Renewable Energy Production and Environmental Policy Stringency

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Overview

The importance of increased share of renewable energy in the total energy mix has been advocated as one of the principal outcomes of environmental policies to accomplish sustainable development goals in the last few decades in OECD (Organization of Economic Cooperation and Development) countries. OECD countries underwent colossal investment in renewable technologies, exerted substantial influence in administering renewable energy strategies, and focused on the synchronization of the member countries to continue sustainable development issues (OECD, 2011). OECD countries have also placed topmost priority for promoting low carbon technology and eliminating fossil fuel subsidies by 2025 (OECD, 2011). In addition, many OECD countries also strive to reduce the dependency on imported crude oil from OPEC countries. Given several markets and non-market-based policies in place, it is plausible to investigate their efficacy in fostering renewable energy production in OECD member countries. It is found that the environmental policy stringency, including market and non-market approaches, is positively associated with the growth in renewable energy production. Our finding is comprehensive as EPS provides a composite measure of policy stringency, including both market and non-market approaches, encompasses a maximum number of countries and time dimensions and presents reasonable stability concerning changes, weighting and aggregation. Furthermore, we conducted the robustness checks by using alternative proxies for EPS. Our empirical findings also affirm the proposition that proven oil reserves are antagonistic to the growth of renewable energy production considering the intergenerational energy security aspect. Positive shock in oil price augments the renewable energy production validating the substitution effect between renewable energy and non-renewable energy. Our findings are robust when alternative measures of policy stringency considering both supply-side and demand-side incentives are used. We applied both environmental technology, government expenditure for environmental protection (supply-side incentives) and environmental taxes (demand-side incentives) to complement the baseline analysis. The results of the robustness checks do comply with the findings of the baseline modelling. The empirical findings reinforce existing mitigation policies to promote renewable energy production adhering to the energy security agenda of sustainable development goal.

Methods

The CS-ARDL Method

This paper applies the CS-ARDL (Cross-Sectional Auto Regressive Distributed Lag Model) estimation method developed by Chudik and Pesaran (2015) which is an advanced version of pooled mean group estimation method developed by Pesaran et al. (1999). It provides long-run and short term parameter estimates together with error correction coefficients for each variable under consideration. The model's robustness is demonstrated through a series of Monte Carlo simulations to address potential endogeneity, serial correlation, potential dynamic heterogeneity and common correlation biased problems.

The variables included in the model have large probability of interdependence among cross-sections due to the financial integration and adoption and adherence of common environmental policies to pursue common environmental goals. This CS-ARDL method has been shown to be effective in the presence of unobserved common factors and can address the CD (cross –sectional dependence) problem both in the short run and long run (Chudik et al. 2016). This approach addresses the bias that may occur due to the unobserved common factors by considering residual spatial dependence. The reliance of mean group estimators on standard ARDL assumptions makes it asymptotically unbiased as $N \rightarrow \infty$ for both fixed T and $T \rightarrow \infty$. The three different versions of CS-ARDL are estimated and presented to control cross-sectional bias independently in the short run, the long run, and for both the short and long run.

The baseline regression equation for the empirical model is as follows:

$$\Delta REP_{it} = \mu_i + \varphi_i(REP_{it-1} - \beta_i X_{it-1} - \phi_{1i}\overline{REP}_{t-1} - \phi_{2i}\bar{X}_{t-1}) + \sum_{j=1}^{p-1}\lambda_{ij}\,\Delta REP_{it-j} + \sum_{j=0}^{q-1}\zeta_{ij}\,\Delta X_{it-j} + \eta_{1i}\Delta\overline{REP}_t + \eta_{2i}\Delta\bar{X}_t + \varepsilon_{it}) \ldots\ldots (2)$$

where ΔREP_{it} is the dependent variable with first difference, X_{it} denotes the independent variables in the long run, $\overline{REP}_{t-1}$ is the mean of the dependent variable in the long run, $\bar{X}_{t-1}$is the mean of the independent variables in the long run, ΔREP_{it-j} is the autoregressive term of the dependent variable, $\Delta X_{it-j}$is the independent variables in the short run, $\Delta\overline{REP}_t$is the mean of the dependent variable in the short run, $\Delta\bar{X}_t$is the mean of the independent variable in the short run, ε_{ij} is the error term. Further, we define *i* as the cross-sectional dimension, λ_{ij} as the short-run coefficient of the dependent variable, ζ_{ij} as the short-run coefficient of the independent variables, and $\eta_{1i}\ and\ \eta_{2i}$ as the means of the dependent and independent variables in the short run.

Results

The empirical results reveal the positive nexus between EPS (Environmental Policy Stringency) and REP (Renewable Energy Production) in SR (short run), LR (long run) and for both LR & SR. More stringent environmental policies particularly climate and air policies in energy and transport sectors augment productivity growth of technologically advanced firms due to the advancement in pro-environmental technologies. Stringent environmental policies in the form of R & D expenditure on environmental protection render a significant incentive for the procreation of environment-friendly technologies. This supply-side incentive is harmonized with the environmental taxes which reduce the demand for non-renewable energy production and consumption. The greater availability of country-specific proven oil reserves creates a negative incentive for REP by making the average cost of non-renewable energy production cheaper due to the increment in supply in the long run. Therefore, greater availability and discovery of proven oil reserves is a challenging factor for expanding renewable energy production. OP (oil prices) is positively associated with REP. The existence of substitution motive and speculative trader behaviour is validated further with this positive association. LGDPC (log of GDP per capita) and FD (financial development) have a negative relation with REP, substantiates the dependence on fossil fuel usage and an indication of the financial resources directed by the private sector in non-environmental friendly projects. Hence, the growth pattern of the OECD countries, is predominantly non-renewable energy induced growth.

The robustness checks were performed from the perspectives of both demand and supply sides, revealing and confirm the results of the main analysis. Expenditure on R & D is positively associated with REP after controlling for CD in SR, LR and for both SR and LR. Likewise, expenditure on environmental protection is positively connected with REP. Environmental taxes are positively associated with REP. The negative relation between POR_C and REP and positive relation between OP and REP is authenticated in the robustness analysis validating the substitution effect between renewable and non-renewable energy sector. The negative relation between LGDPC and REP, FD and REP is endorsed in the robustness analysis, controlling for CD in both SR and LR. The environmental policies executed in previous years has a significant effect on present value of REP.

Conclusions

This is the first article to explore the nexus between environmental policy and renewable energy production over 1990-2016 for OECD countries by applying the CS-ARDL estimation. The OECD countries have implemented comprehensive environmental policies to promote low carbon technology and eliminate fossil fuel subsidies by 2025. This article presents several policy implications for the OECD countries. *First*, appropriate policies, including both the market and non-market approaches for bringing changes in the relative price between renewable and non-renewable energy are encouraged. *Second*, R&D expenditure, environmental taxes and environmental protection expenditure can be useful tools to augment renewable energy production and help maintain energy security to comply with the Sustainable Development Goal. *Third*, the high upfront cost of renewable energy projects make them less attractive in terms of receiving loans from financial institutions. The execution of environmental polices provides a prerequisite for the financial markets and institutions for guiding financial assistance towards renewable energy sector. *Finally*, the combination of both market and non-market environmental policies can help maximize the benefits of environmental policies. More foreign collaboration to promote pro-environmental patents should be encouraged.

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