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POWER PLANTS EFFICIENCY ASSESSMENT: CASE OF TURKEY

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Overview

A multi input-multi output performance evaluation is presented in this paper comparing a large set of power plants in Turkey based on real data. A key issue in any such multi-factor analysis is the determination of the frontier functions to assess the efficiencies of the DMUs relative to this function. In this study, this issue is handled with two different methodologies. First one is the Data Envelopment Analysis (DEA), which was introduced by Charnes et al. (1978). Second one is the Stochastic Frontier Analysis which was introduced by Aigner et.al. (1977), Meeusen and van den Broeck (1977) simultaneously.
Two models, one focusing on annual operational performance and the other on long term investment performance, are defined. Evaluations and comparisons within the framework of these models give consideration to various factors including cost, resource availability, production and pollutant emissions. The quantification (and monetarization) of environmental effects is based on the findings of an earlier project supported by the European Commission, namely ExternE (1995). The results of the study not only provide a general efficiency ranking and evaluation of the power plants, but also facilitate various interesting efficiency comparisons, such as public versus private sector plants, coal versus natural gas plants, renewable versus thermal plants. Furthermore, relationships between efficiency scores and various input/output factors are investigated yielding some interesting trends.

Methods

The aim has been to develop mathematical models which will facilitate efficiency/ effectiveness comparisons of electric energy generation facilities. For this purpose, two types of models are formed: one is related to the annual operational performance of the targeted facilities and the other is related to their long term investment performance.
Two Operational Efficiency Models have been developed: one for thermal power plants, the other for renewable power plants. The basic model for the operational performance of thermal power plants consists of six parameters. These are: fuel cost, production quantity, plant availability, thermal efficiency, environmental cost, and carbon monoxide (CO) emissions. The first three parameters are chosen in order to give due consideration to the primary mission of a power plant (i.e. reliable generation of electric energy at an acceptable cost). The last three parameters are chosen to reflect the key societal condition imposed on power plants (which are related to externality effects on the local and global environment). The model developed for the operational performance of renewable power plants has one input factor (operating cost) and two output factors (production quantity and availability). Similar to the case of thermal power plants, these three parameters are chosen in order to give due consideration to the primary mission of a power plant (which is reliable generation of electric energy at an acceptable cost).
The DEA model developed for the evaluation of the power plants' long term investment performance has four parameters: investment cost, installed capacity, construction time and verage utilization rate. These parameters are chosen to reflect the overall effectiveness of an electricity generating facility.
Data Envelopment Analysis (DEA) is a linear programming (LP) based technique thatprovides an objective assessment of the relative efficiency of similar organizational

units. In their seminal study, Charnes *et al.* (1978) introduce the generic term "Decision Making Units" (DMU) to describe the collection of firms, departments, or divisions that have multiple incommensurate inputs and outputs which are being assessed for efficiency. Since then DEA has been successfully deployed in many different fields to assess and compare the efficiency of DMUs (e.g. Banker *et al.,* 1992, Dyson *et al.,* 1987, Golany *et al.,* 1994, Korhonen *et al.,*2003). The DEA models deployed in this study are CCR (Charnes *et al.* (1978)), BCC (Banker *et al* (1984)), AR-I-C (Dyson (1988))and AR-I-V(Thompson *et al*. (1986) and Tone (1999)).

Other method to measure the efficiency of power plants is Stochastic Frontier Analysis which is a parametric method used to estimate the efficient frontier and efficiency values. With the assumptions about the firm's production technologies, the method recognizes the possibility of stochastic errors but requires the specification of the distance functions (Coelli, et al., 1998). The stochastic frontier production function was independently proposed by Aigner et.al.(1977) and Meeusen and van den Broeck (1977).

Results

		Operational Performance			*Investment Performance*		
Model	Partition	*Efficient*	*Projected*	*Total*	*Efficient*	*Projected*	*Total*
BCC	Number of IRS	1	19	20	0	0	0
	Number of CRS	3	12	15	6	23	29
	Number of DRS	1	0	1	1	0	1
AR-I-V	Number of IRS	0	0	0	0	0	0
	Number of CRS	1	22	23	1	16	17
	Number of DRS	2	11	13	4	9	13

Table 1. Return to scale analysis of renewable power plants

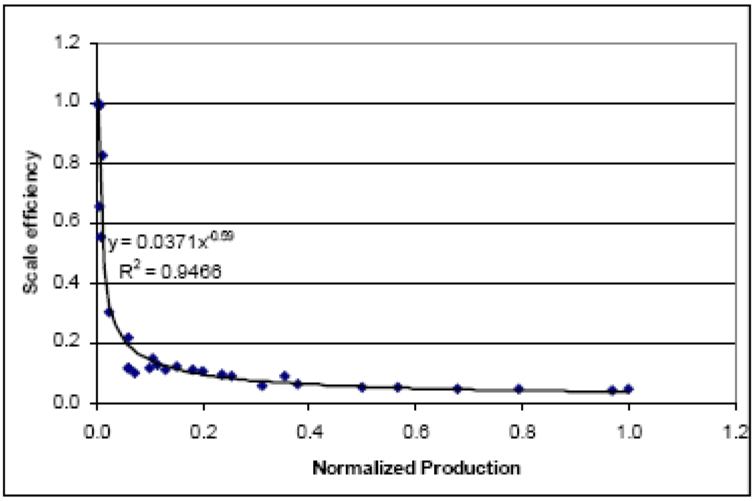

Figure 1. Scale efficiency versus production in thermal plants' operational performance

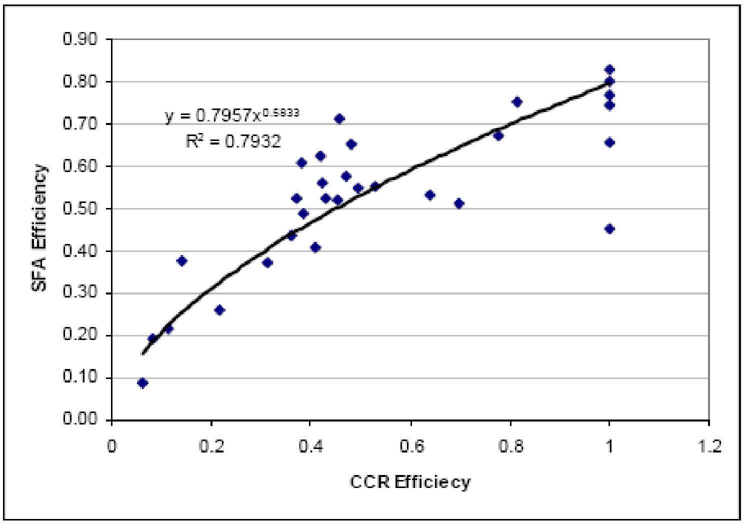

Figure 2. Relationships between SFA results and DEA results: Renewable plants investment performance

Conclusions

- Thermal power plants' global and scale efficiencies exhibit a strong exponentially decreasing trend with respect to plant size (production).
- Thermal power plants' global and scale efficiencies exhibit a linearly increasing trend with respect to availability.
- Thermal power plants' global and scale efficiencies exhibit an exponentially decreasing trend with respect to construction time.
- Operational performance efficiency of coal and oil fired power plants are considerably lower than that of the natural gas fired ones.
- Operational performance efficiency of public sector natural gas fired power plants is slightly lower than that of the privately owned ones (which is a reflection of the high ratioof coal and oil fired plants in the public portfolio).
- Regarding thermal power plants' investment performance efficiency, the private sector plants perform significantly better than the publicly owned ones.

Results obtained by SFA and DEA based models are compared. And it is found that for investment performance indices the rankings and efficiency scores tend to support each other except for several power plants. For operational performance case model results diverge from each other. Especially CCR model results get significantly different from other model results. The highest disturbance between the model results is seen for thermal power plants case.

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