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Energy consumption and economic growth revisited in African countries ☆

Jude C. Eggoh [a,*], Chrysost Bangake [a,b], Christophe Rault [a,c]

[a] Laboratoire d'Economie d'Orléans (LEO), Université d'Orléans, Rue de Blois, BP: 6739, 45067 Orléans Cedex 2, France
[b] Université d'Artois & Laboratoire EQUIPPE, Lille 1, FSES, 59655 Villeneuve d'Ascq Cedex, France
[c] Toulouse Business School, France

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ABSTRACT

The aim of this paper is to provide new empirical evidence on the relationship between energy consumption and economic growth for 21 African countries over the period from 1970 to 2006, using recently developed panel cointegration and causality tests. The countries are divided into two groups: net energy importers and net energy exporters. It is found that there exists a long-run equilibrium relationship between energy consumption, real GDP, prices, labor and capital for each group of countries as well as for the whole set of countries. This result is robust to possible cross-country dependence and still holds when allowing for multiple endogenous structural breaks, which can differ among countries. Furthermore, we find that decreasing energy consumption decreases growth and vice versa, and that increasing energy consumption increases growth, and vice versa, and that this applies for both energy exporters and importers. Finally, there is a marked difference in the cointegration relationship when country groups are considered.

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1. Introduction

Although 14.1% of the world's total population lives in Africa, the continent consumed only 4.2% of world delivered energy for industrial uses in 2007 (International Energy Agency (IEA), 2010). According to the prediction of the IEA, Africa's total industrial energy use and the demand for electricity grow at an average annual rate of 1.4% and 2.6%, respectively, whilst the sub-Saharan Africa region grows by an average of 3.6% per year. In Africa, natural gas consumption has grown substantially in recent years, stimulated by increased economic activity, large investments in new infrastructure and domestic price subsidies.

Since the Earth Summit of Rio de Janeiro in 1992 and the Kyoto Protocol in 1997, which state that environmental degradation and climate changes are related to fossil energy consumption, some experts suggest a lowering of the world energy use. Developed countries fear a reduction in their lifestyle due to lower energy consumption, while developing countries, namely those emerging ones perceive this as a brake on growth.

Economic growth is among the most important factors to be considered in projecting changes in world energy consumption. In this regard, the analysis of the relationship between energy consumption and economic growth has received a great deal of attention during the past years. Indeed, whether the economic growth promotes energy consumption or whether energy itself is a stimulus for economic growth has motivated interest among economists and policy-makers. Over the last two decades, there has been a large body of published research investigating the causality links between energy consumption and economic growth. This is because the direction of causality has significant policy implications. For instance, if energy consumption is a vital component in economic growth, energy conservation policies, which reduce energy consumption, may adversely affect real GDP. However, a unidirectional causality running from economic growth to energy consumption signifies a less energy dependent economy such that energy conservation policies may be implemented with little or no adverse effect on economic growth.

Recent empirical studies on the relationship between energy consumption and economic growth in African countries failed to reach a consensus as to the direction of causation. Most of these studies have mainly used time series approaches (e.g. Wolde-Rufael, 2005, 2006; Odhiambo, 2007, 2009, 2010; Belloumi, 2009; Ouedraogo, 2010). However, one problem with the results for individual countries studies is that they are often impaired by a short data span that lowers the power of the unit root and cointegration tests. Time series analyses also have the drawback to occult structural breaks.[1] It is well-known that erroneously omitted breaks can cause deception in time series testing and the effects of structural breaks do not disappear simply because one

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* Corresponding author. Tel.: +33 2 38 41 70 37.
E-mail address: comlanvi-jude.eggoh@univ-orleans.fr (J.C. Eggoh).

[1] Gregory et al. (1994) show that, the power of conventional cointegration tests falls sharply when cointegrating relationships are subject to structural changes.

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uses panel data. Lack of careful investigation of these potential structural breaks may thus lead to misspecification of the long-run properties of a dynamical system and inadequate estimation and testing procedures (see for example Lee and Chiu, 2011; Esso, 2010; Narayan and Smyth, 2008, 2009). Indeed, the occurrence of certain events such as economic crisis, energetic crisis and structural adjustment could have affected the trend behavior of the energy consumption and real GDP. Unfortunately, the existing literature on the relationship between energy consumption and economic growth in Africa using panel cointegration ignored this aspect. This paper tries to fill this gap.

The contributions of this study are fourfold. First, we employ recently developed panel methods to test for unit roots, cointegration and Granger causality. Specifically, we employ Westerlund (2007) panel cointegration tests, which do not impose common factor restriction and solve on the problems of Pedroni's (1999) residual-based tests, being also robust to possible cross-country dependence. We also make use of Westerlund (2006) panel cointegration allowing for multiple endogenous structural breaks, which can differ among series. This last test generalizes Im et al. (2005) and assumes that the individual series are not cross-correlated. However, given that this is an overly restrictive assumption in macroeconomics, we draw our empirical conclusions using bootstrap-based critical values. This method allows us to solve another problem of Pedroni's (1999) cointegration test that cannot accommodate structural breaks.

To the best of our knowledge, such an analysis has not been performed to study the relationship between energy consumption and economic growth in African countries. Adoption of such new panel data methods within the macropanel setting is preferred to the usual time series techniques to circumvent the well-known problems associated with the low power of traditional unit root and cointegration tests in small sample sizes (as it is the case here with just over thirty five observations). Adding the cross-sectional dimension to the usual time dimension is indeed very important in the context of non-stationary series in order to increase the power of such tests. As noted by Baltagi and Kao (2000), "the econometrics of non-stationary panel data aims at combining the best of both worlds: the method of dealing with non-stationary data from the time series and the increased data and power from the cross-section".

The second contribution of this paper refers to the use of Dynamic Ordinary Least Square (DOLS) estimator. The DOLS method allows for consistent and efficient estimators of the long-run relationship. It also deals with the endogeneity of regressors and account for integration and cointegration proprieties of data.

The third contribution is to examine the causal relationship between energy consumption and economic growth for heterogeneous panel of 21 African countries within a multivariate framework by including measures of capital, labor and prices. We assume that energy consumption could affect economic growth both as a direct input in the production process and indirectly as a complement to labor and capital inputs. Furthermore, the price level has been chosen as an additional variable because of its effects on both energy consumption and economic growth. From an econometric point of view we employ the Pooled Mean Group (PMG) approach of Pesaran et al. (1999) to estimate a complete panel error-correction model (PECM) and to sort out the long-run versus short-run effects of the countries respective relationship between energy consumption and economic growth. The advantage of such a approach is that it not only informs about the issue of unit-roots in the country panel but also allows for short-run versus long-run analyses of the relationship between energy consumption and economic growth in the same specification. Individual countries may well be on the same long-run path albeit with different short-run developments.

The fourth contribution is to consider a mix of African countries comprising both net energy producers and consumers. Most previous studies paid less attention to this aspect.

The structure of this paper is as follows. Section 2 proposes an overview of energy consumption and economic growth for developing countries. Section 3 outlines the econometric methodology. Section 4 provides details of the estimated model and the empirical results. The last section suggests some policy implications and offers some concluding remarks.

2. A brief overview of energy consumption and economic growth for developing countries

Since the seminal paper of Kraft and Kraft (1978), which supported the unidirectional causality from GNP growth to energy consumption in the USA for the period from 1947 to 1974, the causal relationship between energy consumption and economic growth has been extensively examined in the literature using different techniques and different samples of countries.[2] The empirical outcomes of these studies have been varied and sometime found to be conflicting. Four views currently exist regarding the causal relationship between energy consumption and economic growth. The first view, "*the growth hypothesis*", suggests that energy consumption plays an important role in economic growth. It implies that economic growth is dependent on energy consumption, and a decrease in energy consumption may restrain economic growth. The second view, called "*the conservative hypothesis*", argues unidirectional causality from economic growth to energy consumption. It suggests that energy conservation policies may have little or no impact on economic growth. The conservative hypothesis is supported if an increase in real GDP causes an increase in energy consumption. The third view, "*neutrality hypothesis*", argues that there is no causality between energy consumption and economic growth. In other words, both energy consumption and economic growth are neuter with respect to each other. The "*feedback hypothesis*" (fourth view) suggests that there is bidirectional causal relationship between energy consumption and economic growth reflecting the interdependence and possible complementarities associated with energy policies and economic growth.

Previous empirical studies on energy consumption and economic growth for developing countries provide mixed results (see Table 1). The main reason for the discrepancy in results in the previous research comes from the use of different econometric methods, divergence across countries, time horizon and model specifications that cannot accommodate structural breaks.

The majority of these studies on the causality between energy consumption and economic growth have mainly used the residual-based cointegration test associated with Engle and Granger (1987) and the maximum likelihood test based on Johansen (1988) and Johansen and Juselius (1990). For example, in a two country study, Ebohon (1996) shows a simultaneous causal relationship between energy and economic growth for Nigeria and Tanzania employing Granger causality test. Applying cointegration and error correction vector techniques on data for Malawi from 1970 to 1999, Jumbe (2004) found a bidirectional causality between electricity consumption and economic growth, but a unidirectional causality running from non-agricultural GDP to electricity consumption. Asafu-Adjaye (2000) examined the causal

[2] See for example Yu and Choi (1985), Erol and Yu (1987), Stern (1993), Oh and Lee (2004), Wolde-Rufael (2004), Lee (2005), Sari and Soytas (2007), Mahadevan and Asafu-Adjaye (2007) and Apergis and Payne (2009a, 2009b, 2010). For a recent survey on the literature on energy consumption and growth, see Ozturk (2010) and Payne (2008).

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