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Energy consumption and economic growth: The experience of African countries revisited

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ABSTRACT

The aim of this paper is to re-examine the causal relationship between energy consumption and economic growth for seventeen African countries in a multivariate framework by including labor and capital as additional variables. We apply the variance decomposition analysis due to Pesaran and Shin [Pesaran M.H. and Shin, Y. Generalised impulse response analysis in linear multivariate models, Economics Letters, 1998; 58; 17–29.] to evaluate how important is the causal impact of energy consumption on economic growth relative to labor and capital. The results of our multivariate modified Granger causality analysis due to Toda and Yamamoto [Toda, H.Y. and Yamamoto, T. Statistical inference in vector autoregressions with possibly integrated process, Journal of Econometrics, 1995; 66; 225–250.] tend to reject the neutrality hypothesis for the energy–income relationship in fifteen out of the seventeen countries. In contrast, results of our variance decomposition analyses show that in eleven out of the seventeen countries, energy is no more than a contributing factor to output growth and not an important one when compared to capital and labor. Labor and capital are the most important factors in output growth in fifteen out of the seventeen countries. However, these results should be interpreted with care as they may not be sufficiently robust enough to support the inference that energy consumption plays a minor role in the economic growth of African countries.

1. Introduction

While there are several studies that have investigated the causal relationship between energy consumption and economic growth using a production function framework for developed and some developing countries, such research is conspicuous by its absence for virtually all African countries.[1] The research about African countries is almost exclusively based on the bivariate causality model with energy consumption used as the sole factor input. It is against this backdrop that this paper attempts to fill the gap by investigating the inter-temporal causal relationship between energy consumption and economic growth in a production function framework by including labor and capital as intermitting variables. In doing so, the purpose of this paper is to add to the debate by re-examining the causal relationship between energy consumption and economic growth for seventeen African counties by extending the debate in three methodological approaches. First, unlike previous time series studies for African countries where most of these studies were concentrated in a two-variable case, we include capital and labor as additional variables to the energy-growth nexus as energy alone might not be strong enough to spur economic growth. The potential gains to economic growth may depend on the degree to which capital, energy and labor act as complements. By incorporating capital and labor as additional variables, we not only attempt to underline the importance of these two factors of production for economic growth but we can also test the hypothesis that capital and labor promote economic growth or vice versa. Further, we include these two additional variables because exclusion of a relevant variable(s) makes not only the estimates biased as well as inconsistent but also no-causality in a bivariate system can result from neglected variables (Lütkepohl, 1982). Thus the previous bivariate causality tests between energy consumption and economic growth may be invalid due to the omission of important variables affecting both energy consumption and economic growth. It is possible that the introduction of capital and labor in the causality framework may not only alter the direction of causality but also the magnitude of the estimates (Loizides and Vamvoukas, 2005; Odhiambo, 2008). Further, since a four VAR case incorporates more information than the bivariate case, the causal inference drawn can be more reliable (Loizides and Vamvoukas, 2005). Second, we use a modified version of the Granger causality test proposed by Toda and Yamamoto (1995) where the procedure does not require knowledge of the cointegrating properties of the system and thus avoids the potential bias associated with cointegration tests. Third, as previous

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[1] To the knowledge of the author, Tunisia is the only African country where such a study was carried out by Sari and Soytas (2007). Akinlo (2008) uses a multivariate model but does not include the inputs of labor and capital in his model.

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empirical evidence for Africa did not attempt to evaluate the strength of their causality findings beyond the sample period, we use innovation accounting or variance decomposition analysis due to Pesaran and Shin (1998), which, unlike the conventional method, is invariant to the order of the variables in which they enter the VAR. By doing so, we can assess how each variable responds to the innovation of other variables in the system and also evaluate how important is the causal impact of energy on economic growth relative to capital and labor (Shan, 2005).

The rest of the paper is structured as follows. In Section 2 we make a brief review the empirical literature followed in Section 3 by a short description of the theoretical background. The methodology is outlined in Section 4 while in Section 5 we discuss the empirical evidence. Policy implications of our empirical findings are presented in Section 6 while summary and conclusions are outlined in Section 7.

2. A brief literature review

Over the past few years the relationship between energy consumption and economic growth has been extensively researched. Yet, there seems to be no consensus regarding the direction of causality between energy consumption and economic growth. For instance, in a study of over more than hundred countries, Chontanawat et al. (2008) find that the causal relationship between energy consumption and economic growth is more pronounced in developed than in developing countries. Causality running from energy consumption to economic growth was found in only 35% of the poorest nations and in 42% of the middle-income nations while it was found in 69% the high-income countries. Sari and Soytas (2007) in a study of six developing countries found energy to be an important factor of production. In a bivariate relationship between energy consumption and economic growth in African countries, Wolde-Rufael (2005) also found conflicting evidence with the neutrality hypothesis supported in a substantial number of countries, with little support for the hypothesis that energy consumption causes economic growth. Similarly, using a multivariate causality test, Akinlo (2008) found also conflicting results for eleven African countries. Linear and nonlinear Granger causality carried out for eight newly industrialized Asian and USA by Chiou-Wei et al. (2008) shows also conflicting results.

Panel cointegration and causality studies are also equally conflicting. For instance, Mahadeven and Asafu-Adjaye (2007) found bi-directional causality for some countries while for others they found unidirectional causality running from energy consumption to economic growth. Similarly, Huang et al. (2008) found no causality between energy consumption and economic growth in low-income groups while in middle-income and high-income countries they found that economic growth leads energy consumption. Lee (2005) in a panel cointegration and causality study for a group of 18 developing countries found causality running from energy consumption to economic growth but not vice versa. Similarly, in a panel causality study of sixteen Asian countries, Lee and Chiang (2008) found a long-run causality running from energy consumption to economic growth. Further, for a group of 22 OECD countries Lee et al. (2008) found a bi-directional among energy consumption, the capital stock and economic growth. In a panel of G7 countries, Narayan and Smyth (2008) found that capital formation, energy consumption Granger cause real GDP positively in the long run. Apergis and Payne (2009) in a panel cointegration test for a group some Latin American countries, found both short-run and long-run causality from energy consumption to economic growth. In contrast, Al-Iriani (2006) for a group of six Gulf Cooperation countries found a uni-directional causality running from economic growth to energy consumption.

3. Theoretical background

Until quite recently, energy as a separate factor input in the production process has been neglected as its contribution is considered to be marginal because the cost of energy accounts for only a very small proportion GDP compared to the cost of employment (see, Ghali and El-Sakka, 2004; Lee et al., 2008). However, as Moroney (1992: 337) rightly argues: “It is one thing to correctly cite energy's small cost share in GNP, but an error to conclude, on this account, that energy plays a secondary role. Its role is primary, coequal with capital formation”. Recently numerous studies have attempted to highlight the importance of energy in the production process and they have tried to incorporate energy as an addition factor of production in addition to labor and capital (see, Beaudreau, 2005; Ghali and El-Sakka, 2004; Lee and Chiang, 2008; Lee et al., 2008; Narayan and Smyth, 2008; Oh and Lee, 2004; Sari and Soytas, 2007; Soytas and Sari, 2006; Stern, 2000; Yuan et al., 2008; Wolde-Rufael, 2008). In this paper, following the above-mentioned authors we investigate the causal relationship between energy consumption and economic growth in a conventional neo-classical one-sector aggregate production model where capital, labor and energy are treated as separate factors of production:

$$\mathrm{Y}_t = f(\mathrm{K}_t, \mathrm{L}_t, \mathrm{E}_t) \tag{1}$$

Where Y is aggregate output or real GDP, K is capital stock, L is level of employment, and E is total energy consumption. The log linear form of the above can be expressed as:

$$\mathrm{LY}_t = \alpha_0 + \beta_1 \mathrm{LK}_t + \beta_2 \mathrm{LL}_t + \beta_3 \mathrm{LE}_t + \varepsilon_t \tag{2}$$

The coefficients β_i,i=1, 2, 3 refer to the elasticity of capital stock, employment and total energy consumption respectively (Lee et al., 2008).

4. Methodology

Sims et al. (1990) showed that the asymptotic distribution theory could not be applied for testing causality of integrated variables in level form using the vector autoregressive (VAR) model even if the variables are cointegrated. To obviate some of these problems, Toda and Yamamoto (1995, hereafter TY) based on augmented VAR modelling, introduced a Wald test statistic that asymptotically has a chi square (χ^2) distribution irrespective of the order of integration or cointegration properties of the variables. The novelty of the TY procedure is that it does not require pre testing for the cointegrating properties of the system and thus avoids the potential bias associated with unit roots and cointegration tests as it can be applied regardless of whether a series is $I(0)$, $I(1)$ or $I(2)$, non-cointegrated or cointegrated of an arbitrary order (see Rambaldi and Doran, 1996; Zapata and Rambaldi, 1997; Clark and Mirza, 2006). As has been pointed out by Clark and Mirza (2006) pre-tests for unit root and cointegration might suffer from size distortions, which often imply the use of an inaccurate model for the non-causality test.

The TY approach fits a standard vector auto-regression model on levels of the variables (not on their first difference) that give allowance for the long-run information often ignored in systems that requires first differencing and pre-whitening (see, Clark and Mirza, 2006). TY employs a modified Wald test (MWALD) for restriction on the parameters of the VAR (k) where k is the lag length of the system. The basic idea of the TY approach is to artificially augment the correct order, k, by the maximal order of integration, say $d_{\max}$. Once this is done, a $(k+d_{\max})^{\mathrm{th}}$ order of VAR is estimated and the coefficients of the last lagged $d_{\max}$ vectors are ignored (see Caporale and Pittis, 1999). Therefore, in order to apply the TY procedure, we need to know the true lag length (k) and the maximum order of integration ($d_{\max}$) of the series under consideration. The test (MWALD) statistic is valid regardless of whether a series is $I(0)$, $I(1)$ or $I(2)$, non-cointegrated or cointegrated of an arbitrary order ‘so long as the order of integration of the process does not exceed the true lag length of the model’ (Toda and Yamamoto, 1995: 225). Monte Carlo experiments presented by Zapata and Rambaldi (1997) provide evidence that the MWALD test has a comparable performance in size and power to the