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A satisficing game theory approach for group evaluation of production units

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Abstract

The problem under consideration in this paper is that of analysing the performance of a production unit in two directions: resource utilization versus output perfomance on the one hand and inter-unit comparison (within-group evaluation) on the other hand, all this subjected to possible subjective intervention of a decision maker or group of decision makers (DMs). A well known method that deals mainly with the second point (without intervention of DMs) of this problem which is widely covered in the literature is the so called *data envelopment analysis* (DEA). The point of view that will be expressed in this paper can be thought of as complementary to the DEA approach giving a more complete analysis in terms of the weak points of units identification and DMs' recommendations. The performance of each decision unit is evaluated through the so called *satisfiability functions* in the framework of satisficing game theory.

Keywords: Production systems; Performance analysis; Efficiency evaluation; Group evaluation; DEA; Satisficing game theory

1. Introduction

The problem of evaluating production units' performance is of great importance for efficient management decision making such as restructuring an organization, rewarding production teams, etc. We understand by production unit, a system that utilizes some input items (resources) to produce some goods or to deliver some service. It could be a hospital, a manufacturing plant, a university, a police department, etc. The purpose here is to evaluate the efficiency in terms of resource utilization versus output performance of each production unit of an organization $\mathcal{U}$ that consists of n production units. Each production unit is evaluated individually as well as with regard to its counterparts' efficiency. We suppose that each unit of $\mathcal{U}$ uses p input items expressed as positive numbers I_i^j (value of item j used by unit i) to deliver m output items valued by O_i^j (value of item j produced by unit i).

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A first idea could be to define the efficiency e_i of unit i by

$$e_i = \frac{\sum_{j=1}^{m} O_i^j}{\sum_{j=1}^{p} I_i^j}; \qquad (1)$$

but this definition leads to some problems as all input items or output items do not have the same importance in practice. It is then tempting to weight items in order to take into account this relative importance so that the efficiency is defined by

$$e_i = \frac{\sum_{j=1}^{m} \alpha_i^j O_i^j}{\sum_{j=1}^{p} \beta_i^j I_i^j}, \alpha_i^j, \beta_i^j > 0; \qquad (2)$$

but here again, a problem relative to the determination of weights α_i^j and β_i^j is raised.

A method to deal with the determination of these weights in the literature is the so called data envelopment analysis (DEA) established by [1]. It is an extreme point method that determines weights α_i^j and β_i^j in order to define a relative efficiency of each unit compared to the best production unit (possibly virtual) by solving n linear programs (see for instance [2] for definition of linear programming concepts).

But this approach has some technical drawbacks that will be recalled in the next Section and more importantly, we consider that the spirit of comparing each unit to the "best unit" is not necessarily how humans proceed in practice. They often evaluate each unit firstly with regard to how efficiently it uses its resources to produce its output and secondly they look at how good this unit is compared to its counterparts. If we think of how students are evaluated, we see that each student is first evaluated individually (their marks reflecting the effort they have made) and then compared to the best student of the same class. This observation suggests that a production unit should be evaluated by comparing its positive attributes (output performance) to its negative attributes (input or resource consumption) at first and with regard to the other units in a second stage. Another important issue in the process of evaluating production units is the possible existence of different decision makers that do not have the same point of view regarding the importance of input items and/or output items and this constraint should be taken into account. A framework that seems interesting to tackle this problem with is the recently developed satisficing game theory [3] that, basically for our problem, will consist in defining *selectability* (with regard to output items) and *rejectability* (with regard to input items) functions known as *satisfiability* functions. These functions must have a probability structure (they are non-negative and sum to one on $\mathcal{U}$) which can be thought of as units sharing a unity of input item to produce a unity of output item. An efficient production unit will be that for which the selectability is at least equal to the rejectability. We consider here that there are d decision makers that express their point of view regarding input items and output items by weighting them.

The remainder of this paper is organized as follows: in the Second section the DEA method is briefly presented with its strengths and its drawbacks; the Third section is devoted to a rapid presentation of satisficing game theory that is relevant to our problem and the Fourth section shows how to cast performance evaluation problems into the framework of this theory and finally, in Section five, the approach we have established is applied to a real world problem.

2. Data envelopment analysis

Data envelopment analysis (DEA) is a technique for assessing and ranking the performance of corporations, research projects or other entities where an entire array of indicators of performance are to be evaluated. It was invented by [1] and is a linear programming based technique for measuring the relative performance of organizational units where the presence of multiple inputs and outputs makes comparisons dificult. It is an extreme point method and compares each producer (also known in the DEA literature as decision making unit or DMU) with only the "best" producer (possibly virtual). A fundamental assumption behind the DEA method is that if a given producer, A, is capable of producing $Y(A)$ units of output with $X(A)$ inputs, then other produ-