THE RENEWABLE vs. NON-RENEWABLE ELECTRICITY AND INDUSTRIAL PRODUCTION NEXUS IN GREECE: AN ARDL APPROACH

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Overview: The European Union has set ambitious targets for investment in electricity generation from renewable sources. Within that pathway, analysing the coexistence of various generation sources, including the dynamics of adjustment, and their relationships with economic growth, is of utmost relevance. The literature focusing on the energy consumption – economic growth nexus, is the framework for this study. In particular, the study copes with the worldwide tendency for the electrification of the economy and it is focused on electricity, which allows bringing together to the analysis the several generation sources.

Diversifying electricity generation sources awakens particular challenges, given the idiosyncratic characteristics of each source. Some of these sources, namely the so-called “new” renewables, wind and sun, generate electricity not as a response to demand, but instead as a consequence of both the installed capacity and the availability of natural resources. This could provoke outliers and even structural breaks within the databases. Moreover, the nature of the effects could be dissimilar in time. The literature analysing both of these idiosyncrasies, by separating the sources and by decomposing the effects into short- and long-run remains scarce.

Greece has experienced a period of external financial assistance, as a result of the structural disequilibrium of its economy. While undergoing profound structural reforms and being immersed in a deep recession, Greece has had to continue to comply with its international renewable energy commitments. In such way, Greece benefits from understanding the interrelationship of renewable and non-renewable energy-growth. Knowledge of occasional or more permanent shocks in this relationship is essential, since the energy authorities in Greece are continuously intervening to achieve a viable solution that will enable the country to reach both its Renewable Energy Sources (RES) targets and to liberalize the energy market, providing affordable energy to all citizens and making businesses more competitive.

Methods: Monthly frequency data covering the period from August 2004 till February 2014 were used. The database includes as raw data the electricity production in MWh produced from lignite, oil, gas, hydropower, renewable energy without hydropower, imports and exports of electricity, as well as electricity from water pumping systems. The industrial production index, taken from the Eurostat database, is used to embody economic growth. The conventional fossil sources were aggregated, as well as the “new” renewables, solar and PV. The Pesaran *et al.* (2001) ARDL bounds test approach was followed, considering its several advantages. Firstly, it allows dealing with both stationary and non-stationary series. Secondly, when compared with the Johansen and Juselius’ cointegration technique, the ARDL approach assures greater consistency in the case of small samples, such as noted by Pesaran and Shin (1999). Thirdly, the asymptotic theory developed in the ARDL bounds test approach is not affected by the inclusion of “one-zero” dummy variables (Pesaran *et al.*, 2001). The use of these dummies revealed itself critical in handling idiosyncratic phenomena on the data, otherwise a bias in the estimates would be expected. Fourthly, given that it is free of residual correlation, the ARDL method could handle the eventual phenomenon of endogeneity among variables (Pesaran *et al.*, 2001). This means that even with the explanatory variables having some endogeneity properties, the validity of the ARDL estimations is not compromised. This advantage is of particular relevance considering that, to some extent, this research has behind it, a dynamic endogenous concern faced by the electricity system operator. Indeed, it must keep looking for the appropriate balance of the contribution from several sources towards electricity generation. The principle of parsimony was followed, being sustained on a wide battery of diagnostic tests regarding the quality of the model, namely by testing: normality; serial correlation; heteroscedasticity; and the model’s specification test. Three models were estimated. Model I refers to the

ordinary regime (fossil sources). Model II refers to new renewable sources, and Model III refers to the industrial production index, which embodies economic growth. Regarding Model III, there are no statistically significant long-run effects, and therefore a restricted model was estimated. The bounds test was carried out to confirm the presence of cointegration relationships. Both short- and long-run elasticities were computed, to assess the sensitivity of each variable, and their statistic significances were tested as well.

Results: The results reveal that, in the short-run, a 1% increase in economic growth can lead to an increase of 0.89% in terms of electricity generated from fossil sources. In the meantime, an increase of 1% in electricity generated from fossil fuels leads to an increase of 0.05% on economic growth. In the short-run a 1% increase in electricity generated from new renewables causes a small increase of about 0.07% in fossil fuels. However, there is a negative and permanent relationship between these two variables in the long-run. It looks like the short-run role played by fossil sources is baseload; meanwhile in the long-run there is a relevant contribution from fossil for backing new renewables. Indeed, this result supports the idea that to deploy electricity generated from new renewables requires a strong support from fossil sources.
The ARDL bounds test results reveal that the null hypothesis of no cointegration relationship is undoubtedly rejected at a 1% significance level, both for Model I and Model II. The estimated long-run cointegrating equations (standard error in parenthesis), show that conventional fossil sources (LORP) and new renewables (LRES) move together:

$$LORP = \underset{(0.4746)}{18.5219} - \underset{(0.0298)}{0.1571} LHYDRO - \underset{(0.0228)}{0.1218} LRES \quad (1)$$

and

$$LRES = \underset{(0.0007)}{0.0146} t + \underset{(0.1698)}{0.4743} LFRXM + \underset{(0.0038)}{0.7228} LORP \quad (2)$$

When renewable sources extend their involvement towards electricity generation, then the substitution effect becomes clear, by diminishing the weight of fossil sources. However, the magnitude of this negative effect is relatively small. On the contrary, eq. (2) reveals the high dependency of renewables towards conventional fossil sources. Indeed, the crucial role of backup to overcome intermittency of renewables is fully noticeable in this long-run cointegration equation. Backup is being done not only by conventional sources, but by the adjustment variable of external trade of electricity as well. The adjustment speed towards long-term equilibrium reveals that the adjustment is moderate to fast. Indeed, the speed of adjustment is faster regarding new renewables, when compared to fossil sources. This fact is far from what was expected, and could be seen as an additional proof of robustness and accordance with reality. In fact, the Greece RES targets assumed under the international commitments must be fulfilled, and therefore the long-run path ought to be quickly resumed.

Conclusions: The dissimilar nature of the observed effects in the short- and long-run, in both models, is quite noticeable. This evidence reinforces the need to consider short- and long-run separately, which strengthens the suitability of the use of the ARDL bounds test approach.
There is no evidence of any cointegration among electricity from the renewable and the non-renewable sources, and the economic growth. Indeed, it was proved that, for the sample under analysis, those variables do not move together, revealing dissimilar paths. However, in the short-run, there is evidence of bidirectional causality between fossil sources and growth, thus confirming the *feedback hypothesis*. If industrial production grows, then the electricity generated from non-renewable increases, and the opposite is also true.
The cointegration relationships on LORP and LRES were proved. The signals and magnitude clearly reveal that, in Greece, the path of deployment of renewables requires the support of both the variable of adjustment of external trade, and the strong support of the mature electricity fossil sources as well. This relationship is stable throughout the period under analysis.

References

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