On the global energy consumption and economic growth nexus: A long ARDL bounds test approach.

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Overview

Studying the relationship between energy consumption and economic growth has mainly focused on individual country studies (Shahbaz *et al*., 2012; Wolde-Rufael, 2010) and in multi country studies (Akinlo, 2008; Fuinhas and Marques, 2012). The use of variables measuring total world growth and total world energy consumption (hereinafter global series) has not deserved much attention. To the best of our knowledge there are actually no studies using these macro-variables.
The motivation for this research comes from: (i) the need to understand the energy-growth nexus at worldwide level; and (ii) the possibility of separating the long-run and short-run effects between variables, due to the existence of data since 1965, thus awarding greater robustness to the econometric analysis. Indeed, the use of short series could produce spurious results, such as different conclusions for a single country, in different periods. Consequently, the use of an unrestricted error-correction model (UECM) version of the ARDL model, as Pesaran *et al*. (2001), has been growing due to the possibility of studying cointegration in long time span variables, controlling for outliers and structural breaks.
This research aims to contribute towards the literature by studying the cointegration of global series through the use of the UECM version of the ARDL bounds test. The central question of the study is: Can the *feedback hypothesis* be confirmed at global level? And if the hypothesis is verified, whether it is stable over time? Answering these questions could be important in future explanations on specific countries and their causal relationships. Given that energy is a production factor with impacts upon GDP, it is expected to find at least a causality relation running from energy to growth. Also, it is expected to find cointegration between energy and growth at macro level over a long period of time.

Methods

Annual data on GDP and primary energy consumption from 1965 to 2012 was used. To analyse the series, two bivariate ARDL models were estimated. The use of multivariate models is only preferred when it is not possible to obtain robust bivariate models, or when causality is not achieved. On the ARDL estimation Pesaran *et al*. (2001) were followed. Beyond the bivariate model, we have controlled for crude oil prices. It was verified that the restricted model is the best. Time dummies were integrated into the models in order to control structural breaks. If we do not take into account structural breaks and outliers, a misinterpretation of results could occur. The elasticities of the variables were calculated, and cointegration between variables was tested by the ARDL bounds test. Let Y denote GDP, E denote primary energy consumption, L denote the natural logarithm, and D denote the first difference operator.

Model 1: $$DLY_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{m} \alpha_{2i} DLY_{t-i} + \sum_{i=1}^{n} \alpha_{3i} DLE_{t-i} + \alpha_4 LY_{t-1} + \alpha_5 LE_{t-1} + \mu_{3t} \quad (1)$$

Model 2: $$DLE_t = \beta_0 + \beta_1 t + \sum_{i=1}^{m} \beta_{2i} DLE_{t-i} + \sum_{i=1}^{n} \beta_{3i} DLY_{t-i} + \beta_4 LE_{t-1} + \beta_5 LY_{t-1} + \mu_{4t} \quad (2)$$

A battery of diagnosis tests for normality, serial correlation and heteroscedasticity were carried out. The models revealed to be stable. The robustness of the ARDL models is evaluated by comparing the results with those obtained by Johansen's cointegration tests.

Results

A first appraisal of the series suggests that energy and growth are strongly correlated (0.994198). As expected, structural breaks were found. It was verified that there is only a need to control the periods 2008-2012 and 2009-2012 with shift dummies, in (1) and (2), respectively. The models revealed that energy - growth have a positive contemporary effect upon economic development. The magnitude of ECM in Model 1 (LY_{t-1}) and in Model 2 (LE_{t-1}) reveals a moderate speed of adjustment to the long-run equilibrium in the first, and a slow speed of adjustment in the second. The ECM of Model 1 and 2 are highly significant, which is in line with the presence of cointegration (see Banerjee *et al.*, 1998). The ARDL bounds test was carried out in order to identify the level of cointegration between variables. Cointegration between energy and growth was found, at the significance of 1% and 5% for Model 1 and 2, respectively. There is evidence of the existence of two cointegrating vectors, and this conclusion is also confirmed by Johansen's cointegration test. The estimated elasticities are highly significant. In Model 1, the short run elasticity is 0.348, while in the long run it is 1.706. For Model 2, the short run elasticity is 0.446, while in the long run it is 1.547.

Conclusions

This research adds to the literature on the energy-growth nexus by confirming the *feedback hypothesis* at a global level. Additionally, this nexus is seen both in the short- and in the long-run. Overall, the energy-growth nexus was proved to be robust over a long time span.

The nexus revealed to be essentially a long-term phenomenon. Indeed, long-run elasticities are larger than the short-run elasticities in both models. The former result suggests that the dynamic effects on both ways are huge. Some caution on constrain policies is required. Although in the short-run a reduction on energy consumption has small effects upon economic growth, in the long-run it will cause a huge slow down. As a consequence, any reduction on energy consumption will have a negative impact upon growth, and the opposite is also valid.

The results also revealed that the recent financial crises had a negative impact upon the energy-growth nexus. On the contrary, no significant impacts were detected in the 1970s oil crises.

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