ELECTRICITY DEMAND AND DISAGGREGATE OUTPUT: EVIDENCE FROM BENIN

Arnaud Dakpogan, University of Stellenbosch Business School, +27846206077, 19600585@sun.ac.za
Eon Smit, University of Stellenbosch Business School, +2721 9184225, evdms@usb.sun.ac.za

Overview

The growth-electricity demand nexus has been the focus of many energy economists, especially in a global context where energy is an important variable of production. Many studies when analyzing the demand of electricity have focused on the context of countries outside Africa; significant among them are Houthakker (1951), Fisher and Keysen (1962), Hunt et al. (2003), Filippini and Pachauri (2004), Filippini (1999), Holtedahl and Joutz (2004), Narayan and Smyth (2005), Narayan et al. (2007) Galindo (2007), Halicioglu (2007), Zachariadis and Pashourtidou (2007), Sa'ad (2009). Few empirical studies (Jumbe (2004), De Vita et al. (2006), Wolde-Rufael (2006), Squalli (2007), Ziramba (2008), Babatunde and Shuaibu (2009), Kebede et al. (2010), Ekpo et al. (2011), Adom (2013), Mabea (2014), Ankrah & Ankrah (2015)) have analyzed the demand of electricity for African countries. According to the context, authors have used different methods. Some authors (Amadeh et al. (2009), Fotros et al. (2009), Zamani (2007), Arman and Zare (2005), Acaravci and Ozturk (2010), Yuan et al. (2007), Altinay and Karagol (2005), Ghosh (2002), Kraft and Kraft (1978), Yoo (2005), Zachariadis and Pashourtidou (2007), Squalli (2007), Wolde-Rufael (2006), and Ciarreta and Zarraga (2010)) have focused on the causality relationship between electricity consumption and GDP or electricity price, using Toda and Yomamoto, Engle and Granger cointegration techniques, or Autoregressive Distributive Lag (ARDL). Some of these authors included Yuan et al. (2007), Wolde-Rufael (2006) on Benin, Democratic Republic of Congo, Tunisia, Squalli (2007) on Indonesia, Nigeria and Venezuela, Yoo (2005), Ciarreta and Zarraga (2010) found a unidirectional causality relationship from electricity consumption to GDP. However Wolde-Rufael (2006) when working on Tunisia, and Ciarreta and Zarraga (2010) when working on Panel data of 12 European countries found a negative unidirectional causality relationship from electricity consumption to GDP. While no explanation was provided for the negative causality result of Wolde-Rufael (2006), Ciarreta and Zarraga (2010) interpreted the negative causality as the result of the presence of several unproductive industries in this set of European countries. Other studies included Ghosh (2002), Wolde-Rufael (2006) on Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe, and Squalli (2007) on Algeria, Iraq, Kuwait and Libya found a unidirectional causality relationship from GDP to electricity consumption. In the case of Squalli (2007) on Algeria, Iraq, Kuwait and Libya and Wolde-Rufael (2006) on Zambia, the causality was negative. Whereas these studies found all a unidirectional causality, other studies found opposite results, bidirectional causality and no evidence of causality. Significant among them are: Squalli (2007) on Kuwait who found a unidirectional causality from electricity consumption to GDP when using ARDL and the contrary when using Toda and Yomamoto cointegration techniques; Wolde-Rufael (2006) on Egypt, Gabon and Morocco, Yoo (2005) on Korea, Squalli (2007) for Iran, Qatar and Saudi Arabia who found a bidirectional causality between GDP and electricity consumption, however, in the case of Squalli (2007) on Saudi Arabia the causality was negative, and was due to the reduction in oil production which has led to a decrease in GDP; Jumbe (2004) on Malawi and Acaravci and Ozturk (2010) on 15 European countries who found no evidence of causality. All these studies demonstrated the existence or not of a causality relationship between electricity consumption and an economic variables such as GDP. However, they all have their limitations. First, with the opposite results found, it is difficult to decide on the true direction of the causality relationship; second, these studies could not provide any insight on the causality relationship between electricity consumption and disaggregate output, which can be of great importance for policy makers. No research papers on Benin have investigated the causality relationship between electricity consumption and disaggregate output and account for structural break in a country specific analysis. The current research will address this limitation**.**

Methods

Theoretical framework

An empirical consensus exists on the evidence of a positive correlation between GPD and electricity consumption. But not all authors agree on the direction of the causality relationship between these two variables. Neoclassic economists consider labor, capital and technology as factors of production. Alam (2006) indicated the necessity to include energy as one of the factors of production in addition to labor and capital. He argued in his study titled

"Economic Growth with Energy", that energy is a factor of production and contribute to growth as do capital and labor. In alignment with the work of Odularu & Okonkwo (2009), an economic growth model with energy as one of the independent variable is developed.

$$Y_t = F(E_t, K_t, L_t) \qquad (1)$$

Here, *E, K* and *L* represent respectively energy, capital, and labor. Y is output or real GDP. In this study, the variable energy (*E*) will be limited to electricity. If we assume constant elasticity and take the logarithm of equation (1) we have the following:

$$. \ Ln(Y_t) = \alpha Ln(E_t) + \beta Ln(K_t) + \gamma Ln(L_t) \qquad (2)$$

ɣ, α, and β represents respectively the output elasticity of labor (*L*), electricity (*E*), and capital (*K*). If we convert the equation (2) into its first difference, we obtain the following expression of economic growth rate:

$$\Delta LnY_t = \underset{(+)}{\alpha \Delta Ln(E_t)} + \underset{(+)}{\beta \Delta Ln(K_t)} + \underset{(+)}{\gamma \Delta Ln(L_t)} \qquad (3)$$

We can applied the equation 3 for each sector of GPD: the agricultural sector, the industrial sector, and the service sector. We expect electricity consumption to positively influence each disaggregate output variable. We will proxy capital (*K*) by the Gross Capital formation (*GCF*); because of lack of data we will not account for labor (L). We will be including exports (*X*) as a control variable. Our final equation will be as:

$$\Delta LnY(j)_t = \underset{(+)}{\alpha \Delta Ln(E_t)} + \underset{(+)}{\beta \Delta Ln(GCF_t)} + \underset{(+)}{\gamma \Delta Ln(X_t)} \qquad (4)$$

Where j represents the sectors (Agriculture, industrie, service,). The expected sign on each explanatory variable is below the equation (4).

Data gathering

We have used secondary data which consist of annual series of electricity consumption *(E)*, industrial value added *(In)*, service value added *(Se)*, agricultural value added *(Ag)*, total population, gross capital formation *(GCF)*, and exports *(X)*. The serie on electricity consumption has been collected from both the US Energy Information Administration (US EIA) and the World Development Indicators (2015) databases, while the series on disaggregate output variables *(In, Ag, Se)*, gross capital formation *(GCF)*, exports *(X)*, and total population have been collected only from the World Development Indicators (2015) database. The serie on total population has been collected over the period 1973-1979; the serie on industrial value added, service value added, agricultural value added, gross capital formation, exports has been collected over the period 1973-2014. The serie on electricity consumption has been collected over the period 1973-2012 and comprises data on per capita electricity consumption for the period prior to 1980 and data on total electricity consumption for the period post 1980. Hence we needed to convert all per capita electricity consumption into total electricity consumption by multiplying them by the total number of population. The series on disaggregate output variables *(In, Ag, Se)*, gross capital formation *(GCF)*, and exports *(X)* are in constant 2005 US dollars, and have no missing values. However, there are missing values of per capita electricity consumption *(E)* over 03 years: from 1977 to 1979. The moving average technique has been used to fill all missing values and to extend the series on electricity consumption to 2013 and 2014. Apart from total population, all series have been converted into their logarithm form. A unit root test with breakpoint has been applied to series representing each variables in order to check for their stationarity and the existence of structural break. All variables are I(1) and have different break dates. Hence, we run an autoregressive distributive lag (ARDL) model to investigate both the short and long runs relationship between electricity consumption (E) and each disaggregate output variables (Ag, In, Se).

Results

Results from the ARDL models are as follows: there is a causality relationship running from electricity consumption *(E)* to each disaggregate output (Agricultural value added *(Ag)*, Industrial value added *(In)*, Service value added *(Se)*) in both long and short runs. The most significant break dates are 1990 and 2007. During the years post 1990 and 2007 (1994, 1998, 2006, 2007, 2008, 2012 and 2013), Benin has encountered several energy crises which have negatively affected economic activities in the industrial and service sectors. The downfall of coton's exports during the years post 2007 has negatively affected the agricultural value added. We suggest that the implementation of an energy conservation policy in Benin will negatively affect growth. One of the limitation of these results is that many activities in the agricultural, service, and industrial sectors are informal while they consume electricity, so their contribution to the economy is not computed.

Conclusion:

How to compute the contribution of the informal sector to the economy remains a question to be addressed in the energy-growth nexus debate.