DO THE ENERGY SUPPLY IMPACTS ON ECONOMIC GROWTH EQUAL THAN ENERGY CONSUMPTION? AN AUGMENTED ENERGY-GROWTH NEXUS APPROACH.

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Overview

For decades, the energy-growth nexus has received considerable attention (e.g. Akarca and Long, 1980; Marques *et al.*, 2015; Wolde-Rufael, 2005). The literature evolved from the traditionally bi-variate models to study of augmented energy-growth nexus by the inclusion of additional variables such as the financial development, population, urbanization or industrialization (e.g. Islam *et al.*, 2013; Shahbaz and Lean, 2012). Recently, trade openness caught the researchers' attention and various proxies of globalization have been used, for instance imports, exports, trade liberalization, among others.

Over the next few decades, global energy consumption is expected to continue changing. Energy consumption will most likely increase over the next two decades, at least, driven by emerging economies. It will lead to energy policies that face the new concerns, such as trade openness. Taking this into consideration, the augmented energy-growth nexus including globalization should be examined allowing to find the balance between energy consumption, economic growth and globalization. For this reason, vast literature is aiming to investigate the relationship between energy consumption, economic growth and globalization. (e.g. Kyophilavong *et al.*, 2015; Shahbaz *et al.*, 2016). However, the energy supply wich is also expected to increase over the next decades, to meet demand, has not received the same attention by the researchers. This fact leads to the main question of the research: Are there similarity between the impacts of energy supply and energy consumption on economic growth?

By using the same methodology, a comparation between energy supply and energy consumption impacts on economic growth is made. This approach reveal that energy consumption and supply have heterogeneous impacts on economic growth. This is far from expected, because both energy consumption and energy supply should be similar variables, suggesting the need to go further on this research.

Methods

To answer the paper main question, a panel data approach for 43 countries from 1971 to 2013 was performed. Annual data on gross domestic product, primary energy consumption, primary energy supply and globalization was used. To measure globalization the KOF index of globalization (http://globalization.kof.ethz.ch/) was taken as *proxy*. The KOF overall index is based on economic globalization, social globalization and political globalization. It includes components such as, trades, foreign direct investment, import barriers, number of embassies in a country, international treaties, among others.

Both short- and long-run relationships were estimated through an unrestricted error correction model (UECM) form of an autoregressive distributed lag (ARDL) model. The ARDL approach is robust to the presence of endogeneity and allows to correct outliers with impulse dummies. The prefix "L" denote natural logarithm and "D" denote first difference of the variable. The general UECM form is represented as follows:

$$DLY_{it} = \alpha_{1i} + \delta_{1i}TREND + \sum_{j=1}^{k} \beta_{21ij}DLY_{it-j} + \sum_{i=0}^{k} \beta_{22ij}DLX_{it-i} + \cdots + \gamma_{21i}LY_{it-1} + \gamma_{22i}LX_{it-1} + \cdots + \varepsilon_{1it} \tag{1},$$

where α_{1i} denotes the intercept, δ_{1i}, β_{2kij}, $k = 1, \dots, m$, and γ_{2im} the estimated parameters, and ε_{1it} the error term. 16 models were produced. A battery of diagnosis tests cross-sectional dependence, heteroskedasticity and serial correlation were carried out. Given the presence of cross-sectional dependence, the Driscoll and Kraay estimator was used. In addition, this estimator allows to handle with heteroskedasticity and first order autocorrelation.

Results

The results are consistent with the presence of long memory, i.e. cointegration. The error correction mechanisms (ECM) are negative and statistically significant. In fact, the results reveal a low speed of adjustment.

On the short-run, bidirectional causality between energy consumption and economic growth was found at the statistical significance of 1% level. The short-run results also reveals bidirectional causality between energy supply and economic growth. In what concerns to the long-run, the results reveals bidirectional causality between energy consumption and economic growth, at the statistical significance of 1% level. However, no causality was found from energy supply to ecomomic growth.

Overall, globalization as long-run impacts on economic growth and energy consumption but on energy supply statistical significance was merely found at 10% level. In fact, when globalization is disaggregated it is observed that only political globalization impacts on energy supply.

Conclusions

The research adds to the literature by revealing that the energy-growth nexus is a consumption side phenomena. The use of panel ARDL approach proved to be adequate given that the results are consistent with the existence of cointegration. The results were obtained for a long-time span and by a recent panel data estimator.

Evidence of the traditional *feedback hypothesis* was found between energy consumption and economic growth on both short- and long-run, for a panel of 43 countries. Accordingly, any energy consumption reduction should be made by improving energy efficiency because any energy consumption restriction will most likely hamper economic growth. In addition, globalization drives economic growth and energy consumption on the long-run.

Overall, the results support that energy supply should not be used as substitute of energy consumption in the energy-growth nexus research. Energy consumption and supply was expected to be in their impacts on economic growth. For this reasom, further research is advisable to fully explain the heterogeneous results observed. For instamce, the existence of significant losses between supply and consumption need to be analysed in the future.

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