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Ranking the Electricity Producer Companies in View of Manpower Efficiency by DEA

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Abstract

Abilities, Commitment and Capacity of learning in manpower play a key role for increment of the power stations efficiency. With due to the evolutions in electricity industry there is evolutions need to international competition between power stations and withal so far the dependent companies of electricity industry haven't been ranked from aspect of scientific, in this article an approach for ranking of manpower efficiency has presented in electricity producer companies. The used method is based on linear programming and using of Data Envelopment Analysis (DEA). With use of this approach the efficient companies have been assessed and others companies have been compared with them and they have been ranked. It is obvious that the above method is generalizeable to all regional electricity companies. Withal obtained results from this method can consider as an index for appraisal of companies economic management.

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1 Introduction

Data Envelopment Analysis (DEA) proposed by Charnes et al. [3] (CCR model) and developed by Banker et al. [2] (BCC model) is an approach for evaluating the efficiencies of Decision Making Units (DMUs). DEA does not require any a priori weight for inputs and outputs. Outcome of DEA models is an efficiency score equal to one to efficient DMUs and less than one to inefficient DMUs. So, for inefficient DMUs a ranking is given but for efficient ones no ranking can be given. Some methods for ranking efficient DMUs are proposed. The first method was developed in [1] (AP model). The main difficulty about this method is that the method compares the efficient DMUs with the inefficient ones. The other difficulties about AP model are discussed in detail in [4], [5] and [6]. In [4] (MAJ model), a different ranking method was developed. However, ranking by AP and MAJ models break down in case of units with at least one zero input.

In this article a different approach has presented for ranking of DMUs by using multiple objective issues and the common set of weights. This approach has not the existing difficulties and the presented ranking seems logical because of using common set of weights.

The paper is organized as follows: Section 2 provides a short background about DEA standard, AP, MAJ and revised models. Proposed model is suggested in section 2. A case study is presented in section 3. In section 4, data are introduced. Section 5 closes with results and proposals.

2 Efficiency and rank of DMUs

Assume that there are n DMUs to be evaluated. Each DMU consumes varying amounts of m different inputs to produce s different outputs. In the model formulation, x_{ip} $(i = 1, \ldots, m)$ and y_{rp} $(r = 1, \ldots, s)$ denote, respectively, the input and output values for DMU_p, the DMU under consideration.

The efficiency of pth DMU will be obtained by solution the following linear programming:

$$\min \theta - \epsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \tag{1}$$

$$\text{s.t}: \quad \sum_{j=1}^{n} \lambda_j x_{ij} - \theta x_{ip} + s_i^- = 0 \quad i = 1, ..., m,$$

$$\sum_{j=1}^{n}\lambda_j y_{rj} - s_r^+ = y_{rp} \qquad r = 1, ..., s,$$

$$\lambda_j,\ s_r^+,\ s_i^- \geq 0 \qquad j = 1, ..., n,\ r = 1, ..., s,\ i = 1, ..., m.$$

pth DMU is efficient if and only if the following conditions are satisfied:

i) $\theta^* = 1$,

ii) $s_r^{+^*} = s_i^{-^*} = 0$ for each i and r.

where,"$*$" shows the optimal solution.

If we want to rank all DMUs, we can not rank the efficient units because of all they have efficiency equal to one. Andersen and Petersen (1993) have presented a model that has named AP for ranking of efficient DMUs. They solved n time the model (1), every time with elimination of appraising unit column from coefficients matrix. The problem of corresponding in pth DMU is as follows:

$$\min \quad z_p = \theta - \epsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \tag{2}$$

$$\text{s.t}: \quad \sum_{\substack{j=1\\ j\neq p}}^{n}\lambda_j x_{ij} - \theta x_{ip} + s_i^- = 0 \quad i = 1, ..., m,$$

$$\sum_{\substack{j=1\\ j\neq p}}^{n}\lambda_j y_{rj} - s_r^+ = y_{rp} \qquad r = 1, ..., s,$$

$$\lambda_j,\ s_r^+,\ s_i^- \geq 0 \qquad j = 1, ..., n,\ r = 1, ..., s,\ i = 1, ..., m.$$

If z_p^* is optimal of problem (2) then:

If $z_p^* < 1$ then pth DMU is inefficient,

If $z_p^* = 1$ then pth DMU is non extreme efficiency,

If $z_p^* > 1$ or the problem is infeasible then pth DMU is extreme efficiency.

But this ranking breaks down in some cases, and can be unstable when one of the DMUs has a relatively small value for some of its inputs. In addition to the occurrence of the infeasibility of Andersen/Petersen's model, the difficulties do not end here. Andersen/Petersen's approach may be unstable because of extreme sensitivity to small variations in the data when some DMUs have relatively small values for some of its inputs. An alternative definition of efficiency is proposed by Mehrabian et al [4] that can be extended for ranking efficient DMUs. This model successfully removes the above mentioned difficulties arising from Andersen/Petersen's model. To rank the relative efficiency of DMUs with unit efficiency, Andersen and Petersen propose that evaluated unit be excluded from the mathematical program, leading to the following programs depending on the unit p be evaluated:

$$\min \quad z_p = w_p + 1 \tag{3}$$

$$\text{s.t}: \quad \sum_{\substack{j=1\\ j\neq p}}^{n}\lambda_j x_{ij} + s_i^- = x_{ip} + \widehat{x}_i w_p \quad i=1,...,m,$$

$$\sum_{\substack{j=1\\ j\neq p}}^{n}\lambda_j y_{rj} - s_r^+ = y_{rp} \quad r=1,...,s,$$

$$\lambda_j,\ s_r^+,\ s_i^- \geq 0 \quad j=1,...,n,\ r=1,...,s,\ i=1,...,m.$$

where $\widehat{x}_i = Max\ x_{ij},\ 1 \leq j \leq n$.

If z_p^* is the optimal value of the above then:

If $z_p^* < 1$ then pth DMU is inefficient,

If $z_p^* = 1$ then pth DMU is non extreme efficiency,

If $z_p^* > 1$ then pth DMU is extreme efficiency.

For the DMU ranking in both model AP and JAM, it is necessary that solve n linear programming in number of DMUs. Off course this procedure is difficult, costly and time consuming.

Hosseinzadeh et al. (1999) presented the following approaches for ranking all DMUs by using common set of weights. At first the following model will be resolved for ranking DMUs.

$$\min \quad \sum_{j=1}^{n} z_j \tag{4}$$

$$\text{s.t}: \quad \sum_{r=1}^{s} u_r y_{rj} + z_j \sum_{i=1}^{m} v_i x_{ij} - \sum_{i=1}^{m} v_i x_{ij} = 0 \quad j=1,...,n,$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \quad j=1,...,n,$$

$$u_r,\ v_i \geq \epsilon \quad r=1,...,s,\ i=1,...,m,$$

$$z_j \geq 0 \quad j=1,...,n.$$

After the resolving above problem, the amount of jth unit efficiency will be obtained from relation of $e_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}$. pth unit is efficient if and only if $e_p = 1$.

After assessment of efficient units, we solve model (4) for efficient units with elimination of the related z restrictive constraint. In other word if A is a matrix of efficient DMUs, the corresponding mathematical programming model for pth DMU will be as follows (note that $p \in A$):

$$\min \quad \sum_{j\in A} z_j \tag{5}$$

$$\text{s.t}: \quad \sum_{r=1}^{s} u_r y_{rj} + z_j \sum_{i=1}^{m} v_i x_{ij} - \sum_{i=1}^{m} v_i x_{ij} \geq 0 \quad j \in A,$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \quad j \in A,\ j \neq p,$$
$$u_r,\ v_i \geq \epsilon \quad r = 1, ..., s,\ i = 1, ..., m,$$
$$z_j \geq 0 \quad j \in A,\ j \neq p.$$

The problem (5) is solved for number of efficient DMUs until at last is ranked all DMUs according to obtained z_j.

3 A case study

Increment of productivity is one of the important aims in any organization in diverse grounds such as manpower, machinery, consumer materials, fuel and so forth that manpower productivity has a key role between them. Because it affects on productivity of other production factors in production function.

Therefore the programming for improvement of productivity in any organization requires increment of manpower, that this matter requires scientific understanding about effecting factors on ability of manpower too.

The ranking of electricity producer companies from aspect of ability of manpower can find a ground for using experiment of the companies with high rank.

It is necessary that say the ability consist of three elements of experiment, instruction and education. In the recent years the electricity producer companies have appraised about instruction from aspect of quantitative, but in this study three elements (experiment, instruction, education) will be appraised from aspect of quantitative and qualitative and then the companies will be ranked in view of ability of manpower.

4 Data

In this study DMUs are the heat power stations in throughout of the country (vapory, gas and compound cycle power stations).

There are many indices about ability appraisal of manpower (education, instruction and experiment) in the heat power stations. The following key indices have determined after discussing with related experts in the power stations and the scope of the management in Tavanir Company.

Total cost of instruction (the instruction in sectors of expertness, technicianness, operatorness, and etc.) ; the cost of ceremonies and lecture; number of the staff; number of educable staff; number of staff in instruction sector; number of class; capacity of class; instruction equipments cost; years of service for the staff in job different sectors; the education level of the staff in job different sectors; data about the management (oldness, years of service, years of management, education course, and etc.); data about performed seminars (number of partaker, level of seminar, number of seminar hours); presented educations in job different sectors in parted hours; effectiveness of presented educations and so forth. In order to determination of the above indices quantity in different power stations was needed two kinds of data as follows:

(i) The data that must got from different power stations, such as instruction costs, number of the staff and so forth that for this purpose an information form designed.

(ii) The data that must got from the staff such as effectiveness of presented instructions for purposes of the staff.

Therefore a questioner designed and completed by 20 percent of the staff in the power stations at random. This study preformed on the basis of received data from 10 power stations. With notice to many determined indices the following inputs and outputs that have obtained from combination of above indices is determined.

The above data is related to the heat power stations in throughout of the country in 1999.

Inputs	Outputs
1. Per capita cost of performed instruction 2. per capita cost of equipments and instructional possibilities 3. educations and experiment of the staff 4. educations and experiment of the management	1. performed instructions 2. effectiveness of performed instructions 3. performed seminars

Table 1. Inputs and outputs

5 Results and proposals

With notice to AP model is too sensitive and sometime impossible about the zero data or that those are close to zero, JAM model that hasn't this failure is recommended.

JAM model at number DMUs, programming problem is solved and in that many number of DMUs will be got a lot of time for calculations, hence we can consider presented non linear model as a suitable estimation from JAM model.

The obtained results from the three models have reflected in table 2, that in order to regard of data secretiveness for researchers, to say name of power stations have been avoided. Therefore the power stations have been shown with codes 1 until 10.

In table 2, the columns 1 until 5 shows the power station code, obtained point from AP model, obtained point from JAM model, obtained point from performance of non linear model and the power stations rank. With notice to obtained results from performance of JAM and linear models and in that the number of DMUs isn't many; hence the ranking is performed by use of obtained points from JAM model performance as follows in the 5th column. This column shows that 6, 8 and 3 units respectively have 1st, 2nd, and 3rd ranks.

The managers can by the above method rank the units or the staff in an organization from varied aspects systematically. Hence they can provide suitable appraisal system for performance. The managers by the presented approach can calculate the amount of inputs for obtain a suitable level of outputs.

Rank	NLP	JAM	AP	O2
4	1.4260	118	167	01
5	1.5033	116	211	02
3	1.8809	123	165	03
6	0.9900	103	107	04
10	0.7600	96	95	05
1	0.9000	183	211	06
7	0.9300	99	98	07
2	2.3346	151	192	08
8	0.7800	98	96	09
9	0.9000	97	94	10

Table 2. The obtained results from performance of different models

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