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# Augmented energy-growth nexus: economic, political and social globalization impacts

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**Abstract**

The augmented energy-growth nexus with globalization is analyzed for a panel of 43 countries between 1971 to 2013, by using an autoregressive distributed lag (ARDL) approach. The impacts of economic, political and social globalization on energy-growth nexus are explored. The results are consistent with the presence of cointegration. Evidences of the traditional feedback hypothesis on the energy-growth nexus was found. Economic, political and social globalization have heterogenous impacts on the nexus. In general, globalization is a long-run driver of both energy consumption and economic growth. Accordingly, globalization should be promoted. In addition, restrictive energy policies should be avoided or carefully designed to no hamper economic growth.


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*Keywords:* Augmented energy-growth nexus; globalization; panel data; primary energy consumption.

## 1. Introduction

For decades, the energy-growth nexus has received considerable attention (Wolde-Rufael, 2005; Marques et al., 2015; Akarca and Long, 1980). The literature identified four types of relationships: (i) the "neutrality hypothesis" that asserts that no causality between energy consumption and economic growth is observed; (ii) the "conservation hypothesis" that states that there is uni-directional causality form economic growth to energy consumption; (iii) the "growth hypothesis" stating that uni-directional causality from energy consumption to economic growth; and (iv) the "feedback hypothesis" noting that there is bi-directional causality between energy consumption and economic growth.

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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 (Islam et al., 2013; Shahbaz and Lean, 2012). Recently, new concerns arise, leading to the inclusion of more variables to the energy-growth nexus research, for instance carbon dioxide emissions and trade openness (Apergis and Ozturk, 2015; Farhani and Ozturk, 2015). The study of trade openness impacts on energy consumption, started when Cole (2006) by using the Antweiler et al. (2001) theoretical principles, observed that trade liberalization can increase per capita energy use, for a sample of 32 developed and developing countries. Thenceforth, vast literature aimed to investigate the relationship between energy consumption, economic growth and trade openness, by using individual countries (Kyophilavong et al., 2015; Shahbaz et al., 2016) or panel of countries (Nasreen and Anwar, 2014; Sadorsky, 2012) studies. To do so, various proxies of globalization have been used, for instance imports, exports, trade liberalization, among others. The existent literature supports that on long-run, trade openness conducts to different impacts on energy consumption across the globe. For instance, Sadorsky (2012) found bidirectional causality between energy consumption and exports and between energy consumption and imports for seven South American countries. While, Shahbaz et al. (2016) found that globalization lead to a decline in energy demand for Indian economy.

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 (BP, 2016). It will lead to energy policies that face the new concerns. 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. This fact leads to the central question of this paper: Which are the impacts of economic, social and political globalization on energy-growth nexus?

To analyze the augmented energy-growth nexus, a panel data with 43 countries that encompasses yearly data from 1971 to 2013 is used. By following an autoregressive distributed lag (ARDL) approach, the short- and long-run behaviors are examined. The results found evidence of feedback hypothesis on energy-growth nexus both on short- and long-run. In addition, the results support that economic, political and social globalization have long-run impacts on energy-growth nexus.

The paper evolves as follows: Section 2 describes data and methodology. Section 3 presents and discuss the results. Section 4 concludes.

## 2. Data and methodology

The paper uses annual data, from 1971 to 2013, for 43 countries around the world. It should be said that the used sample was limited by their availability for the different variables. The econometric analysis was performed by using Stata 13.0. The used variables are the following:

(i) Gross Domestic Product *per capita* (YPC) – Corresponds to GDP *per capita* (constant 2010 US$) obtained from World Bank.

(ii) Primary Energy Consumption *per capita* (EPC) – computed by dividing primary energy consumption by total population. The sources of the variables are BP statistical review of world energy 2016 workbook and World Bank, respectively.

(iii) Globalization (G) – To measure globalization the KOF index of globalization (http://globalization.kof.ethz.ch/) was used. 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.

(iv) Economic Globalization (EG) – To measure economic globalization the Economic Globalization index from KOF Index of Globalization was used (http://globalization.kof.ethz.ch/).

(v) Political Globalization (PG) – Is the Political Globalization index from KOF Index of Globalization (http://globalization.kof.ethz.ch/).

(vi) Social Globalization (SG) – Corresponds to the Social Globalization index from KOF Index of Globalization (http://globalization.kof.ethz.ch/).

The prefix “L” denote natural logarithm and “D” denote first difference of the variable. Summary statistics are presented in Table 1.

Table 1. Descriptive statistics.

| Variables | Obs. | Mean. | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| LYPC | 1849 | 9.2204 | 1.361 | 5.4715 | 11.4251 |
| LEPC | 1849 | 0.5316 | 1.1918 | -4.5875 | 2.6276 |
| LG | 1849 | 4.0264 | 0.3633 | 2.4562 | 4.5286 |
| LEG | 1849 | 3.9532 | 0.4263 | 2.2105 | 4.5798 |
| LPG | 1849 | 4.2801 | 0.2854 | 3.0052 | 4.5892 |
| LSG | 1849 | 3.7821 | 0.6142 | 1.8579 | 4.5359 |
| DLYPC | 1806 | 0.0222 | 0.0361 | -0.1734 | 0.2149 |
| DLEPC | 1806 | 0.0199 | 0.051 | -0.2831 | 0.6714 |
| DLG | 1806 | 0.0128 | 0.0328 | -0.2575 | 0.269 |
| DLEG | 1806 | 0.0113 | 0.0373 | -0.1556 | 0.2679 |
| DLPG | 1806 | 0.0111 | 0.0624 | -0.6314 | 0.5551 |
| DLSG | 1806 | 0.018 | 0.0579 | -0.1273 | 0.6547 |

The variance inflation factor (VIF) was computed to check for multicollinearity. The results indicate that multicollinearity is not a problem. In addition, the second-generation panel unit root tests, CIPS (Pesaran, 2007), was used to assess the order of integration of the variables. The unit root tests revealed that only LEPC and LEG are I(0) and the remaining variables are I(1) or near I(1). The use of unrestricted error correction model (UECM) form of an autoregressive distributed lag (ARDL) model allow to handle with I(0) and I(1) variables. The ARDL approach is robust to the presence of endogeneity and allows to correct outliers with impulse dummies. Furthermore, when a parameter is significant, it is identical for testing Granger causality. The general UECM form is represented as follows:

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

where $\alpha_{1i}$ denotes the intercept, $\delta_{1i}$, $\beta_{2kij}$, $k = 1, \ldots, m$, and $\gamma_{2im}$ the estimated parameters, and $\varepsilon_{1it}$ the error term. The use of a macro panel could be a good approach, given that it allows to control for heterogeneity of the cross-sections that are expected to be present. The presence of time-fixed effects and country-fixed effect was tested and both revealed to have statistical significance. For this reason, fixed effects models were computed. The cross-section dependence (CSD) was tested by Pesaran cross section dependence test and revealed that residuals are correlated. To handle with the cross-section dependence, the Driscoll and Kraay (1998) estimator was used. In addition, this estimator allows to handle with heteroskedasticity and first order autocorrelation. Eight models for panel data were produced.

## 3. Results and discussion

The paper examines the augmented energy-growth nexus by introducing globalization variables for a panel of 43 countries. The use of a macro panel with long time span data assures robustness to the analysis. The analysis of the order of integration of variables revealed the possibility of the variables being I(0), I(1) or borderline between I(0) and I(1). For this reason, the use of an UECM form of ARDL models is suitable to assess both short- and long-run relationships. The use of Driscoll and Kraay (1998) estimator allows to handle with cross-sectional dependence. By analysing the models' residuals an outlier was identified in the energy consumption equations. To control their effect an impulse dummy for Saudi Arabia in 1975 was introduced. This is far from unexpected given that energy markets experienced periods of instability in the begin of the 1970s. In fact, the need to introduce an impulse dummy is consistent with the end of oil embargo by the members of Organization of Arab Petroleum Exporting Countries which may be caused a sudden drop on Saudi Arabia energy consumption. The estimation results are shown in Table 2.

The results are consistent with the presence of long memory, i.e. cointegration. The error correction mechanisms (ECM) are negative and statistically significant. The speed of adjustment is low revealing that shocks require longer adjustment time to return to equilibrium. This means that the effects of a shock on the augmented energy-growth nexus remains for years. Results reveals that there is long-run bi-directional causality between energy consumption and economic growth, both on short- and long run. An increase of economic growth will boost energy consumption and the reverse is also true. These results are consistent with the presence of endogeneity. This result reinforces that any impact on economic growth or energy consumption may have persistent effects over the years.

Table 2. Estimation results.

| | Dep. var. DLYPC | | | | Dep. Var. DLEPC | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Constant | 0.1512** | 0.1717** | 0.1622*** | 0.2022*** | -0.5669*** | -0.4637*** | -0.512*** | -0.4459*** |
| Trend | | | | | -0.0011*** | -0.0009*** | -0.0008*** | -0.0009*** |
| DLYPC | | | | | 0.6069*** | 0.6132*** | 0.617*** | 0.6112*** |
| DLEPC | 0.3104*** | 0.3079*** | 0.3137*** | 0.3105*** | | | | |
| DLG | -0.0154 | | | | 0.024 | | | |
| DLEG | | -0.0467 | | | | -0.0219 | | |
| DLPG | | | -0.0047 | | | | 0.2733** | |
| DLSG | | | | 0.014 | | | | 0.0026 |
| DLYPC(-1) | 0.2609*** | 0.2649*** | 0.2638*** | 0.2612*** | -0.0629 | -0.0595 | -0.0586 | -0.0587 |
| DLEPC(-1) | 0.0138 | 0.0129 | 0.0089 | 0.0103 | 0.0024 | 0.0021 | 0.0042 | -0.0002 |
| DLG(-1) | -0.0119 | | | | -0.0168 | | | |
| DLEG(-1) | | 0.0525** | | | | -0.0303 | | |
| DLPG(-1) | | | -0.011 | | | | -0.0131 | |
| DLESC(-1) | | | | -0.0154 | | | | 0.0046 |
| LYPC(-1) | -0.0294*** | -0.0273*** | -0.0223** | -0.0291*** | 0.0482*** | 0.0479*** | 0.05*** | 0.0478*** |
| LEPC(-1) | 0.0108* | 0.0156** | 0.016** | 0.0121* | -0.0613*** | -0.0519*** | -0.0582*** | -0.0562*** |
| LG(-1) | 0.0309*** | | | | 0.0466*** | | | |
| LEG(-1) | | 0.0208*** | | | | 0.0195** | | |
| LPG(-1) | | | 0.0104 | | | | 0.0248*** | |
| LSG(-1) | | | | 0.0185*** | | | | 0.0164*** |

**Notes**: ***, ** and * denote statistically significance at 1, 5 and 10% level, respectively.

Globalization is a driver of both economic growth and energy consumption. When dividing globalization into three different components (economic globalization, political globalization and social globalization), it was observed that economic and social globalization positively impacts on both economic growth and energy consumption. It should be said that, political globalization does not directly cause economic growth revealing that the creation of embassies, inter-governmental organizations, participations in United Nations Security Council or even the creation of international treaties is not leading to economic growth. However, political globalization causes energy consumption both on short- and long-run, what in its turn may contribute to economic growth.

Overall, the results support that energy restrictive policies should be avoided because it may hamper economic growth. Moreover, the promotion of globalization will most likely lead to energy consumption growth and economic growth. On one hand, the promotion of foreign trades, direct investment, international tourism, among other will most likely cause economic growth and energy consumption. On the other hand, some concerns arise given that economic growth may lead to inefficient energy consumption namely by non-productive activities.

## 4. Conclusion

Based on a sample of 43 countries, the augmented energy-growth nexus with globalization was examined. 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.

Evidences of the traditional feedback hypothesis on energy-growth nexus was found both on short- and long-run. In addition, globalization drives economic growth and energy consumption on the long-run. In what concerns to the short-run, only political globalization causes energy consumption. The results also show that the nexus have a limited responsiveness to the shocks, requiring a long period to return to equilibrium.

Overall the results support that any energy consumption reduction should be made by improving energy efficiency because any energy consumption restriction will most likely hamper economic growth. In addition, energy consumption should be monitored to mitigate the possibility of economic growth and globalization lead to inefficient energy consumption.

When more data is available it will be possible to go further on this research by making the sample closest to a globe measure. Additionally, understand the impacts of disaggregated globalization on the nexus in different development levels could be a future path of research.

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