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Using data envelope analysis to compare project efficiency in a multi-project environment

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Abstract

Data envelope analysis (DEA) is currently applied to ongoing organizations such as hospitals, police stations, schools, etc. This paper investigates the possibility of using the DEA approach for evaluating the performances of projects in a multi-project environment, where each project is usually a one-time non-repeated event. Projects are evaluated by the earned value management system (EVMS) and the multidimensional control system (MPCS) methods. In this environment, it is usually necessary to reduce the number of outputs and inputs not to exceed the number of projects. This paper deals with a method for their reduction. The paper illustrates a detailed example on how to apply and interpret the DEA method in a multi-project environment.

Keywords: Managing projects; Managing programmes

1. Introduction

Multi projects occur quite frequently in industry. Virtually all contractors and construction companies run several projects simultaneously and R&D organizations are characterized by having many ongoing projects. Each of these projects is a one time and unique application. At any moment in time, projects are usually at various stages of completion and a major problem for each organization is how to assess the relative performance of each project.

The most popular method of assessment today is the earned value management system (EVMS) which integrates two dimensions – time and cost. Currently, moves are being considered to add other dimensions, but the assessment of these is always converted into cost measures [10,12,13,17]. An alternative approach called the multidimensional project control system (MPCS) was recently described by Rozenes et al. [16] which provides control mechanism for monitoring project characteristics (such as: quality, design, functionality, operations, etc.).

In today's competing business environment, companies are looking for a method for effectively comparing the performances of various projects at a given time period. This is needed in order to effectively allocate resources, to motivate project managers and their teams and to create an improvement environment. The data envelope analysis (DEA) provides the correct method for this need.

2. The data envelope analysis

The DEA is a mathematical programming approach which assesses the comparative efficiency of a set of decision making units (DMU) such as banks, hospitals, factories, universities, etc., where the presence of multiple inputs and outputs makes comparison difficult. Charnes et al. [2] first introduced the DEA concept and many articles have since appeared that deal with various types of implementations (e.g. [3,4,6,11,14]). Thus, DEA has always been

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applied to ongoing activities such as in banks, police, hospitals, etc. The one area in which DEA was not applied is with multi projects which form the motivation for this paper. Thamassoulis [18] introduced a comprehensive explanation elaborating the DEA foundation and applications. The DEA is a non-parametric approach which allows efficiency to be measured without any assumptions regarding the functional form of the production function or the weights for the different inputs and outputs chosen. The DEA defines a best practice efficiency frontier that can be used.

Charnes et al. [2] recognized the difficulty in seeking a common set of weights to determine relative efficiency. They proposed that each DMU should be allowed to adopt a set of weights, which shows it in the most favorable light in comparison to the other DMUs. The efficiency of a DMU is defined as a weighted sum of its m outputs divided by a weighted sum of its n inputs.

The DEA evaluation is constrained by the sum number of inputs and outputs ($m + n$) versus the number of DMUs. In general, the following rule of thumb should be used [6,9]: the sum of input and output types ($m + n$) should not exceed one third of the number of DMUs.

2.1. DEA in a project management environment

In a multi-project environment each project is a DMU having its own inputs and outputs. A typical illustration is given in Fig. 1.

The efficiency of a project would then be a weighted sum of its outputs divided by a weighted sum of its inputs.

The DEA comparison process requires the definition of DMUs, their inputs and outputs. Using the DEA methodology in the multi-project environment, each DMU is a project whose outputs represent all of dimensions by which the project is measured.

2.2. Using DEA methodology to evaluate multi-project performances

It was pointed out earlier that project measurement can be executed via either the EVMS method or else, using the MPCS approach.

The DEA can be effectively used with either system. We have decided to concentrate on the MPCS approach which is more comprehensive since it also utilizes and integrates the EVMS measures in the DEA inputs and outputs.

The MPCS supports an integrative control process during the entire project life cycle and allows the project manager to determine: the integrated project status; where problems exist in the project; when and where to make corrective actions, and how to measure improvements. The control system focuses management's attention on the corrective actions that must be performed.

The MPCS system includes the global project control specifications (GPCS) that determine control specifications by defining control work packages (CWP) through the project life cycle. CWP defines the measurement processes that should be executed in order to successfully perform the project work breakdown structure (WBS).

The GPCS defines control assignments during the course of the project's life. Should there be a gap between planning and performance, a warning is indicated by the system in order to take corrective actions. This comparison process is conducted while measuring actual performance using the yield index.

The paper by Rozenes et al. [16] considers MPCS for single projects. However, there are many instances in which multi projects are involved and there is a need to consider efficiency measures among these projects in order to direct the company's limited resources for corrective actions.

Operating several projects in parallel using the MPCS methodology requires that "Level 1" in the GPCS structure (which defines the control dimensions/categories) to be identical for each project (e.g., see Fig. 2 in the illustration). This enables the comparison process between projects to be made. Furthermore, it enables standardization within the GPCS definition of the different projects following the same standardization which is used with WBS (e.g., FAA [7] and DoD [19]).

2.3. The DEA grouping process: satisfying the rule of thumb

In multi-project environments, it is very common that the number of projects (i.e., the DMU's) may be relatively small and hence the DEA rule of thumb may not be achieved.

Thus, there is a need for a methodology to reduce the inputs and outputs to meet the rule of thumb.

A three-stage methodology was developed, for adjusting the total number of outputs and inputs while also maintaining the necessary information, as follows: stage 1 – input/output definition; stage 2 – grouping algorithm; stage 3 – sequential DEA implementation.

Stage 1: Input/output definitions: a mandatory stage which defines the entire standardized inputs and outputs of the organization's projects.

If the sum of inputs and outputs comply with the stated rule of thumb then stages 2 and 3 are not required.

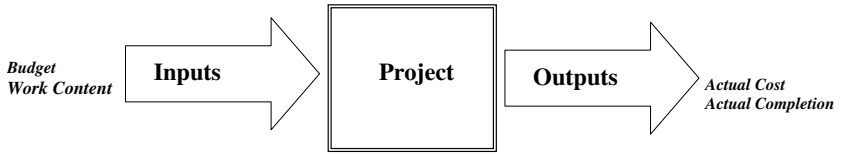

Fig. 1. A project structured as a DMU.