BUCHAREST UNIVERSITY OF ECONOMIC STUDIES
Doctoral Studies Council Doctoral School of Economic Cybernetics and Statistics

NON-PARAMETRIC TECHNIQUES FOR MEASURING ECONOMICAL, ECOLOGICAL AND SOCIAL EFFICIENCY EFFICIENCY

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Bucharest, 2024

Abstract

The complex nature of human needs research, but also the multitude of approaches that can be used to study the links between economic efficiency and the impact of production processes on the environment has determined a high interest in approaching the theme of the sustainable development of a nation.

The increasing importance given to the achievement of economic and environmental sustainability objectives in the current context of climate change and ecosystem fragility has determined the emergence of a considerable number of studies to estimate economic, ecological and social efficiency using parametric and non-parametric techniques.

Among the non-parametric efficiency estimation techniques, most studies in the field of eco-efficiency research focus on the construction of DEA estimators and FDH estimators.

The disadvantage of DEA efficiency estimation techniques is that they assume compliance with the assumption of convexity of the multitude of production possibilities, but in reality it may happen that certain production processes do not comply with this assumption. Non-parametric FDH estimation techniques prevent this problem by eliminating the convexity hypothesis. This relaxation of the hypothesis of convergence offers the ideal conditions for determining inefficient units even in a production process that can produce undesirable outputs such as carbon dioxide emissions. This aspect is very important for this paper because this research seeks to determine the efficiency at the country level from an economic, ecological but also social point of view by including undesirable outputs in the efficiency models.

Due to the relative nature of non-parametric estimators that could lead to the formation of an efficiency frontier consisting of extreme values as explained by Daraio and Simar(2007), the current study consists of using a series of preliminary exploratory analysis techniques to identify from the initial set of observations, a homogeneous set of observations from which to eliminate the extreme values. Also, in order to obtain more robust efficiency scores and less sensitive to the presence of outliers in the data set, we constructed the order alpha efficiency frontier (Daraio and Simar, 2007). The order alpha efficiency frontier identifies the percentage of decision units that lie below the curve determined by the alpha parameter. The novelty of this estimator is that it produces much more robust estimators with a convergence rate comparable to parametric methods.

The objective of this paper is to evaluate the economic, but also the ecological efficiency at the country level in the context of economic, ecological and energy sustainability. The built model has the following inputs: Renewable energy consumption per capita, Energy consumption from non-renewable sources per capita and carbon dioxide emissions per capita. Output is the gross domestic product per capita. The choice to treat the undesirable output of the production process, in this case, carbon dioxide emissions, as an input is supported by previous studies that seek to use an input-oriented model that seeks to minimize inputs.

The present study shows that non-parametric techniques applied to eco-efficiency problems reveal the constant efforts of the world's economies to balance environmental impact minimization alongside economic development. We built the input-oriented model and used the FDH frontiers and partial frontiers of order α to gain insight into the eco-efficiency of the countries. We could see that 73% of the efficient countries in the full frontier model had a GDP per capita higher lower than average, which supports the idea that eco-efficiency can be achieved in less developed economies. From the perspective of the partial frontier, we could see that the countries that can increase their production to reach the 100% frontier could be divided into two different groups: large economies and small and medium to small economies. From the two groups we could see that large economies use on average a larger amount of energy from renewable sources than small and medium economies. This could lead to the conclusion that economic development can also occur by using a greater share of renewable sources to cover the necessary energy consumption. Another perspective on countries' efforts to protect the environment could be obtained by introducing into the analysis variables such as government spending on promoting green energy sources, which can be divided into subsidies and funds for research and development.

Keywords: non-parametric methods, Free-Disposal Hull, FDH, partial order alpha frontiers, dimensionality reduction, hyperbolic estimators, eco-efficiency

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