MEASURING THE ENERGY EFFICIENCY OF DEVELOPED AND DEVELOPING COUNTRIES: A DEA MODEL WITH UNDESIRABLE OUTPUT

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Overview

The solar power market has been developing extensively in the last few years. In order to know the performance and allocate resources well, it's necessary to measure productivity of the market. Many researchers have studied this topic by means of Data Envelopment Analysis (DEA). However, previous studies only pay attention on some information available on costs and productive inputs for making international comparisons. This study uses country-level data derived from estimating the performance of the solar power policies in 25 countries over the period 2009-2012. In particular, the performance of developed country (MEDC) and developing country (DC) is examined. The analysis is based on DEA with undesirable output, which accompanies desirable outputs in production. At the second stage of the analysis, potential improvements modelling is applied to analyze the major drivers behind efficiency performance using the given country characteristics.

Based on DEA results, the improvement in overall technical efficiency is observed in all countries over the period. The decomposition of the pure technical efficiency from country-level factors indicates that technology change is primarily responsible for improvements achieved in specific MEDCs. The results show that one MEDC's pure technical efficiency is inefficient in the given period. Besides, four DCs perform the best in pure technical efficiency. Based on these findings, this study proposes some political schemes to improve country-level efficiency.

Methods

Data Envelopment Analysis

Results

First, the pure technical efficiencies of developing countries are, on average, greater than that of developed countries, the overall technical efficiencies of developed countries appear significantly greater than those of developing countries. The policy makers of DCs should focus primarily on promoting RE efficiency in deployments.

Second, the evaluation and decomposition of factors reveal that the potential improvements due to efficiency change have been modest at best (e.g. no more than 20%), whereas improvements due to changes in best practices have been significant in most countries. Based on these estimates, Netherlands is the only MEDC that has factors to be noticed all the period.

Third, a large proportion of RE efficiency variance is due to the internal characteristics. This suggests that policy makers should take into account the intrinsic domestic characteristics when formulating RE efficiency measures. However, they should not ignore the importance of the private sector's contribution to the overall economy, as well as promoting productivity gains and environmental protection.

Conclusions

It can be concluded that the design elements (total government expenditure, gross fixed capital formation, total income per capita and days required getting electricity) of the support mechanisms are by far the most important criteria with respect to the solar power research, development and demonstration and their foreseeable future subject to conditions of developing followers. In this study, we obtain some experiences from some main countries of the EU. From perspective of stimulating the solar power market in some followers, Germany is just considered as a unique benchmark in the worldwide electricity market through promoting solar power with capitalistic incentives. The policy-makers should modify the original incentives by referring to their contexts and/or referring the similar market to localize the instruments efficiently. Three principles contributed in practice to shaping the policy are: 1. Renewable energy productivity review periodically; 2.Liberalization of electricity markets and competition in a regulated-network environment; 3.Complementary service infrastructures in conjunction with incentive mechanisms.

References

Antunes, C. H., Martins, A. G., and Brito, I. S. (2004): "A multiple objective mixed integer linear programming model for power generation expansion planning, " Energy, 29(4), 613-627.

Chiu, Y. H., and Wu, M. F. (2010): "Environmental Efficiency Evaluation in China: Application of 'Undesirable' Data Envelopment Analysis, " Polish Journal of Environmental Studies, 19(6), 1159-1169.

del Rio, P., and Mir-Artigues, P. (2012): "Support for solar PV deployment in Spain: Some policy lessons, " Renewable & Sustainable Energy Reviews, 16(8), 5557-5566. doi:10.1016/j.rser.2012.05.011

del Río, P., and Unruh, G. (2007): "Overcoming the lock-out of renewable energy technologies in Spain: The cases of wind and solar electricity, " Renewable and Sustainable Energy Reviews, 11(7), 1498-1513.

Deshmukh, R., Bharvirkar, R., Gambhir, A., and Phadke, A. (2012): "Changing Sunshine: Analyzing the dynamics of solar electricity policies in the global context, " Renewable & Sustainable Energy Reviews, 16(7), 5188-5198.

Dusonchet, L., and Telaretti, E. (2010): "Economic analysis of different supporting policies for the production of electrical energy by solar photovoltaics in eastern European Union countries, " Energy Policy, 38(8), 4011-4020.

Fare, R., Grosskopf, S., Lovell, C. A. K., and Yaisawarng, S. (1993): "Derivation of Shadow Prices for Undesirable Outputs - a Distance Function-Approach, " Review of Economics and Statistics, 75(2), 374-380.

Fouquet, D., and Johansson, T. B. (2008): "European renewable energy policy at crossroads-Focus on electricity support mechanisms, " Energy Policy, 36(11), 4079-4092.

Gomes, E. G., and Lins, M. P. E. (2008): "Modelling undesirable outputs with zero sum gains data envelopment analysis models, " Journal of the Operational Research Society, 59(5), 616-623.

Guo, X. D., Zhu, L., Fan, Y., and Xie, B. C. (2011): "Evaluation of potential reductions in carbon emissions in Chinese provinces based on environmental DEA., " Energy Policy, 39(5), 2352-2360.

Komor, P., and Bazilian, M. (2005): "Renewable energy policy goals, programs, and technologies, " Energy Policy, 33(14), 1873-1881.

Loiter, J. M., and Norberg-Bohm, V. (1999): "Technology policy and renewable energy: public roles in the development of new energy technologies, " Energy Policy, 27(2), 85-97.

Nemet, G. F., and Baker, E. (2009): "Demand Subsidies Versus R&D: Comparing the Uncertain Impacts of Policy on a Pre-commercial Low-carbon Energy Technology, " Energy Journal, 30(4), 49-80.

Oikonomou, V., Flamos, A., Gargiulo, M., Giannakidis, G., Kanudia, A., Spijker, E., and Grafakos, S. (2011): "Linking least-cost energy system costs models with MCA: An assessment of the EU renewable energy targets and supporting policies, " Energy Policy, 39(5), 2786-2799.

Patlitzianas, K. D., Doukas, H., Kagiannas, A. G., and Psarras, J. (2008): "Sustainable energy policy indicators: Review and recommendations, " Renewable Energy, 33(5), 966-973.

Sarkis, J., and Talluri, S. (2004): "Ecoefficiency measurement using data envelopment analysis: research and practitioner issues, " Journal of Environmental Assessment Policy and Management, 06(01), 91-123.

Seiford, L. M., and Zhu, J. (2005): "A response to comments on modeling undesirable factors in efficiency evaluation, " European Journal of Operational Research, 161(2), 579-581.

Shum, K. L., and Watanabe, C. (2010): "Network externality perspective of feed-in-tariffs (FIT) instruments-Some observations and suggestions, " Energy Policy, 38(7), 3266-3269.

Solangi, K. H., Islam, M. R., Saidur, R., Rahim, N. A., and Fayaz, H. (2011): "A review on global solar energy policy, " Renewable & Sustainable Energy Reviews, 15(4), 2149-2163.

Zhou, P., Ang, B. W., and Poh, K. L. (2008): "Measuring environmental performance under different environmental DEA technologies, " Energy Economics, 30(1), 1-14.