an electricity production particularly provided by thermal energy (76% of the total production) toughen also the access to electric energy in the countries from the said area. As electric energy cannot be stocked but as it is transferable, the inequalities of access to electricity among countries, the limits of regional inter-connection projects are somehow any arguments that drive to the following questions: What is the movement of the electricity demand in the WAEMU area? How could one forecast the demand in electricity for an offer improvement of the WAEMU area? Hence, the main goal of the present study is to analyze the movement of the electricity demand and to forecast it. More specifically, we look forward to: a) Analyzing the movement of the electricity demand in the WAEMU area; b) Analyzing the forecasting capacity of the different estimators (homogenous and heterogeneous) for the demand of electricity in the WAEMU area. The remaining of the analysis is organized as following: the literature review in the second part; in the third part the modelling specification, the methodology used and the data source are introduced. The fourth part will be dealing with the analysis and the interpretation of the empiric results; eventually the implications of the economic policies are highlighted in the conclusion.

2. LITERATURE REVIEW

There is an abundant literary production about the thematic of energetic demand. Most studies on the need of energy put it in relationship with the economic development (Stevens, 2000). Facts and time arrived to depict that the recourse to econometrics allows a better appreciation of that complex issue about the relationship energy-development by qualifying some actions and favoring the involvement of shocks since the technical-economic critic. According to the empirical point of view, there two widespread actions. The very first one consists in a double-varied or multi-varied analysis from the panel's data or from individual temporal series based on the theory of cointegration and that of stationary conditions which has come back. Then, Al-Azzam and Hawdon (1999) have been studying the elasticity of energetic demand by using annual data going from 1968 to 1997 in Jordan. The long term relationship among the consumption of energy, the annual revenue, the real price of energy and the building activities show the elasticity of the price is comprised between -0.22 and -0.08 so do the elasticity of pocket revenues of 1. One finds the same results for the elasticity of the revenue but the elasticity of the price is in order of -0.16 for Holtedahl and Joutz (2004) whose studies pertain to the residential electricity demand in Taiwan from 1955 to 1996. For a period that goes from 1980 to 1999, Saed (2004) gets the elasticity-price and revenue respectively -1.14 and 1.15 in Jordan. Vita (2006) show the existence of a cointegration relationship among the consumption of energy, the real GDP and the temperature. They obtain in the course some elasticity-price and revenue respectively of -0.3 and -1.3 from 1990 to 2002 in Namibia. The consumption of energy is then elastic compared to the revenue but inelastic in comparison to the price. On the contrary, an analysis on the microeconomic data in India shows that the electricity demand is inelastic in comparison to the price and to the revenue during three seasons (monsoon, summer and winter) and that the variables related to households, to the population and the geography are significant in determining the electricity demand (Filippini and Pachauri, 2004). With the help of a cointegration test in panel, proposed by Pedroni (2001); Al-Rabbaie and Hunt (2004) have found some price and revenue-elasticity of 0.96 and -0.09 for 17 countries in the OECD from 1960 to 2000. Other studies use modern econometrical techniques for estimating the price and revenue-elasticity of energetic demand (Medlock and Soligo, 2001). In that train (Galli, 1998) remarks a decrease of the energetic intensity due to economic growth of 10 Asian countries by considering a quadratic form of the energetic demand equation that often presents a U relationship as underlined by Bethem and Romani (2009). But that result is contradictory to the ones got by Bethem and Romani (2009) when they were studying the relationship among the energetic demand, the revenues and the prices in 24 countries out of the OECD from 1978 to 2003 by using a linear form. They also find that the price-elasticity of the demand in energy increases with the price level just as the revenue-elasticity is with the revenue level. Then, it clearly comes out that the elasticity is disparate from a country to another one depending on the analysis period and the estimation technique used. Considering the non-linear characteristic of the relationship between the energetic intensity and the Gross Domestic Product, Djezou (2013) remarks that there exists a revenue from which the energetic intensity increases evidently just after a decrease. That fact finds explanations in the fact that at very first steps of the development, economies consume less energy as they are essentially turned towards agriculture. But at an advanced level, they intensify their energetic consumption by a unit of produced goods hence the idea of a U curve as the function of energetic intensity stated by Bethem and Romani (2009). However, Galli (1998) showed the contrary by proving a non-monotone relationship between the energetic demand and the revenue. By analyzing the relationship between the consumption of energy and the economic development in seven sub-Saharan african countries, Loesse (2010) shows from two econometrical standpoints that of Gregory and Hansen (1996a; 1996b) and that of Toda and Yamamoto (1995) that the consumption of electric energy is cointegrated to the economic growth in a state of structural rupture in 5 countries: Cote d'Ivoire, Ghana, Nigeria, South Africa and Cameroon. Generally, that structural rupture is attributed to the structural adjustment policies which negatively and deeply impacted most of those countries. The errors corrections model shows that the economic development has a long-term significant and positive impact on the energy consumption before 1988, while that effect appear to be negative after the rupture for South Africa and Ghana. The second approach uses the VAR (vector autoregressive) model and Granger causality that allow discovering the sense of that causality between two or several variables which are generally the GDP and the energy consumption. In that same train, Kraft and Kraft (1978) find the existence of a unidirectional causality going from the GDP towards the energy consumption. That sense of unidirectional causality is also found by Masih and Masih (1998) in Taiwan and South Korea. Jumbe, also finds in Malawi a unidirectional causality of the GDP to the consumption of energy. That means that a permanent variation of the GDP causes a variation of the consumption of electricity in the same sense. That hypothesis is supported by Zamani (2007) when he analyzes the relationship between economic activities and the consumption of electricity in Iran from 1967 to 2003. Moreover, other research works show that unidirectional causality is rather in the opposite sense. It is in that sense that Wolde-Rafael (2004) shows that, that unidirectional causality goes from the consumption of energy to the GDP starting from disintegrated data on the consumption of energy in Shanghai and in Benin respectively from 1952 to 1999 and from 1971 to 2002. The research led by Narayan and Singh (2007) drives also to a long-term unidirectional causality of the energy consumption towards the GDP in the relationship between the electricity consumption, the GDP and the labor factor in Fiji from 1971 to 2002. More recently, Khobai (2017) analyzes the causality relationship between the electricity consumption and the economic growth in the BRICS countries from 1990 to 2014. Kao and Johansen-Fisher's panel cointegration techniques reveal a long term relationship between the variables. To say it better, those results throw light on a unidirectional causality which starts from the economic growth to a long term consumption of electricity. The production of carbon dioxide and urbanization has been included as supplementary variables to form a multivaried setting. Albiman *et al.* (2015) and Khobai *et al.* (2017) found that same sense of causality by using (Toda and Yamamoto, 1995). In another side, Okey (2009) related to the WAEMU countries indicates that a long term causality between the growth of the GDP and the demand of energy is rather bidirectional. That bidirectional causality between the development and the consumption of energy are also dealt with in the analysis of Loesse (2010) in Cote d'Ivoire from 1970 to 2007 with a rupture point in 1988. Frauke (2011) find from the causality tests, the presence of a bidirectional relationship between the economic growth and the consumption of energy for OECD countries from 1981 to 2007 with an elasticity of the energetic demand compared to the price. Besides, other methods are also found and they are generally based on simulations and optimization modellings. Urban *et al.* (2007) makes a list of some of them said to be appropriated for developing countries: LEAP[1], MESSAGE[2], WEM[3]. Those modelling take into account 4 main scenarios which are: *The "Business As Usual"* which reproduces the regional and directive plans; *the scenario for promoting renewable energies* in the mix-electric; and *the scenarios of offer efficiency* which analyzes the impact of energetic efficiency measures on food systems. For example Ouedraogo (2016) holds a simultaneous analysis the offer and the demand of electricity in Africa by using scenarios-based approaches and by applying the theory developed by Schwartz in the LEAP context. The results of the scenarios that take into account the offer and the demand show a 4% rise of the

[1]LEAP (Long range Energy Alternatives Planning System). Key Characteristics: accounting framework, scenario-based, integrated energy-environment model-building tool. Scope: energy demand, energy supply, resources, environmental loadings, cost-benefit analysis, non-energy sector emissions.

[2]Model Energy Supply Strategy Alternatives and their General Environmental impact.

[3]World Energy Model

electricity demand until 2040; a lack of provisions and severe greenhouse gas emissions. Unlike the involvement of economic and policies extolling the exploitation of renewable resources for the future electrification of regions, the scenarios of renewable resources did not emerged as the best solution to a lasting electrification in Africa. The low access to the modern energy (services) is seen as a lack to be filled for the growth of African economies. The projections of the rates of population growth and that urbanization supposed to be growing will certain drive a larger demand of electricity. Then, according to Ceteris Paribus, the energetic shortages could become more severe.

3. SPECIFICATION OF APPLIED METHODOLOGY MODELLING AND DATA SOURCES.

3.1. Specification of the Modelling and the Applied Methodology.

The choice is put on a dynamic formulation of the residential demand of electricity for taking into account the adaptation delays, the consumption habits and the technical and habitual roughness techniques. Next, the demand of energy of the *t* year depends not only on the revenue and on the price of the *t* year but also on the passed values of those variables (Mairet, 2009). The demand of electricity is estimated through a modelling of linear dynamic regression taking into account the mechanisms of the error correction and those of partial adjustment $ADRL(p,q)$ on the panel composed of the WAEMU countries. The problem that is dealt with here drives to keep in mind the basic theoretical modelling, that of Maddala *et al.* (1997) reoriented by Baltagi *et al.* (2002) on panel data. That modelling of linear and dynamic regression is even derived from that proposed by Alogoskoufis and Smith (1991). Following that general modelling of linear and dynamic regression, we consider a function of electricity demand (consumption of electricity) near that of Maddala *et al.* (1997) in United States. That function is estimated for a panel of countries from the WAEMU area by integrating a new variable pertaining to demography which is the rate of population growth. That function first becomes:

$$C_{it} = \alpha_0 + \alpha_1 CP_{it} + \alpha_2 Y_{it} + \alpha_3 OP_{it} + \alpha_4 PG_{it} + \varepsilon_{it} \tag{1}$$

Where C_{it} represents the residential consumption of electricity in Kilowatt-hour by inhabitant per year for each country. CP_{it} is the subscript of the prices to the proxy consumption of the residential price of the proxy energy (Asafu-Adjaye and Mahadevan, 2007; Djezou, 2013) knowing the unavailability of the electricity price in the WAEMU areas.

Y_{it} is the Gross Domestic Product per inhabitant that measures the medium revenue of the agents of an economy. OP_{it} is the oil price per liter at the pump. That variable is taken into account in the modelling of energy consumption since the shock that constituted its rise from 1973 to 1974. PG_{it} is the population growth rate covering the countries involved in the analysis without regard to the inhabitants' citizenship. The PG_{it} variable is broken down for taking into account the geographical situation of the populations involved in the present analysis.

Then we do get:

$$PG_{it} = PG.ub_{it} + PG.ru_{it} \tag{2}$$

Where $PG.ub_{it}$ and $PG.ru_{it}$ represents respectively the annual urban growth rate and the annual rural growth rate.

So by incorporation of logarithm, we obtain equation 3 as follow:

$$LnC_{it} = \alpha_0 + \alpha_1 LnCP_{it} + \alpha_2 LnY_{it} + \alpha_3 LnOP_{it} + \alpha_4 LnPG_{it} + \varepsilon_{it} \tag{3}$$

As we know economy policies display their impact on macroeconomic variables applications in a delay of a specific time interval. Therefore in this paper, ARDL procedure, which is a cointegration method and developed by Pesaran and Shin (1995) and Pesaran *et al.* (1997) was utilized to examine the lagged values based on theoretical and empirical research. Pesaran and Smith (1995) examine the use of autoregressive distributed lag (ARDL) models for the analysis of long-run relationships when the underlying variables follow for some conditions. According to the study of Pesaran and Shin (1997) the following basic $ADRL(p,q)$ model is written as:

$$Y_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{p} \theta_i Y_{t-i} + \beta' X_t + \sum_{i=0}^{q-1} \beta_i' \Delta X_{t-i} + u_t \tag{4}$$

$$\Delta X_t = P_1 \Delta X_{t-1} + P_2 \Delta X_{t-2} + \ldots + P_i \Delta X_{t-i} + \varepsilon_t \tag{5}$$

Where X_t is the k -dimensional $I(1)$ variables that are not cointegrated among themselves, u_t and ε_t are serially uncorrelated disturbances with zero means and constant variance-covariance, and P_i are $k \times k$ coefficient matrices such that the vector autoregressive process in ΔX_t is stable. This panel being thus constituted in equation (3), we propose the dynamic panel linear model based on the following ARDL-ECM equation (6) as follows:

$$\begin{aligned}\Delta LnC_{it} &= \alpha_0 + \alpha_1 LnC_{it-1} + \alpha_2 LnCP_{it-1} + \alpha_3 LnY_{it-1} + \alpha_4 LnOP_{it-1} + \alpha_5 LnPG.ub_{it-1} + \alpha_6 LnPG.ur_{it-1} \\ &+ \sum_{i=1}^{k} \gamma_{1ip} \Delta LnC_{it-p} + \sum_{i=1}^{k} \gamma_{2ip} \Delta LnCP_{it-p} + \sum_{i=1}^{k} \gamma_{3ip} \Delta LnY_{it-p} + \sum_{i=1}^{k} \gamma_{4ip} \Delta LnOP_{it-p} + \sum_{i=1}^{k} \gamma_{5ip} \Delta LnPG.ub_{it-p} \\ &+ \sum_{i=1}^{k} \gamma_{6ip} \Delta LnPG.ur_{it-p} + \varepsilon_{it-1}\end{aligned}$$

(6)

Note that the lag length k can be estimated utilizing the BIC or AIC (Stock and Watson, 2003). In the present study, apart from considering the traditional determinants of the electricity demand which are the revenue and the prices, we integrate the population growth, allowing to formulate the following hypothesis: H_1: consumers' reaction just after a change of price or revenue is spread through time. H_2: The homogenous estimators produce the best performances of prevision for the residential demand of electricity in the WAEMU area. Before performing cointegration methodology it's important for us to determine the order of integration. In so doing we will use panel unit root by taking in to account first and second generation panel unit root tests. More details will be given in the next section.

3.2. Data Sources

The data which are used here in the course of that analysis are annual and stem from the WDI (2017) database from 1991 to 2016. They take into account four countries out of eight from the WAEMU area for instance Benin, Senegal, Ivory Coast and Togo considering the unavailability and the insufficiency of data related to the other countries of the said area.

4. EMPIRICAL RESULTS AND INTERPRETATIONS

4.1. Empirical Results

In a chronological order, we will begin by cross-sectional dependence tests that will allow choosing the appropriate stationarity test or the test of unit root and we will at last reach the cointegration tests for checking the existence of a long and short term dynamic between the different variables of our modelling depending on the panel's data methodology. The literature related to the tests about the panel's data is very vast and is still growing. In fact, beyond the issue of heterogeneity in the difficulties which the panel's data modelling face, another problematic remains central: the involvement of the possible cross-sectional dependence (Hurlin and Mignon, 2005). That cross-sectional dependence could be shown through the diverse phenomena like ignored common effects, common shocks among variables or rather through a spatial dependence. Several tests have been then proposed, like the ones by Breusch and Pagan (1980); Pesaran (2004); Friedman (1937) and Frees (1995). So, the present analysis will lean on the test of individual dependence and multiplier of Lagrange proposed by Breusch and Pagan (1980) rather than that of Pesaran (2004) considering the structure of our data (N<T): a short number of cross-sections (N=4) and a larger temporal dimension (T=26). The results are shown in the chart 1 below.

Chart-1. Dependence Test of Breusch and Pagan (1980)

Test	Statistic	d.f	Prob.
Breusch-Pagan LM	123.3976	6	0.0000*
Pesaran scaled LM	32.73508		0.0000*
Bias-corrected scaled LM	32.65508		0.0000*
Pesaran CD	11.09643		0.0000*

Notes: * indicates the rejection of the null hypothesis of interindividual independence at the 1% level.
Source: Own computation from the data used in the regression

Secondly, we introduce the Multiplier dependence test of Lagrange proposed by Breusch and Pagan (1980) which aims at checking the null hypothesis according to which the interindividual residues are not correlated. It is more efficient that the one performed by Pesaran when the individual dimension is inferior to the temporal dimension. The rejection of the null hypothesis shows the presence of an interindividual dependence. Let's consider a linear modelling of panel's data:

$$y_{it} = \alpha_i + \beta_i x_{it} + u_{it} \tag{7}$$

Noting that $\hat{\alpha}$ and $\hat{\beta}$ are the estimators of the equation (6) we get:

$$e_{it} = y_{it} - \hat{\alpha}_i - \hat{\beta}_i x_{it} \tag{8}$$

The estimators Φ_{ij} of the correlation are given by:

$$\Phi_{ij} = \Phi_{ji} \frac{\sum_{t=i}^{T} e_{ij} e_{ji}}{\sqrt{\sum_{t=1}^{T} e_{it}^2 \sum_{i=1}^{T} e_{ji}^2}} \tag{9}$$

Breusch and Pagan (1980) propose the following statistic:

$$CM_{\mathrm{Im}} = \sqrt{\frac{1}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\Phi}_{ij}^2 - 1) \right) \tag{10}$$

The results are shown in the chart 2 that follows.

Chart-2. Results of Lagrange Multiplier proposed by Breusch and Pagan (1980)

Test	Statistic	d.f	Prob.
Breusch-Pagan LM	137.9382	6	0.0000*

Notes: * and** indicates the rejection of the null hypothesis of interindividual independence at the 1% and 5% level.
Source: Own computation from the data used in the regression

The results (probability inferior to 5%) of that test allow a rejection of the null hypothesis. Then, there is the existence of an interindividual dependence.

Thirdly, Hurlin and Mignon (2005) sustain that the tests of unit root on panel's data are in fact more powerful than their analogue with time series in small samples. Considering the particular way, they eliminate the structural dependence factors, and the way they aggregate individual information, two types of unit root tests are sorted. Those of the first generation and those of the second one. Among the tests of the first generation, there are those by Breitung (2000); Levin *et al.* (2002); Hadri (2000); Im *et al.* (2003); Choi (2001). Those tests lay on the notion of inter-dependence between the people who compose the panels without taking into account the common temporal effects; that is somehow unrealistic in empirical analysis and could drive to the appearance of biases during the analysis Hurlin and Mignon (2005). Unlike the tests of the first generation, the tests of second generation take into account the dependence that could exist among the individuals of a given panel. Among the tests of unitary root of the second generation, there are the tests proposed by Bai and Ng (2004); Choi (2002); Pesaran (2003); Moon and Perron (2004); Pesaran (2007). The difference between those tests dwells on the method used to extract from the raw series the idiosyncratic and unobservable component. The tests of second generation of unit root are preferred to the first as soon as the presence of a cross-sectional dependence is remarked. The results of those tests are comprised in the charts 3a and 3b below.

Chart-3a. Cross-sectional Augmented Dickey Fuller (CADF) Unit Root Test (Pesaran, 2003): *with trend*

	Level		First Difference	
Variables	**Z-t-bar**	**p-value**	**Z-t-bar**	**p-value**
LnC	-0,456	0,324	-3,868	0,000*
CP	0,719	0,764	-3,786	0,000*
LnY	1,798	0,964	-2,7	0,003*
LnOP	-1,788	0,037**	-3,594	0,000*
LnPG.ub	-4,603	0,000*	-2,766	0,001*
LnPG.ru	-2,815	0,002*	-3,114	0,003*

Notes: * and ** denote respectively significance at the 1% and 5% level. The rejection of the null hypothesis (p-value <5%) indicates the absence of a unit root.
Source: Own computation from the data used in the regression

Chart-3b. Cross-sectional Augmented Dickey Fuller (CADF) Unit Root Test (Pesaran, 2003): without trend

	Level		First Difference	
Variables	**Z-t-bar**	**p-value**	**Z-t-bar**	**p-value**
LnC	0, 304	0,620	-4,919	0,000*
CP	0,289	0,614	-4,180	0,000*
LnY	0,738	0,770	-3,129	0,001*
LnOP	-0,883	0,189	-4,833	0,000*
LnPG.ub	-1,346	0,089	-2,910	0,002*
LnPG.ru	-3,983	0000*	-4,827	0,000*

Notes: * and ** denote respectively significance at the 1% and 5% level. The rejection of the null hypothesis (p-value <5%) indicates the absence of a unit root.
Source: Own computation from the data used in the regression

Fourth, for checking the presence of a long term relationship between the variables, we have choses the cointegration tests of Kao (1999) and Pedroni (1999). Their tests are based on the residues and are built on the basis of the tests produced by Engle and Granger (1987) that are their analogue in the domain of temporal series. Nevertheless, those tests are all the same so powerful when there is a good estimation of the residues beforehand. Kao's test matches best for in cases of a low size of the N sample compared to the one of the temporal dimension. The outcomes are shown in the charts 4a and 4b below.

Chart-4a. Kao Panel Cointegration Results.

	t-Statistic	**Prob.**
ADF	-3.317701	0.0005*
Residual variance	0.006066	
HAC variance	0.003130	

Notes: * and ** indicates the rejection of the null hypothesis of non-cointegration respectively at1% and 5 significance.
Source: Own computation from the data used in the regression

Chart-4b. Pedroni (1999) panel Cointegration Test

Alternative hypothesis: common AR coefs. (Within dimension) Weighted

	Statistic	**Prob.**	**Statistic**	**Prob.**
Panel v-Statistic	0.328295	0.3713	-1.315528	0.9058
Panel rho-Statistic	0.188926	0.5749	0.211533	0.5838
Panel PP-Statistic	-3.684605*	0.0001	-1.919692	0.0274
Panel ADF-Statistic	-3.200065*	0.0007	-0.894075	0.1856

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	**Prob.**
Group rho-Statistic	0.881451	0.8110
Group PP-Statistic	-7.447070*	0.0000
Group ADF-Statistic	-2.966464*	0.0015

Notes: * and ** indicates the rejection of the null hypothesis of non-cointegration respectively at1% and 5% Significance.
Source: Own computation from the data used in the regression

Fifth, for forecasting tests, our estimations are realized by the means of the estimators of error corrections proposed by Pesaran and Smith (1995) and Pesaran *et al.* (1999) in literature that's the estimators Mean-Group[4] (MG) and Pooled Mean-Group[5] (PMG). Those estimators are said to be efficient for the estimation of a cointegration relationship on a panel's data and lay on the estimation of dynamic autoregressive modellings with lag value; that fact supports our choice for them in conducting the present research. More recently, Pesaran and Smith (1995) and Pesaran *et al.* (1999) have proposed the PMG estimator that combines the means techniques, and the "pooling". That intermediary estimator is built with a hypothesis of short term heterogeneity of coefficients including the constants, the adjustment speed to the long term balance values and to the errors of variances to be

[4] See Pesaran and Smith (1995) for details.

[5] See Pesaran and Smith (1995); Pesaran, Shin and Smith (1999). for details.

heterogeneous from country to country and homogeneity of long term slop coefficient. Then, long term coefficients are non-linear combinations of short term coefficient. Accordingly, Hausman's (Hausman, 1979) joint test is done and the results allow accepting the null hypothesis the "Pooled Mean Group" estimator is efficient against the alternative hypothesis according to which the "Mean Group" estimator does not match. Then, for the rest of our estimations, we choose the PMG estimator. The chart 5 explore the results

Chart-5. Estimation **PMG** de l'équation de la consommation résidentielle d'électricité

	$D\ln C$	Coeff.	Std. Error	T.Statistics	P.Value
	LnCP	0.3574	0.0668	5.3500***	0.0000
	LnY	1.2825	0.1819	7.0500***	0.0000
Long Run	*LnOP*	0.1671	0.0277	6.0400***	0.0000
MCO*	*LnPG.ub*	0.0926	0.5557	1.6700*	0.095
	LnPG.ru	-0.0814	0.0434	-1.870*	0.061
	ECT	-0.7216	0.0790	-9.13***	0.000
	DLnCP	-0.0105	0.0143	-0.73	0.463
Short Run	*DLnY*	-0.4267	0.4020	-1.06	0.289
ECM*	*DLnOP*	-0.0310	0.0259	-1.20	0.230
	DLnPG.ub	0.1962	0.1021	1.92**	0.055
	DLnPG.ru	-0.1894	0.1933	-0.98	0.327
	Cons	-3.9477	0.3639	-10.85***	0.000

Test joint d'Hausman (PMG=0.863)

Note: The asterisks *, **, and *** denote statistical significance at 1%, 5%, and 10% levels. The error correction term is depicted by ECT .
Source: Own computation from the data used in the regression.

At last, we compare the "out-of-sample" forecasting performance of the heterogeneous[6] and homogenous[7] estimators by applying them to the analyzed demand of electricity. The comparison of the forecasting performance of those estimators real forecasting; and we use the Root Mean Square Error (RMSE)[8] as comparison criterion. The estimator that holds the lowest RMSE is the most efficient in terms of « out-of-sample » forecasting.

4.2. Interpretations of the Empirical Results.

The results of cross-sectional dependence tests (probability inferior to 5%) allow to reject the null hypothesis and to conclude that there is an individual dependence (Chart 1 and 2) above. As the cross-sectional dependence has been put forward in our analysis, it is then logical that we lean on of the tests of second generation, particularly that of Pesaran (2003) in the course of the study. The results of the unit root tests from the statistic by CADF (Cross section Augmented Dickey Fuller) of Pesaran (2003) drive to a rejection of the null hypothesis of unit root for the whole panel but at the first difference. The variables are all integrated in order one (see chart 3a and 3b). As our different series are stable and as they follow the process $I(1)$, we are able to conduct the cointegration tests of the panel. The results of those tests allow rejecting the null hypothesis of cointegration. Then, there exists a long term relationship between the consumption of electricity and its determinants. The results of the cointegration tests held by Pedroni (1999) confirm that long term relationship (see chart 4a and 4b). As the cointegration was formerly shown, we can estimate our long and short term modelling of linear and dynamic

[6] See Hsiao (1986) for details.

[7] See Swamy and Arora (1972) for details.

[8] See Bouthevillain and Mathis (1995a; 1995b).

regression with lag value $k=1$ for getting the dynamic settings of long and short term. From the results of that estimation by the PMG (chart 5), it comes out that the electricity price influences positively and significantly the consumption of electricity per inhabitant, meaning that a 1% rise of the electricity price brings about an increase of the consumption of 0.36%. Although the electricity price in kWh and its consumption per inhabitant grow in the same direction and the consumption of electricity grows less proportionally in comparison to the price. As the price elasticity (0.36) is inferior to 1, the demand of electricity measured by the consumption is then inelastic compared to a long term price. The demand is not so sensible to the price variations. The residential price of oil significantly explains the consumption of electricity on the brink of 5%. A 10% increase of the oil residential price at the pump drives to a 1.67% rise of the electricity demand. The price of oil cannot be directly linked to the variations of the consumption of electricity but as oil is an important factor in the process of production of electricity, the changes of the said price bring about supplementary costs for the producers. It is that change of the price of production cost that affects the demand in the market system. That result confirms the inelasticity of the residential demand of electricity compared to the price. Electricity could be then being a first range necessity. Just as the residential prices of electricity and oil, the revenue positively and significantly impacts the consumption of electricity. A 1% rise of the revenue drives to a 1.28% increase of the electricity demand. That large elasticity (1.28>1) drives to consider electricity, according to the logic of the revenue, as a luxury because a rise of the revenue causes an inappropriate increase of the electricity demand. Those results match with those shown in literature mainly with that of Babusiaux (2001) who finds a price-elasticity close to 1 or superior to 1 mainly in developing countries. The rates of the urban and rural population growth become significant just on the brink of 10%. While the rural growth rate negatively explains the electricity demand, the urban growth rate provides a rather positive explanation. An increase of the rural population of only 1 point of percentage brings about a 0.08% decrease of the consumption of electricity while a rise of only one point of percentage of the urban population brings about a 0.09% increase of the electricity demand. The results of the estimation of the error correcting modelling show that the coefficient associated to the recall strength is negative (-0.7216) and significant on the brink of 5%. Then, there is an error correction adjustment mechanism. Furthermore, we can infer that the deviations in comparison to the long term solution drive to short term evolution of the electricity consumption or the other variables of explanation of the modelling so as to force the system to converge towards its long term equilibrium. That value of the recall coefficient represents the adjustment speed according to which any unbalance between the expected levels and the number of electricity consumption is resorbed during year (Keho, 2013). From that standpoint, around 72.16% of the balances of consumption compared to its long term level are corrected the following year. That means that a shock observed during a year is totally resorbed at the end of approximately one year and 4 months (1/0.7216). We can also remark that all the price-elasticity of the long term demand is superior to the ones of short term in the eyes of the microeconomic theory. The second law of the demand is then acknowledged. When too much time is left after a change of price, the effect on the demand variations become more severe. Accordingly, we estimate the long term relationships that exist between the rate of the growth of the electricity consumption and its determiners from countries to countries for deepening our analysis. In all the short term equations in each country, the recalling strength is so negative and significant. The correction of errors is then proved. The country-to-country estimation shows that some variables are significant (chart 6 annex). Generally, the short term changes of variation do not have significant influence on the residential consumption of electricity in all the four countries. Only, in one country out of four, that's Senegal, that influence becomes significant on the brink of 10%. A 10% rise of the revenue could reduce the electricity consumption to 15.49%. Electricity appears then as an inferior good in the eyes of microeconomics for a short term period. That can be explained by the acquisition of sophisticated and expensive equipment materials which take less energy Gbaguidi (2010) and Percebois (2001).

The coefficients of the $PG.ru$ variable call to be significant for all the countries of the panel. The rural population growth rate justifies then the residential consumption of electricity per inhabitant. On the contrary, the direction of that influence changes depending on the country. The variations of the population growth rate hold a positive impact on the consumption of electricity in Benin and in Cote d'Ivoire but a rather negative impact in Senegal and in Togo. An increase of only one point of the percentage of the rural development rate brings about a rise of the consumption of electricity for 0.067% and 0.0773% respectively in Benin and in Cote d'Ivoire.

That could be explained by the subventions that those populations receive in the domain of electricity. As the management constraint is weaker, their consumption habit could be following a steady rise. On the contrary, a one point increase of the growth percentage brings about a decrease of the consumption for 0.7465% and 0.155% respectively in Senegal and in Togo. Unlike the rural growth rate, the urban one is not significant in Senegal. On the brink of 5%, it becomes rather significant in the equation of the residential consumption of electricity in Benin, Cote d'Ivoire and in Togo. Once more, the impact of the urban growth rate on the residential consumption of electricity differs from country to country. The rate of urban growth holds a positive impact on the residential consumption of electricity in Benin and in Togo. In Cote d'Ivoire, a one point increase of that rate brings about a decrease of the residential consumption of electricity for 0.047%. In a short term, the displacement of the rural populations towards towns brings about a new demand of electricity addressed electricity companies. But it takes time to respond to that demand (installments and subscriptions). Then there appears an increase of the population but the consumption remains the steady. The relationship consumption/inhabitant decreases. Then, it clearly appears that the evolution of the population (rural or urban) has a short term and different influence on economic agents' consumption habits. Eventually, the Swamy and MG estimators show the highest forecasting performances ranking 8th and 9th in the chart 7 (annex). That great performance from standard heterogeneous estimators is also depicted in the research works of Baltagi *et al.* (2002). That is generally due to the issue of instability in the individual regressive parameters. As far as we are concerned in the present research work, the height of the sample does not influence the performances of the forecasting of those estimators considering the former research works that sample of larger size and longer periods. The greatest part of homogenous estimators provides weakest RMSE thus they give the best forecasting on average for the residential demand of electricity in those four countries from the WAEMU area. The DF-2OLS, Within 2-OLS, and Within, are respectively ranked 1st, 2nd and 4th .The problem of endogenous issue seems not to be severe considering that ranking. The standard estimators OLS, 2OLS, and GMM work less than the former ones but better than the heterogeneous ones. In a nutshell, the homogenous estimators provide the best forecasting for the demand of electricity in the said zone.

5. CONCLUSION AND POLICIES IMPLICATIONS

Considering the results we obtained through the present research work, some economic and political implications are retained. The analysis of the habit of the electricity demand shows that the subscript of the consumption prices, the oil price and the income per inhabitant have a significant impact on the electricity demand, given that the long term elasticity are superior to the short term ones. Then, it is necessary to promote an opening to competitions in the domain of electricity in order to get more optimal price systems for bettering people's living standards in the households of all the countries of the Union. Moreover, apart from the requirements of the electricity production companies, the price scale should take into account the socio-economic features of the households. The initiatives based on the increase of the offer of electricity have to be undertaken in that growing demographic context, that context of low access to electricity, of abundant energetic resources and of flourishing development policies. At the regional level, the production of electricity and the inter-connections networks from inputs that easy the task to the countries of the Union like hydraulics, natural gas and solar systems have to be undertaken to the detriment of oil which price negatively impacts the electricity demand. In terms of prevision, the homogenous estimators provide on average the best forecasting for the four countries.

Regional policies are then welcome and it is crucial to keep implementing them as the countries show several common features in a demographical, energetic and monetary point of view. In other words, it is important to develop some modellings to plan the electric energy that take into account the realities and priorities of the areas that shelter the said populations (rural, urban, and suburban).

But, the strength and the preciseness of those forecasting can be improved if only the technicians, researchers and scientists hold trustful data about the electricity domain, at the regional and national level. For that, the regional authorities should invest in data collection, the management of information systems and they should establish a strategy for coordinating development projects by involving the companies of the domain to improve the strength of the forecasting. Eventually, a permanent analysis of the habits of the residential consumption of electricity and a good forecasting will allow elaborating better offer policies, and that will better people's living conditions and it will have a positive impact on the economic growth.

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Annex

Chart-6. Equation of residential electricity consumption in the short run for each country

Pays	Variables	Coefficients	P-value
	Cons	*-3.1405*	*0.1879*
	DLnCP	*-0.3097**	*0.002*
	DLnY	*-0.3131*	*0.6161*
BENIN	*DLnOP*	*-0.078**	*0.0049*
	DLnPG.ub	*0.1584**	*0.0006*
	DLnPG.ru	*0.0667***	*0.0187*
	ECT	*-0.54**	*0.0006*
	Cons	*-37608*	*0.2022*
	DLnCP	*0.2819***	*0.0117*
COTE	*DLnY*	*0.3506*	*0.1422*
D'IVOIRE	*DLnOP*	*-0.0073*	*0.6827*
	DLnPG.ub	*-0.0470***	*0.0378*
	DLnPG.ru	*0.0773***	*0.0035*
	ECT	*-0.6488**	*0.0001*

	Cons	*-4.8963****	*0.0778*
	DLnCP	*-0.3368***	*0.0118*
	DLnY	*-1.5492****	*0.07*
SENEGAL	*DLnOP*	*-0.0306***	*0.0019*
	DLnPG.ub	*0.2251*	*0.1052*
	DLnPG.ru	*-0.7475**	*0.0085*
	ECT	*-0.897**	*0.0001*
	Cons	*-3.9929****	*0.0774*
	DLnCP	*-0.0573*	*0.4054*
	DLnY	*-0.2031*	*0.2035*
TOGO	*DLnOP*	*0.0694***	*0.0004*
	DLnPG.ub	*0.4482**	*0.0015*
	DLnPG.ru	*-0.1550***	*0.0152*
	ECT	*-0.7994**	*0.0001*

Note: The asterisks *, **, and *** denote statistical significance at 1%, 5%, and 10% levels.
Source: Own computation from the data use in the regression.

Chart-7. Comparison of forecast performance for electricity demand

Forecast period 2011-2016		
Rank	**Estimators**	**RMSE**
1	DF-2OLS*	0,0438
2	Within 2OLS*	0,6497
3	MV**	0,6504
4	Within*	0,6518
5	2OLS*	0,6751
6	OLS*	0,8011
7	GMM*	0,8077
8	Swamy**	0,8432
9	MG**	7,7455

Notes: Asteristic* and ** represent respectively the homogeneous estimators and the heterogeneous estimators.
Source Own computation from the data use in the regression.