Chapter 36
Data Envelopment Analysis in Environmental Technologies

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ABSTRACT

Contemporary scientific and economic developments in environmental technology suggest that it is of great importance to introduce new approaches that would enable the comparison of different scenarios for their effectiveness, their distributive effects, their enforceability, their costs and many other dimensions. Data Envelopment Analysis (DEA) is one of such methods. The DEA is receiving an increasing importance as a tool for evaluating and improving the performance of manufacturing and service operations. It has been extensively applied in performance evaluation and benchmarking of several types of organizations, so-called Decision Making Units (DMU) with similar goals and objectives. Among these are schools, hospitals, libraries, bank branches, production plants, but also climate policies, urban public transport systems, renewable energy plants, pollutant emission systems, environmental economics, etc. The purpose of this chapter is to present the basic principles of the DEA and give an overview of its application possibilities for the problems of environmental technology.

INTRODUCTION

The Earth is the common home for all of us and because of this the great attention paid to environmental problems is more than natural and urgent. The lack of economic value of environmental goods often leads to over-exploitation and degradation of these resources. It is extremely important to monitor and control interactions between production technologies and the environment. To keep and conserve the natural environment, environmental technology is developed. Independently of application areas of environment sciences, new approaches and methods, particularly of mathematical modeling, are extremely needed and welcome in this area. It is well-known that mathematical modelling is the most efficient method for investigating different processes, their simulation and prediction.

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Data Envelopment Analysis (DEA) is a relatively new data oriented mathematical method for evaluating the performance of a set of peer entities traditionally called Decision Making Units (DMU) which convert multiple inputs into multiple outputs. Since DEA was first introduced, in its present form, in 1978 (Charnes et al., 1978), we have seen a great variety of applications of DEA being used in evaluating the performances of many different kinds of entities engaged in many different activities in many different contexts in many different countries. These DEA applications have used DMUs of various forms, such as hospitals, schools, universities, cities, courts, business firms, and others, including the performance of countries, regions, etc. The DEA is frequently applied in many areas of applied economic sciences, including agricultural economics, development economics, financial economics, public economics, macroeconomic policy, etc.; and among others, in addition to its traditional confinements in productivity and efficiency analysis; it has also diffused into the field of environmental economics and environmental technology. As it requires very few theoretical assumptions, DEA has opened up possibilities for its use in cases which have been resistant to other approaches because of the complex (often unknown) nature of the relations between the multiple inputs and multiple outputs involved in DMU.

There are several examples of areas of environmental science, where DEA is used and where remarkable theoretical and practical results have been achieved. In the framework of problems raised by climate change, one of the major threats to the Earth's sustainability, we see that DEA is applied for assessing the relative performance of different climate policy scenarios as DMUs, through accounting their long-term economic, social and environmental impacts as input and output parameters. (Bosetti & Buchner, 2008) Quantitative techniques are crucial here in order to make adequate decisions quickly. In the sense of climate change measuring the carbon emission performance is also important. (Zhou et al., 2008) In another context, the paper by (Piot-Lepetit, 1997) considers the usefulness of DEA for estimating potential input reductions and assessing potential reductions of environmental impact on agricultural inputs. We can see the same in the paper (Madlener et al., 2006), where the assessment of the performance of biogas plants is realized. In the study (Rodrigues Diaz et al., 2004) DEA was used to select the most representative irrigation districts in Andalusia. One can find the use of DEA to assess corporate enactment of Environmentally Benign Manufacturing as work parts move from place to place in a company (Wu et al., 2006); this work touches green manufacturing problems. The DEA is used even in political decision making (Taniguchi et al., 2000), and to discuss a methodology to assess the performances of tourism management of local governments when economic and environmental aspects are considered as equally relevant. (Bosetti et al., 2004)

The structure of the present chapter is the following. First an overview of DEA method is given. Today the DEA itself has developed and has several forms, versions and modifications, each of which has specific application features. Below we formulate only the basic version of it because there is a lot of literature available in libraries and on the internet. The main part of the paper deals with the case studies, the results of which have been achieved by using the DEA. There is a rising trend to apply DEA and naturally some selection of them is included. Finally the reader finds the conclusions and references. One important objective of this chapter is to emphasize that environmental technologies are very open to innovation, and using new methods of mathematical modeling is a part of this.

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